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MINISTRY OF ENERGY AND WATER

LEBANON ELECTRICITY SERVICES EMERGENCY SUPPORT PROJECT

ELECTRICITY SERVICES EMERGENCY SUPPORT PROJECT (P177846)

(Situations in Urgent Need of Assistance or Capacity Constraints)

ENVIRONMENTAL AND SOCIAL REVIEW FOR DEIR AMMAR POWER PLANT AND ARAB GAS PIPELINE

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LIST OF ACRONYMS

AGP	Arab Gas Pipeline
ALARP	As Low as Reasonably Practicable
CDR	Council for Development and Reconstruction
COM	Council of Ministers
COVID-19	Corona Virus Disease
CEMS	Continuous Emission Monitoring System
DAPP	Deir Ammar Power Plant
DGUP	General Directorate of Urban Planning
EDL	Electricité du Liban
E&S	Environmental and Social
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ELV	Environmental Limit Values
ERP	Emergency Response Plan
ES	Environmental and Social
ESHS	Environmental, Social, Health and Safety
ESCP	Environmental and Social Commitment Plan
ESF	Environment and Social Framework
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standard
EU	European Union
FGRM	Feedback and Grievance Redress Mechanism
GASCO	Egyptian Company for Natural Gas .
GASYLE	The Lebanese Gas Pipeline
GBV	Gender Based Violence

GRM	Grievance Redress Mechanism
HAZID	Hazard Identification
HQ	Headquarters
HSE	Health, Safety and Environment
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Examination
IPC	Iraq Petroleum Company
ISO	International Organization for Standardization
ISIC	International Standard Industrial Classification
ISWM	Integrated Solid Waste Management
KPI	Key Performance Indicators
LMP	Labor Management Procedures
LOI	Lebanon Oil Installations
LOPA	Layer of Protection Analysis
LOTO	Lock Out Tag Out
MEW	Ministry of Energy and Water
MoE	Ministry of Environment
MoF	Ministry of Finance
MOPO	Manual of Permitted Operations
MW	Megawatt
MWth	Megawatt Thermal
MSDS	Material Safety Data Sheet
NGO	Non-Governmental Organization
OHS	Occupational Health and Safety
OMCO	Operation and Maintenance Company
PAPs	Project Affected Parties
PBCs	Performance-Based Conditions
PDO	Project Development Objective
PMU	Project Management Unit
POM	Project Operations Manual
PP	Power PLant
PPE	Personal Protective Equipment

QRA	Quantitative Risk Assessment
ROW	Right of Way
SEA/SH	Sexual Exploitation and Abuse / Sexual Harassment
SEP	Stakeholder Engagement Plan
SIMOPS	Simultaneous Operations
SMP	Security Management Plan
SWM	Solid Waste Management
STP	Sewage Treatment Plant
TOIL	Tripoli Oil Installations - Lebanon
UNDP	United Nations Development Program
WB	World Bank
WBG	World Bank Group
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The World Bank is considering providing emergency support to Lebanon's power sector by importing natural gas from Egypt through Jordan and Syria using the existing Arab Gas Pipeline (AGP). The imported gas will be used by the existing Deir Amar power plant north of Tripoli, which is connected to the AGP but has been running on more expensive gasoil (diesel) since the interruption of gas supply at the start of the Syrian War in 2011. The Project is to be financed by a US$200 million IBRD loan and will be implemented by Electricité du Liban (EDL) and Lebanon Oil Installations (LOI).

The total length of the Arab Gas Pipeline (AGP) is 1,200 km (Fig. 1). The Lebanese Gas Pipeline (GASYLE) is a branch of the AGP. It was built between 2003 and 2007 and was first put in service in 2009 in cooperation with Egyptian Company for Natural Gas (GASCO). It extends from the Syrian border to Deir Ammar for about 31 Km and has a diameter of 24" in the Right of Way (ROW) that was dedicated for Iraq Petroleum Company (IPC) pipe. According to Tripoli Oil Installations – Lebanon (TOIL), GASYLE is still maintained under low gas pressure and monitored for leaks.

Deir Ammar Power Plant (DAPP) is located 90 km north of Beirut approximately. Its construction was commissioned in 1995 and ended in 1998 with a total installed capacity of 435 MW. Deir Ammar power plant is a combined cycle gas (and steam) turbine plant that can run on multiple fuels with natural gas being its "primary" fuel. It can accordingly easily switch back from gasoil to natural gas. The plant's available capacity is currently 410 MW.

The land use / cover in the project area (Deir Ammar PP and along GASYLE) is dominantly agricultural and as well as industrial and commercial as shown in Fig. 2 and Fig. 3.

There are no protected areas or nature reserves crossed by GASYLE while the existence of the pipeline inside an ROW eliminates potential conflict with any cultural and historical landmarks.

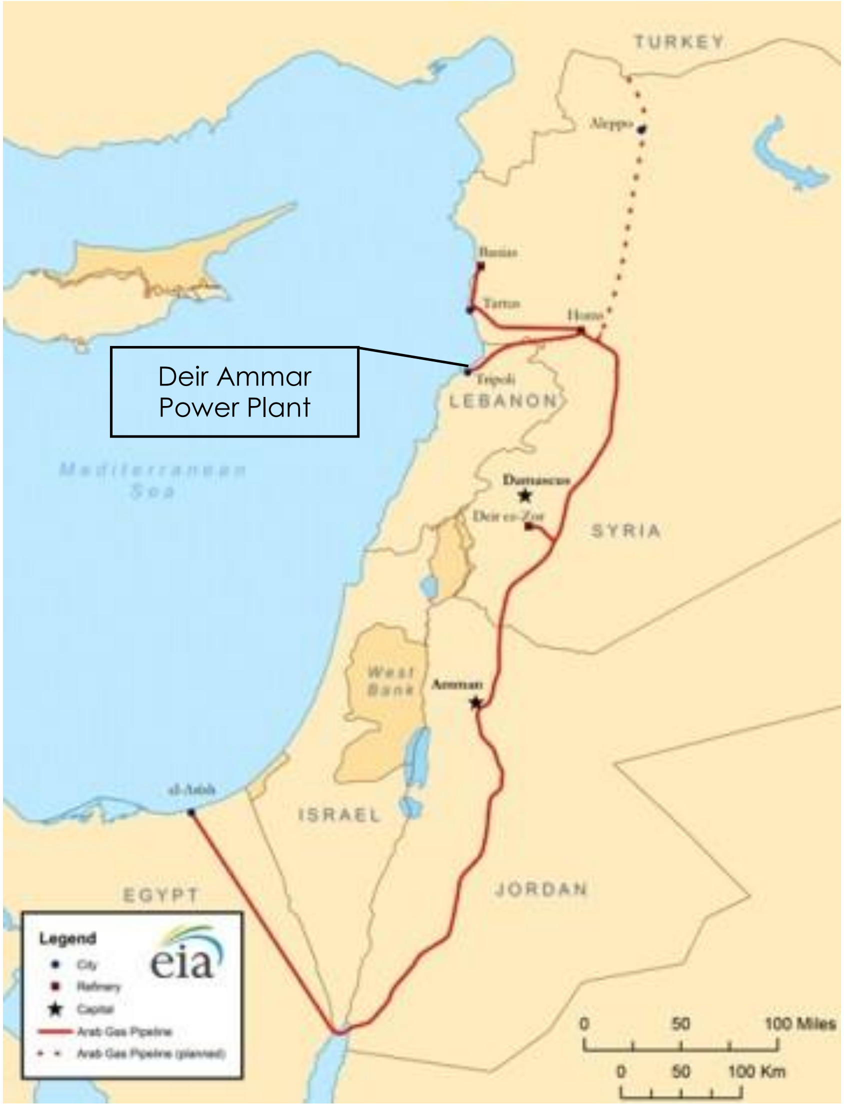

Fig. 1. The Arab Gas Pipeline from Egypt to Deir Amar Power Plant (Source: Journal of Petroleum Technology[1])

[1] Available Online: https://jpt.spe.org/egypt-snubs-lng-plans-to-send-gas-to-lebanon-via-the-arab-gas-pipeline

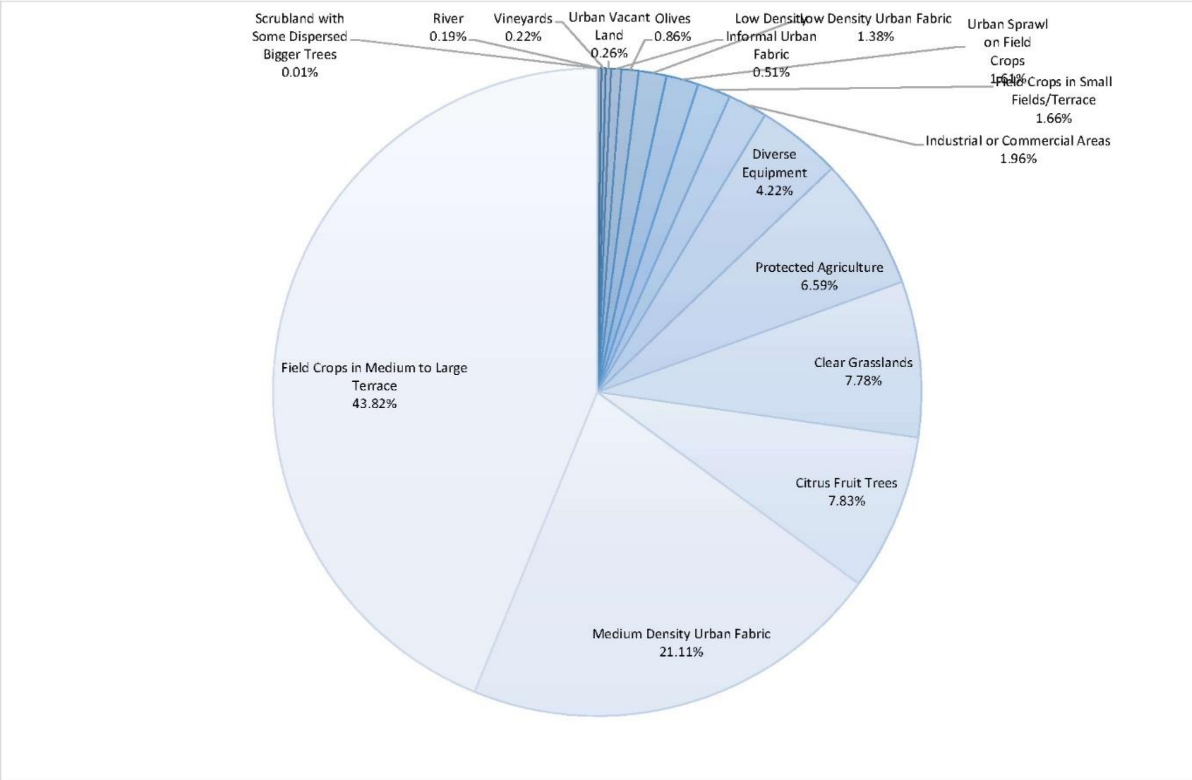

Fig. 2. Pie Chart of Land Use / Cover Percentage Distribution in Ascending Order (Diverse Equipment Category can be Considered as Industrial and Commercial)

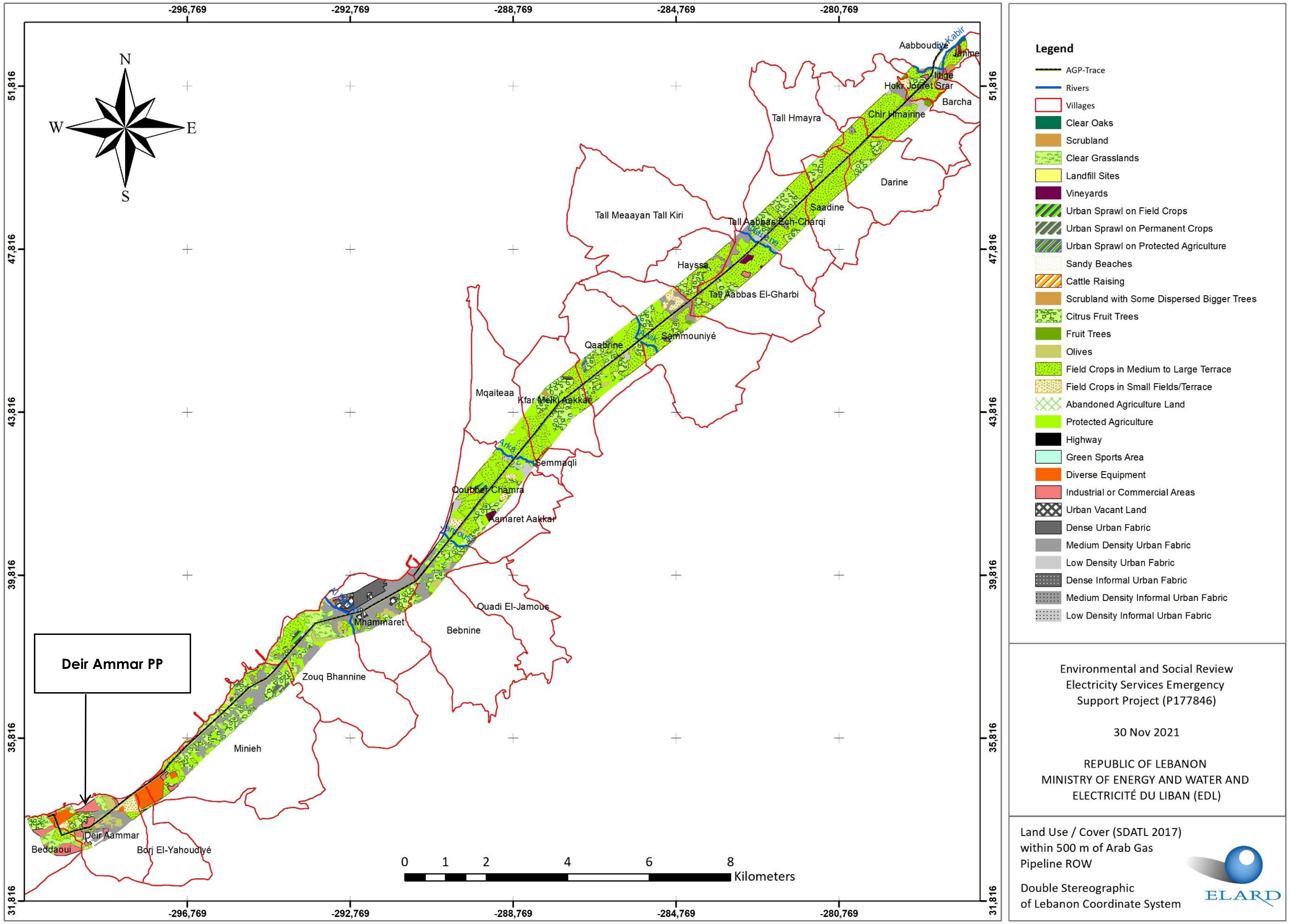

Fig. 3. Land Use / Cover within 500 meter buffer from each side of the AGP Trace

Key environmental and social gaps for the Deir Ammar Power Plant are summarized below:

1. Environmental and social aspects and potential adverse impacts are not explicitly managed (indirectly managed through plant efficiency targets and OHS manual); they are however limited and easily manageable without new/major equipment investments because the plant is a combined cycle gas and steam turbine plant with multi-fuel capability originally designed to operate on natural gas and with good operational performance.
2. Deir Ammar Power Plant lacks an Environmental Audit and Environmental and Social Management Plan (ESMP) based on local regulations and has non-compliances in terms of its emissions and effluent discharges to the sea, most of which can be easily addressed upon switching back to natural gas (i.e., air emissions in general and NOx in particular, and oil water separator effluent); also, switching to gas would eliminate generation of hazardous oily sludge, which is being transported to another EDL power plant for burning as Heavy Fuel Oil. In addition, Oily sludge transporters contracted by the power plant are not properly licensed in accordance with MoE Decision 999/1 of 2020; upon switching to natural gas this risk will be inherently eliminated.
3. A cooling water return flow mixing zone was never established and temperature of cooling water / mixing zone is not being monitored; this is an important aspect that needs to be addressed to ensure that local and WB standards are addressed (i.e., effluent temperature less than 35°C and temperature differential of less than 3 °C at edge of mixing zone respectively).
4. Air emissions are not continuously monitored because the available CEMS is not being operated except occasionally for operational efficiency purposes while additional pertinent parameters are not measured by CEMS (namely particulate matter and heavy metals); however, upon switching back to natural gas, NOx emissions would be the only pertinent emissions essentially, and Environmental Limit Values should not be exceeded even without NOx suppression given manufacturer performance limits.
5. While the risk of fire is covered in the current emergency response plan and while the risks of floods and severe weather conditions are not pertinent in the case of the PP, the risk of a major earthquake that exceeds the earthquake resistance parameters of the PP is real. A scientific research recommended in 2011 (post PP construction) that the seismic hazard for the coastal region of Lebanon be raised to account for at least 0.3g Peak Ground Acceleration) while Tsunamis also occurred historically in Lebanon as a result of strong earthquakes.
6. A Grievance Redress Mechanism including record keeping and explicit measures covering sexual exploitation and abuse, and sexual harassment (SEA/SH) for staff is lacking at the power plant. Those will be covered in a Labor Management Plan (LMP) for the project.
7. There is no Feedback Grievance Redress Mechanism (FGRM) for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.
8. Environmental and social aspect compliance and improvement responsibilities are lacking from HSE Manager responsibilities.

Key environmental and social gaps for the Arab Gas Pipeline are summarized below:

1. The AGP has not been transmitting gas to Lebanon since the start of the Syrian war over a decade ago but it was kept under 5 bars of pressure to protect it from corrosion. The Tripoli Oil Installations – AGP department still keep an all-time presence at the control room and patrol the ROW with the gas pipeline weekly but their AGP operations are practically minimal.

2. There are no systems and management plan in place at TOIL to manage environmental and social risks associated with the operation of the pipeline and linked facilities. The O&M contractor which is currently being contracted (TGS), is ISO 14001:2015, ISO 45001:2018, and ISO 9001:2015 certified and its management system and manual cover most EHS aspects albeit with some social aspect deficiencies. Integrating needed environmental and social gaps in their management system should be easy for TGS.
3. There are repairs to be made on pipeline and facilities because the pipeline has not been operational for more than a decade (refer to TGS repair assessment report); pipeline markers and berms also need rehabilitation.
4. There are trespassing and encroachment of private individuals/entities on the Right-of-Way (ROW), which hinder continued access along the ROW for O&M and thus expose encroachers and the general public to H&S risks. Encroachment includes agricultural activities, private backyard extension onto ROW, neighborhood road access, use of ROW as car and truck park space and as miscellaneous outdoor storage or dump yard.
5. There is no evidence of a previous quantitative risk assessment and an existing manual of permissible and non-permissible activities within the ROW and safety separation distances (not defined as of yet); given that the pipeline has not been in operation for a long time, it is critical to ensure that safety hazards including major accident hazards can be effectively managed through the existing barriers integrated in design, but also to ensure that operational barriers are in place, and consider maintenance activities.
6. A Resettlement Action Plan and/or Livelihood Restoration Plan shall be developed if and as needed in light of the findings of safety studies planned and the SEP.
7. If AGP TOIL team will have actual work as part of the TGS team and not just a supervisory role, there should be no role and responsibility confusion between TGS and TOIL given that they have to be fully integrated in their O&M and EHS Management Systems under one overarching EHS Management System and/or Plan.
8. Neither AGP TOIL nor TGS have explicit SEA/SH and GBV measures in place.

According to environmental and social gaps identified, the following key corrective actions shall occur mostly prior to commissioning and testing:

1. Deir Ammar Power Plant requires an Environmental and Social Management Plan (ESMP) and Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.
2. Environmental, OHS and Social aspects at the Power Plant shall be covered in dedicated procedures including environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures.
3. A stand-alone Occupational Hazards Management Plan for the pipeline shall be prepared.
4. A Labor Management Plan (LMP) shall be developed including a GRM with logs and explicit measures covering SEA/SH; roles and responsibilities shall be also assigned to competent staff with training provided. Staff will sign a code of conduct covering measures they shall adhere to them with all the necessary record keeping in place; security personnel shall have a dedicated code of conduct clearly detailed their interaction with the general public and they shall sign off on it after being properly trained on how to abide by it.
5. An FGRM for the general public shall be developed with facilitated 2-way communication mechanisms and information access.

6. The current Emergency Response and Preparedness Procedure shall account for the increased seismic hazard to the PP and associated Tsunami risk, and coordinate with external parties (e.g., civil defense, fire brigade, emergency services) as relevant to the safety of PP personnel, the general public, and the environment.
7. Damages to pipeline and facilities shall be repaired and measures such as increased pipeline markers and restoration of the pipeline berm shall be undertaken.
8. An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the risks of gas pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, and its environmental and social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as from the adjacent crude oil pipelines shall also be accounted for.
9. Means to access pertinent information on the pipeline at any time shall be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information.
10. A very clear and enforceable communication protocol between the pipeline operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other) shall be defined and implemented to avoid misinformation and confusion.
11. The following risk and safety studies need to be prepared to confirm readiness to operate the gas pipeline system and associated facilities safely (in line with the World Bank's latest EHS guidelines for oil and gas facilities): QRA, Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie), Hazardous Area Classification for Stations (based on IP15), and Fire and Gas Mapping Study for project facilities. It is recommended that these studies be conducted by an independent party and they will be based on international standards and best practice in the sector.
12. The risk and safety studies will inform the preparation of a Right-of-Way (ROW) management plan including permissible and non-permissible activities on the ROW and safety separation distances. Based on the findings of the QRA and other safety studies for the pipeline, the respective mitigation measures and the relevant instrument to be prepared, such as Livelihood Restoration Plan (LRP) or Resettlement Action Plan (RAP), will be determined. The completion and clearance of the determined instrument will be before commissioning and testing and before disbursement of retroactive financing.

To achieve the above measures addressing environmental and social gaps, additional studies and plans are required to be prepared as listed under Table 1.

Table 1. List of Studies and Plans that will be Prepared to Address Environmental and Social Gaps for the Project

Study	Scope	Responsibility	Timeline
HAZID	- HAZID ToRs - HAZID workshop - HAZID worksheet - HAZID close-out forms	Independent E&S consultant	Completed HAZID actions close-out to be done as per timelines determined in the HAZID close-out sheets
HSE plan for pipeline repair and rehabilitation activities	Plan addressing possible health, safety and environmental impacts	TGS	Prior to start of repair and rehabilitation
HSE plan review	Review adequacy of the plan to manage identified hazards	Independent E&S consultant	Prior to start of repair and rehabilitation
ESR/ESCP/SEP public consultation and disclosure	- Finalize documents based on final comments from World Bank/MEW - Prepare summary materials for public consultation - Organize public consultation activities as per the SEP - Finalize the documents based on inputs from public consultations - Disclose all documents as per World Bank standards	Independent E&S consultant	• ESR Consultations is completed • Other consultations will be conducted during the preparation of E&S instruments
Survey of encroachments on GASYLE ROW	Mapping of all encroachments along the ROW	TOIL	Before gas test and commissioning
ESMP for DAPP **ESMP for GASYLE**	- Prepare ESMP in line with World Bank guidelines for the power plant and GASYLE - Stack emission monitoring at power plant (during testing to confirm compliance with standards) (2 stacks) - Noise and vibration measurements (6 locations at near sensitive receptors) (with power plant on and off) - Liquid effluent analysis (5 samples) - Rapid marine ecological survey (4-5 dives) with collection of samples, in-situ measurements (with boat rental and all equipment), and impact assessment (including determination of mixing zone empirically); thermal plume discharge modeling not included - Socio-economic survey along pipeline and near power plant receptors (brief survey with community profiling, determination of vulnerable groups, etc.) - Air dispersion modeling for power plant emissions - Noise and vibration modeling for power plant (this is useful to determine effectiveness of interventions to reduce impacts, if any; at the moment the school claims that when power plant is on they feel the vibration) - Drone survey along pipeline (not costed – cooperation with NCSR is suggested) (optional to support TGS survey) - Integration of safety studies results in the ESMP - Preparation of public consultation materials (leaflets, etc.) - Implementation of public consultation activities in line with SEP - Finalization of ESMP based on public consultation outcomes - Disclosure of ESMP in line with World Bank Standards	Independent E&S consultant	Prior to testing and commissioning Note: air emissions testing should be done during testing and commissioning to confirm compliance with standards when operating with NG
Labor Management Procedure	LMP in line with World Bank standards (ESS2)	Independent E&S consultant	Prior to testing and commissioning
Grievance mechanism operationalization (external)	- Finalization of external FGRM including points of contacts, procedures, and preparation of infographics for dissemination to external stakeholders and local communities during consultation; training of MEW, TOIL and EDL relevant staff in the implementation of the FGRM	Independent E&S consultant	Prior to start of repair and rehabilitation
Grievance mechanism operationalization (internal)	Finalization of internal grievance mechanism in line with ESS2	MEW/EDL/TOIl with support from independent E&S consultant	Prior to testing and commissioning
Livelihood Restoration Plan (LRP) or Resettlement Action Plan (RAP)	Based on findings of QRA and other safety studies for the pipeline, the respective mitigation measures and the relevant instrument to be prepared, such as Livelihood Restoration Plan (LRP) or Resettlement Action Plan (RAP), will be determined RAP / LRP in line with World Bank standards (ESS5)	Independent E&S consultant	Completion and clearance of the determined instrument will be prior to

			testing and commissioning, and before disbursement of retroactive financing
Safety studies for GASYLE	- QRA - Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie) - Hazardous Area Classification for Stations (based on IP15) - Fire and Gas Mapping Study for project facilities	Independent Safety Consultant	Prior to testing and commissioning
HAZOP for pipeline	HAZOP	TGS	Prior to testing and Commissioning
QRA for power plant	- QRA - QRA model for Power Plant will be integrated with Border, Receiving and TOIL Stations QRA	Independent safety consultant	Prior to testing and Commissioning
Emergency response plans for GASYLE and power plant	ERP	TGS and Primesouth	Prior to testing and Commissioning
ERP Review	Review of ERPs to ensure adequacy to handle identified emergencies	Independent safety consultant	Prior to testing and Commissioning
Stand-alone Occupational Health and Safety Plan	OHS plan for operations for GASYLE and DAPP in line with ESS2	TGS and Primesouth	Prior to testing and Commissioning
OHS review	Peer review of adequacy of the OHS plans	Independent E&S consultant	Prior to testing and Commissioning
ESMF for Component 2.1	ESMF to cover Component 2.1 activities related to solar power to water wells including public consultation and disclosure	Independent E&S consultant	Prior to final selection of beneficiary RWEs where the PV and Scada systems will be installed.
ESMP for Component 2.2	ESMP for activity 2.2 including baseline measurements (e.g. water quantity and quality), public consultation and disclosure	Independent E&S consultant	Prior to commencement of procurement to be part of bidding documents and work/supply contracts

I. INTRODUCTION

The World Bank is considering providing emergency support to Lebanon's power sector by importing natural gas from Egypt through Jordan and Syria using the existing Arab Gas Pipeline (AGP). This imported gas will be used to fuel the existing Deir Amar power plant north of Tripoli to increase its electricity supply (Component 1).

The Project is to be financed by a US$200 million IBRD loan and will be implemented by the Ministry of Energy and Water in coordination with Electricité du Liban (EDL) and Lebanon Oil Installations (LOI).

EDL has advised that the plant can relatively easily switch to natural gas operation from diesel oil after conferring with the current Deir Ammar plant Operation and Maintenance Company (OMCO) – Primesouth.

LOI have requested Technical Gas Services (TGS) - OMCO of the AGP section in Jordan, to check the integrity of the gas facilities (gas off-take facility, gas pipeline, gas metering stations, gas treatment units, etc.) and the readiness to resume the gas supply in the Lebanese segment. TGS are currently preparing a technical assessment report for Lebanon's AGP segment (GASYLE) as well as a commercial offer for the needed repairs, and for an operation and maintenance contract.

The Project will also include financing the support to rolling out solar photovoltaic (PV) systems, variable frequency drives (VFDs), and Supervisory Control and Data Acquisition (SCADA) control systems for water pumps of Lebanon's Water Establishments and rehabilitation of the existing Hrache-Jeita Hydro Plant. In addition, the Project will support technical assistance (TA) such that the MEW, and other associated actors such as EDL, LOI, and BDL to achieve the targeted institutional reforms and performance outcomes of the sector

ELARD was commissioned by the Ministry of Energy and Water to assess environmental and social performance of the relevant infrastructure relative to the World Bank Environmental and Social Framework (ESF) requirements as well as national requirements. This assessment includes:

1) E&S review, which identifies gap-filling and enhancement measures with agreed time-bound action plans,

2) preparation of Stakeholder Engagement Plan (SEP), and

3) preparation of an Environmental and Social Commitment Plan (ESCP).

This report covers the E&S Review portion of the assessment with the following scope of work:

- conduct site visits and assess current conditions based on pertinent aspects of the ESF standards
- complete a review of the relevant legal and institutional framework;
- conduct a gap analysis between national and World Bank environmental and social requirements;
- assess level of compliance with the national requirements;
- evaluate the overall environmental and social performance of the facilities; and

- propose gap-filling measures to meet the national and WB ESF requirements, determined in the form of a time-bound action plan with identified responsibilities and allocated human and financial resources.

2. PROJECT DESCRIPTION

2.1. OVERVIEW

The Project Development Objective is to "provide emergency support to improve electricity supply in Lebanon and improve the sector's financial sustainability." The project is to be financed by a US$200 million IBRD loan.

The Project comprises the following components:

- Component 1 Natural Gas Purchases for Power Generation (US$190 million):

  This component will support a payment security mechanism to facilitate the purchase of natural gas from Egypt and transporting this gas through the AGP. The mechanism relies on disbursements from the IBRD loan, which are in turned linked to Performance-Based Conditions (PBCs) focused on three results areas: (i) strengthening sector governance and transparency; (ii) increasing security of supply in a least-cost manner; and (iii) improving the sector's financial sustainability. The PBCs will be designed to motivate changes that require little investments and target action to rationalize sector costs, improve revenues and begin the structural reforms necessary to address broader sector challenges in preparation for subsequent operations that would further these reforms through investments and other types of support.

- Component 2: Enhanced Renewable Energy (US$20 million):

  This component includes two sub-components. The first sub-component (Component 2.1) supports rolling out solar photovoltaic (PV) systems, variable frequency drives (VFDs), and Supervisory Control and Data Acquisition (SCADA) control systems for water pumps of Lebanon's Water Establishments. The second sub-component (Component 2.2) supports rehabilitation of the existing Hrache-Jeita Hydro Plant.

- Component 3: Technical Assistance and Capacity Building (US$10 million):

  This component will support technical assistance (TA) such that the MEW, and other associated actors such as EDL, LOI, and BDL to achieve the targeted institutional reforms and performance outcomes of the sector, including, inter alia, establishing and operationalizing the sector regulator, managing implementation of the Government reform plan to be agreed including a communication campaign, preparing bidding documents for the installation of a floating gas terminal at Zahrani and new power plants at Zahrani and Deir Amar, recruiting the external auditor for EDL and reinforcing its financial reporting and accounting practices, facilitating improvements of collection and commercial losses on the distribution network, developing the cash flow waterfall structure and other parameters of the envisaged payment mechanism under Component 1.

The Ministry of Finance (MoF) will be the Borrower. The implementing agency is the Ministry of Energy and Water (MEW). MEW is responsible to ensure that all safeguard measures are implemented throughout the project's lifecycle. For Component 1, MEW will therefore closely coordinate with Electricite du Liban (EdL) (the subordinate entity responsible for the operation of Deir Ammar Power Plant) and with the Tripoli Oil Installations (TOIL) (the subordinate entity responsible for the operation of the gas pipeline and its associated infrastructure) to ensure implementation of all required measures by the subordinate entities and their sub-contractors. For Component 2, MEW will closely coordination with the Regional Water Authorities.

The Project is expected to provide emergency support to Lebanon's power sector to import natural gas from Egypt through Jordan and Syria on the pre-existing Arab Gas Pipeline (AGP). This imported gas will be used to fuel the existing Deir Amar power plant north of Tripoli to increase its electricity supply while reducing its fuel costs by switching from diesel. The project will not be involved in the distribution segment of the gas other than feeding the power plant. Switching fuel supply from diesel to natural gas will also lead to significant environmental benefits particularly in terms of reduced air pollutant emissions and Green House Gas (GHG) emissions. The project is also expected to support the water sector by providing solar power to groundwater wells to ensure low-cost and sustainable supply of water resources and to rehabilitate the existing Hrache-Jeita Hydro Plant, therefore supporting the achievement of national renewable energy targets.

The total length of the Arab Gas Pipeline (AGP) is 1,200 km (Figure 2-1). The Lebanese Gas Pipeline (GASYLE) is a branch of the AGP. It was built between 2003 and 2007 and was first put in service in 2009 in cooperation with Egyptian Company for Natural Gas (GASCO). It extends from the Syrian border to Deir Ammar for about 31 Km and has a diameter of 24" in the Right of Way (ROW) that was dedicated for Iraq Petroleum Company (IPC) pipe. Until the start of the war in Syria in 2011, this pipeline was in service and it used to supply natural gas to Deir Amar Power Plant. According to Tripoli Oil Installations, it is still under low pressure and being monitored for any leaks.

Deir Ammar power plant is located 90 km north of Beirut approximately. Its construction was commissioned in 1995 and ended in 1998 with a total installed capacity of 435 MW; a description of the PP and its components is provided in Appendix A1 within Annex A. Deir Ammar power plant is ready to be operated with natural gas, which is its primary design fuel, although it is currently running on gasoil (diesel). The plant's available capacity is currently 410 MW. The plant is connected to the currently un-operational GASYLE pipeline.

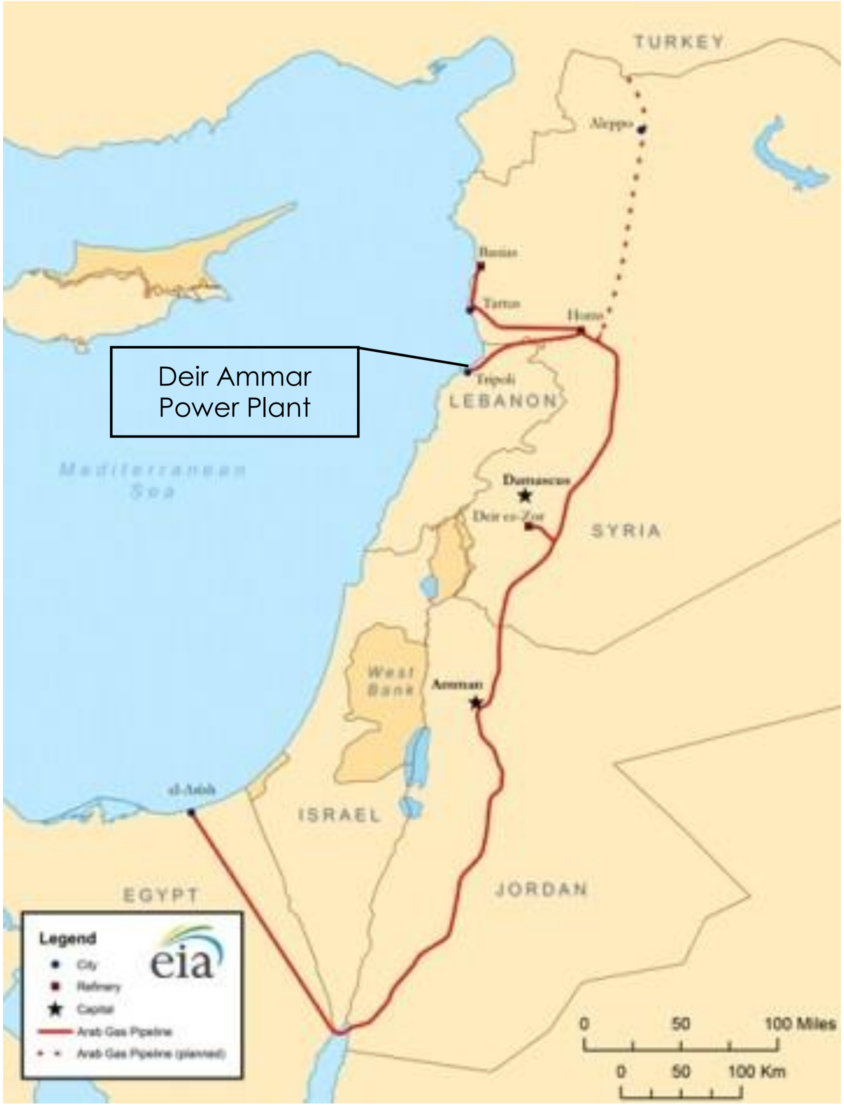

Figure 2-1. The Arab Gas Pipeline from Egypt to Deir Amar Power Plant (Source: Journal of Petroleum Technology[2])

2.2. BASELINE CONDITIONS

The land use / cover in the project area (Deir Ammar PP and along AGP) is dominantly agricultural and as well as industrial and commercial as shown in Figure 2-2 and Figure 2-3.

There are no protected areas or nature reserved crossed by AGP while the existence of the pipeline inside an ROW eliminates potential conflict with any cultural and historical landmarks.

From a natural hazards perspective there are two main aspects:

- Seismicity: Based on a relatively recent study (Huijer et al., 2011), it was recommended to increase the risk rating of the coastal stretch comprising the study area on the basis of a Peak Ground Acceleration of 0.3g whereby the project, which already exists, should account for such a risk in updating its emergency response plan. Tsunami risk should also be accounted for; devastating earthquakes with or without tsunamis have hit the area and while their recurrence interval is > 1,500 years, many studies suggest that the probability of another major one occurring in the next 50 to 100 years is high.

[2] Available Online: https://jpt.spe.org/egypt-snubs-lng-plans-to-send-gas-to-lebanon-via-the-arab-gas-pipeline

- Flooding: Some portions of the AGP extent are mildly flood prone, particularly at and around AGP crossings of main rivers in general and the Kebir River (Syrian Border) in particular. Given that the pipeline has been particularly deeply buried below riverbeds (> 4 meters) and has been encased in concrete, the risk of erosion and damage to the pipe from flooding has been greatly reduced.

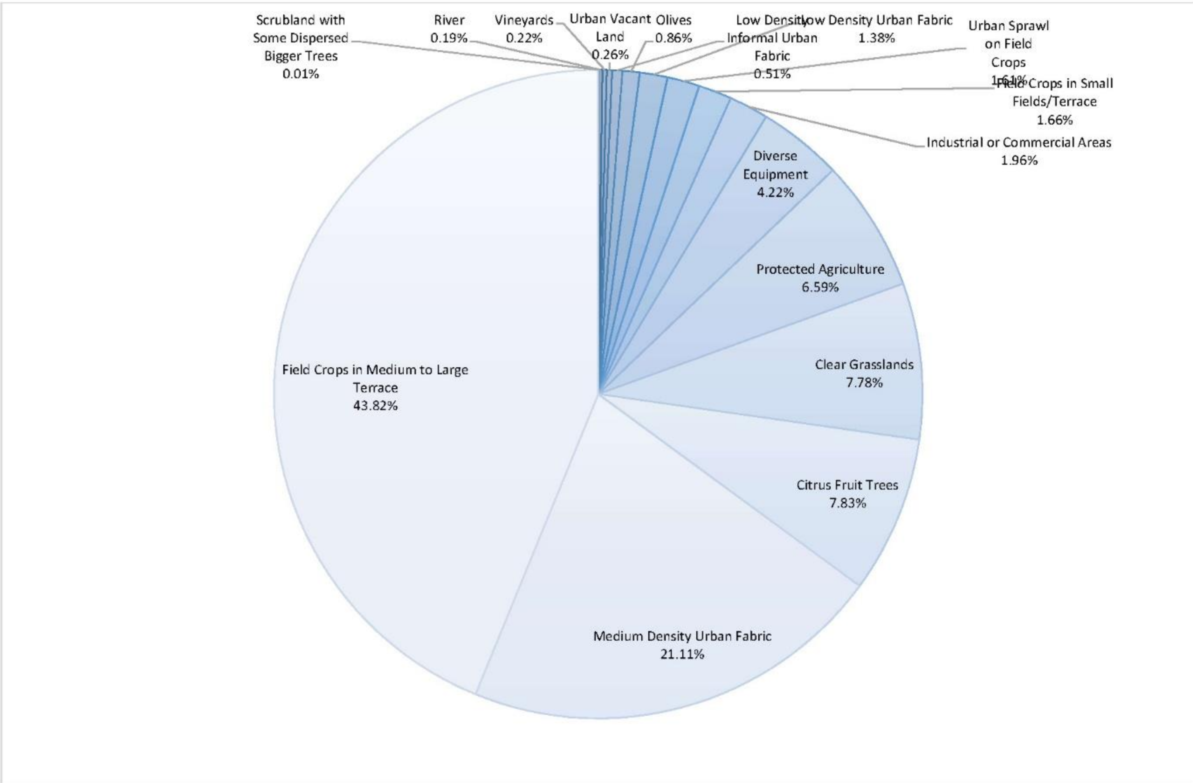

Figure 2-2. Pie Chart of Land Use / Cover Percentage Distribution in Ascending Order (Diverse Equipment Category can be Considered as Industrial and Commercial)

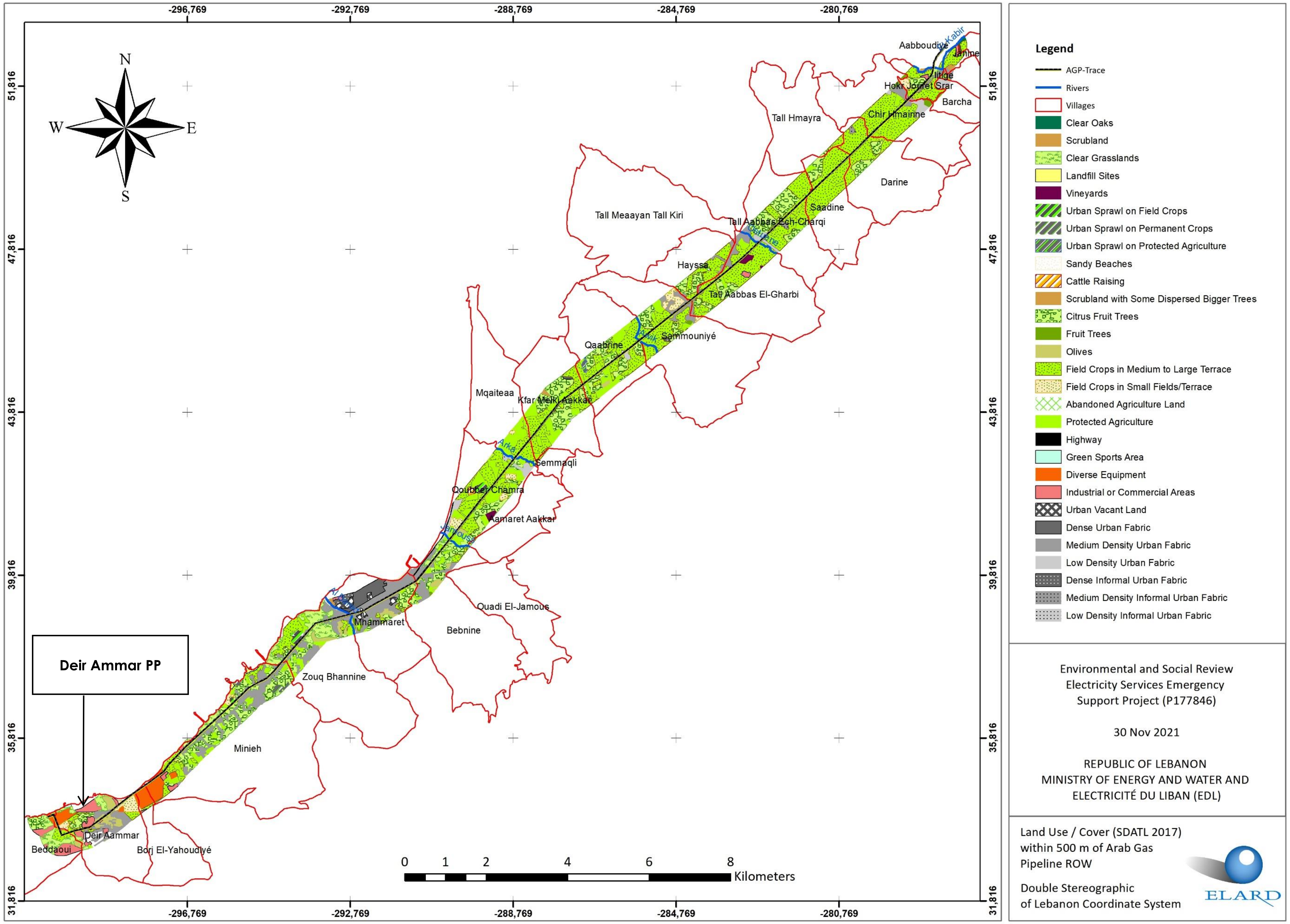

Figure 2-3. Land Use / Cover within 500 meter buffer from each side of the AGP Trace

2.3. POWER PLANT CURRENT OPERATING CONDITION

DAPP is a combined cycle configuration (Siemens GUD2.94), has a nameplate output of 450 MW and 51.25 percent efficiency. It includes two gas turbines (V94.2) provided by Ansaldo-Siemens—each gas turbine has an output of 146.6 MW operating on diesel and 33.5 percent efficiency. The operation of the power plant will result in stack emissions which have to be controlled and regularly monitored to ensure compliance with Local regulations and the World Bank group EHS Guidelines for thermal power plants (Section 3.2). The heat recovery steam generators emissions have a continuous emissions monitoring system (CEMS) installed but needs to be calibrated and operated. Measurement reliability calculation and recording, roles and responsibilities related to the operation of CEMS will need to be clearly determined and the system must be run by qualified and trained personnel. According to DAPP records, when the plant was operating on diesel fuel, nitrogen oxides (NOx) stack emissions significantly exceeded the national and WBG permissible limits. It is expected that when the fuel is switched to natural gas, according to the plant design values, the NOx emissions will be reduced to be within the permissible limits in accordance with WBG EHS Guidelines without additional pollution control equipment (e.g. SCR or similar). Ambient air quality has been within the national limits. When fully operational, the vicinity of the powerplant will be affected by the stack emissions and from other sources of air pollution such as vehicle emissions and recurrent repair, and rehabilitation work. A process must be in place for monitoring ambient air quality and investigating any exceedances of ambient air quality standards. This process shall cover the monitoring of ambient air quality within and in the vicinity of the power plant.

The total energy use of DAPP and AGP is 3,508 GWh and 0.6354 bcm / year respectively.

Management and monitoring manuals and E&S operational management procedures are in place, at DAPP, but need to be updated to comply with the ESF and World Bank group EHS Guidelines for Thermal Power Plants.

Water and effluent management

In DAPP, a demineralized water treatment system is installed to remove impurities from feedwater from the sea entering the power station's boiler, heading off scaling, corrosion, and other issues that can harm equipment and interrupt power delivery. Industrial wastewater is chemically treated before discharging to the sea. The quantity of demineralized water is currently not recorded, and will needs to be monitored for the purpose of increasing water efficiency. No information is recorded for the liquid effluent parameters except pH and Temperature as well as results from a previous environmental audit of the facility. Previous records indicate that the oil-water effluent is non-compliant with national standards for discharge in the sea. It is however expected that with the shift from gasoil to natural gas, the oil-water separator will no longer be operational. Other physico-chemical parameters (e.g. BOD, COD, Oil, Grease, Chlorine) and microbial properties need to be monitored to ensure liquid effluents do not exceeding permissible limits to avoid any negative impacts on the marine environment. It is also essential that temperature of cooling water return flow will continue to be regularly tested.

The frequency of monitoring for abstracted water (component 1) and water flow (component 2.2) are to be determined as part of the environmental and social assessment which will be conducted. Parameters to be monitored under Component 1 include the temperature and pH of the cooling water discharged during normal operation. Also, the temperature of the receiving water at multiple points around the inlet and outlet need to be measured.

3. INSTITUTIONAL AND REGULATORY FRAMEWORK

This chapter presents an overview of public and private institutional stakeholders relevant to the project, as well as applicable legislation, policies, standards and international treaties and agreements setting the regulatory environmental requirements associated with the project.

3.1. INSTITUTIONAL FRAMEWORK RELEVANT TO THE PROTECTION OF THE ENVIRONMENT

Table 3-1 lists the main institutions concerned with the protection of the environment with relevance to the project implementation.

Table 3-1 Public Administrations Concerned with the Protection of the Environment and the Project's Implementation

Public Administration	Prerogatives
Ministry of Environment (MoE)	MoE is the national competent authority responsible for the protection of the environment in Lebanon. MoE is responsible for registering hazardous waste generators in its database and reviewing the quarterly reports submitted by the generator. MoE is responsible for reviewing the environmental audit and ESMP expected for the project. MoE is also responsible of enforcing and supervising the implementation of the ESMP.
Ministry of Public Health (MoPH)	MoPH is responsible for: • protecting the health of the population through the legislation and development of health promotion and protection programs. • eradicating and controlling communicable and non-communicable diseases prevalent in the country • ensuring adequate and reliable supply of safe effective and quality controlled drugs, and promote its rational use • contributing to the social safety net by playing the role of an insurer of last resort • upgrading health facilities including hospitals, primary health care centers, laboratories and all other health institutions at all levels, and linking those through efficient referral system
Ministry of Energy and Water (MEW)- General Directorate of Oil	The MoEW - General Directorate of Oil monitors the operations of distribution companies of liquid fuels and liquid gas and stations selling these products in order to secure internal consumption needs. The directorate is also responsible for monitoring environmental pollution and operational risks related to handling of oil and its derivatives. The ministry also approves the construction of fuel storage facilities as per decree 5509/1994.
Ministry of Public Works and Transport (MPWT)	MoPWT is responsible of authorizing all projects occurring on the public maritime domain after receiving the approval of the Higher Council of Urban Planning (HCUP) (within MPWT), MoE, and MoPH.
Ministry of Interior and Municipalities (MoIM)	MoIM manages the affairs of Municipalities and Unions of Municipalities, and stops all kinds of infractions and violations, including those related to the environment and to the public maritime domain.
Ministry of Labor (MoL)	MoL is responsible for labor and employment issues. The Lebanese Labor Law is applicable to all workers and employers except domestic workers, agricultural workers, enterprises limited to family members and public servants. The Department of Labor Inspection, Prevention and Safety (DLIPS) under the Labor Relations Authority of the MoL, supervises the implementation of all laws, regulations, decrees and rules pertaining to the terms and conditions of employment, and the protection of workers in the workplace, including the provisions of international labor Conventions ratified. Labor inspectors ensure the supervision of compliance with regulations regarding conditions of employment and protection of workers including occupational safety and health. In addition, they monitor if trade unions and occupational associations comply with relevant laws, monitor compliance with protection and safety measures in

Public Administration	Prerogatives
	family enterprises and the work of private employment agencies. Under their functions they also investigate collective labor disputes. They are also involved in conciliation and the control of work permits for foreign workers. Among labor inspectors, some are generic, in charge of inspecting conditions, and others are occupational safety and health inspectors.
Ministry of Social Affairs (MoSA)	MoSA's main function is social assistance and protection. it is concerned with providing assistance to needy groups and achieve an integrated development. Its mission is to: • respond to the basic needs of the groups most in need, based on studying the characteristics of these groups and implementing adequate programs to deal with their problems. • achieve decentralization of social work development and balanced development of geographical regions. • accomplish integration and partnership between the public and private sectors, at various levels. Groups in need that the ministry is concerned with, include: • children • women • elderly • delinquents • prisoners, drug addicts, and the homeless • The disabled
Electricité du Liban (EDL)	Decree No. 16878/1964 exclusively charges EDL with the task and responsibility of generating, transmitting, and distributing electricity all over Lebanon. However, concessions and self-production for personal consumption constitute exceptions to EDL's monopolistic nature.
Higher Council of Urban Planning (HCUP) (within MPWT)	HCUP is responsible for urban and rural planning. In doing so it reviews designs and plans of villages and towns, including zoning proposals for these areas. It also reviews project decrees aiming at expropriation.
Civil Defense	Civil Defense cover all Lebanese territory by providing civil protection for persons, property and environment. The duties of the Civil Defense in Lebanon also cover the following: - Respond to any emergency events that occur at TTF; - Provide safe protection for persons, properties and environment and remedying potential losses. - Identify/Eliminate threats to public safety and limit their consequences in the event of emergencies; - Ensure the implementation of the laws and regulations in force that are relevant to all civil defense activities.
Municipalities of Beddawi, Deir Ammar, Minieh, and Mejdlaya	Municipalities represent the level of local government with legal status, financial and administrative independence, which exercises powers and responsibilities over the territory it is granted by law. The municipality manages complaints from local residents and may be involved if complaints are received during Project implementation. It is also in charge of roads, parks and public places, urban planning (in coordination with DGUP), as well as solid waste management within its jurisdictions.

At a regional level, the Governor of North Lebanon and of Akkar (Mohafez) have direct responsibilities with regards to the project as follows:

- Ensure the proper implementation of all laws, regulations, and circulars during the rehabilitation and operation phase; and
- Take the necessary measurements to implement public health regulations

The District Commissioners (Qaemmaqam) of Minieh-Danniyeh, Zgharta, and Akkar districts are responsible as follows:

- Ensure the proper implementation of all laws, regulations, and circulars;
- Impose legal health measurements if needed after the approval of the Ministry of Public Health

3.2. RELEVANT REGULATIONS AND STANDARDS

3.2.1. Relevant National Legislation

This section describes the most relevant and pertinent national legislations related to the Environment in general and oil and gas facilities in Lebanon in particular.

Table 3-2 presents an overview of the main environmental legislation relevant to the project; legislation distinctly targeting air quality, wastewater discharge, and noise standards are also grouped in this table.

Table 3-2 Summary of Relevant Environmental Legislations

Year	Law / Decree	Reference Entity	Relevant Provisions
ENVIRONMENTAL PROTECTION and ENVIRONMENTAL LIMIT VALUES			
2022	Decision 16/1	MoE	New air emissions Environmental Limit Values that will be applicable one year from the date of publication in the official gazette (ie. starting 10/2/2023).
2016	Decision 189/1	MoE	Defines the mechanism for environmental compliance audit report review at the ministry, which also covers the submission process and report contents.
2015	Decree 539	MoE	Sets the legal deadlines for environmental compliance by facilities covered under Decree 8471.
2015	Decision 261/1	MoE	Sets procedures for review of scoping reports and EIA reports
2015	Circular 6/1	MoE	Defines EIA and IEE review fees and bank guarantees.
2014	Circular 9/1	MoE	Specifies documents to be submitted with IEE and EIA Scoping Reports
2012	Decree 8633	CoM	Sets the EIA Procedures within the framework of the Environmental Law. It defines the EIA procedures and regulations related to all development Projects that have a potential impact on the environment.
2012	Decree 8471	MoE	Sets environmental compliance requirements on dangerous and hazardous facilities as defined in Decree 4917 of 1994 for Class I and II facilities and in Decree 5247 of 2001 for Class I, II, and III industries.
2002	Law 444	MoE	Sets the framework for environmental protection. Provides the principles and rules for protecting different environmental matrices (air, water, soil…) from pollution with wastewater, hazardous wastes, chemicals, and noise, etc.; and specifies the penalties for violating environmental laws. • Section 1 (Basic Principles and General Provision) • Section 2 (Organization of Environmental Protection), paragraph 4 (Environmental Monitoring Mechanisms) • Section 3 (Environmental Information System and Participation in Environmental Management and Protection) • Section 4 (Environmental Impact Assessment)

Year	Law / Decree	Reference Entity	Relevant Provisions
			• Section 5 (Environmental Protection) • Section 6 (Responsibilities and Sanctions)
2001	Decision 8/1	MoE	National Standards for Environmental Quality • Provides standards for stack emission levels and air pollutants emissions limits from the facility's machinery and generators. Appendix 1 (Emission Limit Values (ELV)- Tables 1 to 3) and Appendix 2-9 (minimum stack height for generators) (<u>these are cancelled and replaced by ELVs defined in Decision 16/1 of 2022</u>) • Provides environmental limit values (ELV) for wastewater discharged into different receiving media (sewerage system, surface water, sea). Appendix 4 (ELV for Wastewater Discharged into the Surface Water Bodies)
2001	Decree 5243	COM	Replaces the list classifying industries in Decree 4917/1994 with a new ISIC-based list.
1996	Decision 52/1	MoE	Specifying the National Standards for Environmental Quality and the Environmental Limit Values for air, water, and noise. • Section 9 (Air Quality in the Workplace) • Section 10 (Ambient and Occupational Noise Standards)
1994	Decree 4917	COM	Replaces the list of hazardous and dangerous facilities in Decree 1120 / 1936 and repeals decrees 2009 / 1959 and 7558 / 1961 that amended the classification of some dangerous, harmful and disturbing establishments.
AIR QUALITY and EMISSIONS			
2020	Decree 6212	CoM	Approval of the national strategy for managing ambient air quality in Lebanon. The strategy aims to: • Develop the legal and institutional framework for air quality management in Lebanon; • Improve air quality monitoring and assessment in Lebanon; • Mitigate the impacts arising from air pollutants generation from point sources; • Mitigate the impacts arising from air pollutants generation from mobile sources; • Collaboration among relevant stakeholders for the management of air quality (such as MoPWT, MoEW, MoI, MoA, MoPH, and municipalities); and • Regular reporting and publishing of air quality monitoring results, and the collaboration between MoE and educational/research institutions for future air quality-related studies.

Year	Law / Decree	Reference Entity	Relevant Provisions
2018	Law 78	Parliament	The law for the protection of air quality aims to protect ambient air quality by identifying, monitoring and assessing, preventing and controlling air pollution resulting from anthropogenic activities. This excludes air pollution caused by physical hazards, natural disasters, and occupational and indoor air pollution
			HAZARDOUS WASTE MANAGEMENT
2020	Decision 59/1	MoE	The decision specifies the procedures and principles for hazardous waste storage facilities licensing in Lebanon. • Article 1: Hazardous waste storage facility licensing mechanism. • Article 2: Hazardous waste storage facility license renewal mechanism. • Article 3: Hazardous waste storage facility license modification mechanism. • Article 4: Electronic database for hazardous waste storage facility • Article 5: Permanent cessation of hazardous waste storage facility • Article 6: Accident Reporting Procedure • Article 7: Reporting to the Ministry of Environment
2020	Decision 998/1	MoE	The decision specifies the procedures and principles for hazardous waste generators in Lebanon. • Article 1: Hazardous waste generation reporting mechanism • Article 2: Electronic database for hazardous waste generators • Article 3: Permanent cessation of hazardous waste generation from facilities • Article 4: Recall of hazardous waste from allocated storage facilities and/or treatment facility. • Article 5: Reporting to the Ministry of Environment
2020	Decision 999/1	MoE	The decision specifies the procedures and principles for hazardous waste transporters in Lebanon. • Article 1: Hazardous waste transportation licensing mechanism. • Article 2: Hazardous waste transportation license renewal mechanism. • Article 3: Hazardous waste transportation license modification mechanism. • Article 4: Electronic database for hazardous waste transporters • Article 5: Permanent cessation of hazardous waste transportation • Article 6: Accident Reporting Procedure • Article 7: Reporting to the Ministry of Environment
2019	Decree 5606	CoM	The decree specifies the principles of management (sorting, storage, transport, and disposal) of hazardous waste.

Year	Law / Decree	Reference Entity	Relevant Provisions
			Section 2- Wastes Generation and Transport; specifically chapter 1 (Articles 8, 9, 10, 11 12, 13, 14, 15, 16, and 17) defines the obligations of the waste generator.
1988	Law 64/88	Parliament	Environmental protection against hazardous waste that could harm air, water, biodiversity, soil, and people; states fines for activities that result in pollution and hazards to the environment and public health. Table 1 (specifies hazardous substances and non-hazardous waste) – updated by Decree 5606/2019
SOLID WASTE MANAGEMENT			
2019	Decree 5605	CoM	The decree specifies the principles for sorting domestic solid waste at the source into three categories: organic waste, recyclables, and inert waste. Section 2: • Article3: Sources of Domestic Solid Waste • Article 4: Composition of Domestic Solid Waste • Article 5: Responsibility for waste sorting • Article 6: Separation of waste according to the suitable color • Article 8: Sorting mechanism and its stages
2018	Law 80	Parliament	Integrated Solid Waste Management Law - sets the framework for Integrated Solid Waste Management based on the principles of Law 444/2002. It combines the ISWM draft law of 2006 with thermal treatment waste to energy plants to be constructed in big cities (Tripoli, Beirut, Saida and Jiyeh). The ISWM law includes the below; the most pertinent to the current Project are highlighted in bold font: • Article 4: Priorities of integrated solid waste management (considers the principle of preventive action and minimizing solid waste generation as a priority) • Article 7: Preventing random disposal, open dumping and burning of solid waste • Article 8: The "Polluter Pays Principle" • Article 10: National Strategy for SWM • Article 11: Local SWM programs • Articles 14 to 16: Responsibilities resulting from SWM • 20: Solid waste collection and transfer • Article 21: Sorting at source • Article 22: Solid waste treatment: reuse, recycling, composting, digestion, and energy recovery

Year	Law / Decree	Reference Entity	Relevant Provisions
			• Article 24: Final Disposal • Articles 25 to 27: Hazardous waste management • Article 28: Financing sources for ISWM • Article 29: non-monetary incentives • Articles 30 to 33: Responsibilities • Articles 34 to 37: Enforcement and penalties
2018	Decision 45	MoE	Sets a new Integrated Solid Waste Management (ISWM) policy for Lebanon having the following targets: • Achieving 35% material recovery, 50% energy recovery and 15% sanitary landfilling by 2035; • Devolving to the municipalities the responsibilities of reduction, re-use, sorting at source in addition to sweeping and waste collection. Municipalities will also be responsible for treatment and final disposal in part or in whole based on environmentally and economically viable projects. • Creating sanitary landfills in Beirut, Mount Lebanon, North and South Governorates • Building three interim storage plants for different types of waste including expired drugs, healthcare waste (hazardous and non-infectious and those requiring special management).
2017	Circular 7/1	MoE	Updates Circular 8/1 (2015) - Guidelines on the Integrated Management of Solid Waste to the attention of Municipalities, Union of Municipalities and Quarries: • Sorting at source • List of establishments accepting recyclables
			WASTEWATER
2019	Circular 7/1	MoE	Regulates the selection of proper wastewater treatment technologies and the construction and operation of wastewater treatment plants for industrial and classified establishments. Refers to the Environmental Safeguards for planned and existing activities developed by MoE/ EU/UNDP
2017	Memo 9/1	MoE	Prohibits the discharge of wastewater into artesian open-bottom wells
1974	Decree 8735	CoM	Protection against pollution from solid and liquid waste (prohibiting the digging of wells for the disposal of raw sewage, banning sewage infiltration from septic tanks and the use of untreated sewage for the irrigation of vegetables and some fruit trees), and assigning solid waste management to municipalities.
1933	Decree 2761	CoM	Provides guidelines related to Wastewater Management and Disposal
			OCCUPATIONAL HEALTH AND SAFETY
2004	Decree 11802	CoM	Regulating occupational prevention, safety and health in all enterprises subject to the code of labor. • Chapter I: Prevention and Safety:

Year	Law / Decree	Reference Entity	Relevant Provisions
			- Article 3: Specifies several locations for strong fencing around pendulous wheels, moving parts in engines, rotating water machines, generators and rotating engines, and dangerous part of any machine. - Article 12: specifies the necessary measures for working in areas emitting dangerous vapors. - Article 18: specifies the necessary measures for every enterprise that involves an emission of dust, smoke, noise or any other polluting substance. - Article 19: specifies the necessary measures relating to exposure of workers to din, noise and vibrations. - Article 20: specifies regulations regarding hazardous materials - Article 23: specifies the measures for prevention and safety at work that shall be determined by decisions of the Minister of Labor - Article 24: the employer shall provide the workers with the appropriate PPEs and ensure their maintenance and preserve them in good conditions for later use • Chapter II: Health - Article 25: measures to keep the workplace clean - Articles 28 and 30: specify the utilities required for workers - Article 32: necessary and sufficient seating facilities shall be provided for workers who work while standing, as well as during the breaks allotted between working hours. - Article 33: specifies all necessary first aid products that should be provided - Article 34 to 39: specifies the requirements for appointing a physician for the workers and the necessary medical examinations. • Articles of Chapter III: Safe Use of Chemicals at Work • Chapter V: General Provisions - Article 58: Workers shall be given sufficient information on the risks related to their work and should be informed of any legal texts or guidelines pertinent to the rules of occupational safety and health. - Article 59: Workers shall strictly abide by all guidelines and instructions related to the rules of occupational safety. - Table 1 – Occupational noise standards
2004	Decree 11958	CoM	Provides health and safety requirements during construction

3.2.2. Relevant National Standards for Environmental Protection

Pertinent environmental standards in Lebanon are provided in the following subsections.

3.2.2.1. *Ambient Air Quality*

The maximum allowable limits of atmospheric ambient air pollutants (Decision 52/1) are shown in Table 3-3.

Table 3-3. Maximum Allowable Limits for Ambient Air Pollutants (MoE Decision 52/1)

Pollutant	Maximum Allowable Concentration (in μg/m^3)	Averaging Period
Sulfur Dioxide (SO_2)	350	1 hour
	120	24 hours
	80	1 year
Nitrogen Dioxide (NO_2)	200	1 hour
	150	24 hours
	100	1 year
Ozone (O_3)	150	1 hour
	100	8 hours
Carbon Monoxide (CO)	30,000	1 hour
	10,000	8 hours
Total Suspended Particulate (TSP)	120	24 hours
Particulate Matter (PM-10)	80	24 hours
Lead	1.0	1 year
Benzene	5 ppb	1 year

The latest maximum allowable limits for air emissions are set in Decision 16/1 which has just been published in the official gazette on February 10, 2022 and will become enforceable on February 10, 2023.

3.2.2.2. *Wastewater pollutants*

Standards of pollutants being discharged into water bodies were set in Decision 52/1 and updated in Decision 8/1, as described in Table 3-4.

Table 3-4. Wastewater discharge standards into different media (Decision 8/1)

Substance	Limits for Water Bodies		
	Sewerage system	Surface water	Sea
Color	None	none	none
pH	6-9	6-9	6-9
Temperature	35°C	30 °C	35°C
BOD (5 day, 20°C)	125 mg/l	25 mg/l	25 mg/l
COD (dichromate)	500 mg/l	125 mg/l	125 mg/l
Total Phosphorus	10 mg/l	10 mg/l	10 mg/l
Total Nitrogen[3]	60 mg/l	30 mg/l	30 mg/l
Suspended solids	600 mg/l	60 mg/l	60 mg/l
AOX	5	5	5
Detergents	-	3 mg/l	3 mg/l
Coliform Bacteria 370 C in 100 ml[4]	-	2,000	2,000
Salmoellae	Absence	Absence	Absence
Hydrocarbons	20 mg/l	20 mg/l	20 mg/l
Phenol Index	5 mg/l	0.3 mg/l	0.3 mg/l
Oil and grease	50 mg/l	30 mg/l	30 mg/l
Total Organic Carbon			
Ammonia ($NH4^+$)	-	10 mg/l	10 mg/l
Silver (Ag)	0.1 mg/l	0.1mg/l	0.1 mg/l
Aluminium (Al)	10 mg/l	10 mg/l	10 mg/l
Arsenic (As)	0.1 mg/l	0.1 mg/l	0.1 mg/l
Barium (Ba)	2 mg/l	2 mg/l	2 mg/l
Cadmium (Cd)	0.2 mg/l	0.2 mg/l	0.2 mg/l
Cobalt (Co)	1 mg/l	0.5 mg/l	0.5 mg/l
Chromium total (Cr)	2 mg/l	2 mg/l	2 mg/l
Hexavalent Chromium (Cr^{VI+})	Chromium		
Copper total (Cu)	1 mg/l	0.5 mg/l	1.5 mg/l
Iron total (Fe)	5 mg/l	5 mg/l	5 mg/l
Mercury total (Hg)	0.05 mg/l	0.05 mg/l	0.05 mg/l
Manganese (Mn)	1 mg/l	1 mg/l	1 mg/l
Nickel total (Ni)	2 mg/l	0.5 mg/l	0.5 mg/l
Lead total (Pb)	1 mg/l	0.5 mg/l	0.5 mg/l
Antimony (Sb)	0.3mg/l	0.3mg/l	0.3mg/l
Tin total (Sn)	2 mg/l	2 mg/l	2 mg/l
Zinc total (Zn)	10 mg/l	5 mg/l	5 mg/l

3 Sum of Kjeldahl-N(organic N + NH_3),NO_3-N, NO_2-N
4 For discharges in close distance to bathing water, a stricter environmental limit value could be necessary

Substance	Limits for Water Bodies		
	Sewerage system	Surface water	Sea
Active (Cl_2)	-	1 mg/l	1 mg/l
Cyanides (CN^-)	1 mg/l	0.1mg/l	0.1mg/l
Fluorides (F)	15 mg/l	25 mg/l	25 mg/l
Nitrate (NO_3^-)	-	90 mg/l	90 mg/l
Phosphate (PO_4^{3-})	-	5 mg/l	5 mg/l
Sulphate (SO_4^{2-})	1,000 mg/l	1,000 mg/l	1,000 mg/l
Sulphide (S2-)	1 mg/l	1 mg/l	1 mg/l

3.2.2.3. *Noise Levels*

Table 3-5 and Table 3-6 below present respectively ambient noise standards and occupational Noise Exposure standards allowed for and set in Decision 52/1.

Table 3-5. Ambient Noise Standards as per Decision 52/1

Region Type	Limit for Ambient Noise Level dB(A)		
	Day Time (7 a.m. - 6 p.m.)	Evening Time (6 p.m. - 10 p.m.)	Night Time (10 p.m.- 7 a.m.)
Commercial and administrative areas in town centers	55-65	50-60	45-55
Residential areas with some construction sites or along a main road	50-60	45-55	40-50
Urban residential areas	45-55	40-50	35-45
Residential suburbs with slight traffic	40-50	35-45	30-40
Industrial areas	60-70	55-65	50-60
Rural residential areas, public gardens and hospitals	35 – 45	30 – 40	25 – 35

Table 3-6. National Occupational Noise Exposure Standards in Work Areas

Duration per Day (hours)	Allowed Sound Level Exposure, dB(A)
8	90
4	95
2	100
1	105
½	110
¼	115

3.3. INTERNATIONAL AGREEMENTS AND TREATIES

Treaties and conventions ratified by Lebanon and which are most relevant to the proposed project activities are summarized hereunder in Table 3-7.

Table 3-7. Ratified or Signed International Agreements

Agreement	Objective	Relevance To Project
Minamata Convention on Mercury-August 2017 Accession by Lebanon on 13/10/2017	To draw attention to a global and ubiquitous metal that, while naturally occurring, has broad uses in everyday objects and is released to the atmosphere, soil and water from a variety of sources. It bans new mercury mines, obliges phasing-out existing mines, the phasing-out and phasing-down of mercury use in a number of products and processes; sets control measures on emissions to air and on releases to land and water; regulates the informal sector of artisanal and small-scale gold mining; addresses interim storage of mercury and its disposal once it becomes waste, sites contaminated by mercury as well as health issues.	Control the use of mercury and its release into the environment
Parties to the UN Framework Convention on Climate Change (UNFCCC) Paris Agreement - 2015	To reaffirm the goal of limiting global temperature increase well below 2 degrees Celsius; To establish binding commitments by all parties to make “nationally determined contributions” (NDCs), and to pursue domestic measures aimed at achieving them; To commit all countries to report regularly on their emissions and “progress made in implementing and achieving” their NDCs, and to undergo international review; To commit all countries to submit new NDCs every five years, with the clear expectation that they will “represent a progression” beyond previous ones; To extend a mechanism to address “loss and damage” resulting from climate change; and To call for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country’s NDC.	Culminates a four-year negotiating round, the new treaty ends the strict differentiation between developed and developing countries that characterized earlier efforts, replacing it with a common framework that commits all countries to put forward their best efforts and to strengthen them in the years ahead. The ultimate aim is to reduce GHG emissions from the project.
Ratification of the amendments made to the Barcelona Convention on the protection from polluting the Mediterranean Sea Ratified via Law No. 34/2008	The main amendments made in 1995 concerned: 1) the extension of the Convention's geographical field of application to the coast; 2) the application of the precautionary principle; 3) the application of the "polluter pays" principle; 4) the promotion of impact assessments; 5) the protection and preservation of biological diversity; 6) combating pollution from cross-border movements of dangerous waste; and 7) access to information and public participation.	Aims at the protection of the Mediterranean in case of transferring potentially hazardous wastes across national boundaries.
Kyoto Protocol -1997 Ratified by Lebanon in 2006	To reduce greenhouse gas emissions in an effort to prevent anthropogenic climate change	Control GHG emissions Implement Energy Efficiency measures
Stockholm Convention on Persistent Organic Pollutants (POPs) – 2001. Signed by Lebanon in 2001	To reduce intentional and unintentional production of POPs; To develop country-specific implementation plans for this purpose	Regulates the emissions of POPs from waste burning, including dioxins and furans
The Framework Convention on Climate Change, or Global Warming Convention (UNFCCC)– 1994 Ratified by Lebanon in 1994	To achieve stabilization of greenhouse gas concentrations in the atmosphere in order to prevent dangerous anthropogenic interference with the climate system	Regulates GHG from operations
Convention on Biological Diversity, Rio de Janeiro - 1992 Ratified by Lebanon in 1994	1. To conserve biological diversity; 2. To use biological diversity in a sustainable way; and 3. To share the benefits of biological diversity fairly and equitably.	Aims at the protection and conservation of biodiversity during construction and operation activities
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989. Ratified by Lebanon in 1994.	To control the transportation of dangerous non-radiant materials and their disposal across the border	Regulates the transfer of potentially hazardous wastes across national boundaries
Barcelona Convention: 1980 Land-Based Sources Protocol (LBS Protocol) Ratified via Law No. 292/1994	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (LBS Protocol): This Protocol applies: (a) To discharges originating from land-based point and diffuse sources and activities within the territories of the Contracting Parties that may affect directly or indirectly the Mediterranean Sea Area. These discharges shall include those which reach the Mediterranean Area, through coastal disposals, rivers, outfalls, canals, or other watercourses, including ground water flow, or through run-off and disposal under the seabed with access from land; (b) To inputs of polluting substances transported by the atmosphere to the Mediterranean Sea Area from land-based sources or activities within the territories of the Contracting Parties under the conditions defined in annex III to the Protocol. This Protocol shall also apply to polluting discharges from fixed man-made offshore structures which are under the jurisdiction of a Party and which serve purposes other than exploration and exploitation of mineral resources of the continental shelf and the sea-bed and its subsoil.	Aims at the protection of the Mediterranean Sea Area from any pollution caused by discharges from rivers, coastal establishments or outfalls, or emanating from any other land-based sources and activities
MARPOL 73/78 and its annexes: Annex1, Annex II, Annex III, Annex IV, and Annex V Ratified via Law No. 13/1983	The MARPOL Convention also known as the « Marine Pollution Convention » is an International Convention for the Prevention of Pollution from Ships from operational or accidental causes. The Convention includes the following Annexes: • Annex I: Regulations for the Prevention of Pollution by Oil. Covers prevention of pollution by oil from operational measures as well as from accidental discharges. It states that: - Ship must be proceeding en route, not within a "special area" and oil must not exceed 15 ppm (without dilution). Vessel must be equipped with an oil filtering system, automatic cut-off, and an oil retention system. - Shipboard oil pollution emergency plan (SOPEP) is required. • Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Includes details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk; some 250 substances were evaluated and included in the list appended to the Convention; the discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with. In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.	Aims at the prevention of pollution of the marine environment by ships from operational or accidental causes

Agreement	Objective	Relevance To Project
	• Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form. Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications. For the purpose of this Annex, "harmful substances" are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III. • Annex IV: Psrevention of Pollution by Sewage from Ships. Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land. • Annex V: Prevention of Pollution by Garbage from Ships. Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics. It stipulates that: - Disposal of garbage from ships and fixed or floating platforms is prohibited; - Ships must have a garbage management plan and shall be provided with a Garbage Record Book; and - Discharge of food waste ground to pass through a 25-mm mesh is permitted for facilities more than 12 nmi from land.	
Barcelona Convention and two of its protocols: a) 1976 Dumping Protocol , b)1976 Emergency Protocol Ratified via Leg. Decree No. 126/1977	The 1976 Barcelona Convention for Protection against Pollution in the Mediterranean Sea is a regional convention to prevent and abate pollution from ships, aircraft and land based sources in the Mediterranean Sea. This includes, but is not limited to, dumping, run-off and discharges. Signers agreed to cooperate and assist in dealing with pollution emergencies, monitoring and scientific research. Article (7): Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil: The Contracting Parties shall take all appropriate measures to prevent, abate and combat pollution of the Mediterranean Sea area resulting from exploration and exploitation of the continental shelf and the seabed and its subsoil. a)1976 Dumping Protocol: Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft. It was amended in 1995 and recorded as: Protocol for the Prevention and Elimination of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea. b)1976 Emergency Protocol: Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency. It was replaced by the Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea in 2002.	Aims at the protection of the Mediterranean in case of transferring potentially hazardous wastes across national boundaries.
Barcelona Convention of 1976	The Barcelona Convention of 1976, amended in 1995, and its Protocols aim at protecting and improving the marine and coastal environment in the Mediterranean while promoting regional and national plans contributing to sustainable development; and its Protocol against Pollution from Land-Based Sources and the Prevention and Emergency Protocol.	Aims at the protection of the Mediterranean in case of transferring potentially hazardous wastes across national boundaries.
International Labor Convention No. 174 - Prevention of Major Industrial Accidents Convention, 1993	(a) prevent major accidents; (b) minimize the risks of major accidents; and (c) minimize the effects of major accidents. This Convention does not apply to: (a) nuclear installations and plants processing radioactive substances except for facilities handling non-radioactive substances at these installations; (b) military installations; (c) transport outside the site of an installation other than by pipeline.	"In respect of each major hazard installation employers shall establish and maintain a documented system of major hazard control which includes provision for: (a) the identification and analysis of hazards and the assessment of risks including consideration of possible interactions between substances; (b) technical measures, including design, safety systems, construction, choice of chemicals, operation, maintenance and systematic inspection of the installation; (c) organizational measures, including training and instruction of personnel, the provision of equipment in order to ensure their safety, staffing levels, hours of work, definition of responsibilities, and controls on outside contractors and temporary workers on the site of the installation; (d) emergency plans and procedures, including: (i) the preparation of effective site emergency plans and procedures, including emergency medical procedures, to be applied in case of major accidents or threat thereof, with periodic testing and evaluation of their effectiveness and revision as necessary; (ii) the provision of information on potential accidents and site emergency plans to authorities and bodies responsible for the preparation of emergency plans and procedures for the protection of the public and the environment outside the site of the installation; (iii) any necessary consultation with such authorities and bodies; (e) measures to limit the consequences of a major accident; (f) consultation with workers and their representatives; (g) improvement of the system, including measures for gathering information and analyzing accidents and near misses. The lessons so learnt shall be discussed with the workers and their representatives and shall be recorded in accordance with national law and practice."

Agreement	Objective	Relevance To Project
International Labor Convention No. 139, 120 and 136 Lebanon has ratified 50 International Labor Conventions (48 actually in force)	To prevent vocational risks ensuing from cancer causing materials and tools Deals with sanitation in offices To protect workers against the risks of intoxication ensuing from benzene	Protects workers health and ensures proper sanitation and hygiene for base camps, work environment and offices

3.4. WORLD BANK EHS GUIDELINES AND STANDARDS

World Bank Guidelines consulted for the project (DAPP and GASYLE) consist of the following:

- General EHS Guidelines (April 30, 2007)
- Thermal Power Plant Guidelines (December 19, 2008)
- Onshore and Offshore Oil and Gas Development (April 30, 2007)

The above guideline documents are provided in full in Annex C – World Bank Guidelines while pertinent emission standards extracted from documents are listed below:

Table 3-8. WB General EHS Guidelines (Table 1.1.1.) WHO Ambient Air Quality Guidelines

	Averaging Period	Guideline value in $\mu g/m^3$
Sulfur dioxide (SO_2)	24-hour 10 minute	125 (Interim target-1) 50 (Interim target-2) 20 (guideline) 500 (guideline)
Nitrogen dioxide (NO_2)	1-year 1-hour	40 (guideline) 200 (guideline)
Particulate Matter PM_{10}	1-year 24-hour	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline) 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year 24-hour	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline) 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

Table 3-9. WB General EHS Guidelines (Table 1.3.1.) Indicative Limits for Discharge of Liquid Effluent into Surface Water

Parameters/pollutant	Effluent pollutants threshold (WB requirements)
pH	6 – 9 pH
BOD mg/l	30
COD mg/l	125
Total nitrogen mg/l	10

Parameters/pollutant	Effluent pollutants threshold (WB requirements)
Total phosphorus mg/l	2
Oil and grease mg/l	10
Total suspended solids mg/l	50
Total coliform bacteria (Most Probable Number/100 ml)	400

Table 3-10. WB General EHS Guidelines (Table 1.7.1.) Noise Level Guidelines

WB Ambient Noise Limits		
Receptor	**One hour LAeq (dBA)**	
	Day (07:00– 22:00)	**Night (22:00 - 07:00)**
Residential; Institutional; educational	55	45
Industrial; commercial	70	70

Table 3-11. WB General EHS Guidelines (Table 2.3.1) Noise Limits for Various Working Environments

Location /activity	Equivalent level $LA_{eq},8h$	Maximum $LA_{max},fast$
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Table 3-12. WB Thermal Power Plant EHS Guidelines (Table 4) - Typical CO2 Emissions Performance of New Thermal Power Plants

Fuel	Efficiency	CO2 (gCO2 / kWh – Gross)
Efficiency (% Net, HHV)		
Coal (*1, *2)	Ultra-Supercritical (*1): 37.6 – 42.7 Supercritical: 35.9-38.3 (*1) 39.1 (w/o CCS) (*2) 24.9 (with CCS) (*2) Subcritical: 33.1-35.9 (*1) 36.8 (w/o CCS) (*2) 24.9 (with CCS) (*2) IGCC: 39.2-41.8 (*1) 38.2–41.1 (w/o CCS) (*2) 31.7–32.5 (with CCS) (*2)	 676-795 756-836 763 95 807-907 808 102 654-719 640 – 662 68 – 86
Gas (*2)	Advanced CCGT (*2): 50.8 (w/o CCS) 43.7 (with CCS)	355 39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical) 40 (Supercritical) 30 – 38 (Subcritical) 46 (IGCC) 38 (IGCC+CCS)	811 851 896-1,050 760 134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC) >41(Coal-FBC) 42-45 (Lignite-PC) >40 (Lignite-FBC)	(*6) 725-792 (Net) <831 (Net) 808-866 (Net) <909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT) 38-45 (Gas Engine) 40-42 (Boiler) 54-58 (CCGT)	(*6) 505-561 (Net) 531-449 (Net) 481-505 (Net) 348-374 (Net)
Oil (*4, *7)	(*4) 40 – 45 (HFO/LFO Reciprocating Engine)	(*6) 449-505 (Net)
Efficiency (% Gross, LHV)		
Coal (*5, *7)	(*5) 47 (Ultra-supercritical) 44 (Supercritical) 41-42 (Subcritical) 47-48 (IGCC)	(*6) 725 774 811-831 710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine) 41 (Boiler)	(*6) 648 680
Gas (*5)	(*5) 34 (Simple Cycle GT) 51 (CCGT)	(*6) 594 396
Source: (*1) US EPA 2006, (*2) US DOE/NETL 2007, (*3) World Bank, April 2006, (*4) European Commission 2006, (*5) World Bank Group, Sep 2006, (*6) World Bank Group estimates		

Table 3-13. WB Thermal Power Plant EHS Guidelines (Table 5) - Effluent Guidelines

(To be applicable at relevant wastewater stream: e.g., from FGD system, wet ash transport, washing boiler / air preheater and precipitator, boiler acid washing, regeneration of demineralizers and condensate polishers, oil-separated water, site drainage, coal pile runoff, and cooling water)	
Parameter	**mg/L, except pH and temp**
pH	6 – 9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium - Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	• Site specific requirement to be established by the EA. • Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.
Note: Applicability of heavy metals should be determined in the EA. Guideline limits in the Table are from various references of effluent performance by thermal power plants.	

Table 3-14. WB Thermal Power Plant EHS Guidelines (Table 6B) - Emissions Guidelines (in mg/Nm3 or as indicated) for Combustion Turbine

Note:
- **Guidelines are applicable for new facilities.**
- **EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.**
- **For projects to rehabilitate existing facilities, case by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.**
- **EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.**

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)[a]	15%

General notes:
- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):
- Natural Gas-fired Combustion Turbine – NOx
o Guideline limits: 51 (25 ppm)
o EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
o US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
o (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)

- Liquid Fuel-fired Combustion Turbine – NOx
o Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
o EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))

- Liquid Fuel-fired Combustion Turbine – SOx
o Guideline limits: Use of 1% or less S fuel
o EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Table 3-15. WB Thermal Power Plant EHS Guidelines (Table 6C) - Emissions Guidelines (in mg/Nm3 or as indicated) for Boiler

Note:

- **Guidelines are applicable for new facilities.**
- **EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.**
- **For projects to rehabilitate existing facilities, case by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.**
- **EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.**

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)		Dry Gas, Excess O_2 Content (%)
Boiler	NDA	DA	NDA	DA	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	240	240	3%
Other Gaseous Fuels	50	30	400	400	240	240	3%
Liquid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	400	200	3%
Liquid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200	400	200	3%
Solid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	510[c] Or up to 1,100 if volatile matter of fuel < 10%	200	6%
Solid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200			6%

General notes:
- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; CFB = circulating fluidized bed coal-fired; PC = pulverized coal-fired; Nm_3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- a. Targeting the lower guidelines values and recognizing issues related to quality of available fuel, cost effectiveness of controls on smaller units, and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). b. Targeting the lower guidelines values and recognizing variability in approaches to the management of SO_2 emissions (fuel quality vs. use of secondary controls) and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). Larger plants are expected to have additional emission control measures. Selection of the emission level in the range is to be determined by EA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance. c. Stoker boilers may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):
-Natural Gas-fired Boiler – NOx
o Guideline limits: 240
o EU: 150 (50 to 300 MWth), 200 (> 300 MWth)

-Solid Fuels-fired Boiler - PM
o Guideline limits: 50

o EU: 50 (50 to 100 MWth), 30 (> 100 MWth), China: 50, India: 100 - 150

-Solid Fuels-fired Boiler – SO_2
o Guideline limits: 900 – 1,500 (Plant > 50 MWth to < 600 MWth), 200 – 850 (Plant ≥ 600 MWth) o EU: 850 (50 – 100 MWth), 200 (> 100 MWth)
o US: 180 ng/J gross energy output OR 95% reduction (≈ 200 mg/Nm3 at 6%O_2 assuming 38% HHV efficiency)
o China: 400 (general), 800 (if using coal < 12,550 kJ/kg), 1,200 (if mine-mouth plant located in non-double control area of western region and burning low S coal (<0.5%))

Source: EU (LCP Directive 2001/80/EC October 23 2001), US (NSPS for Electric Utility Steam Generating Units (Subpart Da), Final Rule – June 13, 2007), China (GB 13223-2003)

Table 3-16. WB Thermal Power Plant EHS Guidelines (Table 7) – Typical Air Emissions Monitoring Parameters / Frequency for Thermal power Plants (Note: Detailed Monitoring Programs should be Determined Based on EA)

<table>
<tr><th rowspan="2">Combustion Technology / Fuel</th><th colspan="3">Emission Monitoring</th><th colspan="4">Stack Emission Testing</th><th rowspan="2">Ambient Air Quality</th><th rowspan="2">Noise</th></tr>
<tr><th>Particulate Matter (PM)</th><th>Sulfur Dioxide (SO_2)</th><th>Nitrogen Oxides (NOx)</th><th>PM</th><th>SO_2</th><th>NOx</th><th>Heavy Metals</th></tr>
<tr><td colspan="8">Reciprocating Engine</td><td rowspan="17">If incremental impacts predicted by EA >/= 25 % of relevant short-term ambient air quality standards or if the plant >/= 1,200 MWth:
- Monitor parameters (e.g., PM_{10}/$PM_{2.5}$/SO_2/NOx to be consistent with the relevant ambient air quality standards) by continuous ambient air quality monitoring system (typically a minimum of 2 systems to cover predicted maximum ground level concentration point / sensitive receptor / background point).

If incremental impacts predicted by EA < 25% of relevant short term ambient air quality standards and if the facility < 1,200 MWth but >/= 100 MWth
- Monitor parameters either by passive samplers (monthly average) or by seasonal manual sampling (e.g., 1 weeks/season) for parameters consistent with the relevant air quality standards.

Effectiveness of the ambient air quality monitoring program should be reviewed regularly. It could be simplified or reduced if alternative program is developed (e.g., local government's monitoring network). Continuation of the program is recommended during the life of the project if there are sensitive receptors or if monitored levels are not far below the relevant ambient air quality standards.</td><td rowspan="17">If EA predicts noise levels at residential receptors or other sensitive receptors are close to the relevant ambient noise standards / guidelines, or if there are such receptors close to the plant boundary (e.g., within 100m) then, conduct ambient noise monitoring every year to three years depending on the project circumstances.

Elimination of noise monitoring can be considered acceptable if a comprehensive survey showed that there are no receptors affected by the project or affected noise levels are far below the relevant ambient noise standards / guidelines.</td></tr>
<tr><td>Natural Gas (Plant >50 MWth to <300 MWth)</td><td>N/A</td><td>N/A</td><td>Continuous or indicative</td><td>N/A</td><td>N/A</td><td>Annual</td><td>N/A</td></tr>
<tr><td>Natural Gas (Plant >/= 300 MWth)</td><td>N/A</td><td>N/A</td><td>Continuous</td><td>N/A</td><td>N/A</td><td>Annual</td><td>N/A</td></tr>
<tr><td>Liquid (Plant >50 MWth to <300 MWth)</td><td>Continuous or indicative</td><td rowspan="2">Continuous if FGD is used or monitor by S content.</td><td>Continuous or indicative</td><td colspan="4" rowspan="2">Annual</td></tr>
<tr><td>Liquid (Plant >/=300 MWth)</td><td>Continuous or indicative</td><td>Continuous</td></tr>
<tr><td>Biomass</td><td>Continuous or indicative</td><td>N/A</td><td>Continuous or indicative</td><td>Annual</td><td>N/A</td><td>Annual</td><td>N/A</td></tr>
<tr><td colspan="8">Combustion Turbine</td></tr>
<tr><td>Natural Gas (all turbine types of Unit > 50MWth)</td><td>N/A</td><td>N/A</td><td>Continuous or indicative</td><td>N/A</td><td>N/A</td><td>Annual</td><td>N/A</td></tr>
<tr><td>Fuels other than Natural Gas (Unit > 50MWth)</td><td>Continuous or indicative</td><td>Continuous if FGD is used or monitor by S content.</td><td>Continuous or indicative</td><td colspan="4">Annual</td></tr>
<tr><td colspan="8">Boiler</td></tr>
<tr><td rowspan="2">Natural Gas</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2">Continuous or indicative</td><td>N/A</td><td>N/A</td><td>Annual</td><td>N/A</td></tr>
<tr><td>Annual</td><td>Annual</td><td>Annual</td><td>N/A</td></tr>
<tr><td>Other Gaseous fuels</td><td>Indicative</td><td>Indicative</td><td>Continuous or indicative</td><td colspan="4" rowspan="5">Annual</td></tr>
<tr><td>Liquid (Plant >50 MWth to <600 MWth)</td><td rowspan="4">Continuous or indicative</td><td>Continuous if FGD is used or monitor by S content.</td><td>Continuous or indicative</td></tr>
<tr><td>Liquid (Plant >=600 MWth)</td><td colspan="2">Continuous</td></tr>
<tr><td>Solid (Plant >50 MWth to <600 MWth)</td><td>Continuous if FGD is used or monitor by S Content.</td><td>Continuous or indicative</td></tr>
<tr><td>Solid (Plant >/=600 MWth)</td><td colspan="2">Continuous</td></tr>
<tr><td colspan="10">Note: Continuous or indicative means "Continuously monitor emissions or continuously monitor indicative parameters". Stack emission testing is to have direct measurement of emission levels to counter check the emission monitoring system.</td></tr>
</table>

4. ES REVIEW FINDINGS, CORRECTIVE ACTIONS AND SCHEDULE

Key findings, associated corrective actions, and recommended schedule are presented in Table 4-1, Table 4-2, Table 4-3, and Table 4-4.

The list of studies and plans required to be prepared as part of addressing environmental and social gaps are provided under Table 4-5.

For the complete list of findings and supporting documentation, please refer to Annex A – Complete List of Findings for Deir Ammar Power Plant and Annex B - Complete List of Findings for Arab Gas pipeline.

Table 4-1. Key Historical Background Findings for Deir Ammar Power Plant

Aspect	Summary of Key Issues
Geographical location documented by historical Google maps	Layout and components + Google Earth historical images until oldest available in 2004 + Google Earth KMZ file showing boundary and offshore structures as provided by facility in **Appendix A1.**
Start and end of construction dates	1995 – 1998
Financing the construction and installations and main contractor(s)/suppliers involved	Financing by SAN PAOLO IMI (EX CREDIOP), COMMERZBANK, PARIBAS, FADES, and others 1995 – 1998: EPC by Ansaldo (Italian) and Siemens (German) 1998 – 2000: O&M by Ansaldo (Italian) 2000 – 2002 : O&M by ENEL (Italian) 2002 – Feb 2006: O&M by EDL[5] Lebanese Subcontractor PSM (Poor experience with contract model) Feb 2006 – Feb 2011: O&M by KEPCO (Korean) Feb 2011 – Feb 2016: O&M by YTL (Malaysian) Feb 2016 – Feb 2021: O&M by Primesouth (American) Feb 2021 – Feb 2022: O&M by Primesouth (American) Feb 2022 – Feb 2027: O&M contract renewal negotiations with Primesouth being undertaken
Any legacy issues concerning environmental aspects, land ownership, social and community issues, etc.6	- Pending Al Dohaibi Claim against EDL for compensation for lost trees in PP area when PP was constructed in 1995 is following legal course. - Public complaint regarding petroleum spill at sea in 2018; this issue has had no legal or publicity follow-up. - Public complaint and demand letter for financial compensation (LBP 1 Billion) by family lawyer regarding army member who drowned while spearfishing opposite the facility, which was attributed to suction flow from the inlet pipe (**Appendix A2**). Case has not gone to court yet as communicated by EDL.
Historical land use of the facility site and surroundings (supported by maps)	Initially owned by Iraqi Petroleum Company and Mediterranean Sea Pipeline Company Limited then nationalized by GoL[7] in 1973 and ownership transferred to EDL – MEW **(Appendix A2)**. Prior to construction of the Power Plant, the land comprised a golf court for LOI[8] from the 1950's until construction of the PP in 1995.

Table 4-2. Key ESS Findings, and {Corrective Actions and Timeline} for Deir Ammar Power Plant

ESS Key Issues	Non Compliance Risk	Corrective Actions	Timeline
ESS1: Assessment and management of Environmental and Social Risks and Impacts ***Permits Licenses, Management and Monitoring Systems***			
Environmental and social aspects and potential adverse impacts are not explicitly managed.	Substantial	Environmental, OHS and Social aspect shall be covered in dedicated procedures covering environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. Occupational health and safety performance shall be evaluated against internationally published exposure guidelines. A GRM for employees and FGRM for the general public need to be developed with facilitated 2-way communication mechanisms. A list of studies and plans to be prepared as next steps and their timeline is provided in (Section 5)	Prior to Operation on NG
- **Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and has non-compliances in terms of its emissions and effluent discharges to the sea.** - **Due diligence on oily sludge transporters must be conducted to ensure they are properly licensed in accordance with Decree 999/1 of 2020.** - **A cooling water return flow mixing zone was never established and temperature of cooling water return flow is not being monitored.** - **Air emissions are not continuously monitored because the available CEMS is not being used for such a purpose and additional parameters not measured by CEMS (Particulate Matter) are not also being monitored.**	Substantial	Deir Ammar Power Plant requires an Environmental and Social Management Plan (ESMP) and Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB. Compliance with environmental emission standards requires a third party audit with measurements for the different types of emissions followed up by yearly audits and inspections by MoE or a third party consultant on behalf of MoE. A mixing zone shall be defined for cooling water discharge and monitored particularly for chlorine and temperature; compliance is based on effluent temperature being less than 35°C in national standards (Table 3-7) and temperature differential of less than 3°C at edge of mixing zone in WB Standards (Refer to Annex C > General EHS Guidelines > Wastewater from Utilities Operations; p. 28) while Chlorine (currently measured at 0.4 mg/l) should be less than 1 mg/l in national guidelines (Table 3-7) and less than 0.2 mg/l in WB Guidelines (Table 3-16).	Prior to Operation on NG
- **The power plant has safety requirements in its design based on international standards and is according to EDL in compliance with the national requirements prevalent at the time of construction. Construction permits could not be obtained for review because EDL reported that the hard copies stored at EDL HQ in Beirut may have been lost during Beirut Port Blast.** - **While the risk of fire is covered in the current emergency response plan and while the risks of floods and severe weather conditions are not pertinent in the case of the PP, the risk of a major earthquake that exceeds the earthquake resistance parameters of the PP is real (a scientific research[17] had recommended in 2011 post PP construction that the seismic hazard for the coastal region of Lebanon be raised to account for at least 0.3g Peak Ground Acceleration). Tsunamis also occurred historically in Lebanon as a result of large seismic events. The recurrence interval of such events is generally > 1,500 years but based on historical records and the opinion of many geologists, a large earthquake may very well be overdue; the adequate emergency measures must therefore be accounted for in an updated emergency response plan for the plant.**	Substantial	The current Emergency Response and Preparedness Procedure shall account for the increased seismic hazard to the PP and associated Tsunami risk, and coordinate with external parties (e.g., civil defense, fire brigade, emergency services) as relevant to the safety of PP personnel, the general public, and the environment.	Prior to Operation on NG

[5] Electricite du Liban
[6] This may require consultations and interviews with surrounding communities and local NGOs.
[7] Government of Lebanon
[8] Lebanon Oil Installations

ESS Key Issues	Non Compliance Risk	Corrective Actions	Timeline
- **Environmental and social aspect compliance and improvement responsibilities are lacking from HSE Manager responsibilities.** - **HSE Manager is a safety engineer with no relevant training or background in environmental affairs.** - **Roles and Responsibilities procedure covering environmental and social aspects is lacking.**	Substantial	Environmental and social aspect compliance and improvement responsibilities shall be added to HSE Manager responsibilities in addition to developing and implementing a training so that HSE manager can deliver on these responsibilities. Alternative would be to hire a dedicated environmental manager. An external consultant shall be contracted to ensure E&S compliance and provide training to the HSE manager and develop the needed E&S procedures including roles and responsibilities.	Prior to Operation on NG
No reporting on environmental and social aspects is occurring.	Substantial	Standardized and regular reporting on environmental and social aspects shall be created and added to monthly reports and quarterly audit reports.	Prior to Operation on NG
ESS2: Labor and Working Conditions			
There is no GRM for staff and no associated records apart from the code of conduct warning against discrimination and harassment and referring staff to the Assistant General Manager in such cases.	Moderate	A Labor Management Plan (LMP) shall be developed including a GRM with logs and explicit measures covering SEA/SH; roles and responsibilities shall be also assigned to competent staff with training provided.	Prior to Operation on NG
Emergency preparedness plans do not cover environmental risks except indirectly through safety.	Substantial	Pertinent environmental risks shall be identified following an environmental audit (refer to ESS1-1) and emergency preparedness and response plans shall be updated as needed.	Prior to Operation on NG
There was no safety induction provided to visitors.	Moderate	A standard safety induction shall be created and provided to all non-regular visitors.	Prior to Operation on NG
ESS3 (Resource Efficiency and Pollution Prevention and Management)			
Water Efficiency Upon switching to gas, the desalination plant capacity may become underused and the spare capacity (> 90 m^3/hr.) shall be evaluated by MEW for potentially relieving water shortage in the coastal area of Mineh-Danniyeh as a last resort. This should occur in the future after current demand mismanagement and Unaccounted For Water, have been resolved first and the potential for sustainably conveying water from adjacent water basins or mountainous regions with a positive water balance has been assessed. Increased seawater desalination has adverse impacts on the marine environment and should be a last resort. Increased desalination will also consume power that should be accounted for along with its potential impacts.	Negligible	No action required except for assessing the potential use of spare desalination capacity for relieving water shortage for neighboring communities, which should only be a last resort after reducing unaccounted for water percentage to below 30% and options for sustainably diverting freshwater for mountainous areas with a positive water balance (consistently with a regional water supply strategy and phased plan over at least 15 years in the future) have been exhausted.	
Wastewater Management Wastewater effluent discharges from the PP are not adequately monitored to ensure and/or prove compliance with local discharge standards.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG
Spill control and management Hazardous liquid chemicals are not contained and the storage of hazardous chemicals has not accounted for incompatible chemical neighbors.	Substantial	The safety audits shall account for incompatible chemical neighbors and all liquid receptacles shall be contained.	Prior to Operation on NG
Waste Management Municipal solid waste is not being sorted and the contractor collecting the waste may be improperly disposing of waste through unsafe dumping and unsafe handling by vulnerable individuals. Hazardous oily sludge from the oil-water separator burnt as HFO at Jiyeh Power Plant may be incompatible with the incineration process resulting in non-compliant emissions.	Substantial	Develop a solid waste management plan for the facility.	Prior to Operation on NG
Violations, fines, and complaints Ministry of environment is yet to answer on any violations or complaints recorded against the PP. A nearbyschool that was identified as a potentially affected party and contacted because it is located not far from the PP has reported having concerns from vibrations caused by the operation of the PP.	Moderate	Compliance of noise and vibrations at nearby receptors including Al Rawda School shall be measured for compliance as part of the ESMP development phase.	Prior to Operation on NG
Air pollution and greenhouse Gases The available CEMS at the facility is not operated except for taking discrete measurements. In a 2018 stack test following rehabilitation works, NOx measurements showed noncompliance with MoE Decision 8/1 ELVs.	Substantial	The CEMS shall be operated continuously (or at least one operational day per week) for measurements and compliance; calibration shall occur as per manufacturer guidance. In addition, one yearly stack emissions test by an independent third party shall be conducted.	Prior to Operation on NG
Air emissions monitoring parameters and key performance indicators The available CEMS at the facility is not operated except for taking discrete measurements. In a 2018 stack test following rehabilitation works, NOx measurements showed noncompliance with MoE Decision 8/1 ELVs.	Substantial	The CEMS shall be operated continuously (or at least one operational day per week) for measurements and compliance; calibration shall occur as per manufacturer guidance. In addition, one yearly stack emissions test by an independent third party shall be conducted.	Prior to Operation on NG
ESS4 (Community Health and Safety)			
- **Concerns from vibrations caused by the operation of the PP.** - **A** swimmer lost his life while diving because he was sucked b**y the cooling water intake pipe, as claimed by the family lawyer and based on his location close to intake grate openings along pipe.**	Moderate	- Compliance of noise and vibrations at nearby receptors including nearby School shall be measured for compliance as part of the ESMP development phase. - The restricted area of the intake pipe and/or the intake pipe extension at sea shall be delineated with visible buoys.	Prior to Operation on NG

ESS Key Issues	Non Compliance Risk	Corrective Actions	Timeline
A code of conduct specific to security personnel was not observed.	Moderate	Code of conduct for security personnel must be explicitly defined, they should sign off on it, and they should be trained on the proper response in case of interaction with the community. This will be part of an LMP recommended for the facility.	Prior to Operation on NG
There is no FGRM for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.	Substantial	An FGRM shall be created and implemented to facilitate feedback, claims, and complaints from the general public; it will be widely disseminated with information on the resolution timelines, responsible persons, and option for appeals. Referral pathways for SEA/SH shall be established and communicated.	Prior to Operation on NG
Last hydrostatic test was conducted when pipeline was built – a new one will be conducted during testing phase after rehabilitation.	Negligible	A hydrostatic test will be conducted during testing phase of pipeline rehabilitation as contractually agreed with the future operator of the gas pipeline (TGS).	
ESS5 (Land Acquisition, restrictions on Land use and Involuntary resettlement)			
An individual claim is reported against EDL on the basis that the individual lost trees in the same land where the plant was built based on a concession provided to him by the previous owner of the land (IPC).	Minor	Claim is being processed along legal course	
ESS6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources)			
Monitoring and analysis of water quality and temperature within and at edge of mixing zone (to be defined) from PP discharges are lacking.	Moderate	Monitoring and analysis of water quality and temperature within and at edge of mixing zone (to be defined) from PP discharges shall be performed.	Prior to Operation on NG and to be continued afterward.
Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea.	Moderate	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG and to be continued afterward.
ESS8 (Cultural heritage) **No Key Issues**			
ESS10 (Stakeholder Engagement and Information Disclosure)			
There is no FGRM for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.	Substantial	An FGRM shall be created and implemented to facilitate feedback, claims, and complaints from the general public; it will be widely disseminated with information on the resolution timelines, responsible persons, and option for appeals. Referral pathways for SEA/SH shall be established and communicated. A SEP is currently lacking but under preparation by the Ministry of Energy and Water which will be cleared by the World Bank and disclosed prior to the appraisal stage.	Prior to Operation on NG

Table 4-3. Key Historical Background Findings for Arab Gas Pipeline

Aspect	Summary of Key Issues
Geographical location documented by historical Google maps for PRS and Metering Station	- Approximate boundaries of Receiving Station, Pressure Reducing Station (PRS), and Border Station are shown **Appendix B1**. - Receiving Station is located within Tripoli Oil Installations – Lebanon (TOIL) owned premises in Beddawi Village, Minieh-Danniye Caza, and North Lebanon Governorate. - PRS is located within Electricité Du Liban (EDL) owned Deir Ammar Power Plant premises but under LOI ownership and jurisdiction, in Beddawi Village, Minieh-Danniye Caza, North Lebanon Governorate. - Border Station is located within LOI owned land adjacent to Lebanon-Syria border along el Kebir River in Hokr Jouret Srar village, Akkar Caza and Governorate.
Routing	Refer to **Appendix B2**
Start and end of construction dates	2003-2005
Financing the construction and installations and main contractor(s)/suppliers involved	Financing was secured by LOI according to MEW Contractor: Hawi Bros Contracting and Trading Consultant: Kershner Owner: Tripoli Oil Installations Lebanon
Any legacy issues concerning environmental aspects, land ownership, social and community issues, etc.[9]	- Land ownership: Historically owned from 1931 to 1973 by Iraq Petroleum Company (IPC) and Mediterranean Sea Pipeline Company until nationalized in 1973 by the Government of Lebanon (GoL) following nationalization of these companies in 1961-1972 by the Iraqi Government and failing to fulfill their contractual obligation in Lebanon; their ownership was later transferred to the Ministry of Energy and Water (MEW) – Lebanon Oil Installations in 1970s (**Appendix B3**). - Environmental: Mainly oil spills from adjacent crude pipelines within 32 km Right-of-Way (ROW) resulting from deterioration of pipeline and from theft attempts whereby the pipes are perforated and crude pumped out (refer to photo in **Appendix B4** showing punctured pipe location and stained soil where pipe is exposed within stream and welded by Tripoli Oil Installations - Lebanon (TOIL) after being repeatedly punctured for theft of crude). - Relatively recently, the gas pipeline, which is still pressurized at 5 bars to protect it from corrosion, was punctured by individuals trying to steel crude oil from adjacent crude oil pipelines within the same ROW; TOIL staff reported witnessing a small drop in pressure in the control room and they were alerted to the location of the hole by locals who heard the whistling sound of gas escaping. The emergency shutdown and flaring system was not triggered because of the low pressure maintained and small size of the hole and gas leak. - Social and Community: Mostly after pipeline stopped operating in 2010, locals have been recurrently trespassing on the ROW reserved for crude oil pipes and the gas pipeline while being repeatedly asked to stop their trespassing activities for their safety. In the case of some more explicit constructions, security forces were brought in to remove trespassers and secure the integrity of the ROW. Main types of encroachment activities that still exist include agriculture and plowing of the ROW, backyards extending into ROW, using the ROW as road access, for parking cars and trailers, and as miscellaneous outdoor storage areas or dumps (**Appendix B4**). - The gas pipeline trace and ROW were visited in certain portions along its length to observe it within different land uses (agricultural, rural, urban, under paved roads, and across streams and rivers); it was observed that the previously built gravel road allowing continuous maintenance and emergency access along the whole extent of the gas pipeline and ROW has been particularly eroded along agricultural terrains because local farmers use it for easier access with their tractors (Refer to Figure showing lad use / cover crossed by ROW).
Historical land use of the facility site and surroundings (supported by maps) for PRS and Metering Station	- The PRS location is located on an artificially cut hill side, likely to make room for the station. The rest of the hill side, remains bare land until today with the exception of shrubs; this suggests that the PRS location was historically similar. - The Metering Station is located within TOIL premises; it consisted of bare land and reeds according to the contractor who built the pipeline (S. Hawi, Personal Communication, November 17, 2021).

Table 4-4. Key ESS Findings, and {Corrective Actions and Timeline} for Arab Gas Pipeline

ESS Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline
ESS1: Assessment and management of Environmental and Social Risks and Impacts ***Permits Licenses, Management and Monitoring Systems***			
While an ESIA is not required for the pipeline and linked facilities because they were built before an the EIA decree was enforced (2012), the lack of it means there are no systems and no management plan in place to manage environmental and social risks associated with the operation of the pipeline and associated facilities.	Substantial	An Environmental and Social Management Plan for the pipeline and linked facilities shall be prepared. Refer also to ESS1-3	Prior to Operation
TOIL do not have any management system certification.	Moderate	Refer to ESS1-3 to offset the lack of a certified management System.	Prior to Operation
TGS are ISO 14001:2015, ISO 45001:2018, ISO 9001:2015 certified and their management system and manual covers EHS albeit with some social aspect deficiencies. TOIL lack the required management system and manual as well as the associated competencies.	Substantial	TGS shall introduce the necessary social aspect procedures in their EHS manual including social aspects and FGRM, communication mechanisms and protocols, and communication strategy with local communities. The owner of EHS risks shall be clearly defined (TGS and/or TOIL) the manual must cover all foreseeable EHS and social risks. Where there are risks owned by TOIL, they will develop a manual with the help of a qualified consultant including Social Management System (ESMS) to manage these risks. The manual shall also be updated based on the results of additional safety and risk assessment studies to be conducted. If it is decided that TOIL are in fully in charge of the ESMS, then one will developed for them by a qualified consultant and it shall cover TGS and all relevant stakeholder risks; they will also be trained on it and they will hire/train competent staff capable of implementing it (EHS Manager and Officer(s)).	Prior to Operation
- TOIL lack environmental and social monitoring. - TGS have environmental and social monitoring albeit with some social aspect gaps.	Substantial	TGS need to add social monitoring records in line with ESS1-3	Prior to Operation

[9] This may require consultations and interviews with surrounding communities and local NGOs.

ESS Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline
TGS have mainly environmental reviews and action trackers; social aspects are mostly lacking.	Substantial	TGS need to add social reviews and trackers in line with ESS1-3 and ESS3-4	Prior to Operation
- Receiving Station has an underground cesspool that is designed to infiltrate into the ground, which is a noncompliance with local legislation that mandates impermeable septic tanks if no connection to sewerage system is available. - It could not be confirmed if toilet facility at border station is connected to sewer main.	Moderate	Recommendation is to either construct a sewerage connection to closest sewer main if such a network is connected to a functional sewage treatment plant with secondary treatment or to install an impermeable septic tank and regularly empty it and transport it to a nearby treatment plant – the secondary treatment plant present within Power Plant with 1.5 m^3/hr. and 3 m^3/hr. average and peak capacities respectively should be able to easily accommodate the 0.5-1 m^3 per day of sewage generated assuming 10 individuals at the Receiving Station. It is recommended to confirm that the toilet facility at the border station is connected to a sewerage main.	Within 12 months after start of operation
Key environmental legislation regulating environmental aspects and emissions pertaining to air quality, noise, waste, effluent discharge, and chemical and hazardous material are summarized in Section 3.2.2. These national regulations offer sufficient environmental protection if implemented and enforced.	Low	EHS management shall identify all applicable environmental standards and legal requirements in its environmental aspects register and it shall ensure they are compliant with national legislation where applicable.	Prior to rehabilitation and operation phases
- Gas pipeline was built based on international engineering standards; however, vulnerability to earthquake prone Lebanon has not been characterized and neither appropriate response plans. - Seismic risk characterization for control rooms and automatic shutdown and flaring systems at Receiving Station, PRS, and Border Station is lacking	Moderate	Assess seismic risk as part of the risk assessment planned for the pipeline (refer to Section ESS5-1) and develop the appropriate emergency response plan with the involvement of other authorities (e.g., civil defense, fire brigade, security forces, paramedics) in addition to a training schedule and drills.	Prior to operation
• **Environment and OHS** There are repairs to be made on pipeline and facilities because the pipeline has not been operational for more than a decade (refer to TGS repair assessment report); pipeline markers and berms need rehabilitation and there are general public activities encroaching on the pipeline and ROW. • **Community Health and Safety** There is no evidence of a quantitative risk assessment and a manual of permissible and non-permissible activities within ROW and safety separation distance (not defined as of yet) Given that the pipelines has not been in operation for a long time, it is critical to ensure that safety hazards including major accident hazards can be effectively managed through the existing barriers integrated in design, but also to ensure that operational barriers are in place, and consider maintenance activities • **Performance Indicators and Monitoring** TGS will cover needed aspects	Substantial	• Environment and OHS - Damages to pipeline and facilities shall be repaired and measures such as increased pipeline markers and restoration of the pipeline berm shall be undertaken. - A stand-alone Occupational Hazards Management Plan shall be prepared. Occupational health and safety performance shall be evaluated against internationally published exposure guidelines. • Community Health and Safety - The following risk and safety studies need to be prepared to confirm readiness to operate the gas pipeline system and associated facilities safely (in line with the World Bank's latest EHS guidelines for oil and gas facilities): QRA, Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie), Hazardous Area Classification for Stations (based on IP15), and Fire and Gas Mapping Study for project facilities; it is recommended that this studies be conducted by an independent party commissioned by TGS as part of its preparatory activities and repair works; the recommended risk studies are based on international standards and best practice in the sector - The assessments will inform the preparation of an ROW management plan including permissible and non-permissible activities on the ROW and the safety buffer area as identified by the risk studies - An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the risks of gas pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, Environmental and Social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as from the adjacent crude oil pipelines is also important. - Signage shall clearly indicate an abbreviated phone number to use for reporting leaks or vandalism to the gas pipeline or adjacent crude oil ones. - A very clear and enforceable communication protocol between the operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other shall be defined and implemented to avoid misinformation and confusion; this will anyway be needed in emergency management. Incentives such as rewards for reporting leaks and vandalism may be considered conditional to not conflicting with cultural and ethical norms. - Means to access pertinent information at any time shall be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information.	Prior to Operation
TGS advised that they will dispatch and hire an EHS team including EHS Manager/Officer for AGP-Lebanon once they are commissioned its O&M.	Substantial	The Operator will dispatch / hire a competent EHS team including EHS Manager / Officer.	Prior to rehabilitation and operation
TGS advised that they will dispatch and hire a competent EHS team including EHS Manager/Officer.	Substantial	The Operator will dispatch / hire a competent EHS team including EHS Manager / Officer.	Prior to rehabilitation and operation
Environmental and Social roles and responsibilities are integral to TGS being ISO 14001 certified and TGS informed that all necessary documentation and records will be maintained once they are commissioned the O&M of AGP-Lebanon.	Substantial	All necessary documentation and records will be maintained by the Operator and Borrower upon commissioning the O&M of AGP-Lebanon.	Prior to rehabilitation and operation
The Operator will report to the Borrower in addition to WB as required (Examples of reporting in Appendix B7).	Substantial	The Operator will report to the Borrower in addition to WB as required	
ESS2: Labor and Working Conditions			

ESS Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline
A suitable EHS Management System covering OHS and COVID19 and managing all stakeholders including TOIL staff and sub-contractors should be put in place and implemented for Lebanon-AGP.	Substantial	A suitable EHS Management System covering OHS and COVID19 and managing all stakeholders including TOIL staff and sub-contractors shall be put in place and implemented for Lebanon-AGP.	
- AGP has not been functional for over a decade. It is recommended that if AGP TOIL team will have actual work as part of the TGS team and not just a supervisory role that they be fully responsible under TGS leadership given they have to be fully integrated in their O&M and EHS Management Systems. Responsibilities should not be lost or confused due to unclear authority and accountability between TGS and TOIL-MEW especially since one is a contractor and the other is the client while both have staff working on the project. - Neither AGP TOIL nor TGS have SEA/SH and GBV measures in place; those will need to be added in TGS' EHS Management System, all staff shall be trained on them, should sign a code of conduct covering them, and shall adhere to them and be regularly trained on them with all the necessary record keeping in place.	Substantial	Integrated AGP TOIL within TGS's EHS Management System to have an overarching EHSMS covering applicable risks with clear assignment of responsibilities and accountability. SEA/SH and GBV measures will be added in the EHSMS and adhered to by all concerned staff and as per the Labor Management Procedures prepared for the project; all staff shall be trained on them, should sign a code of conduct covering them, and shall adhere to them and be regularly trained on them with all the necessary record keeping in place. Occupational health and safety performance shall be evaluated against internationally published exposure guidelines.	Prior to Operation
Both AGP LOIL and TGS currently have emergency management plans while a revised unified one is expected for both rehabilitation and operation phases of AGP.	Low	Revised Emergency Management Plans covering all risks identified in the pre-rehabilitation risk assessment will be developed for both rehabilitation and operation phases of AGP.	Prior to rehabilitation and operation
The Receiving Station does not currently have an escape plan and procedure while keeping mind that the building is small with 2 exits that provide sufficient emergency egress.	Low	TGS will account for an escape plan and procedure for the Receiving Station and will familiarize staff working on the PRS with the PP's escape plan	Prior to Operation
ESS3: Resource Efficiency and Pollution Prevention and management			
Wastewater Management If conducted, hydrostatic testing of gas pipeline is not expected to generate wastewater exceeding discharge standards.	Low	TGS are expected to identify wastewater associated hazards and recommend appropriate monitoring prior to discharge and treatment if needed, including for hydrostatic testing if conducted.	Prior to Operation
Spill control and management Spills are only associated with existing generator diesel tanks present at Receiving Station and Border Station. Both these tanks are located above concrete pavement but are not bunded; spills can accordingly reach nearby soil **(Appendix B11).**	Moderate	Spill trays and bunding equivalent to at least 110% of the capacity of the tanks in addition to spill kits and the appropriate spill prevention and control procedure should be in place.	Prior to Operation
Waste Management - Municipal waste at the Receiving Station is currently being collected by the Beddawi municipality contractor – Lavajet. - The PRS at the Deir Ammar PP is expected to generate a limited quantity of solid waste (manned by one if any staff). - Municipal waste at the Border Station will be minor given it is not expected to be continuously staffed except for the continuous presence of a security guard.	Low	The Operator will coordinate with Lavajet to secure bins for sorting at source at the Receiving Station (Control Room) and staff shall sort municipal solid waste generated. Any petroleum-contaminated soil excavated during the rehabilitation phase, shall be identified and managed in accordance with an EHS Plan (ESMP) and procedure approved with the authorities and particularly MoE; such a procedure would define the screening of excavated soil in terms of identification by observation, transfer onto isolated surface and containment, analysis for comparison with contamination thresholds, and transport and treatment / containment.	Prior to Rehabilitation for Contaminated Soil and during first 3 months of Operation for municipal waste
Operational and Maintenance Program - TGS communicated that there are no major maintenance requirements for the gas distribution network once rehabilitated. - Spare part inventory will need to be managed either based on a software with threshold based notifications or a manual inventory schedule ensuring there is no risk of spare part shortage.	Low	Spare part inventory will be managed based on either a software with threshold based notifications or a manual inventory schedule ensuring there is no risk of spare part shortage.	At start of operation
Violations, fines, and complaints TOIL do not have an environmental register but TGS will develop one being the Operator.	Low	The Operator (TGS) will develop an environmental aspect for the project.	Prior to Rehabilitation and Operation
ESS4: Community health and Safety			
No evidence of Safety Distance has been observed nor a Manual of Permitted and Non-Permitted Activities within ROW and safety distance (to be defined). There seems to be no code of conduct for security personnel at present and this may need to be addressed in the EHS management system.	Substantial	Refer to ESS1-12 TGS and TOIL shall account for a code of conduct for security personnel.	Prior to Operation
TOIL premises can be occasionally accessed without being stopped. More stringent access control is recommended.	Substantial	More stringent access control to TOIL premises shall be enforced.	Immediate
An FGRM including SEA/SH is currently lacking.	Substantial	An FGRM including SEA/SH shall be developed for the AGP.	Prior to Operation
ESS5: Land Acquisition, restrictions on Land use and Involuntary Resettlement			
- There are trespassing and encroachment of private individuals/entities on the ROW which hinder continued access along the ROW for O&M and thus expose encroachers and the general public to H&S risks. Encroachment includes agricultural activities, private backyard extension onto ROW, neighborhood road access, use of ROW as car and truck park space and as miscellaneous outdoor storage or dumps. - In case safety studies and separation distance do not trigger additional resettlement needs, impacts on livelihood are expected to be low if any. This is mainly because the encroachment of agricultural land is mainly from large agricultural fields and not small right holders.	Substantial	- Any compensation of encroaching parties shall be evaluated following a risk assessment for the gas pipeline within the ROW in terms of whether it is safe to allow encroaching parties to continue their activities or to require their removal for the sake of future integrity of the ROW and their own safety. - What is not known at the moment is the safety distance from the pipeline as a result of a quantitative risk assessment, and once defined, what would be the impacts and associated requirements, if any, to relocate structures and activities. It is therefore recommended to conduct the following:	Prior to rehabilitation pipeline before operation

ESS Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline
- Main risk would be related to a wider separation distance, if required through safety studies, and which trigger further resettlement needs.		- A Resettlement Action Plan or Livelihood Restoration Plan consistent with ESS5 covering both economic and/or physical resettlement in case triggered by safety studies - Safety studies and workshops (HAZID, QRA, As Low As Reasonably Practicable (ALARP) study and workshop, and a Manual of Permitted Operations study and workshop (MOPO))	
ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources **No Key Issues**			
ESS8: Cultural heritage **No Key Issues**			
ESS10: Stakeholder Engagement and Information Disclosure			
- A SEP is currently lacking but under preparation by the Ministry of Energy and Water which will be cleared by the World Bank and disclosed prior to the appraisal stage - Parties illegally encroaching on the existing ROW and gas pipeline path would need to be identified and characterized to also assess whether they fit the vulnerability criteria set by the Bank in case of resettlement or livelihood restoration need. - Impacts could arise in case safety studies indicate the need for a wider safety distance than ROW or special measures whenever gas pipeline crosses within urban centers; this needs to be confirmed once safety studies are completed; this safety assessment process has been initiated by MEW. - A GRM is currently lacking. - A communication strategy is currently lacking.	Substantial	- A SEP is currently lacking but under preparation by the Ministry of Energy and Water which will be cleared by the World Bank and disclosed prior to the appraisal stage. - An FGRM including SEA/SH shall be developed for the AGP as part of the EHS Management System prior to start of rehabilitation. - An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the risks of gas pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, Environmental and Social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as from the adjacent crude oil pipelines is also important. - Signage shall clearly indicate an abbreviated phone number to use for reporting leaks or vandalism to the gas pipeline or adjacent crude oil ones. - A very clear and enforceable communication protocol between the operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other shall be defined and implemented to avoid misinformation and confusion; this will anyway be needed in emergency management. Incentives such as rewards for reporting leaks and vandalism may be considered conditional to not conflicting with cultural and ethical norms. - Means to access pertinent information at any time shall be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information. - A communication strategy shall be prepared.	Prior to Rehabilitation

Table 4-5. List of Studies and Plans that will be Prepared to Address Environmental and Social Gaps for the Project

Study	Scope	Responsibility	Timeline
HAZID	- HAZID ToRs - HAZID workshop - HAZID worksheet - HAZID close-out forms	Independent E&S consultant	Completed HAZID actions close-out to be done as per timelines determined in the HAZID close-out sheets
HSE plan for pipeline repair and rehabilitation activities	Plan addressing possible health, safety and environmental impacts	TGS	Prior to start of repair and rehabilitation
HSE plan review	Review adequacy of the plan to manage identified hazards	Independent E&S consultant	Prior to start of repair and rehabilitation
ESR/ESCP/SEP public consultation and disclosure	- Finalize documents based on final comments from World Bank/MEW - Prepare summary materials for public consultation - Organize public consultation activities as per the SEP - Finalize the documents based on inputs from public consultations - Disclose all documents as per World Bank standards	Independent E&S consultant	• ESR Consultations is completed • Other consultations will be conducted during the preparation of E&S instruments
Survey of encroachments on GASYLE ROW	Mapping of all encroachments along the ROW	TOIL	Before gas test and commissioning
ESMP for DAPP **ESMP for GASYLE**	- Prepare ESMP in line with World Bank guidelines for the power plant and GASYLE - Stack emission monitoring at power plant (during testing to confirm compliance with standards) (2 stacks) - Noise and vibration measurements (6 locations at near sensitive receptors) (with power plant on and off) - Liquid effluent analysis (5 samples) - Rapid marine ecological survey (4-5 dives) with collection of samples, in-situ measurements (with boat rental and all equipment), and impact assessment (including determination of mixing zone empirically); thermal plume discharge modeling not included - Socio-economic survey along pipeline and near power plant receptors (brief survey with community profiling, determination of vulnerable groups, etc.) - Air dispersion modeling for power plant emissions - Noise and vibration modeling for power plant (this is useful to determine effectiveness of interventions to reduce impacts, if any; at the moment the school claims that when power plant is on they feel the vibration) - Drone survey along pipeline (not costed – cooperation with NCSR is suggested) (optional to support TGS survey) - Integration of safety studies results in the ESMP - Preparation of public consultation materials (leaflets, etc.) - Implementation of public consultation activities in line with SEP - Finalization of ESMP based on public consultation outcomes - Disclosure of ESMP in line with World Bank Standards	Independent E&S consultant	Prior to testing and commissioning Note: air emissions testing should be done during testing and commissioning to confirm compliance with standards when operating with NG
Labor Management Procedure	LMP in line with World Bank standards (ESS2)	Independent E&S consultant	Prior to testing and commissioning
Grievance mechanism operationalization (external)	- Finalization of external FGRM including points of contacts, procedures, and preparation of infographics for dissemination to external stakeholders and local communities during consultation; training of MEW, TOIL and EDL relevant staff in the implementation of the FGRM	Independent E&S consultant	Prior to start of repair and rehabilitation
Grievance mechanism operationalization (internal)	Finalization of internal grievance mechanism in line with ESS2	MEW/EDL/TOIl with support from independent E&S consultant	Prior to testing and commissioning
Resettlement Policy Framework	Based on findings of QRA and other safety studies for the pipeline, the respective mitigation measures and the relevant instrument to be prepared, such as Livelihood Restoration Plan (LRP) or Resettlement Action Plan (RAP), will be determined RAP / LRP in line with World Bank standards (ESS5)	Independent E&S consultant	Completion and clearance of the determined instrument will be prior to

			testing and commissioning, and before disbursement of retroactive financing
Safety studies for GASYLE	- QRA - Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie) - Hazardous Area Classification for Stations (based on IP15) - Fire and Gas Mapping Study for project facilities	Independent Safety Consultant	Prior to testing and commissioning
HAZOP for pipeline	HAZOP	TGS	Prior to testing and Commissioning
QRA for power plant	- QRA - QRA model for Power Plant will be integrated with Border, Receiving and TOIL Stations QRA	Independent safety consultant	Prior to testing and Commissioning
Emergency response plans for GASYLE and power plant	ERP	TGS and Primesouth	Prior to testing and Commissioning
ERP Review	Review of ERPs to ensure adequacy to handle identified emergencies	Independent safety consultant	Prior to testing and Commissioning
Stand-alone Occupational Health and Safety Plan	OHS plan for operations for GASYLE and DAPP in line with ESS2	TGS and Primesouth	Prior to testing and Commissioning
OHS review	Peer review of adequacy of the OHS plans	Independent E&S consultant	Prior to testing and Commissioning
ESMF for Component 2.1	ESMF to cover Component 2.1 activities related to solar power to water wells including public consultation and disclosure	Independent E&S consultant	Prior to final selection of beneficiary RWEs where the PV and Scada systems will be installed
ESMP for Component 2.2	ESMP for activity 2.2 including public consultation and disclosure	Independent E&S consultant	Prior to commencement of procurement to be part of bidding documents and work/supply contracts

5. STAKEHOLDER CONSULTATIONS

Initial stakeholder identification and consultation was conducted during the Environmental and Social Review phase during November / December 2021 followed by consultations with local communities on February 2, 2022 to present the SEP and obtain feedback from the local communities; consultation records are provided in Table 5-1 and Table 5-2. MEW will continue following-up with all stakeholders who have not responded or could not be reached as part of the due diligence/preparation phase and will engage with all stakeholders as part of the proposed SEP programme.

The most pertinent feedback is described below:

- Municipality of Beddawi indicated that a claim against air pollution from the Deir Ammar Power Plant was filed to MoE a few years back but the official claim could not be found (MoE has not responded yet). The municipality also indicated that a Lebanese army officer drowned because of the suction of the cooling water intake pipe; this happened on 19 September 2020 while spearfishing opposite the power plant.
- A principal of a school located 300 m approximately from the power plant noted that the school is affected by vibrations whenever the power plant is operational. The principal also noted that her balcony tiles were deteriorating because of acid rain.
- The fishermen cooperative in Tripoli indicated that fish stocks were declining but could not scientifically attribute that to the power plant; they are not sure if cooling water outflow into the sea has an adverse impact and they believe sewage is the most important problem in terms of sea pollution.
- Minieh Governmental Hospital referred to increased pulmonary diseases and cancer rates in the area while stating that a scientific study was needed to identify the reasons behind this increase.

In addition to the above, EDL revealed that there was a pending claim against EDL and that EDL had reached out to MEW for more information on this claim (the correspondence is dated 2018-2019 but the actual claim, which may go back to when the power plant was constructed in 1995 could not be obtained). The claim itself could not be obtained but it was understood that it was about compensation for trees lost based on a land use concession from the previous owner of the land where the power plant was built – Iraq Petroleum Company (IPC). EDL became the new owner of the land after IPC lands where the Deir Ammar Power Plant now stands were expropriated for the benefit of EDL.

The legal department of LOI, the current owner of the pipeline ROW, extending from the gas pipeline Receiving Station at TOIL until the Border Station was also contacted regarding encroachments on the pipeline ROW. LOI's legal department indicated that there are several claims filed by LOI against various parties who had encroached on the ROW and several of them led to the removal of the encroachments while some are still in process (LOI correspondence provided in the Environmental and Social Review (ESR) provides more details and examples on such encroachments).

Consultations with the local communities have also been undertaken on February 2nd, 2022 to discuss this SEP and the findings of the Environmental and Social Review (ESR). The consultations were conducted in the form of interviews with the municipalities and vulnerable groups located in the areas closest to the pipeline. The consultations were held in Minieh, Mhammar, Sammounyeh and Chir Hmairine as these villages have a relatively high population density around the pipeline's RoW and twenty one (21) people were interviewed in total. The vulnerable groups that participated in the consultation were mostly refugees and women.

During the consultation, interviewees were provided a brief background about the project and explained its benefits. Safety measures that are already put in place to ensure the gas pipeline's integrity were explained and it was explained that environmental, social and safety studies are being conducted to ensure that the project is environmental friendly, socially acceptable and safe.

The aim of the stakeholder engagement with vulnerable groups was to understand this group's concerns regarding the project and about the restrictions that could be implemented and to identify their preferred means to have access to important information. In addition, the municipalities were also interviewed to highlight key issues related to the use of the pipeline's RoW.

The following key questions were asked during the interviews to ensure that vulnerable groups in the area expressed their concerns, in order to consider their needs in the project:

1. For what purpose is the RoW used for, what are the main concerns on possible restrictions on the use of the RoW and what are the potential social impacts that exist from the possible restricted uses of the RoW.

2. What are the best ways to communicate those restrictions and any other project information.

3. What environmental, social, and safety concerns related to the project should be considered during the project operation.

4. What is the best way for them to send a grievance (uptake channel).

Table 5-2 summarizes the main findings of these consultations. Main points are summarized below:

- There is a generally positive attitude towards the project

- There are primarily agricultural activities that encroach on the pipeline; its relative extent compared to the total agricultural plot will need to be assessed during the ESMP, to assess whether restrictions to these lands, if required, would trigger significant impacts on livelihood; these are however mostly small patches of larger land and are not necessarily going to trigger important impacts on livelihood; communities do expect compensation in case restrictions affect their livelihoods

- No permanent structures on the ROW have been identified during the site visits and consultations, noting that the areas visited are the ones where human activities are the most dense

- No one really raised the issue of being too close to the pipeline; focus has been to require stringent safety measures to avoid a major accident; some of the consultees had actually witnessed the construction of the pipeline and felt re-assured by the professional work being undertaken

Table 5-1. Affected Parties Other than Borrower (MEW, EDL, LOI, TOIL) Contacted during E&S Review Phase

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
National Government			
Ministry of Environment (MoE)	Competent authority for Environmental Matters	Official letter signed by MEW Minister requesting: • Log of all historical complaints against Power Plant / Pipeline / Owner / Operator since design phase prior to inception • Copies of all correspondence with MoE since design phase • Copies of all inspection reports prepared by MoE • General and specific environmental monitoring requirements requested from Deir Ammar PP	No feedback received as of date of this report. Based on latest follow-up made on January 21, 2022, MoE is still collecting the information. MoE is significantly under-resourced at the moment and is not being able to efficiently respond to requests.
Ministry of Labor	Labor Authority – OHS aspects and labor conditions	Official letter signed by MEW Minister requesting: • Copies of labor related complaints • Records of labor or OHS related inspections conducted by MoL	MoL replied officially stating that there are no records of complaints and grievances against Power Plant and AGP.
Civil Defense	Fire history	Official letter signed by MEW Minister requesting: Log and report copies of all historical fires	Civil defense replied reporting one fire incident near the pipeline in Aabdeh on 14 Nov 2020 at 9:35 am because of nearby crude oil pipeline. An investigation was launched and a technical report was submitted at the time: The fire's likely cause was a cigarette butt thrown on the side of the road, and the fire spread to reach a small

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
			oil spill from the decaying and corroded crude oil pipeline underneath vehicular traffic that may have additionally contributed in the fracturing of the pipeline.
Ministry of Defense	Security history	Official letter signed by MEW Minister requesting: Log and report copies /description of all historical security breaches	The Ministry of Defense noted that it is concerned with the ROW crossing urban areas and associated fire and explosion risk this constitutes. It listed a number of vandalism events, fires, and crude oil thefts and arrests made in regard to the crude oil pipelines; given the dire economic situation and price of fuel, attempts to siphon off very old crude oil (40-50 years old) from the pipelines had increased in the last few years.
Lebanese Army	Security history	Official letter signed by MEW Minister requesting: Log and report copies /description of all historical security breaches	No feedback received as of date of this report
Ministry of Interior and Municipalities (MoIM) - Internal Security Forces	Security history	Official letter signed by MEW Minister requesting: Log and report copies /description of all historical security breaches	No feedback received as of date of this report
Regional and Local Authorities			
Governor of North (محافظ)	Highest authority in Governorate (Mohafazat)	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Could not be reached. MEW will ensure that Governor is contacted and engaged during the preparatory phase of this project.

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
District Commissioner (قائم مقام) – Minie-Danniyeh	Highest authority in district (Caza) including Deir Ammar Village with Power Plant (PP)	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Has confirmed that there are no grievances or complaints raised against the power plant.
District Commissioner (قائم مقام) – Zgharta	Highest authority in adjacent district (Caza) that includes villages directly adjacent to Deir Ammar Village with PP	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Has confirmed that there are no grievances or complaints raised against the power plant.
Municipality of Beddawe – Mayor	Village adjacent to Deir Ammar Village including PP	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Stated that a complaint has been filed to Ministry of Environment (MoE) a few years ago (5 or 6 years ago approximately) regarding the air emissions from the power plant. No additional details or proof about the issue was provided.
Municipality of Beddawe – Member			• Lebanese army member (whom is also a community member) drowned a few months ago after getting sucked by the sea water inlet to the power plant while he was off duty spearfishing. • Can check with local fishermen who practice fishing near the power plant. • Could not find any official copies of any complaint submitted by the Municipality to MoE
Municipality of Deir Ammar	Village including Power Plant	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Could not be reached

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
Municipality of Minieh	Village almost adjacent to Deir Ammar Village including PP but extending along a considerable distance (4.6 km) downwind from the PP starting from 1.2 km until 5.8 km	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Could not be reached
Municipality of Mejdlaiya	Village adjacent to Deir Ammar Village including PP	Telephone Inquiry on: Knowledge and records of EHS (pollution) / OHS / community objections related issues	Could not be reached
NGOs and Civil Society Groups			
Marine Biodiversity / Protection NGOs	Interest group	Telephone Inquiry on: Observations supporting marine pollution from the power plant (cooling water effluent and wastewater discharges) / decline of quality/quantity of fisheries stocks	No details available on local marine biodiversity.
Akkarouna	Interest Group Active in the entire North region (Akkar included) and supports vulnerable groups, including women and refugees. The NGO works under five pillars: Shelter, Protection, Governance, Livelihood and Social Stability. Two years ago, an emergency response unit was established	The director of the NGO Akkarouna was contacted over the phone on the 2nd of February 2022 in order to ask if they could provide support during different project phases and mainly in stakeholder engagement activities in the region and especially with vulnerable groups	Akkarouna is ready to assist in the project by supporting the access of information to local communities and vulnerable groups of any age and gender, in organizing and delivering focus group meeting and preparation of information briefs. The NGO is also ready to serve as a referral pathway to Gender Based Violence and sexual harassment. Akkarouna have a "hotline" number that can be used by the local community, and they are within the referral mechanism.

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
Trade unions / Cooperatives / Syndicates			
Cooperative for Fishermen - Tripoli	Interest group	Telephone Inquiry on: Observations supporting marine pollution from the power plant (cooling water effluent and wastewater discharges) / decline of quality/quantity of fisheries stocks	• The impact of the power plant on fish needs a detailed scientific study. However fishermen in the area are noticing a decline in fish populations in the area. • Not certain if the cooling water discharged into the sea affects marine life. • The main impact comes from the discharge of untreated WW into the sea from the area. The entire area is not served by wastewater treatment plants and therefore it can be assumed that all sewage generated in the area is discharged untreated in the sea.
Affected Communities and Social Welfare Resources			
Minieh Governmental Hospital	Sensitive receptor downwind in Minieh Village	Telephone Inquiry on: Indications of air pollution related diseases in medical history of local population suggesting Power Plant as a source	It is possible that the increased rates of people suffering from allergy, asthma, cancer, and Chronic obstructive pulmonary disease (especially in areas located downwind) are due to the emissions from the power plant. However, this needs to be thoroughly studied.
Rawda Public School	Sensitive receptor 290 m south of PP stacks (prevailing wind is southwesterly)	Telephone Inquiry on: • Observations supporting air pollution • Indications of air pollution related diseases in medical history of staff / faculty / students	• The school has around 350 students. Around 4 students in each class suffers from asthma. • She noticed increased cancer rates in the area surrounding the power plant but there is no information to ascertain

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
			whether this is directly attributed to the power plant. • There are many other sources of air pollution in the region extending between Deir Ammar and Tripoli (upwind) (DAPP2 Prelim. EIA)): Traffic, ships (port), car painting, furniture painting, landfill, ready mixed concrete plant, building construction, dust (geological) suspension from paved roads, fishing boats, unpaved unfenced parcels, road surface erosion, furniture manufacturing, and petrol transfer from tanks to road trucks, electrical power generators, and domestic heating. • The main source of NOx other than DAPP would be the main Tripoli-Akkar Road separating DAPP from Deir Ammar village. • The school suffers from vibration impacts (when the power plant is operational). • They sometimes smell gas odors at the school, but she is not certain if this originates from somewhere else. • A dweller lives nearby as well, and noticed the weathering of her balcony tiles following winter rain.
Deir Ammar Technical Institute	Sensitive receptor 290 m south of PP stacks	Telephone Inquiry on: • Observations supporting air pollution	Did not accept to talk stating that they need an approval from the Directorate of technical education to do so.

Stakeholder Name	Justification for Engagement during Review Phase	Means of Communication / Information Requested	Summary of Feedback
		• Indications of air pollution related diseases in medical history of staff / faculty / students	
Al Marba Abd el Hadi Al Duhaibi Public School	Sensitive receptor 320 m south of PP stacks	Telephone Inquiry on: • Observations supporting air pollution • Indications of air pollution related diseases in medical history of staff / faculty / students	Could not be found
Other Affected Parties			
Piscine Aramen Beach Resort	Adjacent receptor to PP	Telephone Inquiry on: • Indications of associated air pollution suggesting Power Plant as a source • Indications of air pollution and marine water pollution and of associated diseases in medical history of staff suggesting Power Plant as a source • Observations supporting marine pollution from the power plant (cooling water effluent and wastewater discharges)	Contact number could not be found.
Academic Institutions			
Balamand University – Institute of Environment	Research/source of scientific data	Telephone Inquiry on: • Findings supporting marine pollution from the power plant (cooling water effluent and wastewater discharges)	There are no available studies on the marine environment near the power plant.

Table 5-2. Summary of consultations with local communities

Stakeholder category	Number/gender of stakeholders interviewed	Main concerns on possible restrictions on the use of the RoW	Communication pathways	Environmental, social and safety concerns	Grievance Mechanism uptake channels	Additional comments/ concerns
Mhammara						
Municipality of Mhammara	2 males	• The RoW is used mainly for agricultural purposes • Some structures are being established along the pipeline's RoW (nothing permanent)	• Establishing a committee at the municipality that supports access of information to local communities • Using posters • Though WhatsApp groups • Inviting the concerned people to the municipality to communicate the main restrictions that will be imposed	• The pipeline crosses agricultural areas and could cause vegetation poisoning • The gas pipeline is in close proximity to the oil pipeline that leaks and therefore could cause accidents and affect people's safety • Water networks could damage the gas pipeline	• Through the committee that can be established at the municipality • Through WhatsApp groups	• Safety measures should be put in place to avoid accidents • Waste is being dumped on the RoW which can affect the pipeline's integrity • The RoW should be supervised to limit activities that affect the pipeline's integrity, and the exact location of the water networks should be identified.
Vulnerable Groups: Refugee	1 male	• Stores and agricultural areas are located on the RoW • If restrictions related to permanent structures located on the RoW were imposed (mainly of the houses located along the RoW), affected people should be offered a compensation	• WhatsApp groups	• Not concerned about any potential impact on the environment, society and safety	• WhatsApp groups	

Stakeholder category	Number/gender of stakeholders interviewed	Main concerns on possible restrictions on the use of the RoW	Communication pathways	Environmental, social and safety concerns	Grievance Mechanism uptake channels	Additional comments/ concerns
Community located along the pipeline's RoW	1 male	• Owns a vegetable shop on the RoW • No specific concerns regarding any restriction that might be imposed on the RoW	• WhatsApp groups	• The project presents a positive impact as long as safety measures are implemented	• WhatsApp groups	
Sammounyeh						
Vulnerable Groups: Refugee women, men and elderly	10 refugees including 7 women, 2 elderly (males) and 1 man	• The RoW is used for agricultural purposes • Residential units are located on the RoW • Most of the refugees work in the agricultural area and hence restrictions on agricultural activities can affect the people's livelihood. Therefore, the affected people should be compensated	• WhatsApp groups or verbally over the phone	• Gas leaks could occur in case the pipeline was damaged and can hence affect the vegetation and generate odors • An explosion could occur	• WhatsApp groups	
Chir Hmairine						
Municipality of El Aabboudiye – Chir Hmairine	1 male	• Agricultural areas and around five houses are located on the RoW	• WhatsApp groups	• The project does not have a negative impact as the pipeline is underground and safety measures are implemented	• WhatsApp groups	

Stakeholder category	Number/gender of stakeholders interviewed	Main concerns on possible restrictions on the use of the RoW	Communication pathways	Environmental, social and safety concerns	Grievance Mechanism uptake channels	Additional comments/ concerns
Vulnerable Groups: Low income population living on the RoW (including women)	3 in total including 2 women and 1 man	• Residential units and agricultural areas are located on the RoW • Concerns regarding the possibility of resettlement	• Meetings can be conducted at the municipality and information should be communicated verbally	• The occurrence of gas leaks can affect people's safety • The gas pipeline is in close proximity to the oil pipeline. This oil pipeline is being ruptured by people for the purpose of stealing which is causing leakage and this can potentially affect the gas pipeline • An explosion could occur in case the pipe was damaged hence, regular maintenance should be conducted	• Through the municipality	The RoW should be constantly supervised to prevent any activities that can affect the pipeline's integrity and people's safety
Minieh						
Municipality of Minieh	1 male	• The RoW is used for agricultural and residential purposes	• Through the municipality	• The project does not have any potential negative impact on the environment, society and safety	• Through the municipality	The oil installations are limiting the establishment of permanent and temporary structures on the RoW
Vulnerable Groups located on the RoW: Women	1 female	• Owns a perfume store located on the RoW and other stores are also located on the RoW	• Through social media	• Gas leaks could cause health issues	• Whatsapp Groups	

Stakeholder category	Number/gender of stakeholders interviewed	Main concerns on possible restrictions on the use of the RoW	Communication pathways	Environmental, social and safety concerns	Grievance Mechanism uptake channels	Additional comments/ concerns
Vulnerable Groups located on the RoW: Refugees	1 male	• Owns a Kiosk located on the RoW • Stores and residential units are found on the RoW • Compensation should be offered in case restrictions were imposed on the operation of the kiosk during project implementation	• Information and restrictions should be communicated verbally and in person	• Gas leaks could occur		

6. CONCLUSION AND RECOMMENDATIONS

This potential World Bank financed project consists of rehabilitation and operation of the Lebanese segment of the Arab Gas Pipeline (31 km approx.) and subsequent operation of the Deir Ammar Power Plant (DAPP) based on NG instead of gasoil; DAPP is already connected to the pipeline.

DAPP, which is a combined cycle gas (and steam) turbine based plant, was initially designed and built to run on natural gas; it relied on gasoil in the last decade because the war in Syria resulted in shutting down NG supply from Syria. DAPP can easily switch back to NG, which will reduce and eliminate key emissions and hazardous waste, namely air emissions, oil-water separator effluent discharge at sea and oil-water separator sludge being currently used as HFO in other power plants.

GASYLE was built inside an ROW averaging a width of 24 meters that comprises old crude oil pipelines from the days when the TOIL Beddawi refinery was operational (1950s-1960s). GASYLE has not been operational for over a decade but a low gas pressure inside the pipe has been maintained to prevent its deterioration and the TOIL-AGP team kept monitoring it during all this time. Notwithstanding, it is in need of repairs and the contractor operating the AGP Jordan segment of the AGP (TGS) is in the process of being contracted to conduct the repairs and operate the GASYLE pipeline.

Despite having a safety manual and reporting on OHS aspects, DAPP is not directly managing environmental and social (E&S) aspects or reporting on them. This leaves DAPP with a set of E&S gaps that require addressing prior to operation on NG in order to achieve compliance with ESF and national standards including environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. It is recommended to first develop an Environmental and Social Management Plan (ESMP) with measurements conducted on different emissions from DAPP to achieve compliance. Cooling water return flow to sea is an important environmental aspect that will persist after the switch to Natural Gas (NG) and therefore must be properly assessed and inspected for compliance with national (35 °C effluent temperature) and WB standards (3 °C temperature differential at edge of mixing zone).

An Emergency Response and Preparedness Procedure shall account for the increased seismic hazard to the PP and associated Tsunami risk, and coordinate with external parties (e.g., civil defense, fire brigade, emergency services) as relevant to the safety of PP personnel, the general public, and the environment.

Given that a GRM and FGRM were found to be lacking / insufficient for employees and the general public respectively, those will be developed for ADPP and the Pipeline to facilitate feedback, claims, and complaints; they will be widely disseminated with information on the resolution timelines, responsible persons, and option for appeals. Referral pathways for SEA/SH shall be established and communicated. The GRM and FGRM will be part of a Labor Management Plan and a SEP developed for the project respectively. A dedicated code of conduct will be developed for security personnel which they will be trained on and will sign off on.

The main gaps for the pipeline were found to be social and Occupational Health and Safety (OHS) related.

In order to address OHS risks, a stand-alone Occupational Hazards Management Plan for the pipeline shall be developed.

Given certain illegal encroachment activities by private individuals along the ROW (such as agriculture, private backyard extension, vehicle parking spaces, and outdoor storage) coupled with a historical lack of safety studies and clear definition of safety distances for the gas pipeline specifically, MEW will be conducting safety and risk studies. Those are needed to confirm readiness to operate the gas pipeline system and associated facilities safely (in line with the World Bank's latest EHS guidelines for oil and gas facilities): QRA, Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie), Hazardous Area Classification for Stations (based on IP15), and Fire and Gas Mapping Study for project facilities. It is recommended that these studies be conducted by an independent party and that they be based on international standards and best practice in the sector.

The risk and safety studies will inform the preparation of a Right-of-Way (ROW) management plan including permissible and non-permissible activities on the ROW and safety separation distances. Based on the findings of the QRA and other safety studies for the pipeline, the respective mitigation measures and the relevant instrument to be prepared, such as Livelihood Restoration Plan (LRP) or Resettlement Action Plan (RAP), will be determined. The completion and clearance of the determined instrument will be before commissioning and testing and before disbursement of retroactive financing.

MEW/TOIL/EDL shall commit to implement the corrective actions identified in this Environmental and Social Review Report and conduct the studies needed to achieve compliance as listed in Table 4-5.

ANNEXES

ANNEX A – COMPLETE LIST OF FINDINGS FOR DEIR AMMAR POWER PLANT

Table A1. Environmental and Social Review of Deir Ammar Power Plant provides the comprehensive list of Environmental and Social review findings at Deir Ammar Power Plant and Table A2. List of Significant Health and Safety Hazards – Deir Ammar Power Plant lists the significant OHS hazards.

Supporting documentation is provided in Appendices as listed below:

Appendix	Documents
A1	- Historical Imagery showing Power Plant(Google Earth TM) - Deir Ammar Power Plant Description - Deir Ammar Power Plant Layout (Colored) - Deir Ammar Power Plant Layout (Black and White) - Deir Ammar Power Plant Boundary, SPM, Water Intake Pipe, Warning Signs, Restricted Marine Area (KMZ file provided by EDL/Primesouth)
A2	- Decree 6862 / 1995 Defining the Construction of Deir Ammar Power Plant Layout as Public Benefit and Expropriation of the Plots for the Benefit of EDL - Memorandum by the Government of Lebanon to Iraq Petroleum Company Declaring the Nationalization of their Assets and Land - Correspondence between EDL and MEW Requesting Information on the Claim against EDL - Demand Letter for Compensation for Diver Fatality - EDL Legal Department Opinion on Diver Fatality Demand Letter - EDL Reply to Demand Letter for Compensation for Diver Fatality
A3	- Power Plant & AGP Relevant Environmental Legislation and Standards - Power Plant Oil Water Separator Effluent Analysis by ELARD in 2019
A4	- Tripoli Oil Installations Correspondence on ROW Encroachment Status
A5	- Power Plant Detailed Technical Requirements - Civil Works - Power Plant Contractual Performance Guarantees Vol. 4 – Select Pages - Power Plant Contractual Performance Guarantees Vol. 6 – Select Pages
A6	- Power Plant 2021 Accident Reports List - Power Plant Monthly EHS Report - Power Plant Quarterly EHS Audit Report
A7	- Power Plant Organizational Chart (Nov-2021) showing Females in Red Font
A8	- Power Plant Chemical Management and Unloading Emergency Procedure - Power Plant Safety Procedures - Power Plant Safety Escape Plan
A9	- Power Plant Administrative Labor Procedure for Code of Conduct
A10	- Power Plant 4 to 10 October 2021 Operational, Maintenance, and Chemical Reports

	- Power Plant September 2021 Monthly Power and Efficiency Monitoring Report for Gas Turbine 1 (GT1) and Steam Turbine (ST) - Power Plant September 2021 Monthly Pump Efficiency Test Report
A11	- Power Plant - Sewage Treatment Plant (STP) Treatment System - Power Plant STP Effluent Analysis by IRI on 19 March 2019 - Power Plant STP Effluent Analysis by IRI on 24 Feb 2020
A12	- Power Plant Folder Including List of Chemicals Stored & Location and MSDS's - Power Plant Chemical Storage Room Photo 1 - Power Plant Chemical Storage Room Photo 2 - Power Plant Above Ground Storage Tanks for Diesel Over Concrete Platform - Power Plant Type of Hazard Identification for Stored Chemicals in May 2021 Quarterly Safety Report - Power Plant Oily Drainage Network
A13	- Power Plant Operation and Maintenance Procedures - Power Plant Training
A14	- Circular 8/2021 on risks to public from Coastal Facilities and Power Plants as well as Precautionary Measures to be taken by such Facilities - Power Plant 2018 Stack Emission Measurements - Power Plant Greenhouse Gas Emission Estimates by MoE/UNDP

TABLE A1. ENVIRONMENTAL AND SOCIAL REVIEW OF DEIR AMMAR POWER PLANT

On-Site Data Collection: 8 November 2021

Task	Applicability	Power Plant Availability / Feedback	Summary of Key Issues	Supporting Docs. Appendix
Document the historical background of the facility such as:				
• **Geographical location documented by historical Google maps**	✓	Layout and components + Google Earth historical images until oldest available in 2004 + Google Earth KMZ file showing boundary and offshore structures as provided by facility in **Appendix A1.**		Appendix A1
• **Routing**	×	NA[10]		
• **Start and end of construction dates**	✓	1995 – 1998		
• **Financing the construction and installations and main contractor(s)/suppliers involved**	✓	Financing by SAN PAOLO IMI (EX CREDIOP), COMMERZBANK, PARIBAS, FADES, and others 1995 – 1998: EPC by Ansaldo (Italian) and Siemens (German) 1998 – 2000: O&M by Ansaldo (Italian) 2000 – 2002 : O&M by ENEL (Italian) 2002 – Feb 2006: O&M by EDL[11] Lebanese Subcontractor PSM (Poor experience with contract model) Feb 2006 – Feb 2011: O&M by KEPCO (Korean) Feb 2011 – Feb 2016: O&M by YTL (Malaysian) Feb 2016 – Feb 2021: O&M by Primesouth (American) Feb 2021 – Feb 2022: O&M by Primesouth (American) Feb 2022 – Feb 2027: O&M contract renewal negotiations with Primesouth being undertaken		
• **Any legacy issues concerning environmental aspects, land ownership, social and community issues, etc.12**	✓	- Pending claim for land exploitation (99 year concession by IPC) and request for compensation for lost trees when Power Plant was built (Supporting documents in **Appendix A2** consist of 2 2018-2019 correspondence forms and data requests from EDL to MEW, with MEW responding that MEW does not have any documents / info concerning the claim and that CDR, as the PP project proponent, should be contacted for that matter (CDR and EDL were contacted but the original claim could not be obtained). - Public complaint with media coverage in 2018 regarding black oil slick observed at sea facing the PP; ELARD inspected the facility and noted that the event chronologically followed a tank cleaning event in addition to showing that the analyzed petroleum residue from the beach outfall from which most wastewater generated on-site except for cooling water exhibited the same chromatographic signature as the analyzed oil-water separator effluent. ELARD also proved by dye testing that the storwater drainage main outside the facility along the Tripol-Akkar Road flows into a culvert underneath the PP and reaches the same beach outflow. The Operator reported that tank cleaning is not drained to sea and is diverted to the oil-water separator that may have been overloaded resulting in poor treatment; EDL reported that pollution may have originated from outside the facility from the public stormwater given the culvert underneath the facility. - Public complaint with media coverage regarding an army member who drowned beginning of 2021 while spearfishing opposite the PP due to be pulled down by the flow of the cooling water inlet pipe. This area at sea is a restricted area albeit poorly delineated onshore at the time and lacking complete delineation with floating signage / buoys at sea. Operator has installed additional signs onshore and ordered a buoy to be placed at sea.	- Pending Claim against EDL for compensation for lost trees in PP area when PP was constructed in 1995 is following legal course. - Public complaint regarding petroleum spill at sea in 2018; this issue has had no legal or publicity follow-up. - Public complaint and demand letter for financial compensation (LBP 1 Billion) by family lawyer regarding army member who drowned while spearfishing opposite the facility, which was attributed to suction flow from the inlet pipe (**Appendix A2**). Case has not gone to court yet as communicated by EDL.	Appendix A2
• **Historical land use of the facility site and surroundings (supported by maps)**	✓	Initially owned by Iraqi Petroleum Company and Mediterranean Sea Pipeline Company Limited then nationalized by GoL[13] in 1973 and ownership transferred to EDL – MEW **(Appendix A2)**. Prior to construction of the Power Plant, the land comprised a golf court for LOI[14] from the 1950's until construction of the PP in 1995.		Appendix A2

[10] Not Applicable
[11] Electricite du Liban
[12] This may require consultations and interviews with surrounding communities and local NGOs.
[13] Government of Lebanon
[14] Lebanon Oil Installations

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
	Determine the conformity of the current environmental and social management system or procedures with the World Bank Environmental and Social Standards (ESS) by answering[15] the following indicative questionnaire to ensure that key aspects of each (ESS) of the ESF are assessed:							
ESS1	**ESS1: Assessment and management of Environmental and Social Risks and Impacts**							
	Permits Licenses, Management and Monitoring Systems							
ESS1-1	• **Do the facilities have a nationally approved Environmental and Social Impact Assessment study or Environmental Review?**	✓	- Existing Facility predates EIA decree 8633/2012 and so no EIA was conducted for Deir Ammar PP 1. According to Decree 539/2015, 8471/2012, and 5243/2001 the PP should have conducted by now an Environmental Audit for Environmental Compliance purposes by an MoE[16]-authorized third party environmental consultant; such an audit was not conducted yet. The WB has communicated that MoE requested an Environmental and Social Management Plan for the facility; such a plan will also require an environmental and social audit given that the facility is operational. - A preliminary EIA was conducted for the planned Deir Ammar PP2 which is adjacent to the current one. It is understood that Deir Ammar PP2, which will be very similar to Deir Ammar 1 as a process and capacity, will practically increase all emissions up to doubling them (load) depending on the plant performance. It is not understood yet whether the planned plant will use the same cooling water outfall or will build a new one to allow for better diffusion and mixing. - ELARD 2019 study results (**Appendix A3**) indicated certain exceedances of seawater discharge standards at the time **(Appendix A3)** suggesting that oil-water separator should preferably be further treated prior to discharge. The PP reported that oil-water separator discharges 2 tonnes/hr. approximately when the plant is operational at base load while the STP is designed to operate at 1.5 m³/hr. and 3 m³/hr. at average and peak capacity. The analysis of the oil-water separator suggests that given the STP design, BOD and COD values may theoretically be reduced to the national ELVs but this may be inhibited by phenols which will not be treated. Given the capacity of the existing STP and the treatment process it cannot be confirmed at this stage if the STP size and treatment process can be retrofitted to accommodate the oil-water separator effluent capacity and quality; however, given that the current project entails substitution of gasoil with natural gas as fuel, then the oil water separator will no longer be operational and no wastewater effluent will be generated from it.	Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG	Appendix A3
ESS1-2	• **Does the facility Operator have any international certification (such as ISO)?**	✓	No		Negligible	No action required	Prior to Operation on NG	
ESS1-3	• **Do the facilities have an environmental and social management manual including operational management procedures for key environmental, social, and health and safety aspects?**	✓	O&M manuals which includes a safety manual. Environment & Social aspects are not covered except indirectly when covered by Safety. Supporting documents obtained include: - O&M manual Outlines - Safety Manual Outline - Monthly HSE report examples - Quarterly H&S audit report examples. - HSE Accident / Incident Notification Form	Environmental and social aspects and potential adverse impacts are not explicitly managed.	Substantial	Environmental, OHS and Social aspect shall be covered in dedicated procedures covering environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. A GRM for employees and FGRM for the general public need to be developed with facilitated 2-way communication mechanisms.	Prior to Operation on NG	
ESS1-4	• **Do the facilities have environmental and social monitoring records with clear set of performance indicators?**	✓	No	Environmental and social aspects and potential adverse impacts are not explicitly managed.	Substantial	Environmental, OHS and Social aspect shall be covered in dedicated procedures covering environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. A GRM for employees and FGRM for the general public need to be developed with facilitated 2-way communication mechanisms.	Prior to Operation on NG	
ESS1-5	• **How often are internal reviews conducted on environmental, social and health & safety aspects? And do the facilities have an action tracker and review findings tracker?**	✓	Monthly Reports and Quarterly Audits on Health and Safety aspects with action tracker. No reviews of Environment and Social aspects or tracking.	Environmental and social aspects and potential adverse impacts are not explicitly managed.	Substantial	Environmental, OHS and Social aspect shall be covered in dedicated procedures covering environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. A GRM for employees and FGRM for the general public need to be developed with facilitated 2-way communication mechanisms.	Prior to Operation on NG	

[15] Avoid Yes/No answers and elaborate on the findings which address each question.
[16] Ministry of Environment

S/N	Task	Power Plant		Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs.
		Applic-ability	Availability / Feedback					Appendix
ESS1-6	• **Do the facilities have all the required (environmentally related and other) permits (such as: extraction of water or ground water, building, environmental, use of soil and construction permits, disposal of solid and hazardous wastes, traffic permits, civil defense, cooling of turbines using sea water...etc.)**	✓	- Permits were requested from EDL; however given that the PP was built in 1995 and that EDL HQ suffered loss of archives or their displacement in the 4th of August Port Explosion, such documents could not be provided during this review's timeline. - Obtained detailed design civil works and guaranteed performance documents **(Appendix A4**.		Negligible	No action required		Appendix A4
ESS1-7	• **Do the facilities have or need wastewater or storm water permits?**	✓	The PP does not require wastewater / storm water approval / permits during operation because such permits/approvals are required during construction phase and CDR would have obtained them given that they were the proponent at the time prior to operation; however, PP is not in compliance with effluent ELVs for discharge at sea (MoE Decision 8/1 of 2001 provided in **Appendix A3**) for at least oil-water separator (ELARD study in **Appendix A3** and Sewage Treatment Plant effluent analysis in **Appendix A11**. PP has following effluents, which are all discharged at sea: - Sanitary WWTP with a secondary treatment process described in **Appendix A11** (Primesouth indicated that effluent joins and mixes with cooling water effluent) - Chemical WWTP (Boiler blowdown and laboratory wastewater) - Demineralization Unit cleaning wastewater (during cleaning events; stored in pH until pH within acceptable range) - Desalination Brine - Cooling Water effluent sea discharge - Oil-water separator effluent (into stormwater draining to sea) - Storm water effluent from facility premises and from external main road public stormwater network both draining through culvert and pipe extending underneath facility and discharging in beach outfall; this beach outfall consists of a manmade concrete "cave" where the culvert pipe in addition to the oil-water separator drainage canal both discharge albeit separately. The effluents mix on the floor of the "cave" and exit toward seawater (pipes and connections inspected and proven by dye testing in previous 2019 study by ELARD). It is also worth noting that the gasoil tank farm containment area has an emergency drainage valve and pipe that can drain it directly into "the "cave" and sea (the normal drainage operation is toward the oil water separator).	Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea. Mixing zone shall be defined for cooling water discharge and monitored particularly for chlorine and temperature.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG	Appendix A3 and A11
ESS1-8	• **Determine the national applicable standards, limits and requirements for:** ○ **Air quality (ambient, stack, indoor)** ○ **Noise (ambient and indoor)** ○ **Waste (including hazardous and non-hazardous wastes) management (handling, storage, transportation and end disposal)** ○ **Effluents management (handling, storage, treatment and end discharges).** ○ **Chemicals and hazardous material management (transportation, handling and storage)**	✓ (effluent discharge limits to the sea to be checked)	Key environmental legislation regulating pertinent environmental aspects and emissions are summarized in **Appendix A3**. According to local legislation, most environmental aspects and emissions are either non-compliant or in need of improvement; however, as described in the relevant ESS portions in the rest of this table, corrective actions are easy to adopt because they rely on either procedures to be developed and implemented or on existing emission control equipment and processes that need to be operated more diligently (no new asset acquisition is required). It is worth noting that air emissions will likely become compliant upon switching from gasoil to natural gas and that the hazardous oily sludge from the oil-water separator, which treats the gasoil fuel and gasoil tank cleaning wastewater, would also be eliminated.	Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB	Prior to Operation on NG	Appendix A3
ESS1-9	• **Are the current operations being conducted in compliance with the facilities' permits?**	✓	- Current operations are not all in compliance with contractual operational requirements, which state that the facility must respect national laws. This is because the facility has emissions and operations that are not in compliance with environmental laws, most importantly air emissions, wastewater effluent discharge standards to sea, and hazardous waste management (refer to rest of documents where each of these non-compliances is described). EDL, as the owner of the facility, is not mandating the operator Primesouth to adhere to environmental standards because they are not the priority of EDL, which is concerned with operational efficiency and cost savings, especially since the country is undergoing an acute economic crisis. - Compliance with environmental emission standards requires a third party audit with measurements for the different types of emissions followed up by yearly audits and inspections by MoE or a third party consultant on behalf of MoE; it is also important that both EDL and the operator commit to compliance and allocate the necessary funds accordingly, which would not be expensive in the case of the PP operating on natural gas.	Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea. Compliance with environmental emission standards requires a third party audit with measurements for the different types of emissions followed up by yearly audits and inspections by MoE or a third party consultant on behalf of MoE; it is also important that both EDL and the operator commit to compliance and allocate the necessary funds accordingly, which would not be expensive in the case of the PP operating on natural gas.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MoE and WB.	Prior to Operation on NG	
ESS1-10	• **Verify that all major permits have been obtained and are in full force and effect, and identify what major permits have not obtained, if any, and comment from a technical perspective, on the likelihood that they may or may not be able to be obtained in a timely manner**	✓	Permits, which are mainly associated with the construction phase handled by CDR prior to handover to EDL, were attempted to be obtained but they could not be because CDR referred ELARD to EDL and EDL indicated that finding the hard copies may be difficult because they may have been lost during the Beirut Port Blast. Operational permits are not required according to CDR and EDL. Obtained detailed design civil works and guaranteed performance documents (**Appendix A5**)	Construction permits could not be obtained while operational permits are not applicable for the government owned power plant.	Negligible	No action required	Prior to Operation on NG	Appendix A5
ESS1-11	• **Does the facilities have building safety permit (earthquake, fire, etc.?)**	✓	- The power plant has safety requirements in its design based on international standards and is according to EDL in compliance with the national requirements prevalent at the time of construction. Construction permits could not be obtained for review because	- The power plant has safety requirements in its design based on international standards and is according to EDL in compliance with the	Substantial	The current Emergency Response and Preparedness Procedure shall account for the increased seismic	Prior to Operation on NG	Appendix A5

<table>
<tr><th>S/N</th><th>Task</th><th>Applic-ability</th><th>Power Plant
Availability / Feedback</th><th>Summary of Key Issues</th><th>Non-Compliance Risk (Low, Moderate, Substantial, High)</th><th>Corrective Actions</th><th>Timeline</th><th>Supporting Docs.
Appendix</th></tr>
<tr><td></td><td></td><td></td><td>EDL reported that the hard copies stored at EDL HQ in Beirut may have been lost during Beirut Port Blast.
- Obtained detailed design civil works (Appendix A5).
- While most applicable facility damage risks including fire are covered in the current Emergency Response and Preparedness Procedure, the risk of a major earthquake that exceeds the earthquake resistance parameters of the PP was not. A scientific research[17] had recommended in 2011 post PP construction that the seismic hazard for the coastal region of Lebanon be raised to account for at least 0.3g Peak Ground Acceleration. Tsunamis also occurred historically in Lebanon as a result of large seismic events.</td><td>national requirements prevalent at the time of construction. Construction permits could not be obtained for review because EDL reported that the hard copies stored at EDL HQ in Beirut may have been lost during Beirut Port Blast.
- While the risk of fire is covered in the current emergency response plan and while the risks of floods and severe weather conditions are not pertinent in the case of the PP, the risk of a major earthquake that exceeds the earthquake resistance parameters of the PP is real (a scientific research[17] had recommended in 2011 post PP construction that the seismic hazard for the coastal region of Lebanon be raised to account for at least 0.3g Peak Ground Acceleration). Tsunamis also occurred historically in Lebanon as a result of large seismic events.</td><td></td><td>hazard to the PP and associated Tsunami risk, and coordinate with external parties (e.g., civil defense, fire brigade, emergency services) as relevant to the safety of PP personnel, the general public, and the environment.</td><td></td><td></td></tr>
<tr><td>ESS1-12</td><td>• What are the relevant industry specific WBG EHS Guidelines Requirements that are applicable to the facilities? How far they are applied?</td><td>✓</td><td>Relevant specific industry WBG EHS Guidance (Thermal Plants) covers:
INDUSTRY SPECIFIC IMPACTS
• Environment
o Air Emissions
- Relevant emissions based on current gasoil operation are sulfur dioxide (SO_2), nitrogen oxides (NOX), particulate matter (PM), carbon monoxide (CO), heavy metals, and greenhouse gases, such as carbon dioxide (CO_2). Upon switching to Natural Gas, NOX will become the most relevant parameter to monitor (refer to table below).
- The PP has a NOx suppression process, which requires desalinated water but it is not being used and this is leading to non-compliant NOx emissions based on 2018 stack emissions test results. Upon switching to Natural Gas, NOx suppression is unlikely to achieve compliance (refer to table below).
- Manufacturer performance levels were requested from the PP and provided in Table below in addition to WB and National Standards + the 2018 stack test results for NOx while noting that based on EDL, equipment upgrades in 2012 should result in lower NOx levels:
<table>
<tr><th>Fuel Type</th><th>PP Performance Values NOx @ 15% O2 (without NOx Suppression)</th><th>PP Performance Values NOx @ 15% O2 (with NOx Suppression)</th><th>WB Standard NOx @ 15% O2</th><th>MoE Decision 8/1 ELV for Existing Facilities NOx @ 15% O2</th><th>2018 Stack Test NOx @ 15% O2</th></tr>
<tr><td>Natural Gas</td><td>52 mg/Nm^3</td><td></td><td>51 mg/Nm^3</td><td rowspan="2">364 mg/Nm3 (derived from 1,000 mg/Nm^3 @ 5% O2 assuming 11% moisture)</td><td></td></tr>
<tr><td>Gasoil</td><td>739 mg/Nm^3</td><td>150 mg/Nm^3</td><td>152 mg/Nm^3</td><td>656 mg/Nm^3</td></tr>
</table>
- Above table indicates that PP manufacturer performance limits are practically compliant for Natural Gas operation (NG) without NOx suppression (only 1mg/Nm^3 exceedance), which is the expected scenario upon switching to NG and only compliant for gasoil operation in the case of NOx suppression, which is not being operated at present at the PP, hence resulting in noncompliance of NOx emissions with both national and WB standards (refer to 2018 stack test in last column)
- The PP has a Continuous Emissions Monitoring System (CEMS) but it is only being occasionally used and not specifically for environmental monitoring and compliance but more for operational efficiency. Continuous / Indicative emission monitoring for key parameters as well as yearly stack emissions testing, which are required under WB Guidance are not accordingly being conducted.
- Particulate Matter is not available in CEMS and it is also not being monitored.
o Energy Efficiency and Greenhouse Gas Emissions</td><td>- Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and has non-compliances in terms of its emissions and effluent discharges to the sea.
- Environmental and social aspects and potential adverse impacts are not explicitly managed.
- Air emissions are not continuously monitored because the available CEMS is not being used for such a purpose and additional parameters not measured by CEMS (Particulate Matter) are not also being monitored.
- Sewage Treatment Plant testing needs to be comprehensive for all 8/1 standards but it showed compliance for BOD and TSS albeit with a slight exceedance for TSS (58 instead of 50 mg/l) – the recommendation is therefore to conduct comprehensive analysis first because the available data are insufficient for requiring improvements to the treatment process.
- For Oil-Water separator, its flow cannot be accommodated by the STP for further treatment and so the hope is that by switching to Natural Gas it won't be needed otherwise additional an additional treatment process after the oil-water separator will need to be installed prior to discharge.
- For cooling water effluent, discussions will take place with DAPP will be conducted to achieve lowering of residual chlorine in effluent prior to discharge without compromising cooling process (organism growth).
- A cooling water return flow mixing zone was never established and temperature of cooling water return flow is not being monitored.
- Due diligence on oily sludge transporters must be conducted to ensure they are properly licensed in accordance with Decree 999/1 of 2020.</td><td>Substantial</td><td>- Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MoE and WB.
- Environmental, OHS and Social aspect shall be covered in dedicated procedures covering environmental and social risks, KPIs, monitoring requirements, reporting, evaluation, and corrective measures. A GRM for employees and FGRM for the general public need to be developed with facilitated 2-way communication mechanisms.</td><td>Prior to Operation on NG</td><td>Appendix A11</td></tr>
</table>

17 Huijer, C., Harajli, M., and Sad, S. 2011. Upgrading the seismic hazard of Lebanon in light of the recent discovery of the offshore thrust fault system. *Lebanese Science Journal*, 12(2): 67-82.

S/N	Task	Applic -ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
			- Switching from gasoil to natural gas, which is efficiently being delivered through an existing pipeline to the power plant achieves the WB EHS Guidance objectives of switching to lower carbon based fuel that is efficiently delivered. - The Deir Ammar Combined Cycle Gas Turbine (CCGT) PP had an estimated average efficiency of 620 and 525 g CO_2/ kWh for 2018 and 2019 respectively based on gasoil, which would drop to 400 g CO_2/ kWh for natural gas; such figures are consistent with the target efficiencies recommended by WB EHS Guidance for such plants (396 g CO_2/ kWh for CCGT Plants). o Water Consumption and Aquatic Habitat Alteration - The 2 gas turbines at the PP are air cooled - The PP has a seawater intake system (33,915 m3/h) that provides seawater supply for Steam Turbine condenser and cooling of closed cooling water system. Seawater is delivered through off-shore intake structure with chlorination and 800m submerged water intake pipe of 2.5m diameter to the on-shore screening facilities. Seawater screening system is designed in two lines, each line consisting of a trash racks (coarse bar screen gap 80mm and fine bar screen of 25mm) and travelling band screen. It is not known at present if technologies to reduce impingement and entrainment of fish and shellfish were introduced. - The intake pipe has secondary inlets along its length but these were reported by the operator to have been closed after the drowning of an army member spearfishing opposite the PP (it is claimed that the diver was sucked in and got stuck to the suction inlets). o Effluents PP has following effluents, which are all discharged at sea: - Sanitary Wastewater Treatment Plant (WWTP) effluent: WWTP has a secondary treatment process described in **Appendix A11** while Operator indicated that effluent mixes with cooling water effluent. Laboratory analysis of treated effluent provided by the operator showed compliance with Decision 8/1 ELVs (Table 3-7) albeit for only 2 parameters analyzed (BOD and TSS); BOD=26 and 18 mg/l and TSS = 58 and 28 mg/l for 2019 and 2020 resp. TSS for 2019 is however slightly higher than WB surface (not sea) water discharge standard of 50 mg/l (Table 3-12). - Chemical WWTP effluent: Operator indicated that WWTP treats boiler blowdown and laboratory wastewater; plant description document obtained indicates that boiler blowdown wastewater and brine from desalination plant both join cooling water effluent. - Demineralization Unit cleaning wastewater during cleaning events: stored in pit until pH becomes within acceptable range prior to discharge back to sea. - Desalination Brine: mixes with cooling water return flow - Cooling Water effluent sea discharge Cooling water return flow is discharged back to sea from outlets located at the shore and protected by a breakwater structure. A mixing zone was never defined for cooling water discharge and its water temperature is not being monitored while MoE Decision 8/1 specifies 35°C as the ELV of any effluent discharged at sea (Table 3-7) and WB Guidelines specify a temperature differential of less than 3°C at edge of mixing zone (Refer to Annex C > General EHS Guidelines > Wastewater from Utilities Operations; p. 28) . Chlorine (currently measured at 0.4 mg/l) should be less than 1 mg/l in national guidelines (Table 3-7) and less than 0.2 mg/l in WB Guidelines (Table 3-16). - Oil-water separator effluent discharges into stormwater draining to sea - wastewater from the oil-water separator is not being measured the correct way and it is non-compliant with national into sea (Table 3-7) and WB discharge standards (Table 3-16) based on a 2019 analysis conducted by ELARD; measured values were as follows relative to ELVs shown in parentheses: BOD=225 mg/l (MoE: 25), COD=955 mg/l (MoE: 125), TOC=200 mg/l (MoE: 75), Oil and Grease = 50 mg/l (MoE: 30 & WB: 10), TPH = 82 mg/l (MoE: 20) and Phenol index=1.5 mg/l (MoE: 0.3. It should be noted that use of the oil water separator is expected to be discontinued upon switching fully to natural gas. - Storm water effluent from facility premises and from external main road public stormwater network both draining through culvert and pipe extending underneath facility and discharging in beach outfall; this beach outfall consists of a manmade concrete "cave" where the culvert pipe in addition to the oil-water separator drainage canal both discharge albeit separately. The effluents mix on the floor of the "cave" and flow into the sea (pipes and connections inspected and proven by dye testing in previous 2019 study by ELARD). It is also worth noting that the gasoil tank farm containment area has an emergency drainage valve and pipe that can drain it directly into "the "cave" and sea (the normal drainage operation is toward the oil water separator). o Solid Wastes					

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
			- Combustion turbines generate little to no solid waste. - Please refer to ESS3-6 to avoid duplication of results o Hazardous Materials and Oil - Please refer to ESS3-5 to avoid duplication of results. - Storage and transportation of hazardous material and waste unlikely to be compliant with local (and WB standards) particularly hazardous waste Decisions 998/1 and 999/1 of 2020; the PP needs to have the necessary paperwork and approvals from MoE and the oily sludge, which is being stored in an outdoor pit is being transported by what the consultant suspects to be a regular sanitary sewage collection truck based on feedback obtained from EDL and Primesouth. o Noise While noise monitoring inside the plant is regularly being conducted, noise and vibration monitoring / measurements outside the facility particularly at the location of neighboring sensitive receptors (e.g., School) to advise on compliance are needed. • OHS: OHS procedures mostly available, some gaps in enforcement observed, external audit recommended for improvement in addition to industry benchmarking, which is currently lacking in the reporting (Refer to ESS2). • Community Health and Safety (Refer to ESS-4 for more specific details on Community Health and Safety): o Not a systematic consideration (except indirectly through an emergency management procedure; hence no compliance with WB standards o No clear procedure regarding traffic outside facility, namely transportation of fuel in tanker trucks to the facility, and transportation of hazardous waste (i.e., oily sludge) by an external contractor from the facility seemingly inconsistently with guidance (unclear if contractor is certified from MoE as hazardous waste transporter) although those are being tracked using material transfer forms					
ESS1-13	• **Do the facility operators have an environmental and social department/unit/officer(s) who is/are responsible for ensuring environmental compliance?**	✓	There is an HSE Manager but only health and safety aspects are covered	Environmental and social aspect compliance and improvement responsibilities are lacking from HSE Manager responsibilities.	Substantial	Environmental and social aspect compliance and improvement responsibilities shall be added to HSE Manager responsibilities in addition to developing and implementing a training so that HSE manager can deliver on these responsibilities. Alternative would be to hire a dedicated environmental manager. An external consultant shall be contracted to ensure E&S compliance and provide training to the HSE manager and develop the needed E&S procedures including roles and responsibilities.	Prior to Operation on NG	
ESS1-14	• **Does the person in charge for environmental affairs have sufficient capacity to perform his/her duties?**	✓	HSE Manager is a safety engineer with no relevant training or background in environmental affairs	HSE Manager is a safety engineer with no relevant training or background in environmental affairs	Substantial	Environmental and social aspect compliance and improvement responsibilities shall be added to HSE Manager responsibilities in addition to developing and implementing a training so that HSE manager can deliver on these responsibilities. Alternative would be to hire a dedicated environmental manager. An external consultant shall be contracted to ensure E&S compliance and provide training to the HSE manager and develop the needed E&S procedures including roles and responsibilities.	Prior to Operation on NG	
ESS1-15	• **Are the environmental and social roles and responsibilities clear? Are they documented?**	✓	Environmental and social roles and responsibilities do not exist for facility	Roles and Responsibilities procedure covering environmental and social aspects is lacking.	Substantial	Environmental and social aspect compliance and improvement responsibilities shall be added to HSE Manager responsibilities in addition to developing and implementing a training so that HSE manager can deliver on these responsibilities. Alternative would be to hire a dedicated environmental manager. An external consultant shall be contracted to ensure E&S compliance and provide training to the HSE manager and develop the	Prior to Operation on NG	

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
						needed E&S procedures including roles and responsibilities.		
ESS1-16	• **Is there any environmental & social reporting requirement? To who? sample**	✓	- No E&S reporting, only monthly and quarterly Health and Safety Reporting **(Appendix A6)**. - Internal and EDL Reporting. - Samples of Monthly and Quarterly reports+ 2021 Accidents Reports obtained (**Appendix A6**).	No reporting on environmental and social aspects is occurring.	Substantial	Standardized and regular reporting on environmental and social aspects shall be created and added to monthly reports and quarterly audit reports.	Prior to Operation on NG	Appendix A6
ESS2	**ESS2: Labor and Working Conditions**							
ESS2-1	**1) Clarify the number and type of workers engaged for the facilities (such as civil servants, contractors/subcontractors, community workers, primary suppliers).** **2) Identify potentially vulnerable groups of workers (such as female workers, migrant workers and informal workers)** **3) Assess the working conditions of workers** i. Is there any rotation of personnel among the various operations in the facilities to reduce potential impact on health from repetitive actions? ii. Assess risks related to labor influx (if any)	✓	**1)** Workforce can be described as follows: o Organization chart **(Appendix A7)** provided indicates 110 staff members out of which 10 are female members including 1 female nurse + 1 male contracted doctor (3 h/day part-time). o Staff members include 4 expats as follows: - Superintendent: male from Ireland - Maintenance Head: male from Iran - Operation Head: male from Egypt - Safety Engineer: male from Philippines. o There are no vulnerable groups. o Staff members are all full-time and include daytime and shift based staff. o A security team of 11 full-time Lebanese are responsible for controlling access to the facility premises based on 2 daily shifts of 12 hours providing 24/7 presence. o There is no labor camp onsite except portcabins installed at the level and adjacent to the main Tripoli-Akkar road, which accommodate between 40 and 70 additional staff (Subcontractors for Operator) brought in during occasional overhaul events for periods of few months such as during July-September 2021 for Major Outage of Gas Turbine 1. o A portion of the current staff (16) are provided by a labor supplier called BCC who has been historically providing staff to different EDL projects including for this PP from start of operation in 1998; Primesouth has accordingly used BCC services when they were contracted and currently have 16 staff members still mapped to BCC although they must adhere to Primesouth operational procedures. o According to EDL and Primesouth, all staff members are above 18 with employment contracts in accordance with local legislation; their records can be obtained from administration where a dedicated employee for social security (Mr. Hamed al Salti) can confirm that all employees are conformably registered in the National Social Security Fund or have legal contracts (for sub-contractors). There is no risk of child labor especially since there is also another layer of oversight by EDL o The operator indicated that subcontractors to the facility consist of landscaping company, facility doctor, and marine unloading company **2)** Vulnerable Groups: EDL and the Operator indicated that there were no vulnerable groups and that all staff were hired in accordance with labor law and are registered in the National Social Security Fund. **3)** Working conditions: o Working conditions are acceptable with a noteworthy amenity to staff, which is the cafeteria that provides low cost subsidized food and healthy cooking for PP staff; all staff pay LBP 5,000 for a full meal, which is worth $0.18. o During the interview of representatives of union workers at the facility, Mr. Mohamad el Kheir – Substation Operator and Union President and Ms. Rania Issa - Operation Department Assistant) reported having a good relationship with Operator.	No key issues	Negligible	No action required		Appendix A7
ESS2-2	• **Assess Occupational, Health and Safety (OHS) [18], and COVID19 contagion**	✓	OHS procedures are in place including one for COVID19. Please refer to the remainder of ESS2 for identified non-compliances in addition to Table A2.	Covered in other ESS2 Tasks	Covered in other ESS2 Tasks	Covered in other ESS2 Tasks	Covered in other ESS2 Tasks	
ESS2-3	**Are the following risks being addressed?[19]** • **Crushing, cutting, severing, trapping, entanglement, falling** • **Rotating parts failure** • **Casing failure** • **Contact with live electrical parts** • **Electrostatic, electromagnetic, lightning** • **Thermal radiation, hot & cold burns** • **Asphyxiation**	✓	Generally yes (Safety Procedures and Chemical Hazard Assessment and Handling Procedure in **Appendix A8**)	No key issues	Negligible	No action required		Appendix A8

[18] See Table 2 for list of significant hazards and preventative measures
[19] See Table 3 on Hazard Identification for Gas Turbines

S/N	Task	Power Plant			Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs.
		Applic-ability	Availability / Feedback	Summary of Key Issues				Appendix
	• **Poor ergonomics** • **Vibration, metal fatigue** • **Fire Explosion** • **Control system failures** • **Power supply failure** • **Gravity, seismic, wind effects**							
ESS2-4	**1) Assess the track record of labor management, including worker-related serious incidents accidents.** **2) Assess the management of such risks at the location level, including whether a system is in place and functions to address risks related to Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH), including Gender-Based Violence (GBV) in line with the national legislations, and the World Bank's Good Practice Note on SEA/SH.** **3) Specify the minimum age for workers. Do the facilities have a staff and workers register, any means for verification of age to prevent child labor?** **4) Is there any risks of forced labor? If so, what is the mitigation in place?** **5) Is there any code of conduct or charter of ethics for the laborers to sign?** **6) Is there any accommodation of workers on site? What is its status** **7) Is there a grievance mechanism available for all laborers and personnel? Is there any log that can be consulted?** **8) Are the laborers of the facilities members of any association of laborers**	✓	1) According to October 2021 HSE monthly report (**Appendix A6**), 5 first aid incidents had occurred by end of September 2021 for the year with a total cumulative accident frequency rate of 0.24 and incidence rate of 0.60. Incident report forms include corrective actions. 1) Operator has a code of conduct policy (**Appendix A9**) that includes equal employment opportunity and pay as well as a specific article for anti-harassment that refers staff to the Assistant General Manager in such cases. The plant superintendent who effectively holds the role of AGM at the facility indicated that he has an open door policy and that anyone can reach out in case of distress. There is however no specialized and competent personnel to specifically manage SEA/SH and GBV probably because it is not a legal requirement. 2) According to EDL and Primesouth, all staff members are above 18 with employment contracts in accordance with local legislation; their records can be obtained from administration where a dedicated employee for social security can confirm that all employees are conformably registered in the National Social Security Fund or have legal contracts (for sub-contractors). There is no risk of child labor especially since there is also another layer of oversight by EDL – the governmental organization for power provision present at the facility and to whom the Operator must seek approval for hiring staff as per O&M contract. 3) There is no risk of forced labor for the same reasons mentioned for child labor. 4) There is a code of conduct that states that all employees must abide by it; employees are not asked to sign it as approval. 5) There are portcabins for temporary subcontractor staff brought in for overhaul events only – facility staff do not have accommodation on site. 6) There is no grievance mechanism in place except for referring to union committee members, who are mostly concerned with negotiating better employment terms and compensation for employees. There is no log for grievances. Interview of representatives of union workers at the facility suggest a good relationship with Operator. 7) Facility staff can optionally join the union of laborers for the facility who are represented by an elected committee of 6 facility staff members in accordance with national law.	There is no GRM for staff and no associated records apart from the code of conduct warning against discrimination and harassment and referring staff to the Assistant General Manager in such cases.	Moderate	A GRM including logs and explicit measures covering SEA/SH shall be added, and roles and responsibilities shall be assigned to competent staff with training provided.	Prior to Operation on NG	Appendix A6 and A9
ESS2-5	• **Are there any emergency preparedness plans?**	✓	Yes (**Appendix A8**). Fire drills are conducted at least twice a year and all staff participate in them as communicated by EDL (Last drill occurred in March 2021).	Emergency preparedness plans do not cover environmental risks except indirectly through safety.	Substantial	Pertinent environmental risks shall be identified following an environmental audit (refer to ESS1-1) and emergency preparedness and response plans shall be updated as needed.	Prior to Operation on NG	Appendix A8
ESS2-6	• **Is there any safety escape plan at the facilities?**	✓	Yes **(Appendix A8).** Ensuring compliance of staff and subcontractors including temporary workers to safety measures and plans is the responsibility of the safety engineer according to the safety procedure while heads of department heads are responsible for disseminating information to staff and contractors. However, there is no safety induction for visitors indicating to them safety exits and location of assembly point in case of an emergency.	There was no safety induction provided to visitors.	Moderate	A standard safety induction shall be created and provided to all non-regular visitors.	Prior to Operation on NG	Appendix A8
ESS3	**ESS3 (Resource Efficiency and Pollution Prevention and Management)**							
ESS3-1	***Energy Efficiency*** • **Does the facility have a record of total energy consumption including the different types of energy sources?** • **Dose the facility have an energy manager?** • **Does the facility have an energy management system? Does it have an energy saving opportunity register? Does it have energy reduction targets and action plan?**	✓	The facility, which is a power plant, is contractually mandated to maintain specified efficiency levels or is penalized by EDL. The facility is mandated to carry out reference performance tests in accordance with ASME PTC 4.4; 6.2; 22; and 46. The following performance aspects are identified and financial penalties are allocated for them: Power, Efficiency/Fuel Consumption, Retest, and Auxiliary Power Consumption. There are monthly efficiency tests and reports (**Appendix A10**).	No key issues	Negligible	No action required		Appendix 10
ESS3-2	***Water Efficiency*** **1) Is water use/water discharged being monitored?** **2) Are water consumption trends being recorded and analyzed? And does the**	✓	1) Water supply to facility is exclusively from desalinated seawater for different uses with further treatment as needed. Water is accordingly pumped to maintain design flow and system is accordingly inspected for leakages and losses. Water losses translate into financial losses because of associated desalination and treatment costs whereby facility has an inherent interest in maintaining such water losses to a minimum. There	Upon switching to gas, the desalination plant capacity may become underused and the spare capacity (> 90 m^3/hr.) shall be evaluated by MEW for potentially relieving water shortage in the coastal area of Mineh-Danniyeh as a last resort.	Negligible	No action required except for assessing the potential use of spare desalination capacity for relieving water shortage for neighboring communities, which should only be a		Appendix A10

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
	power plant have a quantified water consumption baseline? **3) Are water leaks being fixed regularly by the maintenance team?**		are monthly efficiency tests (**Appendix A10**). In fact, to reduce gas oil consumption and increase efficiency, NOx suppression, which is needed to control NOx emissions whenever gas oil is being used as fuel as it is the current case, is turned off at present because of the considerable desalinated water flow it requires; hence, the current once-per-week operation of desalination plant is equivalent to only about 5 m^3/hr. on average instead of the needed 100 m^3/hr. at least during summer. Upon switching to natural gas, NOx water suppression would not be needed; this presents an opportunity to be explored for potentially using the desalinated plant spare capacity to relieve domestic water supply shortage to local communities in coastal region of Minieh-Danniyeh Caza where PP is located (shortage of about 20,000 m^3/day). 2) Water consumption efficiency is tracked for operational efficiency purposes as shown in **Appendix A10**. 3) Water leaks are reportedly being fixed soon after they are detected. Irrigation hydrants and pipes are reportedly inspected on almost daily basis for leaks.	This should occur in the future after current demand mismanagement and Unaccounted For Water, have been resolved first and the potential for sustainably conveying water from adjacent water basins or mountainous regions with a positive water balance has been assessed. Increased seawater desalination has adverse impacts on the marine environment and should be a last resort. Increased desalination will also consume power that should be accounted for along with its potential impacts.		last resort after reducing unaccounted for water percentage to below 30% and options for sustainably diverting freshwater for mountainous areas with a positive water balance (consistently with a regional water supply strategy and phased plan over at least 15 years in the future) have been exhausted.		
ESS3-3	*Raw material use* **1) Are raw materials quantities recorded?** ***2)*** **Is there a procurement procedure in place which assign weight and/or give preference to raw materials with less environmental impacts? And/or place environmental restrictions on certain materials?**	✓	1) Raw material quantities are recorded. Primesouth relies on "COSWIN" (by SIVECO) as a plant maintenance software to also manage their inventory and automatically trigger procurement orders once set thresholds are reached. 2) No preference to raw material with less environmental impacts; abiding by design and contractual requirements is the governing guidance.	No key issues	Negligible	No action required		
ESS3-4	*Wastewater Management* **1) What are the parameters being monitored? And what are the key performance indicators (legal or other requirements)?** **2) What is the monitoring frequency? And are the correct monitoring and sampling analysis methods being used at the right frequency?** **3) In case of exceeding permissible limits, is investigation being performed?** ***4)*** **Where applicable, is cooling water discharge being monitored? As well as ambient water quality of affected areas?**	✓	1) Effluent / Parameter monitored o Desalination Brine / No Monitoring o Demineralization Unit wastewater effluent from cleaning events / monitoring of pH to become within allowed range (6.5-8.5) o Chemical WWTP effluent (Boiler and lab wastewater) / monitoring of pH (6.5-8.5), Fe (<5), and TSS (< 40 ppm) / analyzed once per week when operational o Cooling Water effluent sea discharge / Only free chlorine daily monitoring at condenser outlet (< 0.5 mg/l) o Oil-water separator effluent / monitoring of pH (6.5-8.5), Oil (free product thickness in 100 ml tube column measured visually and based on which concentration is derived and checked against national 30 mg/l Oil and Grease ELV) / analyzed once per week o Sewage Treatment plant effluent / One sample per year reported (2 analyses provided in **Appendix A11** – Only BOD and TSS were analyzed and compared to ELVs for national discharge at sea standards (BOD of 30 and TSS of 50 mg/l) o Facility storm water drainage effluent / No monitoring 2) Monitoring is insufficient because: o All effluents or combined effluents must be compared with national seawater discharge standards o STP effluent is not being monitored for all nationally required parameters o Oil-water separator effluent is not compliant with local discharge standards (**Appendix A3**) and the visual observation of free oil product in a glass tube is not the correct testing method because it does not allow for comparison with local discharge standards o There is no mixing zone for cooling water return flow delineated, no water quality limits at edge of mixing zone, and no monitoring for key parameters within receiving water body, most importantly temperature	Wastewater effluent discharges from the PP are not adequately monitored to ensure and/or prove compliance with local discharge standards.	Substantial	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG	Appendix A11 and A3
ESS3-5	*Spill control and management* **1) What are the current methods of controlling oil spills not only from storage tanks and pipelines, but from tank truck loading and unloading operations?** **2) How many and what kind of spills have occurred and are there records to document satisfactory remediation?** ***3)*** **Safety of storage of hazardous materials**	✓	1) Tank farm comprises fuel tanks inside bunds; smaller diesel tanks are not bunded but located on concrete pavement (**Appendix A12**). Unloading station is bounded by drainage canals from both sides whereby any spills on paved ground would drain into canal leading back eventually to oil-water separator (refer to Plant Oily Drainage System in **Appendix A12**). 2) No spills reported except oily matter reported in seawater at end of 2018 reported by local community and which ELARD inspected and suspected to be related to tank cleaning wastewater that was not treated in oil water separator prior to discharge into seawater (refer to Oil-Water-Effluent Analysis in **Appendix A3**) 3) Storage of hazardous material includes the following: o Hazardous raw materials consisting of process chemical are mostly stored in a room on wooden pallets without any containment preventing mixing in case of spill /leak (of liquids) of different chemicals (**Appendix A12**), which given a quick look at the list of chemicals stored together and some of the MSDS' suggests potentially incompatible storage conditions despite seemingly good ventilation (requires detailed reading of all MSDS' and ensuring compliance with storage requirements and elimination of incompatible chemical neighbors or containment); A safety audit list of chemicals was provided (from 2021 Q1 Safety Audit) but incompatibility with other chemicals was not indicated (**Appendix A12**). Labelling for the different storage zones is inadequate because it consisted of quite recently printed labels on A4 sheets that are not laminated and those will likely fall off in a short period of time. Furthermore, one IBC with hydrochloric acid label on it and fairly corroded base as	Hazardous liquid chemicals are not contained and the storage of hazardous chemicals has not accounted for incompatible chemical neighbors.	Substantial	The safety audits shall account for incompatible chemical neighbors and all liquid receptacles shall be contained.	Prior to Operation on NG	Appendix A12 and A3

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			well as inappropriately stacked cardboard boxes on top was observed in Demineralization Building. Refer to Chemicals List and MSDS in **Appendix A12**. ○ Hazardous petroleum / oily sludge from oil water separator stored in open tank until it becomes full after which it is emptied in IBCs or barrels and transported to be eventually consumed as HFO at Jiyeh Power Plant (not managed by Primesouth)					
ESS3-6	*Waste Management* **1) Are there any waste prevention and/or minimization measures?** **2) What are the current methods of waste disposal?** **3) What offsite facilities have been used for waste disposal?** **4) Are the offsite facilities recognized as "formal" or legally accepted site?** **5) Do the facilities identify and separate hazardous wastes from domestic wastes?** **6) How are the hazardous wastes treated?**	✓	1) No waste prevention 2-6) Two waste streams were reported ○ Municipal waste that includes empty containers and bags of hazardous chemicals; some of the plastic containers were reportedly occasionally taken by facility staff because their need them for personal use while the safety of empty containers and bags still needs to be established in light of their MSDS. A private contractor called Bassem Eid known to the local municipality collects the waste daily from PP and likely conducts sorting at his own land after which dumping and landfilling likely occurs; it is not clear at this stage whether this contractor and his solid waste collection and management process is approved by MoE and licensed on the one hand or if it provides safe working conditions on the other. ○ Hazardous waste consisting of petroleum sludge from oil-water separator. This used to be exported in accordance with Basel Convention outside country but has been lately sent to Zahrani PP where it is added to Zahrani's sludge then sent to Jiyyeh PP to be burnt as HFO for power generation – if confirmed, the burning at Jiyyeh PP must have highly performing air emissions filters to bring those into compliance with local 8/1 decree standards. Primesouth manages Zahrani PP but not Jiyyeh PP.	Municipal solid waste is not being sorted and the contractor collecting the waste may be improperly disposing of waste through unsafe dumping and unsafe handling by vulnerable individuals. Hazardous oily sludge from the oil-water separator burnt as HFO at Jiyeh Power Plant may be incompatible with the incineration process resulting in non-compliant emissions.	Substantial	Develop a solid waste management plan for the facility.	Prior to Operation on NG	
ESS3-7	*Operational and Maintenance Program* ***1)*** **The O&M program of the facilities, including routine and preventative maintenance, review and opine on O&M costs;** **2) Staffing, training program, labor management, key staff qualifications, capability and experience including international exposure/capabilities and track record;** **3) Spare parts inventory and availability/risk of shortage.** ***4)*** **Expected major maintenance requirements**	✓	1) Primesouth has a functional O&M management system that is reportedly delivering on efficiency targets and design parameter ranges (Refer to **Appendix A13**) 2) Training is being provided as reported in correspondence between Primesouth and Client-EDL on training obligations as per contract (refer to **Appendix A13**) 3) Primesouth relies on "COSWIN" as a plant maintenance software (provider is SIVECO) to also manage their inventory and automatically trigger procurement notifications once set thresholds are reached. Maintenance requirements are indicated in the O&M procedure booklet (refer to **Appendix A13**)	No key issues	Negligi ble	No action required		Appendix A13
ESS3-8	*Violations, fines, and complaints* **1) Are there any outstanding violations or pending fines or penalties on the facilities? (Such as air emissions, noise, disposal of wastewater, disposal of wastes, etc.)** **2) Do the facilities have a history of violations or penalties?** **3) Has the facility faced any court cases either through governmental or non-governmental stakeholders?** **4) Has the facility received any formal or informal, verbal or documented complains from the nearby communities?** ***5)*** **Does the facilities maintain and regularly update an environmental register?**	✓	1) Refer to A**ppendix A14** for stakeholder responses; in summary: ○ Ministry of Labor has indicated that its Inspection Department for Labor, Prevention, and Safety has no records of complaints against the Power Plant or the gas pipeline ○ Ministry of Environment has not yet responded (to be added in Appendix A14) ○ Other regional and local authorities could not provide any records of claims despite Beddawi municipality stating that there was one against EDL for facility emissions while EDL denied any complaints **2)** Based on currently available information there are no pollution related court cases against the facility 3) None 4) A school contacted nearby at a distance less than 500 m from the PP during this E&S Review has indicated concern regarding vibrations whenever the plant is operational, which should be confirmed through noise and vibration monitoring. **5)** No	Ministry of environment is yet to answer on any violations or complaints recorded against the PP. Nearby school that was identified as a potentially affected party and contacted because it is located not far from the PP has reported having concerns from vibrations caused by the operation of the PP.	**Moderate**		Prior to Operation on NG	Appendix A14
ESS3-9	**1) Air pollution and greenhouse Gases** **2) Does the facility have a continuous emissions control system (CEMS) or an alternative air emissions control system? In case of CEMS, what is the target reliability?** **3) Is there an annual stack testing? Data verification and reporting? And exceedance investigation?** **4) How often is air emissions sampling being conducted?** **5) How often is exceedance investigation conducted? What is the reliability %** **6) Is there a meteorological monitoring?**	✓	**1-5)** The facility has a CEMS but it is only occasionally turned on whenever data is requested for reporting purposes – it is not therefore being used for environmental monitoring. Stack emissions testing with portable equipment was conducted once end of 2018 (**Appendix A14**) after boilers were rehabilitated; based on those stack measurements from 2018, emissions are not compliant with MoE Decision 8/1 air emission standards for NOx while additional important pollutants such as PM were not measured (Power Plants > 50 MW). The PP is currently not operating its NOx suppression equipment because it requires considerable fresh water, which will therefore increase its gas oil consumption; this is further evidenced by current small quantity of desalinated water relative to desalination plant capacity. When the facility will operate based on natural gas, there would not be a need for NOx suppression given manufacturer performance limits (refer to ESS1-12) and emissions should become compliant if remaining operations are. 6) No	The available CEMS at the facility is not be operated except for taking discrete measurements. In a 2018 stack test following rehabilitation works, NOx measurements showed noncompliance with MoE Decision 8/1 ELVs.	Substantial	The CEMS shall be operated continuously (or at least one operational day per week) for measurements and compliance; calibration shall occur as per manufacturer guidance. In addition, one yearly stack emissions test by an independent third party shall be conducted.	Prior to Operation on NG	
ESS3-10	**1) Does the facilities have a record of greenhouse gases associated with fuel usage and other different activities? Does the record show the different**	✓	The PP does not have a record of GHGs from the plant; however, EDL has been providing data to MoE and UNDP allowing GHGs to be estimated for the PP (**Appendix A14**)	No key issues	Negligible	No action required		

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
	scopes (i.e., scope 1; scope 2; and scope 3)[20]							
ESS3-11	• **Does the facility have ambient air quality monitoring stations? How often are they serviced and calibrated**	✓	Not at present.	No key issues	Negligible	No action required		
ESS3-12	• **What are the air emissions monitoring parameters and key performance indicators?**	✓	No air emission monitoring. Stack emissions testing was conducted once end of 2018 after boilers were rehabilitated while CEMS is off most of the time.	The available CEMS at the facility is not be operated except for taking discrete measurements. In a 2018 stack test following rehabilitation works, NOx measurements showed noncompliance with MoE Decision 8/1 ELVs.	Substantial	The CEMS shall be operated continuously (or at least one operational day per week) for measurements and compliance; calibration shall occur as per manufacturer guidance. In addition, one yearly stack emissions test by an independent third party shall be conducted.	Prior to Operation on NG	
ESS4	**ESS4 (Community health and Safety)**							
ESS4-1	**1) Health issues due to air pollution from the facilities** **2) Safety distance respected?** **3) COVID19 safety measures implemented** **4) Security Personnel present on site and codes of conduct**	✓	1) No studies on health issues associated with Power Plant. Information from MoE requested and pending. 2) This is an existing power plant with security barrier whereby all project rehabilitation activities will be conducted inside facility premises. An army member who was spearfishing opposite the facility lost his life facility on 19 September 2020 because it is claimed by the community and the family lawyer that he was sucked by the cooling water intake pipe. The family lawyer has requested compensation from EDL (LBP 1 Billion) through a demand letter and the latter referred him to the operator (Primesouth) who in their opinion should be addressed for such a claim **(Appendix A2)**. In parallel, a recent circular was issued by the Ministry of Public Works and Transport (after the diver's death) warning the general public from venturing at sea opposite to facilities such as power plants and others **(Appendix A14)**. The same circular mandates that power plants with intake pipes place buoys and delineate the pipe extension and/or restricted marine area. The PP indicated that they have ordered a buoy to be placed at the suction point of the the intake pipe end while lateral intake openings were closed following the diver's death. **3)** COVID19 measures are being implemented for staff and visitors **4)** A security team of 11 Lebanese are responsible for controlling access to the facility premises based on 2 shifts of 12 hours providing 24/7 presence, for which a barrier exists. Interaction with community is limited mostly to unlawful trespassers, which would be arrested and delivered to the authorities. There is no dedicated code of conduct for security personnel.	An army member who was spearfishing opposite the facility lost his life because it is claimed by the community and the family lawyer that he was sucked by the cooling water intake pipe. The family lawyer has requested compensation from EDL (LBP 1 Billion) through a demand letter and the latter referred him to the operator (Primesouth) who in their opinion should be addressed for such a claim **(Appendix A2)**. In parallel, a recent circular was issued by the Ministry of Public Works and Transport (after the diver's death) warning the general public from venturing at sea opposite to facilities such as power plants and others (Appendix A14). The same circular mandates that power plants with intake pipes place buoys and delineate the pipe extension and/or restricted marine area. The PP indicated that they have ordered a buoy to be placed at the suction point of the intake pipe end while lateral intake openings were closed following the diver's death. A code of conduct specific to security personnel was not observed.	Moderate	The restricted area of the intake pipe and/or the intake pipe extension at sea shall be delineated with visible buoys. Code of conduct for security personnel must be explicitly defined, they should sign off on it, and they should be trained on the proper response in case of interaction with the community. This will be part of an LMP recommended for the facility.	Prior to Operation on NG	Appendix A2 Appendix A14
ESS4-2	**1) Noise reducing or elimination devices** **2) Lockable gates, security cameras, security alarms** **3) Site visitor register and restriction of public access,**	✓	1) Noise reducing measures are reported by EDL to be as per design (Appendix A1). Al Rawda school, which is 300 m away approximately reported feeling vibrations associated with plant 2) Lockable gates, CCTV, and automatic and manual fire extinguishers in specific areas are available. 3) Access to premises is controlled with register and no public access unless authorized.	Compliance of noise and vibrations at nearby receptors including Al Rawda School need to be measured for compliance.	Moderate	Compliance of noise and vibrations at nearby receptors including Al Rawda School shall be measured for compliance as part of the ESMP development phase.	Prior to Operation on NG	
ESS4-3	• **Assess the effectiveness of the operation Feedback and Grievance Redress Mechanism (FGRM) in terms of its accessibility, credibility, effectiveness in resolving grievances, resourcing, etc. Specific attention needs to be paid to the assessment of FGRM for SEA/SH and focus will be on understanding whether the system is functioning, and protocols and practices established are in line with the World Bank's Good Practice Note on SEA/SH**	✓	There is no FGRM for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.	There is no FGRM for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.	Substantial	An FGRM shall be created and implemented to facilitate feedback, claims, and complaints from the general public; it will be widely disseminated with information on the resolution timelines, responsible persons, and option for appeals. Referral pathways for SEA/SH shall be established and communicated.	Prior to Operation on NG	
ESS5	**(Land Acquisition, restrictions on Land use and Involuntary resettlement)**							
ESS5-1	• **History of land acquisitions for the facilities if any and the associated history of compensation collections and notifications to landowners** • **Time of land acquired** • **Ownership and land use of acquired land (for instance, vacant state-owned land, state owned land with**	✓	• Land was previously owned by IPC and Mediterranean Sea Pipeline and included a Golf Club (1930s until 1960s) until all assets of these two companies were nationalized by the Lebanese Government in the 70's followed by transfer of ownership for the benefit of MEW and EDL (**Appendix A2**). • While asset (and land) nationalization covers all plots for the benefit of GoL, the transfer of ownership for the benefit of EDL from GoL were completed for most but not all plots, which total 16 in number and 320,204 m² size - some plots still do not have EDL's name on their property statements. The responsibility for completing such documents was	Individual claim against EDL for compensation on lost concession provided by previous owner of land is being processed through local courts	Minor	No action required		Appendix A2

[20] If the data for scope 1, 2, and 3 of GHG emissions is not currently available, is there a plan to track the emissions of different activities related to the facilities?

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
	occupancies and uses, private owned land with legal titles, land used by tenants) • **Approaches of land acquisition (for instance, transferring by government at free of charge, willing buy and willing seller approach, eminent domain)** • **Is there any documentation of land acquisition, is there any Resettlement plan?** • **Is the any presence of formal and informal settlers or land users around the facilities who will need to be physically or economically displaced for the project? What is the number of people affected if any?** • **Compensation value and payment if eminent domain is used for land acquisition** • **The method in determining the compensation value and willing buy-willing seller price** • **Any pending issues or unresolved complaints for the past land acquisition conducted for the facilities, if there is any** • **Is there any restriction on land use or access to lands in the area near the Plant and the AGP because of the facilities?**		reported by LOI to lie with the Ministry of Finance (LOI Legal Department, telephone communication, 15 November 2021). • The only claim brought forward relevant to the project is that of one individual against EDL requesting compensation for the concession (orchard) historically provided by IPC prior to land expropriation. • Land restrictions are not applicable to the Power Plant; however, access to the marine domain opposite to the Power Plant is restricted according to EDL; this is advertised using sign boards along the beach where no activities are allowed within 1,500 m from shore – no fishing / swimming / diving / snorkeling.					
ESS6	**ESS6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources)**							
ESS6-1	• **Clarify the impact(s) if any of the facilities on ecosystem services.** • **Are the facilities affecting any natural reserve or habitat? (for example, Palm Island – Tripoli)**	✓	• No scientific information on adverse impacts on marine water quality or biodiversity could be obtained within the timeline of this study. The Balamand University was consulted and reported not having any info on the matter. Fishermen association closest to site were also contacted and they could not confirm PP related adverse impacts on fish stocks. Monitoring and analysis of water quality and temperature within and at edge of mixing zone (to be defined) from PP discharges are recommended. • Palm Island Nature Reserve is practically more than 11 km west relative to the Power Plant and accordingly up gradient relative to dominant sea currents and up wind from dominant wind direction; this suggests that the reserve is safe from any potential pollution from the plant.	Monitoring and analysis of water quality and temperature within and at edge of mixing zone (to be defined) from PP discharges are lacking.	Moderate	Monitoring and analysis of water quality and temperature within and at edge of mixing zone (to be defined) from PP discharges shall be performed.	Prior to Operation on NG and to be continued afterward.	
ESS6-2	• **Are the facilities affecting marine and coastal ecosystems and biodiversity (cooling of turbines using sea water)?**	✓	• More data are needed – monitoring data at a minimum.	Deir Ammar Power Plant lacks an Environmental Audit and ESMP based on local regulations and likely has non-compliances in terms of its emissions and effluent discharges to the sea.	Moderate	Deir Ammar Power Plant requires an Environmental Audit based on national regulations including environmental measurements for emissions, wastewater discharges, and noise and vibrations inside facility and at nearby sensitive receptors. Based on audit results, corrective actions and an adequate monitoring program shall be proposed and committed to as part of an ESMP approved by MOE and WB.	Prior to Operation on NG and to be continued afterward.	
ESS8	**ESS8 (Cultural heritage)**							
ESS8-1	• **Are there any tangible and intangible heritage (including natural and archeological protected zone), which may be affected by the facilities?**	✓	Not applicable – facility already exists.	No key issues	None	No action required		
ESS10	**ESS10 (Stakeholder Engagement and Information Disclosure)**							
ESS10-1	**1) Review and assess the adequacy of the facilities stakeholder identification, analysis and engagement and communication progress and assess current and planned stakeholder engagement activities.**	✓	1) Deir Ammar Power Plant does not currently have a process for stakeholder identification, analysis, and engagement and does not have a SEP. Any complaints against the facility must be directed officially to EDL headquarters in Beirut so that a proper response is received – no information was obtained as to how long a response would take. 2) Vulnerable groups are not identified nor engaged with.	There is no FGRM for the general public. The facility does not accept direct claims or complaints from the surrounding communities and refers them to formally communicate with the EDL HQ in Beirut.	Substantial	An FGRM shall be created and implemented to facilitate feedback, claims, and complaints from the general public; it will be widely disseminated with information on the resolution timelines, responsible persons, and option for appeals.	Prior to Operation on NG	

S/N	Task	Applic-ability	Power Plant Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Supporting Docs. Appendix
	2) Identify potentially vulnerable groups in this project and assess how the facilities are engaging such stakeholders. **3) Is there any GRM in place that is functional, accessible and inclusive for communities? What is the mechanism, the uptake channels, the timelines to close complaints, and is there a GRM log?** **4) Do students, (Non-Governmental Organizations) NGOs, or researchers have access to information from the facilities? Is there any mechanism that is followed?** **5) Is there a communication strategy in place?**		3) There is no GRM at present. 4) Students and researchers may be granted approval to access the facility; a formal request should be registered at EDL HQ in Beirut. Usually the PP has about 20 students (Year 4 Lebanese University Engineering Students) doing an internship per year. 5) There is no communication strategy.			Referral pathways for SEA/SH shall be established and communicated.		

TABLE A2. LIST OF SIGNIFICANT HEALTH AND SAFETY HAZARDS – DEIR AMMAR POWER PLANT

ANTICIPATED HAZARDS TOGETHER WITH THE SIGNIFICANT CORRESPONDING PREVENTATIVE MEASURES TO REDUCE OR ELIMINATE THESE HAZARDS

ANSWERS PROVIDED BY FACILITY HSE MANAGER

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Lack of safety studies	Devices might not function correctly under all reasonably foreseeable situations	Risk Assessment and Job Safety Analysis
Crushing **Shearing** **Cutting or severing Entanglement**	Moving parts Uncontrolled movement Fingers trapped during maintenance activity Operator trapped in valves/actuators Clothing trapped in rotating parts	Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms. Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions.
Trapping	Person trapped within an enclosed space and unable to escape Operator trapped in enclosure dampers, potential for severing	Work Permit Attendant, Entrants, Entry Supervisor -System strictly followed
Impact	Foreign matter in the gas turbine Mechanical disassembly Blade failure	Regular maintenance of Filters Closing any openings/manhole cover
	Foreign matter in the ventilation system followed by violent disassembly of enclosure ventilation fan blades	
	Violent disassembly of air-blast oil-cooler fan, damage to cooler matrix creating potential for fire	
	High positive/negative enclosure pressure causing uncontrolled door movement/ straining forces Entry hazards	
	Icing at gas turbine compressor air inlet causing gas turbine compressor surge	N/A, Location Ambient Temperature not lower than 5 ^{0}C Anti-icing is existing and maintained regularly.
	Starter-motor rotor failure	
Cutting, severing	Sharp edges/corners	Chamfer the edges/corner If not possible, Installation of Sign/Notice
Falling or ejection of objects	Maintenance tools causing sparks in a hazardous zone Operator injured by falling objects during periods of maintenance	Use a spark resistant tool Clearing the traffic Use of temporary fall protection measures in scaffolds and out edges of elevated work surfaces, such as hand rails and toe boards to prevent materials from being dislodged. Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes
Break-up: Loss of containment	Fault in driven unit causing violent disassembly	
	Failure of high speed rotating components	
High pressure-fluid injection or ejection	Over-pressure in high pressure hydraulic water wash systems, low-pressure gas turbine lubricating oil systems, fuel systems, instrument air supply, and steam-injection supply Over-pressure in fluid lines where fluid is trapped	
Fuel vapor lock	Rupture of pressure equipment containing dangerous media	
Over-pressure ejection	Failure of gas turbine pressure casing containment	
	Over-pressure in enclosures due to extinguishant discharge Over-pressure in the gas turbine enclosure due to breach of gas turbine pressure casing	
	Surge causing over-pressure in the combustion inlet, inlet filter/ducting/flexible fracture and structural failure	
	Exhaust over-pressure due to uncontrolled exhaust damper closure Pulse in exhaust on shut-down due to engine surge	
	Unsafe discharge at gas turbine compressor bleed valve	
	Positive pressure in lube oil tank when opening filler, release of carcinogenic oil vapors into the atmosphere	
	Excess pressure in the fire extinguisher/propellant bottles causing burst disc to blow	
Excess pressure from interface to exhaust heat recovery system	Lack of adequate control with the potential for incorrect operation	

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Loss of stability of machine or machine parts	Collapsing of parts or equipment	Vibration Monitoring on a regular basis. Tightening the loose parts
Slip, trip and fall hazards	Falling from a height due to poor access Standing surfaces, walkway surfaces	Implementing good house-keeping practices, such as the sorting and placing loose materials or tool in established areas away from foot paths Cleaning up excessive waste debris and liquid spills regularly Locating electrical cords, pipe and ropes in common areas and marked corridors Use of slip retardant footwear
Contact of persons with live parts	Inability to isolate/guard a supply, electrocution	LOTO, Using of insulated tools Wear recommended PPE
	Electric shock from stored energy in capacitors	Provide fully visible, manual-grounding devices to render the capacitors safe while they are being worked on. Clearly mark grounding points and use caution to prevent transferring charges to other capacitors.
Electrostatic phenomena External influences	Cross interference from wiring Electrical, static and electromagnetic interference causing loss of control Lightning strikes causing short circuit/ malfunction of equipment and loss of control	Provision of grounding and lightning protection for equipment that handles flammable materials
Thermal radiation	Thermal radiation from hot casings affecting the safe operation of instrumentation	Wear recommended PPE Checking insulation regularly.
Effects from short circuits, overloads, etc.	Generator short-circuit or faulty synchronization causing over-torque	
Environmental influences on electrical equipment	Water ingress causing short circuit/ malfunction of equipment leading to loss of control, electrocution In ocean coastal areas, build-up of salt from spray	
Damage to equipment from environment contamination	Premature failure of turbine components	
Burns, other injuries from contact with temperature	Contact with cold surfaces due to pressure reducing valves or extinguishant/ propellant release Cold surfaces due to expansion of liquid to vapor	
Hot/cold surfaces	Contact with hot/cold surfaces	Wear recommended PPE Checking insulation regularly
Damage to health by hot or cold working environment	Chill factors generated by air flow/ ventilation. Overheating due to inadequately insulated hot surfaces and/or poor location of hot air outlets. Prolonged entry in enclosure producing heat stroke	Wear recommended PPE Checking insulation regularly Must take a break/rest on adequate frequency.
Damage to equipment from cold environment	Equipment failure Brittle fracture	
Noise	High noise level from bleed valves, vents and motor exhausts Noise emission within the environment due to fluid flow	
	Noise levels impairing communications	Install soundproofing if possible
	Noise in the environment due to pulsing of pulse clean inlet system	
	Interference with speech Less effective communication due to noise levels Hearing loss, due to higher than predicted noise levels	Install soundproofing if possible. Wear recommended PPE
	Vibration on high speed equipment leading to failure Critical speed encountered in rotating equipment	Using noise control devices, such as noise barriers and deflectors
	Vibration of unsupported pipe work, structures, etc. leading to failure	Support installation on the pipework
	Higher-than-permitted velocity of gas through the flexible pipes Potential for rupture	Regular maintenance and calibration of installed measuring device – flowmeter.
Low-cycle fatigue failure	Premature failure	
Low-frequency, radiofrequency radiation, micro-waves	Uncontrolled operation of electrical/ electronic equipment due to external interference	
Infrared, visible and ultraviolet light	Failure of non-metal high pressure hose on extinguishant piping caused by UV degradation	
X- and gamma-rays	Damage to health	
Radiation	Arc or other type of flash causing inadvertent operation of fire detectors causing release of extinguishant	
Substances	Exposure to high levels of H2S from gas fuel. Dangerous substances encountered during operation	Install gas detector and maintain/calibrate regularly Wear required PPE
	Materials subjected to H2S contamination failing due to corrosion	
Poor identification of piping contents	Inability to identify piping containing dangerous media	

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Contamination	Reverse flow of fluids into service lines causing contamination Fuel contamination of oil	
	Liquid hydrocarbon contamination of gas fuel	
Asphyxiation	Uncontrolled release of extinguishant inside enclosures/gas turbine hall Smoke within enclosure due to presence of a fire	N/A, Halls are well ventilated
	Asphyxiation and poisoning due to oxygen depletion by leaks from exhaust with high carbon monoxide content on partial load operation	Install gas detector and maintain/calibrate regularly Wear required PPE
	Asphyxiation due to inadequate venting of battery room	Installation of vents on low and high point.
Fire or explosion hazard	Gas leak in enclosures/gas turbine hall	N/A, Halls are well ventilated
	Gases or vapors in the gas turbine enclosure prior to start-up Potential for fire and explosion	N/A, Halls are well ventilated
	Recirculation of gas turbine ventilation air for anti-icing producing a hazard due to an enclosure fuel leak	
	Leak/spray of liquid fuel, hydraulic fluid, lubrication oil onto hot surfaces	
	Ingestion of explosive gas/hydrocarbon vapors into gas turbine compressor air inlet, enclosure ventilation inlet, generator cooling air inlet Leak of gases into the environment in potentially unsafe areas	
	Deliberate ingestion of excess waste substances	
	Pre-ignition of fuel when in contact with hot internal surfaces at start-up	
	Failure of reverse purge during shut-down from low auto-ignition temperature fuel Explosion/fire on re-start	
	Loss of AC whilst running on low auto ignition temperature fuel causing purge failure. Explosion/Fire on re-start.	
	Battery gas ignites in battery room	Regular maintenance Installation of vents
	Over fueling of gas turbine on light-up	
	Excess fuel leading to danger	
	Fuel shut-off valve failure	Regular maintenance
	Unignited gases/liquids and vapors internal to the gas turbine/exhaust system/ waste-heat boiler	
	Failure to detect flame-out while gas turbine is running	
	Gas/liquid fuel flowing into a shut-down gas turbine	
	In-rush of oxygen into the acoustic enclosure following a fire	
	Electrical insulation failure	
	Fire due to incorrect use of solvent wash or other cleaning fluids	
	Internal oil leak within gas turbine following loss of seal air	
	Loss of fire extinguishant leaving no protection	
	Leaking acoustic enclosure depleting extinguishant concentration	
	Rupture of off-package fuel pipework due to a gas turbine structural failure	
	Potential for fire in lubrication system breather ducting due to close proximity of exhaust ducting	
	Loss of ventilation due to icing or other blockage at ventilation inlet	Regular maintenance
	Incorrect use of materials, titanium and magnesium alloys	
	Leakage due to incorrect treatment of drains	
	Detector not sensitive to gas or vapor being detected Gas detection out of calibration	Regular maintenance and calibration
	Insufficient water mist by design to extinguish the fire Water mist extinguishant not distributed to all areas of the gas turbine enclosure	
	Freezing of water prevents water mist extinguishant discharge	
	Blockage of water mist nozzle or system components by rust particles or refill water Blockage of water mist nozzles after discharge	Regular maintenance
	Manually operated extinguishant isolation valve not open	Regular maintenance
	Unburnt liquid fuel in exhaust can escalate to an explosion of any fuel vapors	
	Enclosure ventilation fan failure not detected	Regular maintenance

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
	Enclosure dampers fail to close Inert atmosphere within enclosure depleted, potential re-ignition of any fire	
	Failure to disperse heavier-than-air fuel vapors Potential for vapors to settle in low-level areas/trenches and to migrate to safe areas	
	Auto-ignition of fuel when in contact with hot internal surfaces during start-up	
	Potential explosion of vapors in the drain/ vent tanks due to temperature of purge discharge in piping Explosive mixtures in purge lines	
	High breather backpressure due to failed fan in breather coalescer	
	No signal to fire extinguishant system, no release	Regular maintenance
	Incorrect treatment of vents and drains causing a dangerous situation	
	Incorrect identification of hazardous zones	
	Over-temperature in gas starter motor due to supply contamination causing mechanical failure, potential for failure of casing or seals Gas can leak and ignite	
	Reverse flow through gas starter motor causing failure	
	Reverse flow from heat recovery to turbine	
	Uncontrolled release from H2 cooled generators	
Mechanically generated sparks/hot surfaces	Potential for explosion Sparking of fan blades	Regular maintenance
Smoke	Poisoning of gas detectors and blinding of fire detectors due to vapors from oil on hot gas turbine surfaces, gaskets and other joints burning in	
	Smoke from cabling due to electrical insulation fault Smoke from fire within acoustic enclosure	
Pollution	General pollution hazard	
	Oil mist at breather outlet, potential for carcinogenic exposure, environmental pollution and risk of fire	
	Pollution due to incorrect treatment of drains Pollution due to incorrect treatment/control of vents	
	Disposal of product and components at the end of their useful life	
	Operation of gas vents	
	Tank overflow	
Unhealthy postures or excessive effort	Hard-to-handle components and inadequate lifting provision	Provision of lifting devices
Neglected use of personal protective equipment (PPE)	Injury	Reprimand Strict compliance of using /wearing PPE
Inadequate local lighting	Inadequate lighting preventing escape	Install adequate lightings
Mental overload and stress	Inadequate instructions and maintenance	Brief and concise instruction
Errors made by the operator	Absence or incorrect fitting causing injury or death Human factors leading to incorrect assembly of critical parts Human factors leading to guards missing	Strictly follow the OEM procedures.
Inadequate design, location or identification of manual controls or visual display units	Incorrect operation	Strictly follow the OEM procedures
Combination of hazards	Hazard combinations prevent correct operation of safety devices	Strictly follow the OEM procedures/
	Water in the gas, solids in gas, potential for starter motor damage and failure	Regular maintenance of separator/filters
	Liquid hydrocarbon condensates in starter motor exhaust when gas supply is near dew point	
	Contamination of liquid fuel storage with low auto-ignition fuel. Potential for vapor lock/explosion at fuel burner nozzles, lack of control	
	Lack of effective hazardous-fuel purging, potential for illness from contaminants	
	Wax formation in liquid fuel at low temperature, blockage, loss of control	
Malfunction of control system, software errors	Unexpected operating condition	Strictly follow the OEM procedures Regular update and maintenance
Failure of safety related devices	Fire, explosion, injury to personnel, poisoning, suffocation, etc. due to lack of maintenance	Regular maintenance
Disorder of controls Unexpected start-up	Machine starts when undergoing maintenance Starting of peripheral equipment while maintenance is being carried out	LOTO, required PPE
Uncontrolled device operation	Injury from inadequate means of prevention	LOTO, required PPE

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Failure/disorder of the control system	Loss of internal temperature control in the gas turbine leading to premature fatigue	
	Loss of speed control with the potential for overs peed Loss of effective governing with the potential for over-fueling	
	Loss of control Uncontrolled operation	
Valves out of position	Uncontrolled supply, venting or draining of dangerous media	
Lubrication oil supply control	Inadequate lubricating oil supply leading to machinery failure	
Loss of utility supply	Uncontrolled operation of safety devices	
Failure of energy supplies	Loss of oil supply leading to unsafe shutdown	
	Loss of adequate ventilation Failure of detection devices Uncontrolled operation of safety device	
	Loss of HVAC to control cabinet	
Restoration of energy supply	Gas accumulation on ventilation failure	
Failure of energy supply disconnecting devices	Absence or incorrect fitting can cause injury or death to the operator or bystanders	
External influences, gravity, wind, seismic loads	Structural collapse	
External influences, winds	Uncontrolled rotation of rotors	

ANNEX B - COMPLETE LIST OF FINDINGS FOR ARAB GAS PIPELINE

Table B1. Environmental and Social Review of GASYLE provides the comprehensive list of Environmental and Social review findings for Arab Gas Pipeline Facilities with additional OHS tables following it as follows:

- Table B2. List of Significant Health and Safety Hazards - AGP;
- Table B3: Hazard Identification for Pipeline Stations (Receiving, Pressure Reducing, and Border Stations); and
- Table B4: Hazard Identification for High Pressure Gas Pipelines.

Supporting documentation is provided in Appendices as listed below:

Appendix	Documents
B1	- Google Earth Imagery of Receiving Station PRS, Border Station, and Pipeline
B2	- Google Earth Imagery showing AGP Trace from Deir Ammar until Syrian Border
B3	- Memo from GoL (Ministry of Economy) to IPC informing them of Nationalization of IPC Assets due to Failure of Fulfilling their Contractual Obligations
B4	- Tripoli Oil Installations AGP Safety Requirements Outline
B5	- TGS ISO Certification
B6	- TOIL O&M Monitoring Form - TOIL Preventative Maintenance Schedule for 2018 - Work Permit Form 2015 Example 1 (with Safety Section) - Work Permit Form 2015 Example 2 (with Safety Section)
B7	- TGS June 2020 Industrial & Domestic Treated Effluent Analysis in Jordan - TGS June 2021 Light Monitoring in Jordan - TGS June 2021 Noise Measurements Jordan - TGS March 2021 Emergency Generator Emission Test Jordan - TGS May 2021 Monthly Gas Monitoring Jordan
B8	- TGS Employee Complaint Form - TGS Employee Complaint Register - TGS Environmental Aspect Register 17Jan2020 - TGS IMS Manual - TGS Risks to Interested Parties 2021 - TGS Risk Based Management - TGS Code of Conduct
B9	- AGP Pertinent Legislation
B10	- AGP Design Standards Specifications - Gas Pipeline Profile
B11	- Photo Showing AGP Receiving Station with Uncontained Diesel Tank - Photo Showing Ear Protection Signage at Receiving Station
B12	- TOIL Internal Communication on Legal Follow-up on ROW Encroachments

B13	- TGS Communication Procedure Example

TABLE B1. ENVIRONMENTAL AND SOCIAL REVIEW OF GASYLE

Date of On-Site Data Collection: 9 Nov 2021

Task	Applicability	Natural Gas Facilities Availability / Feedback	Supporting Docs Appendix
Document the historical background of the facility such as:			
• **Geographical location documented by historical Google maps**	Applies to the PRS and metering station	- Approximate boundaries of Receiving Station, Pressure Reducing Station (PRS), and Border Station (**Appendix B1**). - Receiving Station is located within Tripoli Oil Installations – Lebanon (TOIL) owned premises in Beddawi Village, Minieh-Danniye Caza, and North Lebanon Governorate. - PRS is located within Electricité Du Liban (EDL) owned Deir Ammar Power Plant premises but under LOI ownership and jurisdiction, in Beddawi Village, Minieh-Danniye Caza, North Lebanon Governorate. - Border Station is located within LOI owned land adjacent to Lebanon-Syria border along el Kebir River in Hokr Jouret Srar village, Akkar Caza and Governorate.	Appendix B1
• **Routing**	✓	Refer to **Appendix B2**	Appendix B2
• **Start and end of construction dates**	✓	2003-2005	
• **Financing the construction and installations and main contractor(s)/suppliers involved**	✓	Financing was secured by LOI according to MEW Contractor: Hawi Bros Contracting and Trading Consultant: Kershner Owner: Tripoli Oil Installations Lebanon	
• **Any legacy issues concerning environmental aspects, land ownership, social and community issues, etc.**	✓	- Land ownership: Historically owned from 1931 to 1973 by Iraq Petroleum Company (IPC) and Mediterranean Sea Pipeline Company until nationalized in 1973 by the Government of Lebanon (GoL) following nationalization of these companies in 1961-1972 by the Iraqi Government and failing to fulfill their contractual obligation in Lebanon; their ownership was later transferred to the Ministry of Energy and Water (MEW) – Lebanon Oil Installations in 1970s (**Appendix B3**). - Environmental: Mainly oil spills from adjacent crude pipelines within 32 km Right-of-Way (ROW) resulting from deterioration of pipeline and from theft attempts whereby the pipes are perforated and crude pumped out (refer to photo in **Appendix B4** showing punctured pipe location and stained soil where pipe is exposed within stream and welded by Tripoli Oil Installations - Lebanon (TOIL) after being repeatedly punctured for theft of crude). - Relatively recently, the gas pipeline, which is still pressurized at 5 bars to protect it from corrosion, was punctured by individuals trying to steel crude oil from adjacent crude oil pipelines within the same ROW; TOIL staff reported witnessing a small drop in pressure in the control room and they were alerted to the location of the hole by locals who heard the whistling sound of gas escaping. The emergency shutdown and flaring system was not triggered because of the low pressure maintained and small size of the hole and gas leak. - Social and Community: Mostly after pipeline stopped operating in 2010, locals have been recurrently trespassing on the ROW reserved for crude oil pipes and the gas pipeline while being repeatedly asked to stop their trespassing activities for their safety. In the case of some more explicit constructions, security forces were brought in to remove trespassers and secure the integrity of the ROW. Main types of encroachment activities that still exist include agriculture and plowing of the ROW, backyards extending into ROW, using the ROW as road access, for parking cars and trailers, and as miscellaneous outdoor storage areas or dumps (**Appendix B4**). - The gas pipeline trace and ROW were visited in certain portions along its length to observe it within different land uses (agricultural, rural, urban, under paved roads, and across streams and rivers); it was observed that the previously built gravel road allowing continuous maintenance and emergency access along the whole extent of the gas pipeline and ROW has been particularly eroded along agricultural terrains because local farmers use it for easier access with their tractors (Refer to Figure showing lad use / cover crossed by ROW).	Appendix B3 and Appendix B4
• **Historical land use of the facility site and surroundings (supported by maps)**	Applies only to the PRS and metering station	- The PRS location is located on an artificially cut hill side, likely to make room for the station. The rest of the hill side, remains bare land until today with the exception of shrubs; this suggests that the PRS location was historically similar. - The Metering Station is located within TOIL premises; it consisted of bare land and reeds according to the contractor who built the pipeline (S. Hawi, Personal Communication, November 17, 2021).	

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	Determine the conformity of the current *environmental and social management system or procedures with the World Bank Environmental and Social Standards (ESS) by answering the following indicative questionnaire to ensure that key aspects of each (ESS) of the ESF are assessed:*							
ESS1	**ESS1: Assessment and management of Environmental and Social Risks and Impacts**							
	Permits Licenses, Management and Monitoring Systems							
ESS1-1	• **Do the facilities have a nationally approved Environmental and Social Impact Assessment study or Environmental Review?**	✓	Facility was constructed prior to EIA decree; no E&S studies on pipeline were identified.	While an ESIA is not required for the pipeline and linked facilities because they were built before an the EIA decree was enforced (2012), the lack of it means there are no systems and no management plan in place to manage environmental and social risks associated with the operation of the pipeline and associated facilities.	Substantial	An Environmental and Social Management Plan for the pipeline and linked facilities shall be prepared. Refer also to ESS1-3	Prior to Operation	
ESS1-2	• **Does the facility Operator have any international certification (such as ISO)?**	✓	- TOIL do not have any certification. - TGS who are poised to conduct rehabilitation + O&M have the following certificates: ISO 14001:2015, ISO 45001:2018, ISO 9001:2015 (**Appendix B5**)	TOIL do not have any management system certification.	Moderate	Refer to ESS1-3 to offset the lack of a certified management System.	Prior to Operation	Appendix B5
ESS1-3	• **Do the facilities have an environmental and social management manual including**	✓	- TOIL have a safety section to be filled in their Work Permit forms but they lack an EHS manual that also covers social aspects (Refer to forms in **Appendix B6**); TOIL-AGP department have not been properly	TGS are ISO 14001:2015, ISO 45001:2018, ISO 9001:2015 certified and their management system and manual covers EHS albeit with some social aspect deficiencies.	Substantial	TGS shall introduce the necessary social aspect procedures in their EHS manual including social aspects and a GRM, communication mechanisms	Prior to Operation	Appendix B5 and B6

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	operational management procedures for key environmental, social, and health and safety aspects?		operational for over a decade, hence the need for a comprehensive EHS manual and competent/trained EHS staff capable of implementing it. - According to TGS, their manual covers all aspects, which would be the case for EHS and OHS given their ISO 14001 and 45001 certification (**Appendix B5**). During their interview, TGS representatives confirmed that the social aspects will also be covered in their EHS Management System (EHSMS) for AGP Lebanon even if TOIL staff will be assigned some of these responsibilities and that the ultimate successful implementation of the EHSMS will be TGS's after being specifically asked about this issue. It is important to ensure that contractual documents specify this while also providing TGS with the necessary authority and legal enforcement provisions to help them successfully fulfill their responsibilities. Alternatively, if it is decided that TOIL are in charge of the EHSMS, then an EHSMS covering social aspects must be developed for them and they should be trained on it in addition to hiring the competent staff capable of implementing it (EHS Manager and Officer(s)).	TOIL lack the required management system and manual as well as the associated competencies.		and protocols, and communication strategy with local communities. The owner of EHS risks shall be clearly defined (TGS and/or TOIL) the manual must cover all foreseeable EHS and social risks. Where there are risks owned by TOIL, they will develop a manual with the help of a qualified consultant including Social Management System (ESMS) to manage these risks. The manual shall also be updated based on the results of additional safety and risk assessment studies to be conducted. If it is decided that TOIL are in fully in charge of the ESMS, then one will developed for them by a qualified consultant and it shall cover TGS and all relevant stakeholder risks; they will also be trained on it and they will hire/train competent staff capable of implementing it (EHS Manager and Officer(s)).		
ESS1-4	• **Do the facilities have environmental and social monitoring records with clear set of performance indicators?**	✓	- TOIL do not have environmental and social monitoring except for OHS. They provided a gas leak monitoring form sample (**Appendix B6**). - TGS reported having records and performance indicators; they provided samples of environmental monitoring from their Jordan operations (**Appendix B7**) albeit insufficient on social aspects - Employee Complaint Forms and Register, and a KPI of zero violations and complaints associated with neighbors in the List of Interested Parties (**Appendix B8**)	- TOIL lack environmental and social monitoring. - TGS have environmental and social monitoring albeit with some social aspect gaps.	Substantial	TGS need to add social monitoring records in line with ESS1-3	Prior to Operation	Appendix B6, B7, and B8
ESS1-5	• **How often are internal reviews conducted on environmental, social and health & safety aspects? And do the facilities have an action tracker and review findings tracker?**	✓	- Not applicable for TOIL-AGP who have not been properly operational for over a decade – the pipeline is kept under low pressure to avoid corrosion and TOIL staff reported that they are still manning the Control Room in shifts and they are still conducting weekly patrols to check the ROW for encroachments and vandalism. - TGS reported having such reviews and trackers, which should be in line with their ISO certification; however, social aspects have not been covered based on documentation obtained apart from identifying neighboring communities as parties of interest and assigning KPIs for zero violations and complaints, which may be due to the nature of their activities and pertinence of social aspects (Refer to Environment Aspect Register in **Appendix B8**).	TGS have mainly environmental reviews and action trackers; social aspects are mostly lacking.	Substantial	TGS need to add social reviews and trackers in line with ESS1-3 and ESS3-4	Prior to Operation	Appendix B8
ESS1-6	• **Do the facilities have all the required (environmentally related and other) permits (such as: extraction of water or ground water, building, environmental, use of soil and construction permits, disposal of solid and hazardous wastes, traffic permits, civil defense, cooling of turbines using sea water...etc.)**	✓ e.g. disposal of solid and hazardous wastes, civil defense	Not applicable to TOIL.	Not applicable	None	No action required		
ESS1-7	• **Do the facilities have or need wastewater or storm water permits?**	✓	- Receiving Station toilets drain into an underground cesspool that is designed to infiltrate into the ground, which is a noncompliance with local legislation that mandates impermeable septic tanks to be built if no connection to sewerage system is available. - It could not be confirmed if toilet facility at border station is connected to sewer main.	- Receiving Station has an underground cesspool that is designed to infiltrate into the ground, which is a noncompliance with local legislation that mandates impermeable septic tanks if no connection to sewerage system is available. - It could not be confirmed if toilet facility at border station is connected to sewer main.	Moderate	Recommendation is to either construct a sewerage connection to closest sewer main if such a network is connected to a functional sewage treatment plant with secondary treatment or to install an impermeable septic tank and regularly empty it and transport it to a nearby treatment plant – the secondary treatment plant present within Power Plant with 1.5 m^3/hr. and 3 m^3/hr. average and peak capacities respectively should be able to easily accommodate the 0.5-1 m^3 per day of sewage generated assuming 10 individuals at the Receiving Station. It is recommended to confirm that the toilet facility at the border station is connected to a sewerage main.	Within 12 months after start of operation	
ESS1-8	• **Determine the national applicable standards, limits and requirements for:** • **Air quality (ambient, stack, indoor)** • **Noise (ambient and indoor)** • **Waste (including hazardous and non-hazardous wastes) management (handling, storage, transportation and end disposal)**	✓	Key environmental legislation regulating environmental aspects and emissions pertaining to air quality, noise, waste, effluent discharge, and chemical and hazardous material are summarized in Section 3.2.2 and in **Appendix B9.** These national regulations offer sufficient environmental protection if implemented and enforced.	No key issues	Low	EHS management shall identify all applicable environmental standards and legal requirements in its environmental aspects register and it shall ensure they are compliant with national legislation where applicable.	Prior to rehabilitation and operation phases	Appendix B9

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	• **Effluents management (handling, storage, treatment and end discharges).** • **Chemicals and hazardous material management (transportation, handling and storage)**							
ESS1-9	• **Are the current operations being conducted in compliance with the facilities' permits?**	✓	Not applicable to TOIL-AGP department	No key issues	None	No action required		
ESS1-10	• **Verify that all major permits have been obtained and are in full force and effect, and identify what major permits have not obtained, if any, and comment from a technical perspective, on the likelihood that they may or may not be able to obtained in a timely manner**	✓	Not applicable to TOIL-AGP department	No key issues	None	No action required		
ESS1-11	• **Does the facilities have building safety permit (earthquake, fire, etc.?)**	✓	- Gas pipeline was built based on international engineering standards; seismic risks and response plans are lacking. - Seismic risk characterization for control rooms and automatic shutdown and flaring systems at Receiving Station, PRS, and Border Station is lacking.	- Gas pipeline was built based on international engineering standards; however, vulnerability to earthquake prone Lebanon has not been characterized and neither appropriate response plans. - Seismic risk characterization for control rooms and automatic shutdown and flaring systems at Receiving Station, PRS, and Border Station is lacking	Moderate	Assess seismic risk as part of the risk assessment planned for the pipeline (refer to Section ESS5-1) and develop the appropriate emergency response plan with the involvement of other authorities (e.g., civil defense, fire brigade, security forces, paramedics) in addition to a training schedule and drills.	Prior to operation	
ESS1-12	• **What are the relevant industry specific WBG EHS Guidelines Requirements that are applicable to the facilities? How far they are applied?**	✓	Relevant specific industry WBG EHS Guidance (Oil and Gas Development) covers: **INDUSTRY SPECIFIC IMPACTS** • Environment o Air Emissions > Gas leakage - Installation and pipe joining techniques meet international standards (**Appendix B10**). - Corrosion prevention including cathodic protection and polyethylene wrapping were followed during construction; however, damage to the pipeline and components has occurred and repairs would need to be conducted as identified in the TGS rehabilitation report and to cover additional damages such as one cathodic protection station (**Appendix B4**). - Leak and corrosion detection programs will be followed. - Control system installed is able to detect pressure variations, there are gas detection sensors installed in sensitive locations, and an inspection program using portable gas detectors will be implemented. o Wastewater - Hydrotesting water sourcing is planned from a spring with clean water while no chemicals are planned to be added to it (T. Hannouf[21], personal communication, 10 Jan 2022) - Hydrotesting wastewater shall be compliant with the following ELVs: Total hydrocarbon content: 10 mg/L | pH: 6 – 9 | BOD: 25 mg/L |COD: 125 mg/L | TSS: 35 mg/L | Phenols: 0.5 mg/L |Sulfides: 1 mg/L |Heavy metals (total for Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc): 5 mg/L | Chlorides: 600 mg/l (average), 1200 mg/L (maximum). o Habitat Alteration - The pipeline already exists, it is buried and there is no fence; accordingly, no habitat alteration is expected unless a fence without terrestrial access corridors for fauna will be built. This is not being considered at present despite its advantages in protecting the integrity and higher public	• Environment and OHS There are repairs to be made on pipeline and facilities because the pipeline has not been operational for more than a decade (refer to TGS repair assessment report); pipeline markers and berms need rehabilitation and there are general public activities encroaching on the pipeline and ROW. Hydrostatic wastewater shall be monitored prior to discharge to ensure that WB hydrotesting wastewater discharge ELVs for onshore discharge are not exceeded • Community Health and Safety There is no evidence of a quantitative risk assessment and a manual of permissible and non-permissible activities within ROW and safety separation distance (not defined as of yet) Given that the pipeline has not been in operation for a long time, it is critical to ensure that safety hazards including major accident hazards can be effectively managed through the existing barriers integrated in design, but also to ensure that operational barriers are in place, and consider maintenance activities • Performance Indicators and Monitoring TGS will cover needed aspects	Substantial	• Environment and OHS Damages to pipeline and facilities shall be repaired and measures such as increased pipeline markers and restoration of the pipeline berm shall be undertaken. A stand-alone Occupational Hazards Management Plan shall be prepared. Occupational health and safety performance shall be evaluated against internationally published exposure guidelines. • Community Health and Safety - The following risk and safety studies need to be prepared to confirm readiness to operate the gas pipeline system and associated facilities safely (in line with the World Bank's latest EHS guidelines for oil and gas facilities): HAZID, QRA, Dedicated Operations Safety Case (includes MOPO, ALARP & Bow-Tie), Hazardous Area Classification for Stations (based on IP15), and Fire and Gas Mapping Study for project facilities; it is recommended that this studies be conducted by an independent party commissioned by TGS as part of its preparatory activities and repair works; the recommended risk studies are based on international standards and best practice in the sector - The assessments will inform the preparation of a ROW management plan including permissible and non-permissible activities on the ROW and the safety buffer area as identified by the risk studies - An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the risks of gas	Prior to Rehabilitation and Operation	Appendix B10, B4, B7, and B8

[21] Dr. Talal Hannouf - previous gas pipeline manager at TOIL and current advisor to MEW for this project

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			safety of the ROW, which is subject to daily infringement activities by locals. • OHS o Occupational Exposure to gas leaks - Training of staff on gas safety procedures and detection techniques/tools as well as emergency management procedures in liaison with local authorities will occur - Operation and maintenance procedures including works on gas pipeline will be highly regulated and controlled in terms of purging pipeline when needed, etc. - Visual Markings of gas pipeline were reportedly installed every 500m (refer to gas pipeline profile in **Appendix B10** for as-built locations); however some were stolen for their steel content and while concrete plates were used as replacement, some of those were even pushed aside to allow for agriculture by local trespassers using the ROW for agricultural activities (**Appendix B4**). Erection of additional signs to shorten distance between signs is recommended. - A continuous berm overlying the gas route was also removed in certain stretches and requires restoration. Restoration of the berm is recommended. - Other trespassing activities include using the ROW including the gas pipeline as access road to residential neighborhoods and to agricultural terrains as well as for car and trailer-parks and miscellaneous outdoor storage / dumps. - Work in confined spaces and electrocution are covered in TGS procedures if and where applicable • Community Health and Safety – the following aspects, which are recommended by WB and as international best practice are currently missing: o Risk assessments including HAZID, Hazardous Area Classification, Fire impact assessment, safety case, and Asset Integrity Management are required in the applicable EHS Guidelines o An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the health and safety risks of gas pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, and Environmental and Social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as form the adjacent crude oil pipelines is also important. o Signage should clearly indicate an abbreviated phone number to use for reporting leaks or vandalism to the gas pipeline or adjacent crude oil ones. o A very clear and enforceable communication protocol between the operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other should be defined and implemented to avoid misinformation and confusion; this will anyway be needed in emergency management. Incentives such as rewards for reporting leaks and vandalism may be considered conditional to not conflicting with cultural and ethical norms. o Means to access pertinent information at any time should be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information. o A Community Emergency Preparedness and Response Plan is required. **PERFORMANCE INDICATORS AND MONITORING** • Environment > Emissions and Effluent Guidelines In addition to the presence of a metering station at the Receiving Station and another one at the Deir Ammar Power Station, which will be the only client in the anticipated renewed operational phase, potential leaks and fugitive emissions will be detected through an O&M maintenance program comprising inspections and gas detection devices that TGS will implement. • Environment > Monitoring			pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, Environmental and Social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as from the adjacent crude oil pipelines is also important. - Signage shall clearly indicate an abbreviated phone number to use for reporting leaks or vandalism to the gas pipeline or adjacent crude oil ones. - A very clear and enforceable communication protocol between the operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other shall be defined and implemented to avoid misinformation and confusion; this will anyway be needed in emergency management. Incentives such as rewards for reporting leaks and vandalism may be considered conditional to not conflicting with cultural and ethical norms. - Means to access pertinent information at any time shall be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information.		

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			TGS will conduct environmental monitoring as a response to environmental hazard assessment, not only as part of O&M procedures (refer to TGS' monitoring Jordan examples in **Appendix B7** and to Environmental Aspect Register Jordan example in **Appendix B8**) • OHS > Guidelines / Accident and Fatality Rates / Monitoring TGS is certified for ISO 45001/2018, which is the international replacement of OHSAS 18001 starting 2018; TGS has advised that it will accordingly be monitoring and evaluating its OHS performance in accordance with necessary international standards. TGS will be setting KPIS aimed at eliminating Accidents and Fatalities.					
ESS1-13	• **Do the facility operators have an environmental and social department/unit/officer(s) who is/are responsible for ensuring environmental compliance?**	✓	TGS advised that they will dispatch and hire an EHS team including EHS Manager/Officer for AGP-Lebanon once they are commissioned its O&M.	TGS advised that they will dispatch and hire an EHS team including EHS Manager/Officer for AGP-Lebanon once they are commissioned its O&M.	Substantial	The Operator will dispatch / hire a competent EHS team including EHS Manager / Officer.	Prior to rehabilitation and operation	
ESS1-14	• **Does the person in charge for environmental affairs have sufficient capacity to perform his/her duties?**	✓	TGS advised that they will dispatch and hire a competent EHS team including EHS Manager/Officer.	TGS advised that they will dispatch and hire a competent EHS team including EHS Manager/Officer.	Substantial	The Operator will dispatch / hire a competent EHS team including EHS Manager / Officer.	Prior to rehabilitation and operation	
ESS1-15	• **Are the environmental and social roles and responsibilities clear? Are they documented?**	✓	This is integral to being ISO 14001 certified and TGS informed that all necessary documentation and records will be maintained once they are commissioned the O&M of AGP-Lebanon.	This is integral to being ISO 14001 certified and TGS informed that all necessary documentation and records will be maintained once they are commissioned the O&M of AGP-Lebanon.	Substantial	All necessary documentation and records will be maintained by the Operator and Borrower upon commissioning the O&M of AGP-Lebanon.	Prior to rehabilitation and operation	
ESS1-16	• **Is there any environmental & social reporting requirement? To who? sample**	✓	The Operator will report to the Borrower in addition to WB as required (Examples of reporting in **Appendix B7**).	The Operator will report to the Borrower in addition to WB as required (Examples of reporting in **Appendix B7**).	Substantial	The Operator will report to the Borrower in addition to WB as required		Appendix B7
ESS2	**ESS2 Labor and Working Conditions**							
ESS2-1	1. **Clarify the number and type of workers engaged for the facilities (such as civil servants, contractors/subcontractors, community workers, primary suppliers).** 2. **Identify potentially vulnerable groups of workers (such as female workers, migrant workers and informal workers)** 3. **Assess the working conditions of workers** o **Is there any rotation of personnel among the various operations in the facilities to reduce potential impact on health from repetitive actions?** o **Assess risks related to labor influx (if any)**	✓	1. AGP TOIL staff expect to have 8 members during the operation phase. They currently have 1 daily staff member and 7 shift-based staff based on 3 shifts of 8 hours per day. 2. Not currently applicable. TGS team may have females on their team most likely as local hire. 3. Current AGP team at TOIL have reduced work responsibilities toward AGP; there is no rotation of responsibilities, and there is no risk of labor influx. TGS team expected on the project will unlikely have rotation of responsibilities and there will be no risk of labor influx on this project.	No action required	Low			
ESS2-2	• **Assess Occupational, Health and Safety (OHS) [22], and COVID19 contagion**	✓	• AGP TOIL team have work permit procedures with safety risks identified on them. It is not clear to what extent COVID procedures are in place and are being adhered to. Staff can refer to TOIL medical unit and doctor in case of medical concerns and they can be in turn referred to a specialist. - TGS seem to be adequately implementing OHS procedures for their Jordan operations; they additionally advised that their staff should either be vaccinated or conduct PCR testing twice a week. - Refer to Tables 2-4 addressed by TGS below.	A suitable EHS Management System covering OHS and COVID19 and managing all stakeholders including TOIL staff and sub-contractors shall be put in place and implemented for Lebanon-AGP.	Substantial	A suitable EHS Management System covering OHS and COVID19 and managing all stakeholders including TOIL staff and sub-contractors shall be put in place and implemented for Lebanon-AGP.		
ESS2-3	1. **Assess the track record of labor management, including worker-related serious incidents accidents.** 2. **Assess the management of such risks at the location level, including whether a system is in place and functions to address**	✓	1. AGP has not been functional for over a decade. It is recommended that if AGP TOIL team will have actual work as part of the TGS team and not just a supervisory role that they be fully responsible under TGS leadership given they have to be fully integrated in their O&M and EHS Management Systems. TOIL and MEW must have the right mechanism in place to support TGS in fulfilling its EHS and OHS KPIs and contractual obligations. Responsibilities should not be lost or confused due to unclear authority and accountability between TGS and TOIL-MEW especially since one is a	- AGP has not been functional for over a decade. It is recommended that if AGP TOIL team will have actual work as part of the TGS team and not just a supervisory role that they be fully responsible under TGS leadership given they have to be fully integrated in their O&M and EHS Management Systems. Responsibilities should not be lost or confused due to unclear authority and accountability between	Substantial	Integrated AGP TOIL within TGS's EHS Management System to have an overarching EHSMS covering applicable risks with clear assignment of responsibilities and accountability. SEA/SH and GBV measures will be added in the EHSMS and adhered to by all concerned staff and as per the Labor Management Procedures prepared for the project; all staff shall be trained on them, should sign a code of conduct covering them, and shall adhere to them	Prior to Operation	Appendix B8

[22] See Table 2 for list of significant hazards and preventative measures

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	risks related to Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH), including Gender-Based Violence (GBV) in line with the national legislations, and the World Bank's Good Practice Note on SEA/SH. 3. **Specify the minimum age for workers. Do the facilities have a staff and workers register, any means for verification of age to prevent child labor?** 4. **Is there any risks of forced labor? If so, what is the mitigation in place?** 5. **Is there any code of conduct or charter of ethics for the laborers to sign?** 6. **Is there any accommodation of workers on site? What is its status** 7. **Is there a grievance mechanism available for all laborers and personnel? Is there any log that can be consulted?** 8. **Are the laborers of the facilities members of any association of laborers**		contractor and the other is the client while both have staff working on the project. 2. Neither AGP TOIL nor TGS have SEA/SH and GBV measures in place; those will need to be added in TGS' EHS Management System and adhered to by all concerned staff and as per the Labor Management Procedures prepared for the project; all relevant staff shall be trained on them, should sign a code of conduct covering them, and shall adhere to them and be regularly trained on them with all the necessary record keeping in place. TGS' code of conduct (**Appendix B8**) includes a section on sexual harassment and bullying (Section 23) in code of conduct; however, it could not be confirmed whether a mechanism and qualified personnel / professionals handle such cases. 3. Neither AGP TOIL nor TGS reported hiring children; the Lebanese labor law also prevents it. Employee registers are required by law and will be maintained by both AGP TOIL and TGS staff. 4. There is no risk of forced labor in this project. 5. TGS has a code of ethics including a section on sexual harassment and bullying; staff are required to adhere to it without needing to sign off on it. 6. There are old accommodation portcabins onsite (Receiving Station) from the construction phase of AGP but they are not being used. Those will not be used and need to be removed as reported by TOIL. TGS communicated that they will be renting accommodation outside the facility in nearby residential areas for all their staff. AGP TOIL staff have homes outside the facility. 7. AGP TOIL do not have a Grievance Mechanism; they can join the union for TOIL personnel whose committee can then take their issues to Management. Usually, unions are mostly concerned with negotiating better compensation. TGS have a grievance mechanism in place (TGS provided an unfilled employee complaint register in **Appendix B8**	TGS and TOIL-MEW especially since one is a contractor and the other is the client while both have staff working on the project. - Neither AGP TOIL nor TGS have SEA/SH and GBV measures in place; those will need to be added in TGS' EHS Management System, all staff shall be trained on them, should sign a code of conduct covering them, and shall adhere to them and be regularly trained on them with all the necessary record keeping in place.		and be regularly trained on them with all the necessary record keeping in place.		
ESS2-4	• **Are there any emergency preparedness plans?**	✓	Yes, both AGP LOIL and TGS currently have emergency management plans while a revised unified one is expected for both rehabilitation and operation phases of AGP.	Both AGP LOIL and TGS currently have emergency management plans while a revised unified one is expected for both rehabilitation and operation phases of AGP.	Low	Revised Emergency Management Plans covering all risks identified in the pre-rehabilitation risk assessment will be developed for both rehabilitation and operation phases of AGP.	Prior to rehabilitation and operation	
ESS2-5	• **Is there any safety escape plan at the facilities?**	Applies only to the PRS and metering station	The Metering Station (Receiving Station) is relatively small and has 2 exit doors, while the design and size of the station implies that exiting any office inside leads to facing one exit door. Notwithstanding, a plan and procedure need to be put in place with clear responsibilities need to be developed. The PRS is located within the Deir Ammar PP premises and needs to adhere to the PP's escape plan especially since the names of AGP staff accessing the PP should be recorded at the security gate of the PP, which should also be referred to during an emergency for a proper head count.	The Receiving Station does not currently have an escape plan and procedure while keeping mind that the building is small with 2 exits that provide sufficient emergency egress.	Low	TGS will account for an escape plan and procedure for the Receiving Station and will familiarize staff working on the PRS with the PP's escape plan	Prior to Operation	
ESS3	**ESS3 (Resource Efficiency and Pollution Prevention and management)**							
ESS3-1	***Energy Efficiency*** • **Does the facility have a record of total energy consumption including the different types of energy sources?** • **Dose the facility have an energy manager?** • **Does the facility have an energy management system? Does it have an energy saving opportunity register? Does it have energy reduction targets and action plan?**	×						
ESS3-2	***Water Efficiency*** • **Is water use/water discharged being monitored?** • **Are water consumption trends being recorded and analyzed? And does the power plant have a quantified water consumption baseline?** • **Are water leaks being fixed regularly by the maintenance team?**	×						

S/N	Task	Applica-bility	Natural Gas facilities Availability / Feedback	Summary of Key Issues	Non-Compliance Risk (Low, Moderate, Substantial, High)	Corrective Actions	Timeline	Support-ing Docs Appendix
ESS3-3	***Raw material use*** • **Are raw materials quantities recorded?** • **Is there a procurement procedure in place which assign weight and/or give preference to raw materials with less environmental impacts? And/or place environmental restrictions on certain materials?**	×						
ESS3-4	***Wastewater Management*** • **What are the parameters being monitored? And what are the key performance indicators (legal or other requirements)?** • **What is the monitoring frequency? And are the correct monitoring and sampling analysis methods being used at the right frequency?** • **In case of exceeding permissible limits, is investigation being performed?** • **Where applicable, is cooling water discharge being monitored? As well as ambient water quality of affected areas?**	Applicable to the PRS only (flaring of excess gas, gas leaks)	Essentially, hydrostatic testing of gas pipeline if conducted is not expected to generate wastewater exceeding discharge standards.	Hydrostatic testing of gas pipeline if conducted is not expected to generate wastewater exceeding discharge standards.	Low	TGS are expected to identify wastewater associated hazards and recommend appropriate monitoring prior to discharge and treatment if needed, including for hydrostatic testing if conducted.	Prior to Operation	
ESS3-5	***Spill control and management*** • **What are the current methods of controlling oil spills not only from storage tanks and pipelines, but from tank truck loading and unloading operations?** • **How many and what kind of spills have occurred and are there records to document satisfactory remediation?** • **Safety of storage of hazardous materials**	✓	Spills are only associated with existing generator diesel tanks present at Receiving Station and Border Station. Both these tanks are located above concrete pavement but are not bunded; spills can accordingly reach nearby soil (**Appendix B11**).	Spills are only associated with existing generator diesel tanks present at Receiving Station and Border Station. Both these tanks are located above concrete pavement but are not bunded; spills can accordingly reach nearby soil (**Appendix B11**).	Moderate	Spill trays and bunding equivalent to at least 110% of the capacity of the tanks in addition to spill kits and the appropriate spill prevention and control procedure should be in place.	Prior to Operation	Appendix B11
ESS3-6	***Waste Management*** • **Are there any waste prevention and/or minimization measures?** • **What are the current methods of waste disposal?** • **What offsite facilities have been used for waste disposal?** • **Are the offsite facilities recognized as "formal" or legally accepted site?** • **Do the facilities identify and separate hazardous wastes from domestic wastes?** • **How are the hazardous wastes treated?**	✓	Municipal waste at the Receiving Station is currently being collected by the Beddawi municipality contractor – Lavajet. The PRS at the Deir Ammar PP is expected to generate a small quantity of solid waste. Municipal waste at the Border Station will be minor given it is not expected to be continuously staffed except for the continuous presence of a security guard. There may be petroleum-contaminated soil encountered during the rehabilitation phase, at the location where the gas pipeline was punctured, which will be excavated; this could occur if adjacent crude oil pipelines have been also punctured in the past and led to soil contamination.	- Municipal waste at the Receiving Station is currently being collected by the Beddawi municipality contractor – Lavajet. - The PRS at the Deir Ammar PP is not expected to generate solid waste. - Municipal waste at the Border Station will be minor given it is not expected to be continuously staffed except for the continuous presence of a security guard. - There may be petroleum-contaminated soil encountered during the rehabilitation phase, at the location where the gas pipeline was punctured, which will be excavated; this could occur if adjacent crude oil pipelines have been also punctured in the past and led to soil contamination.	Low	The Operator will coordinate with Lavajet to secure bins for sorting at source at the Receiving Station (Control Room) and staff shall sort municipal solid waste generated. Any petroleum-contaminated soil excavated during the rehabilitation phase, shall be identified and managed in accordance with an EHS Plan (ESMP) and procedure approved with the authorities and particularly MoE; such a procedure would define the screening of excavated soil in terms of identification by observation, transfer onto isolated surface and containment, analysis for comparison with contamination thresholds, and transport and treatment / containment.	Upon start of operation	
ESS3-7	***Operational and Maintenance Program*** • **The O&M program of the facilities, including routine and preventative maintenance, review and opine on O&M costs;** • **Staffing, training program, labor management, key staff qualifications, capability and experience including international exposure/capabilities and track record;** • **Spare parts inventory and availability/risk of shortage.** • **Expected major maintenance requirements**	✓	TGS communicated that the O&M program as well as staffing will be finalized based on contractual agreement. Spare part inventory will need to be managed either based on a software with threshold based notifications or a manual inventory schedule ensuring there is no risk of spare part shortage.	- TGS communicated that there are no major maintenance requirements for the gas distribution network once rehabilitated. - Spare part inventory will need to be managed either based on a software with threshold based notifications or a manual inventory schedule ensuring there is no risk of spare part shortage.	Low	Spare part inventory will be managed based on either a software with threshold based notifications or a manual inventory schedule ensuring there is no risk of spare part shortage.	Upon start of operation	

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ESS3-8	***Violations, fines, and complaints*** • **Are there any outstanding violations or pending fines or penalties on the facilities? (such as air emissions, noise, disposal of wastewater, disposal of wastes, etc.)** • **Do the facilities have a history of violations or penalties?** • **Has the facility faced any court cases either through governmental or non-governmental stakeholders?** • **Has the facility received any formal or informal, verbal or documented complains from the nearby communities?** • **Does the facilities maintain and regularly update an environmental register?**	✓	No violations, fines, or complaints were reported by AGP TOIL staff on AGP TOIL. No community complaints related to AGP were identified through the consultations made. TOIL do not have an environmental register but TGS will develop one being the Operator.	TOIL do not have an environmental register but TGS will develop one being the Operator.	Low	The Operator (TGS) will develop an environmental aspect for the project.	Prior to Rehabilitation and Operation	
ESS3-9	***Air pollution and greenhouse Gases*** • **Does the facility have a continuous emissions control system (CEMS) or an alternative air emissions control system? In case of CEMS, what is the target reliability?** • **Is there an annual stack testing? Data verification and reporting? And exceedance investigation?** • **How often is air emissions sampling being conducted?** • **How often is exceedance investigation conducted? What is the reliability %** • **Is there a meteorological monitoring?**	×						
ESS3-10	• **Does the facilities have a record of greenhouse gases associated with fuel usage and other different activities? Does the record show the different scopes (i.e., scope 1; scope 2; and scope 3)[23]**	In case of gas flaring, is there a system to monitor GHS emissions?	There are 3 gas flaring units located at the Receiving Station – TOIL, PRS at the Deir Ammar PP, and at the Border Station. These are to be used for emergency situations only.	No key issues	Low	No action required		
ESS3-11	• **Does the facility have ambient air quality monitoring stations? How often are they serviced and calibrated**	✓	No ambient air quality station exists except for one owned by MoE, which is located in the Tripoli Tank Farm farther up the mountain from TOIL premises and has not been operational since 2019 due to lack of funds for O&M and a meteorological station measuring wind speed and direction located inside TOIL premises and owned and maintained by Lebanon's Meteorological Department (Beirut International Airport)	No key issues	Low			
ESS3-12	• **What are the air emissions monitoring parameters and key performance indicators?**	✓	Minor monitoring is currently being conducted, which is mainly associated with fugitive gas leak detection. No other emission and ambient air quality monitoring is required.	No key issues	Low			
ESS4	**ESS4 (Community health and Safety)**							
ESS4-1	**1. Health issues due to air pollution from the facilities** **2. Safety distance respected?** **3. COVID19 safety measures implemented** ***4.* Security Personnel present on site and codes of conduct**	✓	1. Air pollution from the gas network is not a pertinent environmental aspect considering that detecting leaks and eliminating them is at the core of the O&M program given the associated financial losses associated with those. Natural gas leaks are more relevant to GHG emissions rather than air pollution. 2. Any safety distances, which are subject to being defined by TGS depending on where the pipeline is passing, are not currently being respected. This is because the gas pipeline is located within a government owned ROW that is repeatedly being trespassed and	No evidence of Safety Distance has been observed nor a Manual of Permitted and Non-Permitted Activities within ROW and safety distance (to be defined). There seems to be no code of conduct for security personnel at present and this may need to be addressed in the EHS management system.	Substantial	Refer to ESS1-12 TGS and TOIL shall account for a code of conduct for security personnel.	Prior to Operation	

[23] If the data for scope 1, 2, and 3 of GHG emissions is not currently available, is there a plan to track the emissions of different activities related to the facilities?

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			encroached upon with different types of activities occurring; TOIL were successful at preventing permanent construction from being built on the ROW but they have been unable to stop agricultural activities and private backyards from extending on it as well as its use as road access, as a truck and car park and as miscellaneous outdoor storage or dumps. 3. Not applicable at present 4. Security personnel are present but they only control access to the site and have no authority in terms of officially communicating to the public. There seems to be no code of conduct for security personnel at present and this will need to be addressed in the EHS management system.					
ESS4-2	**1. Noise reducing or elimination devices** **2. Lockable gates, security cameras, security alarms** **3. Site visitor register and restriction of public access,**	Metering station and PRS	1. PPE requirements in general and ear protection in particular are indicated using signs (**Appendix B11**) 2. Lockable gates and security cameras at present at the Receiving Station. The PRS is monitored by the CCTV system of the Deir Ammar PP. 3. The Receiving Station is located within TOIL premises with already controlled access while it also has its own controlled access – it is not clear yet if this access will also be operational of TOIL access control will be relied on. It is important to note that TOIL premises can be occasionally accessed without being stopped. More stringent access control is recommended.	TOIL premises can be occasionally accessed without being stopped. More stringent access control is recommended.	Substantial	More stringent access control is recommended to TOIL premises shall be enforced.	Immediate	Appendix B11
ESS4-3	• **Assess the effectiveness of the operation Feedback and Grievance Redress Mechanism (FGRM) in terms of its accessibility, credibility, effectiveness in resolving grievances, resourcing, etc. Specific attention needs to be paid to the assessment of FGRM for SEA/SH and focus will be on understanding whether the system is functioning, and protocols and practices established are in line with the World Bank's Good Practice Note on SEA/SH**	✓	An FGRM including SEA/SH is currently lacking.	An FGRM including SEA/SH is currently lacking.	Substantial	An FGRM including SEA/SH shall be developed for the AGP.	Prior to Operation	
ESS5	**ESS5 (Land Acquisition, restrictions on Land use and Involuntary resettlement)**							
ESS5-1	**1. History of land acquisitions for the facilities if any and the associated history of compensation collections and notifications to landowners** **2. Time of land acquired** **3. Ownership and land use of acquired land (for instance, vacant state-owned land, state owned land with occupancies and uses, private owned land with legal titles, land used by tenants)** **4. Approaches of land acquisition (for instance, transferring by government at free of charge, willing buy and willing seller approach, eminent domain)** **5. Is there any documentation of land acquisition, is there any Resettlement plan?** **6. Is the any presence of formal and informal settlers or land users around the facilities who will need to be physically or economically displaced for the**	✓ In addition, what is the current status of the land use within the right of way of the pipeline?	1-5. All lands were nationalized by GOL from IPC and the Mediterranean Sea Pipeline Company (**Appendix B3**) and their ownership was later transferred to the benefit of MEW-LOIL in 1973 with the process of changing plot owner names on property records still ongoing today 6-8 There are trespassing and encroachment of private individuals/entities on the ROW which hinder continued access along the ROW for O&M and thus expose encroachers and the general public to H&S risks.. Encroachment includes agricultural activities, private backyard extension onto ROW, neighborhood road access, use of ROW as car and truck park space and as miscellaneous outdoor storage or dumps. More serious encroachment like concrete constructions (on ROW in general and other LOIL land) often lead to legal cases against encroachers and are managed by LOIL and TOIL's legal department (examples in TOIL correspondence in **Appendix B12**). 9. No complaints regarding land seizure by GoL were reported and LOIL legal department indicated that statute of limitations (10 years) has elapsed. 10. No restrictions associated with the facilities directly were reported; any restrictions would be due to the zoning code in the areas in questions.	- There are trespassing and encroachment of private individuals/entities on the ROW which hinder continued access along the ROW for O&M and thus expose encroachers and the general public to H&S risks. Encroachment includes agricultural activities, private backyard extension onto ROW, neighborhood road access, use of ROW as car and truck park space and as miscellaneous outdoor storage or dumps. - In case safety studies and separation distance do not trigger additional resettlement needs, impacts on livelihood are expected to be low if any. This is mainly because TOIL reported that the encroachment of agricultural land is mainly from large agricultural fields and not small right holders. - Main risk would be related to a wider separation distance, if required through safety studies, which could trigger further resettlement needs.	Substantial	- Any compensation of encroaching parties shall be evaluated following a risk assessment for the gas pipeline within the ROW in terms of whether it is safe to allow encroaching parties to continue their activities or to require their removal for the sake of future integrity of the ROW and their own safety. At the moment the only activities that if removed, could lead to economic displacement are agricultural activities. Livelihood restoration measures would in this case apply. - What is not known at the moment is the safety distance from the pipeline as a result of a quantitative risk assessment, and once defined, what would be the impacts and associated requirements, if any, to relocate structures and activities. It is therefore recommended to conduct the following: - A Resettlement Action Plan and/or Livelihood Restoration Plan consistent with ESS5 covering both economic and physical resettlement (in case triggered by safety studies) - Safety studies and workshops (HAZID, QRA, As Low As Reasonably Practicable (ALARP) study and workshop, and a Manual of Permitted Operations study and workshop (MOPO))	Prior to rehabilitation pipeline before operation	Appendix B12

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	project? What is the number of people affected if any? **7. Compensation value and payment if eminent domain is used for land acquisition** **8. The method in determining the compensation value and willing buy-willing seller price** **9. Any pending issues or unresolved complaints for the past land acquisition conducted for the facilities, if there is any** **10. Is there any restriction on land use or access to lands in the area near the Plant and the AGP because of the facilities?**							
ESS6	**ESS6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources)**							
ESS6-1	• **Clarify the impact(s) if any of the facilities on ecosystem services.** • **Are the facilities affecting any natural reserve or habitat? (for example, Palm Island – Tripoli)**	✓	The AGP facilities have no pertinent impact on ecosystem services – the pipeline is buried 2 meter below ground level at least and 4 meters below important river beds as well as being encased in concrete when crossing underneath stream beds (refer to Pipeline Profile in **Appendix B10**).	No key issues	None	No action required		Appendix B10
ESS6-2	• **Are the facilities affecting marine and coastal ecosystems and biodiversity (cooling of turbines using sea water)?**	×						
ESS8	**ESS8 (Cultural heritage)**							
ESS8-1	• **Are there any tangible and intangible heritage (including natural and archeological protected zone), which may be affected by the facilities?**	✓	The gas pipeline already exists inside a historically cleared ROW	No key issues	None	No action required		
ESS10	**ESS10 (Stakeholder Engagement and Information Disclosure)**							
ESS10-1	**1. Review and assess the adequacy of the facilities stakeholder identification, analysis and engagement and communication progress and assess current and planned stakeholder engagement activities.** **2. Identify potentially vulnerable groups in this project and assess how the facilities are engaging such stakeholders.** **3. Is there any GRM in place that is functional, accessible and inclusive for communities? What is the mechanism, the uptake channels, the timelines to close complaints, and is there a GRM log?** **4. Do students, (Non-Governmental Organizations) NGOs, or researchers have access to information from the facilities? Is there any mechanism that is followed?** **5. Is there a communication strategy in place?**	✓	1. There is no stakeholder engagement planning yet. 2. In the context of the gas pipeline present inside an ROW, the parties illegally encroaching on the existing ROW and gas pipeline path would need to be identified and characterized to assess whether they fit the vulnerability criteria set by the Bank[24]. Encroachments activities fall under the following categories: o Agriculture o Road access along the ROW o Private backyard extension on the ROW o Car and truck park areas o Miscellaneous outdoor storage or dumps Parties undertaking such activities are aware of the illegal nature of their encroachment given that they have been repeatedly advised of them by TOIL staff who reportedly still patrol the ROW at least once a week. If a decision is taken to clear the ROW, parties illegally encroaching on the ROW may face the following losses: o Loss of a season's agricultural produce if clearance occurs during an active agricultural season; o Road access to neighborhood – this needs to be coordinated with the local municipality who used the ROW as road access and even asphalted it in some cases to grant such access (it is not known if the municipality requested access from the Ministry of Public Works and Transport and the Ministry did not respond, which led to this situation) o Rebuilding private backyard fence at the correct plot boundary with due consideration to legal setback distances.	- A SEP is currently lacking but under preparation by the Ministry of Energy and Water which will be cleared by the World Bank and disclosed prior to the appraisal stage - Parties illegally encroaching on the existing ROW and gas pipeline path would need to be identified and characterized to also assess whether they fit the vulnerability criteria set by the Bank in case of resettlement or livelihood restoration need. - Impacts could arise in case safety studies indicate the need for a wider safety distance than ROW or special measures whenever gas pipeline crosses within urban centers; this needs to be confirmed once safety studies are completed; this safety assessment process has been initiated by MEW. - A GRM is currently lacking. - A communication strategy is currently lacking.	Substantial	- A SEP is currently lacking but under preparation by the Ministry of Energy and Water which will be cleared by the World Bank and disclosed prior to the appraisal stage. - An FGRM including SEA/SH shall be developed for the AGP as part of the EHS Management System prior to start of rehabilitation. - An explicit communication and awareness campaign is required as part of a SEP to inform and sensitize the public on the risks of gas pipelines, on its direct financial benefits in terms of increased power supply and associated cost reduction to them, Environmental and Social benefits. Information dissemination on the risks associated with vandalism of the gas pipeline and structure as well as from the adjacent crude oil pipelines is also important. - Signage shall clearly indicate an abbreviated phone number to use for reporting leaks or vandalism to the gas pipeline or adjacent crude oil ones. - A very clear and enforceable communication protocol between the operator, owner, authorities (civil defense, paramedics, the army, and internal security forces on the one hand and the general public and the press on the other shall be defined and implemented to avoid misinformation and confusion; this will anyway be needed in emergency management. Incentives such as rewards for reporting leaks and vandalism	Prior to Rehabilitation	Appendix B13

[24] Those who may be more likely to be adversely affected by the project impacts and/or more limited than others in their ability to take advantage of a project's benefits.

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			o Additional impacts could arise in case safety studies indicate the need for a wider safety distance 3. There is no GRM yet at present. 4. Students have been historically allowed to serve internships at TOIL facilities. 5. There is no communication strategy in place yet. TGS provided a sample Communication Procedure for their Jordan activities (**Appendix B13**)			may be considered conditional to not conflicting with cultural and ethical norms. - Means to access pertinent information at any time shall be advertised for the general public so that they can directly obtain information following an incident or accident thus avoiding misinformation from anecdotal information. - A communication strategy shall be prepared.		

TABLE B2. LIST OF SIGNIFICANT HEALTH AND SAFETY HAZARDS - AGP

Anticipated hazards together with the significant corresponding preventative measures to reduce or eliminate these hazards
ANSWERS PROVIDED BY TGS

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Lack of safety studies	Devices might not function correctly under all reasonably foreseeable situations	HAZOP STUDY , MANAGEMENT OF CHANGE PROCEDURE
Crushing Shearing Cutting or severing Entanglement	Moving parts Uncontrolled movement Fingers trapped during maintenance activity Operator trapped in valves/actuators Clothing trapped in rotating parts	PERMIT TO WORK PROCEDURE , WORK INSTRUCTIONS , MECHANICAL ISOLATION , RISK ASSESMENT FOR OPERATION or HAZARD IDENTIFICATION
Trapping	Person trapped within an enclosed space and unable to escape Operator trapped in enclosure dampers, potential for severing	PERMIT TO WORK PROCEDURE , CONFINED SPACE ENTRY WORK INSTRUCTION
Impact	Foreign matter in the gas turbine Mechanical disassembly Blade failure	N/A NO TURBINE
	Foreign matter in the ventilation system followed by violent disassembly of enclosure ventilation fan blades	N/A NO TURBINE
	Violent disassembly of air-blast oil-cooler fan, damage to cooler matrix creating potential for fire	N/A NO TURBINE
	High positive/negative enclosure pressure causing uncontrolled door movement/ straining forces Entry hazards	HYDRAULIC AUTOMATIC DOOR CLOSER
	Icing at gas turbine compressor air inlet causing gas turbine compressor surge	N/A NO TURBINE
	Starter-motor rotor failure	N/A NO TURBINE
Cutting, severing	Sharp edges/corners	INSPECTION , NEARMISS , SAFETY SIGN
Falling or ejection of objects	Maintenance tools causing sparks in a hazardous zone Operator injured by falling objects during periods of maintenance	TOE BOARD , PRE JOB INSPECTION , PERMIT TO WORK PROCEDURE
Break-up: Loss of containment	Fault in driven unit causing violent disassembly	PREVENTIVE MAINTENANCE
	Failure of high speed rotating components	PREVENTIVE MAINTENANCE , SCADA SYSTEM , WORK STATION
High pressure-fluid injection or ejection	Over-pressure in high pressure hydraulic water wash systems, low-pressure gas turbine lubricating oil systems, fuel systems, instrument air supply, and steam-injection supply Over-pressure in fluid lines where fluid is trapped	WORK STATION
Fuel vapor lock	Rupture of pressure equipment containing dangerous media	SAFETY RELIEF VALVE
Over-pressure ejection	Failure of gas turbine pressure casing containment	N/A NO TURBINE
	Over-pressure in enclosures due to extinguishant discharge Over-pressure in the gas turbine enclosure due to breach of gas turbine pressure casing	N/A NO TURBINE
	Surge causing over-pressure in the combustion inlet, inlet filter/ducting/flexible fracture and structural failure	N/A NO TURBINE
	Exhaust over-pressure due to uncontrolled exhaust damper closure Pulse in exhaust on shut-down due to engine surge	OVER PRESSURE ALARM
	Unsafe discharge at gas turbine compressor bleed valve	N/A
	Positive pressure in lube oil tank when opening filler, release of carcinogenic oil vapors into the atmosphere	N/A
	Excess pressure in the fire extinguisher/propellant bottles causing burst disc to blow	SAFETY RELIEF VALVE
Excess pressure from interface to exhaust heat recovery system	Lack of adequate control with the potential for incorrect operation	N/A
Loss of stability of machine or machine parts	Collapsing of parts or equipment	PREVENTIVE MAINTENANCE , CORRECTIVE MAINTENANCE CHECKLIST , TEST
Slip, trip and fall hazards	Falling from a height due to poor access Standing surfaces, walkway surfaces	RAIL SYSTEM , FALL PROTECTION SYSTEM , PERMIT TO WORK PROCEDURE
Contact of persons with live parts	Inability to isolate/guard a supply, electrocution	MECHANICAL BARRIER, RISK ASSESMENT , PERMIT TO WORK PROCEDURE, PERSONAL PROTECTIVE EQUIPMENT
	Electric shock from stored energy in capacitors	DISCHARGE CAPACITOR , TEST CAPACITOR
Electrostatic phenomena External influences	Cross interference from wiring Electrical, static and electromagnetic interference causing loss of control Lightning strikes causing short circuit/ malfunction of equipment and loss of control	EARTHING SYSTEM PREVENTIVE MAINTENANCE
Thermal radiation	Thermal radiation from hot casings affecting the safe operation of instrumentation	HEAT ISOLATION

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
Effects from short circuits, overloads, etc.	Generator short-circuit or faulty synchronization causing over-torque	ELECTRICAL PROTECTION
Environmental influences on electrical equipment	Water ingress causing short circuit/ malfunction of equipment leading to loss of control, electrocution In ocean coastal areas, build-up of salt from spray	CALSSIFIED ELECTRICAL COMPONANT - PREVENTIVE MAINTENANCE
Damage to equipment from environment contamination	Premature failure of turbine components	N/A NO TURBINE
Burns, other injuries from contact with temperature	Contact with cold surfaces due to pressure reducing valves or extinguishant/ propellant release Cold surfaces due to expansion of liquid to vapor	PERSONAL PROTECTIVE EQUIPMENT , PERMIT TO WORK PROCEDURE , SAFETY SIGN , THERMAL ISOLATION , FIRST AID
Hot/cold surfaces	Contact with hot/cold surfaces	PERSONAL PROTECTIVE EQUIPMENT , PERMIT TO WORK PROCEDURE , SAFETY SIGN , BARRIER , FIRST AID
Damage to health by hot or cold working environment	Chill factors generated by air flow/ ventilation. Overheating due to inadequately insulated hot surfaces and/or poor location of hot air outlets. Prolonged entry in enclosure producing heat stroke	PERSONAL PROTECTIVE EQUIPMENT , PERMIT TO WORK PROCEDURE , SAFETY SIGN , BARRIER , FIRST AID
Damage to equipment from cold environment	Equipment failure Brittle fracture	VENT AT LARGE INTERVALS
Noise	High noise level from bleed valves, vents and motor exhausts Noise emission within the environment due to fluid flow	PERSONAL PROTECTIVE EQUIPMENT , WORK INSTRUCTIONS, MEASURING AND MONITORING NOISE MAESURE, SAFETY SIGN
	Noise levels impairing communications	N/A
	Noise in the environment due to pulsing of pulse clean inlet system	N/A
	Interference with speech Less effective communication due to noise levels Hearing loss, due to higher than predicted noise levels	N/A
	Vibration on high speed equipment leading to failure Critical speed encountered in rotating equipment	PREVENTIVE MAINTENANCE , WORK STATION , ESD
	Vibration of unsupported pipe work, structures, etc. leading to failure	DESIGN (STRESS ANALYSIS)
	Higher-than-permitted velocity of gas through the flexible pipes Potential for rupture	N/A
Low-cycle fatigue failure	Premature failure	INSPECTION
Low-frequency, radiofrequency radiation, micro-waves	Uncontrolled operation of electrical/ electronic equipment due to external interference	N/A
Infrared, visible and ultraviolet light	Failure of non-metal high pressure hose on extinguishant piping caused by UV degradation	N/A
X- and gamma-rays	Damage to health	R.T. PERMIT TO WORK
Radiation	Arc or other type of flash causing inadvertent operation of fire detectors causing release of extinguishant	PERMIT TO WORK PROCEDURE , WORK INSTRUCTION
Substances	Exposure to high levels of H2S from gas fuel. Dangerous substances encountered during operation	N/A
	Materials subjected to H2S contamination failing due to corrosion	N/A
Poor identification of piping contents	Inability to identify piping containing dangerous media	TYPE AND FLOW DIRECTION SIGNS
Contamination	Reverse flow of fluids into service lines causing contamination Fuel contamination of oil	N/A
	Liquid hydrocarbon contamination of gas fuel	FILTRATION AND DRAIN SYSTEM
Asphyxiation	Uncontrolled release of extinguishant inside enclosures/gas turbine hall Smoke within enclosure due to presence of a fire	N/A NO TURBINE
	Asphyxiation and poisoning due to oxygen depletion by leaks from exhaust with high carbon monoxide content on partial load operation	WORK INSTRUCTION
	Asphyxiation due to inadequate venting of battery room	EXPLOSION PROOFE VENTILATION SYSTEM, DETECTION SYSTEM
Fire or explosion hazard	Gas leak in enclosures/gas turbine hall	MEASURIND AND MONITORING GAS LEAK TEST , WORK STATION/ N/A
	Gases or vapors in the gas turbine enclosure prior to start-up Potential for fire and explosion	N/A NO TURBINE
	Recirculation of gas turbine ventilation air for anti-icing producing a hazard due to an enclosure fuel leak	N/A NO TURBINE
	Leak/spray of liquid fuel, hydraulic fluid, lubrication oil onto hot surfaces	DETECTION SYSTEM , PREVENTIVE MAINTENANCE
	Ingestion of explosive gas/hydrocarbon vapors into gas turbine compressor air inlet, enclosure ventilation inlet, generator cooling air inlet Leak of gases into the environment in potentially unsafe areas	MSDS , DETECTION SYSTEM , PREVENTIVE MAINTENANCE
	Deliberate ingestion of excess waste substances	MSDS , WASTE MANAGEMENT PROCEDURE
	Pre-ignition of fuel when in contact with hot internal surfaces at start-up	ESD

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
	Failure of reverse purge during shut-down from low auto-ignition temperature fuel Explosion/fire on re-start	ESD
	Loss of AC whilst running on low auto ignition temperature fuel causing purge failure. Explosion/Fire on re-start.	ESD
	Battery gas ignites in battery room	DETECTION SYSTEM , TOTAL SUPRESSION SYSTEM
	Over fueling of gas turbine on light-up	N/A NO TURBINE
	Excess fuel leading to danger	ESD , DETECTION SYSTEM
	Fuel shut-off valve failure	HAZOP STUDY (DESIGN)
	Unignited gases/liquids and vapors internal to the gas turbine/exhaust system/ waste-heat boiler	N/A NO TURBINE
	Failure to detect flame-out while gas turbine is running	N/A NO TURBINE
	Gas/liquid fuel flowing into a shut-down gas turbine	N/A NO TURBINE
	In-rush of oxygen into the acoustic enclosure following a fire	ESD, DETECTION SYSTEM
	Electrical insulation failure	PREVENTIVE MAINTENANCE , INSPECTION
	Fire due to incorrect use of solvent wash or other cleaning fluids	DETECTION SYSTEM , SUPPLIER WORK INSTRUCTION
	Internal oil leak within gas turbine following loss of seal air	N/A NO TURBINE
	Loss of fire extinguishant leaving no protection	INSPECTION , MAINTENANCE
	Leaking acoustic enclosure depleting extinguishant concentration	INSPECTION , MAINTENANCE
	Rupture of off-package fuel pipework due to a gas turbine structural failure	N/A NO TURBINE
	Potential for fire in lubrication system breather ducting due to close proximity of exhaust ducting	DESIGN
	Loss of ventilation due to icing or other blockage at ventilation inlet	N/A
	Incorrect use of materials, titanium and magnesium alloys	N/A
	Leakage due to incorrect treatment of drains	WORK INSTRUCTION
	Detector not sensitive to gas or vapor being detected Gas detection out of calibration	MEASURIND AND MONITORING GAS LEAK TEST , CALIBRATION PLAN , PREVENTIVE MAINTENANCE
	Insufficient water mist by design to extinguish the fire Water mist extinguishant not distributed to all areas of the gas turbine enclosure	N/A NO TURBINE
	Freezing of water prevents water mist extinguishant discharge	N/A
	Blockage of water mist nozzle or system components by rust particles or refill water Blockage of water mist nozzles after discharge	PREVENTIVE MAINTENANCE
	Manually operated extinguishant isolation valve not open	INSPECTION , MAINTENANCE
	Unburnt liquid fuel in exhaust can escalate to an explosion of any fuel vapors	ESD
	Enclosure ventilation fan failure not detected	PREVENTIVE MAINTENANCE
	Enclosure dampers fail to close Inert atmosphere within enclosure depleted, potential re-ignition of any fire	PREVENTIVE MAINTENANCE
	Failure to disperse heavier-than-air fuel vapors Potential for vapors to settle in low-level areas/trenches and to migrate to safe areas	PREVENTIVE MAINTENANCE
	Auto-ignition of fuel when in contact with hot internal surfaces during start-up	DETECTION SYSTEM , TOTAL SUPPRESSION SYSTEM , ESD
	Potential explosion of vapors in the drain/ vent tanks due to temperature of purge discharge in piping Explosive mixtures in purge lines	SAFETY RELIEF VALVE
	High breather backpressure due to failed fan in breather coalescer	TEMPERATURE RELIEF VALVE
	No signal to fire extinguishant system, no release	PREVENTIVE MAINTENANCE
	Incorrect treatment of vents and drains causing a dangerous situation	PREVENTIVE MAINTENANCE PROCEDURE
	Incorrect identification of hazardous zones	REVIEW BY CONSULTANT
	Over-temperature in gas starter motor due to supply contamination causing mechanical failure, potential for failure of casing or seals Gas can leak and ignite	N/A NO TURBINE
	Reverse flow through gas starter motor causing failure	N/A NO TURBINE
	Reverse flow from heat recovery to turbine	N/A NO TURBINE
	Uncontrolled release from H2 cooled generators	N/A
Mechanically generated sparks/hot surfaces	Potential for explosion Sparking of fan blades	PREVENTIVE MAINTENANCE
Smoke	Poisoning of gas detectors and blinding of fire detectors due to vapors from oil on hot gas turbine surfaces, gaskets and other joints burning in	PREVENTIVE MAINTENANCE

HAZARD	HAZARDOUS SITUATION	PREVENTATIVE MEASURES
	Smoke from cabling due to electrical insulation fault Smoke from fire within acoustic enclosure	DETECTION SYSTEM
Pollution	General pollution hazard	MEASURING AND MONITORING (EMISSIONS) – FOR NEIGHBOURS E.R.P.
	Oil mist at breather outlet, potential for carcinogenic exposure, environmental pollution and risk of fire	PREVENTIVE MAINTENANCE
	Pollution due to incorrect treatment of drains Pollution due to incorrect treatment/control of vents	PREVENTIVE MAINTENANCE
	Disposal of product and components at the end of their useful life	WASTE MANAGEMNT PROCEDURE
	Operation of gas vents	FALRE SYSTEM
	Tank overflow	LIMIT SWITCH , DYKE SYSTEM
Unhealthy postures or excessive effort	Hard-to-handle components and inadequate lifting provision	HANDLING PROCEDURE , LIFTING PROCEDURE
Neglected use of personal protective equipment (PPE)	Injury	PERSONAL PROTECTIVE EQUIPMENT , AWARNESS , TRAINING
Inadequate local lighting	Inadequate lighting preventing escape	MEASURING AND MONITORING (LIGHT)
Mental overload and stress	Inadequate instructions and maintenance	LEGAL REQUIRMENT
Errors made by the operator	Absence or incorrect fitting causing injury or death Human factors leading to incorrect assembly of critical parts Human factors leading to guards missing	WORK INSTRUCTION , OPERATING PROCEDURE
Inadequate design, location or identification of manual controls or visual display units	Incorrect operation	CODE AND STANDERED
Combination of hazards	Hazard combinations prevent correct operation of safety devices	PREVENTIVE MAINTENANCE
	Water in the gas, solids in gas, potential for starter motor damage and failure	KNOCK OUT DRUM (SEPARATOR)
	Liquid hydrocarbon condensates in starter motor exhaust when gas supply is near dew point	ESD
	Contamination of liquid fuel storage with low auto-ignition fuel. Potential for vapor lock/explosion at fuel burner nozzles, lack of control	GAS ANALYSER
	Lack of effective hazardous-fuel purging, potential for illness from contaminants	PURGE STANDERED
	Wax formation in liquid fuel at low temperature, blockage, loss of control	N/A
Malfunction of control system, software errors	Unexpected operating condition	PREVENTIVE MAINTENANCE
Failure of safety related devices	Fire, explosion, injury to personnel, poisoning, suffocation, etc. due to lack of maintenance	DETECTION SYSTEM , TOTAL SUPRESSION SYSTEM , PREVENTIVE MAINTENANCE
Disorder of controls Unexpected start-up	Machine starts when undergoing maintenance Starting of peripheral equipment while maintenance is being carried out	HAZOP STUDY , MANAGEMENT OF CHANGE PROCEDURE
Uncontrolled device operation	Injury from inadequate means of prevention	PERMIT TO WORK PROCEDURE , WORK INSTRUCTIONS , MECHANICAL ISOLATION , RISK ASSESMENT FOR OPERATION or HAZARD IDENTIFICATION
Failure/disorder of the control system	Loss of internal temperature control in the gas turbine leading to premature fatigue	PERMIT TO WORK PROCEDURE , CONFINED SPACE ENTRY WORK INSTRUCTION
	Loss of speed control with the potential for overs peed Loss of effective governing with the potential for over-fueling	N/A NO TURBINE
	Loss of control Uncontrolled operation	N/A NO TURBINE
Valves out of position	Uncontrolled supply, venting or draining of dangerous media	N/A NO TURBINE
Lubrication oil supply control	Inadequate lubricating oil supply leading to machinery failure	HYDRAULIC AUTOMATIC DOOR CLOSER
Loss of utility supply	Uncontrolled operation of safety devices	N/A NO TURBINE
Failure of energy supplies	Loss of oil supply leading to unsafe shutdown	N/A NO TURBINE
	Loss of adequate ventilation Failure of detection devices Uncontrolled operation of safety device	INSPECTION , NEARMISS , SAFETY SIGN
	Loss of HVAC to control cabinet	TOE BOARD , PRE JOB INSPECTION , PERMIT TO WORK PROCEDURE
Restoration of energy supply	Gas accumulation on ventilation failure	PREVENTIVE MAINTENANCE
Failure of energy supply disconnecting devices	Absence or incorrect fitting can cause injury or death to the operator or bystanders	PREVENTIVE MAINTENANCE , SCADA SYSTEM , WORK STATION
External influences, gravity, wind, seismic loads	Structural collapse	WORK STATION
External influences, winds	Uncontrolled rotation of rotors	SAFETY RELIEF VALVE

TABLE B3: HAZARD IDENTIFICATION FOR PIPELINE STATIONS (RECEIVING, PRESSURE REDUCING, AND BORDER STATIONS)

ANSWERS PROVIDED BY TGS

EVENT	CAUSE	CONSEQUENCE	PROTECTION OR SAFETY MEASURE
Pipeline gas release leading to jet fire	General leaks	Continuing incident with heat radiation to surrounding land use	PREVENTIVE MAINTENANCE , MEASURING AND MONITORING GAS LEAK TEST
Pipeline pinhole, hole/rupture leading to gas release	1.External Damage from 3rd party interference	Gas release leading to jet fire.	OPERATION PHILOSIPHY , SCADA SYSTEM , PATROLLING
	2. Corrosion: - internal - external - stress corrosion cracking - high voltage (AC) transmission lines closely parallel to the pipeline, resulting in stray currents and increased corrosion.	Gas release leading to jet fire.	MEASURING AND MONITORING (CATHODIC PROTECTION – THICKNESS), ONLINE INSPECTION
	3.Ground movement	Gas release leading to jet fire.	ONLINE INSPECTION
	4.Construction and material defects	Gas release leading to jet fire.	ONLINE INSPECTION
	5.Flood scour damage	Gas release leading to jet fire.	PIPE LINE PHYSICAL PROTECTION
	6.Sabotage	Gas release leading to jet fires.	EMERGENCY RESPONSE PLAN
	7.Bushfire / grassfire	Damage to compressor station leading to pipeline failure and gas release.	EMERGENCY RESPONSE PLAN
Compressor Station small, medium and large leaks	1. Corrosion of gas meter and equipment	1. Gas release leading to jet fire 2. Explosion potential in compressor building	MEASURING AND MONITORING (CATHODIC PROTECTION)
	2. Impact / Vibration and failure of small bore fittings	1. Gas release leading to jet fire 2. Explosion potential in compressor building	MEASURING AND MONITORING
	3. Sabotage	1. Gas release leading to jet fire 2. Explosion potential in compressor building	EMERGENCY RESPONSE PLAN
	4. Lightning Strike	1. Gas release leading to jet fire 2. Explosion potential in compressor building	MEASURING AND MONITORING (EARTHING)
	5. Hole in gas pipework, valves, gland leak & flange gasket leak (including flanges); 6. Leaks in compressor seals, casing; 7. Pinholes, holes in gas cooler.	1. Gas release leading to jet fire 2. Explosion potential in compressor building	MEASURING AND MONITORING GAS LEAK TEST N/A NO TURBINE PREVENTIVE MAINTENANCE
Gas receivable station (within the Power Station)	1. Impact 2. Corrosion 3. Small bore fitting failure 4. Flange gasket leak 5. Valve gland leaks	1. Gas release leading to jet fire 2. Explosion potential in compressor building	PHYSICAL BARRIER, SAFETY SIGN MEASURING AND MONITORING (CATHODIC PROTECTION) MEASURING AND MONITORING GAS LEAK TEST MEASURING AND MONITORING GAS LEAK TEST MEASURING AND MONITORING GAS LEAK TEST
Gas turbine facility leaks	1. Corrosion 2. Small bore fitting failure 3. Flange gasket leak 4. Valve gland leaks	1. Gas release leading to jet fire 2. Explosion potential in gas turbine enclosure	NA
Diesel tank fire	1. Hot work 2. Pump overheating 3. Incorrect product specification 4. Tank overfill	1. Tank roof fire 2. Bund fire	PERMIT TO WORK N/A NO TURBINE N/A LIMIT SWITCH

TABLE B4: HAZARD IDENTIFICATION FOR HIGH PRESSURE GAS PIPELINES

ANSWERS PROVIDED BY TGS

EVENT	CAUSE	CONSEQUENCE	PROTECTION OR SAFETY MEASURE
1. Mechanical impact on the pipeline causes leak of natural gas from the pipeline.	3 rd party involvement e.g. digging or trenching, or other earth work. 1 st party involvement. Non through wall damage, i.e. part wall or delayed failure damage.	Massive release of natural gas (NG). If ignition, then possibility of flash or jet fire. Physical explosion from the pressure of the pipeline creates projectiles (earth, sand, stones). Injury and property damage.	PERMIT TO WORK, PATROLLING PERMIT TO WORK, ONLINE INSPECTION, MEASURING AND MONITORING (THICKNESS)
2. Corrosion leads to leak of natural gas from the gas pipeline.	Damage of pipeline coating due to excavation inspection damage leads to corrosion. Construction damage or coating flaw or faulty materials	Release of gas. If ignition, a jet fire is possible. Injury and property damage.	ONLINE INSPECTION , EXTERNAL COATING DIRECT ASSESSMENT
3. Nearby explosion at neighboring natural gas pipeline or tie-offs.	Incident (wear and tear, mechanical impact, lightning strike etc. etc.) at the parallel natural gas pipeline.	Possible damage to gas pipeline with release of natural gas (NG). If ignition, then possibility of flash or jet fire. Injury and property damage.	EMERGENCY RESPONSE PLAN
4. Pressure excursion leads to failure of the pipeline.	Operational error upstream or downstream facility.	Over pressuring the gas pipeline causing failures, leaks and release of natural gas. If ignition, then possibility of fire. Injury and property damage.	WORKSTATION AND SCADA ISOLATE AFFECTED PIPE SEGMENT FROM BOTH ENDS, AND TRIGGER HIGH FLOW VENTING AND FLARING OF GAS IN ISOLATED PIPE SEGMENT.
5. Spontaneous loss of integrity of pipe	Construction defect or operational error (repeated).	Massive release of natural gas. If ignition, then possibility of flash or jet fire. Injury and property damage.	ONLINE INSPECTION
6. Erosion results in damage to piping and equipment.	Flooding	Potential for flood waters to wash away soil cover. May cause pipeline to be exposed. Possibility of damage to coating and subsequent corrosion issues. If not corrected may eventually lead to failure of pipeline.	PIPE LINE PHYSICAL BARRIER
7. Land subsidence results in pipeline damage.	Mining activities in area or earthquake creates	Failure of pipeline resulting in potential for rupture or massive leak. Release of natural gas. If ignition, then possibility of flash or jet fire. Injury and property damage.	PATROLLING
8. Aircraft, train or heavy vehicle crash result in damage to pipeline resulting in hazardous releases.	Aircraft crash. Heavy vehicle crash.	Potential damage to pipeline resulting in hazardous releases, fire / explosion.	EMERGENCY RESPONSE PLAN , PATROLLING , PIPE LINE PHYSICAL BARRIER , SAFETY SIGN
9. Damage to pipeline through terrorism / vandalism.	Malicious damage.	Massive release of natural gas. If ignition, then possibility of flash or jet fire.	EMERGENCY RESPONSE PLAN , IN CASE OF MALICIOUS DAMAGE, SCADA -ISOLATES AFFECTED PIPE SEGMENT FROM BOTH ENDS, TRIGGERS HIGH FLOW VENTING AND FLARING OF GAS IN ISOLATED PIPE SEGMENT.
10. Neighboring fire.	Bush / brush fire.	Possible heat radiation at pipeline. If damage to pipe and equipment then possibility of release of hazardous material and fire risk.	EMERGENCY RESPONSE PLAN , PUBLIC CONSULTATION, AWARENESS OF OUR BUSINESS , PATROLLING

ANNEX C – WORLD BANK GUIDELINES

Environmental, Health, and Safety General Guidelines

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These **General EHS Guidelines** are designed to be used together with the relevant **Industry Sector EHS Guidelines** which provide guidance to users on EHS issues in specific industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment[2] in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The **General EHS Guidelines** are organized as follows:

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

[2] For IFC, such assessment is carried out consistent with Performance Standard 1, and for the World Bank, with Operational Policy 4.01.

General Approach to the Management of EHS Issues at the Facility or Project Level

Effective management of environmental, health, and safety (EHS) issues entails the inclusion of EHS considerations into corporate- and facility-level business processes in an organized, hierarchical approach that includes the following steps:

- Identifying EHS project hazards[3] and associated risks[4] as early as possible in the facility development or project cycle, including the incorporation of EHS considerations into the site selection process, product design process, engineering planning process for capital requests, engineering work orders, facility modification authorizations, or layout and process change plans.
- Involving EHS professionals, who have the experience, competence, and training necessary to assess and manage EHS impacts and risks, and carry out specialized environmental management functions including the preparation of project or activity-specific plans and procedures that incorporate the technical recommendations presented in this document that are relevant to the project.
- Understanding the likelihood and magnitude of EHS risks, based on:
    - The nature of the project activities, such as whether the project will generate significant quantities of emissions or effluents, or involve hazardous materials or processes;
    - The potential consequences to workers, communities, or the environment if hazards are not adequately managed, which may depend on the proximity of project activities to people or to the environmental resources on which they depend.
- Prioritizing risk management strategies with the objective of achieving an overall reduction of risk to human health and the environment, focusing on the prevention of irreversible and / or significant impacts.
- Favoring strategies that eliminate the cause of the hazard at its source, for example, by selecting less hazardous materials or processes that avoid the need for EHS controls.
- When impact avoidance is not feasible, incorporating engineering and management controls to reduce or minimize the possibility and magnitude of undesired consequences, for example, with the application of pollution controls to reduce the levels of emitted contaminants to workers or environments.
- Preparing workers and nearby communities to respond to accidents, including providing technical and financial resources to effectively and safely control such events, and restoring workplace and community environments to a safe and healthy condition.
- Improving EHS performance through a combination of ongoing monitoring of facility performance and effective accountability.

[3] Defined as "threats to humans and what they value" (Kates, et al., 1985).

[4] Defined as "quantitative measures of hazard consequences, usually expressed as conditional probabilities of experiencing harm" (Kates, et. al., 1985)

1.0 Environmental

1.1 Air Emissions and Ambient Air Quality

Applicability and Approach

This guideline applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

Emissions of air pollutants can occur from a wide variety of activities during the construction, operation, and decommissioning phases of a project. These activities can be categorized based on the spatial characteristic of the source including point sources, fugitive sources, and mobile sources and, further, by process, such as combustion, materials storage, or other industry sector-specific processes.

Where possible, facilities and projects should avoid, minimize, and control adverse impacts to human health, safety, and the environment from emissions to air. Where this is not possible, the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency
- Process modification
- Selection of fuels or other materials, the processing of which may result in less polluting emissions
- Application of emissions control techniques

The selected prevention and control techniques may include one or more methods of treatment depending on:

- Regulatory requirements
- Significance of the source
- Location of the emitting facility relative to other sources
- Location of sensitive receptors
- Existing ambient air quality, and potential for degradation of the airshed from a proposed project
- Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions

Ambient Air Quality

General Approach

Projects with significant[5,6] sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards[9] by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines[10] (see Table 1.1.1), or other internationally recognized sources[11];
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.[12]

At facility level, impacts should be estimated through qualitative or quantitative assessments by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Local atmospheric, climatic, and air quality data should be applied when modeling dispersion, protection against atmospheric downwash, wakes, or eddy effects of the source, nearby[13] structures, and terrain features. The dispersion model applied should be internationally recognized, or comparable. Examples of acceptable emission estimation and dispersion modeling approaches for point and fugitive sources are

Table 1.1.1: WHO Ambient Air Quality Guidelines[7,8]

	Averaging Period	Guideline value in $\mu g/m^3$
Sulfur dioxide (SO_2)	24-hour 10 minute	125 (Interim target-1) 50 (Interim target-2) 20 (guideline) 500 (guideline)
Nitrogen dioxide (NO_2)	1-year 1-hour	40 (guideline) 200 (guideline)
Particulate Matter PM_{10}	1-year 24-hour	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline) 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year 24-hour	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline) 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

5 Significant sources of point and fugitive emissions are considered to be general sources which, for example, can contribute a net emissions increase of one or more of the following pollutants within a given airshed: PM10: 50 tons per year (tpy); NOx: 500 tpy; SO2: 500 tpy; or as established through national legislation; and combustion sources with an equivalent heat input of 50 MWth or greater. The significance of emissions of inorganic and organic pollutants should be established on a project-specific basis taking into account toxic and other properties of the pollutant.

6 United States Environmental Protection Agency, Prevention of Significant Deterioration of Air Quality, 40 CFR Ch. 1 Part 52.21. Other references for establishing significant emissions include the European Commission. 2000. "Guidance Document for EPER implementation." http://ec.europa.eu/environment/ippc/eper/index.htm ; and Australian Government. 2004. "National Pollutant Inventory Guide." http://www.npi.gov.au/handbooks/pubs/npiguide.pdf

7 World Health Organization (WHO). Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile.

8 Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

9 Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, and ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological, and epidemiological evidence (such as those published by the World Health Organization).

10 Available at World Health Organization (WHO). http://www.who.int/en

11 For example the United States National Ambient Air Quality Standards (NAAQS) (http://www.epa.gov/air/criteria.html) and the relevant European Council Directives (Council Directive 1999/30/EC of 22 April 1999 / Council Directive 2002/3/EC of February 12 2002).

12 US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds.

included in Annex 1.1.1. These approaches include screening models for single source evaluations (SCREEN3 or AIRSCREEN), as well as more complex and refined models (AERMOD OR ADMS). Model selection is dependent on the complexity and geo-morphology of the project site (e.g. mountainous terrain, urban or rural area).

Projects Located in Degraded Airsheds or Ecologically Sensitive Areas

Facilities or projects located within poor quality airsheds[14], and within or next to areas established as ecologically sensitive (e.g. national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment. Suitable mitigation measures may also include the relocation of significant sources of emissions outside the airshed in question, use of cleaner fuels or technologies, application of comprehensive pollution control measures, offset activities at installations controlled by the project sponsor or other facilities within the same airshed, and buy-down of emissions within the same airshed.

Specific provisions for minimizing emissions and their impacts in poor air quality or ecologically sensitive airsheds should be established on a project-by-project or industry-specific basis. Offset provisions outside the immediate control of the project sponsor or buy-downs should be monitored and enforced by the local agency responsible for granting and monitoring emission permits. Such provisions should be in place prior to final commissioning of the facility / project.

Point Sources

Point sources are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere. They are typically located in manufacturing or production plants. Within a given point source, there may be several individual 'emission points' that comprise the point source.[15]

Point sources are characterized by the release of air pollutants typically associated with the combustion of fossil fuels, such as nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM), as well as other air pollutants including certain volatile organic compounds (VOCs) and metals that may also be associated with a wide range of industrial activities.

Emissions from point sources should be avoided and controlled according to good international industry practice (GIIP) applicable to the relevant industry sector, depending on ambient conditions, through the combined application of process modifications and emissions controls, examples of which are provided in Annex 1.1.2. Additional recommendations regarding stack height and emissions from small combustion facilities are provided below.

Stack Height

The stack height for all point sources of emissions, whether 'significant' or not, should be designed according to GIIP (see Annex 1.1.3) to avoid excessive ground level concentrations due to downwash, wakes, and eddy effects, and to ensure reasonable diffusion to minimize impacts. For projects where there are multiple sources of emissions, stack heights should be established with due consideration to emissions from all other project sources, both point and fugitive. Non-significant sources of emissions,

13 "Nearby" generally considers an area within a radius of up to 20 times the stack height.

14 An airshed should be considered as having poor air quality if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly.

15 Emission points refer to a specific stack, vent, or other discrete point of pollution release. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. The characterization of point sources into multiple emissions points is useful for allowing more detailed reporting of emissions information.

including small combustion sources,[16] should also use GIIP in stack design.

Small Combustion Facilities Emissions Guidelines

Small combustion processes are systems designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type, with a total, rated heat input capacity of between three Megawatt thermal (MWth) and 50 MWth.

The emissions guidelines in Table 1.1.2 are applicable to small combustion process installations operating more than 500 hours per year, and those with an annual capacity utilization of more than 30 percent. Plants firing a mixture of fuels should compare emissions performance with these guidelines based on the sum of the relative contribution of each applied fuel[17]. Lower emission values may apply if the proposed facility is located in an ecologically sensitive airshed, or airshed with poor air quality, in order to address potential cumulative impacts from the installation of more than one small combustion plant as part of a distributed generation project.

[16] Small combustion sources are those with a total rated heat input capacity of 50MWth or less.

[17] The contribution of a fuel is the percentage of heat input (LHV) provided by this fuel multiplied by its limit value.

Table 1.1.2 - Small Combustion Facilities Emissions Guidelines (3MWth – 50MWth) – (in mg/Nm^3 or as indicated)				
Combustion Technology / Fuel	**Particulate Matter (PM)**	**Sulfur Dioxide (SO_2)**	**Nitrogen Oxides (NOx)**	**Dry Gas, Excess O_2 Content (%)**
Engine				
Gas	N/A	N/A	200 (Spark Ignition) 400 (Dual Fuel) 1,600 (Compression Ignition)	15
Liquid	50 or up to 100 if justified by project specific considerations (e.g. Economic feasibility of using lower ash content fuel, or adding secondary treatment to meet 50, and available environmental capacity of the site)	1.5 percent Sulfur or up to 3.0 percent Sulfur if justified by project specific considerations (e.g. Economic feasibility of using lower S content fuel, or adding secondary treatment to meet levels of using 1.5 percent Sulfur, and available environmental capacity of the site)	If bore size diameter [mm] < 400: 1460 (or up to 1,600 if justified to maintain high energy efficiency.) If bore size diameter [mm] > or = 400: 1,850	15
Turbine				
Natural Gas =3MWth to < 15MWth	N/A	N/A	42 ppm (Electric generation) 100 ppm (Mechanical drive)	15
Natural Gas =15MWth to < 50MWth	N/A	N/A	25 ppm	15
Fuels other than Natural Gas =3MWth to < 15MWth	N/A	0.5 percent Sulfur or lower percent Sulfur (e.g. 0.2 percent Sulfur) if commercially available without significant excess fuel cost	96 ppm (Electric generation) 150 ppm (Mechanical drive)	15
Fuels other than Natural Gas =15MWth to < 50MWth	N/A	0.5% S or lower % S (0.2%S) if commercially available without significant excess fuel cost	74 ppm	15
Boiler				
Gas	N/A	N/A	320	3
Liquid	50 or up to 150 if justified by environmental assessment	2000	460	3
Solid	50 or up to 150 if justified by environmental assessment	2000	650	6

Notes: -N/A/ - no emissions guideline; Higher performance levels than these in the Table should be applicable to facilities located in urban / industrial areas with degraded airsheds or close to ecologically sensitive areas where more stringent emissions controls may be needed.; MWth is heat input on HHV basis; Solid fuels include biomass; Nm^3 is at one atmosphere pressure, 0°C.; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack except for NOx and PM limits for turbines and boilers. Guidelines values apply to facilities operating more than 500 hours per year with an annual capacity utilization factor of more than 30 percent.

Fugitive Sources

Fugitive source air emissions refer to emissions that are distributed spatially over a wide area and not confined to a specific discharge point. They originate in operations where exhausts are not captured and passed through a stack. Fugitive emissions have the potential for much greater ground-level impacts per unit than stationary source emissions, since they are discharged and dispersed close to the ground. The two main types of fugitive emissions are Volatile Organic Compounds (VOCs) and particulate matter (PM). Other contaminants (NO_x, SO_2 and CO) are mainly associated with combustion processes, as described above. Projects with potentially significant fugitive sources of emissions should establish the need for ambient quality assessment and monitoring practices.

Open burning of solid wastes, whether hazardous or non-hazardous, is not considered good practice and should be avoided, as the generation of polluting emissions from this type of source cannot be controlled effectively.

Volatile Organic Compounds (VOCs)

The most common sources of fugitive VOC emissions are associated with industrial activities that produce, store, and use VOC-containing liquids or gases where the material is under pressure, exposed to a lower vapor pressure, or displaced from an enclosed space. Typical sources include equipment leaks, open vats and mixing tanks, storage tanks, unit operations in wastewater treatment systems, and accidental releases. Equipment leaks include valves, fittings, and elbows which are subject to leaks under pressure. The recommended prevention and control techniques for VOC emissions associated with equipment leaks include:

- Equipment modifications, examples of which are presented in Annex 1.1.4;
- Implementing a leak detection and repair (LDAR) program that controls fugitive emissions by regularly monitoring to detect leaks, and implementing repairs within a predefined time period.[18]

For VOC emissions associated with handling of chemicals in open vats and mixing processes, the recommended prevention and control techniques include:

- Substitution of less volatile substances, such as aqueous solvents;
- Collection of vapors through air extractors and subsequent treatment of gas stream by removing VOCs with control devices such as condensers or activated carbon absorption;
- Collection of vapors through air extractors and subsequent treatment with destructive control devices such as:
    - Catalytic Incinerators: Used to reduce VOCs from process exhaust gases exiting paint spray booths, ovens, and other process operations
    - Thermal Incinerators: Used to control VOC levels in a gas stream by passing the stream through a combustion chamber where the VOCs are burned in air at temperatures between 700º C to 1,300º C
    - Enclosed Oxidizing Flares: Used to convert VOCs into CO_2 and H_2O by way of direct combustion
- Use of floating roofs on storage tanks to reduce the opportunity for volatilization by eliminating the headspace present in conventional storage tanks.

Particulate Matter (PM)

The most common pollutant involved in fugitive emissions is dust or particulate matter (PM). This is released during certain operations, such as transport and open storage of solid materials, and from exposed soil surfaces, including unpaved roads.

[18] For more information, see Leak Detection and Repair Program (LDAR), at: http://www.ldar.net

Recommended prevention and control of these emissions sources include:

- Use of dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles, or controls, including air extraction and treatment through a baghouse or cyclone for material handling sources, such as conveyors and bins;
- Use of water suppression for control of loose materials on paved or unpaved road surfaces. Oil and oil by-products is not a recommended method to control road dust. Examples of additional control options for unpaved roads include those summarized in Annex 1.1.5.

Ozone Depleting Substances (ODS)

Several chemicals are classified as ozone depleting substances (ODSs) and are scheduled for phase-out under the Montreal Protocol on Substances that Deplete the Ozone Layer.[19] No new systems or processes should be installed using CFCs, halons, 1,1,1-trichloroethane, carbon tetrachloride, methyl bromide or HBFCs. HCFCs should only be considered as interim / bridging alternatives as determined by the host country commitments and regulations.[20]

Mobile Sources – Land-based

Similar to other combustion processes, emissions from vehicles include CO, NO_x, SO_2, PM and VOCs. Emissions from on-road and off-road vehicles should comply with national or regional programs. In the absence of these, the following approach should be considered:

- Regardless of the size or type of vehicle, fleet owners / operators should implement the manufacturer recommended engine maintenance programs;
- Drivers should be instructed on the benefits of driving practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits;
- Operators with fleets of 120 or more units of heavy duty vehicles (buses and trucks), or 540 or more light duty vehicles[21] (cars and light trucks) within an airshed should consider additional ways to reduce potential impacts including:
    - Replacing older vehicles with newer, more fuel efficient alternatives
    - Converting high-use vehicles to cleaner fuels, where feasible
    - Installing and maintaining emissions control devices, such as catalytic converters
    - Implementing a regular vehicle maintenance and repair program

Greenhouse Gases (GHGs)

Sectors that may have potentially significant emissions of greenhouse gases (GHGs)[22] include energy, transport, heavy industry (e.g. cement production, iron / steel manufacturing, aluminum smelting, petrochemical industries, petroleum refining, fertilizer manufacturing), agriculture, forestry and waste management. GHGs may be generated from direct emissions

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[19] Examples include: chlorofluorocarbons (CFCs); halons; 1,1,1-trichloroethane (methyl chloroform); carbon tetrachloride; hydrochlorofluorocarbons (HCFCs); hydrobromofluorocarbons (HBFCs); and methyl bromide. They are currently used in a variety of applications including: domestic, commercial, and process refrigeration (CFCs and HCFCs); domestic, commercial, and motor vehicle air conditioning (CFCs and HCFCs); for manufacturing foam products (CFCs); for solvent cleaning applications (CFCs, HCFCs, methyl chloroform, and carbon tetrachloride); as aerosol propellants (CFCs); in fire protection systems (halons and HBFCs); and as crop fumigants (methyl bromide).

[20] Additional information is available through the Montreal Protocol Secretariat web site available at: http://ozone.unep.org/

[21] The selected fleet size thresholds are assumed to represent potentially significant sources of emissions based on individual vehicles traveling 100,000 km / yr using average emission factors.

[22] The six greenhouse gases that form part of the Kyoto Protocol to the United Nations Framework Convention on Climate Change include carbon dioxide ($C0_2$); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6).

from facilities within the physical project boundary and indirect emissions associated with the off-site production of power used by the project.

Recommendations for reduction and control of greenhouse gases include:

- Carbon financing;[23]
- Enhancement of energy efficiency (see section on 'Energy Conservation');
- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forms of agriculture and forestry;
- Promotion, development and increased use of renewable forms of energy;
- Carbon capture and storage technologies;[24]
- Limitation and / or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (coal, oil, and gas).

Monitoring

Emissions and air quality monitoring programs provide information that can be used to assess the effectiveness of emissions management strategies. A systematic planning process is recommended to ensure that the data collected are adequate for their intended purposes (and to avoid collecting unnecessary data). This process, sometimes referred to as a data quality objectives process, defines the purpose of collecting the data, the decisions to be made based on the data and the consequences of making an incorrect decision, the time and geographic boundaries, and the quality of data needed to make a correct decision.[25] The air quality monitoring program should consider the following elements:

- *Monitoring parameters*: The monitoring parameters selected should reflect the pollutants of concern associated with project processes. For combustion processes, indicator parameters typically include the quality of inputs, such as the sulfur content of fuel.
- *Baseline calculations*: Before a project is developed, baseline air quality monitoring at and in the vicinity of the site should be undertaken to assess background levels of key pollutants, in order to differentiate between existing ambient conditions and project-related impacts.
- *Monitoring type and frequency*: Data on emissions and ambient air quality generated through the monitoring program should be representative of the emissions discharged by the project over time. Examples of time-dependent variations in the manufacturing process include batch process manufacturing and seasonal process variations. Emissions from highly variable processes may need to be sampled more frequently or through composite methods. Emissions monitoring frequency and duration may also range from continuous for some combustion process operating parameters or inputs (e.g. the quality of fuel) to less frequent, monthly, quarterly or yearly stack tests.
- *Monitoring locations*: Ambient air quality monitoring may consists of off-site or fence line monitoring either by the project sponsor, the competent government agency, or by collaboration between both. The location of ambient air

[23] Carbon financing as a carbon emissions reduction strategy may include the host government-endorsed Clean Development Mechanism or Joint Implementation of the United Nations Framework Convention on Climate Change.

[24] Carbon dioxide capture and storage (CCS) is a process consisting of the separation of CO_2 from industrial and energy-related sources; transport to a storage location; and long-term isolation from the atmosphere, for example in geological formations, in the ocean, or in mineral carbonates (reaction of CO_2 with metal oxides in silicate minerals to produce stable carbonates). It is the object of intensive research worldwide (Intergovernmental Panel on Climate Change (IPCC), Special Report, Carbon Dioxide Capture and Storage (2006).

[25] See, for example, United States Environmental Protection Agency, Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4, EPA/240/B-06/001 February 2006.

quality monitoring stations should be established based on the results of scientific methods and mathematical models to estimate potential impact to the receiving airshed from an emissions source taking into consideration such aspects as the location of potentially affected communities and prevailing wind directions.

- *Sampling and analysis methods*: Monitoring programs should apply national or international methods for sample collection and analysis, such as those published by the International Organization for Standardization,[26] the European Committee for Standardization,[27] or the U.S. Environmental Protection Agency.[28] Sampling should be conducted by, or under, the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance / Quality Control (QA/QC) plans should be applied and documented to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). Monitoring reports should include QA/QC documentation.

Monitoring of Small Combustion Plants Emissions

- Additional recommended monitoring approaches for **boilers**:

  Boilers with capacities between =3 MWth and < 20 MWth:

  - Annual Stack Emission Testing: SO_2, NO_x and PM. For gaseous fuel-fired boilers, only NO_x. SO_2 can be calculated based on fuel quality certification if no SO_2 control equipment is used.
  - If Annual Stack Emission Testing demonstrates results consistently and significantly better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
  - Emission Monitoring: None

  Boilers with capacities between =20 MWth and < 50 MWth

  - Annual Stack Emission Testing: SO_2, NO_x and PM. For gaseous fuel-fired boilers, only NO_x. SO_2 can be calculated based on fuel quality certification (if no SO_2 control equipment is used)
  - Emission Monitoring: SO_2. Plants with SO_2 control equipment: Continuous. NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters. PM: Continuous monitoring of either PM emissions, opacity, or indicative PM emissions using combustion parameters / visual monitoring.

- Additional recommended monitoring approaches for **turbines**:
  - Annual Stack Emission Testing: NO_x and SO_2 (NO_x only for gaseous fuel-fired turbines).
  - If Annual Stack Emission Testing results show constantly (3 consecutive years) and significantly (e.g. less than 75 percent) better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
  - Emission Monitoring: NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters.SO_2: Continuous monitoring if SO_2 control equipment is used.

- Additional recommended monitoring approaches for **engines**:
  - Annual Stack Emission Testing: NO_x ,SO_2 and PM (NO_x only for gaseous fuel-fired diesel engines).

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[26] An on-line catalogue of ISO standards relating to the environment, health protection, and safety is available at: http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?ICS1=13&ICS2=&ICS3=&scopelist=

[27] An on-line catalogue of European Standards is available at: http://www.cen.eu/catweb/cwen.htm .

[28] The National Environmental Methods Index provides a searchable clearinghouse of U.S. methods and procedures for both regulatory and non-regulatory monitoring purposes for water, sediment, air and tissues, and is available at http://www.nemi.gov/.

- If Annual Stack Emission Testing results show constantly (3 consecutive years) and significantly (e.g. less than 75 percent) better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
- Emission Monitoring: NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters. SO_2: Continuous monitoring if SO_2 control equipment is used. PM: Continuous monitoring of either PM emissions or indicative PM emissions using operating parameters.

Annex 1.1.1 – Air Emissions Estimation and Dispersion Modeling Methods

The following is a partial list of documents to aid in the estimation of air emissions from various processes and air dispersion models:

Australian Emission Estimation Technique Manuals
http://www.npi.gov.au/handbooks/

Atmospheric Emission Inventory Guidebook, UN / ECE / EMEP and the European Environment Agency
http://www.aeat.co.uk/netcen/airqual/TFEI/unece.htm

Emission factors and emission estimation methods, US EPA Office of Air Quality Planning & Standards
http://www.epa.gov/ttn/chief

Guidelines on Air Quality Models (Revised), US Environmental Protection Agency (EPA), 2005
http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

Frequently Asked Questions, Air Quality Modeling and Assessment Unit (AQMAU), UK Environment Agency
http://www.environment-agency.gov.uk/subjects/airquality/236092/?version=1&lang=_e

OECD Database on Use and Release of Industrial Chemicals
http://www.olis.oecd.org/ehs/urchem.nsf/

Annex 1.1.2 – Illustrative Point Source Air Emissions Prevention and Control Technologies

Principal Sources and Issues	General Prevention / Process Modification Approach	Control Options	Reduction Efficiency (%)	Gas Condition	Comments
Particulate Matter (PM)					
Main sources are the combustion of fossil fuels and numerous manufacturing processes that collect PM through air extraction and ventilation systems. Volcanoes, ocean spray, forest fires and blowing dust (most prevalent in dry and semiarid climates) contribute to background levels.	Fuel switching (e.g. selection of lower sulfur fuels) or reducing the amount of fine particulates added to a process.	Fabric Filters	99 - 99.7%	Dry gas, temp <400F	Applicability depends on flue gas properties including temperature, chemical properties, abrasion and load. Typical air to cloth ratio range of 2.0 to 3.5 cfm/ft^2 Achievable outlet concentrations of 23 mg/Nm^3
		Electrostatic Precipitator (ESP)	97 – 99%	Varies depending of particle type	Precondition gas to remove large particles. Efficiency dependent on resistivity of particle. Achievable outlet concentration of 23 mg/Nm^3
		Cyclone	74 – 95%	None	Most efficient for large particles. Achievable outlet concentrations of 30 - 40 mg/Nm^3
		Wet Scrubber	93 – 95%	None	Wet sludge may be a disposal problem depending on local infrastructure. Achievable outlet concentrations of 30 - 40 mg/Nm3
Sulfur Dioxide (SO_2)					
Mainly produced by the combustion of fuels such as oil and coal and as a by-product from some chemical production or wastewater treatment processes.	Control system selection is heavily dependent on the inlet concentration. For SO2 concentrations in excess of 10%, the stream is passed through an acid plant not only to lower the SO2 emissions but also to generate high grade sulfur for sale. Levels below 10% are not rich enough for this process and should therefore utilize absorption or 'scrubbing,' where SO2 molecules are captured into a liquid phase or adsorption, where SO2 molecules are captured on the surface of a solid adsorbent.	Fuel Switching	>90%		Alternate fuels may include low sulfur coal, light diesel or natural gas with consequent reduction in particulate emissions related to sulfur in the fuel. Fuel cleaning or beneficiation of fuels prior to combustion is another viable option but may have economic consequences.
		Sorbent Injection	30% - 70%		Calcium or lime is injected into the flue gas and the SO_2 is adsorbed onto the sorbent
		Dry Flue Gas Desulfurization	70%-90%		Can be regenerable or throwaway.
		Wet Flue Gas Desulfurization	>90%		Produces gypsum as a by-product

Annex 1.1.2: Illustrative Point Source Air Emissions Prevention and Control Technologies (continued)

Oxides of Nitrogen (NOx)		Percent Reduction by Fuel Type			Comments
Associated with combustion of fuel. May occur in several forms of nitrogen oxide; namely nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O), which is also a greenhouse gas. The term NOx serves as a composite between NO and NO_2 and emissions are usually reported as NOx. Here the NO is multiplied by the ratio of molecular weights of NO_2 to NO and added to the NO_2 emissions. Means of reducing NOx emissions are based on the modification of operating conditions such as minimizing the resident time at peak temperatures, reducing the peak temperatures by increasing heat transfer rates or minimizing the availability of oxygen.	**Combustion modification** (Illustrative of boilers)	**Coal**	**Oil**	**Gas**	These modifications are capable of reducing NOx emissions by 50 to 95%. The method of combustion control used depends on the type of boiler and the method of firing fuel.
	Low-excess-air firing	10–30	10–30	10–30	
	Staged Combustion	20–50	20–50	20–50	
	Flue Gas Recirculation	N/A	20–50	20–50	
	Water/Steam Injection	N/A	10–50	N/A.	
	Low-NOx Burners	30–40	30–40	30–40	
	Flue Gas Treatment	**Coal**	**Oil**	**Gas**	Flue gas treatment is more effective in reducing NOx emissions than are combustion controls. Techniques can be classified as SCR, SNCR, and adsorption. SCR involves the injection of ammonia as a reducing agent to convert NOx to nitrogen in the presence of a catalyst in a converter upstream of the air heater. Generally, some ammonia slips through and is part of the emissions. SNCR also involves the injection of ammonia or urea based products without the presence of a catalyst.
	Selective Catalytic Reduction (SCR)	60–90	60–90	60–90	
	Selective Non-Catalytic Reduction (SNCR)	N/A	30–70	30–70	

Note: Compiled by IFC based on inputs from technical experts.

Annex 1.1.3 - Good International Industry Practice (GIIP) Stack Height

(Based on United States 40 CFR, part 51.100 (ii)).

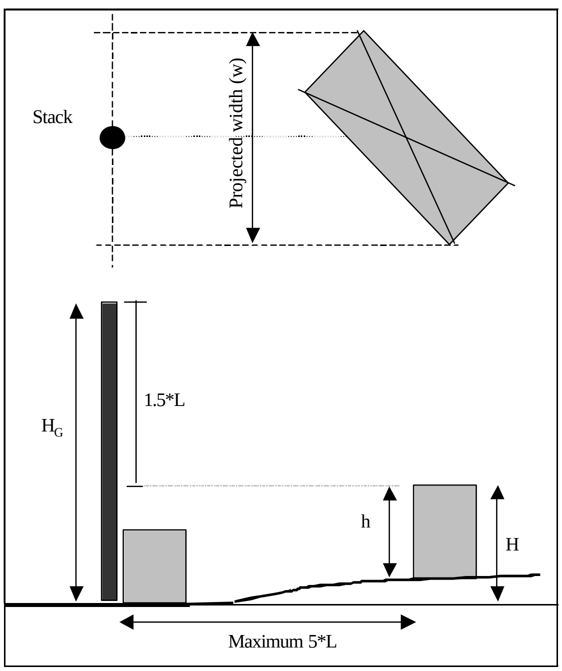
$H_G = H + 1.5L$; where

H_G = GEP stack height measured from the ground level elevation at the base of the stack

H = Height of nearby structure(s) above the base of the stack.

L = Lesser dimension, height (h) or width (w), of nearby structures

"Nearby structures" = Structures within/touching a radius of 5L but less than 800 m.



Annex 1.1.4 - Examples of VOC Emissions Controls

Equipment Type	Modification	Approximate Control Efficiency (%)
Pumps	Seal-less design	100[29]
	Closed-vent system	90[30]
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the pumped fluid	100
Compressors	Closed-vent system	90
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the compressed gas	100
Pressure Relief Devices	Closed-vent system	Variable[31]
	Rupture disk assembly	100
Valves	Seal-less design	100
Connectors	Weld together	100
Open-ended Lines	Blind, cap, plug, or second valve	100
Sampling Connections	Closed-loop sampling	100
Note: Examples of technologies are provided for illustrative purposes. The availability and applicability of any particular technology will vary depending on manufacturer specifications.		

29 Seal-less equipment can be a large source of emissions in the event of equipment failure.
30 Actual efficiency of a closed-vent system depends on percentage of vapors collected and efficiency of control device to which the vapors are routed.
31 Control efficiency of closed vent-systems installed on a pressure relief device may be lower than other closed-vent systems.

Annex 1.1.5 - Fugitive PM Emissions Controls

Control Type	Control Efficiency
Chemical Stabilization	0% - 98%
Hygroscopic salts Bitumens/adhesives	60% - 96%
Surfactants	0% - 68%
Wet Suppression – Watering	12% - 98%
Speed Reduction	0% - 80%
Traffic Reduction	Not quantified
Paving (Asphalt / Concrete)	85% - 99%
Covering with Gravel, Slag, or "Road Carpet"	30% - 50%
Vacuum Sweeping	0% - 58%
Water Flushing/Broom Sweeping	0% - 96%

1.2 Energy Conservation

Applicability and Approach

This guideline applies to facilities or projects that consume energy in process heating and cooling; process and auxiliary systems, such as motors, pumps, and fans; compressed air systems and heating, ventilation and air conditioning systems (HVAC); and lighting systems. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for energy conservation that may be applied to a range of industry sectors.

Energy management at the facility level should be viewed in the context of overall consumption patterns, including those associated with production processes and supporting utilities, as well as overall impacts associated with emissions from power sources. The following section provides guidance on energy management with a focus on common utility systems often representing technical and financially feasible opportunities for improvement in energy conservation. However, operations should also evaluate energy conservation opportunities arising from manufacturing process modifications.

Energy Management Programs

Energy management programs should include the following elements:

- Identification, and regular measurement and reporting of principal energy flows within a facility at unit process level
- Preparation of mass and energy balance;
- Definition and regular review of energy performance targets, which are adjusted to account for changes in major influencing factors on energy use
- Regular comparison and monitoring of energy flows with performance targets to identify where action should be taken to reduce energy use
- Regular review of targets, which may include comparison with benchmark data, to confirm that targets are set at appropriate levels

Energy Efficiency

For any energy-using system, a systematic analysis of energy efficiency improvements and cost reduction opportunities should include a hierarchical examination of opportunities to**:**

- Demand/Load Side Management by reducing loads on the energy system
- Supply Side Management by:
    - Reduce losses in energy distribution
    - Improve energy conversion efficiency
    - Exploit energy purchasing opportunities
    - Use lower-carbon fuels

Common opportunities in each of these areas are summarized below.[32]

Process Heating

Process heating is vital to many manufacturing processes, including heating for fluids, calcining, drying, heat treating, metal heating, melting, melting agglomeration, curing, and forming[33].

In process heating systems, a system heat and mass balance will show how much of the system's energy input provides true process heating, and quantify fuel used to satisfy energy losses caused by excessive parasitic loads, distribution, or conversion losses. Examination of savings opportunities should be directed by the results of the heat and mass balance, though the following techniques are often valuable and cost-effective.

Heating Load Reduction

- Ensure adequate insulation to reduce heat losses through furnace/oven etc. structure
- Recover heat from hot process or exhaust streams to reduce system loads
- In intermittently-heated systems, consider use of low thermal mass insulation to reduce energy required to heat the system structure to operating temperature
- Control process temperature and other parameters accurately to avoid, for example, overheating or overdrying
- Examine opportunities to use low weight and/or low thermal mass product carriers, such as heated shapers, kiln cars etc.
- Review opportunities to schedule work flow to limit the need for process reheating between stages
- Operate furnaces/ovens at slight positive pressure, and maintain air seals to reduce air in-leakage into the heated system, thereby reducing the energy required to heat unnecessary air to system operating temperature
- Reduce radiant heat losses by sealing structural openings and keep viewing ports closed when not in use
- Where possible, use the system for long runs close to or at operating capacity
- Consider use of high emissivity coatings of high temperature insulation, and consequent reduction in process temperature
- Near net weight and shape heat designs
- Robust Quality assurance on input material
- Robust Scheduled maintenance programs

Heat Distribution Systems

Heat distribution in process heating applications typically takes place through steam, hot water, or thermal fluid systems. Losses can be reduced through the following actions:

- Promptly repair distribution system leaks
- Avoid steam leaks despite a perceived need to get steam through the turbine. Electricity purchase is usually cheaper overall, especially when the cost to treat turbine-quality boiler feed water is included. If the heat-power ratio of the distribution process is less than that of power systems, opportunities should be considered to increase the ratio; for example, by using low-pressure steam to drive absorption cooling systems rather than using electrically-driven vapor-compression systems.
- Regularly verify correct operation of steam traps in steam systems, and ensure that traps are not bypassed. Since

32 Additional guidance on energy efficiency is available from sources such as Natural Resources Canada (NRCAN http://oee.nrcan.gc.ca/commercial/financial-assistance/new-buildings/mnecb.cfm?attr=20); the European Union (EUROPA. http://europa.eu.int/scadplus/leg/en/s15004.htm), and United States Department of Energy (US DOE, http://www.eere.energy.gov/consumer/industry/process.html).

33 US DOE. http://www.eere.energy.gov/consumer/industry/process.html

steam traps typically last approximately 5 years, 20% should be replaced or repaired annually

- Insulate distribution system vessels, such as hot wells and de-aerators, in steam systems and thermal fluid or hot water storage tanks
- Insulate all steam, condensate, hot water and thermal fluid distribution pipework, down to and including 1" (25 mm) diameter pipe, in addition to insulating all hot valves and flanges
- In steam systems, return condensate to the boiler house for re-use, since condensate is expensive boiler-quality water and valuable beyond its heat content alone
- Use flash steam recovery systems to reduce losses due to evaporation of high-pressure condensate
- Consider steam expansion through a back-pressure turbine rather than reducing valve stations
- Eliminate distribution system losses by adopting point-of-use heating systems

Energy Conversion System Efficiency Improvements

The following efficiency opportunities should be examined for process furnaces or ovens, and utility systems, such as boilers and fluid heaters:

- Regularly monitor CO, oxygen or CO2 content of flue gases to verify that combustion systems are using the minimum practical excess air volumes
- Consider combustion automation using oxygen-trim controls
- Minimize the number of boilers or heaters used to meet loads. It is typically more efficient to run one boiler at 90% of capacity than two at 45%. Minimize the number of boilers kept at hot–standby
- Use flue dampers to eliminate ventilation losses from hot boilers held at standby
- Maintain clean heat transfer surfaces; in steam boilers, flue gases should be no more than 20 K above steam temperature)
- In steam boiler systems, use economizers to recover heat from flue gases to pre-heat boiler feed water or combustion air
- Consider reverse osmosis or electrodialysis feed water treatment to minimize the requirement for boiler blowdown
- Adopt automatic (continuous) boiler blowdown
- Recover heat from blowdown systems through flash steam recovery or feed-water preheat
- Do not supply excessive quantities of steam to the de-aerator
- With fired heaters, consider opportunities to recover heat to combustion air through the use of recuperative or regenerative burner systems
- For systems operating for extended periods (> 6000 hours/year), cogeneration of electrical power, heat and /or cooling can be cost effective
- Oxy Fuel burners
- Oxygen enrichment/injection
- Use of turbolators in boilers
- Sizing design and use of multiple boilers for different load configurations
- Fuel quality control/fuel blending

Process Cooling

The general methodology outlined above should be applied to process cooling systems. Commonly used and cost-effective measures to improve process cooling efficiency are described below.

Load Reduction

- Ensure adequate insulation to reduce heat gains through cooling system structure and to below-ambient temperature refrigerant pipes and vessels
- Control process temperature accurately to avoid overcooling
- Operate cooling tunnels at slight positive pressure and maintain air seals to reduce air in-leakage into the cooled system, thus reducing the energy required to cool this unnecessary air to system operating temperature
- Examine opportunities to pre-cool using heat recovery to a process stream requiring heating, or by using a higher temperature cooling utility
- In cold and chill stores, minimize heat gains to the cooled space by use of air curtains, entrance vestibules, or rapidly opening/closing doors. Where conveyors carry products into chilled areas, minimize the area of transfer openings, for example, by using strip curtains
- Quantify and minimize "incidental" cooling loads, for example, those due to evaporator fans, other machinery, defrost systems and lighting in cooled spaces, circulation fans in cooling tunnels, or secondary refrigerant pumps (e.g. chilled water, brines, glycols)
- Do not use refrigeration for auxiliary cooling duties, such as compressor cylinder head or oil cooling
- While not a thermal load, ensure there is no gas bypass of the expansion valve since this imposes compressor load while providing little effective cooling
- In the case of air conditioning applications, energy efficiency techniques include:
  - Placing air intakes and air-conditioning units in cool, shaded locations
  - Improving building insulation including seals, vents, windows, and doors
  - Planting trees as thermal shields around buildings
  - Installing timers and/or thermostats and/or enthalpy-based control systems
  - Installing ventilation heat recovery systems[34]

Energy Conversion

The efficiency of refrigeration service provision is normally discussed in terms of Coefficient of Performance ("COP"), which is the ratio of cooling duty divided by input power. COP is maximized by effective refrigeration system design and increased refrigerant compression efficiency, as well as minimization of the temperature difference through which the system works and of auxiliary loads (i.e. those in addition to compressor power demand) used to operate the refrigeration system.

System Design

- If process temperatures are above ambient for all, or part, of the year, use of ambient cooling systems, such as provided by cooling towers or dry air coolers, may be appropriate, perhaps supplemented by refrigeration in summer conditions.
- Most refrigeration systems are electric-motor driven vapor compression systems using positive displacement or centrifugal compressors. The remainder of this guideline relates primarily to vapor-compression systems. However, when a cheap or free heat source is available (e.g. waste heat from an engine-driven generator—low-pressure steam

[34] More information on HVAC energy efficiency can be found at the British Columbia Building Corporation (Woolliams, 2002. http://www.greenbuildingsbc.com/new_buildings/pdf_files/greenbuild_strategies_guide.pdf), NRCAN's EnerGuide (http://oee.nrcan.gc.ca/equipment/english/index.cfm?PrintView=N&Text=N) and NRCAN's Energy Star Programs (http://oee.nrcan.gc.ca/energystar/english/consumers/heating.cfm?text=N&printview=N#AC), and the US Energy Star Program (http://www.energystar.gov/index.cfm?c=guidelines.download_guidelines).

that has passed through a back-pressure turbine), absorption refrigeration may be appropriate.

- Exploit high cooling temperature range: precooling by ambient and/or 'high temperature' refrigeration before final cooling can reduce refrigeration capital and running costs. High cooling temperature range also provides an opportunity for countercurrent (cascade) cooling, which reduces refrigerant flow needs.
- Keep 'hot' and 'cold' fluids separate, for example, do not mix water leaving the chiller with water returning from cooling circuits.
- In low-temperature systems where high temperature differences are inevitable, consider two-stage or compound compression, or economized screw compressors, rather than single-stage compression.

Minimizing Temperature Differences

A vapor-compression refrigeration system raises the temperature of the refrigerant from somewhat below the lowest process temperature (the evaporating temperature) to provide process cooling, to a higher temperature (the condensing temperature), somewhat above ambient, to facilitate heat rejection to the air or cooling water systems. Increasing evaporating temperature typically increases compressor cooling capacity without greatly affecting power consumption. Reducing condensing temperature increases evaporator cooling capacity and substantially reduces compressor power consumption.

Elevating Evaporating Temperature

- Select a large evaporator to permit relatively low temperature differences between process and evaporating temperatures. Ensure that energy use of auxiliaries (e.g. evaporator fans) does not outweigh compression savings. In air-cooling applications, a design temperature difference of 6-10 K between leaving air temperature and evaporating temperature is indicative of an appropriately sized evaporator. When cooling liquids, 2K between leaving liquid and evaporating temperatures can be achieved, though a 4K difference is generally indicative of a generously-sized evaporator.
- Keep the evaporator clean. When cooling air, ensure correct defrost operation. In liquid cooling, monitor refrigerant/process temperature differences and compare with design expectations to be alert to heat exchanger contamination by scale or oil.
- Ensure oil is regularly removed from the evaporator, and that oil additions and removals balance.
- Avoid the use of back-pressure valves.
- Adjust expansion valves to minimize suction superheat consistent with avoidance of liquid carry-over to compressors.
- Ensure that an appropriate refrigerant charge volume is present.

Reducing Condensing Temperature

- Consider whether to use air-cooled or evaporation-based cooling (e.g. evaporative or water cooled condensers and cooling towers). Air-cooled evaporators usually have higher condensing temperatures, hence higher compressor energy use, and auxiliary power consumption, especially in low humidity climates. If a wet system is used, ensure adequate treatment to prevent growth of *legionella* bacteria.
- Whichever basic system is chosen, select a relatively large condenser to minimize differences between condensing and the heat sink temperatures. Condensing temperatures with air cooled or evaporative condensers should not be more than 10K above design ambient condition, and a 4K approach in a liquid-cooled condenser is possible.

- Avoid accumulation of non-condensable gases in the condenser system. Consider the installation of refrigerated non-condensable purgers, particularly for systems operating below atmospheric pressure.
- Keep condensers clean and free from scale. Monitor refrigerant/ambient temperature differences and compare with design expectations to be alert to heat exchanger contamination.
- Avoid liquid backup, which restricts heat transfer area in condensers. This can be caused by installation errors such as concentric reducers in horizontal liquid refrigerant pipes, or "up and over" liquid lines leading from condensers.
- In multiple condenser applications, refrigerant liquid lines should be connected via drop-leg traps to the main liquid refrigerant line to ensure that hot gases flow to all condensers.
- Avoid head pressure control to the extent possible. Head pressure control maintains condensing temperature at, or near, design levels. It therefore prevents reduction in compressor power consumption, which accompanies reduced condensing temperature, by restricting condenser capacity (usually by switching off the condenser, or cooling tower fans, or restricting cooling water flow) under conditions of less severe than design load or ambient temperature conditions. Head pressure is often kept higher than necessary to facilitate hot gas defrost or adequate liquid refrigerant circulation. Use of electronic rather than thermostatic expansion valves, and liquid refrigerant pumps can permit effective refrigerant circulation at much reduced condensing temperatures.
- Site condensers and cooling towers with adequate spacing so as to prevent recirculation of hot air into the tower.

Refrigerant Compression Efficiency

- Some refrigerant compressors and chillers are more efficient than others offered for the same duty. Before purchase, identify the operating conditions under which the compressor or chiller is likely to operate for substantial parts of its annual cycle. Check operating efficiency under these conditions, and ask for estimates of annual running cost. Note that refrigeration and HVAC systems rarely run for extended periods at design conditions, which are deliberately extreme. Operational efficiency under the most commonly occurring off-design conditions is likely to be most important.
- Compressors lose efficiency when unloaded. Avoid operation of multiple compressors at part-load conditions. Note that package chillers can gain coefficient of performance (COP) when slightly unloaded, as loss of compressor efficiency can be outweighed by the benefits of reduced condensing and elevated evaporating temperature. However, it is unlikely to be energy efficient to operate a single compressor-chiller at less than 50% of capacity.
- Consider turndown efficiency when specifying chillers. Variable speed control or multiple compressor chillers can be highly efficient at part loads.
- Use of thermal storage systems (e.g., ice storage) can avoid the need for close load-tracking and, hence, can avoid part-loaded compressor operation.

Refrigeration System Auxiliaries

Many refrigeration system auxiliaries (e.g. evaporator fans and chilled water pumps) contribute to refrigeration system load, so reductions in their energy use have a double benefit. General energy saving techniques for pumps and fans, listed in the next section of these guidelines, should be applied to refrigeration auxiliaries.

Additionally, auxiliary use can be reduced by avoidance of part-load operation and in plant selection (e.g. axial fan evaporative condensers generally use less energy than equivalent centrifugal fan towers).

Under extreme off-design conditions, reduction in duty of cooling system fans and pumps can be worthwhile, usually when the lowest possible condensing pressure has been achieved.

Compressed Air Systems

Compressed air is the most commonly found utility service in industry, yet in many compressed air systems, the energy contained in compressed air delivered to the user is often 10% or less of energy used in air compression. Savings are often possible through the following techniques:

Load reduction

- Examine each true user of compressed air to identify the air volume needed and the pressure at which this should be delivered.
- Do not mix high volume low pressure and low volume high pressure loads. Decentralize low volume high-pressure applications or provide dedicated low-pressure utilities, for example, by using fans rather than compressed air.
- Review air use reduction opportunities, for example:
    - Use air amplifier nozzles rather than simple open-pipe compressed air jets
    - Consider whether compressed air is needed at all
    - Where air jets are required intermittently (e.g. to propel product), consider operating the jet via a process-related solenoid valve, which opens only when air is required
    - Use manual or automatically operated valves to isolate air supply to individual machines or zones that are not in continuous use
    - Implement systems for systematic identification and repair of leaks
    - All condensate drain points should be trapped. Do not leave drain valves continuously 'cracked open'
    - Train workers never to direct compressed air against their bodies or clothing to dust or cool themselves down.

Distribution

- Monitor pressure losses in filters and replace as appropriate
- Use adequately sized distribution pipework designed to minimize pressure losses

1.3 Wastewater and Ambient Water Quality

Applicability and Approach

This guideline applies to projects that have either direct or indirect discharge of process wastewater, wastewater from utility operations or stormwater to the environment. These guidelines are also applicable to industrial discharges to sanitary sewers that discharge to the environment without any treatment. Process wastewater may include contaminated wastewater from utility operations, stormwater, and sanitary sewage. It provides information on common techniques for wastewater management, water conservation, and reuse that can be applied to a wide range of industry sectors. This guideline is meant to be complemented by the industry-specific effluent guidelines presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines. Projects with the potential to generate process wastewater, sanitary (domestic) sewage, or stormwater should incorporate the necessary precautions to avoid, minimize, and control adverse impacts to human health, safety, or the environment.

In the context of their overall ESHS management system, facilities should:

- Understand the quality, quantity, frequency and sources of liquid effluents in its installations. This includes knowledge about the locations, routes and integrity of internal drainage systems and discharge points
- Plan and implement the segregation of liquid effluents principally along industrial, utility, sanitary, and stormwater categories, in order to limit the volume of water requiring specialized treatment. Characteristics of individual streams may also be used for source segregation.
- Identify opportunities to prevent or reduce wastewater pollution through such measures as recycle/reuse within their facility, input substitution, or process modification (e.g. change of technology or operating conditions/modes).
- Assess compliance of their wastewater discharges with the applicable: (i) discharge standard (if the wastewater is discharged to a surface water or sewer), and (ii) water quality standard for a specific reuse (e.g. if the wastewater is reused for irrigation).

Additionally, the generation and discharge of wastewater of any type should be managed through a combination of:

- Water use efficiency to reduce the amount of wastewater generation
- Process modification, including waste minimization, and reducing the use of hazardous materials to reduce the load of pollutants requiring treatment
- If needed, application of wastewater treatment techniques to further reduce the load of contaminants prior to discharge, taking into consideration potential impacts of cross-media transfer of contaminants during treatment (e.g., from water to air or land)

When wastewater treatment is required prior to discharge, the level of treatment should be based on:

- Whether wastewater is being discharged to a sanitary sewer system, or to surface waters
- National and local standards as reflected in permit requirements and sewer system capacity to convey and treat wastewater if discharge is to sanitary sewer
- Assimilative capacity of the receiving water for the load of contaminant being discharged wastewater if discharge is to surface water
- Intended use of the receiving water body (e.g. as a source of drinking water, recreation, irrigation, navigation, or other)
- Presence of sensitive receptors (e.g., endangered species) or habitats
- Good International Industry Practice (GIIP) for the relevant industry sector

General Liquid Effluent Quality

Discharge to Surface Water

Discharges of process wastewater, sanitary wastewater, wastewater from utility operations or stormwater to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria or, in the absence of local criteria, other sources of ambient water quality.[35] Receiving water use[36] and assimilative capacity[37], taking other sources of discharges to the receiving water into consideration, should also influence the acceptable pollution loadings and effluent discharge quality. Additional considerations that should be included in the setting of project-specific performance levels for wastewater effluents include:

- Process wastewater treatment standards consistent with applicable Industry Sector EHS Guidelines. Projects for which there are no industry-specific guidelines should reference the effluent quality guidelines of an industry sector with suitably analogous processes and effluents;
- Compliance with national or local standards for sanitary wastewater discharges or, in their absence, the indicative guideline values applicable to sanitary wastewater discharges shown in Table 1.3.1 below;
- Temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations.

Discharge to Sanitary Sewer Systems

Discharges of industrial wastewater, sanitary wastewater, wastewater from utility operations or stormwater into public or private wastewater treatment systems should:

- Meet the pretreatment and monitoring requirements of the sewer treatment system into which it discharges.
- Not interfere, directly or indirectly, with the operation and maintenance of the collection and treatment systems, or pose a risk to worker health and safety, or adversely impact

35 An example is the US EPA National Recommended Water Quality Criteria http://www.epa.gov/waterscience/criteria/wqcriteria.html

36 Examples of receiving water uses as may be designated by local authorities include: drinking water (with some level of treatment), recreation, aquaculture, irrigation, general aquatic life, ornamental, and navigation. Examples of health-based guideline values for receiving waters include World Health Organization (WHO) guidelines for recreational use (http://www.who.int/water_sanitation_health/dwq/guidelines/en/index.html)

37 The assimilative capacity of the receiving water body depends on numerous factors including, but not limited to, the total volume of water, flow rate, flushing rate of the water body and the loading of pollutants from other effluent sources in the area or region. A seasonally representative baseline assessment of ambient water quality may be required for use with established scientific methods and mathematical models to estimate potential impact to the receiving water from an effluent source.

characteristics of residuals from wastewater treatment operations.

- Be discharged into municipal or centralized wastewater treatment systems that have adequate capacity to meet local regulatory requirements for treatment of wastewater generated from the project. Pretreatment of wastewater to meet regulatory requirements before discharge from the project site is required if the municipal or centralized wastewater treatment system receiving wastewater from the project does not have adequate capacity to maintain regulatory compliance.

Land Application of Treated Effluent

The quality of treated process wastewater, wastewater from utility operations or stormwater discharged on land, including wetlands, should be established based on local regulatory requirements. . Where land is used as part of the treatment system and the ultimate receptor is surface water, water quality guidelines for surface water discharges specific to the industry sector process should apply.[38] Potential impact on soil, groundwater, and surface water, in the context of protection, conservation and long term sustainability of water and land resources should be assessed when land is used as part of any wastewater treatment system.

Septic Systems

Septic systems are commonly used for treatment and disposal of domestic sanitary sewage in areas with no sewerage collection networks, Septic systems should only be used for treatment of sanitary sewage, and unsuitable for industrial wastewater treatment. When septic systems are the selected form of wastewater disposal and treatment, they should be:

- Properly designed and installed in accordance with local regulations and guidance to prevent any hazard to public health or contamination of land, surface or groundwater.
- Well maintained to allow effective operation.
- Installed in areas with sufficient soil percolation for the design wastewater loading rate.
- Installed in areas of stable soils that are nearly level, well drained, and permeable, with enough separation between the drain field and the groundwater table or other receiving waters.

Wastewater Management

Wastewater management includes water conservation, wastewater treatment, stormwater management, and wastewater and water quality monitoring.

Industrial Wastewater

Industrial wastewater generated from industrial operations includes process wastewater, wastewater from utility operations,, runoff from process and materials staging areas, and miscellaneous activities including wastewater from laboratories, equipment maintenance shops, etc.. The pollutants in an industrial wastewater may include acids or bases (exhibited as low or high pH), soluble organic chemicals causing depletion of dissolved oxygen, suspended solids, nutrients (phosphorus, nitrogen), heavy metals (e.g. cadmium, chromium, copper, lead, mercury, nickel, zinc), cyanide, toxic organic chemicals, oily materials, and volatile materials. , as well as from thermal characteristics of the discharge (e.g., elevated temperature). Transfer of pollutants to another phase, such as air, soil, or the sub-surface, should be minimized through process and engineering controls.

Process Wastewater – – Examples of treatment approaches typically used in the treatment of industrial wastewater are summarized in Annex 1.3.1. While the choice of treatment

[38] Additional guidance on water quality considerations for land application is available in the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume 2: Wastewater Use in Agriculture http://www.who.int/water_sanitation_health/wastewater/gsuweg2/en/index.html

technology is driven by wastewater characteristics, the actual performance of this technology depends largely on the adequacy of its design, equipment selection, as well as operation and maintenance of its installed facilities. Adequate resources are required for proper operation and maintenance of a treatment facility, and performance is strongly dependent on the technical ability and training of its operational staff. One or more treatment technologies may be used to achieve the desired discharge quality and to maintain consistent compliance with regulatory requirements. The design and operation of the selected wastewater treatment technologies should avoid uncontrolled air emissions of volatile chemicals from wastewaters. Residuals from industrial wastewater treatment operations should be disposed in compliance with local regulatory requirements, in the absence of which disposal has to be consistent with protection of public health and safety, and conservation and long term sustainability of water and land resources.

Wastewater from Utilities Operations - Utility operations such as cooling towers and demineralization systems may result in high rates of water consumption, as well as the potential release of high temperature water containing high dissolved solids, residues of biocides, residues of other cooling system anti-fouling agents, etc. Recommended water management strategies for utility operations include:

- Adoption of water conservation opportunities for facility cooling systems as provided in the Water Conservation section below;
- Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations;
- Minimizing use of antifouling and corrosion inhibiting chemicals by ensuring appropriate depth of water intake and use of screens. Least hazardous alternatives should be used with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential. Dose applied should accord with local regulatory requirements and manufacturer recommendations;
- Testing for residual biocides and other pollutants of concern should be conducted to determine the need for dose adjustments or treatment of cooling water prior to discharge.

Stormwater Management - Stormwater includes any surface runoff and flows resulting from precipitation, drainage or other sources. Typically stormwater runoff contains suspended sediments, metals, petroleum hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), coliform, etc. Rapid runoff, even of uncontaminated stormwater, also degrades the quality of the receiving water by eroding stream beds and banks. In order to reduce the need for stormwater treatment, the following principles should be applied:

- Stormwater should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge
- Surface runoff from process areas or potential sources of contamination should be prevented
- Where this approach is not practical, runoff from process and storage areas should be segregated from potentially less contaminated runoff
- Runoff from areas without potential sources of contamination should be minimized (e.g. by minimizing the area of impermeable surfaces) and the peak discharge rate should

be reduced (e.g. by using vegetated swales and retention ponds);

- Where stormwater treatment is deemed necessary to protect the quality of receiving water bodies, priority should be given to managing and treating the first flush of stormwater runoff where the majority of potential contaminants tend to be present;
- When water quality criteria allow, stormwater should be managed as a resource, either for groundwater recharge or for meeting water needs at the facility;
- Oil water separators and grease traps should be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas.
- Sludge from stormwater catchments or collection and treatment systems may contain elevated levels of pollutants and should be disposed in compliance with local regulatory requirements, in the absence of which disposal has to be consistent with protection of public health and safety, and conservation and long term sustainability of water and land resources.

Sanitary Wastewater

Sanitary wastewater from industrial facilities may include effluents from domestic sewage, food service, and laundry facilities serving site employees. Miscellaneous wastewater from laboratories, medical infirmaries, water softening etc. may also be discharged to the sanitary wastewater treatment system. Recommended sanitary wastewater management strategies include:

- Segregation of wastewater streams to ensure compatibility with selected treatment option (e.g. septic system which can only accept domestic sewage);
- Segregation and pretreatment of oil and grease containing effluents (e.g. use of a grease trap) prior to discharge into sewer systems;
- If sewage from the industrial facility is to be discharged to surface water, treatment to meet national or local standards for sanitary wastewater discharges or, in their absence, the indicative guideline values applicable to sanitary wastewater discharges shown in Table 1.3.1;
- If sewage from the industrial facility is to be discharged to either a septic system, or where land is used as part of the treatment system, treatment to meet applicable national or local standards for sanitary wastewater discharges is required.
- Sludge from sanitary wastewater treatment systems should be disposed in compliance with local regulatory requirements, in the absence of which disposal has to be consistent with protection of public health and safety, and conservation and long term sustainability of water and land resources.

Table 1.3.1 Indicative Values for Treated Sanitary Sewage Discharges[a]

Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN[b] / 100 ml	400[a]

Notes:
[a] Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.
[b] MPN = Most Probable Number

Emissions from Wastewater Treatment Operations

Air emissions from wastewater treatment operations may include hydrogen sulfide, methane, ozone (in the case of ozone disinfection), volatile organic compounds (e.g., chloroform generated from chlorination activities and other volatile organic compounds (VOCs) from industrial wastewater), gaseous or volatile chemicals used for disinfection processes (e.g., chlorine and ammonia), and bioaerosols. Odors from treatment facilities can also be a nuisance to workers and the surrounding community. Recommendations for the management of emissions are presented in the Air Emissions and Ambient Air Quality section of this document and in the EHS Guidelines for Water and Sanitation.

Residuals from Wastewater Treatment Operations

Sludge from a waste treatment plant needs to be evaluated on a case-by-case basis to establish whether it constitutes a hazardous or a non-hazardous waste and managed accordingly as described in the Waste Management section of this document.

Occupational Health and Safety Issues in Wastewater Treatment Operations

Wastewater treatment facility operators may be exposed to physical, chemical, and biological hazards depending on the design of the facilities and the types of wastewater effluents managed. Examples of these hazards include the potential for trips and falls into tanks, confined space entries for maintenance operations, and inhalation of VOCs, bioaerosols, and methane, contact with pathogens and vectors, and use of potentially hazardous chemicals, including chlorine, sodium and calcium hypochlorite, and ammonia. Detailed recommendations for the management of occupational health and safety issues are presented in the relevant section of this document. Additional guidance specifically applicable to wastewater treatment systems is provided in the EHS Guidelines for Water and Sanitation.

Monitoring

A wastewater and water quality monitoring program with adequate resources and management oversight should be developed and implemented to meet the objective(s) of the monitoring program. The wastewater and water quality monitoring program should consider the following elements:

- *Monitoring parameters*: The parameters selected for monitoring should be indicative of the pollutants of concern from the process, and should include parameters that are regulated under compliance requirements;

- *Monitoring type and frequency*: Wastewater monitoring should take into consideration the discharge characteristics from the process over time. Monitoring of discharges from processes with batch manufacturing or seasonal process variations should take into consideration of time-dependent variations in discharges and, therefore, is more complex than monitoring of continuous discharges. Effluents from highly variable processes may need to be sampled more frequently or through composite methods. Grab samples or, if automated equipment permits, composite samples may offer more insight on average concentrations of pollutants over a 24-hour period. Composite samplers may not be appropriate where analytes of concern are short-lived (e.g., quickly degraded or volatile).

- *Monitoring locations*: The monitoring location should be selected with the objective of providing representative monitoring data. Effluent sampling stations may be located at the final discharge, as well as at strategic upstream points prior to merging of different discharges. Process discharges should not be diluted prior or after treatment with the objective of meeting the discharge or ambient water quality standards.

- *Data quality*: Monitoring programs should apply internationally approved methods for sample collection, preservation and analysis. Sampling should be conducted by or under the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and Analysis Quality Assurance/Quality Control (QA/QC) plans should be prepared and, implemented. QA/QC documentation should be included in monitoring reports.

Annex 1.3.1 - Examples of Industrial Wastewater Treatment Approaches

Pollutant/Parameter	Control Options / Principle	Common End of Pipe Control Technology
pH	Chemical, Equalization	Acid/Base addition, Flow equalization
Oil and Grease / TPH	Phase separation	Dissolved Air Floatation, oil water separator, grease trap
TSS - Settleable	Settling, Size Exclusion	Sedimentation basin, clarifier, centrifuge, screens
TSS - Non-Settleable	Floatation, Filtration - traditional and tangential	Dissolved air floatation, Multimedia filter, sand filter, fabric filter, ultrafiltration, microfiltration
Hi - BOD (> 2 Kg/m^3)	Biological - Anaerobic	Suspended growth, attached growth, hybrid
Lo - BOD (< 2 Kg/m^3)	Biological - Aerobic, Facultative	Suspended growth, attached growth, hybrid
COD - Non-Biodegradable	Oxidation, Adsorption, Size Exclusion	Chemical oxidation, Thermal oxidation, Activated Carbon, Membranes
Metals - Particulate and Soluble	Coagulation, flocculation, precipitation, size exclusion	Flash mix with settling, filtration - traditional and tangential
Inorganics / Non-metals	Coagulation, flocculation, precipitation, size exclusion, Oxidation, Adsorption	Flash mix with settling, filtration - traditional and tangential, Chemical oxidation, Thermal oxidation, Activated Carbon, Reverse Osmosis, Evaporation
Organics - VOCs and SVOCs	Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation	Biological : Suspended growth, attached growth, hybrid; Chemical oxidation, Thermal oxidation, Activated Carbon
Emissions – Odors and VOCs	Capture – Active or Passive; Biological; Adsorption, Oxidation	Biological : Attached growth; Chemical oxidation, Thermal oxidation, Activated Carbon
Nutrients	Biological Nutrient Removal, Chemical, Physical, Adsorption	Aerobic/Anoxic biological treatment, chemical hydrolysis and air stripping, chlorination, ion exchange
Color	Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation	Biological Aerobic, Chemical oxidation, Activated Carbon
Temperature	Evaporative Cooling	Surface Aerators, Flow Equalization
TDS	Concentration, Size Exclusion	Evaporation, crystallization, Reverse Osmosis
Active Ingredients/Emerging Contaminants	Adsorption, Oxidation, Size Exclusion, Concentration	Chemical oxidation, Thermal oxidation, Activated Carbon, Ion Exchange, Reverse Osmosis, Evaporation, Crystallization
Radionuclides	Adsorption,Size Exclusion, Concentration	Ion Exchange, Reverse Osmosis, Evaporation, Crystallization
Pathogens	Disinfection, Sterilization	Chlorine, Ozone, Peroxide, UV, Thermal
Toxicity	Adsorption, Oxidation, Size Exclusion, Concentration	Chemical oxidation, Thermal oxidation, Activated Carbon, Evaporation, crystallization, Reverse Osmosis

1.4 Water Conservation

Applicability and Approach

Water conservation programs should be implemented commensurate with the magnitude and cost of water use. These programs should promote the continuous reduction in water consumption and achieve savings in the water pumping, treatment and disposal costs. Water conservation measures may include water monitoring/management techniques; process and cooling/heating water recycling, reuse, and other techniques; and sanitary water conservation techniques.

General recommendations include:

- Storm/Rainwater harvesting and use
- Zero discharge design/Use of treated waste water to be included in project design processes
- Use of localized recirculation systems in plant/facility/shops (as opposed to centralized recirculation system), with provision only for makeup water
- Use of dry process technologies e.g. dry quenching
- Process water system pressure management
- Project design to have measures for adequate water collection, spill control and leakage control system

Water Monitoring and Management

The essential elements of a water management program involve:

- Identification, regular measurement, and recording of principal flows within a facility;
- Definition and regular review of performance targets, which are adjusted to account for changes in major factors affecting water use (e.g. industrial production rate);
- Regular comparison of water flows with performance targets to identify where action should be taken to reduce water use.

Water measurement (metering) should emphasize areas of greatest water use. Based on review of metering data, 'unaccounted' use–indicating major leaks at industrial facilities–could be identified.

Process Water Reuse and Recycling

Opportunities for water savings in industrial processes are highly industry-specific. However, the following techniques have all been used successfully, and should be considered in conjunction with the development of the metering system described above.

- *Washing Machines:* Many washing machines use large quantities of hot water. Use can increase as nozzles become enlarged due to repeated cleaning and /or wear. Monitor machine water use, compare with specification, and replace nozzles when water and heat use reaches levels warranting such work.

- *Water reuse:* Common water reuse applications include countercurrent rinsing, for example in multi-stage washing and rinsing processes, or reusing waste water from one process for another with less exacting water requirements. For example, using bleaching rinse water for textile washing, or bottle-washer rinse water for bottle crate washing, or even washing the floor. More sophisticated reuse projects requiring treatment of water before reuse are also sometimes practical.

- *Water jets/sprays:* If processes use water jets or sprays (e.g. to keep conveyors clean or to cool product) review the accuracy of the spray pattern to prevent unnecessary water loss.
- *Flow control optimization:* Industrial processes sometimes require the use of tanks, which are refilled to control losses. It is often possible to reduce the rate of water supply to such tanks, and sometimes to reduce tank levels to reduce spillage. If the process uses water cooling sprays, it may be possible to reduce flow while maintaining cooling performance. Testing can determine the optimum balance.
    - If hoses are used in cleaning, use flow controls to restrict wasteful water flow
    - Consider the use of high pressure, low volume cleaning systems rather than using large volumes of water sprayed from hosepipes
    - Using flow timers and limit switches to control water use
    - Using 'clean-up' practices rather than hosing down

Building Facility Operations

Consumption of building and sanitary water is typically less than that used in industrial processes. However, savings can readily be identified, as outlined below:

- Compare daily water use per employee to existing benchmarks taking into consideration the primary use at the facility, whether sanitary or including other activities such as showering or catering
- Regularly maintain plumbing, and identify and repair leaks
- Shut off water to unused areas
- Install self-closing taps, automatic shut-off valves, spray nozzles, pressure reducing valves, and water conserving fixtures (e.g. low flow shower heads, faucets, toilets, urinals; and spring loaded or sensored faucets)
- Operate dishwashers and laundries on full loads, and only when needed
- Install water-saving equipment in lavatories, such as low-flow toilets

Cooling Systems

Water conservation opportunities in cooling systems include:

- Use of closed circuit cooling systems with cooling towers rather than once-through cooling systems
- Limiting condenser or cooling tower blowdown to the minimum required to prevent unacceptable accumulation of dissolved solids
- Use of air cooling rather than evaporative cooling, although this may increase electricity use in the cooling system
- Use of treated waste water for cooling towers
- Reusing/recycling cooling tower blowdown

Heating Systems

Heating systems based on the circulation of low or medium pressure hot water (which do not consume water) should be closed. If they do consume water, regular maintenance should be conducted to check for leaks. However, large quantities of water may be used by steam systems, and this can be reduced by the following measures:

- Repair of steam and condensate leaks, and repair of all failed steam traps
- Return of condensate to the boilerhouse, and use of heat exchangers (with condensate return) rather than direct steam injection where process permits
- Flash steam recovery
- Minimizing boiler blowdown consistent with maintaining acceptably low dissolved solids in boiler water. Use of reverse osmosis boiler feed water treatment substantially reduces the need for boiler blowdown
- Minimizing deaerator heating

1.5 Hazardous Materials Management

Applicability and Approach

These guidelines apply to projects that use, store, or handle any quantity of hazardous materials (Hazmats), defined as materials that represent a risk to human health, property, or the environment due to their physical or chemical characteristics. Hazmats can be classified according to the hazard as explosives; compressed gases, including toxic or flammable gases; flammable liquids; flammable solids; oxidizing substances; toxic materials; radioactive material; and corrosive substances. Guidance on the transport of hazardous materials is covered in Section 3 of this document.

When a hazardous material is no longer usable for its original purpose and is intended for disposal, but still has hazardous properties, it is considered a *hazardous waste* (see Section 1.4).

This guidance is intended to be applied in conjunction with traditional occupational health and safety and emergency preparedness programs which are included in Section 2.0 on Occupational Health and Safety Management, and Section 3.7 on Emergency Preparedness and Response. Guidance on the Transport of Hazardous Materials is provided in Section 3.5.

This section is divided into two main subsections:

General Hazardous Materials Management: Guidance applicable to all projects or facilities that handle or store any quantity of hazardous materials.

Management of Major Hazards: Additional guidance for projects or facilities that store or handle hazardous materials at, or above, threshold quantities[39], and thus require special treatment to prevent accidents such as fire, explosions, leaks or spills, and to prepare and respond to emergencies.

The overall objective of hazardous materials management is to avoid or, when avoidance is not feasible, minimize uncontrolled releases of hazardous materials or accidents (including explosion and fire) during their production, handling, storage and use. This objective can be achieved by:

[39] For examples, threshold quantities should be those established for emergency planning purposes such as provided in the US Environmental Protection Agency. *Protection of Environment* (Title Threshold quantities are provided in the US Environmental Protection Agency. *Protection of Environment* (Title 40 CFR Parts 68, 112, and 355).

- Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment;
- Where practicable, avoiding or minimizing the use of hazardous materials. For example, non-hazardous materials have been found to substitute asbestos in building materials, PCBs in electrical equipment, persistent organic pollutants (POPs) in pesticides formulations, and ozone depleting substances in refrigeration systems;
- Preventing uncontrolled releases of hazardous materials to the environment or uncontrolled reactions that might result in fire or explosion;
- Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard;
- Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures.

General Hazardous Materials Management

Projects which manufacture, handle, use, or store hazardous materials should establish management programs that are commensurate with the potential risks present. The main objectives of projects involving hazardous materials should be the protection of the workforce and the prevention and control of releases and accidents. These objectives should be addressed by integrating prevention and control measures, management actions, and procedures into day-to-day business activities. Potentially applicable elements of a management program include the following:

Hazard Assessment

The level of risk should be established through an on-going assessment process based on:

- The types and amounts of hazardous materials present in the project. This information should be recorded and should include a summary table with the following information:
    - o Name and description (e.g. composition of a mixture) of the Hazmat
    - o Classification (e.g. code, class or division) of the Hazmat
    - o Internationally accepted regulatory reporting threshold quantity or national equivalent[40] of the Hazmat
    - o Quantity of Hazmat used per month
    - o Characteristic(s) that make(s) the Hazmat hazardous (e.g. flammability, toxicity)
- Analysis of potential spill and release scenarios using available industry statistics on spills and accidents where available
- Analysis of the potential for uncontrolled reactions such as fire and explosions
- Analysis of potential consequences based on the physical-geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas

Hazard assessment should be performed by specialized professionals using internationally-accepted methodologies such as Hazardous Operations Analysis (HAZOP), Failure Mode and Effects Analysis (FMEA), and Hazard Identification (HAZID).

Management Actions

The management actions to be included in a Hazardous Materials Management Plan should be commensurate with the level of

[40] Threshold quantities are provided in the US Environmental Protection Agency. *Protection of Environment* (Title 40 CFR Parts 68, 112, and 355).

potential risks associated with the production, handling, storage, and use of hazardous materials.

Release Prevention and Control Planning

Where there is risk of a spill of uncontrolled hazardous materials, facilities should prepare a spill control, prevention, and countermeasure plan as a specific component of their Emergency Preparedness and Response Plan (described in more detail in Section 3.7). The plan should be tailored to the hazards associated with the project, and include:

- Training of operators on release prevention, including drills specific to hazardous materials as part of emergency preparedness response training
- Implementation of inspection programs to maintain the mechanical integrity and operability of pressure vessels, tanks, piping systems, relief and vent valve systems, containment infrastructure, emergency shutdown systems, controls and pumps, and associated process equipment
- Preparation of written Standard Operating Procedures (SOPs) for filling USTs, ASTs or other containers or equipment as well as for transfer operations by personnel trained in the safe transfer and filling of the hazardous material, and in spill prevention and response
- SOPs for the management of secondary containment structures, specifically the removal of any accumulated fluid, such as rainfall, to ensure that the intent of the system is not accidentally or willfully defeated
- Identification of locations of hazardous materials and associated activities on an emergency plan site map
- Documentation of availability of specific personal protective equipment and training needed to respond to an emergency
- Documentation of availability of spill response equipment sufficient to handle at least initial stages of a spill and a list of external resources for equipment and personnel, if necessary, to supplement internal resources
- Description of response activities in the event of a spill, release, or other chemical emergency including:
    - Internal and external notification procedures
    - Specific responsibilities of individuals or groups
    - Decision process for assessing severity of the release, and determining appropriate actions
    - Facility evacuation routes
    - Post-event activities such as clean-up and disposal, incident investigation, employee re-entry, and restoration of spill response equipment.

Occupational Health and Safety

The Hazardous Materials Management Plan should address applicable, essential elements of occupational health and safety management as described in Section 2.0 on Occupational Health and Safety, including:

- Job safety analysis to identify specific potential occupational hazards and industrial hygiene surveys, as appropriate, to monitor and verify chemical exposure levels, and compare with applicable occupational exposure standards[41]
- Hazard communication and training programs to prepare workers to recognize and respond to workplace chemical hazards. Programs should include aspects of hazard identification, safe operating and materials handling procedures, safe work practices, basic emergency procedures, and special hazards unique to their jobs.

[41] Including: Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®), American Conference of Governmental Industrial Hygienists (ACGIH), http://www.acgih.org/TLV/; U.S. National Institute for Occupational Health and Safety (NIOSH), http://www.cdc.gov/niosh/npg/; Permissible Exposure Limits (PELs), U.S. Occupational Safety and Health Administration (OSHA), http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992; Indicative Occupational Exposure Limit Values, European Union, http://europe.osha.eu.int/good_practice/risks/ds/oel/; and other similar sources.

Training should incorporate information from Material Safety Data Sheets[42] (MSDSs) for hazardous materials being handled. MSDSs should be readily accessible to employees in their local language.

- Definition and implementation of permitted maintenance activities, such as hot work or confined space entries
- Provision of suitable personal protection equipment (PPE) (footwear, masks, protective clothing and goggles in appropriate areas), emergency eyewash and shower stations, ventilation systems, and sanitary facilities
- Monitoring and record-keeping activities, including audit procedures designed to verify and record the effectiveness of prevention and control of exposure to occupational hazards, and maintaining accident and incident investigation reports on file for a period of at least five years

Process Knowledge and Documentation

The Hazardous Materials Management Plan should be incorporated into, and consistent with, the other elements of the facility ES/OHS MS and include:

- Written process safety parameters (i.e., hazards of the chemical substances, safety equipment specifications, safe operation ranges for temperature, pressure, and other applicable parameters, evaluation of the consequences of deviations, etc.)
- Written operating procedures
- Compliance audit procedures

[42] MSDSs are produced by the manufacturer, but might not be prepared for chemical intermediates that are not distributed in commerce. In these cases, employers still need to provide workers with equivalent information.

Preventive Measures

Hazardous Materials Transfer

Uncontrolled releases of hazardous materials may result from small cumulative events, or from more significant equipment failure associated with events such as manual or mechanical transfer between storage systems or process equipment. Recommended practices to prevent hazardous material releases from processes include:

- Use of dedicated fittings, pipes, and hoses specific to materials in tanks (e.g., all acids use one type of connection, all caustics use another), and maintaining procedures to prevent addition of hazardous materials to incorrect tanks
- Use of transfer equipment that is compatible and suitable for the characteristics of the materials transferred and designed to ensure safe transfer
- Regular inspection, maintenance and repair of fittings, pipes and hoses
- Provision of secondary containment, drip trays or other overflow and drip containment measures, for hazardous materials containers at connection points or other possible overflow points.

Overfill Protection

Overfills of vessels and tanks should be prevented as they are among the most common causes of spills resulting in soil and water contamination, and among the easiest to prevent. Recommended overfill protection measures include:

- Prepare written procedures for transfer operations that includes a checklist of measures to follow during filling operations and the use of filling operators trained in these procedures
- Installation of gauges on tanks to measure volume inside
- Use of dripless hose connections for vehicle tank and fixed connections with storage tanks

- Provision of automatic fill shutoff valves on storage tanks to prevent overfilling
- Use of a catch basin around the fill pipe to collect spills
- Use of piping connections with automatic overfill protection (float valve)
- Pumping less volume than available capacity into the tank or vessel by ordering less material than its available capacity
- Provision of overfill or over pressure vents that allow controlled release to a capture point

Reaction, Fire, and Explosion Prevention

Reactive, flammable, and explosive materials should also be managed to avoid uncontrolled reactions or conditions resulting in fire or explosion. Recommended prevention practices include:

- Storage of incompatible materials (acids, bases, flammables, oxidizers, reactive chemicals) in separate areas, and with containment facilities separating material storage areas
- Provision of material-specific storage for extremely hazardous or reactive materials
- Use of flame arresting devices on vents from flammable storage containers
- Provision of grounding and lightning protection for tank farms, transfer stations, and other equipment that handles flammable materials
- Selection of materials of construction compatible with products stored for all parts of storage and delivery systems, and avoiding reuse of tanks for different products without checking material compatibility
- Storage of hazardous materials in an area of the facility separated from the main production works. Where proximity is unavoidable, physical separation should be provided using structures designed to prevent fire, explosion, spill, and other emergency situations from affecting facility operations
- Prohibition of all sources of ignition from areas near flammable storage tanks

Control Measures

Secondary Containment (Liquids)

A critical aspect for controlling accidental releases of liquid hazardous materials during storage and transfer is the provision of secondary containment. It is not necessary for secondary containment methods to meet long term material compatibility as with primary storage and piping, but their design and construction should hold released materials effectively until they can be detected and safely recovered. Appropriate secondary containment structures consist of berms, dikes, or walls capable of containing the larger of 110 percent of the largest tank or 25% percent of the combined tank volumes in areas with above-ground tanks with a total storage volume equal or greater than 1,000 liters and will be made of impervious, chemically resistant material. Secondary containment design should also consider means to prevent contact between incompatible materials in the event of a release.

Other secondary containment measures that should be applied depending on site-specific conditions include:

- Transfer of hazardous materials from vehicle tanks to storage in areas with surfaces sufficiently impervious to avoid loss to the environment and sloped to a collection or a containment structure not connected to municipal wastewater/stormwater collection system
- Where it is not practical to provide permanent, dedicated containment structures for transfer operations, one or more alternative forms of spill containment should be provided, such as portable drain covers (which can be deployed for the duration of the operations), automatic shut-off valves on storm water basins, or shut off valves in drainage or sewer facilities, combined with oil-water separators

- Storage of drummed hazardous materials with a total volume equal or greater than 1,000 liters in areas with impervious surfaces that are sloped or bermed to contain a minimum of 25 percent of the total storage volume
- Provision of secondary containment for components (tanks, pipes) of the hazardous material storage system, to the extent feasible
- Conducting periodic (e.g. daily or weekly) reconciliation of tank contents, and inspection of visible portions of tanks and piping for leaks;
- Use of double-walled, composite, or specially coated storage and piping systems particularly in the use of underground storage tanks (USTs) and underground piping. If double-walled systems are used, they should provide a means of detecting leaks between the two walls.

Storage Tank and Piping Leak Detection

Leak detection may be used in conjunction with secondary containment, particularly in high-risk locations[43]. Leak detection is especially important in situations where secondary containment is not feasible or practicable, such as in long pipe runs. Acceptable leak detection methods include:

- Use of automatic pressure loss detectors on pressurized or long distance piping
- Use of approved or certified integrity testing methods on piping or tank systems, at regular intervals
- Considering the use of SCADA[44] if financially feasible

[43] High-risk locations are places where the release of product from the storage system could result in the contamination of drinking water source or those located in water resource protection areas as designated by local authorities.

[44] Supervisory Control and Data Acquisition

Underground Storage Tanks (USTs)[45]

Although there are many environmental and safety advantages of underground storage of hazardous materials, including reduced risk of fire or explosion, and lower vapor losses into the atmosphere, leaks of hazardous materials can go undetected for long periods of time with potential for soil and groundwater contamination. Examples of techniques to manage these risks include:

- Avoiding use of USTs for storage of highly soluble organic materials
- Assessing local soil corrosion potential, and installing and maintaining cathodic protection (or equivalent rust protection) for steel tanks
- For new installations, installing impermeable liners or structures (e.g., concrete vaults) under and around tanks and lines that direct any leaked product to monitoring ports at the lowest point of the liner or structure
- Monitoring the surface above any tank for indications of soil movement
- Reconciling tank contents by measuring the volume in store with the expected volume, given the stored quantity at last stocking, and deliveries to and withdrawals from the store
- Testing integrity by volumetric, vacuum, acoustic, tracers, or other means on all tanks at regular intervals
- Considering the monitoring groundwater of quality down gradient of locations where multiple USTs are in use
- Evaluating the risk of existing UST in newly acquired facilities to determine if upgrades are required for USTs that will be continued to be used, including replacement with new systems or permanent closure of abandoned USTs. Ensuring that new USTs are sited away from wells,

[45] Additional details on the management of USTs is provided in the EHS Guidelines for Retail Petroleum Stations.

reservoirs and other source water protection areas and floodplains, and maintained so as to prevent corrosion.

Management of Major Hazards

In addition to the application of the above-referenced guidance on prevention and control of releases of hazardous materials, projects involving production, handling, and storage of hazardous materials *at or above threshold limits*[46] should prepare a Hazardous Materials Risk Management Plan, in the context of its overall ES/OHS MS, containing all of the elements presented below.[47] The objective of this guidance is the prevention and control of catastrophic releases of toxic, reactive, flammable, or explosive chemicals that may result in toxic, fire, or explosion hazards.[48]

Management Actions

- *Management of Change:* These procedures should address:
  - The technical basis for changes in processes and operations
  - The impact of changes on health and safety
  - Modification to operating procedures
  - Authorization requirements
  - Employees affected
  - Training needs
- *Compliance Audit*: A compliance audit is a way to evaluate compliance with the prevention program requirements for each process. A compliance audit covering each element of the prevention measures (see below) should be conducted at least every three years and should include:
  - Preparation of a report of the findings
  - Determination and documentation of the appropriate response to each finding
  - Documentation that any deficiency has been corrected
- *Incident Investigation:* Incidents can provide valuable information about site hazards and the steps needed to prevent accidental releases. An incident investigation mechanism should include procedures for:
  - Initiation of the investigation promptly
  - Summarizing the investigation in a report
  - Addressing the report findings and recommendations
  - A review of the report with staff and contractors
- *Employee Participation:* A written plan of action should describe an active employee participation program for the prevention of accidents.
- *Contractors:* There should be a mechanism for contractor control which should include a requirement for them to develop hazard materials management procedures that meet the requirements of the hazardous materials management plan. Their procedures should be consistent with those of the contracting company and the contractor workforce should undergo the same training. Additionally, procedures should require that contractors are:
  - Provided with safety performance procedures and safety and hazard information
  - Observe safety practices
  - Act responsibly
  - Have access to appropriate training for their employees
  - Ensure that their employees know process hazards and applicable emergency actions

[46] Threshold quantities should be those established for emergency planning purposes such as provided in the US Environmental Protection Agency. *Protection of Environment* (Title 40 CFR Parts 300-399 and 700 to 789).

[47] For further information and guidance, please refer to International Finance Corporation (IFC) Hazardous Materials Risk Management Manual. Washington, D.C. December 2000.

[48] The approach to the management of major hazards is largely based on an approach to Process Safety Management developed by the American Institute of Chemical Engineers.

- Prepare and submit training records for their employees to the contracting company
- Inform their employees about the hazards presented by their work
- Assess trends of repeated similar incidents
- Develop and implement procedures to manage repeated similar incidents

- *Training*: Project employees should be provided training on Hazmat management. The training program should include:
  - A list of employees to be trained
  - Specific training objectives
  - Mechanisms to achieve the objectives (i.e., hands-on workshops, videos, etc.)
  - The means to determine whether the training program is effective
  - Training procedures for new hires and refresher courses for existing employees

Preventive Measures

The purpose of preventive measures is to ensure that safety-related aspects of the process and equipment are considered, limits to be placed on the operations are well known, and accepted standards and codes are adopted, where they apply.

- *Process Safety Information:* Procedures should be prepared for each hazardous materials and include:
  - Compilation of Material Safety Data Sheets (MSDS)
  - Identification of maximum intended inventories and safe upper/lower parameters
  - Documentation of equipment specifications and of codes and standards used to design, build and operate the process
- *Operating Procedures:* SOPs should be prepared for each step of all processes or operations within the project (e.g. initial startup, normal operations, temporary operations, emergency shutdown, emergency operations, normal shutdown, and start-up following a normal or emergency shutdown or major change). These SOPs should include special considerations for Mazmats used in the process or operations (e.g. temperature control to prevent emissions of a volatile hazardous chemical; diversion of gaseous discharges of hazardous pollutants from the process to a temporary storage tank in case of emergency).

Other procedures to be developed include impacts of deviations, steps to avoid deviations, prevention of chemical exposure, exposure control measures, and equipment inspections.

Mechanical Integrity of process equipment, piping and instrumentation: Inspection and maintenance procedures should be developed and documented to ensure mechanical integrity of equipment, piping, and instrumentation and prevent uncontrolled releases of hazardous materials from the project. These procedures should be included as part of the project SOPs. The specific process components of major interest include pressure vessels and storage tanks, piping systems, relief and vent systems and devices, emergency shutdown systems, controls, and pumps. Recommended aspects of the inspection and maintenance program include:

- Developing inspection and maintenance procedures
- Establishing a quality assurance plan for equipment, maintenance materials, and spare parts
- Conducting employee training on the inspection and maintenance procedures
- Conducting equipment, piping, and instrumentation inspections and maintenance
- Identifying and correcting identified deficiencies

- Evaluating the inspection and maintenance results and, if necessary, updating the inspection and maintenance procedures
- Reporting the results to management.

- *Hot Work Permit:* Hot work operations – such as brazing, torch-cutting, grinding, soldering, and welding – are associated with potential health, safety, and property hazards resulting from the fumes, gases, sparks, and hot metal and radiant energy produced during hot work. Hot work permit is required for any operation involving open flames or producing heat and/or sparks. The section of SOPs on hot work should include the responsibility for hot work permitting, personal protection equipment (PPE), hot work procedures, personnel training, and recordkeeping.
- *Pre-Start Review:* Procedures should be prepared to carry out pre-start reviews when a modification is significant enough to require a change in safety information under the management of change procedure. The procedures should:
    - Confirm that the new or modified construction and/or equipment meet design specifications
    - Ensure that procedures for safety, operation, maintenance, and emergency are adequate
    - Include a process hazard assessment, and resolve or implement recommendations for new process
    - Ensure that training for all affected employees is being conducted

Emergency Preparedness and Response

When handling hazardous materials, procedures and practices should be developed allowing for quick and efficient responses to accidents that could result in human injury or damage to the environment. An Emergency Preparedness and Response Plan, incorporated into and consistent with, the facility's overall ES/OHS MS, should be prepared to cover the following:[49]

- *Planning Coordination:* Procedures should be prepared for:
    - Informing the public and emergency response agencies
    - Documenting first aid and emergency medical treatment
    - Taking emergency response actions
    - Reviewing and updating the emergency response plan to reflect changes, and ensuring that employees are informed of such changes
- *Emergency Equipment:* Procedures should be prepared for using, inspecting, testing, and maintaining the emergency response equipment.
- *Training:* Employees and contractors should be trained on emergency response procedures.

Community Involvement and Awareness

When hazardous materials are in use above threshold quantities, the management plan should include a system for community awareness, notification and involvement that should be commensurate with the potential risks identified for the project during the hazard assessment studies. This should include mechanisms for sharing the results of hazard and risk assessment studies in a timely, understandable and culturally sensitive manner with potentially affected communities that provides a means for public feedback. Community involvement activities should include:

- Availability of general information to the potentially affected community on the nature and extent of project operations, and the prevention and control measures in place to ensure no effects to human health

[49] For a comprehensive treatment of the development of emergency response plans in conjunction with communities refer to the Awareness and Preparedness for Emergencies at Local Level (APELL) Guidelines available at: http://www.uneptie.org/pc/apell/publications/handbooks.html

- The potential for off-site effects to human health or the environment following an accident at planned or existing hazardous installations
- Specific and timely information on appropriate behavior and safety measures to be adopted in the event of an accident including practice drills in locations with higher risks
- Access to information necessary to understand the nature of the possible effect of an accident and an opportunity to contribute effectively, as appropriate, to decisions concerning hazardous installations and the development of community emergency preparedness plans.

1.6 Waste Management

Applicability and Approach

These guidelines apply to projects that generate, store, or handle any quantity of waste across a range of industry sectors. It is not intended to apply to projects or facilities where the primary business is the collection, transportation, treatment, or disposal of wastes. Specific guidance for these types of facilities is presented in the Environmental Health and Safety (EHS) Guidelines for Waste Management Facilities.

A *waste* is any solid, liquid, or contained gaseous material that is being discarded by disposal, recycling, burning or incineration. It can be byproduct of a manufacturing process or an obsolete commercial product that can no longer be used for intended purpose and requires disposal.

Solid (non-hazardous) wastes generally include any garbage, refuse. Examples of such waste include domestic trash and garbage; inert construction / demolition materials; refuse, such as metal scrap and empty containers (except those previously used to contain hazardous materials which should, in principle, be managed as a hazardous waste); and residual waste from industrial operations, such as boiler slag, clinker, and fly ash.

Hazardous waste shares the properties of a hazardous material (e.g. ignitability, corrosivity, reactivity, or toxicity), or other physical, chemical, or biological characteristics that may pose a potential risk to human health or the environment if improperly managed. Wastes may also be defined as "hazardous" by local regulations or international conventions, based on the origin of the waste and its inclusion on hazardous waste lists, or based on its characteristics.

Sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial operations needs to be evaluated on a case-by-case basis to establish whether it constitutes a hazardous or a non-hazardous waste.

Facilities that generate and store wastes should practice the following:

- Establishing waste management priorities at the outset of activities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts and considering waste generation and its consequences
- Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes.
- Avoiding or minimizing the generation waste materials, as far as practicable
- Where waste generation cannot be avoided but has been minimized, recovering and reusing waste

- Where waste can not be recovered or reused, treating, destroying, and disposing of it in an environmentally sound manner

General Waste Management

The following guidance applies to the management of non-hazardous and hazardous waste. Additional guidance specifically applicable to hazardous wastes is presented below. Waste management should be addressed through a Waste management system that addresses issues linked to waste minimization, generation, transport, disposal, and monitoring.

Waste Management Planning

Facilities that generate waste should characterize their waste according to composition, source, types of wastes produced, generation rates, or according to local regulatory requirements. Effective planning and implementation of waste management strategies should include:

- Review of new waste sources during planning, siting, and design activities, including during equipment modifications and process alterations, to identify expected waste generation, pollution prevention opportunities, and necessary treatment, storage, and disposal infrastructure
- Collection of data and information about the process and waste streams in existing facilities, including characterization of waste streams by type, quantities, and potential use/disposition
- Establishment of priorities based on a risk analysis that takes into account the potential EHS risks during the waste cycle and the availability of infrastructure to manage the waste in an environmentally sound manner
- Definition of opportunities for source reduction, as well as reuse and recycling
- Definition of procedures and operational controls for on-site storage
- Definition of options / procedures / operational controls for treatment and final disposal

Waste Prevention

Processes should be designed and operated to prevent, or minimize, the quantities of wastes generated and hazards associated with the wastes generated in accordance with the following strategy:

- Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower waste volumes
- Applying manufacturing process that convert materials efficiently, providing higher product output yields, including modification of design of the production process, operating conditions, and process controls[50]
- Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off-specification, contaminated, damaged, or excess to plant needs
- Instituting procurement measures that recognize opportunities to return usable materials such as containers and which prevents the over ordering of materials
- Minimizing hazardous waste generation by implementing stringent waste segregation to prevent the commingling of non-hazardous and hazardous waste to be managed

[50] Examples of waste prevention strategies include the concept of Lean Manufacturing found at http://www.epa.gov/epaoswer/hazwaste/minimize/lean.htm

Recycling and Reuse

In addition to the implementation of waste prevention strategies, the total amount of waste may be significantly reduced through the implementation of recycling plans, which should consider the following elements:

- Evaluation of waste production processes and identification of potentially recyclable materials
- Identification and recycling of products that can be reintroduced into the manufacturing process or industry activity at the site
- Investigation of external markets for recycling by other industrial processing operations located in the neighborhood or region of the facility (e.g., waste exchange)
- Establishing recycling objectives and formal tracking of waste generation and recycling rates
- Providing training and incentives to employees in order to meet objectives

Treatment and Disposal

If waste materials are still generated after the implementation of feasible waste prevention, reduction, reuse, recovery and recycling measures, waste materials should be treated and disposed of and all measures should be taken to avoid potential impacts to human health and the environment. Selected management approaches should be consistent with the characteristics of the waste and local regulations, and may include one or more of the following:

- On-site or off-site biological, chemical, or physical treatment of the waste material to render it non-hazardous prior to final disposal
- Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include: composting operations for organic non-hazardous wastes; properly designed, permitted and operated landfills or incinerators designed for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials such as bioremediation.

Hazardous Waste Management

Hazardous wastes should always be segregated from non-hazardous wastes. If generation of hazardous waste can not be prevented through the implementation of the above general waste management practices, its management should focus on the prevention of harm to health, safety, and the environment, according to the following additional principles:

- Understanding potential impacts and risks associated with the management of any generated hazardous waste during its complete life cycle
- Ensuring that contractors handling, treating, and disposing of hazardous waste are reputable and legitimate enterprises, licensed by the relevant regulatory agencies and following good international industry practice for the waste being handled
- Ensuring compliance with applicable local and international regulations[51]

Waste Storage

Hazardous waste should be stored so as to prevent or control accidental releases to air, soil, and water resources in area location where:

[51] International requirements may include host-country commitments under the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their disposal (http://www.basel.int/) and Rotterdam Convention on the prior Inform Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (http://www.pic.int/)

- Waste is stored in a manner that prevents the commingling or contact between incompatible wastes, and allows for inspection between containers to monitor leaks or spills. Examples include sufficient space between incompatibles or physical separation such as walls or containment curbs
- Store in closed containers away from direct sunlight, wind and rain
- Secondary containment systems should be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment
- Secondary containment is included wherever liquid wastes are stored in volumes greater than 220 liters. The available volume of secondary containment should be at least 110 percent of the largest storage container, or 25 percent of the total storage capacity (whichever is greater), in that specific location
- Provide adequate ventilation where volatile wastes are stored.

Hazardous waste storage activities should also be subject to special management actions, conducted by employees who have received specific training in handling and storage of hazardous wastes:

- Provision of readily available information on chemical compatibility to employees, including labeling each container to identify its contents
- Limiting access to hazardous waste storage areas to employees who have received proper training
- Clearly identifying (label) and demarcating the area, including documentation of its location on a facility map or site plan
- Conducting periodic inspections of waste storage areas and documenting the findings
- Preparing and implementing spill response and emergency plans to address their accidental release (additional information on Emergency Plans in provided in Section 3 of this document)
- Avoiding underground storage tanks and underground piping of hazardous waste

Transportation

On-site and Off-site transportation of waste should be conducted so as to prevent or minimize spills, releases, and exposures to employees and the public. All waste containers designated for off-site shipment should be secured and labeled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site, and be accompanied by a shipping paper (i.e., manifest) that describes the load and its associated hazards, consistent with the guidance provided in Section 3.4 on the Transport of Hazardous Materials.

Treatment and Disposal

In addition to the recommendations for treatment and disposal applicable to general wastes, the following issues specific to hazardous wastes should be considered:

Commercial or Government Waste Contractors

In the absence of qualified commercial or government-owned waste vendors (taking into consideration proximity and transportation requirements), facilities generating waste should consider using:

- Have the technical capability to manage the waste in a manner that reduces immediate and future impact to the environment
- Have all required permits, certifications, and approvals, of applicable government authorities

- Have been secured through the use of formal procurement agreements

In the absence of qualified commercial or government-owned waste disposal operators (taking into consideration proximity and transportation requirements), project sponsors should consider using:

- Installing on-site waste treatment or recycling processes
- As a final option, constructing facilities that will provide for the environmental sound long-term storage of wastes on-site (as described elsewhere in the General EHS Guidelines) or at an alternative appropriate location up until external commercial options become available

Small Quantities of Hazardous Waste

Hazardous waste materials are frequently generated in small quantities by many projects through a variety of activities such as equipment and building maintenance activities. Examples of these types of wastes include: spent solvents and oily rags, empty paint cans, chemical containers; used lubricating oil; used batteries (such as nickel-cadmium or lead acid); and lighting equipment, such as lamps or lamp ballasts. These wastes should be managed following the guidance provided in the above sections.

Monitoring

Monitoring activities associated with the management of hazardous and non-hazardous waste should include:

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labeled and stored. When significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:
    - Inspection of vessels for leaks, drips or other indications of loss
    - Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors
    - Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied)
    - Checking the operability of emergency systems
    - Documenting results of testing for integrity, emissions, or monitoring stations (air, soil vapor, or groundwater)
    - Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage
- Regular audits of waste segregation and collection practices
- Tracking of waste generation trends by type and amount of waste generated, preferably by facility departments
- Characterizing waste at the beginning of generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste, especially hazardous wastes
- Keeping manifests or other records that document the amount of waste generated and its destination
- Periodic auditing of third party treatment, and disposal services including re-use and recycling facilities when significant quantities of hazardous wastes are managed by third parties. Whenever possible, audits should include site visits to the treatment storage and disposal location

- Regular monitoring of groundwater quality in cases of Hazardous Waste on site storage and/or pretreatment and disposal
- Monitoring records for hazardous waste collected, stored, or shipped should include:
  - Name and identification number of the material(s) composing the hazardous waste
  - Physical state (i.e., solid, liquid, gaseous or a combination of one, or more, of these)
  - Quantity (e.g., kilograms or liters, number of containers)
  - Waste shipment tracking documentation to include, quantity and type, date dispatched, date transported and date received, record of the originator, the receiver and the transporter
  - Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific manifest document numbers applicable to the hazardous waste
  - Location of each hazardous waste within the facility, and the quantity at each location

1.7 Noise

Applicability

This section addresses impacts of noise beyond the property boundary of the facilities. Worker exposure to noise is covered in Section 2.0 on Occupational Health and Safety.

Prevention and Control

Noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception.[52] The preferred method for controlling noise from stationary sources is to implement noise control measures at source.[53] Methods for prevention and control of sources of noise emissions depend on the source and proximity of receptors. Noise reduction options that should be considered include:

- Selecting equipment with lower sound power levels
- Installing silencers for fans
- Installing suitable mufflers on engine exhausts and compressor components
- Installing acoustic enclosures for equipment casing radiating noise
- Improving the acoustic performance of constructed buildings, apply sound insulation
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective
- Installing vibration isolation for mechanical equipment
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding
- Siting permanent facilities away from community areas if possible
- Taking advantage of the natural topography as a noise buffer during facility design
- Reducing project traffic routing through community areas wherever possible
- Planning flight routes, timing and altitude for aircraft (airplane and helicopter) flying over community areas
- Developing a mechanism to record and respond to complaints

Noise Level Guidelines

Noise impacts should not exceed the levels presented in Table 1.7.1, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

[52] A point of reception or receptor may be defined as any point on the premises occupied by persons where extraneous noise and/or vibration are received. Examples of receptor locations may include: permanent or seasonal residences; hotels / motels; schools and daycares; hospitals and nursing homes; places of worship; and parks and campgrounds.

[53] At the design stage of a project, equipment manufacturers should provide design or construction specifications in the form of *"Insertion Loss Performance"* for silencers and mufflers, and *"Transmission Loss Performance"* for acoustic enclosures and upgraded building construction.

Table 1.7.1- Noise Level Guidelines[54]		
	One Hour L_{Aeq} (dBA)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational[55]	55	45
Industrial; commercial	70	70

Highly intrusive noises, such as noise from aircraft flyovers and passing trains, should not be included when establishing background noise levels.

Monitoring

Noise monitoring[56] may be carried out for the purposes of establishing the existing ambient noise levels in the area of the proposed or existing facility, or for verifying operational phase noise levels.

Noise monitoring programs should be designed and conducted by trained specialists. Typical monitoring periods should be sufficient for statistical analysis and may last 48 hours with the use of noise monitors that should be capable of logging data continuously over this time period, or hourly, or more frequently, as appropriate (or else cover differing time periods within several days, including weekday and weekend workdays). The type of acoustic indices recorded depends on the type of noise being monitored, as established by a noise expert. Monitors should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface (e.g., wall). In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the facility or noise source(s) under investigation.

[54] Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.
[55] For acceptable indoor noise levels for residential, institutional, and educational settings refer to WHO (1999).

[56] Noise monitoring should be carried out using a Type 1 or 2 sound level meter meeting all appropriate IEC standards.

1.8 Contaminated Land

Applicability and Approach

This section provides a summary of management approaches for land contamination due to anthropogenic releases of hazardous materials, wastes, or oil, including naturally occurring substances. Releases of these materials may be the result of historic or current site activities, including, but not limited to, accidents during their handling and storage, or due to their poor management or disposal.

Land is considered contaminated when it contains hazardous materials or oil concentrations above background or naturally occurring levels.

Contaminated lands may involve surficial soils or subsurface soils that, through leaching and transport, may affect groundwater, surface water, and adjacent sites. Where subsurface contaminant sources include volatile substances, soil vapor may also become a transport and exposure medium, and create potential for contaminant infiltration of indoor air spaces of buildings.

Contaminated land is a concern because of:

- The potential risks to human health and ecology (e.g. risk of cancer or other human health effects, loss of ecology);
- The liability that it may pose to the polluter/business owners (e.g., cost of remediation, damage of business reputation and/or business-community relations) or affected parties (e.g. workers at the site, nearby property owners).

Contamination of land should be avoided by preventing or controlling the release of hazardous materials, hazardous wastes, or oil to the environment. When contamination of land is suspected or confirmed during any project phase, the cause of the uncontrolled release should be identified and corrected to avoid further releases and associated adverse impacts.

Contaminated lands should be managed to avoid the risk to human health and ecological receptors. The preferred strategy for land decontamination is to reduce the level of contamination at the site while preventing the human exposure to contamination.

To determine whether risk management actions are warranted, the following assessment approach should be applied to establish whether the three risk factors of ‘Contaminants’, ‘Receptors’, and ‘Exposure Pathways’ co-exist, or are likely to co-exist, at the project site under current or possible future land use:

- *Contaminant(s)*: Presence of hazardous materials, waste, or oil in any environmental media at potentially hazardous concentrations
- *Receptor(s)*: Actual or likely contact of humans, wildlife, plants, and other living organisms with the contaminants of concern
- *Exposure pathway(s)*: A combination of the route of migration of the contaminant from its point of release (e.g., leaching into potable groundwater) and exposure routes

(e.g., ingestion, transdermal absorption), which would allow receptor(s) to come into actual contact with contaminants

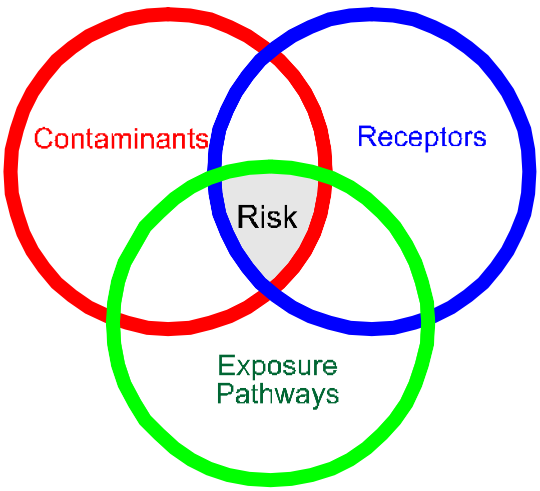


FIGURE 1.8.1: Inter-Relationship of Contaminant Risk Factors

When the three risk factors are considered to be present (in spite of limited data) under current or foreseeable future conditions, the following steps should be followed (as described in the remaining parts of this section):

1) Risk screening;
2) Interim risk management;
3) Detailed quantitative risk assessment; and
4) Permanent risk reduction measures.

Risk Screening

This step is also known as "problem formulation" for environmental risk assessment. Where there is potential evidence of contamination at a site, the following steps are recommended:

- Identification of the location of suspected highest level of contamination through a combination of visual and historical operational information;
- Sampling and testing of the contaminated media (soils or water) according to established technical methods applicable to suspected type of contaminant[57,58];
- Evaluation of the analytical results against the local and national contaminated sites regulations. In the absence of such regulations or environmental standards, other sources of risk-based standards or guidelines should be consulted to obtain comprehensive criteria for screening soil concentrations of pollutants.[59]
- Verification of the potential human and/or ecological receptors and exposure pathways relevant to the site in question

The outcome of risk-screening may reveal that there is no overlap between the three risk-factors as the contaminant levels identified are below those considered to pose a risk to human health or the environment. Alternatively, interim or permanent

57 BC MOE. http://www.env.gov.bc.ca/epd/epdpa/contam_sites/guidance

58 Massachusetts Department of Environment. http://www.mass.gov/dep/cleanup

59 These may include the USEPA Region 3 Risk-Based Concentrations (RBCs). http://www.epa.gov/reg3hwmd/risk/human/index.htm. These RBCs are considered acceptable for specific land use and contaminant exposure scenarios as they have been developed by governments using risk assessment techniques for use as general targets in the site remediation. Separate PRGs have been developed or adopted for soil, sediment or groundwater, and often a distinction is made between land uses (as noted earlier) because of the need for more stringent guidelines for residential and agricultural versus commercial/industrial landuse. The RBC Tables contains Reference Doses (RfDs) and Cancer Slope Factors (CSFs) for about 400 chemicals. These toxicity factors have been combined with "standard" exposure scenarios to calculate RBCs--chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1, or lifetime cancer risk of 1E-6, whichever occurs at a lower concentration) in water, air, fish tissue, and soil for individual chemical substances. The primary use of RBCs is for chemical screening during baseline risk assessment (see EPA Regional Guidance EPA/903/R-93-001, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening"). Additional useful soil quality guidelines can also be obtained from Lijzen et al. 2001.

risk reduction measures may need to be taken with, or without, more detailed risk assessment activities, as described below.

Interim Risk Management

Interim risk management actions should be implemented at any phase of the project life cycle if the presence of land contamination poses an "imminent hazard", i.e., representing an immediate risk to human health and the environment if contamination were allowed to continue, even a short period of time. Examples of situations considered to involve imminent hazards include, but are not restricted to:

- Presence of an explosive atmosphere caused by contaminated land
- Accessible and excessive contamination for which short-term exposure and potency of contaminants could result in acute toxicity, irreversible long term effects, sensitization, or accumulation of persistent biocumulative and toxic substances
- Concentrations of pollutants at concentrations above the Risk Based Concentrations (RBCs[60]) or drinking water standards in potable water at the point of abstraction

Appropriate risk reduction should be implemented as soon as practicable to remove the condition posing the imminent hazard.

Detailed Risk Assessment

As an alternative to complying with numerical standards or preliminary remediation goals, and depending on local regulatory requirements, a detailed site-specific, environmental risk assessment may be used to develop strategies that yield acceptable health risks, while achieving low level contamination on-site. An assessment of contaminant risks needs to be considered in the context of current and future land use, and development scenarios (e.g., residential, commercial, industrial, and urban parkland or wilderness use).

A detailed quantitative risk assessment builds on risk screening (problem formulation). It involves first, a detailed site investigation to identify the scope of contamination.[61] Site investigation programs should apply quality assurance/quality control (QA/QC) measures to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). The site investigation in turn should be used to develop a *conceptual site model* of how and where contaminants exist, how they are transported, and where routes of exposure occur to organisms and humans. The risk factors and conceptual site model provide a framework for assessing contaminant risks.

Human or ecological risk assessments facilitate risk management decisions at contaminated sites. Specific risk assessment objectives include:

- Identifying relevant human and ecological receptors (e.g., children, adults, fish, wildlife)
- Determining if contaminants are present at levels that pose potential human health and/or ecological concerns (e.g., levels above applicable regulatory criteria based on health or environmental risk considerations)
- Determining how human or ecological receptors are exposed to the contaminants (e.g., ingestions of soil, dermal contact, inhalation of dust)

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60 For example, USEPA Region 3 Risk-Based Concentrations (RBCs). http://www.epa.gov/reg3hwmd/risk/human/index.htm.

61 Examples include processes defined by the American Society of Testing and Materials (ASTM) Phase II ESA Process; the British Columbia Ministry of Environment Canada (BC MOE) http://www.env.gov.bc.ca/epd/epdpa/contam_sites/guidance); and the Massachusetts Department of Environment http://www.mass.gov/dep/cleanup.

- Identifying the types of adverse effects that might result from exposure to the contaminants (e.g., effect on target organ, cancer, impaired growth or reproduction) in the absence of regulatory standards
- Quantifying the magnitude of health risks to human and ecological receptors based on a quantitative analysis of contaminant exposure and toxicity (e.g. calculate lifetime cancer risk or ratios of estimated exposure rates compared to safe exposure rates)
- Determining how current and proposed future land use influence the predicted risks (e.g. change of land use from industrial to residential with more sensitive receptors such as children)
- Quantifying the potential environmental and/or human health risks from off-site contaminant migration (e.g., consider if leaching and groundwater transport, or surface water transport results in exposure at adjacent lands/receptors)
- Determining if the risk is likely to remain stable, increase, or decrease with time in the absence of any remediation (e.g., consider if the contaminant is reasonably degradable and likely to remain in place, or be transported to other media)[62]

Addressing these objectives provides a basis to develop and implement risk reduction measures (e.g., clean-up, on-site controls) at the site. If such a need exists, the following additional objectives become relevant:

- Determining where, and in what conceptual manner, risk reduction measures should be implemented
- Identifying the preferred technologies (including engineering controls) needed to implement the conceptual risk reduction measures
- Developing a monitoring plan to ascertain whether risk reduction measures are effective
- Considering the need and appropriateness for institutional controls (e.g. deed restriction, land use restrictions) as part of a comprehensive approach

Permanent Risk Reduction Measures

The *risk factors* and *conceptual site model* within the contaminant risk approach described also provide a basis to manage and mitigate environmental contaminant health risks. The underlying principle is to reduce, eliminate, or control any or all of the three risk factors illustrated in Figure 1.8.1. A short list of examples of risk mitigation strategies is provided below, although actual strategies should be developed based on site-specific conditions, and the practicality of prevailing factors and site constraints. Regardless of the management options selected, the action plan should include, whenever possible, *contaminant source reduction* (i.e., net improvement of the site) as part of the overall strategy towards managing health risks at contaminated sites, as this alone provides for improved environmental quality.

Figure 1.8.2 presents a schematic of the inter-relationship of risk factors and example strategies to mitigate contaminant health risk by modifying the conditions of one or more risk factors to ultimately reduce contaminant exposure to the receptor. The selected approach should take into consideration the technical and financial feasibility (e.g. operability of a selected technology given the local availability of technical expertise and equipment and its associated costs).

Example risk mitigation strategies for contaminant source and exposure concentrations include:

[62] An example of a simplified quantitative risk assessment method is the ASTM E1739-95(2002) Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites and the ASTM E2081-00(2004)e1 Standard Guide for Risk-Based Corrective Action (at chemical release sites).

- Soil, sediment, and sludge:
  - In situ biological treatment (aerobic or anaerobic)
  - In situ physical/chemical treatment (e.g., soil vapor extraction with off-gas treatment, chemical oxidation)
  - In situ thermal treatment (e.g., steam injection, 6-phase heating)
  - Ex situ biological treatment (e.g., excavation and composting)
  - Ex situ physical/chemical treatment (e.g., excavation and stabilization)
  - Ex situ thermal treatment (e.g., excavation and thermal desorption or incineration)
  - Containment (e.g. landfill)
  - Natural attenuation
  - Other treatment processes
- Groundwater, surface water, and leachate:
  - In situ biological treatment (aerobic and/or aerobic)
  - In situ physical/chemical treatment (e.g., air sparging, zero-valent iron permeable reactive barrier)
  - Ex situ biological, physical, and or chemical treatment (i.e., groundwater extraction and treatment)
  - Containment (e.g., slurry wall or sheet pile barrier)
  - Natural attenuation
  - Other treatment processes
- Soil vapor intrusion:
  - Soil vapor extraction to reduce VOC contaminant source in soil
  - Installation of a sub-slab depressurization system to prevent migration of soil vapor into the building
  - Creating a positive pressure condition in buildings
  - Installation (during building construction) of an impermeable barrier below the building and/or an alternative flow pathway for soil vapor beneath building foundations (e.g., porous media and ventilation to shunt vapors away from building)

Example risk mitigation strategies for receptors include:

- Limiting or preventing access to contaminant by receptors (actions targeted at the receptor may include signage with instructions, fencing, or site security)
- Imposing health advisory or prohibiting certain practices leading to exposure such as fishing, crab trapping, shellfish collection
- Educating receptors (people) to modify behavior in order to reduce exposure (e.g., improved work practices, and use of protective clothing and equipment)

Example risk mitigation strategies for exposure pathways include:

- Providing an alternative water supply to replace, for example, a contaminated groundwater supply well
- Capping contaminated soil with at least 1m of clean soil to prevent human contact, as well as plant root or small mammal penetration into contaminated soils
- Paving over contaminated soil as an interim measure to negate the pathway of direct contact or dust generation and inhalation
- Using an interception trench and pump, and treat technologies to prevent contaminated groundwater from discharging into fish streams

The above-reference containment measures should also be considered for immediate implementation in situations where source reduction measures are expected to take time.

Occupational Health and Safety Considerations

Investigation and remediation of contaminated lands requires that workers be mindful of the occupational exposures that could arise from working in close contact with contaminated soil or other environmental media (e.g., groundwater, wastewater, sediments, and soil vapor). Occupational health and safety precautions should be exercised to minimize exposure, as described in Section 2 on Occupational Health and Safety. In addition, workers on contaminated sites should receive special health and safety training specific to contaminated site investigation and remediation activities.[63]

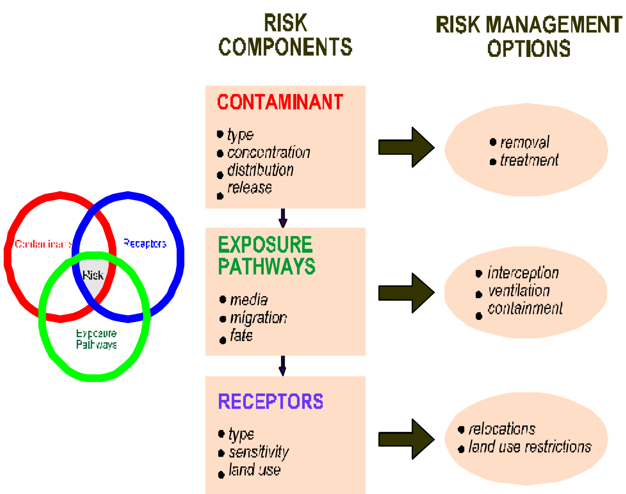

FIGURE 1.8.2: Inter-Relationship of Risk Factors and Management Options

[63] For example, US Occupational Safety and Health Agency (OSHA) regulations found at 40 CFR 1910.120. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9765

2.0 Occupational Health and Safety

Applicability and Approach

Employers and supervisors are obliged to implement all reasonable precautions to protect the health and safety of workers. This section provides guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety. Although the focus is placed on the operational phase of projects, much of the guidance also applies to construction and decommissioning activities. Companies should hire contractors that have the technical capability to manage the occupational health and safety issues of their employees, extending the application of the hazard management activities through formal procurement agreements.

Preventive and protective measures should be introduced according to the following order of priority:

- *Eliminating the hazard* by removing the activity from the work process. Examples include substitution with less hazardous chemicals, using different manufacturing processes, etc;
- *Controlling the hazard* at its source through use of engineering controls. Examples include local exhaust ventilation, isolation rooms, machine guarding, acoustic insulating, etc;
- *Minimizing the hazard* through design of safe work systems and administrative or institutional control measures. Examples include job rotation, training safe work procedures, lock-out and tag-out, workplace monitoring, limiting exposure or work duration, etc.
- *Providing appropriate personal protective equipment (PPE)* in conjunction with training, use, and maintenance of the PPE.

The application of prevention and control measures to occupational hazards should be based on comprehensive job safety or job hazard analyses. The results of these analyses should be prioritized as part of an action plan based on the likelihood and severity of the consequence of exposure to the identified hazards. An example of a qualitative risk ranking or analysis matrix to help identify priorities is described in Table 2.1.1.

Table 2.1.1. Risk Ranking Table to Classify Worker Scenarios Based on Likelihood and Consequence

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catas-trophic 5
A. Almost certain	L	M	E	E	E
B. Likely	L	M	H	E	E
C. Moderate	L	M	H	E	E
D. Unlikely	L	L	M	H	E
E. Rare	L	L	M	H	H

Legend

E: extreme risk; immediate action required

H: high risk; senior management attention needed

M: moderate risk; management responsibility should be specified

L: low risk; manage by routine procedures

2.1 General Facility Design and Operation

Integrity of Workplace Structures

Permanent and recurrent places of work should be designed and equipped to protect OHS:

- Surfaces, structures and installations should be easy to clean and maintain, and not allow for accumulation of hazardous compounds.
- Buildings should be structurally safe, provide appropriate protection against the climate, and have acceptable light and noise conditions.
- Fire resistant, noise-absorbing materials should, to the extent feasible, be used for cladding on ceilings and walls.
- Floors should be level, even, and non-skid.
- Heavy oscillating, rotating or alternating equipment should be located in dedicated buildings or structurally isolated sections.

Severe Weather and Facility Shutdown

- Work place structures should be designed and constructed to withstand the expected elements for the region and have an area designated for safe refuge, if appropriate.
- Standard Operating Procedures (SOPs) should be developed for project or process shut-down, including an evacuation plan. Drills to practice the procedure and plan should also be undertaken annually.

Workspace and Exit

- The space provided for each worker, and in total, should be adequate for safe execution of all activities, including transport and interim storage of materials and products.
- Passages to emergency exits should be unobstructed at all times. Exits should be clearly marked to be visible in total darkness. The number and capacity of emergency exits should be sufficient for safe and orderly evacuation of the greatest number of people present at any time, and there should be a minimum two exits from any work area.

- Facilities also should be designed and built taking into account the needs of disabled persons.

Fire Precautions

The workplace should be designed to prevent the start of fires through the implementation of fire codes applicable to industrial settings. Other essential measures include:

- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. The equipment should be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present.
- Provision of manual firefighting equipment that is easily accessible and simple to use
- Fire and emergency alarm systems that are both audible and visible

The IFC Life and Fire Safety Guideline should apply to buildings accessible to the public (See Section 3.3).

Lavatories and Showers

- Adequate lavatory facilities (toilets and washing areas) should be provided for the number of people expected to work in the facility and allowances made for segregated facilities, or for indicating whether the toilet facility is "In Use" or "Vacant". Toilet facilities should also be provided with adequate supplies of hot and cold running water, soap, and hand drying devices.
- Where workers may be exposed to substances poisonous by ingestion and skin contamination may occur, facilities for showering and changing into and out of street and work clothes should be provided.

Potable Water Supply

- Adequate supplies of potable drinking water should be provided from a fountain with an upward jet or with a sanitary means of collecting the water for the purposes of drinking
- Water supplied to areas of food preparation or for the purpose of personal hygiene (washing or bathing) should meet drinking water quality standards

Clean Eating Area

- Where there is potential for exposure to substances poisonous by ingestion, suitable arrangements are to be made for provision of clean eating areas where workers are not exposed to the hazardous or noxious substances

Lighting

- Workplaces should, to the degree feasible, receive natural light and be supplemented with sufficient artificial illumination to promote workers' safety and health, and enable safe equipment operation. Supplemental 'task lighting' may be required where specific visual acuity requirements should be met.
- Emergency lighting of adequate intensity should be installed and automatically activated upon failure of the principal artificial light source to ensure safe shut-down, evacuation, etc.

Safe Access

- Passageways for pedestrians and vehicles within and outside buildings should be segregated and provide for easy, safe, and appropriate access
- Equipment and installations requiring servicing, inspection, and/or cleaning should have unobstructed, unrestricted, and ready access
- Hand, knee and foot railings should be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays, ramps, etc.

- Openings should be sealed by gates or removable chains
- Covers should, if feasible, be installed to protect against falling items
- Measures to prevent unauthorized access to dangerous areas should be in place

First Aid

- The employer should ensure that qualified first-aid can be provided at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work
- Eye-wash stations and/or emergency showers should be provided close to all workstations where immediate flushing with water is the recommended first-aid response
- Where the scale of work or the type of activity being carried out so requires, dedicated and appropriately equipped first-aid room(s) should be provided. First aid stations and rooms should be equipped with gloves, gowns, and masks for protection against direct contact with blood and other body fluids
- Remote sites should have written emergency procedures in place for dealing with cases of trauma or serious illness up to the point at which patient care can be transferred to an appropriate medical facility.

Air Supply

- Sufficient fresh air should be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use, and process-related emissions. Air distribution systems should be designed so as not to expose workers to draughts
- Mechanical ventilation systems should be maintained in good working order. Point-source exhaust systems required for maintaining a safe ambient environment should have local indicators of correct functioning.
- Re-circulation of contaminated air is not acceptable. Air inlet filters should be kept clean and free of dust and microorganisms. Heating, ventilation and air conditioning (HVAC) and industrial evaporative cooling systems should be equipped, maintained and operated so as to prevent growth and spreading of disease agents (e.g. *Legionnella pneumophilia*) or breeding of vectors (e.g. mosquitoes and flies) of public health concern.

Work Environment Temperature

- The temperature in work, rest room and other welfare facilities should, during service hours, be maintained at a level appropriate for the purpose of the facility.

2.2 Communication and Training

OHS Training

- Provisions should be made to provide OHS orientation training to all new employees to ensure they are apprised of the basic site rules of work at / on the site and of personal protection and preventing injury to fellow employees.
- Training should consist of basic hazard awareness, site-specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate. Any site-specific hazard or color coding in use should be thoroughly reviewed as part of orientation training.

Visitor Orientation

- If visitors to the site can gain access to areas where hazardous conditions or substances may be present, a visitor orientation and control program should be established to ensure visitors do not enter hazard areas unescorted.

New Task Employee and Contractor Training

- The employer should ensure that workers and contractors, prior to commencement of new assignments, have received adequate training and information enabling them to

understand work hazards and to protect their health from hazardous ambient factors that may be present.
The training should adequately cover:

- Knowledge of materials, equipment, and tools
- Known hazards in the operations and how they are controlled
- Potential risks to health
- Precautions to prevent exposure
- Hygiene requirements
- Wearing and use of protective equipment and clothing
- Appropriate response to operation extremes, incidents and accidents

Basic OHS Training

- A basic occupational training program and specialty courses should be provided, as needed, to ensure that workers are oriented to the specific hazards of individual work assignments. Training should generally be provided to management, supervisors, workers, and occasional visitors to areas of risks and hazards.
- Workers with rescue and first-aid duties should receive dedicated training so as not to inadvertently aggravate exposures and health hazards to themselves or their co-workers. Training would include the risks of becoming infected with blood–borne pathogens through contact with bodily fluids and tissue.
- Through appropriate contract specifications and monitoring, the employer should ensure that service providers, as well as contracted and subcontracted labor, are trained adequately before assignments begin.

Area Signage

- Hazardous areas (electrical rooms, compressor rooms, etc), installations, materials, safety measures, and emergency exits, etc. should be marked appropriately.
- Signage should be in accordance with international standards and be well known to, and easily understood by workers, visitors and the general public as appropriate.

Labeling of Equipment

- All vessels that may contain substances that are hazardous as a result of chemical or toxicological properties, or temperature or pressure, should be labeled as to the contents and hazard, or appropriately color coded.
- Similarly, piping systems that contain hazardous substances should be labeled with the direction of flow and contents of the pipe, or color coded whenever the pipe passing through a wall or floor is interrupted by a valve or junction device.

Communicate Hazard Codes

- Copies of the hazard coding system should be posted outside the facility at emergency entrance doors and fire emergency connection systems where they are likely to come to the attention of emergency services personnel.
- Information regarding the types of hazardous materials stored, handled or used at the facility, including typical maximum inventories and storage locations, should be shared proactively with emergency services and security personnel to expedite emergency response when needed.
- Representatives of local emergency and security services should be invited to participate in periodic (annual) orientation tours and site inspections to ensure familiarity with potential hazards present.

2.3 Physical Hazards

Physical hazards represent potential for accident or injury or illness due to repetitive exposure to mechanical action or work activity. Single exposure to physical hazards may result in a wide range of injuries, from minor and medical aid only, to disabling, catastrophic, and/or fatal. Multiple exposures over prolonged periods can result in disabling injuries of comparable significance and consequence.

Rotating and Moving Equipment

Injury or death can occur from being trapped, entangled, or struck by machinery parts due to unexpected starting of equipment or unobvious movement during operations. Recommended protective measures include:

- Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions. Examples of proper design considerations include two-hand operated machines to prevent amputations or the availability of emergency stops dedicated to the machine and placed in strategic locations. Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards.[64]
- Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance, in conformance with a standard such as CSA Z460 Lockout or equivalent ISO or ANSI standard
- Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms

Noise

Noise limits for different working environments are provided in Table 2.3.1.

- No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).
- Although hearing protection is preferred for any period of noise exposure in excess of 85 dB(A), an equivalent level of protection can be obtained, but less easily managed, by limiting the duration of noise exposure. For every 3 dB(A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50 percent.[65]
- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible
- Periodic medical hearing checks should be performed on workers exposed to high noise levels

Vibration

Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Limits for vibration and

[64] For example: CSA Z432.04 Safe Guarding of Machinery, CSA Z434 Robot Safety, ISO 11161 Safety of Machinery – Integrated Manufacturing Systems or ISO 14121 Safety of Machinery – Principals of Risk Management or equivalent ANSI standard.

[65] The American Conference of Governmental Industrial Hygienists (ACGIH), 2006

action values, (i.e. the level of exposure at which remediation should be initiated) are provided by the ACGIH[66]. Exposure levels should be checked on the basis of daily exposure time and data provided by equipment manufacturers.

Electrical

Exposed or faulty electrical devices, such as circuit breakers, panels, cables, cords and hand tools, can pose a serious risk to workers. Overhead wires can be struck by metal devices, such as poles or ladders, and by vehicles with metal booms. Vehicles or grounded metal objects brought into close proximity with overhead wires can result in arcing between the wires and the object, without actual contact. Recommended actions include:

Table 2.3.1. Noise Limits for Various Working Environments

Location /activity	Equivalent level $L_{Aeq,8h}$	Maximum $L_{Amax,fast}$
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

- Marking all energized electrical devices and lines with warning signs
- Locking out (de-charging and leaving open with a controlled locking device) and tagging-out (warning sign placed on the lock) devices during service or maintenance
- Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools
- Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits
- Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas
- Appropriate labeling of service rooms housing high voltage equipment ('electrical hazard') and where entry is controlled or prohibited (see also Section 3 on Planning, Siting, and Design);
- Establishing "No Approach" zones around or under high voltage power lines in conformance with Table 2.3.2
- Rubber tired construction or other vehicles that come into direct contact with, or arcing between, high voltage wires may need to be taken out of service for periods of 48 hours and have the tires replaced to prevent catastrophic tire and wheel assembly failure, potentially causing serious injury or death;
- Conducting detailed identification and marking of all buried electrical wiring prior to any excavation work

[66] ACGIH, 2005

Table 2.3.2. No Approach Zones for High Voltage Power Lines

Nominal phase-to-phase voltage rating	Minimum distance
750 or more volts, but no more than 150,000 volts	3 meters
More than 150,000 volts, but no more than 250,000 volts	4.5 meters
More than 250,000 volts	6 meters

Eye Hazards

Solid particles from a wide variety of industrial operations, and / or a liquid chemical spray may strike a worker in the eye causing an eye injury or permanent blindness. Recommended measures include:

- Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO (see also Section 2.3 on Rotating and Moving Equipment and 2.7 on Personal Protective Equipment).
- Moving areas where the discharge of solid fragments, liquid, or gaseous emissions can reasonably be predicted (e.g. discharge of sparks from a metal cutting station, pressure relief valve discharge) away from places expected to be occupied or transited by workers or visitors. Where machine or work fragments could present a hazard to transient workers or passers-by, extra area guarding or proximity restricting systems should be implemented, or PPE required for transients and visitors.
- Provisions should be made for persons who have to wear prescription glasses either through the use overglasses or prescription hardened glasses.

Welding / Hot Work

Welding creates an extremely bright and intense light that may seriously injur a worker's eyesight. In extreme cases, blindness may result. Additionally, welding may produce noxious fumes to which prolonged exposure can cause serious chronic diseases. Recommended measures include:

- Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required.
- Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding work stations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hotwork on tanks or vessels that have contained flammable materials.

Industrial Vehicle Driving and Site Traffic

Poorly trained or inexperienced industrial vehicle drivers have increased risk of accident with other vehicles, pedestrians, and equipment. Industrial vehicles and delivery vehicles, as well as private vehicles on-site, also represent potential collision scenarios. Industrial vehicle driving and site traffic safety practices include:

- Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits
- Ensuring drivers undergo medical surveillance
- Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms
- Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), and control of traffic patterns or direction
- Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate

Working Environment Temperature

Exposure to hot or cold working conditions in indoor or outdoor environments can result temperature stress-related injury or death. Use of personal protective equipment (PPE) to protect against other occupational hazards can accentuate and aggravate heat-related illnesses. Extreme temperatures in permanent work environments should be avoided through implementation of engineering controls and ventilation. Where this is not possible, such as during short-term outdoor work, temperature-related stress management procedures should be implemented which include:

- Monitoring weather forecasts for outdoor work to provide advance warning of extreme weather and scheduling work accordingly
- Adjustment of work and rest periods according to temperature stress management procedures provided by ACGIH[67], depending on the temperature and workloads
- Providing temporary shelters to protect against the elements during working activities or for use as rest areas
- Use of protective clothing
- Providing easy access to adequate hydration such as drinking water or electrolyte drinks, and avoiding consumption of alcoholic beverages

Ergonomics, Repetitive Motion, Manual Handling

Injuries due to ergonomic factors, such as repetitive motion, over-exertion, and manual handling, take prolonged and repeated exposures to develop, and typically require periods of weeks to months for recovery. These OHS problems should be minimized or eliminated to maintain a productive workplace. Controls may include:

- Facility and workstation design with 5th to 95th percentile operational and maintenance workers in mind
- Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools and work objects, and requiring multi-person lifts if weights exceed thresholds
- Selecting and designing tools that reduce force requirements and holding times, and improve postures
- Providing user adjustable work stations
- Incorporating rest and stretch breaks into work processes, and conducting job rotation
- Implementing quality control and maintenance programs that reduce unnecessary forces and exertions
- Taking into consideration additional special conditions such as left handed persons

Working at Heights

Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters; into operating machinery; into water or other liquid; into hazardous substances; or through an opening in a work surface. Fall prevention / protection measures may also be warranted on a case-specific basis when there are risks of falling from lesser heights. Fall prevention may include:

[67] ACGIH, 2005

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area
- Proper use of ladders and scaffolds by trained employees
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting inertial fall arrest devices attached to fixed anchor point or horizontal life-lines
- Appropriate training in use, serviceability, and integrity of the necessary PPE
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall

Illumination

Work area light intensity should be adequate for the general purpose of the location and type of activity, and should be supplemented with dedicated work station illumination, as needed. The minimum limits for illumination intensity for a range of locations/activities appear in Table 2.3.3.

Table 2.3.3. Minimum Limits For Workplace Illumination Intensity	
Location / Activity	**Light Intensity**
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Controls should include:

- Use of energy efficient light sources with minimum heat emission
- Undertaking measures to eliminate glare / reflections and flickering of lights
- Taking precautions to minimize and control optical radiation including direct sunlight. Exposure to high intensity UV and IR radiation and high intensity visible light should also be controlled
- Controlling laser hazards in accordance with equipment specifications, certifications, and recognized safety standards. The lowest feasible class Laser should be applied to minimize risks.

2.4 Chemical Hazards

Chemical hazards represent potential for illness or injury due to single acute exposure or chronic repetitive exposure to toxic, corrosive, sensitizing or oxidative substances. They also represent a risk of uncontrolled reaction, including the risk of fire and explosion, if incompatible chemicals are inadvertently mixed. Chemical hazards can most effectively be prevented through a hierarchical approach that includes:

- Replacement of the hazardous substance with a less hazardous substitute
- Implementation of engineering and administrative control measures to avoid or minimize the release of hazardous substances into the work environment keeping the level of exposure below internationally established or recognized limits
- Keeping the number of employees exposed, or likely to become exposed, to a minimum

- Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel
- Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE

Air Quality

Poor air quality due to the release of contaminants into the work place can result in possible respiratory irritation, discomfort, or illness to workers. Employers should take appropriate measures to maintain air quality in the work area. These include:

- Maintaining levels of contaminant dusts, vapors and gases in the work environment at concentrations below those recommended by the ACGIH[68] as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after-week), without sustaining adverse health effects.
- Developing and implementing work practices to minimize release of contaminants into the work environment including:
  - Direct piping of liquid and gaseous materials
  - Minimized handling of dry powdered materials;
  - Enclosed operations
  - Local exhaust ventilation at emission / release points
  - Vacuum transfer of dry material rather than mechanical or pneumatic conveyance
  - Indoor secure storage, and sealed containers rather than loose storage
- Where ambient air contains several materials that have similar effects on the same body organs (additive effects), taking into account combined exposures using calculations recommended by the ACGIH[69]
- Where work shifts extend beyond eight (8) hours, calculating adjusted workplace exposure criteria recommended by the ACGIH[70]

Fire and Explosions

Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be:
  - Remote from entry and exit points into buildings
  - Away from facility ventilation intakes or vents
  - Have natural or passive floor and ceiling level ventilation and explosion venting
  - Use spark-proof fixtures
  - Be equipped with fire extinguishing devices and self-closing doors, and constructed of materials made to withstand flame impingement for a moderate period of time
- Providing bonding and grounding of, and between, containers and additional mechanical floor level ventilation if materials are being, or could be, dispensed in the storage area
- Where the flammable material is mainly comprised of dust, providing electrical grounding, spark detection, and, if needed, quenching systems

[68] ACGIH, 2005

[69] ACGIH, 2005.

[70] ACGIH, 2005.

- Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment)
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression

Corrosive, oxidizing, and reactive chemicals

Corrosive, oxidizing, and reactive chemicals present similar hazards and require similar control measures as flammable materials. However, the added hazard of these chemicals is that inadvertent mixing or intermixing may cause serious adverse reactions. This can lead to the release of flammable or toxic materials and gases, and may lead directly to fires and explosions. These types of substances have the additional hazard of causing significant personal injury upon direct contact, regardless of any intermixing issues. The following controls should be observed in the work environment when handling such chemicals:

- Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills
- Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc).
- Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid should be ensured at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water

Asbestos Containing Materials (ACM)

The use of asbestos containing materials (ACM) should be avoided in new buildings or as a new material in remodeling or renovation activities. Existing facilities with ACM should develop an asbestos management plan which clearly identifies the locations where the ACM is present, its condition (e.g. whether it is in friable form with the potential to release fibers), procedures for monitoring its condition, procedures to access the locations where ACM is present to avoid damage, and training of staff who can potentially come into contact with the material to avoid damage and prevent exposure. The plan should be made available to all persons involved in operations and maintenance activities. Repair or removal and disposal of existing ACM in buildings should only be performed by specially trained personnel[71] following host country requirements, or in their absence, internationally recognized procedures.[72]

2.5 Biological Hazards

Biological agents represent potential for illness or injury due to single acute exposure or chronic repetitive exposure. Biological hazards can be prevented most effectively by implementing the following measures:

- If the nature of the activity permits, use of any harmful biological agents should be avoided and replaced with an agent that, under normal conditions of use, is not dangerous or less dangerous to workers. If use of harmful agents can not be avoided, precautions should be taken to keep the risk of exposure as low as possible and maintained below internationally established and recognized exposure limits.

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[71] Training of specialized personnel and the maintenance and removal methods applied should be equivalent to those required under applicable regulations in the United States and Europe (examples of North American training standards are available at: http://www.osha.gov/SLTC/asbestos/training.html)

[72] Examples include the American Society for Testing and Materials (ASTM) E 1368 - Standard Practice for Visual Inspection of Asbestos Abatement Projects; E 2356 - Standard Practice for Comprehensive Building Asbestos Surveys; and E 2394 - Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products.

- Work processes, engineering, and administrative controls should be designed, maintained, and operated to avoid or minimize release of biological agents into the working environment. The number of employees exposed or likely to become exposed should be kept at a minimum.
- The employer should review and assess known and suspected presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs.
- Measures to eliminate and control hazards from known and suspected biological agents at the place of work should be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards.

Biological agents should be classified into four groups[73]:

- ***Group 1:*** Biological agents unlikely to cause human disease, and consequently only require controls similar to those required for hazardous or reactive chemical substances;
- ***Group 2:*** Biological agents that can cause human disease and are thereby likely to require additional controls, but are unlikely to spread to the community;
- ***Group 3***: Biological agents that can cause severe human disease, present a serious hazard to workers, and may present a risk of spreading to the community, for which there usually is effective prophylaxis or treatment available and are thereby likely to require extensive additional controls;
- ***Group 4:*** Biological agents that can cause severe human disease, are a serious hazard to workers, and present a high risk of spreading to the community, for which there is usually no effective prophylaxis or treatment available and are thereby likely to require very extensive additional controls.

The employer should at all times encourage and enforce the highest level of hygiene and personal protection, especially for activities employing biological agents of Groups 3 and 4 above. Work involving agents in Groups 3 and 4 should be restricted only to those persons who have received specific verifiable training in working with and controlling such materials.

Areas used for the handling of Groups 3 and 4 biological agents should be designed to enable their full segregation and isolation in emergency circumstances, include independent ventilation systems, and be subject to SOPs requiring routine disinfection and sterilization of the work surfaces.

HVAC systems serving areas handling Groups 3 and 4 biological agents should be equipped with High Efficiency Particulate Air (HEPA) filtration systems. Equipment should readily enable their disinfection and sterilization, and maintained and operated so as to prevent growth and spreading of disease agents, amplification of the biological agents, or breeding of vectors e.g. mosquitoes and flies of public health concern.

73 World Health Organization (WHO) Classification of Infective Microorganisms by Risk Group (2004).

2.6 Radiological Hazards

Radiation exposure can lead to potential discomfort, injury or serious illness to workers. Prevention and control strategies include:

- Places of work involving occupational and/or natural exposure to ionizing radiation should be established and operated in accordance with recognized international safety standards and guidelines.[74] The acceptable effective dose limits appear Table 2.6.1.
- Exposure to non-ionizing radiation (including static magnetic fields; sub-radio frequency magnetic fields; static electric fields; radio frequency and microwave radiation; light and near-infrared radiation; and ultraviolet radiation) should be controlled to internationally recommended limits[75].

Table 2.6.1. Acceptable Effective Dose Limits for Workplace Radiological Hazards

Exposure	Workers (min.19 years of age)	Apprentices and students (16-18 years of age)
Five consecutive year average – effective dose	20 mSv/year	
Single year exposure – effective dose	50 mSv/year	6 mSv/year
Equivalent dose to the lens of the eye	150 mSv/year	50 mSv/year
Equivalent dose to the extremities (hands, feet) or the skin	500 mSv/year	150 mSv/year

- In the case of both ionizing and non-ionizing radiation, the preferred method for controlling exposure is shielding and limiting the radiation source. Personal protective equipment is supplemental only or for emergency use. Personal protective equipment for near-infrared, visible and ultraviolet range radiation can include appropriate sun block creams, with or without appropriate screening clothing.

2.7 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems.

PPE is considered to be a last resort that is above and beyond the other facility controls and provides the worker with an extra level of personal protection. Table 2.7.1 presents general examples of occupational hazards and types of PPE available for different purposes. Recommended measures for use of PPE in the workplace include:

- Active use of PPE if alternative technologies, work plans or procedures cannot eliminate, or sufficiently reduce, a hazard or exposure
- Identification and provision of appropriate PPE that offers adequate protection to the worker, co-workers, and occasional visitors, without incurring unnecessary inconvenience to the individual
- Proper maintenance of PPE, including cleaning when dirty and replacement when damaged or worn out. Proper use of PPE should be part of the recurrent training programs for employees

[74] International Basic Safety Standard for protection against Ionizing Radiation and for the Safety of Radiation Sources and its three interrelated Safety Guides.

IAEA. http://www-ns.iaea.org/standards/documents/default.asp?sub=160

[75] For example ACGIH (2005) and International Commission for Non-Ionizing Radiation (ICNIRP).

- Selection of PPE should be based on the hazard and risk ranking described earlier in this section, and selected according to criteria on performance and testing established by recognized organizations[76].

Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard

Objective	Workplace Hazards	Suggested PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety Glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic Helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs).
Foot protection	Falling or rolling objects, pointed objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving & falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors.	Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapors and gases). Single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

2.8 Special Hazard Environments

Special hazard environments are work situations where all of the previously described hazards may exist under unique or especially hazardous circumstances. Accordingly, extra precautions or rigor in application of precautions is required.

Confined Space

A confined space is defined as a wholly or partially enclosed space not designed or intended for human occupancy and in which a hazardous atmosphere could develop as a result of the contents, location or construction of the confined space or due to work done in or around the confined space. A “permit-required” confined space is one that also contains physical or atmospheric hazards that could trap or engulf the person.[77]

Confined spaces can occur in enclosed or open structures or locations. Serious injury or fatality can result from inadequate preparation to enter a confined space or in attempting a rescue from a confined space. Recommended management approaches include:

- Engineering measures should be implemented to eliminate, to the degree feasible, the existence and adverse character of confined spaces.
- Permit-required confined spaces should be provided with permanent safety measures for venting, monitoring, and rescue operations, to the extent possible. The area adjoining an access to a confined space should provide ample room for emergency and rescue operations.

[76] Examples include the American National Standards Institute (ANSI), http://www.ansi.org/; National Institute for Occupational Safety and Health[76] (NIOSH), http://www.cdc.gov/niosh/homepage.html; Canadian Standards Association[76] (CSA), http://www.csa.ca/Default.asp?language=english; Mine Safety and Health Administration[76] (MSHA), http://www.msha.gov.

[77] US OSHA CFR 1910.146

- Access hatches should accommodate 90% of the worker population with adjustments for tools and protective clothing. The most current ISO and EN standards should be consulted for design specifications;
- Prior to entry into a permit-required confined space:
  - Process or feed lines into the space should be disconnected or drained, and blanked and locked-out.
  - Mechanical equipment in the space should be disconnected, de-energized, locked-out, and braced, as appropriate.
  - The atmosphere within the confined space should be tested to assure the oxygen content is between 19.5 percent and 23 percent, and that the presence of any flammable gas or vapor does not exceed 25 percent of its respective Lower Explosive Limit (LEL).
  - If the atmospheric conditions are not met, the confined space should be ventilated until the target safe atmosphere is achieved, or entry is only to be undertaken with appropriate and additional PPE.
- Safety precautions should include Self Contained Breathing Apparatus (SCBA), life lines, and safety watch workers stationed outside the confined space, with rescue and first aid equipment readily available.
- Before workers are required to enter a permit-required confined space, adequate and appropriate training in confined space hazard control, atmospheric testing, use of the necessary PPE, as well as the serviceability and integrity of the PPE should be verified. Further, adequate and appropriate rescue and / or recovery plans and equipment should be in place before the worker enters the confined space.

Lone and Isolated Workers

A lone and isolated worker is a worker out of verbal and line of sight communication with a supervisor, other workers, or other persons capable of providing aid and assistance, for continuous periods exceeding one hour. The worker is therefore at increased risk should an accident or injury occur.

- Where workers may be required to perform work under lone or isolated circumstances, Standard Operating Procedures (SOPs) should be developed and implemented to ensure all PPE and safety measures are in place before the worker starts work. SOPs should establish, at a minimum, verbal contact with the worker at least once every hour, and ensure the worker has a capability for summoning emergency aid.
- If the worker is potentially exposed to highly toxic or corrosive chemicals, emergency eye-wash and shower facilities should be equipped with audible and visible alarms to summon aid whenever the eye-wash or shower is activated by the worker and without intervention by the worker.

2.9 Monitoring

Occupational health and safety monitoring programs should verify the effectiveness of prevention and control strategies. The selected indicators should be representative of the most significant occupational, health, and safety hazards, and the implementation of prevention and control strategies. The occupational health and safety monitoring program should include:

- *Safety inspection, testing and calibration:* This should include regular inspection and testing of all safety features and hazard control measures focusing on engineering and personal protective features, work procedures, places of work, installations, equipment, and tools used. The inspection should verify that issued PPE continues to provide adequate protection and is being worn as required. All instruments installed or used for monitoring and recording of working environment parameters should be regularly tested and calibrated, and the respective records maintained.
- *Surveillance of the working environment:* Employers should document compliance using an appropriate combination of

portable and stationary sampling and monitoring instruments. Monitoring and analyses should be conducted according to internationally recognized methods and standards. Monitoring methodology, locations, frequencies, and parameters should be established individually for each project following a review of the hazards. Generally, monitoring should be performed during commissioning of facilities or equipment and at the end of the defect and liability period, and otherwise repeated according to the monitoring plan.

- *Surveillance of workers health:* When extraordinary protective measures are required (for example, against biological agents Groups 3 and 4, and/or hazardous compounds), workers should be provided appropriate and relevant health surveillance prior to first exposure, and at regular intervals thereafter. The surveillance should, if deemed necessary, be continued after termination of the employment.
- *Training:* Training activities for employees and visitors should be adequately monitored and documented (curriculum, duration, and participants). Emergency exercises, including fire drills, should be documented adequately. Service providers and contractors should be contractually required to submit to the employer adequate training documentation before start of their assignment.

Accidents and Diseases monitoring

- The employer should establish procedures and systems for reporting and recording:
    - o Occupational accidents and diseases
    - o Dangerous occurrences and incidents

  These systems should enable workers to report immediately to their immediate supervisor any situation they believe presents a serious danger to life or health.
- The systems and the employer should further enable and encourage workers to report to management all:
    - o Occupational injuries and near misses
    - o Suspected cases of occupational disease
    - o Dangerous occurrences and incidents
- All reported occupational accidents, occupational diseases, dangerous occurrences, and incidents together with near misses should be investigated with the assistance of a person knowledgeable/competent in occupational safety. The investigation should:
    - o Establish what happened
    - o Determine the cause of what happened
    - o Identify measures necessary to prevent a recurrence
- Occupational accidents and diseases should, at a minimum, be classified according to Table 2.10.1. Distinction is made between fatal and non-fatal injuries. The two main categories are divided into three sub-categories according to time of death or duration of the incapacity to work. The total work hours during the specified reporting period should be reported to the appropriate regulatory agency.

Table 2.9.1. Occupational Accident Reporting

a. Fatalities (number)	**b. Non-fatal injuries** (number) [78]	**c. Total time lost** non-fatal injuries (days)
a.1 Immediate	**b.1** Less than one day	
a.2 Within a month	**b.2** Up to 3 days	**c.1** Category b.2
a.3 Within a year	**b.3** More than 3 days	**c.2** Category b.3

[78] The day on which an incident occurs is not included in b.2 and b.3.

3.0 Community Health and Safety

This section complements the guidance provided in the preceding environmental and occupational health and safety sections, specifically addressing some aspects of project activities taking place outside of the traditional project boundaries, but nonetheless related to the project operations, as may be applicable on a project basis. These issues may arise at any stage of a project life cycle and can have an impact beyond the life of the project.

3.1 Water Quality and Availability

Groundwater and surface water represent essential sources of drinking and irrigation water in developing countries, particularly in rural areas where piped water supply may be limited or unavailable and where available resources are collected by the consumer with little or no treatment. Project activities involving wastewater discharges, water extraction, diversion or impoundment should prevent adverse impacts to the quality and availability of groundwater and surface water resources.

Water Quality

Drinking water sources, whether public or private, should at all times be protected so that they meet or exceed applicable national acceptability standards or in their absence the current edition of WHO Guidelines for Drinking-Water Quality. Air emissions, wastewater effluents, oil and hazardous materials, and wastes should be managed according to the guidance provided in the respective sections of the General EHS Guidelines with the objective of protecting soil and water resources.

Where the project includes the delivery of water to the community or to users of facility infrastructure (such as hotel hosts and hospital patients), where water may be used for drinking, cooking, washing, and bathing, water quality should comply with national acceptability standards or in their absence the current edition of with WHO Drinking Water Guidelines. Water quality for more sensitive well-being-related demands such as water used in health care facilities or food production may require more stringent, industry-specific guidelines or standards, as applicable. Any dependency factors associated with the deliver of water to the local community should be planned for and managed to ensure the sustainability of the water supply by involving the community in its management to minimize the dependency in the long-term.

Water Availability

The potential effect of groundwater or surface water abstraction for project activities should be properly assessed through a combination of field testing and modeling techniques, accounting for seasonal variability and projected changes in demand in the project area.

Project activities should not compromise the availability of water for personal hygiene needs and should take account of potential future increases in demand. The overall target should be the availability of 100 liters per person per day although lower levels may be used to meet basic health requirements.[79] Water volume requirements for well-being-related demands such as water use in health care facilities may need to be higher.

3.2 Structural Safety of Project Infrastructure

Hazards posed to the public while accessing project facilities may include:

- Physical trauma associated with failure of building structures
- Burns and smoke inhalation from fires
- Injuries suffered as a consequence of falls or contact with heavy equipment
- Respiratory distress from dust, fumes, or noxious odors
- Exposure to hazardous materials

Reduction of potential hazards is best accomplished during the design phase when the structural design, layout and site modifications can be adapted more easily. The following issues should be considered and incorporated as appropriate into the planning, siting, and design phases of a project:

- Inclusion of buffer strips or other methods of physical separation around project sites to protect the public from major hazards associated with hazardous materials incidents or process failure, as well as nuisance issues related to noise, odors, or other emissions
- Incorporation of siting and safety engineering criteria to prevent failures due to natural risks posed by earthquakes, tsunamis, wind, flooding, landslides and fire. To this end, all project structures should be designed in accordance with engineering and design criteria mandated by site-specific risks, including but not limited to seismic activity, slope stability, wind loading, and other dynamic loads
- Application of locally regulated or internationally recognized building codes[80] to ensure structures are designed and constructed in accordance with sound architectural and engineering practice, including aspects of fire prevention and response
- Engineers and architects responsible for designing and constructing facilities, building, plants and other structures should certify the applicability and appropriateness of the structural criteria employed.

International codes, such as those compiled by the International Code Council (ICC)[81], are intended to regulate the design, construction, and maintenance of a built environment and contain detailed guidance on all aspects of building safety, encompassing methodology, best practices, and documenting compliance. Depending on the nature of a project, guidance provided in the ICC or comparable codes should be followed, as appropriate, with respect to:

- Existing structures
- Soils and foundations
- Site grading
- Structural design
- Specific requirements based on intended use and occupancy
- Accessibility and means of egress
- Types of construction
- Roof design and construction
- Fire-resistant construction
- Flood-resistant construction

[79] World Health Organization (WHO) defines 100 liters/capita/day as the amount required to meet all consumption and hygiene needs. Additional information on lower service levels and potential impacts on health are described in "Domestic Water Quantity, Service Level and Health" 2003. http://www.who.int/water_sanitation_health/diseases/wsh0302/en/index.html

[80] ILO-OSH, 2001. http://www.ilo.org/public/english/protection/safework/cops/english/download/e000013.pdf

[81] ICC, 2006.

- Construction materials
- Interior environment
- Mechanical, plumbing and electrical systems
- Elevators and conveying systems
- Fire safety systems
- Safeguards during construction
- Encroachments into public right-of-way

Although major design changes may not be feasible during the operation phase of a project, hazard analysis can be undertaken to identify opportunities to reduce the consequences of a failure or accident. Illustrative management actions, applicable to hazardous materials storage and use, include:

- Reducing inventories of hazardous materials through inventory management and process changes to greatly reduce or eliminate the potential off-site consequences of a release
- Modifying process or storage conditions to reduce the potential consequences of an accidental off-site release
- Improving shut-down and secondary containment to reduce the amount of material escaping from containment and to reduce the release duration
- Reducing the probability that releases will occur through improved site operations and control, and through improvements in maintenance and inspection
- Reducing off-site impacts of releases through measures intended to contain explosions and fires, alert the public, provide for evacuation of surrounding areas, establish safety zones around a site, and ensure the provision of emergency medical services to the public

3.3 Life and Fire Safety (L&FS)

Applicability and Approach

All new buildings accessible to the public should be designed, constructed, and operated in full compliance with local building codes, local fire department regulations, local legal/insurance requirements, and in accordance with an internationally accepted life and fire safety (L&FS) standard. The Life Safety Code[82], which provides extensive documentation on life and fire safety provisions, is one example of an internationally accepted standard and may be used to document compliance with the Life and Fire Safety objectives outlined in these guidelines. With regard to these objectives:

- Project sponsors' architects and professional consulting engineers should demonstrate that affected buildings meet these life and fire safety objectives.
- Life and fire safety systems and equipment should be designed and installed using appropriate prescriptive standards and/or performance based design, and sound engineering practices.
- Life and fire safety design criteria for all existing buildings should incorporate all local building codes and fire department regulations.

These guidelines apply to buildings that are accessible to the public. Examples of such buildings include:

- Health and education facilities
- Hotels, convention centers, and leisure facilities
- Retail and commercial facilities
- Airports, other public transport terminals, transfer facilities

Specific Requirements for New Buildings

The nature and extent of life and fire safety systems required will depend on the building type, structure, construction, occupancy, and exposures. Sponsors should prepare a Life and Fire Safety Master Plan identifying major fire risks, applicable codes, standards and regulations, and mitigation measures. The Master

82 US NFPA. http://www.nfpa.org/catalog/product.asp?category%5Fname=&pid=10106&target%5Fpid=10106&src%5Fpid=&link%5Ftype=search

Plan should be prepared by a suitably qualified professional, and adequately cover, but not be limited to, the issues addressed briefly in the following points. The suitably qualified professional selected to prepare the Master Plan is responsible for a detailed treatment of the following illustrative, and all other required, issues.

Fire Prevention

Fire prevention addresses the identification of fire risks and ignition sources, and measures needed to limit fast fire and smoke development. These issues include:

- Fuel load and control of combustibles
- Ignition sources
- Interior finish flame spread characteristics
- Interior finish smoke production characteristics
- Human acts, and housekeeping and maintenance

Means of Egress

Means of Egress includes all design measures that facilitate a safe evacuation by residents and/or occupants in case of fire or other emergency, such as:

- Clear, unimpeded escape routes
- Accessibility to the impaired/handicapped
- Marking and signing
- Emergency lighting

Detection and Alarm Systems

These systems encompass all measures, including communication and public address systems needed to detect a fire and alert:

- Building staff
- Emergency response teams
- Occupants
- Civil defense

Compartmentation

Compartmentation involves all measures to prevent or slow the spread of fire and smoke, including:

- Separations
- Fire walls
- Floors
- Doors
- Dampers
- Smoke control systems

Fire Suppression and Control

Fire suppression and control includes all automatic and manual fire protection installations, such as:

- Automatic sprinkler systems
- Manual portable extinguishers
- Fire hose reels

Emergency Response Plan

An Emergency Response Plan is a set of scenario–based procedures to assist staff and emergency response teams during real life emergency and training exercises. This chapter of the Fire and Life Safety Master Plan should include an assessment of local fire prevention and suppression capabilities.

Operation and Maintenance

Operation and Maintenance involves preparing schedules for mandatory regular maintenance and testing of life and fire safety features to ensure that mechanical, electrical, and civil structures and systems are at all times in conformance with life and fire safety design criteria and required operational readiness.

L&FS Master Plan Review and Approval

- A suitably qualified professional prepares and submits a Life and Fire Safety (L&FS) Master Plan, including preliminary drawings and specifications, and certifies that the design meets the requirements of these L&FS guidelines. The findings and recommendations of the review are then used to establish the conditions of a Corrective Action Plan and a time frame for implementing the changes.

- The suitably qualified professional conducts a review as part of the project completion test at the time of life and fire safety systems testing and commissioning, and certifies that construction of these systems has been carried out in accordance with the accepted design. The findings and recommendations of the review are used as the basis for establishing project completion or to establish the conditions of a Pre-Completion Corrective Action Plan and a time frame for implementing the changes.

Specific Requirements for Existing Buildings

- All life and fire safety guideline requirements for new buildings apply to existing buildings programmed for renovation. A suitably qualified professional conducts a complete life and fire safety review of existing buildings slated for renovation. The findings and recommendations of the review are used as the basis to establish the scope of work of a Corrective Action Plan and a time frame for implementing the changes.
- If it becomes apparent that life and fire safety conditions are deficient in an existing building that is not part of the project or that has not been programmed for renovation, a life and fire safety review of the building may be conducted by a suitably qualified professional. The findings and recommendations of the review are used as the basis to establish the scope of work of a Corrective Action Plan and a time frame for implementing the changes.

Other Hazards

- Facilities, buildings, plants, and structures should be situated to minimize potential risks from forces of nature (e.g. earthquakes, tsunamis, floods, windstorms, and fires from surrounding areas).
- All such structures should be designed in accordance with the criteria mandated by situation-, climatic-, and geology-specific location risks (e.g. seismic activity, wind loading, and other dynamic loads).
- Structural engineers and architects responsible for facilities, buildings, plants and structures should certify the applicability and appropriateness of the design criteria employed.
- National or regional building regulations typically contain fire safety codes and standards[83] or these standards are found in separate Fire Codes.[84,85] Generally, such codes and regulations incorporate further compliance requirements with respect to methodology, practice, testing, and other codes and standards[86]. Such nationally referenced material constitutes the acceptable fire life safety code.

3.4 Traffic Safety

Traffic accidents have become one of the most significant causes of injuries and fatalities among members of the public worldwide. Traffic safety should be promoted by all project personnel during displacement to and from the workplace, and during operation of project equipment on private or public roads. Prevention and control of traffic related injuries and fatalities should include the adoption of safety measures that are protective of project workers and of road users, including those who are most vulnerable to road traffic accidents[87]. Road safety initiatives proportional to the scope and nature of project activities should include:

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83 For example, Australia, Canada, South Africa, United Kingdom

84 Réglementation Incendie [des ERP]

85 USA NFPA, 2006.

86 Prepared by National Institutes and Authorities such as American Society for Testing and Materials (ASTM), British Standards (BS), German Institute of Standardization (DIN), and French Standards (NF)

87 Additional information on vulnerable users of public roads in developing countries is provided by Peden et al., 2004.

- Adoption of best transport safety practices across all aspects of project operations with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public. Measures should include:
  - Emphasizing safety aspects among drivers
  - Improving driving skills and requiring licensing of drivers
  - Adopting limits for trip duration and arranging driver rosters to avoid overtiredness
  - Avoiding dangerous routes and times of day to reduce the risk of accidents
  - Use of speed control devices (governors) on trucks, and remote monitoring of driver actions
- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure.

Where the project may contribute to a significant increase in traffic along existing roads, or where road transport is a significant component of a project, recommended measures include:

- Minimizing pedestrian interaction with construction vehicles
- Collaboration with local communities and responsible authorities to improve signage, visibility and overall safety of roads, particularly along stretches located near schools or other locations where children may be present. Collaborating with local communities on education about traffic and pedestrian safety (e.g. school education campaigns)[88]
- Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents
- Using locally sourced materials, whenever possible, to minimize transport distances. Locating associated facilities such as worker camps close to project sites and arranging worker bus transport to minimizing external traffic
- Employing safe traffic control measures, including road signs and flag persons to warn of dangerous conditions

3.5 Transport of Hazardous Materials

General Hazardous Materials Transport

- Projects should have procedures in place that ensure compliance with local laws and international requirements applicable to the transport of hazardous materials, including:
  - IATA requirements[89] for air transport
  - IMDG Code[90] sea transport
  - UN Model Regulations[91] of other international standards as well as local requirements for land transport
  - Host-country commitments under the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their disposal and Rotterdam Convention on the prior Inform Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, if applicable to the project activities
- The procedures for transportation of hazardous materials (Hazmats) should include:
  - Proper labeling of containers, including the identify and quantity of the contents, hazards, and shipper contact information
  - Providing a shipping document (e.g. shipping manifest) that describes the contents of the load and its associated hazards in addition to the labeling of the containers. The shipping document should establish a chain-of-custody using multiple signed copies to show that the waste was properly shipped, transported and received by the recycling or treatment/disposal facility

88 Additional sources of information for implementation of road safety measures is available at WHO, 1989, Ross et al., 1991, Tsunokawa and Hoban, 1997, and OECD, 1999

89 IATA, 2005. www.iata.org

90 IMO. www.imo.org/safety

91 United Nations. Transport of Dangerous Goods - Model Regulations. 14th Revised Edition. Geneva 2005. http://www.unece.org/trans/danger/publi/unrec/rev14/14files_e.html

- Ensuring that the volume, nature, integrity and protection of packaging and containers used for transport are appropriate for the type and quantity of hazardous material and modes of transport involved
- Ensuring adequate transport vehicle specifications
- Training employees involved in the transportation of hazardous materials regarding proper shipping procedures and emergency procedures
- Using labeling and placarding (external signs on transport vehicles), as required
- Providing the necessary means for emergency response on call 24 hours/day

Major Transportation Hazards

Guidance related to major transportation hazards should be implemented in addition to measures presented in the preceding section for preventing or minimizing the consequences of catastrophic releases of hazardous materials, which may result in toxic, fire, explosion, or other hazards during transportation.

In addition to these aforementioned procedures, projects which transport hazardous materials *at or above the threshold quantities*[92] should prepare a Hazardous Materials Transportation Plan containing all of the elements presented below[93].

Hazard Assessment

The hazard assessment should identify the potential hazard involved in the transportation of hazardous materials by reviewing:

- The hazard characteristics of the substances identified during the screening stage
- The history of accidents, both by the company and its contractors, involving hazardous materials transportation
- The existing criteria for the safe transportation of hazardous materials, including environmental management systems used by the company and its contractors

This review should cover the management actions, preventive measures and emergency response procedures described below. The hazard assessment helps to determine what additional measures may be required to complete the plan.

Management Actions

- *Management of Change:* These procedures should address:
    - The technical basis for changes in hazardous materials offered for transportation, routes and/or procedures
    - The potential impact of changes on health and safety
    - Modification required to operating procedures
    - Authorization requirements
    - Employees affected
    - Training needs
- *Compliance Audit:* A compliance audit evaluates compliance with prevention requirements for each transportation route or for each hazardous material, as appropriate. A compliance audit covering each element of the prevention measures (see below) should be conducted at least every three years. The audit program should include:
    - Preparation of a report of the findings
    - Determination and documentation of the appropriate response to each finding
    - Documentation that any deficiency has been corrected.
- *Incident Investigation:* Incidents can provide valuable information about transportation hazards and the steps needed to prevent accidental releases. The implementation of incident investigation procedures should ensure that:
    - Investigations are initiated promptly
    - Summaries of investigations are included in a report
    - Report findings and recommendations are addressed

92 Threshold quantities for the transport of hazardous materials are found in the UN – Transport of Dangerous Goods – Model Regulations cited above.

93 For further information and guidance, please refer to International Finance Corporation (IFC) Hazardous Materials Transportation Manual. Washington, D.C. December 2000.

- Reports are reviewed with staff and contractors

- *Employee Participation:* There should be a written plan of action regarding the implementation of active employee participation in the prevention of accidents.

- *Contractors:* The plan should include procedures to ensure that:
    - The contractor is provided with safety performance procedures and safety and hazard information
    - Contractors observe safety practices
    - Verify that the contractor acts responsibly

  The plan should also include additional procedures to ensure the contractors will:
    - Ensure appropriate training for their employees
    - Ensure their employees know process hazards and applicable emergency actions
    - Prepare and submit training records
    - Inform employees about the hazards presented by their work

- *Training:* Good training programs on operating procedures will provide the employees with the necessary information to understand how to operate safely and why safe operations are needed. The training program should include:
    - The list of employees to be trained
    - Specific training objectives
    - Mechanisms to achieve objectives (i.e. hands-on workshops, videos, etc.)
    - Means to determine the effectiveness of the training program
    - Training procedures for new hires and refresher programs

Preventive Measures

The plan should include procedures to implement preventive measures specific to each hazardous material offered for transportation, including:

- Classification and segregation of hazardous materials in warehouses and transport units
- Packaging and packaging testing
- Marking and labeling of packages containing hazardous materials
- Handling and securing packages containing hazardous materials in transport units
- Marking and placarding of transport units
- Documentation (e.g. bills of lading)
- Application of special provisions, as appropriate

Emergency Preparedness and Response

It is important to develop procedures and practices for the handling of hazardous materials that allow for quick and efficient responses to accidents that may result in injury or environmental damage. The sponsor should prepare an Emergency Preparedness and Response Plan that should cover:

- *Planning Coordination:* This should include procedures for:
    - Informing the public and emergency response agencies
    - Documenting first aid and emergency medical treatment
    - Taking emergency response actions
    - Reviewing and updating the emergency response plan to reflect changes and ensuring that the employees are informed of such changes

- *Emergency Equipment:* The plan should include procedures for using, inspecting, testing, and maintaining emergency response equipment.

- *Training:* Employees should be trained in any relevant procedures

3.6 Disease Prevention

Communicable Diseases

Communicable diseases pose a significant public health threat worldwide. Health hazards typically associated with large development projects are those relating to poor sanitation and living conditions, sexual transmission and vector-borne infections. Communicable diseases of most concern during the construction phase due to labor mobility are sexually-transmitted diseases (STDs), such as HIV/AIDS. Recognizing that no single measure is likely to be effective in the long term, successful initiatives typically involve a combination of behavioral and environmental modifications.

Recommended interventions at the project level include[94]:

- Providing surveillance and active screening and treatment of workers
- Preventing illness among workers in local communities by:
  - Undertaking health awareness and education initiatives, for example, by implementing an information strategy to reinforce person-to-person counseling addressing systemic factors that can influence individual behavior as well as promoting individual protection, and protecting others from infection, by encouraging condom use
  - Training health workers in disease treatment
  - Conducting immunization programs for workers in local communities to improve health and guard against infection
  - Providing health services
- Providing treatment through standard case management in on-site or community health care facilities. Ensuring ready access to medical treatment, confidentiality and appropriate care, particularly with respect to migrant workers
- Promoting collaboration with local authorities to enhance access of workers families and the community to public health services and promote immunization

Vector-Borne Diseases

Reducing the impact of vector-borne disease on the long-term health of workers is best accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease. Project sponsors, in close collaboration with community health authorities, can implement an integrated control strategy for mosquito and other arthropod-borne diseases that might involve:

- Prevention of larval and adult propagation through sanitary improvements and elimination of breeding habitats close to human settlements
- Elimination of unusable impounded water
- Increase in water velocity in natural and artificial channels
- Considering the application of residual insecticide to dormitory walls
- Implementation of integrated vector control programs
- Promoting use of repellents, clothing, netting, and other barriers to prevent insect bites
- Use of chemoprophylaxis drugs by non-immune workers and collaborating with public health officials to help eradicate disease reservoirs
- Monitoring and treatment of circulating and migrating populations to prevent disease reservoir spread
- Collaboration and exchange of in-kind services with other control programs in the project area to maximize beneficial effects
- Educating project personnel and area residents on risks, prevention, and available treatment
- Monitoring communities during high-risk seasons to detect and treat cases

[94] Additional sources of information on disease prevention include IFC, 2006; UNDP, 2000, 2003; Walley et al., 2000; Kindhauser, 2003; Heymann, 2004.

- Distributing appropriate education materials
- Following safety guidelines for the storage, transport, and distribution of pesticides to minimize the potential for misuse, spills, and accidental human exposure

3.7 Emergency Preparedness and Response

An emergency is an unplanned event when a project operation loses control, or could lose control, of a situation that may result in risks to human health, property, or the environment, either within the facility or in the local community. Emergencies do not normally include safe work practices for frequent upsets or events that are covered by occupational health and safety.

All projects should have an Emergency Preparedness and Response Plan that is commensurate with the risks of the facility and that includes the following basic elements:

- Administration (policy, purpose, distribution, definitions, etc)
- Organization of emergency areas (command centers, medical stations, etc)
- Roles and responsibilities
- Communication systems
- Emergency response procedures
- Emergency resources
- Training and updating
- Checklists (role and action list and equipment checklist)
- Business Continuity and Contingency

Additional information is provided for key components of the emergency plan, as follows below.

Communication Systems

Worker notification and communication

Alarm bells, visual alarms, or other forms of communication should be used to reliably alert workers to an emergency. Related measures include:

- Testing warning systems at least annually (fire alarms monthly), and more frequently if required by local regulations, equipment, or other considerations
- Installing a back-up system for communications on-site with off-site resources, such as fire departments, in the event that normal communication methods may be inoperable during an emergency

Community Notification

If a local community may be at risk from a potential emergency arising at the facility, the company should implement communication measures to alert the community, such as:

- Audible alarms, such as fire bells or sirens
- Fan out telephone call lists
- Vehicle mounted speakers
- Communicating details of the nature of the emergency
- Communicating protection options (evacuation, quarantine)
- Providing advise on selecting an appropriate protection option

Media and Agency Relations

Emergency information should be communicated to the media through:

- A trained, local spokesperson able to interact with relevant stakeholders, and offer guidance to the company for speaking to the media, government, and other agencies
- Written press releases with accurate information, appropriate level of detail for the emergency, and for which accuracy can be guaranteed

Emergency Resources

Finance and Emergency Funds

- A mechanism should be provided for funding emergency activities.

Fire Services

- The company should consider the level of local fire fighting capacity and whether equipment is available for use at the facility in the event of a major emergency or natural disaster. If insufficient capacity is available, fire fighting capacity should be acquired that may include pumps, water supplies, trucks, and training for personnel.

Medical Services

- The company should provide first aid attendants for the facility as well as medical equipment suitable for the personnel, type of operation, and the degree of treatment likely to be required prior to transportation to hospital.

Availability of Resources

Appropriate measures for managing the availability of resources in case of an emergency include:

- Maintaining a list of external equipment, personnel, facilities, funding, expert knowledge, and materials that may be required to respond to emergencies. The list should include personnel with specialized expertise for spill clean-up, flood control, engineering, water treatment, environmental science, etc., or any of the functions required to adequately respond to the identified emergency
- Providing personnel who can readily call up resources, as required
- Tracking and managing the costs associated with emergency resources
- Considering the quantity, response time, capability, limitations, and cost of these resources, for both site-specific emergencies, and community or regional emergencies
- Considering if external resources are unable to provide sufficient capacity during a regional emergency and whether additional resources may need to be maintained on-site

Mutual Aid

Mutual aid agreements decrease administrative confusion and provide a clear basis for response by mutual aid providers.

- Where appropriate, mutual aid agreements should be maintained with other organizations to allow for sharing of personnel and specialized equipment.

Contact List

- The company should develop a list of contact information for all internal and external resources and personnel. The list should include the name, description, location, and contact details (telephone, email) for each of the resources, and be maintained annually.

Training and Updating

The emergency preparedness facilities and emergency response plans require maintenance, review, and updating to account for changes in equipment, personnel, and facilities. Training programs and practice exercises provide for testing systems to ensure an adequate level of emergency preparedness. Programs should:

- Identify training needs based on the roles and responsibilities, capabilities and requirements of personnel in an emergency
- Develop a training plan to address needs, particularly for fire fighting, spill response, and evacuation

- Conduct annual training, at least, and perhaps more frequent training when the response includes specialized equipment, procedures, or hazards, or when otherwise mandated
- Provide training exercises to allow personnel the opportunity to test emergency preparedness, including:
  - Desk top exercises with only a few personnel, where the contact lists are tested and the facilities and communication assessed
  - Response exercises, typically involving drills that allow for testing of equipment and logistics
- Debrief upon completion of a training exercise to assess what worked well and what aspects require improvement
- Update the plan, as required, after each exercise. Elements of the plan subject to significant change (such as contact lists) should be replaced
- Record training activities and the outcomes of the training

Business Continuity and Contingency

Measures to address business continuity and contingency include:

- Identifying replacement supplies or facilities to allow business continuity following an emergency. For example, alternate sources of water, electricity, and fuel are commonly sought.
- Using redundant or duplicate supply systems as part of facility operations to increase the likelihood of business continuity.
- Maintaining back-ups of critical information in a secure location to expedite the return to normal operations following an emergency.

4.0 Construction and Decommissioning

Applicability and Approach

This section provides additional, specific guidance on prevention and control of community health and safety impacts that may occur during new project development, at the end of the project life-cycle, or due to expansion or modification of existing project facilities. Cross referencing is made to various other sections of the General EHS Guidelines.

4.1 Environment{ TC "4.1 Environment" \f C \l "2" }

Noise and Vibration

During construction and decommissioning activities, noise and vibration may be caused by the operation of pile drivers, earth moving and excavation equipment, concrete mixers, cranes and the transportation of equipment, materials and people. Some recommended noise reduction and control strategies to consider in areas close to community areas include:

- Planning activities in consultation with local communities so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance
- Using noise control devices, such as temporary noise barriers and deflectors for impact and blasting activities, and exhaust muffling devices for combustion engines.
- Avoiding or minimizing project transportation through community areas

Soil Erosion

Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earth moving, and excavation activities. The mobilization and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may result in impacts to the quality of natural water systems and ultimately the biological systems that use these waters. Recommended soil erosion and water system management approaches include:

Sediment mobilization and transport

- Reducing or preventing erosion by:
  - o Scheduling to avoid heavy rainfall periods (i.e., during the dry season) to the extent practical
  - o Contouring and minimizing length and steepness of slopes
  - o Mulching to stabilize exposed areas
  - o Re-vegetating areas promptly
  - o Designing channels and ditches for post-construction flows
  - o Lining steep channel and slopes (e.g. use jute matting)
- Reducing or preventing off-site sediment transport through use of settlement ponds, silt fences, and water treatment, and modifying or suspending activities during extreme rainfall and high winds to the extent practical.

Clean runoff management

- Segregating or diverting clean water runoff to prevent it mixing with water containing a high solids content, to minimize the volume of water to be treated prior to release

Road design

- Limiting access road gradients to reduce runoff-induced erosion
- Providing adequate road drainage based on road width, surface material, compaction, and maintenance

Disturbance to water bodies

- Depending on the potential for adverse impacts, installing free-spanning structures (e.g., single span bridges) for road watercourse crossings
- Restricting the duration and timing of in-stream activities to lower low periods, and avoiding periods critical to biological cycles of valued flora and fauna (e.g., migration, spawning, etc.)
- For in-stream works, using isolation techniques such as berming or diversion during construction to limit the exposure of disturbed sediments to moving water
- Consider using trenchless technology for pipeline crossings (e.g., suspended crossings) or installation by directional drilling

Structural (slope) stability

- Providing effective short term measures for slope stabilization, sediment control and subsidence control until long term measures for the operational phase can be implemented
- Providing adequate drainage systems to minimize and control infiltration

Air Quality

Construction and decommissioning activities may generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil, and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment, as well as from open burning of solid waste on-site. Techniques to consider for the reduction and control of air emissions from construction and decommissioning sites include:

- Minimizing dust from material handling sources, such as conveyors and bins, by using covers and/or control equipment (water suppression, bag house, or cyclone)
- Minimizing dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing the moisture content
- Dust suppression techniques should be implemented, such as applying water or non-toxic chemicals to minimize dust from vehicle movements
- Selectively removing potential hazardous air pollutants, such as asbestos, from existing infrastructure prior to demolition
- Managing emissions from mobile sources according to Section 1.1
- Avoiding open burning of solid (refer to solid waste management guidance in Section 1.6)

Solid Waste

Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities. *Hazardous solid waste* includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill cleanup materials from oil and fuel spills. Techniques for preventing and controlling non-hazardous and hazardous construction site solid waste include those already discussed in Section 1.6.

Hazardous Materials

Construction and decommissioning activities may pose the potential for release of petroleum based products, such as lubricants, hydraulic fluids, or fuels during their storage, transfer, or use in equipment. These materials may also be encountered during decommissioning activities in building components or industrial process equipment. Techniques for prevention, minimization, and control of these impacts include:

- Providing adequate secondary containment for fuel storage tanks and for the temporary storage of other fluids such as lubricating oils and hydraulic fluids,
- Using impervious surfaces for refueling areas and other fluid transfer areas
- Training workers on the correct transfer and handling of fuels and chemicals and the response to spills
- Providing portable spill containment and cleanup equipment on site and training in the equipment deployment
- Assessing the contents of hazardous materials and petroleum-based products in building systems (e.g. PCB containing electrical equipment, asbestos-containing building materials) and process equipment and removing them prior to initiation of decommissioning activities, and managing their treatment and disposal according to Sections 1.5 and 1.6 on Hazardous Materials and Hazardous Waste Management, respectively
- Assessing the presence of hazardous substances in or on building materials (e.g., polychlorinated biphenyls, asbestos-containing flooring or insulation) and decontaminating or properly managing contaminated building materials

Wastewater Discharges

Construction and decommissioning activities may include the generation of sanitary wastewater discharges in varying quantities depending on the number of workers involved. Adequate portable or permanent sanitation facilities serving all workers should be provided at all construction sites. Sanitary wastewater in construction and other sites should be managed as described in Section 1.3.

Contaminated Land

Land contamination may be encountered in sites under construction or decommissioning due to known or unknown historical releases of hazardous materials or oil, or due to the presence of abandoned infrastructure formerly used to store or handle these materials, including underground storage tanks. Actions necessary to manage the risk from contaminated land will depend on factors such as the level and location of contamination, the type and risks of the contaminated media, and the intended land use. However, a basic management strategy should include:

- Managing contaminated media with the objective of protecting the safety and health of occupants of the site, the surrounding community, and the environment post construction or post decommissioning
- Understanding the historical use of the land with regard to the potential presence of hazardous materials or oil prior to initiation of construction or decommissioning activities
- Preparing plans and procedures to respond to the discovery of contaminated media to minimize or reduce the risk to health, safety, and the environment consistent with the approach for Contaminated Land in Section 1.6
- Preparation of a management plan to manage obsolete, abandoned, hazardous materials or oil consistent with the approach to hazardous waste management described in Section 1.6.

Successful implementation of any management strategy may require identification and cooperation with whoever is responsible and liable for the contamination.

4.2 Occupational Health and Safety{ TC "4.2 Occupational Health and Safety" \f C \l "2" }

Over-exertion

Over-exertion, and ergonomic injuries and illnesses, such as repetitive motion, over-exertion, and manual handling, are among the most common causes of injuries in construction and decommissioning sites. Recommendations for their prevention and control include:

- Training of workers in lifting and materials handling techniques in construction and decommissioning projects, including the placement of weight limits above which mechanical assists or two-person lifts are necessary
- Planning work site layout to minimize the need for manual transfer of heavy loads
- Selecting tools and designing work stations that reduce force requirements and holding times, and which promote improved postures, including, where applicable, user adjustable work stations
- Implementing administrative controls into work processes, such as job rotations and rest or stretch breaks

Slips and Falls

Slips and falls on the same elevation associated with poor housekeeping, such as excessive waste debris, loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent cause of lost time accidents at construction and decommissioning sites. Recommended methods for the prevention of slips and falls from, or on, the same elevation include:

- Implementing good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in established areas away from foot paths
- Cleaning up excessive waste debris and liquid spills regularly
- Locating electrical cords and ropes in common areas and marked corridors
- Use of slip retardant footwear

Work in Heights

Falls from elevation associated with working with ladders, scaffolding, and partially built or demolished structures are among the most common cause of fatal or permanent disabling injury at construction or decommissioning sites. If fall hazards exist, a fall protection plan should be in place which includes one or more of the following aspects, depending on the nature of the fall hazard[95]:

- Training and use of temporary fall prevention devices, such as rails or other barriers able to support a weight of 200 pounds, when working at heights equal or greater than two meters or at any height if the risk includes falling into operating machinery, into water or other liquid, into hazardous substances, or through an opening in a work surface
- Training and use of personal fall arrest systems, such as full body harnesses and energy absorbing lanyards able to support 5000 pounds (also described in this section in Working at Heights above), as well as fall rescue procedures to deal with workers whose fall has been successfully arrested. The tie in point of the fall arresting system should also be able to support 5000 pounds
- Use of control zones and safety monitoring systems to warn workers of their proximity to fall hazard zones, as well as

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95 Additional information on identification of fall hazards and design of protection systems can be found in the United States Occupational Health and Safety Administration's (US OSHA) web site: http://www.osha.gov/SLTC/fallprotection/index.html

securing, marking, and labeling covers for openings in floors, roofs, or walking surfaces

Struck By Objects

Construction and demolition activities may pose significant hazards related to the potential fall of materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities. Techniques for the prevention and control of these hazards include:

- Using a designated and restricted waste drop or discharge zones, and/or a chute for safe movement of wastes from upper to lower levels
- Conducting sawing, cutting, grinding, sanding, chipping or chiseling with proper guards and anchoring as applicable
- Maintaining clear traffic ways to avoid driving of heavy equipment over loose scrap
- Use of temporary fall protection measures in scaffolds and out edges of elevated work surfaces, such as hand rails and toe boards to prevent materials from being dislodged
- Evacuating work areas during blasting operations, and using blast mats or other means of deflection to minimize fly rock or ejection of demolition debris if work is conducted in proximity to people or structures
- Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes

Moving Machinery

Vehicle traffic and use of lifting equipment in the movement of machinery and materials on a construction site may pose temporary hazards, such as physical contact, spills, dust, emissions, and noise. Heavy equipment operators have limited fields of view close to their equipment and may not see pedestrians close to the vehicle. Center-articulated vehicles create a significant impact or crush hazard zone on the outboard side of a turn while moving. Techniques for the prevention and control of these impacts include:

- Planning and segregating the location of vehicle traffic, machine operation, and walking areas, and controlling vehicle traffic through the use of one-way traffic routes, establishment of speed limits, and on-site trained flag-people wearing high-visibility vests or outer clothing covering to direct traffic
- Ensuring the visibility of personnel through their use of high visibility vests when working in or walking through heavy equipment operating areas, and training of workers to verify eye contact with equipment operators before approaching the operating vehicle
- Ensuring moving equipment is outfitted with audible back-up alarms
- Using inspected and well-maintained lifting devices that are appropriate for the load, such as cranes, and securing loads when lifting them to higher job-site elevations.

Dust

- Dust suppression techniques should be implemented, such as applying water or non-toxic chemicals to minimize dust from vehicle movements
- PPE, such as dusk masks, should be used where dust levels are excessive

Confined Spaces and Excavations

Examples of confined spaces that may be present in construction or demolition sites include: silos, vats, hoppers, utility vaults, tanks, sewers, pipes, and access shafts. Ditches and trenches may also be considered a confined space when access or egress is limited. In addition to the guidance provided in Section 2.8 the occupational hazards associated with confined spaces and excavations in construction and decommissioning sites should be prevented according to the following recommendations:

- Controlling site-specific factors which may contribute to excavation slope instability including, for example, the use of excavation dewatering, side-walls support, and slope gradient adjustments that eliminate or minimize the risk of collapse, entrapment, or drowning
- Providing safe means of access and egress from excavations, such as graded slopes, graded access route, or stairs and ladders
- Avoiding the operation of combustion equipment for prolonged periods inside excavations areas where other workers are required to enter unless the area is actively ventilated

Other Site Hazards

Construction and decommissioning sites may pose a risk of exposure to dust, chemicals, hazardous or flammable materials, and wastes in a combination of liquid, solid, or gaseous forms, which should be prevented through the implementation of project-specific plans and other applicable management practices, including:

- Use of specially trained personnel to identify and remove waste materials from tanks, vessels, processing equipment or contaminated land as a first step in decommissioning activities to allow for safe excavation, construction, dismantling or demolition
- Use of specially trained personnel to identify and selectively remove potentially hazardous materials in building elements prior to dismantling or demolition including, for example, insulation or structural elements containing asbestos and Polychlorinated Biphenyls (PCBs), electrical components containing mercury[96]
- Use of waste-specific PPE based on the results of an occupational health and safety assessment, including respirators, clothing/protective suits, gloves and eye protection

4.3 Community Health and Safety{ TC "4.3 Community Health and Safety" \f C \l "2" }

General Site Hazards

Projects should implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning. Risks may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media, buildings that are vacant or under construction, or excavations and structures which may pose falling and entrapment hazards. Risk management strategies may include:

- Restricting access to the site, through a combination of institutional and administrative controls, with a focus on high risk structures or areas depending on site-specific situations, including fencing, signage, and communication of risks to the local community
- Removing hazardous conditions on construction sites that cannot be controlled affectively with site access restrictions, such as covering openings to small confined spaces, ensuring means of escape for larger openings such as trenches or excavations, or locked storage of hazardous materials

Disease Prevention

Increased incidence of communicable and vector-borne diseases attributable to construction activities represents a potentially serious health threat to project personnel and residents of local communities. Recommendations for the prevention and control of communicable and vector-borne diseases also applicable to

[96] Additional information on the management and removal of asbestos containing building materials can be found in ASTM Standard E2356 and E1368

construction phase activities are provided in Section 3.6 (Disease Prevention).

Traffic Safety

Construction activities may result in a significant increase in movement of heavy vehicles for the transport of construction materials and equipment increasing the risk of traffic-related accidents and injuries to workers and local communities. The incidence of road accidents involving project vehicles during construction should be minimized through a combination of education and awareness-raising, and the adoption of procedures described in Section 3.4 (Traffic Safety).

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Environmental, Health, and Safety Guidelines for Thermal Power Plants

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/sustainability.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, based on environmental assessments and/or environmental audits as appropriate, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

This document includes information relevant to combustion processes fueled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste which is covered under a separate Guideline for Waste Management Facilities), with a total rated heat input capacity above 50 Megawatt thermal input (MWth) on Higher Heating Value (HHV) basis.[2] It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities. Annex A contains a detailed description of industry activities for this sector, and Annex B contains guidance for Environmental Assessment (EA) of thermal power projects. Emissions guidelines applicable to facilities with a total heat input capacity of less than 50 MWth are presented in Section 1.1 of the **General EHS Guidelines.** Depending on the characteristics of the project and its associated activities (i.e., fuel sourcing and evacuation of generated electricity), readers should also consult

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

[2] Total capacity applicable to a facility with multiple units.

the EHS Guidelines for Mining and the EHS Guidelines for Electric Power Transmission and Distribution.

Decisions to invest in this sector by one or more members of the World Bank Group are made within the context of the World Bank Group strategy on climate change.

This document is organized according to the following sections:

Section 1.0 – Industry Specific Impacts and Management
Section 2.0 – Performance Indicators and Monitoring
Section 3.0 – References and Additional Sources
Annex A – General Description of Industry Activities
Annex B – Environmental Assessment Guidance for Thermal Power Projects.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of the most significant EHS issues associated with thermal power plants, which occur during the operational phase, along with recommendations for their management.

As described in the introduction to the **General EHS Guidelines**, the general approach to the management of EHS issues in industrial development activities, including power plants, should consider potential impacts as early as possible in the project cycle, including the incorporation of EHS considerations into the site selection and plant design processes in order to maximize the range of options available to prevent and control potential negative impacts.

Recommendations for the management of EHS issues common to most large industrial and infrastructure facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues in thermal power plant projects primarily include the following:

- Air emissions
- Energy efficiency and Greenhouse Gas emissions
- Water consumption and aquatic habitat alteration
- Effluents
- Solid wastes
- Hazardous materials and oil
- Noise

Air Emissions

The primary emissions to air from the combustion of fossil fuels or biomass are sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon monoxide (CO), and greenhouse gases, such as carbon dioxide (CO_2). Depending on the fuel type and quality, mainly waste fuels or solid fuels, other substances such as heavy metals (i.e., mercury, arsenic, cadmium, vanadium, nickel, etc), halide compounds (including hydrogen fluoride), unburned hydrocarbons and other volatile organic compounds (VOCs) may be emitted in smaller quantities, but may have a significant influence on the environment due to their toxicity and/or persistence. Sulfur dioxide and nitrogen oxide are also implicated in long-range and trans-boundary acid deposition.

The amount and nature of air emissions depends on factors such as the fuel (e.g., coal, fuel oil, natural gas, or biomass), the type and design of the combustion unit (e.g., reciprocating engines, combustion turbines, or boilers), operating practices, emission control measures (e.g., primary combustion control, secondary flue gas treatment), and the overall system efficiency. For example, gas-fired plants generally produce negligible quantities of particulate matter and sulfur oxides, and levels of nitrogen oxides are about 60% of those from plants using coal (without emission reduction measures). Natural gas-fired plants also release lower quantities of carbon dioxide, a greenhouse gas.

Some measures, such as choice of fuel and use of measures to increase energy conversion efficiency, will reduce emissions of multiple air pollutants, including CO_2, per unit of energy generation. Optimizing energy utilization efficiency of the generation process depends on a variety of factors, including the nature and quality of fuel, the type of combustion system, the operating temperature of the combustion turbines, the operating pressure and temperature of steam turbines, the local climate conditions, the type of cooling system used, etc. Recommended measures to prevent, minimize, and control air emissions include:

- Use of the cleanest fuel economically available (natural gas is preferable to oil, which is preferable to coal) if that is consistent with the overall energy and environmental policy of the country or the region where the plant is proposed. For most large power plants, fuel choice is often part of the national energy policy, and fuels, combustion technology and pollution control technology, which are all interrelated, should be evaluated very carefully upstream of the project to optimize the project's environmental performance;
- When burning coal, giving preference to high-heat-content, low-ash, and low-sulfur coal;
- Considering beneficiation to reduce ash content, especially for high ash coal;[3]
- Selection of the best power generation technology for the fuel chosen to balance the environmental and economic benefits. The choice of technology and pollution control systems will be based on the site-specific environmental assessment (some examples include the use of higher energy-efficient systems, such as combined cycle gas turbine system for natural gas and oil-fired units, and supercritical, ultra-supercritical or integrated coal gasification combined cycle (IGCC) technology for coal-fired units);
- Designing stack heights according to Good International Industry Practice (GIIP) to avoid excessive ground level concentrations and minimize impacts, including acid deposition;[4]
- Considering use of combined heat and power (CHP, or co-generation) facilities. By making use of otherwise wasted heat, CHP facilities can achieve thermal efficiencies of 70 – 90 percent, compared with 32 – 45 percent for conventional thermal power plants.

- As stated in the General EHS Guidelines, emissions from a single project should not contribute more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed.[5]

Pollutant-specific control recommendations are provided below.

Sulfur Dioxide

The range of options for the control of sulfur oxides varies substantially because of large differences in the sulfur content of different fuels and in control costs as described in Table 1. The choice of technology depends on a benefit-cost analysis of the environmental performance of different fuels, the cost of controls, and the existence of a market for sulfur control by-products[6]. Recommended measures to prevent, minimize, and control SO_2 emissions include:

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[3] If sulfur is inorganically bound to the ash, this will also reduce sulfur content.

[4] For specific guidance on calculating stack height see Annex 1.1.3 of the General EHS Guidelines. Raising stack height should not be used to allow more emissions. However, if the proposed emission rates result in significant incremental ambient air quality impacts to the attainment of the relevant ambient air quality standards, options to raise stack height and/or to further reduce emissions should be considered in the EA. Typical examples of GIIP stack heights are up to around 200m for large coal-fired power plants, up to around 80m for HFO-fueled diesel engine power plants, and up to 100m for gas-fired combined cycle gas turbine power plants. Final selection of the stack height will depend on the terrain of the surrounding areas, nearby buildings, meteorological conditions, predicted incremental impacts and the location of existing and future receptors.

[5] For example, the US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds provide the following: SO_2 (91 μg/m^3 for 2nd highest 24-hour, 20 μg/m^3 for annual average), NO_2 (20 μg/m^3 for annual average), and PM_{10} (30 μg/m^3 for 2nd highest 24-hour, and 17 μg/m^3 for annual average).

- Use of fuels with a lower content of sulfur where economically feasible;
- Use of lime (CaO) or limestone ($CaCO_3$) in coal-fired fluidized bed combustion boilers to have integrated desulfurization which can achieve a removal efficiency of up to 80-90 % through use of Fluidized Bed Combustion[7, 8];
- Depending on the plant size, fuel quality, and potential for significant emissions of SO_2 , use of flue gas desulfurization (FGD) for large boilers using coal or oil and for large reciprocating engines . The optimal type of FGD system (e.g., wet FGD using limestone with 85 to 98% removal efficiency, dry FGD using lime with 70 to 94% removal efficiency, seawater FGD with up to 90% removal efficiency) depends on the capacity of the plant, fuel properties, site conditions, and the cost and availability of reagent as well as by-product disposal and utilization.[9]

Table 1 - Performance / Characteristics of FGDs

Type of FGD	Characteristics	Plant Capital Cost Increase
Wet FGD	• Flue gas is saturated with water • Limestone ($CaCO_3$) as reagent • Removal efficiency up to 98% • Use 1-1.5% of electricity generated • Most widely used • Distance to limestone source and the limestone reactivity to be considered • High water consumption • Need to treat wastewater • Gypsum as a saleable by-product or waste	11-14%
Semi-Dry FGD	• Also called "Dry Scrubbing" – under controlled humidification. • Lime (CaO) as reagent • Removal efficiency up to 94% • Can remove SO_3 as well at higher removal rate than Wet FGD • Use 0.5-1.0% of electricity generated, less than Wet FGD • Lime is more expensive than limestone • No wastewater • Waste – mixture of fly ash, unreacted additive and $CaSO_3$	9-12%
Seawater FGD	• Removal efficiency up to 90% • Not practical for high S coal (>1%S) • Impacts on marine environment need to be carefully examined (e.g., reduction of pH, inputs of remaining heavy metals, fly ash, temperature, sulfate, dissolved oxygen, and chemical oxygen demand) • Use 0.8-1.6% of electricity generated • Simple process, no wastewater or solid waste,	7-10%

Sources: EC (2006) and World Bank Group.

Nitrogen Oxides

Formation of nitrogen oxides can be controlled by modifying operational and design parameters of the combustion process (primary measures). Additional treatment of NO_X from the flue gas (secondary measures; see Table 2) may be required in some cases depending on the ambient air quality objectives. Recommended measures to prevent, minimize, and control NO_X emissions include:

- Use of low NO_X burners with other combustion modifications, such as low excess air (LEA) firing, for boiler plants. Installation of additional NO_X controls for boilers may be necessary to meet emissions limits; a selective catalytic reduction (SCR) system can be used for pulverized coal-fired, oil-fired, and gas-fired boilers or a selective non-catalytic reduction (SNCR) system for a fluidized-bed boiler;
- Use of dry low-NO_X combustors for combustion turbines burning natural gas;
- Use of water injection or SCR for combustion turbines and

[6] Regenerative Flue Gas Desulfurization (FGD) options (either wet or semi-dray) may be considered under these conditions.
[7] EC (2006).
[8] The SO2 removal efficiency of FBC technologies depends on the sulfur and lime content of fuel, sorbent quantity, ratio, and quality.
[9] The use of wet scrubbers, in addition to dust control equipment (e.g. ESP or Fabric Filter), has the advantage of also reducing emissions of HCl, HF, heavy metals, and further dust remaining after ESP or Fabric Filter. Because of higher costs, the wet scrubbing process is generally not used at plants with a capacity of less than 100 MWth (EC 2006).

reciprocating engines burning liquid fuels;[10]

- Optimization of operational parameters for existing reciprocating engines burning natural gas to reduce NOx emissions;
- Use of lean-burn concept or SCR for new gas engines.

Table 2 - Performance / Characteristics of Secondary NOx Reduction Systems		
Type	**Characteristics**	**Plant Capital Cost Increase**
SCR	• NOx emission reduction rate of 80 – 95% • Use 0.5% of electricity generated • Use ammonia or urea as reagent. • Ammonia slip increases with increasing NH_3/NOx ratio may cause a problem (e.g., too high ammonia in the fly ash). Larger catalyst volume / improving the mixing of NH_3 and NOx in the flue gas may be needed to avoid this problem. • Catalysts may contain heavy metals. Proper handling and disposal / recycle of spent catalysts is needed. • Life of catalysts has been 6-10 years (coal-fired), 8-12 years (oil-fired) and more than 10 years (gas-fired).	4-9% (coal-fired boiler) 1-2% (gas-fired combined cycle gas turbine) 20-30% (reciprocating engines)
SNCR	• NOx emission reduction rate of 30 – 50% • Use 0.1-0.3% of electricity generated • Use ammonia or urea as reagent. • Cannot be used on gas turbines or gas engines. • Operates without using catalysts.	1-2%
Source: EC (2006), World Bank Group		

Particulate Matter

Particulate matter[11] is emitted from the combustion process, especially from the use of heavy fuel oil, coal, and solid biomass. The proven technologies for particulate removal in power plants are fabric filters and electrostatic precipitators (ESPs), shown in Table 3. The choice between a fabric filter and an ESP depends on the fuel properties, type of FGD system if used for SO_2 control, and ambient air quality objectives. Particulate matter can also be released during transfer and storage of coal and additives, such as lime. Recommendations to prevent, minimize, and control particulate matter emissions include:

- Installation of dust controls capable of over 99% removal efficiency, such as ESPs or Fabric Filters (baghouses), for coal-fired power plants. The advanced control for particulates is a wet ESP, which further increases the removal efficiency and also collects condensables (e.g., sulfuric acid mist) that are not effectively captured by an ESP or a fabric filter;[12]
- Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors;
- Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments;
- Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;
- For solid fuels of which fine fugitive dust could contain vanadium, nickel and Polycyclic Aromatic Hydrocarbons (PAHs) (e.g., in coal and petroleum coke), use of full enclosure during transportation and covering stockpiles where necessary;
- Design and operate transport systems to minimize the generation and transport of dust on site;
- Storage of lime or limestone in silos with well designed, extraction and filtration equipment;
- Use of wind fences in open storage of coal or use of enclosed storage structures to minimize fugitive dust

[10] Water injection may not be practical for industrial combustion turbines in all cases. Even if water is available, the facilities for water treatment and the operating and maintenance costs of water injection may be costly and may complicate the operation of a small combustion turbine.

[11] Including all particle sizes (e.g. TSP, PM_{10}, and $PM_{2.5}$)

[12] Flue gas conditioning (FGC) is a recommended approach to address the issue of low gas conductivity and lower ESP collection performance which occurs when ESPs are used to collect dust from very low sulfur fuels. One particular FGC design involves introduction of sulfur trioxide (SO_3) gas into the flue gas upstream of the ESP, to increase the conductivity of the flue gas dramatically improve the ESP collection efficiency. There is typically no risk of increased SOx emissions as the SO_3 is highly reactive and adheres to the dust.

emissions where necessary, applying special ventilation systems in enclosed storage to avoid dust explosions (e.g., use of cyclone separators at coal transfer points).

See Annex 1.1.2 of the **General EHS Guidelines** for an additional illustrative presentation of point source emissions prevention and control technologies.

Table 3 – Performance / Characteristics of Dust Removal Systems	
Type	**Performance / Characteristics**
ESP	• Removal efficiency of >96.5% (<1 µm), >99.95% (>10 µm) • 0.1-1.8% of electricity generated is used • It might not work on particulates with very high electrical resistivity. In these cases, flue gas conditioning (FGC) may improve ESP performance. • Can handle very large gas volume with low pressure drops
Fabric Filter	• Removal efficiency of >99.6% (<1 µm), >99.95% (>10 µm). Removes smaller particles than ESPs. • 0.2-3% of electricity generated is used • Filter life decreases as coal S content increases • Operating costs go up considerably as the fabric filter becomes dense to remove more particles • If ash is particularly reactive, it can weaken the fabric and eventually it disintegrates.
Wet Scrubber	• Removal efficiency of >98.5% (<1 µm), >99.9% (>10 µm) • Up to 3% of electricity generated is used. • As a secondary effect, can remove and absorb gaseous heavy metals • Wastewater needs to be treated
Sources: EC (2006) and World Bank Group.	

Other Pollutants

Depending on the fuel type and quality, other air pollutants may be present in environmentally significant quantities requiring proper consideration in the evaluation of potential impacts to ambient air quality and in the design and implementation of management actions and environmental controls. Examples of additional pollutants include mercury in coal, vanadium in heavy fuel oil, and other heavy metals present in waste fuels such as petroleum coke (petcoke) and used lubricating oils[13]. Recommendations to prevent, minimize, and control emissions of other air pollutants such as mercury in particular from thermal power plants include the use of conventional secondary controls such as fabric filters or ESPs operated in combination with FGD techniques, such as limestone FGD, Dry Lime FGD, or sorbent injection.[14] Additional removal of metals such as mercury can be achieved in a high dust SCR system along with powered activated carbon, bromine-enhanced Powdered Activated Carbon (PAC) or other sorbents. Since mercury emissions from thermal power plants pose potentially significant local and transboundary impacts to ecosystems and public health and safety through bioaccumulation, particular consideration should be given to their minimization in the environmental assessment and accordingly in plant design.[15]

Emissions Offsets

Facilities in degraded airsheds should minimize incremental impacts by achieving emissions values outlined in Table 6. Where these emissions values result nonetheless in excessive ambient impacts relative to local regulatory standards (or in their absence, other international recognized standards or guidelines, including World Health Organization guidelines), the project should explore and implement site-specific offsets that result in no net increase in the total emissions of those pollutants (e.g., particulate matter, sulfur dioxide, or nitrogen dioxide) that are responsible for the degradation of the airshed. Offset provisions should be implemented before the power plant comes fully on stream. Suitable offset measures could include reductions in emissions of particulate matter, sulfur dioxide, or nitrogen dioxide, as necessary through (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in

[13] In these cases, the EA should address potential impacts to ambient air quality for such heavy metals as mercury, nickel, vanadium, cadmium, lead, etc.

[14] For Fabric Filters or Electrostatic Precipitators operated in combination with FGD techniques, an average removal rate of 75% or 90 % in the additional presence of SCR can be obtained (EC, 2006).

[15] Although no major industrial country has formally adopted regulatory limits for mercury emissions from thermal power plants, such limitations where under consideration in the United States and European Union as of 2008. Future updates of these EHS Guidelines will reflect changes in the international state of

the same airshed, (b) the installation of new or more effective controls at other large sources, such as district heating plants or industrial plants, in the same airshed, or (c) investments in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers. Wherever possible, the offset provisions should be implemented within the framework of an overall air quality management strategy designed to ensure that air quality in the airshed is brought into compliance with ambient standards. The monitoring and enforcement of ambient air quality in the airshed to ensure that offset provisions are complied with would be the responsibility of the local or national agency responsible for granting and supervising environmental permits. Project sponsors who cannot engage in the negotiations necessary to put together an offset agreement (for example, due to the lack of the local or national air quality management framework) should consider the option of relying on an appropriate combination of using cleaner fuels, more effective pollution controls, or reconsidering the selection of the proposed project site. The overall objective is that the new thermal power plants should not contribute to deterioration of the already degraded airshed.

Energy Efficiency and GHG Emissions

Carbon dioxide, one of the major greenhouse gases (GHGs) under the UN Framework Convention on Climate Change, is emitted from the combustion of fossil fuels. Recommendations to avoid, minimize, and offset emissions of carbon dioxide from new and existing thermal power plants include, among others:

- Use of less carbon intensive fossil fuels (i.e., less carbon containing fuel per unit of calorific value -- gas is less than oil and oil is less than coal) or co-firing with carbon neutral fuels (i.e., biomass);
- Use of combined heat and power plants (CHP) where feasible;
- Use of higher energy conversion efficiency technology of the same fuel type / power plant size than that of the country/region average. New facilities should be aimed to be in top quartile of the country/region average of the same fuel type and power plant size. Rehabilitation of existing facilities must achieve significant improvements in efficiency. Typical CO_2 emissions performance of different fuels / technologies are presented below in Table 4;
- Consider efficiency-relevant trade-offs between capital and operating costs involved in the use of different technologies. For example, supercritical plants may have a higher capital cost than subcritical plants for the same capacity, but lower operating costs. On the other hand, characteristics of existing and future size of the grid may impose limitations in plant size and hence technological choice. These tradeoffs need to be fully examined in the EA;
- Use of high performance monitoring and process control techniques, good design and maintenance of the combustion system so that initially designed efficiency performance can be maintained;
- Where feasible, arrangement of emissions offsets (including the Kyoto Protocol's flexible mechanisms and the voluntary carbon market), including reforestation, afforestation, or capture and storage of CO_2 or other currently experimental options[16];
- Where feasible, include transmission and distribution loss reduction and demand side measures. For example, an investment in peak load management could reduce cycling requirements of the generation facility thereby improving its operating efficiency. The feasibility of these types of off-set options may vary depending on whether the facility is part of a vertically integrated utility or an independent power producer;
- Consider fuel cycle emissions and off-site factors (e.g., fuel

practice regarding mercury emissions prevention and control.

[16] The application of carbon capture and storage (CCS) from thermal power projects is still in experimental stages worldwide although consideration has started to be given to CCS-ready design. Several options are currently under evaluation including CO_2 storage in coal seams or deep aquifers and oil reservoir injection for enhanced oil recovery.

supply, proximity to load centers, potential for off-site use of waste heat, or use of nearby waste gases (blast furnace gases or coal bed methane) as fuel. etc).

Table 4 - Typical CO_2 Emissions Performance of New Thermal Power Plants

Fuel	Efficiency	CO_2 (gCO_2 / kWh – Gross)
Efficiency (% Net, HHV)		
Coal (*1, *2)	Ultra-Supercritical (*1): 37.6 – 42.7 Supercritical: 35.9-38.3 (*1) 39.1 (w/o CCS) (*2) 24.9 (with CCS) (*2) Subcritical: 33.1-35.9 (*1) 36.8 (w/o CCS) (*2) 24.9 (with CCS) (*2) IGCC: 39.2-41.8 (*1) 38.2–41.1 (w/o CCS) (*2) 31.7–32.5 (with CCS) (*2)	 676-795 756-836 763 95 807-907 808 102 654-719 640 – 662 68 – 86
Gas (*2)	Advanced CCGT (*2): 50.8 (w/o CCS) 43.7 (with CCS)	 355 39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical) 40 (Supercritical) 30 – 38 (Subcritical) 46 (IGCC) 38 (IGCC+CCS)	811 851 896-1,050 760 134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC) >41(Coal-FBC) 42-45 (Lignite-PC) >40 (Lignite-FBC)	(*6) 725-792 (Net) <831 (Net) 808-866 (Net) <909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT) 38-45 (Gas Engine) 40-42 (Boiler) 54-58 (CCGT)	(*6) 505-561 (Net) 531-449 (Net) 481-505 (Net) 348-374 (Net)
Oil (*4, *7)	(*4) 40 – 45 (HFO/LFO Reciprocating Engine)	(*6) 449-505 (Net)
Efficiency (% Gross, LHV)		
Coal (*5, *7)	(*5) 47 (Ultra-supercritical) 44 (Supercritical) 41-42 (Subcritical) 47-48 (IGCC)	(*6) 725 774 811-831 710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine) 41 (Boiler)	(*6) 648 680
Gas (*5)	(*5) 34 (Simple Cycle GT) 51 (CCGT)	(*6) 594 396
Source: (*1) US EPA 2006, (*2) US DOE/NETL 2007, (*3) World Bank, April 2006, (*4) European Commission 2006, (*5) World Bank Group, Sep 2006, (*6) World Bank Group estimates		

Water Consumption and Aquatic Habitat Alteration

Steam turbines used with boilers and heat recovery steam generators(HRSG) used in combined cycle gas turbine units require a cooling system to condense steam used to generate electricity. Typical cooling systems used in thermal power plants include: (i) once-through cooling system where sufficient cooling water and receiving surface water are available; (ii) closed circuit wet cooling system; and (iii) closed circuit dry cooling system (e.g., air cooled condensers).

Combustion facilities using once-through cooling systems require large quantities of water which are discharged back to receiving surface water with elevated temperature. Water is also required for boiler makeup, auxiliary station equipment, ash handling, and FGD systems.[17] The withdrawal of such large quantities of water has the potential to compete with other important water uses such as agricultural irrigation or drinking water sources. Withdrawal and discharge with elevated temperature and chemical contaminants such as biocides or other additives, if used, may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life. Aquatic organisms drawn into cooling water intake structures are either impinged on components of the cooling water intake structure or entrained in the cooling water system itself. In the case of either impingement or entrainment, aquatic organisms may be killed or subjected to significant harm. In some cases (e.g., sea turtles), organisms are entrapped in the intake canals. There may be special concerns about the potential impacts of cooling water intake structures located in or near habitat areas that support threatened, endangered, or other protected species or where local fishery is active.

Conventional intake structures include traveling screens with relative high through-screen velocities and no fish handling or

[17] The availability of water and impact of water use may affect the choice of FGD

return system.[18] Measures to prevent, minimize, and control environmental impacts associated with water withdrawal should be established based on the results of a project EA, considering the availability and use of water resources locally and the ecological characteristics of the project affected area. Recommended management measures to prevent or control impacts to water resources and aquatic habitats include[19]:

- Conserving water resources, particularly in areas with limited water resources, by:
  - Use of a closed-cycle, recirculating cooling water system (e.g., natural or forced draft cooling tower), or closed circuit dry cooling system (e.g., air cooled condensers) if necessary to prevent unacceptable adverse impacts. Cooling ponds or cooling towers are the primary technologies for a recirculating cooling water system. Once-through cooling water systems may be acceptable if compatible with the hydrology and ecology of the water source and the receiving water and may be the preferred or feasible alternative for certain pollution control technologies such as seawater scrubbers
  - Use of dry scrubbers in situations where these controls are also required or recycling of wastewater in coal-fired plants for use as FGD makeup
  - Use of air-cooled systems
- Reduction of maximum through-screen design intake velocity to 0.5 ft/s;
- Reduction of intake flow to the following levels:
  - For freshwater rivers or streams to a flow sufficient to maintain resource use (i.e., irrigation and fisheries) as well as biodiversity during annual mean low flow conditions[20]
  - For lakes or reservoirs, intake flow must not disrupt the thermal stratification or turnover pattern of the source water
  - For estuaries or tidal rivers, reduction of intake flow to 1% of the tidal excursion volume
- If there are threatened, endangered, or other protected species or if there are fisheries within the hydraulic zone of influence of the intake, reduction of impingement and entrainment of fish and shellfish by the installation of technologies such as barrier nets (seasonal or year-round), fish handling and return systems, fine mesh screens, wedgewire screens, and aquatic filter barrier systems. Examples of operational measures to reduce impingement and entrainment include seasonal shutdowns, if necessary, or reductions in flow or continuous use of screens. Designing the location of the intake structure in a different direction or further out into the water body may also reduce impingement and entrainment.

Effluents

Effluents from thermal power plants include thermal discharges, wastewater effluents, and sanitary wastewater.

Thermal Discharges

As noted above, thermal power plants with steam-powered generators and once-through cooling systems use significant volume of water to cool and condense the steam for return to the boiler. The heated water is normally discharged back to the source water (i.e., river, lake, estuary, or the ocean) or the nearest surface water body. In general, thermal discharge should be designed to ensure that discharge water temperature does not result in exceeding relevant ambient water quality temperature standards outside a scientifically established mixing zone. The mixing zone is typically defined as the zone where initial dilution of a discharge takes place within which relevant water quality

system used (i.e., wet vs. semi-dry).

[18] The velocity generally considered suitable for the management of debris is 1 fps [0.30 m/s] with wide mesh screens; a standard mesh for power plants of 3/8 in (9.5 mm).

[19] For additional information refer to Schimmoller (2004) and USEPA (2001).

[20] Stream flow requirements may be based on mean annual flow or mean low flow. Regulatory requirements may be 5% or higher for mean annual flows and 10% to 25% for mean low flows. Their applicability should be verified on a site-specific

temperature standards are allowed to exceed and takes into account cumulative impact of seasonal variations, ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations. Establishment of such a mixing zone is project specific and may be established by local regulatory agencies and confirmed or updated through the project's environmental assessment process. Where no regulatory standard exists, the acceptable ambient water temperature change will be established through the environmental assessment process. Thermal discharges should be designed to prevent negative impacts to the receiving water taking into account the following criteria:

- The elevated temperature areas because of thermal discharge from the project should not impair the integrity of the water body as a whole or endanger sensitive areas (such as recreational areas, breeding grounds, or areas with sensitive biota);
- There should be no lethality or significant impact to breeding and feeding habits of organisms passing through the elevated temperature areas;
- There should be no significant risk to human health or the environment due to the elevated temperature or residual levels of water treatment chemicals.

If a once-through cooling system is used for large projects (i.e., a plant with > 1,200MWth steam generating capacity), impacts of thermal discharges should be evaluated in the EA with a mathematical or physical hydrodynamic plume model, which can be a relatively effective method for evaluating a thermal discharge to find the maximum discharge temperatures and flow rates that would meet the environmental objectives of the receiving water.[21]

Recommendations to prevent, minimize, and control thermal discharges include:

- Use of multi-port diffusers;
- Adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level (i.e., extend length of discharge channel before reaching the surface water body for pre-cooling or change location of discharge point to minimize the elevated temperature areas);
- Use of a closed-cycle, recirculating cooling water system as described above (e.g., natural or forced draft cooling tower), or closed circuit dry cooling system (e.g., air cooled condensers) if necessary to prevent unacceptable adverse impacts. Cooling ponds or cooling towers are the primary technologies for a recirculating cooling water system.

Liquid Waste

The wastewater streams in a thermal power plant include cooling tower blowdown; ash handling wastewater; wet FGD system discharges; material storage runoff; metal cleaning wastewater; and low-volume wastewater, such as air heater and precipitator wash water, boiler blowdown, boiler chemical cleaning waste, floor and yard drains and sumps, laboratory wastes, and backflush from ion exchange boiler water purification units. All of these wastewaters are usually present in plants burning coal or biomass; some of these streams (e.g., ash handling wastewater) may be present in reduced quantities or may not be present at all in oil-fired or gas-fired power plants. The characteristics of the wastewaters generated depend on the ways in which the water has been used. Contamination arises from demineralizers; lubricating and auxiliary fuel oils; trace contaminants in the fuel (introduced through the ash-handling wastewater and wet FGD system discharges); and chlorine, biocides, and other chemicals used to manage the quality of water in cooling systems. Cooling tower blowdown tends to be very high in total dissolved solids but is generally classified as non-contact cooling water and, as such,

basis taking into consideration resource use and biodiversity requirements.

[21] An example model is CORMIX (Cornell Mixing Zone Expert System) hydrodynamic mixing zone computer simulation, which has been developed by the U.S. Environmental Protection Agency. This model emphasizes predicting the site- and discharge-specific geometry and dilution characteristics to assess the environmental effects of a proposed discharge.

is typically subject to limits for pH, residual chlorine, and toxic chemicals that may be present in cooling tower additives (including corrosion inhibiting chemicals containing chromium and zinc whose use should be eliminated).

Recommended water treatment and wastewater conservation methods are discussed in Sections 1.3 and 1.4, respectively, of the **General EHS Guidelines**. In addition, recommended measures to prevent, minimize, and control wastewater effluents from thermal power plants include:

- Recycling of wastewater in coal-fired plants for use as FGD makeup. This practice conserves water and reduces the number of wastewater streams requiring treatment and discharge[22];
- In coal-fired power plants without FGD systems, treatment of process wastewater in conventional physical-chemical treatment systems for pH adjustment and removal of total suspended solids (TSS), and oil / grease, at a minimum. Depending on local regulations, these treatment systems can also be used to remove most heavy metals to part-per-billion (ppb) levels by chemical precipitation as either metal hydroxide or metal organosulfide compounds;
- Collection of fly ash in dry form and bottom ash in drag chain conveyor systems in new coal-fired power plants;
- Consider use of soot blowers or other dry methods to remove fireside wastes from heat transfer surfaces so as to minimize the frequency and amount of water used in fireside washes;
- Use of infiltration and runoff control measures such as compacted soils, protective liners, and sedimentation controls for runoff from coal piles;
- Spraying of coal piles with anionic detergents to inhibit bacterial growth and minimize acidity of leachate;[23]
- Use of SO_X removal systems that generate less wastewater, if feasible; however, the environmental and cost characteristics of both inputs and wastes should be assessed on a case-by-case basis;
- Treatment of low-volume wastewater streams that are typically collected in the boiler and turbine room sumps in conventional oil-water separators before discharge;
- Treatment of acidic low-volume wastewater streams, such as those associated with the regeneration of makeup demineralizer and deep-bed condensate polishing systems, by chemical neutralization in-situ before discharge;
- Pretreatment of cooling tower makeup water, installation of automated bleed/feed controllers, and use of inert construction materials to reduce chemical treatment requirements for cooling towers;
- Elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers;
- Use the minimum required quantities of chlorinated biocides in place of brominated biocides or alternatively apply intermittent shock dosing of chlorine as opposed to continuous low level feed.

Sanitary Wastewater

Sewage and other wastewater generated from washrooms, etc. are similar to domestic wastewater. Impacts and management of sanitary wastewater is addressed in Section 1.3 of the **General EHS Guidelines.**

Solid Wastes

Coal-fired and biomass-fired thermal power plants generate the greatest amount of solid wastes due to the relatively high percentage of ash in the fuel.[24] The large-volume coal

[22] Suitable wastewater streams for reuse include gypsum wash water, which is a different wastewater stream than the FGD wastewater. In plants that produce marketable gypsum, the gypsum is rinsed to remove chloride and other undesirable trace elements.

[23] If coal pile runoff will be used as makeup to the FGD system, anionic detergents may increase or create foaming within the scrubber system. Therefore, use of anionic surfactants on coal piles should be evaluated on a case-by-case basis.

[24] For example, a 500 MWe plant using coal with 2.5% sulfur (S), 16% ash, and 30,000 kilojoules per kilogram (kJ/kg) heat content will generate about 500 tons of

combustion wastes (CCW) are fly ash, bottom ash, boiler slag, and FGD sludge. Biomass contains less sulfur; therefore FGD may not be necessary. Fluidized-bed combustion (FBC) boilers generate fly ash and bottom ash, which is called bed ash. Fly ash removed from exhaust gases makes up 60–85% of the coal ash residue in pulverized-coal boilers and 20% in stoker boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash. Due to the presence of sorbent material, FBC wastes have a higher content of calcium and sulfate and a lower content of silica and alumina than conventional coal combustion wastes. Low-volume solid wastes from coal-fired thermal power plants and other plants include coal mill rejects/pyrites, cooling tower sludge, wastewater treatment sludge, and water treatment sludge.

Oil combustion wastes include fly ash and bottom ash and are normally only generated in significant quantities when residual fuel oil is burned in oil-fired steam electric boilers. Other technologies (e.g., combustion turbines and diesel engines) and fuels (e.g., distillate oil) generate little or no solid wastes. Overall, oil combustion wastes are generated in much smaller quantities than the large-volume CCW discussed above. Gas-fired thermal power plants generate essentially no solid waste because of the negligible ash content, regardless of the combustion technology.

Metals are constituents of concern in both CCW and low-volume solid wastes. For example, ash residues and the dust removed from exhaust gases may contain significant levels of heavy metals and some organic compounds, in addition to inert materials.

Ash residues are not typically classified as a hazardous waste due to their inert nature.[25] However, where ash residues are expected to contain potentially significant levels of heavy metals, radioactivity, or other potentially hazardous materials, they should be tested at the start of plant operations to verify their classification as hazardous or non-hazardous according to local regulations or internationally recognized standards. Additional information about the classification and management of hazardous and non-hazardous wastes is presented in Section 1.6 of the **General EHS Guidelines.**

The high-volume CCWs wastes are typically managed in landfills or surface impoundments or, increasingly, may be applied to a variety of beneficial uses. Low-volume wastes are also managed in landfills or surface impoundments, but are more frequently managed in surface impoundments. Many coal-fired plants co-manage large-volume and low-volume wastes.

Recommended measures to prevent, minimize, and control the volume of solid wastes from thermal power plants include:

- Dry handling of the coal combustion wastes, in particular fly ash. Dry handling methods do not involve surface impoundments and, therefore, do not present the ecological risks identified for impoundments (e.g., metal uptake by wildlife);
- Recycling of CCWs in uses such as cement and other concrete products, construction fills (including structural fill, flowable fill, and road base), agricultural uses such as calcium fertilizers (provided trace metals or other potentially hazardous materials levels are within accepted thresholds), waste management applications, mining applications, construction materials (e.g., synthetic gypsum for plasterboard), and incorporation into other products provided the residues (such as trace metals and radioactivity) are not considered hazardous. Ensuring consistent quality of fuels and additives helps to ensure the CCWs can be recycled. If beneficial reuse is not feasible, disposal of CCW in permitted landfills with environmental controls such as run-on/run-off controls, liners, leachate collection systems, ground-water monitoring, closure controls, daily (or other operational) cover, and fugitive dust controls is recommended;

solid waste per day.

25 Some countries may categorize fly ash as hazardous due to the presence of arsenic or radioactivity, precluding its use as a construction material.

- Dry collection of bottom ash and fly ash from power plants combusting heavy fuel oil if containing high levels of economically valuable metals such as vanadium and recycle for vanadium recovery (where economically viable) or disposal in a permitted landfill with environmental controls;
- Management of ash disposal and reclamation so as to minimize environmental impacts – especially the migration of toxic metals, if present, to nearby surface and groundwater bodies, in addition to the transport of suspended solids in surface runoff due to seasonal precipitation and flooding. In particular, construction, operation, and maintenance of surface impoundments should be conducted in accordance with internationally recognized standards.[26, 27]
- Reuse of sludge from treatment of waste waters from FGD plants. This sludge may be re-used in the FGD plant due to the calcium components. It can also be used as an additive in coal-fired plant combustion to improve the ash melting behavior

Hazardous Materials and Oil

Hazardous materials stored and used at combustion facilities include solid, liquid, and gaseous waste-based fuels; air, water, and wastewater treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint certain types of lubricants, and cleaners). Spill prevention and response guidance is addressed in Sections 1.5 and 3.7 of the **General EHS Guidelines**.

In addition, recommended measures to prevent, minimize, and control hazards associated with hazardous materials storage and handling at thermal power plants include the use of double-walled, underground pressurized tanks for storage of pure liquefied ammonia (e.g., for use as reagent for SCR) in quantities over 100 m^3; tanks of lesser capacity should be manufactured using annealing processes (EC 2006).

Noise

Principal sources of noise in thermal power plants include the turbine generators and auxiliaries; boilers and auxiliaries, such as coal pulverizers; reciprocating engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. Thermal power plants used for base load operation may operate continually while smaller plants may operate less frequently but still pose a significant source of noise if located in urban areas.

Noise impacts, control measures, and recommended ambient noise levels are presented in Section 1.7 of the **General EHS Guidelines**. Additional recommended measures to prevent, minimize, and control noise from thermal power plants include:

- Siting new facilities with consideration of distances from the noise sources to the receptors (e.g., residential receptors, schools, hospitals, religious places) to the extent possible. If the local land use is not controlled through zoning or is not effectively enforced, examine whether residential receptors could come outside the acquired plant boundary. In some cases, it could be more cost effective to acquire additional land as buffer zone than relying on technical noise control measures, where possible;
- Use of noise control techniques such as: using acoustic machine enclosures; selecting structures according to their noise isolation effect to envelop the building; using mufflers or silencers in intake and exhaust channels; using sound-absorptive materials in walls and ceilings; using vibration isolators and flexible connections (e.g., helical steel springs and rubber elements); applying a carefully detailed design to prevent possible noise leakage through openings or to minimize pressure variations in piping;

[26] See, for example, U.S. Department of Labor, Mine Safety and Health Administration regulations at 30 CFR §§ 77.214 - 77.216.

[27] Additional detailed guidance applicable to the prevention and control of impacts to soil and water resources from non-hazardous and hazardous solid waste disposal is presented in the World Bank Group EHS Guidelines for Waste Management Facilities.

- Modification of the plant configuration or use of noise barriers such as berms and vegetation to limit ambient noise at plant property lines, especially where sensitive noise receptors may be present.

Noise propagation models may be effective tools to help evaluate noise management options such as alternative plant locations, general arrangement of the plant and auxiliary equipment, building enclosure design, and, together with the results of a baseline noise assessment, expected compliance with the applicable community noise requirements.

1.2 Occupational Health and Safety

Occupational health and safety risks and mitigation measures during construction, operation, and decommissioning of thermal power plants are similar to those at other large industrial facilities, and are addressed in Section 2.0 of the **General EHS Guidelines**. In addition, the following health and safety impacts are of particular concern during operation of thermal power plants:

- Non-ionizing radiation
- Heat
- Noise
- Confined spaces
- Electrical hazards
- Fire and explosion hazards
- Chemical hazards
- Dust

Non-ionizing radiation

Combustion facility workers may have a higher exposure to electric and magnetic fields (EMF) than the general public due to working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines. Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

- Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities;
- Training of workers in the identification of occupational EMF levels and hazards;
- Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers;
- Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Institute of Electrical and Electronics Engineers (IEEE).[28] Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g., 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

Heat

Occupational exposure to heat occurs during operation and maintenance of combustion units, pipes, and related hot equipment. Recommended prevention and control measures to address heat exposure at thermal power plants include:

- Regular inspection and maintenance of pressure vessels and piping;
- Provision of adequate ventilation in work areas to reduce heat and humidity;

[28] The ICNIRP exposure guidelines for Occupational Exposure are listed in Section 2.2 of this Guideline.

- Reducing the time required for work in elevated temperature environments and ensuring access to drinking water;
- Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc;
- Use of warning signs near high temperature surfaces and personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.

Noise

Noise sources in combustion facilities include the turbine generators and auxiliaries; boilers and auxiliaries, such as pulverizers; diesel engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. Recommendations for reducing noise and vibration are discussed in Section 1.1, above. In addition, recommendations to prevent, minimize, and control occupational noise exposures in thermal power plants include:

- Provision of sound-insulated control rooms with noise levels below 60 dBA[29];
- Design of generators to meet applicable occupational noise levels;
- Identify and mark high noise areas and require that personal noise protecting gear is used all the time when working in such high noise areas (typically areas with noise levels >85 dBA).

Confined Spaces

Specific areas for confined space entry may include coal ash containers, turbines, condensers, and cooling water towers (during maintenance activities). Recommend confined space entry procedures are discussed in Section 2.8 of the **General EHS Guidelines**.

Electrical Hazards

Energized equipment and power lines can pose electrical hazards for workers at thermal power plants. Recommended measures to prevent, minimize, and control electrical hazards at thermal power plants include:

- Consider installation of hazard warning lights inside electrical equipment enclosures to warn of inadvertent energization;
- Use of voltage sensors prior to and during workers' entrance into enclosures containing electrical components;
- Deactivation and proper grounding of live power equipment and distribution lines according to applicable legislation and guidelines whenever possible before work is performed on or proximal to them;
- Provision of specialized electrical safety training to those workers working with or around exposed components of electric circuits. This training should include, but not be limited to, training in basic electrical theory, proper safe work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tagout procedures, first aid including CPR, and proper rescue procedures. Provisions should be made for periodic retraining as necessary.

Fire and Explosion Hazards

Thermal power plants store, transfer, and use large quantities of fuels; therefore, careful handling is necessary to mitigate fire and explosion risks. In particular, fire and explosion hazards increase as the particle size of coal is reduced. Particle sizes of coal that can fuel a propagating explosion occur within thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment. Fire and explosion prevention management guidance is provided in Section 2.1 and

[29] Depending on the type and size of the thermal power plants, distance between control room and the noise emitting sources differs. CSA Z107.58 provides design guidelines for control rooms as 60 dBA. Large thermal power plants using steam boilers or combustion turbines tend to be quieter than 60 dBA. Reciprocating engine manufacturers recommend 65 to 70 dBA instead of 60 dBA (Euromot Position as of 9 May 2008). This guideline recommends 60 dBA as GIIP, with an understanding that up to 65 dBA can be accepted for reciprocating engine power plants if 60 dBA is economically difficult to achieve.

2.4 of the **General EHS Guidelines**. Recommended measures to prevent, minimize, and control physical hazards at thermal power plants include:

- Use of automated combustion and safety controls;
- Proper maintenance of boiler safety controls;
- Implementation of startup and shutdown procedures to minimize the risk of suspending hot coal particles (e.g., in the pulverizer, mill, and cyclone) during startup;
- Regular cleaning of the facility to prevent accumulation of coal dust (e.g., on floors, ledges, beams, and equipment);
- Removal of hot spots from the coal stockpile (caused by spontaneous combustion) and spread until cooled, never loading hot coal into the pulverized fuel system;
- Use of automated systems such as temperature gauges or carbon monoxide sensors to survey solid fuel storage areas to detect fires caused by self-ignition and to identify risk points.

Chemical Hazards

Thermal power plants utilize hazardous materials, including ammonia for NO_X control systems, and chlorine gas for treatment of cooling tower and boiler water. Guidance on chemical hazards management is provided in Section 2.4 of the **General EHS Guidelines.** Additional, recommended measures to prevent, minimize, and control physical hazards at thermal power plants include:

- Consider generation of ammonia on site from urea or use of aqueous ammonia in place of pure liquefied ammonia;
- Consider use of sodium hypochlorite in place of gaseous chlorine.

Dust

Dust is generated in handing solid fuels, additives, and solid wastes (e.g., ash). Dust may contain silica (associated with silicosis), arsenic (skin and lung cancer), coal dust (black lung), and other potentially harmful substances. Dust management guidance is provided in the Section 2.1 and 2.4 of the **General EHS Guidelines.** Recommended measures to prevent, minimize, and control occupational exposure to dust in thermal power plants include:

- Use of dust controls (e.g., exhaust ventilation) to keep dust below applicable guidelines (see Section 2) or wherever free silica levels in airborne dust exceed 1 percent;
- Regular inspection and maintenance of asbestos containing materials (e.g., insulation in older plants may contain asbestos) to prevent airborne asbestos particles.

1.3 Community Health and Safety

Many community health and safety impacts during the construction, operation, and decommissioning of thermal power plant projects are common to those of most infrastructure and industrial facilities and are discussed in Section 3.0 the **General EHS Guidelines**. In addition to these and other aspects covered in Section 1.1, the following community health and safety impacts may be of particular concern for thermal power plant projects:

- Water Consumption;
- Traffic Safety.

Water Consumption

Boiler units require large amounts of cooling water for steam condensation and efficient thermal operation. The cooling water flow rate through the condenser is by far the largest process water flow, normally equating to about 98 percent of the total process water flow for the entire unit. In a once-through cooling water system, water is usually taken into the plant from surface waters, but sometimes ground waters or municipal supplies are used. The potential effects of water use should be assessed, as discussed in Section 3.1 of the **General EHS Guidelines**, to ensure that the project does not compromise the availability of water for personal hygiene, agriculture, recreation, and other community needs.

Traffic Safety

Operation of a thermal power plant will increase traffic volume, in particular for facilities with fuels transported via land and sea, including heavy trucks carrying fuel, additives, etc. The increased traffic can be especially significant in sparsely populate areas where some thermal power plants are located. Prevention and control of traffic-related injuries are discussed in Section 3.4 of the **General EHS Guidelines**. Water transport safety is covered in the **EHS Guidelines for Shipping**.

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Effluent guidelines are described in Table 5. Emissions guidelines are described in Table 6. Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guideline.** Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in standards of countries with recognized regulatory frameworks. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels due to specific local project conditions should be justified in the environmental assessment.

Table 5 - Effluent Guidelines
(To be applicable at relevant wastewater stream: e.g., from FGD system, wet ash transport, washing boiler / air preheater and precipitator, boiler acid washing, regeneration of demineralizers and condensate polishers, oil-separated water, site drainage, coal pile runoff, and cooling water)

Parameter	mg/L, except pH and temp
pH	6 – 9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium - Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	• Site specific requirement to be established by the EA. • Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.

Note: Applicability of heavy metals should be determined in the EA. Guideline limits in the Table are from various references of effluent performance by thermal power plants.

Emissions levels for the design and operation of each project should be established through the EA process on the basis of country legislation and the recommendations provided in this guidance document, as applied to local conditions. The emissions levels selected should be justified in the EA.[30] The maximum emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems. In contrast, poor operating or maintenance procedures affect actual pollutant removal efficiency and may reduce it to well

[30] For example, in cases where potential for acid deposition has been identified as a significant issue in the EA, plant design and operation should ensure that emissions mass loadings are effectively reduced to prevent or minimize such impacts.

below the design specification. Dilution of air emissions to achieve these guidelines is unacceptable. Compliance with ambient air quality guidelines should be assessed on the basis of good international industry practice (GIIP) recommendations.

As described in the General EHS Guidelines, emissions should not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards[31] by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines[32], or other internationally recognized sources[33]. Also, emissions from a single project should not contribute more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed. [34]

As described in the General EHS Guidelines, facilities or projects located within poor quality airsheds[35], and within or next to areas established as ecologically sensitive (e.g., national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment.

Environmental Monitoring

Environmental monitoring programs for this sector are presented in Table 7. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Examples of emissions, stack testing, ambient air quality, and noise monitoring recommendations applicable to power plants are provided in Table 7. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

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31 Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, and ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological, and epidemiological evidence (such as those published by the World Health Organization).

32 Available at World Health Organization (WHO). http://www.who.int/en

33 For example the United States National Ambient Air Quality Standards (NAAQS) (http://www.epa.gov/air/criteria.html) and the relevant European Council Directives (Council Directive 1999/30/EC of 22 April 1999 / Council Directive 2002/3/EC of February 12 2002).

34 US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds.

35 An airshed should be considered as having poor air quality if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly.

Table 6 (A) - Emissions Guidelines (in mg/Nm³ or as indicated) for Reciprocating Engine

Note:

- **Guidelines are applicable for new facilities.**
- **EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.**
- **For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.**
- **EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.**

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)		Dry Gas, Excess O_2 Content (%)
Reciprocating Engine	NDA	DA	NDA	DA	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	200 (Spark Ignition) 400 (Dual Fuel) (a)	200(SI) 400 (Dual Fuel / CI)	15%
Liquid Fuels (Plant >50 MWth to <300 MWth)	50	30	1,170 or use of 2% or less S fuel	0.5% S	1,460 (Compression Ignition, bore size diameter [mm] < 400) 1,850 (Compression Ignition, bore size diameter [mm] ≥ 400) 2,000 (Dual Fuel)	400	15%
Liquid Fuels (Plant >/=300 MWth)	50	30	585 or use of 1% or less S fuel	0.2% S	740 (contingent upon water availability for injection)	400	15%
Biofuels / Gaseous Fuels other than Natural Gas	50	30	N/A	N/A	30% higher limits than those provided above for Natural Gas and Liquid Fuels.	200 (SI, Natural Gas), 400 (other)	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- (a) Compression Ignition (CI) engines may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Reciprocating Engine – NOx
  - Guideline limits: 200 (SI), 400 (DF)
  - UK: 100 (CI) , US: Reduce by 90% or more, or alternatively 1.6 g/kWh
- Liquid Fuels-fired Reciprocating Engine – NOx (Plant >50 MWth to <300 MWth)
  - Guideline limits: 1,460 (CI, bore size diameter < 400 mm), 1,850 (CI, bore size diameter ≥ 400 mm), 2,000 (DF)
  - UK: 300 (> 25 MWth), India: 1,460 (Urban area & ≤ 75 MWe (≈ 190 MWth), Rural area & ≤ 150 MWe (≈ 380 MWth))
- Liquid Fuels-fired Reciprocating Engine – NOx (Plant ≥300 MWth)
  - Guideline limits: 740 (contingent upon water availability for injection)
  - UK: 300 (> 25 MWth), India: 740 (Urban area & > 75MWe (≈ 190 MWth), Rural area & > 150 MWe (≈ 380 MWth))
- Liquid Fuels-fired Reciprocating Engine – SO2
  - Guideline limits: 1,170 or use of ≤ 2% S (Plant >50 MWth to <300 MWth), 585 or use of ≤ 1% S (Plant ≥300 MWth)
  - EU: Use of low S fuel oil or the secondary FGD (IPCC LCP BREF), HFO S content ≤ 1% (Liquid Fuel Quality Directive), US: Use of diesel fuel with max S of 500 ppm (0.05%); EU: Marine HFO S content ≤ 1.5% (Liquid Fuel Quality Directive) used in SOx Emission Control Areas; India: Urban (< 2% S), Rural (< 4%S), Only diesel fuels (HSD, LDO) should be used in Urban

Source: UK (S2 1.03 Combustion Processes: Compression Ignition Engines, 50 MWth and over), India (SOx/NOx Emission Standards for Diesel Engines ≥ 0.8 MW), EU (IPCC LCP BREF July 2006), EU (Liquid Fuel Quality Directive 1999/32/EC amended by 2005/33/EC), US (NSPS for Stationary Compression Ignition Internal Combustion Engine – Final Rule – July 11, 2006)

Table 6 (B) - Emissions Guidelines (in mg/Nm^3 or as indicated) for Combustion Turbine

Note:

- **Guidelines are applicable for new facilities.**
- **EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.**
- **For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.**
- **EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.**

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)[a]	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm^3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
  - (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)
- Liquid Fuel-fired Combustion Turbine – NOx
  - Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
  - EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))
- Liquid Fuel-fired Combustion Turbine – SOx
  - Guideline limits: Use of 1% or less S fuel
  - EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Table 6 (C) - Emissions Guidelines (in mg/Nm^3 or as indicated) for Boiler

Note:
- **Guidelines are applicable for new facilities.**
- **EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.**
- **For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.**
- **EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.**

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)		Dry Gas, Excess O_2 Content (%)
Boiler	NDA	DA	NDA	DA	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	240	240	3%
Other Gaseous Fuels	50	30	400	400	240	240	3%
Liquid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	400	200	3%
Liquid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200	400	200	3%
Solid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	510[c] Or up to 1,100 if volatile matter of fuel < 10%	200	6%
Solid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200			6%

General notes:
- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; CFB = circulating fluidized bed coal-fired; PC = pulverized coal-fired; Nm^3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- a. Targeting the lower guidelines values and recognizing issues related to quality of available fuel, cost effectiveness of controls on smaller units, and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). b. Targeting the lower guidelines values and recognizing variability in approaches to the management of SO_2 emissions (fuel quality vs. use of secondary controls) and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). Larger plants are expected to have additional emission control measures. Selection of the emission level in the range is to be determined by EA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance. c. Stoker boilers may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):
- Natural Gas-fired Boiler – NOx
  - Guideline limits: 240
  - EU: 150 (50 to 300 MWth), 200 (> 300 MWth)
- Solid Fuels-fired Boiler - PM
  - Guideline limits: 50
  - EU: 50 (50 to 100 MWth), 30 (> 100 MWth), China: 50, India: 100 - 150
- Solid Fuels-fired Boiler – SO_2
  - Guideline limits: 900 – 1,500 (Plant > 50 MWth to < 600 MWth), 200 – 850 (Plant ≥ 600 MWth)
  - EU: 850 (50 – 100 MWth), 200 (> 100 MWth)
  - US: 180 ng/J gross energy output OR 95% reduction (≈ 200 mg/Nm3 at 6%O_2 assuming 38% HHV efficiency)
  - China: 400 (general), 800 (if using coal < 12,550 kJ/kg), 1,200 (if mine-mouth plant located in non-double control area of western region and burning low S coal (<0.5%))

Source: EU (LCP Directive 2001/80/EC October 23 2001), US (NSPS for Electric Utility Steam Generating Units (Subpart Da), Final Rule – June 13, 2007), China (GB 13223-2003)

Table 7 – Typical Air Emission Monitoring Parameters / Frequency for Thermal Power Plants
(Note: Detailed monitoring programs should be determined based on EA)

Combustion Technology / Fuel	Emission Monitoring			Stack Emission Testing				Ambient Air Quality	Noise
	Particulate Matter (PM)	Sulfur Dioxide (SO_2)	Nitrogen Oxides (NOx)	PM	SO_2	NOx	Heavy Metals		
Reciprocating Engine								If incremental impacts predicted by EA >/= 25 % of relevant short-term ambient air quality standards or if the plant >/= 1,200 MWth: - Monitor parameters (e.g., PM_{10}/$PM_{2.5}$/SO_2/NOx to be consistent with the relevant ambient air quality standards) by continuous ambient air quality monitoring system (typically a minimum of 2 systems to cover predicted maximum ground level concentration point / sensitive receptor / background point). If incremental impacts predicted by EA < 25% of relevant short term ambient air quality standards and if the facility < 1,200 MWth but >/= 100 MWth - Monitor parameters either by passive samplers (monthly average) or by seasonal manual sampling (e.g., 1 weeks/season) for parameters consistent with the relevant air quality standards. Effectiveness of the ambient air quality monitoring program should be reviewed regularly. It could be simplified or reduced if alternative program is developed (e.g., local government's monitoring network). Continuation of the program is recommended during the life of the project if there are sensitive receptors or if monitored levels are not far below the relevant ambient air quality standards.	If EA predicts noise levels at residential receptors or other sensitive receptors are close to the relevant ambient noise standards / guidelines, or if there are such receptors close to the plant boundary (e.g., within 100m) then, conduct ambient noise monitoring every year to three years depending on the project circumstances. Elimination of noise monitoring can be considered acceptable if a comprehensive survey showed that there are no receptors affected by the project or affected noise levels are far below the relevant ambient noise standards / guidelines.
Natural Gas (Plant >50 MWth to <300 MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
Natural Gas (Plant >/= 300 MWth)	N/A	N/A	Continuous	N/A	N/A	Annual	N/A		
Liquid (Plant >50 MWth to <300 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Liquid (Plant >/=300 MWth)	Continuous or indicative		Continuous						
Biomass	Continuous or indicative	N/A	Continuous or indicative	Annual	N/A	Annual	N/A		
Combustion Turbine									
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
Fuels other than Natural Gas (Unit > 50MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Boiler									
Natural Gas	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
				Annual	Annual	Annual	N/A		
Other Gaseous fuels	Indicative	Indicative	Continuous or indicative	Annual					
Liquid (Plant >50 MWth to <600 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative						
Liquid (Plant >=600 MWth)		Continuous							
Solid (Plant >50 MWth to <600 MWth)		Continuous if FGD is used or monitor by S Content.	Continuous or indicative						
Solid (Plant >/=600 MWth)		Continuous							

Note: Continuous or indicative means "Continuously monitor emissions or continuously monitor indicative parameters". Stack emission testing is to have direct measurement of emission levels to counter check the emission monitoring system.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[36] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[37] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[38] Indicative Occupational Exposure Limit Values published by European Union member states,[39] or other similar sources.

Additional indicators specifically applicable to electric power sector activities include the ICNIRP exposure limits for occupational exposure to electric and magnetic fields listed in Table 8. Additional applicable indicators such as noise, electrical hazards, air quality, etc. are presented in Section 2.0 of the **General EHS Guidelines**.

Table 8 - ICNIRP exposure limits for occupational exposure to electric and magnetic fields.

Frequency	Electric Field (V/m)	Magnetic Field (µT)
50 Hz	10,000	500
60 Hz	8300	415

Source: ICNIRP (1998) : "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. The accident and fatality rates of the specific facility may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., US Bureau of Labor Statistics and UK Health and Safety Executive)[40].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[41] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[36] http://www.acgih.org/TLV/[36] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/

[37] Available at: http://www.cdc.gov/niosh/npg/

[38] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

[39] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

[40] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm

[41] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

Thermal power plants burn fossil fuels or biomass to generate electrical energy and heat. Mechanical power is produced by a heat engine, which transforms thermal energy from combustion of a fossil fuel into rotational energy. A generator converts that mechanical energy into electrical energy by creating relative motion between a magnetic field and a conductor. Figure A-1 is a generalized flow diagram of a boiler-based thermal power plant and its associated operations.

Not all thermal energy can be transformed to mechanical power, according to the second law of thermodynamics. Therefore, thermal power plants also produce low-temperature heat. If no use is found for the heat, it is lost to the environment. If reject heat is employed as useful heat (e.g., for industrial processes or district heating), the power plant is referred to as a cogeneration power plant or CHP (combined heat-and-power) plant.

Types of Thermal power plants

Thermal power plants can be divided based on the type of combustion or gasification: boilers, internal reciprocating engines, and combustion turbines. In addition, combined-cycle and cogeneration systems increase efficiency by utilizing heat lost by conventional combustion systems. The type of system is chosen based on the loads, the availability of fuels, and the energy requirements of the electric power generation facility. Other ancillary processes, such as coal processing and pollution control, must also be performed to support the generation of electricity. The following subsections describe each system and then discuss ancillary processes at the facility (USEPA 1997).

Boilers (Steam Turbines)

Conventional steam-producing thermal power plants generate electricity through a series of energy conversion stages: fuel is burned in boilers to convert water to high-pressure steam, which is then used to drive a steam turbine to generate electricity. Heat for the system is usually provided by the combustion of coal, natural gas, oil, or biomass as well as other types of waste or recovered fuel. High-temperature, high-pressure steam is generated in the boiler and then enters the steam turbine. At the other end of the steam turbine is the condenser, which is maintained at a low temperature and pressure. Steam rushing from the high-pressure boiler to the low-pressure condenser drives the turbine blades, which powers the electric generator.

Low-pressure steam exiting the turbine enters the condenser shell and is condensed on the condenser tubes, which are maintained at a low temperature by the flow of cooling water. As the steam is cooled to condensate, the condensate is transported by the boiler feedwater system back to the boiler, where it is used again. A constant flow of low-temperature cooling water in the condenser tubes is required to keep the condenser shell (steam side) at proper pressure and to ensure efficient electricity generation. Through the condensing process, the cooling water is warmed. If the cooling system is an open or a once-through system, this warm water is released back to the source water body.[42] In a closed system, the warm water is cooled by recirculation through cooling towers, lakes, or ponds, where the heat is released into the air through evaporation and/or sensible heat transfer. If a recirculating cooling system is used, only a relatively small amount of make-up water is required to offset the evaporative losses and cooling tower blowdown that must be discharged periodically to control the build-up of solids. A recirculating system uses about one-twentieth the water of a once-through system.

Steam turbines typically have a thermal efficiency of about 35 percent, meaning that 35 percent of the heat of combustion is transformed into electricity. The remaining 65 percent of the heat either goes up the stack (typically 10 percent) or is

[42] If groundwater is used for cooling, the cooling water is usually discharged to a

discharged with the condenser cooling water (typically 55 percent).

Coal and lignite are the most common fuels in thermal power plants although heavy fuel oil is also used. Coal-fired steam generation systems are designed to use pulverized coal or crushed coal. Several types of coal-fired steam generators are in use, and are generally classified based on the characteristics of the coal fed to the burners and the mode of burning the coal. In fluidized-bed combustors, fuel materials are forced by gas into a state of buoyancy. The gas cushion between the solids allows the particles to move freely, thus flowing like a liquid. By using this technology, SO_2 and NO_X emissions are reduced because an SO_2 sorbent, such as limestone, can be used efficiently. Also, because the operating temperature is low, the amount of NO_X gases formed is lower than those produced using conventional technology.

Natural gas and liquid fuels are usually transported to thermal power plants via pipelines. Coal and biomass fuels can be transported by rail, barge, or truck. In some cases, coal is mixed with water to form slurry that can be pumped to the thermal power plant in a pipeline. Once coal arrives at the plant, it is unloaded to storage or directly to the stoker or hopper. In transporting coal during warmer months and in dry climates, dust suppression may be necessary.

Coal may be cleaned and prepared before being either crushed or pulverized. Impurities in coal such as ash, metals, silica, and sulfur can cause boiler fouling and slagging. Coal cleaning can be used to reduce sulfur in the coal to meet sulfur dioxide (SO_2) emissions regulations and also reduce ash content and the amount of heavy metals. Cleaning the coal is costly, but the cost can be at least partially offset by an increase in fuel efficiency, reduced emission control requirements, and lower waste management costs. Coal cleaning is typically performed at the mine by using gravity concentration, flotation, or dewatering methods.

Coal is transported from the coal bunker or silo to be crushed, ground, and dried further before it is fired in the burner or combustion system. Many mechanisms can be used to grind the coal and prepare it for firing. Pulverizers, cyclones, and stokers are all used to grind and dry the coal. Increasing the coal's particle surface area and decreasing its moisture content greatly boosting its heating capacity. Once prepared, the coal is transported within the plant to the combustion system. Devices at the bottom of the boilers catch ash and/or slag.

Reciprocating Engines

Internal combustion engines convert the chemical energy of fuels (typically diesel fuel or heavy fuel oil) into mechanical energy in a design similar to a truck engine, and the mechanical energy is used to turn a generator. Two types of engines normally used: the medium-speed, four-stroke trunk piston engine and the low-speed, two-stroke crosshead engine. Both types of engine operate on the air-standard diesel thermodynamic cycle. Air is drawn or forced into a cylinder and is compressed by a piston. Fuel is injected into the cylinder and is ignited by the heat of the compression of the air. The burning mixture of fuel and air expands, pushing the piston. The products of combustion are then removed from the cylinder, completing the cycle.

The exhaust gases from an engine are affected by the load profile of the prime mover; ambient conditions such as air humidity and temperature; fuel oil quality, such as sulfur content, nitrogen content, viscosity, ignition ability, density, and ash content; and site conditions and the auxiliary equipment associated with the prime mover, such as cooling properties and exhaust gas back pressure. The engine parameters that affect NO_X emissions are fuel injection in terms of timing, duration, and atomization; combustion air conditions, which are affected by

surface water body.

valve timing, the charge air system, and charge air cooling before cylinders; and the combustion process, which is affected by air and fuel mixing, combustion chamber design, and the compression ratio.[43] The particulate matter emissions are dependent on the general conditions of the engine, especially the fuel injection system and its maintenance, in addition to the ash content of the fuel, which is in the range 0.05–0.2%. SOx emissions are directly dependent on the sulfur content of the fuel. Fuel oil may contain as little as 0.3% sulfur and, in some cases, up to 5% sulfur.

Diesel engines are fuel flexible and can use fuels such as diesel oil, heavy fuel oil, natural gas, crude oil, bio-fuels (such as palm oil, etc.) and emulsified fuels (such as Orimulsion, etc.).

Typical electrical efficiencies in single mode are typically ranging from 40 % for the medium speed engines up to about 50 % for large engines and even higher efficiencies in combined cycle mode. Total efficiency in CHP (Combined Heat and Power) is typically in liquid operation up to 60 – 80 % and in gas mode even higher dependent on the application. The heat to power ratio is typically 0.5 to 1.3 in CHP applications, dependent on the application.

Lean Burn Gas Engines

Typical electrical efficiencies for bigger stationary medium speed engines in single mode are typically 40 – 47 % and up to close to 50 % in combined cycle mode. Total efficiency in CHP facilities is typically up to 90 % dependent on the application. The heat to power ratios are typically 0.5 to 1.3 in CHP-applications, dependent on the application.

Spark Ignition (SG)

Often a spark ignited gas-otto engine works according to the lean burn concept meaning that a lean mixture of combustion air and fuel is used in the cylinder (e.g., much more air than needed for the combustion). In order to stabilize the ignition and combustion of the lean mixture, in bigger engine types a prechamber with a richer air/fuel mixture is used. The ignition is initiated with a spark plug or some other device located in the prechamber, resulting in a high-energy ignition source for the main fuel charge in the cylinder. The most important parameter governing the rate of NOx formation in internal combustion engines is the combustion temperature; the higher the temperature the higher the NOx content of the exhaust gases. One method is to lower the fuel/air ratio, the same specific heat quantity released by the combustion of the fuel is then used to heat up a larger mass of exhaust gases, resulting in a lower maximum combustion temperature. This method low fuel/air ratio is called lean burn and it reduces NOx effectively. The spark-ignited lean-burn engine has therefore low NOx emissions. This is a pure gas engine; it operates only on gaseous fuels.

Dual fuel engines (DF)

Some DF engine types are fuel versatile, these can be run on low pressure natural gas or liquid fuels such as diesel oil (as back-up fuel, etc.), heavy fuel oil, etc. This engine type can operate at full load in both fuel modes. Dual Fuel (DF) engines can also be designed to work in gas mode only with a pilot liquid fuel used for ignition of the gas.

Combustion Turbines

Gas turbine systems operate in a manner similar to steam turbine systems except that combustion gases are used to turn the turbine blades instead of steam. In addition to the electric generator, the turbine also drives a rotating compressor to pressurize the air, which is then mixed with either gas or liquid

[43] If the fuel timing is too early, the cylinder pressure will increase, resulting in higher nitrogen oxide formation. If injection is timed too late, fuel consumption and turbocharger speed will increase. NO_X emissions can be reduced by later injection timing, but then particulate matter and the amount of unburned species will increase.

fuel in a combustion chamber. The greater the compression, the higher the temperature and the efficiency that can be achieved in a gas turbine. Higher temperatures, however, typically lead to increases in NO_X emissions. Exhaust gases are emitted to the atmosphere from the turbine. Unlike a steam turbine system, gas turbine systems do not have boilers or a steam supply, condensers, or a waste heat disposal system. Therefore, capital costs are much lower for a gas turbine system than for a steam system.

In electrical power applications, gas turbines are often used for peaking duty, where rapid startup and short runs are needed. Most installed simple gas turbines with no controls have only a 20- to 30-percent efficiency.

Combined Cycle

Combined-cycle generation is a configuration using both gas turbines and steam generators. In a combined-cycle gas turbine (CCGT), the hot exhaust gases of a gas turbine are used to provide all, or a portion of, the heat source for the boiler, which produces steam for the steam generator turbine. This combination increases the thermal efficiency to approximately 50 - 60 percent. Combined-cycle systems may have multiple gas turbines driving one steam turbine. Combined-cycle systems with diesel engines and steam generators are also sometimes used.

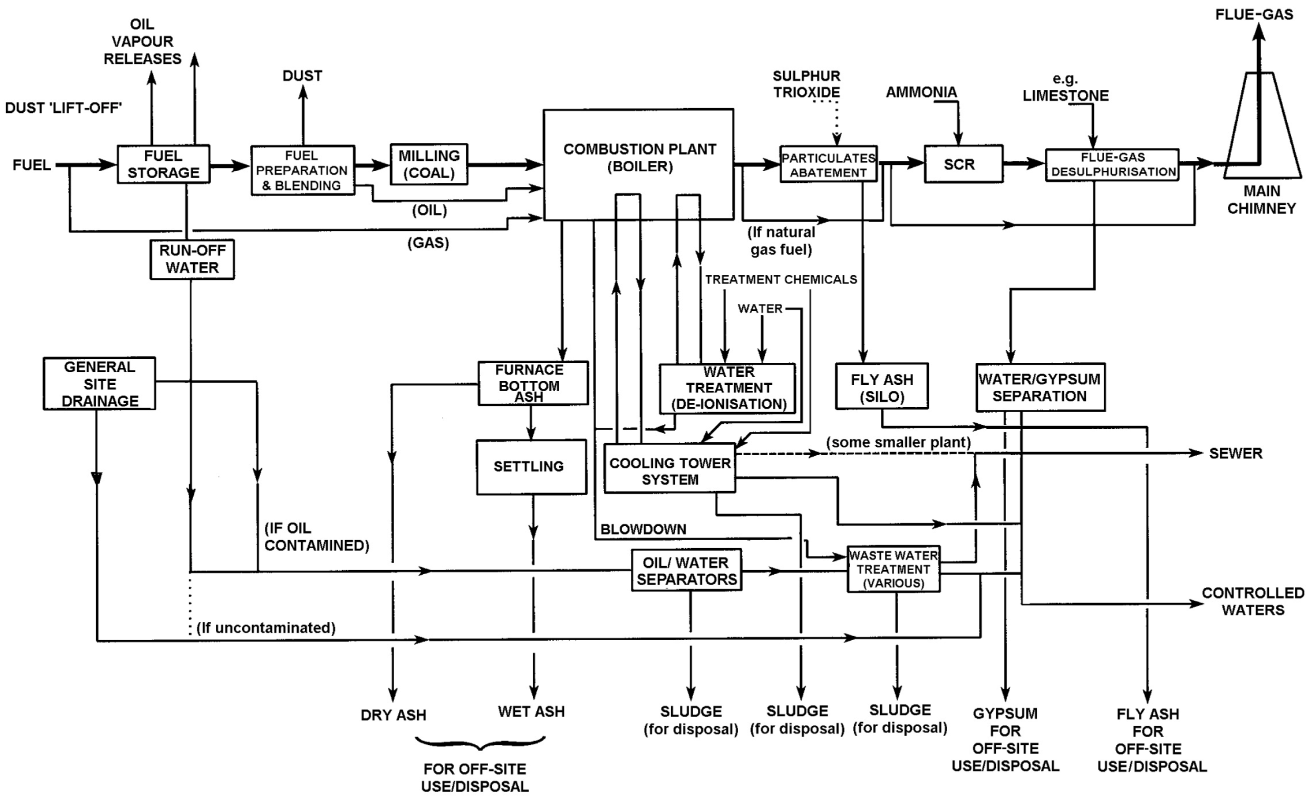
In addition, integrated coal gasification combined-cycle (IGCC) units are emerging technologies. In an IGCC system, coal gas is manufactured and cleaned in a "gasifier" under pressure, thereby reducing emissions and particulates.[44] The coal gas then is combusted in a CCGT generation system.

Cogeneration

Cogeneration is the merging of a system designed to produce electric power and a system used for producing industrial heat and steam and/or municipal heating. This system is a more efficient way of using energy inputs and allows the recovery of otherwise wasted thermal energy for use in an industrial process. Cogeneration technologies are classified as "topping cycle" and "bottoming cycle" systems, depending on whether electrical (topping cycle) or thermal (bottoming cycle) energy is derived first. Most cogeneration systems use a topping cycle.

[44] Gasification is a process in which coal is introduced to a reducing atmosphere with oxygen or air and steam.

Figure A-1
Generalized Flow Diagram of a Thermal power plant[45] and Associated Operations



Source: EC 2006

[45] Applicable to boiler plant with cooling tower only. Diagram does not apply to engines and turbines which have completely different configurations.

Annex B: Environmental Assessment Guidance for Thermal Power Projects

The development of an environmental assessment (EA) for a thermal power project should take into account any government energy and/or environmental policy or strategy including strategic aspects such as energy efficiency improvements in existing power generation, transmission, and distribution systems, demand side management, project siting, fuel choice, technology choice, and environmental performance.

New Facilities and Expansion of Existing Facilities

An (EA) for new facilities and a combined EA and environmental audit for existing facilities should be carried out early in the project cycle in order to establish site-specific emissions requirements and other measures for a new or expanded thermal power plant. Table B-1 provides suggested key elements of the EA, the scope of which will depend on project-specific circumstances.

Table B-1 Suggested Key EHS Elements for EA of New Thermal Power Project	
Analysis of Alternatives	• Fuel selection including non-fossil fuel options (coal, oil, gas, biomass, other renewable options – wind, solar, geothermal, hydro), fuel supply sources • Power generation technology ○ Thermal generating efficiency (HHV-gross, LHV-gross, HHV-net, LHV-net) ○ Cost ○ CO_2 emissions performance (gCO2/kWh) • GHG emissions reduction / offset options ○ Energy conversion efficiency ○ Offset arrangement ○ Use of renewable energy sources, etc. • Baseline water quality of receiving water bodies • Water supply ○ Surface water, underground water, desalination • Cooling system ○ Once-through, wet closed circuit, dry closed circuit • Ash disposal system - wet disposal vs. dry disposal • Pollution control ○ Air emission – primary vs. secondary flue gas treatment (cost, performance) ○ Effluent (cost, performance) • Effluent discharge ○ Surface water ○ Evaporation ○ Recycling – zero discharge • Siting ○ Land acquisition consideration ○ Access to fuel / electricity grid ○ Existing and future land use zoning ○ Existing and predicted environmental baseline (air, water, noise)
Impact Assessment	• Estimation of GHG emissions (tCO_2/year, gCO_2/kWh) • Air quality impact ○ SO_2, NO_2, PM_{10}, $PM_{2.5}$, Heavy metals as appropriate, Acid deposition if relevant ○ Incremental impacts to the attainment of relevant air quality standards ○ Isopleth concentration lines (short-term, annual average, as appropriate) overlaid with land use and topographic map ○ Cumulative impacts of existing sources / future projects if known ○ Stack height determination ○ Health impact consideration • Water quality / intake impact ○ thermal discharge if once-through cooling system is used ○ other key contaminants as appropriate ○ water intake impact • Noise impact ○ Noise contour lines overlaid with land use and locations of receptors • Determination of pollution prevention and abatement measures
Mitigation Measures /	• Air (Stack height, pollution control measures, cost)

Management Program	• Effluent (wastewater treatment measures, cost) • Noise (noise control measures, cost) • Waste utilization / disposal (e.g., ash, FGD by-product, used oil) ○ Ash management plan (quantitative balance of ash generation, disposal, utilization, size of ash disposal site, ash transportation arrangement) • Fuel supply arrangement • Emergency preparedness and response plan • Industrial risk assessment if relevant
Monitoring Program	• Parameters • Sampling Frequency • Evaluation Criteria • Sampling points overlaid with relevant site layout / surrounding maps • Cost

Tasks related to carrying out the quality impact analysis for the EA should include:

- Collection of baseline data ranging from relatively simple qualitative information (for smaller projects) to more comprehensive quantitative data (for larger projects) on ambient concentrations of parameters and averaging time consistent with relevant host country air quality standards (e.g., parameters such as PM_{10}, $PM_{2.5}$, SO_2 (for oil and coal-fired plants), NO_X, and ground-level ozone; and averaging time such as 1-hour maximum, 24-hour maximum, annual average), within a defined airshed encompassing the proposed project;[46]
- Evaluation of the baseline airshed quality (e.g., degraded or non-degraded);
- Evaluation of baseline water quality, where relevant;
- Use of appropriate mathematical or physical air quality dispersion models to estimate the impact of the project on the ambient concentrations of these pollutants;
- If acid deposition is considered a potentially significant impact, use of appropriate air quality models to evaluate long-range and trans-boundary acid deposition;
- The scope of baseline data collection and air quality impact assessment will depend on the project circumstances (e.g., project size, amount of air emissions and the potential impacts on the airshed). Examples of suggested practices are presented in Table B-2.

Table B-2 - Suggested Air Quality Impact Assessment Approach	
Baseline air quality collection	• Qualitative information (for small projects e.g., < 100MWth) • Seasonal manual sampling (for mid-sized projects e.g., < 1,200MWth) • Continuous automatic sampling (for large projects e.g., >= 1,200MWth) • Modeling existing sources
Baseline meteorological data collection	• Continuous one-year data for dispersion modeling from nearby existing meteorological station (e.g., airport, meteorological station) or site-specific station, if installed, for mid-sized and large projects
Evaluation of airshed quality	• Determining if the airshed is degraded (i.e., ambient air quality standards are not attained) or non-degraded (i.e., ambient air quality standards are attained)
Air quality impact assessment	• Assess incremental and resultant levels by screening models (for small projects) • Assess incremental and resultant levels by refined models (for mid-sized and large projects, or for small projects if determined necessary after using screening models)[47] • Modify emission levels, if needed, to ensure that incremental impacts are small (e.g., 25% of relevant ambient air quality standard levels) and that the airshed will not become degraded.

[46] The term “airshed” refers to the local area around the plant whose ambient air quality is directly affected by emissions from the plant. The size of the relevant local airshed will depend on plant characteristics, such as stack height, as well as on local meteorological conditions and topography. In some cases, airsheds are defined in legislation or by the relevant environmental authorities. If not, the EA should clearly define the airshed on the basis of consultations with those responsible for local environmental management.

[47] For further guidance on refined / screening models, see Appendix W to Part 51 – Guidelines on Air Quality Models by US EPA (Final Rule, November 9, 2005)

When there is a reasonable likelihood that in the medium or long term the power plant will be expanded or other pollution sources will increase significantly, the analysis should take account of the impact of the proposed plant design both immediately and after any formally planned expansion in capacity or in other sources of pollution. Plant design should allow for future installation of additional pollution control equipment, should this prove desirable or necessary based upon predicted air quality impacts and/or anticipated changes in emission standards (i.e., impending membership into the EU). The EA should also address other project-specific environmental concerns, such as fuel and emissions from fuel impurities. In cases where fuel impurities lead to known hazardous emissions, the EA should estimate the emission amount, assess impacts and propose mitigations to reduce emissions.[48] Examples of compounds which may be present in certain types of coal, heavy fuel oil, petroleum coke, etc. include cadmium, mercury, and other heavy metals.

Rehabilitation of Existing Facilities

An environmental assessment of the proposed rehabilitation should be carried out early in the process of preparing the project in order to allow an opportunity to evaluate alternative rehabilitation options before key design decisions are finalized. The assessment should include an environmental audit that examines the impacts of the existing plant's operations on nearby populations and ecosystems, supplemented by an EA that examines the changes in these impacts that would result under alternative specifications for the rehabilitation, and the estimated capital and operating costs associated with each option. Depending on the scale and nature of the rehabilitation, the audit/environmental assessment may be relatively narrow in scope, focusing on only a small number of specific concerns that would be affected by the project, or it may be as extensive as would be appropriate for the construction of a new unit at the same site. Normally, it should cover the following points:

- Ambient environmental quality in the airshed or water basin affected by the plant, together with approximate estimates of the contribution of the plant to total emissions loads of the main pollutants of concern
- The impact of the plant, under existing operating conditions and under alternative scenarios for rehabilitation, on ambient air and water quality affecting neighboring populations and sensitive ecosystems
- The likely costs of achieving alternative emissions standards or other environmental targets for the plant as a whole or for specific aspects of its operations
- Recommendations concerning a range of cost effective measures for improving the environmental performance of the plant within the framework of the rehabilitation project and any associated emissions standards or other requirements implied by the adoption of specific measures.

These issues should be covered at a level of detail appropriate to the nature and scale of the proposed project. If the plant is located in an airshed or water basin that is polluted as a result of emissions from a range of sources, including the plant itself, comparisons should be made of the relative costs of improving ambient air or water quality by reducing emissions from the plant or by reducing emissions from other sources.

[48] Several U.S. states have adopted regulations that give coal-fired power plants the option to meet either a mercury emissions standard based on electricity output or a control-based standard. For instance, Illinois requires all coal-fired power plants of 25 MW electrical capacity or greater to meet either an emissions standard of 0.0080 lbs mercury per gigawatt hour (GWh) gross electrical output or an emissions control requirement of 90 percent relative to mercury input.

ENVIRONMENTAL, HEALTH, AND SAFETY GUIDELINES FOR OFFSHORE OIL AND GAS DEVELOPMENT

INTRODUCTION

1. The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).[1] When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry sector guidelines may be necessary. A complete list of industry sector guidelines can be found at: www.ifc.org/ehsguidelines.

2. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

3. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

4. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever are more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

APPLICABILITY

5. The **EHS Guidelines for Offshore Oil and Gas Development** include information relevant to seismic exploration, exploratory and production drilling, development and production activities, offshore pipeline operations, offshore transportation, tanker loading and unloading, ancillary and support operations, and decommissioning. They also address potential onshore impacts that may result from offshore oil and gas activities.

[1] Defined as the exercise of professional skill, diligence, prudence, and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

This document is organized in the following manner:

1. INDUSTRY-SPECIFIC IMPACTS AND MANAGEMENT

6. This section provides a summary of EHS issues associated with offshore oil and gas development, along with recommendations for their management. These issues may be relevant to any of the activities listed as applicable to these guidelines. Guidance for the management of EHS issues common to most large industrial facilities during the construction phase is provided in the **General EHS Guidelines**. The **EHS Guidelines for Crude Oil and Petroleum Product Terminals** include information relevant to land- and shore-based petroleum storage terminals receiving and dispatching bulk shipments of crude oil and refined products from pipelines, tankers, railcars, and trucks for subsequent commercial distribution.

1.1 Environment

7. The following environmental issues should be considered as part of a comprehensive assessment and management program that addresses project-specific risks and potential impacts. Potential environmental issues associated with offshore oil and gas development projects include the following:

- Air emissions
- Wastewater discharges
- Solid and liquid waste management
- Noise generation (including underwater)
- Spills
- Energy efficiency and resource conservation

1.1.1 Air Emissions

8. The main sources of air emissions (continuous or intermittent) from offshore activities include: combustion sources (boilers, turbines) for power and heat generation; the use of compressors, pumps, and reciprocating and other engines on offshore facilities, including support and supply vessels and helicopters; emissions resulting from flaring and venting of hydrocarbons; intermittent emissions (e.g., well-testing emissions, safety flaring, engine exhaust, etc.) and fugitive emissions.

9. One of the most important components of these emission sources is carbon dioxide (CO_2). Principal pollutants include nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and particulates. Additional pollutants can include hydrogen sulfide (H_2S); volatile organic compounds (VOCs); methane and ethane; benzene, ethyl benzene, toluene, and xylenes (BTEX); glycols; and polycyclic aromatic hydrocarbons (PAHs). In some cases, mercaptans and mercury may be present, which require specific care. Firefighting and refrigeration systems may contain halons and chlorofluorocarbons, which are Ozone Depleting Substances (ODS).[2]

10. Aggregate greenhouse gas (GHG) emissions from all facilities and offshore support activities should be quantified annually in accordance with internationally recognized methodologies.

11. All reasonable attempts should be made to implement appropriate methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of offshore facilities and to maximize energy efficiency and design facilities for lowest energy use. The overall objective is to reduce air emissions. Cost-effective and technically feasible options for reducing emissions should be evaluated. Additional recommendations on the management of greenhouse gases and energy conservation are addressed in the **General EHS Guidelines**.

Exhaust Gases

12. Exhaust gas emissions produced by the combustion of gas or liquid fuels in turbines, reciprocating engines or boilers, used for heat or power generation or to drive machinery such as compressors or pumps can be the most significant source of air emissions from offshore facilities. During equipment selection, air emission specifications should be taken into account, as should the use of very low sulfur content fuels and/or natural gas.

13. Guidance for the management of small combustion source emissions with a capacity of up to 50 megawatt thermal (MWth), including air emission standards for exhaust emissions, is provided in the **General EHS Guidelines**. For combustion source emissions with a capacity of greater than 50 MWth, refer to the **EHS Guidelines for Thermal Power**.

Venting and Flaring

14. Associated gas brought to the surface with crude oil during oil production is sometimes disposed of at offshore facilities by venting or flaring. This practice is now widely recognized to be a waste of valuable resources as well as a significant source of GHG emissions.

15. However, flaring and venting are important safety measures on offshore oil and gas facilities, helping to ensure that gas and other hydrocarbons are safely disposed of in the event of an emergency, a power or equipment failure, or other facility upset condition. Risk assessment processes (e.g., hazard and operability study (HAZOP), hazard identificatiosn study (HAZID), etc.) to estimate the implications of situations of this type should be used in such facilities.

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[2] See also Oil and Gas UK, "About the Industry," last updated November 2009, http://www.oilandgasuk.co.uk/knowledgecentre/atmospheric_emissions.cfm.

16. Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard[3] (part of the Global Gas Flaring Reduction Public-Private Partnership) should be adopted when considering venting and flaring options for offshore activities. The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas.

17. Continuous venting of associated gas is not good practice and should be avoided. The associated gas stream should be routed to an efficient flare system, although continuous flaring of gas should be avoided if alternatives are available. Before flaring is adopted, all feasible alternatives for the gas's use should be evaluated to the maximum extent possible and integrated into production design.[4]

18. Alternative options may include gas utilization for on-site energy needs, gas injection for reservoir pressure maintenance, enhanced oil recovery using gas lift, or export of the gas to a neighboring facility or to market. An assessment of alternatives should be made and adequately documented. If none of the options for the associated gas's use is feasible, measures to minimize flare volumes should be evaluated and flaring should be considered as an interim solution, with the elimination of continuous production-associated gas flaring as the preferred goal.

19. New facilities should be designed, constructed, and operated so as to avoid routine flaring. Cost-effective options to reduce flaring from existing or legacy facilities that offer sustainable social benefits (e.g., gas-to-power) should be identified and evaluated in collaboration with host country governments and other stakeholders and with a particular focus on GHG emissions.

20. If flaring is the only viable solution, continuous improvement of flaring through the implementation of good practices and new technologies should be demonstrated. The following pollution prevention and control measures should be considered for gas flaring:

- Implement source gas reduction measures to the extent possible.
- Use efficient flare tips and optimize the size and number of burning nozzles.
- Maximize flare combustion efficiency by controlling and optimizing flare fuel, air, and stream flow rates to ensure the correct ratio of assist stream to flare stream.
- Minimize flaring from purges and pilots—without compromising safety—through measures including installation of purge gas reduction devices, vapor recovery units, inert purge gas, soft seat valve technology where appropriate, and installation of conservation pilots.
- Minimize risk of pilot blowout by ensuring sufficient exit velocity and providing wind guards.
- Use a reliable pilot ignition system.
- Install high-integrity instrument pressure protection systems, where appropriate, to reduce overpressure events and avoid or reduce flaring situations.
- Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system.
- Minimize flame lift off and/or flame lick.
- Operate flare to control odor and visible smoke emissions (no visible black smoke).

[3] See World Bank (2004).

[4] Ibid.

- Situate flare at a safe distance from accommodation units.
- Implement burner maintenance and replacement programs to ensure continuous maximum flare efficiency.
- Meter flare gas.

21. In the event of an emergency or equipment breakdown, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system. Emergency venting may be necessary under specific field conditions where a flare gas system is not available or when flaring of the gas stream is not possible, such as when there is a lack of sufficient hydrocarbon content in the gas stream to support combustion or a lack of sufficient gas pressure to allow it to enter the flare system. Justification for excluding a gas flaring system on offshore facilities should be fully documented before an emergency gas venting facility is considered.

22. To minimize flaring events as a result of equipment breakdowns and facility upsets, plant reliability should be high (>95 percent) and provisions should be made for equipment sparing and plant turn-down protocols.

23. Flaring volumes for new facilities should be estimated during the initial commissioning period so that appropriate flaring targets can be developed. The volumes of gas flared for all flaring events should be recorded and reported.

Well Testing

24. During well testing, flaring of produced hydrocarbons should be avoided, especially in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of these test fluids, with the safety of handling volatile hydrocarbons considered, either for transfer to a processing facility or for alternative disposal options. An evaluation of alternatives for produced hydrocarbons should be adequately documented.

25. If flaring is the sole option available for the disposal of test fluids, only the minimum volume of hydrocarbons required for the test should be flowed and well-test durations should be reduced to the extent practical. An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout to the sea. Volumes of hydrocarbons flared should be recorded.

Fugitive Emissions

26. Fugitive emissions in offshore facilities may be associated with cold vents (collected gaseous stream that is directly released to the atmosphere without burning in flare), leaking tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, open tanks for Non-Aqueous Drilling Fluids (NADF) (generating diffuse emissions), and hydrocarbon loading and unloading operations.

27. Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should consider the equipment's safety and suitability requirements as well

as its capacity to reduce gas leaks and fugitive emissions. Additionally, all collected gaseous streams should be burned in high efficiency flare(s), and leak detection and repair programs should be implemented.

1.1.2 Wastewaters

Produced Water

28. Oil and gas reservoirs contain water (formation water) that becomes produced water when brought to the surface during hydrocarbon production. Oil reservoirs can contain large volumes of this water, whereas gas reservoirs typically produce smaller quantities, with the exception of Coal Bed Methane (CBM) reservoirs, from which a large amount of produced water is initially generated. CBM reservoirs are infrequently exploited offshore. In addition, in many fields water is injected into the reservoir to maintain pressure and/or maximize production. The total produced water stream can be one of the operation's largest waste products, by volume, and therefore requires management by offshore operators.

29. Produced water contains a complex mixture of inorganic (dissolved salts, trace concentrations of certain metals, suspended particles), organic (suspended and dissolved hydrocarbons, traces of fatty acids and other organic compounds), and in some cases residual trace concentrations of chemical additives (for example, scale and corrosion inhibitors, hydrate inhibitors), which are sometimes used to enhance the hydrocarbon production process.

30. Feasible alternatives to the management and disposal of produced water should be evaluated and integrated into facility and production design. These alternatives may include injection along with seawater for reservoir pressure maintenance, injection into a suitable offshore disposal well,[5] or export to shore with produced hydrocarbons for reuse or disposal after proper treatment.

31. When disposal wells are the adopted solution, geological and technical aspects should be considered to avoid leakage of the disposed water to the seabed or shallow confined aquifers. The conversion of existing wells to injection wells should be considered first, to minimize both geological risk and the construction costs of dedicated disposal wells.

32. If none of these options is technically or financially feasible and disposal to sea is the only feasible option, the Environmental and Social Impact Assessment (ESIA) should establish mitigation targets for produced water according to the discharge guidelines provided in Table 1 of Section 2 prior to its disposal into the marine environment.

33. Treatment technologies to consider include combinations of gravity and/or mechanical separation and chemical treatment and may include a multistage system, typically including a skim tank or a parallel plate separator, followed by a gas flotation cell or hydrocyclone. A number of treatment package technologies are available and should be considered, depending on the application and particular field conditions.

[5] See also as technical reference, U.S. Bureau of Safety and Environmental Enforcement (US BSEE) (2009).

34. Sufficient treatment system backup capability should be in place to ensure continual operation and should be available for use if an alternative disposal method—or example, a produced water injection system—should fail.

35. Where disposal to sea is necessary, all means to reduce the volume of produced water should be considered, including:

- Adequate well management during well-completion activities to minimize water production
- Recompletion of high water-producing wells to minimize water production
- Use of downhole fluid separation techniques, where possible, and water shutoff techniques, when technically and economically feasible
- Shutting in high water-producing wells

36. To minimize environmental hazards related to residual chemical additives in the produced water stream, where surface disposal methods are used, production chemicals should be selected carefully by taking into account their application rate, toxicity, bioavailability, and bioaccumulation potential.[6] In particular, the use and dispersion of Kinetic Hydrate Inhibitors (KHI) should be assessed to avoid possible accumulation of poorly degraded residuals.

Flowback Water

37. The water that flows back from the well to the surface after hydraulic fracturing, is generally referred to as *flowback water.* If hydraulic fracturing is planned or forms part of the project,[7] as in the case of shale gas projects or CBM, all environmental aspects—including fracture propagation and related possible fugitive emissions, fracturing fluid management, and the fate and management of flowback water—should be evaluated.[8] Flowback water requires considerations separate from or in addition to those bearing on produced water. Flowback water characteristics depend on the type of fluid (water or diesel) and chemicals injected to induce rock fracturing and can also be present in large quantities. Flowback water can thus constitute one of the most important environmental management issues for hydraulic fracturing operations.

38. Feasible alternatives for the management and disposal of flowback water should be evaluated and integrated into operational design. Alternatives may include temporary storage in sealed tanks prior to injection into a suitable offshore disposal well, temporary storage for reuse in further hydraulic fracturing operations, or export to shore with the produced hydrocarbons for treatment and disposal. If none of these alternatives is technically or economically feasible, flowback water should be treated according to the discharge guidelines provided in Table 1 of Section 2 for oil and grease content prior to its disposal into the marine environment. An assessment of alternatives should be adequately documented. In addition, an environmental risk assessment on the chemicals mixed with the hydraulic fracturing water—

[6] Adequate tools and approaches should be adopted with the intent of assessing the hazards and risks deriving from the use of any chemicals in the hydrocarbons production. Chemical Hazard Assessment and Risk Management is one such approach.

[7] See International Association of Oil and Gas Producers (IOGP) (2013c); and IOGP and International Petroleum Industry Environmental Conservation Association (IPIECA) (2013).

[8] Any possible social concerns (for example, related to induced microseismicity) should also be assessed.

including their toxicity, bioavailability, and bioaccumulation potential—should be conducted to assess the maximum site-specific allowable concentrations.

Hydrostatic Testing Water

39. Hydrostatic testing of offshore equipment and marine pipelines involves pressure testing with water (typically filtered seawater, unless equipment specifications do not allow it) to verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, biocides, and dyes) may be added to the water to prevent internal corrosion or to identify leaks. In managing hydrotest waters, the following pollution prevention and control measures should be considered:

- Minimize the volume of hydrotest water offshore by testing equipment at an onshore site prior to loading the equipment onto the offshore facilities.
- Use the same water for multiple tests.
- Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline.
- Carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential.
- Send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical.

40. If the discharge of hydrotest waters to the sea is the only feasible alternative for disposal, a hydrotest water disposal plan should be prepared that considers points of discharge, rate of discharge, chemical use and dispersion,[9] environmental risk, and monitoring. Hydrotest water disposal into shallow coastal waters and sensitive ecosystems should be avoided.

Cooling Water

41. Antifoulant chemical dosing to prevent marine fouling of offshore facility cooling water systems should be carefully considered. Available alternatives should be evaluated and, where practical, the seawater intake depth should be optimized to reduce the need for use of chemicals. An assessment of alternatives should be adequately documented. Appropriate screens should be fitted to the seawater intake, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.

42. The cooling water discharge depth should be selected to maximize mixing and cooling of the thermal plume to ensure that the temperature is within 3 degrees Celsius of ambient seawater temperature at the edge of the defined mixing zone, or if the mixing zone is not defined, within 100 meters of the discharge point, as noted in Table 1 of Section 2 of these guidelines.

Desalination Brine

43. Operators should consider mixing desalination brine from the potable water system with cooling water or other effluent streams. If mixing with other discharge streams is not feasible, the discharge

[9] See Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic Commission (OSPAR) (2010a).

location should be carefully selected with respect to potential environmental impacts. In particular, in the case of coastal and/or brackish water, the reverse osmosis process should be designed to allow reduction of the salinity of the rejected effluent.

Other Waste Waters

44. Other waste waters routinely generated at offshore facilities are listed below, along with appropriate treatment measures:

- *Sewage*: Gray and black water from showers, toilets, and kitchen facilities should be treated in an appropriate on-site marine sanitary treatment unit in compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 requirements.
- *Food waste*: Organic (food) waste from the kitchen should, at a minimum, be macerated to acceptable levels and discharged to sea, in compliance with MARPOL 73/78 requirements.
- *Ballast and storage displacement water*:[10] Water pumped into and out of storage during loading and off-loading operations should be contained and treated before discharge to meet the guidelines provided in Table 1 of Section 2.
- *Bilge waters*: Bilge waters from machinery spaces in offshore facilities and support vessels should be routed to the facility's closed drainage system or contained and treated before discharge to meet the guidelines provided in Table 1 of Section 2. If treatment to this standard is not possible, these waters should be contained and shipped to shore for disposal.
- *Deck drainage water*: Drainage water generated from precipitation, sea spray, or routine operations, such as deck and equipment cleaning and fire drills, should be routed to separate drainage systems in offshore facilities. This includes drainage water from process areas that could be contaminated with oil (closed drains) and drainage water from nonprocess areas (open drains). All process areas should be bunded to ensure that drainage water flows into the closed drainage system. Drip trays should be used to collect runoff from equipment that is not contained within a bunded area and the contents routed to the closed drainage system. Contaminated drainage waters should be treated before discharge to meet the guidelines provided in Table 1 of Section 2.

1.1.3 Waste Management

45. Typical nonhazardous and hazardous wastes[11] routinely generated at offshore facilities include general office and packaging wastes, waste oils, oil-contaminated rags, hydraulic fluids, used batteries, paint cans, waste chemicals and used chemical containers, used filters, fluorescent tubes, scrap metals, and medical waste, among others.

46. At a minimum, these waste materials should be segregated offshore into nonhazardous and hazardous wastes and shipped to shore for reuse, recycling, or disposal. A waste management plan for the offshore facility should be developed and should contain a mechanism allowing waste consignments to be tracked from the originating location offshore to the final waste treatment and disposal location onshore. Efforts should be made to eliminate, reduce, or recycle wastes at all times.

[10] U.S. Environmental Protection Agency (US EPA) (2012a).

[11] As defined by local legislation or international conventions.

47. Guidance for onshore management of these typical wastes is provided in the **General EHS Guidelines**.

48. Additional waste streams that can be associated with offshore development activities include:

- Drilling fluids and drilled cuttings
- Produced sand
- Completion and well work-over fluids
- Naturally occurring radioactive materials (NORM)

Drilling Fluids and Drilled Cuttings

49. The primary functions of drilling fluids used in oil and gas field operations include removal of drilled cuttings (rock chippings) from the wellbore and control of formation pressures. Other important functions include sealing permeable formations, maintaining wellbore stability, cooling and lubricating the drill bit, and transmitting hydraulic energy to the drilling tools and bit. Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams, by volume and weight, generated during oil and gas drilling activities.

50. Though various drilling fluids are available, they can generally be categorized into the following:

- Water-based drilling fluids (WBDF): Fluids for which the continuous phase and suspending medium for solids is seawater or a water-miscible fluid. There are many WBDF variations, including gel, salt-polymer, salt-glycol, and salt-silicate fluids.
- Non-Aqueous Drilling Fluids (NADF): The continuous phase and suspending medium for solids is a water-immiscible fluid that is oil based, enhanced mineral oil based, or synthetic based.

51. The selection of a drilling fluid should be made after evaluating its technical suitability and environmental impact. The use of fluids that contain diesel as the principal component of the drilling mud liquid phase is not good practice for offshore drilling programs and should be avoided.

52. Typically, barite (barium sulfate) is the solid medium used to increase the specific density of most drilling fluids, with bentonite clays also used as a viscosifier. Drilling fluids can also contain a variety of other components to enhance their performance and/or to address reservoir compatibility requirements.

53. Drilling fluids are (i) circulated downhole with direct loss to the seabed, along with displaced cuttings, particularly while drilling well sections nearest to the surface of the seabed, or (ii) recovered for reuse when returned to the drilling rig via casing or marine riser and routed to a solids removal system. The direct loss system is to be considered an interim solution for the first drilling phase and applied only when the chemical content is low and water-based drilling mud is used.

54. In the solids removal system, the drilling fluids are separated from the cuttings so that they may be recirculated downhole, leaving the cuttings behind for disposal. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole sections drilled. The cuttings contain residual drilling fluid.

55. The drilling fluid rheological properties and density are adjusted during drilling via solid control systems; the fluid is eventually replaced (i) when its rheological properties or density can no longer be maintained or (ii) at the end of the drilling program. These spent fluids are then contained for reuse or disposal. Disposal of spent NADF by discharge to the sea must be avoided. Instead, NADF should be transferred to shore for recycling or treatment and disposal.

56. Feasible alternatives for the disposal of spent WBDF and drilled cuttings from well sections drilled with either WBDF or NADF should be evaluated. Options include injection into a dedicated disposal well offshore, injection into the annular space of a well, and containment and transfer to shore for treatment and disposal. When no alternative options are available, residual WBDF might be discharged to sea at the end of a drilling program, provided that the overall ESIA conducted for the site has considered this scenario, demonstrating the environmental acceptability of this practice.

57. When discharge to sea is the only alternative, a drilled cuttings and fluid disposal plan should be prepared, taking into account cuttings and fluid dispersion, chemical use, environmental risk, and necessary monitoring. Discharge of cuttings to sea from wells drilled with NADF should be avoided. If discharge is necessary, cuttings should be treated before discharge to meet the guidelines provided in table 1 of section 2.

58. Guidance for the treatment and disposal of fluids and cuttings shipped to shore is provided in the **EHS Guidelines for Onshore Oil and Gas Development**.

59. Pollution prevention and control measures to consider prior to the discharge of spent drilling fluids and drilled cuttings should include the following guidelines:

- Minimize environmental hazards related to residual chemical additives on discharged cuttings by careful selection of the fluid system. WBDFs should be selected whenever appropriate.
- Carefully select drilling fluid additives, taking into account their concentration, toxicity, bioavailability, and bioaccumulation potential.
- Use high-efficiency solids control equipment to reduce the need for fluid change out.
- Use high-efficiency solids removal and treatment equipment to reduce and minimize the amount of residual fluid contained in drilled cuttings.
- Use directional drilling (horizontal and extended reach) techniques to avoid sensitive surface areas and to gain access to the reservoir from less sensitive surface areas.
- Use slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings.

60. Drilling fluids to be discharged to sea (including as residual material on drilled cuttings) are subject to tests for toxicity, barite contamination, and oil content provided in Table 1 of Section 2. Barite contamination by mercury (Hg) and cadmium (Cd) must be checked to ensure compliance with the discharge limits provided in Table 1. Suppliers should be asked to guarantee that barite quality meets this standard with pre-treatment, if necessary.

61. WBDF and treated drilled cuttings discharge should be made via a caisson submerged at an appropriate depth to ensure suitable dispersion of the effluent (i.e., a dispersion study demonstrates that the relevant impact is acceptable).

Produced Sand

62. Sand produced from the reservoir is separated from the formation fluids during hydrocarbon processing. The produced sand can contain hydrocarbons, and the hydrocarbon content can vary substantially, depending on location, depth, and reservoir characteristics. Well completion should aim to reduce the production of sand at source using effective downhole sand control measures.

63. Whenever practical, produced sand removed from process equipment should be transported to shore for treatment and disposal, or routed to an offshore injection disposal well if available. Direct discharge to sea is not good practice. If discharge to sea is the only demonstrably feasible option, then the discharge should meet the guideline values in Table 1 of Section 2.

64. Any oily water generated from the treatment of produced sand should be recovered and treated to meet the guideline values for produced water in Table 1 of Section 2.

Completion and Well Work-Over Fluids

65. Completion and well work-over fluids (including intervention fluids and service fluids) can include solid material, residual drilling fluids, weighted brines or acids, hydrocarbons, methanol and glycols, and other types of performance-enhancing additives. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons or may be used to maintain downhole pressure. Once used, these fluids may contain contaminants including solid material, oil, and chemical additives.

66. Feasible disposal options should be considered, including the following:

- Collect the fluids where handled in closed systems and ship them to shore to the original vendors for recycling
- Inject in a disposal well, where available
- Ship onshore for treatment and disposal

67. If discharge to sea is the only demonstrably feasible option:

- Select chemical systems in relation to their concentration, toxicity, bioavailability, and bioaccumulation potential
- Consider routing these fluids to the produced water stream for treatment and disposal, if available
- Neutralize spent acids before treatment and disposal
- Ensure the fluids meet the discharge levels in Table 1 of Section 2

Naturally Occurring Radioactive Materials (NORM)

68. Depending on the field reservoir characteristics, NORM may be present in the produced fluids.[12] NORM may precipitate as scale or sludge in process piping and production vessels in which the concentration of NORM can be higher than in the fluid.[13] Where NORM is present, or NORM precipitation and/or accumulation conditions are known or expected to exist, a NORM management program should be developed to ensure worker safety and the use of appropriate handling and waste management procedures.

69. If removal of NORM is required, disposal options may include canister disposal during well abandonment, injection into the annular space of a well, shipment to shore for disposal in an engineered and properly operated landfill within sealed containers, and, depending on the type of NORM and in cases where no other option is available, discharge to sea with the facility drainage.

70. NORM-containing sludge, scale, or equipment should be treated, processed, isolated, and/or disposed of according to good international industry practices,[14] so that potential future human exposure to the treated waste will be within internationally accepted limits.[15]

1.1.4 Hazardous Materials Management

71. Hazardous materials (including some chemicals) are sometimes used in offshore oil and gas operations. General guidance for the management of hazardous materials is provided in the **General EHS Guidelines**.

72. The following additional principles should be followed for the management of hazardous materials offshore:

- Use chemical hazard assessment and risk management techniques to evaluate chemicals and their effects.
- Select only those chemicals that have been previously tested for environmental hazards.
- Select chemicals based on the OSPAR[16] Harmonised Offshore Chemical Notification Format or similar internationally recognized system.
- Select chemicals with the least hazard and lowest potential environmental and health risks, whenever possible.
- Avoid chemicals suspected to cause taint or known endocrine disruptors.

[12] NORM is defined as "Radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides. Material in which the activity concentrations of the naturally occurring radionuclides have been changed by some process are included in NORM." International Commission on Radiological Protection (ICRP) (2007).

[13] See IOGP (2008a).

[14] For more on the management of NORM residues, see International Atomic Energy Agency (IAEA) (2013).

[15] ICRP (2007).

[16] The name comes from the Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic, http://www.ospar.org/.

- For new offshore oil and gas facilities, Ozone Depleting Substances (ODS) should not be used;[17] opportunities to change-out ODS-containing devices in existing offshore oil and gas facilities as part of on-going equipment maintenance and replacement programs should be evaluated.
- Avoid chemicals known to contain heavy metals of concern, in anything other than trace quantities.

1.1.5 Noise

73. Offshore oil and gas development activities generating noise include seismic operations, drilling and production activities, offshore and nearshore structural installation (especially pile driving), construction and decommissioning activities, and marine traffic. Noise from offshore activities (especially from seismic operations) may temporarily affect fish and marine mammals to varying degrees depending on the strength of the noise, local species present, and their distance from the source.[18]

74. Environmental parameters that determine sound propagation in the sea are site specific, and different species of marine life have different hearing sensitivities as a function of frequency. An impact assessment should be conducted to (i) identify where and/or when anthropogenic sound has the potential to create significant impacts and (ii) determine what mitigation measures, if any, are appropriate. Recommended measures to reduce the risk of sound impact to marine species include the following:

- Identify sensitive areas for marine life, such as feeding, breeding, calving, and spawning grounds.
- Plan seismic surveys and offshore construction activities so as to avoid sensitive times of the year.
- Identify fishing areas and reduce disturbances by scheduling seismic surveys and construction activities for less productive times of the year, where possible.
- Maximize the efficiency of seismic surveys to reduce operation times, where possible.
- If sensitive species are anticipated in the area, monitor their presence using experienced observers[19] before the onset of sound-creating activities that have the potential to produce adverse effects, and continue monitoring throughout the seismic program or construction.
- When marine mammals are observed congregating close to the area of planned activities, seismic start-up or construction should begin at least 500 meters away.
- If marine mammals are sighted within 500 meters of the proposed seismic array or construction area, postpone start-up of seismic activities or construction until they have moved away, allowing adequate time after the last sighting.
- Use soft-start procedures—also called ramp-up or slow buildup—in areas of known marine mammal activity. This involves a gradual increase in sound pressure to full operational levels.

[17] As defined by the 1989 Montreal Protocol on Substances that Deplete the Ozone Layer, http://ozone.unep.org/new_site/en/montreal_protocol.php.

[18] See Joint Nature Conservation Committee (JNCC) (2010); International Association of Geophysical Contractors (IAGC) and IOGP (2011); and further references in section 3.0.

[19] See also IAGC (2011); and JNCC (2010).

- Use the lowest practicable power levels to image the target surface throughout the seismic surveys and document their use.
- Where possible, use methods to reduce and/or baffle unnecessary high-frequency noise produced by air guns or other acoustic energy sources.
- For pile driving, use vibratory hammers, air bubble curtains (confined or unconfined), temporary noise attenuation piles, air filled fabric barriers, and isolated piles or coffer dams, where practical.

1.1.6 Spills

75. Spills from offshore facilities can occur due to leaks, equipment failure, accidents, or human error. Guidelines for release prevention and control planning are provided in the **General EHS Guidelines**, including the requirement to develop a spill prevention and control plan. Additional spill prevention and control measures specific to offshore oil and gas facilities include the following tasks:

- Conduct a spill risk assessment for offshore facilities and support vessels.[20]
- Design process, utility, and drilling systems to reduce the risk of major uncontained spills.[21]
- Install a Blowout Prevention System (BOP) during the drilling phase and valves during commissioning for production—including subsea shutdown valves, if required—for the reduction of risk and to allow early shutdown or isolation in an emergency.
- Ensure adequate corrosion allowance for the lifetime of the facilities and/or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks.
- Develop maintenance and monitoring programs to ensure the integrity of well field equipment. For export pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should also be considered as required.
- Install leak detection systems. Use subsea pipeline measures, such as telemetry systems, Supervisory Control and Data Acquisition systems,[22] pressure sensors, shut-in valves, and pump-off systems, including at normally unattended installations and unmanned facilities to ensure rapid detection of loss of containment.
- An Emergency Shutdown System should be in place in all facilities, able to initiate automatic shutdown actions to bring the offshore facility to a safe condition; it should be activated in case of any significant release.
- Implement adequate personnel training and field exercises in oil spill prevention, containment, and response.
- Ensure that spill response and containment equipment, routinely inspected, maintained, and operationally exercised and tested, is deployed or available as necessary for response. Document and report all spills, as well as near misses. Following a spill or near miss, carry out a root cause investigation and undertake corrective actions to prevent recurrence.

[20] IOGP and IPIECA (2013).

[21] See also National Research Council (NRC) (2014).

[22] These may be used in oil and gas and other industrial facilities to assist in the monitoring and control of plants and equipment.

1.1.7 Spill Response Planning

76. A Spill Response Plan (SRP) should be prepared, and the capability to implement the plan should be in place. A preliminary SRP is recommended, commencing at the project development phase and based on the initial project design, and it should include community consultation and feedback.

77. The SRP should address potential oil, chemical, and fuel spills from offshore facilities and support vessel—including tankers—and pipeline ruptures and leaks. The SRP should include all appropriate oil spill response tools and options in order to allow responders, in cooperation with the appropriate authorities, to develop response strategies that mitigate environmental impacts to the greatest extent practicable. The plan should also include the following:

- A description of operations, site conditions, product(s) characteristics, expected seasonal current and wind data, sea conditions and water depth, and logistical support arrangements.
- A spill risk assessment, defining expected frequency and size of spills from potential release sources, including an assessment of foreseeable scenarios.[23]
- Ranking of foreseeable spill scenarios in terms of potential severity, with tiered response approaches for each.
- Identification of persons responsible for managing and participating in spill response efforts, their specific training requirements, responsibilities, authority, roles, and contact details.
- Sensitivity mapping of marine and coastal environmental habitats, associated wildlife, and socioeconomic resources that could be affected by spills generated by offshore oil and gas development and production activities.[24]
- Cooperative measures with government agencies, if appropriate, and relevant notification process and procedures.

78. The SRP should also include the following:

- Clear demarcation of spill severity, according to the size of a spill, using a clearly defined Tier 1, Tier 2, and Tier 3 approach.[25]
- Oil spill trajectory modeling approach, supported by internationally recognized models (in accordance with the relevant regulatory jurisdiction prescriptions, if any), for the prediction of oil fate and relevant environmental impacts for a number of spill simulations (including worst-case scenario, such as blowout from an oil well), with the ability to input local current and wind data.
- Strategies for managing Tier 1, Tier 2, and Tier 3 spills from the offshore installation and support vessels.

[23] See also IOGP (2013c), as a reference in case of fracking; and IOGP and IPIECA (2013).

[24] See, for reference, IPIECA, International Maritime Organization (IMO), and IOGP (2012).

[25] See IPIECA (2008). Tier 1 spills are operational in nature, occurring at or near an operator's own facilities, as a consequence of its own activities. The individual operator is expected to respond with its own resources. Tier 2 spills are most likely to extend outside the remit of the Tier 1 response area and possibly be larger in size, where additional resources are needed from a variety of potential sources, and a broader range of stakeholders may be involved in the response. Tier 3 spills are those that, due to their scale and likelihood to cause major impacts, call for substantial further resources from a range of national and international sources.

- For Tier 1 spills, description of the minimum response equipment that must be available on board (minimum equipment for Tier 2 and Tier 3 spills may also be included).
- Arrangements and procedures to mobilize external resources in responding to larger spills and strategies for their deployment.
- Full list, description, location, and use of on-site and off-site response equipment and the response times for deployment.
- Strategies for containment and recovery of floating oil, including use (and limitations) of mechanical recovery equipment and chemical dispersants.[26]
- Priorities for response (with input from potentially affected or concerned parties).
- Methods to maximize recovery and response capabilities (e.g., remote sensing, aerial observation and command and control, infrared, RADAR, etc.).
- Shoreline protection and cleanup strategies.
- Measures to rehabilitate wildlife such as seabirds, mammals, and turtles.
- Handling instructions for recovered spilled oil, chemicals, fuels, or other recovered contaminated materials, including their transportation, temporary storage, and disposal.
- Measures to be taken to protect health and safety of oil spill personnel.

79. The SRP should clearly define storage and maintenance instructions for Tier 1 spill response equipment and relevant routine inspection, testing, and exercises. In addition, each offshore facility and group of facilities should install and maintain a meteorological and marine data monitoring station for planning simulation and response activities.

1.1.8 Loading, Storage, Processing, and Offloading Operations

80. Procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, should be utilized to minimize spill risks. Pumps, hoses, and valves should be inspected and maintained or replaced as necessary.

81. Floating (Production) Storage and Offloading (FSO/FPSO) vessels and Floating (Liquefaction) Storage Unit (FSU/FLSU) vessels should be subject to inspection and certification by an appropriate national or international body, in accordance with International Maritime Organization (IMO) requirements. Double hull vessels are preferred, whenever available.[27]

82. All offloading activities should be supervised by the designated Mooring Master,[28] who has the authority to prescribe whether an "in tandem" or "side-by-side" array should be adopted, according to the conditions of the sea.

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[26] NRC (2005).

[27] IMO (2005–2006).

[28] The qualified person in charge of, among other things, assessing and guaranteeing that the vessel's design and condition are up to par for the operation, reporting to the Offshore Field Manager for decisions, advising masters of both FSO/FPSO and export tanker, supervising the vessels' approach, maneuvering into final position, mooring and positioning of the lightering hoses, monitoring the transfer of oil into the lightering vessel to ensure that no leaks or spills occur, overseeing the connection of hoses, and maneuvering of vessels upon completion of the operation.

83. The conditions and characteristics of the export tankers should be assessed by the Mooring Master and reported to the Offshore Field Manager[29] prior to commencing offloading operations; only properly registered and well-maintained double-hull vessels should be utilized.

1.1.9 Decommissioning

84. Where more stringent local regulatory requirements do not exist, internationally recognized guidelines and standards issued by IMO and OSPAR[30] should be followed for the decommissioning of offshore facilities.[31]

85. IMO standards state that installations or structures of less than 4,000 tonnes, excluding the deck and superstructure, in less than 75 meters of water should be removed entirely at decommissioning, unless an alternative use for the structure has been approved. In addition, installations or structures installed after January 1, 1998 must be designed to be entirely removed. The standards indicate that exceptions will be considered on a case-by-case basis for installations or structures installed before 1998 that cannot be fully removed for demonstrable reasons of technical or financial feasibility, but these facilities must be partially removed to provide a clear water column depth of 55 meters.

86. An OSPAR decision recognizes the entire removal of the facility from offshore locations for reuse, recycling, or final disposal on land as the preferred option for the decommissioning of offshore facilities. Alternative disposal options may be considered if justified on the basis of an alternative options assessment. This assessment should consider facility type, disposal methods, disposal sites, and environmental and social impact, including interference with other sea users, impacts on safety, energy and raw material consumption, and emissions.

87. A preliminary decommissioning plan for offshore facilities should be developed that considers well abandonment, removal of hydrocarbons from flowlines, facility removal, and subsea pipeline decommissioning, along with disposal options for all equipment and materials. This plan can be further developed during field operations and fully defined in advance of the end of field life. The plan should include details on the provisions for the implementation of decommissioning activities and arrangements for post-decommissioning monitoring and aftercare.

1.2 Occupational Health and Safety

88. The requirements that follow apply to fixed and floating offshore drilling, production and accommodation facilities. Additional requirements related to hazard prevention for floating facilities are provided in section 1.1, paragraph "Loading, Storage, Processing, and Offloading Operations."

89. Occupational health and safety and major hazard issues should be considered as part of a comprehensive risk assessment of an offshore facility through, for example, a combination including a HAZID study, HAZOP study, or other risk assessment studies that encompass occupational hazards as

[29] The Offshore Field Manager is the company's officer in charge of, among other things, inspecting the facility and field, writing up reports, and notifying Management of all activities.

[30] See the OSPAR Convention, http://www.ospar.org/.

[31] See IMO (1989); OSPAR (1998); and the OSPAR Convention.

well as major accident hazards (including blowout risk). The results should be used for health and safety management planning, in the design of the facility and safe working systems, and in the preparation of safe working procedures. Health and safety management planning should demonstrate that a systematic and structured approach to managing offshore health and safety will be adopted and that controls are in place to reduce risks to as low as reasonably practical. Occupational hazards should be identified and assessed through an Occupational Hazards Management Plan, detailing prevention and mitigation measures (including operational procedures) to be considered. All workers should be made aware of the contents of this document through induction training.

90. Offshore facilities should be designed to eliminate or reduce the potential for injury or risk of an accident.[32] General facility design measures and requirements are provided in the **General EHS Guidelines**. In addition, the following issues should be considered in the design of offshore facilities:

- Environmental conditions at the offshore location (e.g., seismicity, extreme wind and wave events, currents, ice formations).
- Proper selection of materials and development of a monitoring plan to ensure the protection of equipment and structures from corrosion.
- Adequate living accommodations appropriate to outside environmental conditions, plus related policies that consider the physical and mental strain on personnel living on production or drilling facilities; space for recreation and social activities and/or consideration of a limit to the number of consecutive days permitted on the offshore facility.
- Limited accommodations in production and drilling facilities for staff related to asset operation only.
- Temporary refuges or safe havens located in a protected area at the facility for use by personnel in the event of an emergency.
- A sufficient number of escape routes leading to designated personnel muster points and escape from the facility.
- Handrails, toeboards, and nonslip surfaces on elevated platforms and walkways, stairways, and ramps to prevent person overboard incidents.
- Crane and equipment laydown area positioning to avoid moving loads over critical areas and reducing the impacts from dropped objects. (Alternatively, structural protection measures should be provided.)

91. Occupational health and safety (OHS) risk management should be based on application of risk assessment principles to identify hazards, risks, and controls (e.g., HAZID) and should include communicating to personnel the importance of conducting work activities in a safe and skillful manner, OHS training for staff, and maintaining equipment in a safe condition.

92. A formal Permit to Work (PTW) system should be developed for offshore facilities. The PTW system will ensure that all potentially hazardous work is carried out safely and ensures effective authorization of designated work; effective communication of the work to be carried out, including hazards involved; and safe isolation procedures to be followed before commencing work. A lockout and/or tagout procedure for

[32] National Academy of Engineering (NAE) and National Research Council of the National Academies (NRCNA) (2011); Transportation Research Board of the National Academies (TRBNA) (2012).

equipment should be implemented to ensure that all equipment is isolated from energy sources before servicing or removal.

93. Offshore facilities should be equipped, at a minimum, with specialized first-aid providers (industrial prehospital care personnel) and the means to provide short-term remote patient care. Depending on the number of personnel present and the complexity of the facility, provision of an on-site medical unit and a doctor may need to be considered. In specific cases, telemedicine facilities may be an alternative option.

94. An alarm system should be installed that can be heard throughout the offshore facility. Alarms for fire, H_2S and hydrocarbon gas leak, and person overboard should be provided.

95. Clear responsibilities for EHS matters should be defined, including identification of a functional role for managing the facility's EHS issues. An officer responsible for EHS should be continuously present in the facility, and health and safety inductions should be provided to the entire workforce prior to mobilizing offshore and documented.

96. Guidance for the management of physical hazards common to all industries and specifically relating to hazards from rotating and moving equipment, exposure to noise and vibration, electrical hazards, hot work, working with heavy equipment, confined space entry, working at heights, and the general working environment is provided in the **General EHS Guidelines**. These guidelines also provide guidance on Personal Protective Equipment (PPE) for workers.

97. Additional occupational health and safety issues in offshore oil and gas operations include the following:

- Fire and explosion prevention and control
- Air quality
- Hazardous materials
- Personnel transfer and vessels
- Well blowouts
- Ship collision
- Dropped objects and material handling issues
- Emergency preparedness and response

1.2.1 Fire and Explosion Prevention and Control

98. Guidance on fire precautions and the prevention and control of fire and explosions is provided in the **General EHS Guidelines**.

99. The most effective ways to prevent fires and explosions in offshore facilities is to prevent the release of flammable material and gas, to implement early detection procedures, and to ensure the interruption of leaks. Potential ignition sources should be kept to a minimum and adequate separation distances between potential ignition sources and flammable materials should be in place. Any venting or flaring shall be remote from potential ignition sources; a gas dispersion analysis from vent should document the

adequacy of vent position. Offshore facilities should be classified into various hazard areas, based on international standards,[33] and in accordance with the likelihood of release of flammable gases and liquids.

100. Appropriate fire and explosion prevention and control measures for offshore facilities should include the following:

- Provide passive fire protection throughout the facility to prevent the spread of fire in the event of an incident. Fire protection measures should be designed on the basis of consideration of the fire hazard.[34] The fire protection measures should
    - provide passive fire protection on load-bearing structures and fire-rated walls and build fire-rated partitions between rooms;
    - take into account explosion loads in the design of load-bearing structures or install blast-rated walls;
    - design items and structures to protect against explosion and evaluate the need for blast walls based on an assessment of likely explosion characteristics; and
    - consider blast panel or explosion venting, and fire and explosion protection should specifically consider wellheads, safe areas, and living areas.
- Ensure the protection of accommodation areas by distance or by fire walls. The ventilation air intakes shall be designed to prevent smoke and flammable or hazardous gases from entering accommodation areas.
- Locate fire systems (for example, firewater pumps or control room) in a safe area of the facility, protected from fire by distance or by fire walls. If the system or item is located within a fire area, it should be passive fire-protected or fail-safe in nature.
- Avoid explosive atmospheres in confined spaces by making spaces inert or by including adequate ventilation.
- In unmanned facilities, signal the occurrence of gas leaks, fire, or explosion to the remote control center to ensure that appropriate action is taken.
- Conduct a fire impact assessment to determine the type and extent of fire detection and protection required for an offshore facility. A combination of automatic and manual fire alarm systems are typically provided on offshore facilities. Active fire protection systems should be installed on offshore facilities and should be strategically located to enable rapid and effective response. A combination of active fire suppression mechanisms can be used, depending on the type of fire and the fire impact assessment: for example, fixed foam system, fixed fire water system, CO2 extinguishing system, water mist system, gaseous extinguishing system, fixed dry chemical system, fixed wet chemical system, fire water monitors, live hose reels, and portable fire extinguishing equipment). For new offshore oil and gas developments, halon-based fire systems should be avoided. Firewater pumps should be available and designed to deliver water at an appropriate rate. Regular checks and maintenance of firefighting equipment are essential.
- Provide fire safety training and response as part of workforce health and safety induction and training, with advanced fire safety training provided to a designated firefighting team.

[33] Such as American Petroleum Institute (API) (1997c, 1997d) Recommended Practices 500 and 505; International Electrotechnical Commission; or British Standards.

[34] API (2013b).

1.2.2 Air Quality

101. Guidance for the maintenance of air quality in the workplace, along with required air quality levels, is provided in the **General EHS Guidelines**.

102. Due to the risk of gas releases caused by leaks or emergency events, adequate ventilation in closed or partially closed spaces is required on offshore oil and gas facilities. Air intakes should be installed to ventilate facility safe areas and areas that need to be operable during emergency situations. If necessary, the means to detect gas in the intakes and alarm or automatic shut-down systems should be installed.[35]

103. The facilities should be equipped with a reliable system for gas detection that allows the source of release to be isolated and the inventory of gas that can be released to be reduced. Blowdown of pressure equipment should be initiated to reduce system pressure and consequently reduce the release flow rate. Gas detection devices should also be used to authorize entry and operations into enclosed spaces.

104. Wherever hydrogen sulfide (H_2S) gas may accumulate, monitors should be installed and set to activate warning signals whenever detected concentrations of H_2S exceed 7 milligrams per cubic meter (mg/m3). Personnel should also be provided with personal H_2S detectors and response training in the event of a leak. A self-contained breathing apparatus should be provided and the apparatus designed and conveniently located to enable personnel to safely interrupt tasks and reach a temporary refuge or safe haven.

1.2.3 Hazardous Materials

105. The design of the offshore facilities should reduce the exposure of personnel to chemical substances, fuels, and products containing hazardous substances. Use of substances and products classified as highly toxic, carcinogenic, allergenic, mutagenic, teratogenic, or strongly corrosive should be identified and the products replaced by less hazardous alternatives, wherever possible. For each chemical used, a Material Safety Data Sheet should be readily available on the facility. A general hierarchical approach to the prevention of impacts from chemical hazards is provided in the **General EHS Guidelines**.

106. A procedure for the control and management of radioactive sources used offshore should be prepared, along with a designated shielded container for storage when the source is not in use. The container should be locked in a secure store that is used exclusively for this purpose.

107. In locations where NORM may precipitate as scale or sludge in process piping and production vessels, facilities and/or process equipment that have been taken out of service for maintenance, replacement, or decommissioning should be monitored for NORM. NORM can have adverse health effects through external irradiation or internal exposure (if NORM is taken into the body via inhalation, ingestion, or absorption). Where NORM is detected, the expected annual doses and the probability and magnitude of potential exposures should be assessed and a workforce monitoring and management program, appropriate to the magnitude and nature of the risks, should be developed and implemented

[35] Typically, alarm levels for flammable gas are set no higher than approximately 25 percent of the Lower Explosive Limit of the substance. It is common practice to use several detectors and select higher set points for automatic shutdown and dampener closure.

(e.g., source control, exposure monitoring, worker education and safe operating practices, including appropriate PPE). Procedures should determine the classification of the area where NORM is present and the level of supervision and control required.

108. The operator should determine whether to leave the NORM in-situ, or to remove it for disposal, as described in Section 1.1 of this Guideline.

1.2.4 Personnel Transfer and Vessels

109. Personnel transfer to and from offshore facilities typically occurs by helicopter or boat. Safety procedures for helicopter and vessel transport of personnel are required. Passengers should systematically receive a safety briefing and safety equipment as part of helicopter or vessel transport.

110. Equipment used for personnel transportation should be certified and the transportation crew qualified according to applicable national and international regulations. In the event of helicopter transport, the helicopter should be certified according to International Civil Aviation Organization (ICAO) rules. In the event of marine transport, the vessel should be class approved.

111. Helicopter decks (helidecks) onboard offshore facilities should follow the requirements of the ICAO. Facilities and equipment for station keeping of vessels during the transfer of personnel should consider adverse sea conditions to protect the boat and the facility structure from heavy impacts.

112. If personnel are transferred from a boat to an offshore facility by crane, only cranes, cables, and baskets certified for personnel transfer should be used.

113. Support vessels should have the relevant permits and certifications to comply with IMO requirements. A Vessel Safety Management System should be implemented.

1.2.5 Well Blowouts

114. A blowout (i.e., loss of well control) can be caused by the uncontrolled flow of reservoir fluids into the wellbore and may result in an uncontrolled release of formation fluids and gases into the environment. Blowout can occur during drilling and work-over phases (where it is of particular concern) or during production phases.

115. Blowout prevention measures should focus on maintaining wellbore hydrostatic pressure by effectively estimating formation fluid pressures and the strength of subsurface formations. This can be achieved with techniques such as proper prewell planning and technical reviews (i.e., audits of the well control equipment and personnel competency, independent review of well design and control procedures), drilling fluid logging, and using sufficient hydrostatic head of weighted drilling fluid or completion fluid to balance the pressures in the wellbore. Well-integrity testing (e.g., negative pressure test, cement bond log) should be performed, with the type of test and frequency defined by the operator, based on the actual operation characteristics and as informed by a risk-based process to confirm that the proposed testing approach is adequate to ensure well integrity and control.[36]

[36] See IOGP (2011a).

116. A BOP system should be installed that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained. The BOP system should be tested at installation and at regular intervals (at least every 14 days) via partial or complete shutdown and based on availability considerations related to the specific application. The BOP system should be pressure tested at installation, after the disconnection or repair of any pressure containment seal in the BOP system, and at regular intervals, as operations allow. Surface BOP stacks should be tested to their rated working pressure during an initial pressure test, and then to the maximum anticipated surface pressure during subsequent tests. Subsea BOP stacks should initially be tested to the rated working pressure of the ram preventers or the wellhead system, whichever is lower, and then during subsequent tests to the maximum anticipated wellhead pressure for the current well program. Facility personnel should conduct well-control drills at regular intervals, and key personnel should attend well control courses periodically; well control training and drills should be documented. BOP testing should be conducted by an independent specialist, particularly for critical wells (e.g., deep water, high pressure, or high temperature wells). Facility personnel should conduct well-control drills at regular intervals, and key personnel should attend well control courses periodically; well control training and drills should be documented.

117. The BOP system design, maintenance, and repair should be in general compliance with international standards. It is recommended that, at a minimum, subsea BOP systems consist of one annular preventer, two blind-shear ram preventers, and two pipe ram preventers, and that they be equipped with choke and kill lines and failsafe choke and kill close valves. The BOP preventers should be able to close the BOP for the maximum drill pipe string foreseen for the drilling operations. BOP systems shall operate (failsafe) in the event of a loss of control signal from the surface. At a minimum, subsea BOP systems should allow closure of one set of pipe rams and all blind shearing type rams by Remotely Operated Vehicle (ROV) intervention, should automatic systems fail.[37]

118. Contingency plans should be prepared for well operations and should include identification of provisions for well capping in the event of uncontrolled blowout (providing indication of the tools, equipment, and intervention time required) and identification of spill recovery measures.[38]

119. A dedicated blowout risk analysis and emergency plan should be prepared, detailing the measures in place to prevent a blowout, the provisions for well control in a blowout scenario (including capping tools and oil spill recovery means), and indicating the time necessary for the intervention. The risk analysis should include a failure mode and effect analysis as well as a reliability analysis of the technical systems in place to control a blowout, as well as reliability analysis of the systems. The risk analysis should include an assessment of conditions under which gas hydrates are formed,[39] the impact of hydrate formation on well safety and control during the containment of a kick and on well control equipment operations, and the relevant mitigations. Blowout risk analysis is mandatory in the case of deep water wells, where

[37] See API (2012), Standard 53, section 6 (Surface BOP) and section 7 (Subsea BOP), for testing frequencies, pressures and documentation expectations. API Standard 53 also includes guidelines for testing auxiliary well-control equipment, including choke/kill lines, annular diverter, choke manifold, etc. for both surface and subsea wells. BOP requirements and safety considerations on well safety are provided in American Bureau of Shipping (ABS) (2012); API (2012) Standard 53; IOGP (2011a); NORSOK (2004); and US BSEE (2013b).

[38] See IOGP (2011b, 2011c).

[39] Methane gas hydrate formation is a potential drilling hazard for drilling operations in shallow waters in cold environments and in water depths greater than 500 meters.

emergency intervention is more difficult and intervention times higher than is typical, and for high-pressure, high-temperature wells.

1.2.6 Ship Collision

120. To avoid collisions with third-party and support vessels, offshore facilities should be equipped with navigational aids that meet national and international requirements. Navigational aids include radar and lights on facility structures and, where appropriate, on support vessels. A 500-meter radius facility safety zone, at a minimum, should be implemented around offshore facilities. The facility should monitor and communicate with vessels approaching the facility to reduce the risk of vessel collision.

121. The relevant maritime, port, or shipping authority should be notified of all permanent offshore facilities, as well as safety zones and routine shipping routes to be used by project-related vessels. Permanent facility locations should be marked on nautical charts. Maritime authorities should be notified of the schedule and location of activities when there will be a significant increase in vessel movement, such as during facility installation, rig movements, and seismic surveys.

122. A subsea pipeline corridor safety zone (typically 1,000 meters wide) should be established to define anchoring exclusion zones and provide protection for fishing gear. In shallower waters with high shipping activity, consideration should be given to burying the pipeline below the seabed.

1.2.7 Dropped Objects and Material Handling Issues

123. A dedicated dropped objects analysis should be prepared, assessing the risk of loads falling from handling devices and impacting critical areas of the facility or subsea pipelines in the vicinity of the facility. This analysis will identify the need for measures to prevent damage to critical items or structures and to risers and sealines. A material handling study, to identify handling devices and procedures to avoid impacts and stresses and injuries to personnel, should be developed.

1.2.8 Emergency Preparedness and Response

124. Guidance relating to emergency preparedness and response, including emergency resources, is provided in the **General EHS Guidelines**. Offshore facilities should establish and maintain a high level of emergency preparedness to ensure that the response to incidents is effective and without delay. Potential worst-case accidents should be identified by risk assessment and appropriate preparedness requirements designed. An emergency response team should be established for the offshore facilities; such a team should be trained to respond to emergencies, rescue injured persons, and perform emergency actions. The team should coordinate actions with other agencies and organizations that may be involved in emergency response.

125. Personnel should be provided with adequate and sufficient emergency response equipment, including medical emergency equipment and evacuation devices. These devices shall be appropriately located for the evacuation of the facility. Lifeboats should be available in sufficient numbers for the entire workforce. These lifeboats should be enclosed, fire-resistant crafts with trained lifeboat operators. Ice-capable vehicles should be in place for the evacuation from facilities in frozen waters. Sufficient lifejackets, lifebuoys, and survival suits should also be provided.

126. Helicopters should not be considered as the primary means of evacuation.

127. Exercises in emergency preparedness should be practiced at a frequency commensurate with the risk associated with a project or facility. At a minimum, the following practice schedule should be implemented:

- Drills without equipment deployment as a minimum on quarterly basis
- Evacuation drills and training for egress from the platform under different weather conditions and at varying times of day
- Annual mock drills with equipment deployment
- Regular training, updated as needed and based on continuous evaluation

128. An emergency response plan should be prepared, based on the identification of potential emergency scenarios, which contains the following measures, at a minimum:

- A description of the response organization (structure, roles, responsibilities, and decision makers)
- Description of response procedures (details of response equipment and location, procedures, training requirements, duties, etc.)
- Descriptions and procedures for alarm and communications systems
- Precautionary measures for securing a well or wells
- Relief well arrangements, including a description of equipment, consumables, and support systems to be utilized
- Description of on-site first-aid supplies and available backup medical support
- Description of other emergency facilities, such as emergency fueling sites
- Description of survival equipment and gear, alternate accommodation facilities, and emergency power sources
- Procedures for person overboard
- Evacuation procedures
- Emergency Medical Evacuation (MEDEVAC) procedures for injured or ill personnel
- Policies defining measures for limiting or stopping events, and conditions for the termination of actions

1.3 Community Health and Safety

129. Impacts to community health and safety from typical offshore oil and gas facility operations relate primarily to potential interaction with other sea users, primarily shipping companies and fishermen. Impacts may include accidents, loss of containment, and blowouts. A comprehensive assessment addressing potential hazards to local communities and to the environment is required. Based on the findings of the assessment, adequate measures to avoid or control the hazards should be taken and should be factored into emergency planning.

130. Activities such as offshore drilling and construction, pipeline installation, seismic operations, and decommissioning may result in temporary impacts to other users of the sea. Permanent installations and structures, including production and drilling facilities and subsea pipelines, have a potential long-term impact, at least until the end of the life of a field. Notification of the location of offshore facilities (including subsea hazards) and the timing of offshore activities should be provided to local and regional maritime authorities, including fishery groups. The position of fixed facilities and safety exclusion zones should be marked on nautical charts. Clear instructions regarding access limitations to exclusion zones should be communicated to other sea users. Subsea pipeline routes should be regularly monitored for the presence of pipeline spans and identified spans should be repaired in a timely manner.

131. In areas where significant impacts to fishermen are anticipated, a fisheries liaison officer should be appointed to provide a direct link with the fishing community. Arrangements for the management of potential community or amenity impacts resulting from shoreline impacts caused by oil, chemical, or fuel spills shall be included in the spill response plans. These should be effectively communicated to the fishing community.

1.3.1 Security

132. Access to offshore facilities by unauthorized parties should be avoided by means of gates located in the stairs from the boat landings to the deck level. Means for detecting intrusion (for example, closed-circuit television) may be considered, allowing the control room to verify the conditions of the facility. Additional active and passive security measures should be defined on the basis of a site-specific risk assessment.

133. A facility standby vessel should be considered for offshore facilities (in case of multiplatform developments, platforms do not have to have their own dedicated standby vessels). These vessels should support security operations, monitor third-party vessels entering the exclusion zone, manage supply vessel approach to the facility, and support operations during emergency situations.

2. PERFORMANCE INDICATORS MONITORING

2.1 Environment

2.1.1 Emissions and Effluent Guidelines

134. Table 1 presents effluent guidelines for offshore oil and gas development. Guideline values for process effluents in this sector are indicative of good international industry practice, as reflected in the relevant standards of countries with recognized regulatory frameworks. The guidelines are assumed to be achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

135. The effluent guidelines are applicable primarily to discharges in offshore locations. Discharge water quality to near-shore waters should be established on a case-specific basis, taking into account the environmental sensitivities and assimilative capacity of receiving waters.

TABLE 1. EFFLUENT LEVELS FROM OFFSHORE OIL AND GAS DEVELOPMENT	
PARAMETER	**GUIDELINE**
Drilling Fluids and Cuttings – NADF	1) NADF: Reinject or ship-to-shore, no discharge to sea 2) Drilled cuttings: Reinject or ship-to-shore, no discharge to sea except: • Facilities located beyond 3 miles (4.8 km) from shore; • For new facilities:[a] Organic Phase Drilling Fluid[b] concentration lower than 1% by weight on dry cuttings; • For existing facilities[c]: Use of Group III non-aqueous base fluids and treatment in cutting dryers. Maximum residual Non Aqueous Phase Drilling Fluid[d] (NAF) 6.9% (C_{16} -C_{18} internal olefins) or 9.4% (C_{12}-C_{14} ester or C_8 esters) on wet cuttings; • Hg: max 1 mg/kg dry weight in stock barite • Cd: max 3 mg/kg dry weight in stock barite • Discharge via a caisson (at least 15 m below surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)
Drilling Fluids and Cuttings – WBDF	1) WBDF: Reinject or ship-to-shore, no discharge to sea except: • In compliance with 96 hr. LC-50 of Suspended Particulate Phase (SPP)-3% vol. toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment species[e] (preferably site-specific species) 2) WBDF cuttings: Reinject or ship-to-shore, no discharge to sea except: • Facilities located beyond 3 miles (4.8 km) from shore; • Hg: 1 mg/kg dry weight in stock barite • Cd: 3 mg/kg dry weight in stock barite • Maximum chloride concentration must be less than four times the ambient concentration of fresh or brackish receiving water • Discharge via a caisson (at least 15 m below sea surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)
Produced Water	Reinject. Discharge to sea is allowed if oil and grease content does not exceed 42 mg/l daily maximum; 29 mg/L monthly average
Flow-Back Water	Reinject or reuse. Discharge to sea is allowed if oil and grease content does not exceed 42 mg/L daily maximum; 29 mg/L monthly average. An environmental risk assessment to determine the maximum site-specific allowable concentrations should be conducted for all other chemicals
Completion and Well Work-Over Fluids	Ship-to-shore or reinject. No discharge to sea except: • Oil and grease content does not exceed 42 mg/L daily maximum; 29 mg/L monthly average • Neutralize to attain a pH of 5 or more • In compliance with 96 hr. LC-50 of SPP-3% vol. toxicity test first for drilling fluids[e] or alternatively testing based on standard toxicity assessment species (preferably site-specific species)
Produced Sand	Ship-to-shore or reinject: No discharge to sea except when oil concentration lower than 1% by weight on dry sand
Hydrotest Water	• Send to shore for treatment and disposal. • Discharge offshore following environmental risk analysis, careful selection of chemicals[g] • Reduce use of chemicals.

TABLE 1. EFFLUENT LEVELS FROM OFFSHORE OIL AND GAS DEVELOPMENT	
PARAMETER	**GUIDELINE**
Cooling Water	The effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 m from point of discharge.
Desalination Brine	Mix with other discharge waste streams, if feasible.
Sewage	Compliance with MARPOL 73/78[h]
Food Waste	Compliance with MARPOL 73/78[h]
Storage Displacement Water	Compliance with MARPOL 73/78[h]
Bilgewater	Compliance with MARPOL 73/78[h]
Deck Drainage (nonhazardous and hazardous drains)	Compliance with MARPOL 73/78[h]

[a] New facilities include offshore drilling rigs which have been newly designed or structurally modified for the project.

[b] As defined by OSPAR (2000) Decision 2000/3.

[c] Applicable to existing offshore drilling rigs deployed for development well drilling programs. Applicable to exploratory well drilling programs. Technically and financially feasible techniques, including installation of thermo-mechanical cutting cleaning systems, to meet the guidelines for new facilities should be considered for implementation, in relation to the number of wells (including producers and injectors) included in development drilling programs, and/or to potential impacts on critical habitats.

[d] As defined in US EPA (2013a).

[e] 96-hr LC-50: Concentration in parts per million or percent of the SPP from sample that is lethal to 50 percent of the test organism exposed to that concentration for a continuous period of 96 hours. See also: http://www.epa.gov/nrmrl/std/qsar/TEST-user-guide-v41.pdf.

[f] Consistent with US EPA (2013a); OSPAR (2011); IOGP (2005).

[g] In accordance with OSPAR (2010a) “Recommendation 2010/4 on a Harmonised Pre-screening Scheme for Offshore Chemicals” or other applicable process

[h] In nearshore waters, carefully select discharge location based on environmental sensitivities and assimilative capacity of receiving waters.

136. Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines,** with larger power source emissions addressed in the **Thermal Power EHS Guidelines**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines.**

137. All ships, platforms and drilling rigs should be compliant with the Regulations for the Prevention of Air Pollution from Ships set forth in MARPOL Annex VI,[40] where applicable. The provisions of Annex VI are not applicable to emissions directly arising from the exploration, exploitation and associated offshore oil and gas processing.

2.1.2 Environmental Monitoring

138. Environmental monitoring programs for this sector should be implemented as required to address all activities that have been identified to have potentially significant impacts on the environment during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

139. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards, so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety

140. Key performance Indicators should be adopted to monitor operations and anticipate potential health and safety issues. Both lagging indicators (measuring retrospectively the performances of facilities) and leading indicators (indicating situations that could result in future health and safety issues) should be defined for a facility; these indicators should consider both technical systems and operational and management issues.

2.2.1 Occupational Health and Safety Guidelines

141. Occupational health and safety performance should be evaluated against internationally published exposure guidelines. Examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEI®), published by American Conference of Governmental Industrial Hygienists (ACGIH);[41] Pocket Guide to Chemical Hazards, published by the United States National Institute for Occupational Health and Safety (NIOSH);[42] Permissible Exposure Limits (PELs),

[40] International Convention for the Prevention of Pollution from Ships (known universally as MARPOL), revised annex VI adopted in October 2008, which entered into force on July 1, 2010. See http://www.imo.org/OurWork/Environment/PollutionPrevention/.

[41] http://www.acgih.org/TLV/ and http://www.acgih.org/store/.

[42] http://www.cdc.gov/niosh/npg/.

published by the Occupational Safety and Health Administration of the United States (OSHA);[43] Health Leading Performance Indicators, published by IPIECA and IOGP);[44] Indicative Occupational Exposure Limit Values, published by European Union member states;[45] or other similar sources. Particular attention should be given to the occupational exposure guidelines for hydrogen sulfide (H_2S).

142. Guidance on occupational exposure to ionizing radiation and its monitoring when NORM is present is provided in the **General EHS Guidelines** and other internationally recognized sources.[46]

2.2.2 Accident and Fatality Rates

143. Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., U.S. Bureau of Labor Statistics and UK Health and Safety Executive).[47]

2.2.3 Occupational Health and Safety Monitoring

144. The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals as part of an occupational health and safety monitoring program.[48] Facilities should also maintain a record of occupational accidents and diseases, as well as dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[43] http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992.

[44] http://www.ogp.org.uk/publications/health-committee/health-performance-indicators-data/health-performance-indicators-2012-data/.

[45] http://europe.osha.eu.int/good_practice/risks/ds/oel/.

[46] ICRP (2007).

[47] http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm.

[48] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, Certified Safety Professionals, or their equivalents.

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ANNEX A. GENERAL DESCRIPTION OF INDUSTRY ACTIVITIES

145. The primary products of the offshore oil and gas industry are crude oil, natural gas liquids, and natural gas. Crude oil consists of a mixture of hydrocarbons having varying molecular weights and properties. Natural gas can be produced from oil wells, or wells can be drilled with natural gas as the primary objective. Methane is the predominant component of natural gas, but ethane, propane, and butane can also be significant components. The heavier components, including propane and butane, exist as liquids when cooled and compressed, and these are often separated and processed as natural gas liquids.

A.1 Exploration Activities

Seismic Surveys

146. Seismic surveys are conducted to pinpoint potential hydrocarbon reserves in geological formations deep below the seafloor. Seismic technology uses the reflection of sound waves to identify subsurface formations. In modern marine seismic surveys, as many as 16 “streamers” (cables containing the hydrophones used to detect the sound reflected from the subsurface) are towed behind the seismic vessel, at a depth of 5 to 10 meters. Each cable can be as long as 8 to 10 kilometers. In addition to the hydrophone array, the vessel tows seismic source arrays comprising a number of airguns, which discharge sound bursts of 200–250 decibels downward. The sound bursts, repeated on average every 6 to 10 seconds, are reflected off deep geological formations and recorded by the hydrophone array.

Exploration Drilling

147. Exploratory drilling activities offshore follow the analysis of seismic data to verify and quantify the amount and extent of oil and gas resources from potentially productive geological formations. If oil or gas is encountered, then additional development drilling may be undertaken.

148. There are various types of offshore drilling rigs, including the following:

- *Jack-up rigs*: Suitable for shallower water up to around 100 m and transported to location, either under their own propulsion or towed by tugs. Once there, electric or hydraulic jacks lower three or four legs to the seafloor to support the drilling platform above water.
- *Semisubmersible rigs*: Suitable for deep waters and transported to location, either under their own propulsion or towed by tugs. The hull is partially submerged and the rig held in place by a series of anchors; it may have dynamic positioning assistance.
- *Submersible rigs*: Limited to shallow waters and towed onto location. Consisting of two hulls: an upper hull, or platform, and lower hull that is filled with water and submerged to the seafloor.
- *Drilling barges as floating platforms*: Suitable for shallow waters, estuarine areas, lakes, marshes, swamps, and rivers. Not suitable for open or deep water. Towed onto location.
- *Drillships*: Designed for drilling in deep water locations. Drilling takes place from a drilling platform and derrick positioned in the middle of the deck, from which drill stems are lowered through a hole in the hull (moonhole). Drillships are usually kept “on station” by means of dynamic positioning technology.

149. Once on location, a series of well sections of decreasing diameter are drilled from the rig. A drill bit, attached to the drill string suspended from the rig's derrick, is rotated in the well. Drill collars are attached to add weight and drilling fluids are circulated through the drill string and pumped through the drill bit. The fluid has a number of functions. It imparts hydraulic force that assists the drill bit cutting action, and it cools the bit, removes rock cuttings from the wellbore, and protects the well against formation pressures. When each well section has been drilled, steel casing is run into the hole and cemented into place to prevent well collapse, fluid slips, and anomalous pressures in the annulus. If hydrocarbons are discovered in quantities that allow them to be economically produced, a wellhead and a "Christmas tree" are installed to allow for future production. Otherwise, the well is plugged (with cement) and abandoned. When the targeted hydrocarbon-bearing formation is reached, the well may be completed and tested by running a production liner and equipment to flow the hydrocarbons to the surface in an effort to establish reservoir properties in a test separator.

A.2 Field Development

150. Field development may occur after exploration (and additional appraisal well drilling) has located and confirmed economically recoverable reserves of hydrocarbons. In many cases, this will involve the installation of an offshore drilling and production platform that is self-sufficient in terms of energy and water needs for the workforce and for drilling wells and processing hydrocarbons ready for export.

151. There are many types of offshore platforms, including the following:

- *Fixed platforms:* Used in water depths of up to around 500 m and consisting of steel or concrete legs (jacket), secured directly to the seabed by steel piles that support a steel deck. Drilling equipment, production facilities, and accommodation are typically housed on the deck.
- *Compliant towers:* Used in water depths ranging from around 500 m up to 1,000 m and consisting of a narrow, flexible tower on a piled foundation supporting a conventional deck.
- *Tension leg platforms:* Used in water depths of up to about 2,000 m and consisting of a floating facility moored to the seabed and fixed in place by anchors. Minitension leg platforms (Seastars) are used in water depths of between 200 m and 1,000 m.
- *Jack-up platforms:* Used in shallower water up to around 100 m and transported to location, where the legs are lowered by hydraulic jacks into position to support the deck.
- *Spar platforms:* Used in water depths of between 500 m and 1,700 m and consisting of a cylindrical hull supporting a floating platform.
- *Floating production systems:* Ships equipped with processing facilities and moored on location with a series of anchors or by global positioning system devices. Sometimes based on a converted oil tanker, the main types of floating production systems are Floating, Production, Storage, and Offloading (FPSO) systems; Floating, Storage, and Offloading (FSO) systems; and Floating Storage Units.

152. Production platforms will provide facilities for the separation of formation fluids into oil, gas, and water. Depending on the project, the platform may be used only for production, as drilling can be conducted from a separate drilling rig brought alongside. Some platforms are used only to bring the hydrocarbons to surface and directly export them for processing, while some gas platforms may be unmanned during routine production operations. Typically, multiple wells are drilled from the platform

location using directional drilling techniques. In some cases, where field extremities not reachable by directional drilling from the fixed location or where small reservoirs exist, subsea production units are installed on the seabed following drilling and the produced hydrocarbons are tied into a nearby platform facility by a system of risers.

153. Following development drilling and well completion in readiness for the flow of formation fluids, a "Christmas tree," which allows the control of flow to the surface, is placed onto the wellhead. The oil and/or gas are produced by separation of the formation fluid mixture into oil and gas and water, or gas and condensates at the platform. Oil is exported from the platform by pumping it into a subsea pipeline to shore, to a floating storage unit offshore, or directly to a tanker. Typically, gas is exported through a pipeline.

154. Most fields produce in a predictable pattern, called a *decline curve*, in which production increases relatively rapidly to a peak and then follows a long, slow decline. Water or gas injection is often used to maintain reservoir pressure and enhance production. In other cases, Enhanced Oil Recovery techniques—such as the injection of steam, nitrogen, carbon dioxide, or surfactants—may be used to enhance recovery.

155. Operators may periodically perform work-overs to clean out the wellbore, allowing oil or gas to move easily to the surface. Other measures to increase production include fracturing and treating the bottom of the wellbore with acid to create better pathways allowing oil and gas to move to the surface.

A.3 Hydraulic Fracturing

156. Hydraulic fracturing of hydrocarbon-containing subsurface strata is a technique for realizing and maximizing commercial gas and oil production from low permeability reservoirs. This technique is applicable to onshore and offshore locations. Though recently becoming controversial, fracking has been used on a smaller scale for many years to improve the flow from conventional oil and gas wells. Today, hydraulic fracturing is largely applied onshore, with some applicability in offshore fields. Differences exist between the technical arrangements adopted offshore with respect to onshore; however, it typically involves injecting, through the wellhead, some thousands of cubic meters of water mixed with sand and fractional amounts of chemical additives; different fluids can also be used, such as hydrocarbons or gases (N_2, CO_2) and foams. The injection pressure is a function of the well depth and the rock characteristics. The average composition of the injected mixture is 90 to 95 percent water, 4.5 to 9.5 percent sand, and 0.5 percent chemical additives. Additives comprise inorganic or organic acids, gelling agents, friction reducers, and surfactants. Biocides, scale inhibitors, corrosion inhibitors, and cross-linking agents may also present in low concentrations. In case of high permeability formations, as it may happen in some offshore reservoirs, the fracturing fluid will usually be more viscous and have a higher sand concentration than similar fluids used onshore. Multistage hydraulic fracturing is now a commonly utilized approach. In some cases, when the target hydrocarbon-producing geological unit comprises loose sand, a specific technique is applied, referred as "frack pack," combining fracking with gravel (sand) packing. In this case, more sand is pumped into the well in order to create a layer of proppant, which reduces or eliminates the production of sand from the well. [49]

[49] See also API (2013a).

A.4 Coalbed Methane

157. Coalbed methane (CBM) is more frequently developed onshore. Limited cases present offshore may include hydraulic fracturing (see above) to improve production performance. CBM wells are characterized by high water production, which requires proper treatment systems (a low concentration of oil and grease, but a possible presence of heavy metals and hydrophilic compounds).

A.5 Storage and Offloading

158. The liquid hydrocarbon phase of produced fluids from a well or group of wells can either be pumped to shore for processing using flowlines, or treated by offshore production facilities (e.g., treatment platforms, FPSOs) to create a product suitable for transportation by tanker carriers.

159. The oil produced and treated offshore is temporarily stored in offshore storage facilities before being transferred to the export tankers. Storage can occur in underwater cylinders, anchored to the structure of gravity platforms, or, more frequently, oil is stored in a permanently (or semipermanently) moored vessel of substantial capacity (150,000–250,000 tons of displacement). From there, the stabilized oil is transferred to the export tanker carriers at regular intervals, according to the field production profile and storage capacity of the facility.

160. Offloading operations (i.e., the transfer from the offshore storage system to the export tankers) may include oil spill risks that should be assessed and minimized. Risks for floating production storage and offloading vessels can be related to the simultaneous operations of oil treatment and product storage. The marine conditions present additional risks; for instance, in typhoon areas, potential collisions between the FSO/FPSO and the export carriers. Preventing ruptures in the large-diameter export tanker loading hoses also warrants a high degree of attention.

A.6 Decommissioning and Abandonment

161. The decommissioning of offshore facilities occurs when the reservoir is depleted or the production of hydrocarbons from that reservoir becomes unprofitable. Parts of the offshore facility, such as platforms, are treated to remove contaminants and are themselves usually removed, while other production components are rendered safe and left in place.

162. Wells are plugged and abandoned to prevent fluid migration within the wellbore, which could contaminate the surface environment. The downhole equipment is removed and the perforated parts of the wellbore are cleaned of sediment, scale, and other debris. The wellbore is then plugged to prevent the inflow of fluids. Fluids with an appropriate density are placed between the plugs to maintain adequate pressure. During this process, the plugs are tested to verify their correct placement and integrity. Finally, the casing is cut off below the surface and capped.

Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account.

The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Onshore Oil and Gas Development include information relevant to seismic exploration; exploration and production drilling; development and production activities; transportation activities including pipelines; other facilities including pump stations, metering stations, pigging stations, compressor stations and storage facilities; ancillary and support operations; and decommissioning. For onshore oil and gas facilities located near the coast (e.g. coastal terminals marine supply bases, loading / offloading terminals), additional guidance is provided in the **EHS Guidelines for Ports, Harbors, and Terminals.** This document is organized according to the following sections:

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

This section provides a summary of EHS issues associated with onshore oil and gas development, along with recommendations for their management. These issues may be relevant to any of the activities listed as applicable to these guidelines. Additional guidance for the management of EHS issues common to most large industrial facilities during the construction phase is provided in the **General EHS Guidelines**.

1.1 Environment

The following environmental issues should be considered as part of a comprehensive assessment and management program that addresses project-specific risks and potential impacts. Potential environmental issues associated with onshore oil and gas development projects include the following:

- Air emissions
- Wastewater / effluent discharges
- Solid and liquid waste management
- Noise generation
- Terrestrial impacts and project footprint
- Spills

Air Emissions

The main sources of air emissions (continuous or non-continuous) resulting from onshore activities include: combustion sources from power and heat generation, and the use of compressors, pumps, and reciprocating engines (boilers, turbines, and other engines); emissions resulting from flaring and venting of hydrocarbons; and fugitive emissions.

Principal pollutants from these sources include nitrogen oxides, sulfur oxides, carbon monoxide, and particulates. Additional pollutants can include: hydrogen sulfide (H_2S); volatile organic compounds (VOC) methane and ethane; benzene, ethyl benzene, toluene, and xylenes (BTEX); glycols; and polycyclic aromatic hydrocarbons (PAHs).

Significant (>100,000 tons CO_2 equivalent per year) greenhouse gas (GHG) emissions from all facilities and support activities should be quantified annually as aggregate emissions in accordance with internationally recognized methodologies and reporting procedures.[2]

All reasonable attempts should be made to maximize energy efficiency and design facilities to minimize energy use. The overall objective should be to reduce air emissions and evaluate cost-effective options for reducing emissions that are technically feasible. Additional recommendations on the management of greenhouse gases and energy conservation are addressed in the **General EHS Guidelines.**

Air quality impacts should be estimated by the use of baseline air quality assessments and atmospheric dispersion models to establish potential ground level ambient air concentrations during facility design and operations planning as described in the **General EHS Guidelines**. These studies should ensure that no adverse impacts to human health and the environment result.

Exhaust gases

Exhaust gas emissions produced by the combustion of gas or liquid fuels in turbines, boilers, compressors, pumps and other engines for power and heat generation, or for water injection or oil and gas export, can be the most significant source of air emissions from onshore facilities. Air emission specifications should be considered during all equipment selection and procurement.

[2] Additional guidance on quantification methodologies can be found in IFC Guidance Note 3, Annex A, available at www.ifc.org/envsocstandards

Guidance for the management of small combustion source emissions with a capacity of up to 50 megawatt hours thermal (MWth), including air emission standards for exhaust emissions, is provided in the **General EHS Guidelines**. For combustion source emissions with a capacity of greater than 50 MWth refer to the **EHS Guidelines for Thermal Power.**

Venting and Flaring

Associated gas brought to the surface with crude oil during oil production is sometimes disposed of at onshore facilities by venting or flaring to the atmosphere. This practice is now widely recognized to be a waste of a valuable resource, as well as a significant source of GHG emissions.

However, flaring or venting are also important safety measures used on onshore oil and gas facilities to ensure gas and other hydrocarbons are safely disposed of in the event of an emergency, power or equipment failure, or other plant upset condition.

Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring Reduction Public-Private Partnership (GGFR program[3]) should be adopted when considering flaring and venting options for onshore activities. The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas.

Continuous venting of associated gas is not considered current good practice and should be avoided. The associated gas stream should be routed to an efficient flare system, although continuous flaring of gas should be avoided if feasible alternatives are available. Before flaring is adopted, feasible alternatives for the use of the gas should be evaluated to the maximum extent possible and integrated into production design. Alternative options may include gas utilization for on-site energy needs, export of the gas to a neighboring facility or to market, gas injection for reservoir pressure maintenance, enhanced recovery using gas lift, or gas for instrumentation. An assessment of alternatives should be adequately documented and recorded. If none of the alternative options are currently feasible, then measures to minimize flare volumes should be evaluated and flaring should be considered as an interim solution, with the elimination of continuous production-associated gas flaring as the preferred goal.

If flaring is necessary, continuous improvement of flaring through implementation of best practices and new technologies should be demonstrated. The following pollution prevention and control measures should be considered for gas flaring:

- Implementation of source gas reduction measures to the maximum extent possible;
- Use of efficient flare tips, and optimization of the size and number of burning nozzles;
- Maximizing flare combustion efficiency by controlling and optimizing flare fuel / air stream flow rates to ensure the correct ratio of assist stream to flare stream;
- Minimizing flaring from purges and pilots, without compromising safety, through measures including installation of purge gas reduction devices, flare gas recovery units, inert purge gas, soft seat valve technology where appropriate, and installation of conservation pilots;
- Minimizing risk of pilot blow-out by ensuring sufficient exit velocity and providing wind guards;
- Use of a reliable pilot ignition system;
- Installation of high integrity instrument pressure protection systems, where appropriate, to reduce over pressure events and avoid or reduce flaring situations;
- Minimizing liquid carry-over and entrainment in the gas flare stream with a suitable liquid separation system;

[3] World Bank Group (2004)

- Minimizing flame lift off and / or flame lick;
- Operating flare to control odor and visible smoke emissions (no visible black smoke);
- Locating flare at a safe distance from local communities and the workforce including workforce accommodation units;
- Implementation of burner maintenance and replacement programs to ensure continuous maximum flare efficiency;
- Metering flare gas.

In the event of an emergency or equipment breakdown, or plant upset conditions, excess gas should not be vented but should be sent to an efficient flare gas system. Emergency venting may be necessary under specific field conditions where flaring of the gas stream is not possible, or where a flare gas system is not available, such as a lack of sufficient hydrocarbon content in the gas stream to support combustion or a lack of sufficient gas pressure to allow it to enter the flare system. Justification for excluding a gas flaring system should be fully documented before an emergency gas venting facility is considered.

To minimize flaring events as a result of equipment breakdowns and plant upsets, plant reliability should be high (>95 percent) and provision should be made for equipment sparing and plant turn down protocols.

Flaring volumes for new facilities should be estimated during the initial commissioning period so that fixed volume flaring targets can be developed. The volumes of gas flared for all flaring events should be recorded and reported.

Fugitive Emissions

Fugitive emissions at onshore facilities may be associated with cold vents, leaking pipes and tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, tanks or open pits / containments, and hydrocarbon loading and unloading operations.

Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should consider safety and suitability requirements as well as their capacity to reduce gas leaks and fugitive emissions. Additionally, leak detection and repair programs should be implemented. Vapor control units should be installed, as needed, for hydrocarbon loading and unloading operations.

Use of open vents in tank roofs should be avoided by installing pressure relief valves. Vapor control units should be installed, as needed, for the loading and unloading of ship tankers. Vapor processing systems may consist of different units, such as carbon adsorption, refrigeration, thermal oxidation, and lean oil absorption units. Additional guidance for the prevention and control of fugitive emissions from storage tanks are provided in the **EHS Guidelines for Crude Oil and Petroleum Product Terminals**.

Well Testing

During well testing, flaring of produced hydrocarbons should be avoided wherever practical and possible, and especially near local communities or in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of hydrocarbon test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of disposal alternatives for produced hydrocarbons should be adequately documented and recorded.

If flaring is the only option available for the disposal of test fluids, only the minimum volume of hydrocarbons required for the test should be flowed and well test durations should be reduced to the extent practical. An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout. Volumes of hydrocarbons flared should be recorded.

Wastewaters

The **General EHS Guidelines** provide information on wastewater management, water conservation and reuse, along with wastewater and water quality monitoring programs. The guidance below is related to additional wastewater streams specific to the onshore oil and gas sector.

Produced Water

Oil and gas reservoirs contain water (formation water) that is produced when brought to the surface during hydrocarbon production. The produced water stream can be one of the largest waste products, by volume, managed and disposed of by the onshore oil and gas industry. Produced water contains a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds, and in many cases, residual chemical additives (e.g. scale and corrosion inhibitors) that are added into the hydrocarbon production process.

Feasible alternatives for the management and disposal of produced water should be evaluated and integrated into production design. The main disposal alternatives may include injection into the reservoir to enhance oil recovery, and injection into a dedicated disposal well drilled to a suitable receiving subsurface geological formation. Other possible uses such as irrigation, dust control, or use by other industry, may be appropriate to consider if the chemical nature of the produced water is compatible with these options. Produced water discharges to surface waters or to land should be the last option considered and only if there is no other option available.

Discharged produced water should be treated to meet the limits included in Table 1 in Section 2.1 of this Guideline.[4]

Produced water treatment technologies will depend on the final disposal alternative selected and particular field conditions. Technologies to consider may include combinations of gravity and / or mechanical separation and chemical treatment, and may require a multistage system containing a number of technologies in series to meet injection or discharge requirements. Sufficient treatment system backup capability should be in place to ensure continual operation and or an alternative disposal method should be available.

To reduce the volume of produced water for disposal the following should be considered:

- Adequate well management during well completion activities to minimize water production;
- Recompletion of high water producing wells to minimize water production;
- Use of downhole fluid separation techniques, where possible, and water shutoff techniques, when technically and economically feasible;
- Shutting in high water producing wells.

To minimize environmental hazards related to residual chemical additives in the produced water stream where surface disposal methods are used, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability, and bioaccumulation potential.

Disposal into evaporation ponds may be an option for produced waters. The construction and management measures included

[4] Effluent discharge to surface waters should not result in significant impact on human health and environmental receptors. A disposal plan that considers points of discharge, rate of discharge, chemical use and dispersion and environmental risk may be necessary. Discharges should be planned away from environmentally sensitive areas, with specific attention to high water tables, vulnerable aquifers, and wetlands, and community receptors, including water wells, water intakes, and high-value agricultural land.

in this Guideline for surface storage or disposal pits should also apply to produced water ponds.

Hydrostatic Testing Water

Hydrostatic testing of equipment and pipelines involves pressure testing with water to detect leaks and verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, and dyes) may be added to the water to prevent internal corrosion or to identify leaks. For pipeline testing, test manifolds installed onto sections of newly constructed pipelines, should be located outside of riparian zones and wetlands.

Water sourcing for hydrotesting purposes should not adversely affect the water level or flow rate of a natural water body, and the test water withdrawal rate (or volume) should not exceed 10 percent of the stream flow (or volume) of the water source. Erosion control measures and fish-screening controls should be implemented as necessary during water withdrawals at the intake locations.

The disposal alternatives for test waters following hydrotesting include injection into a disposal well if one is available or discharge to surface waters or land surface. If a disposal well is unavailable and discharge to surface waters or land surface is necessary the following pollution prevention and control measures should be considered:

- Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline;
- If chemical use is necessary, carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential;
- Conduct toxicity testing as necessary using recognized test methodologies. A holding pond may be necessary to provide time for the toxicity of the water to decrease. Holding ponds should meet the guidance for surface storage or disposal pits as discussed in this Guideline;
- Use the same hydrotest water for multiple tests;
- Hydrostatic test water quality should be monitored before use and discharge and should be treated to meet the discharge limits in Table 1 in Section 2.1 of this Guideline.
- If significant quantities of chemically treated hydrostatic test waters are required to be discharged to a surface water body, water receptors both upstream and downstream of the discharge should be monitored. Post-discharge chemical analysis of receiving water bodies may be necessary to demonstrate that no degradation of environmental quality has occurred;
- If discharged to water, the volume and composition of the test water, as well as the stream flow or volume of the receiving water body, should be considered in selecting an appropriate discharge site to ensure that water quality will not be adversely affected outside of the defined mixing zone;
- Use break tanks or energy dissipators (e.g. protective riprap, sheeting, tarpaulins) for the discharge flow;
- Use sediment control methods (e.g. silt fences, sandbags or hay bales) to protect aquatic biota, water quality, and water users from the potential effect of discharge, such as increased sedimentation and reduced water quality;
- If discharged to land, the discharge site should be selected to prevent flooding, erosion, or lowered agriculture capability of the receiving land. Direct discharge on cultivated land and land immediately upstream of community / public water intakes should be avoided;
- Water discharge during cleaning pig runs and pretest water should be collected in holding tanks and should be discharged only after water-quality testing to ensure that it meets discharge criteria established in Table 1 of Section 2.1 of this Guideline.

Cooling and Heating Systems

Water conservation opportunities provided in the **General EHS Guideline** should be considered for oil and gas facility cooling and heating systems. If cooling water is used, it should be discharged to surface waters in a location that will allow maximum mixing and cooling of the thermal plume to ensure that the temperature is within 3 degrees Celsius of ambient temperature at the edge of the defined mixing zone or within 100 meters of the discharge point, as noted in Table 1 of Section 2.1 of this Guideline.

If biocides and / or other chemical additives are used in the cooling water system, consideration should be given to residual effects at discharge using techniques such as risk based assessment.

Other Waste Waters

Other waste waters routinely generated at onshore oil and gas facilities include sewage waters, drainage waters, tank bottom water, fire water, equipment and vehicle wash waters and general oily water. Pollution prevention and treatment measures that should be considered for these waste waters include:

- *Sewage:* Gray and black water from showers, toilets and kitchen facilities should be treated as described in the **General EHS Guidelines**.

- *Drainage and storm waters:* Separate drainage systems for drainage water from process areas that could be contaminated with oil (closed drains) and drainage water from non-process areas (open drains) should be available to the extent practical. All process areas should be bunded to ensure drainage water flows into the closed drainage system and that uncontrolled contaminated surface run-off is avoided. Drainage tanks and slop tanks should be designed with sufficient capacity for foreseeable operating conditions, and systems to prevent overfilling should be installed. Drip trays, or other controls, should be used to collect run-off from equipment that is not contained within a bunded area and the contents routed to the closed drainage system. Stormwater flow channels and collection ponds installed as part of the open drainage system should be fitted with oil / water separators. Separators may include baffle type or coalescing plate type and should be regularly maintained. Stormwater runoff should be treated through an oil / water separation system able to achieve an oil and grease concentration of 10 mg/L, as noted in Table 1 of Section 2.1 of this Guideline. Additional guidance on the management of stormwater is provided in the **General EHS Guideline.**

- *Tank bottom waters*: The accumulation of tank bottom waters should be minimized by regular maintenance of tank roofs and seals to prevent rainwater infiltration. Consideration should be given to routing these waters to the produced water stream for treatment and disposal, if available. Alternatively they should be treated as a hazardous waste and disposed of in accordance with the facility waste management plan. Tank bottom sludges should also be periodically removed and recycled or disposed of as a hazardous waste.
- *Firewater*: Firewater from test releases should be directed to the facility drainage system.
- *Wash waters*: Equipment and vehicle wash waters should be directed to the closed drainage system.
- *General oily water*: Oily water from drip trays and liquid slugs from process equipment and pipelines should be routed to the closed drainage system.

Surface Storage or Disposal Pits

If surface pits or ponds are used for wastewater storage or for interim disposal during operations, the pits should be constructed outside environmentally sensitive locations.

Wastewater pit construction and management measures should include:

- Installation of a liner so that the bottom and sides of the pit have a coefficient of permeability of no greater than 1×10^{-7} centimeters per second (cm/sec). Liners should be compatible with the material to be contained and of sufficient strength and thickness to maintain the integrity of the pit. Typical liners may include synthetic materials, cement / clay type or natural clays, although the hydraulic conductivity of natural liners should be tested to ensure integrity;
- Construction to a depth of typically 5 m above the seasonal high water table;
- Installation of measures (e.g. careful siting, berms) to prevent natural surface drainage from entering the pit or breaching during heavy storms;
- Installation of a perimeter fence around the pit or installation of a screen to prevent access by people, livestock and wildlife (including birds);
- Regular removal and recovery of free hydrocarbons from the pit contents surface;
- Removal of pit contents upon completion of operations and disposal in accordance with the waste management plan;
- Reinstatement of the pit area following completion of operations.

Waste Management

Typical non-hazardous and hazardous wastes[5] routinely generated at onshore facilities other than permitted effluents and emissions include general office and packaging wastes, waste oils, paraffins, waxes, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, fluorescent tubes, scrap metals, and medical waste, among others.

Waste materials should be segregated into non-hazardous and hazardous wastes for consideration for re-use, recycling, or disposal. Waste management planning should establish a clear strategy for wastes that will be generated including options for waste elimination, reduction or recycling or treatment and disposal, before any wastes are generated. A waste management plan documenting the waste strategy, storage (including facilities and locations) and handling procedures should be developed and should include a clear waste tracking mechanism to track waste consignments from the originating location to the final waste treatment and disposal location. Guidance for waste management of these typical waste streams is provided in the **General EHS Guidelines**.

Significant additional waste streams specific to onshore oil and gas development activities may include:

- Drilling fluids and drilled cuttings
- Produced sand
- Completion and well work-over fluids
- Naturally occurring radioactive materials (NORM)

Drilling Fluids and Drilled Cuttings

The primary functions of drilling fluids used in oil and gas field drilling operations include removal of drilled cuttings (rock chippings) from the wellbore and control of formation pressures. Other important functions include sealing permeable formations, maintaining wellbore stability, cooling and lubricating the drill bit, and transmitting hydraulic energy to the drilling tools and bit. Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams generated during oil and gas drilling activities. Numerous drilling fluid systems are available, but they can generally be categorized into one of two fluid systems:

- *Water-Based Drilling Fluids (WBDF)*: The continuous phase and suspending medium for solids (or liquid) is

[5] As defined by local legislation or international conventions.

water or a water miscible fluid. There are many WBDF variations, including gel, salt-polymer, salt-glycol, and salt-silicate fluids;

- *Non-Aqueous Drilling Fluids (NADF)*: The continuous phase and suspending medium for solids (or liquid) is a water immiscible fluid that is oil-based, enhanced mineral oil-based, or synthetic-based.

Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice.

Typically, the solid medium used in most drilling fluids is barite (barium sulfate) for weight, with bentonite clays as a thickener. Drilling fluids also contain a number of chemicals that are added depending on the downhole formation conditions.

Drilling fluids are circulated downhole and routed to a solids control system at the surface facilities where fluids can be separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole sections drilled. The drilling fluid is replaced when its rheological properties or density of the fluid can no longer be maintained or at the end of the drilling program. These spent fluids are then contained for reuse or disposal (NADFs are typically reused).

Feasible alternatives for the treatment and disposal of drilling fluids and drilled cuttings should be evaluated and included in the planning for the drilling program. Alternative options may include one, or a combination of, the following:

- Injection of the fluid and cuttings mixture into a dedicated disposal well;
- Injection into the annular space of a well;
- Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal;
- On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for re-use, bioremediation, landfarming, or solidification with cement and / or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including landfill cover and capping material where appropriate. In the case of landfarming it should be demonstrated that subsoil chemical, biological, and physical properties are preserved and water resources are protected;
- Recycling of spent fluids back to the vendors for treatment and re-use.

Consider minimizing volumes of drilling fluids and drilled cuttings requiring disposal by:

- Use of high efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of residual fluid on drilled cuttings;
- Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings generated.

Pollution prevention and control measures for spent drilling fluids and drilled cuttings should include:

- Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system.
- Careful selection of fluid additives taking into account technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential;

- Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the fluid formulation.

The construction and management measures included in this guideline for surface storage or disposal pits should also apply to cuttings and drilling fluid pits. For drilling pits, pit closure should be completed as soon as practical, but no longer than 12 months, after the end of operations. If the drilling waste is to be buried in the pit following operations (the Mix-Bury-Cover disposal method), the following minimum conditions should be met:

- The pit contents should be dried out as far as possible;
- If necessary, the waste should be mixed with an appropriate quantity of subsoil (typically three parts of subsoil to one part of waste by volume);
- A minimum of one meter of clean subsoil should be placed over the mix;
- Topsoil should not be used but it should be placed over the subsoil to fully reinstate the area.
- The pit waste should be analyzed and the maximum lifetime loads should be calculated. A risk based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded.

Produced Sand

Produced sand originating from the reservoir is separated from the formation fluids during hydrocarbon processing. The produced sand can be contaminated with hydrocarbons, but the oil content can vary substantially depending on location, depth, and reservoir characteristics. Well completion should aim to reduce the production of sand at source using effective downhole sand control measures.

Produced sand should be treated as an oily waste, and may be treated and disposed of along with other oil contaminated solid materials (e.g. with cuttings generated when NADFs are used or with tank bottom sludges).

If water is used to remove oil from produced sand, it should be recovered and routed to an appropriate treatment and disposal system (e.g. the produced water treatment system when available).

Completion and Well Work-over Fluids

Completion and well work-over fluids (including intervention and service fluids) can typically include weighted brines, acids, methanol and glycols, and other chemical systems. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons, or simply used to maintain downhole pressure. Once used these fluids may contain contaminants including solid material, oil, and chemical additives. Chemical systems should be selected with consideration of their volume, toxicity, bioavailability, and bioaccumulation potential. Feasible disposal options should be evaluated for these fluids. Alternative disposal options may include one, or a combination of, the following:

- Collection of the fluids if handled in closed systems and shipping to the original vendors for recycling;
- Injection to a dedicated disposal well, where available;
- Inclusion as part of the produced water waste stream for treatment and disposal. Spent acids should be neutralized before treatment and disposal;
- On-site or off-site biological or physical treatment at an approved facility in accordance with the waste management plan.

Naturally Occurring Radioactive Materials

Depending on the field reservoir characteristics, naturally occurring radioactive material (NORM) may precipitate as scale or sludges in process piping and production vessels. Where

NORM is present, a NORM management program should be developed so that appropriate handling procedures are followed.

If removal of NORM is required for occupational health reasons (section 1.2), disposal options may include: canister disposal during well abandonment; deep well or salt cavern injection; injection into the annular space of a well or disposal to landfill in sealed containers.

Sludge, scale, or NORM-impacted equipment should be treated, processed, or isolated so that potential future human exposures to the treated waste would be within internationally accepted risk-based limits. Recognized industrial practices should be used for disposal. If waste is sent to an external facility for disposal, the facility must be licensed to receive such waste.

Hazardous Materials Management

General guidance for the management of hazardous materials is provided in the **General EHS Guidelines**. The following additional principles should be followed for chemicals used in the onshore oil and gas sector:

- Use chemical hazard assessment and risk management techniques to evaluate chemicals and their effects. Selected chemicals should have been tested for environmental hazards;
- Select chemicals with least hazard and lowest potential environmental and / or health impact, whenever possible;
- Use of Ozone Depleting Substances[6] should be avoided.

Noise

Oil and gas development activities can generate noise during all phases of development including during seismic surveys, construction activities, drilling and production, aerial surveys and air or road transportation. During operations, the main sources of noise and vibration pollution are likely to emanate from flaring and rotating equipment. Noise sources include flares and vents, pumps, compressors, generators, and heaters. Noise prevention and control measures are described in the **General EHS Guidelines**, along with the recommended daytime and night time noise level guidelines for urban or rural communities.

Noise impacts should be estimated by the use of baseline noise assessments for developments close to local human populations. For significant noise sources, such as flare stacks at permanent processing facilities, noise dispersion models should be conducted to establish the noise level guidelines can be met and to assist in the design of facility siting, stack heights, engineered sound barriers, and sound insulation on buildings.

Field related vehicle traffic should be reduced as far as possible and access through local communities should be avoided when not necessary. Flight access routes and low flight altitudes should be selected and scheduled to reduce noise impacts without compromising aircraft and security.

The sound and vibration propagation arising from seismic operations may result in impacts to human populations or to wildlife. In planning seismic surveys, the following should be considered to minimize impacts:

- Minimize seismic activities in the vicinity of local populations wherever possible;
- Minimize simultaneous operations on closely spaced survey lines;
- Use the lowest practicable vibrator power levels;
- Reduce operation times, to the extent practical;
- When shot-hole methods are employed, charge size and hole depth should be appropriately selected to reduce noise levels. Proper back-fill or plugging of holes will also help to reduce noise dispersion;

[6] As defined by the Montreal Protocol on Substances That Deplete the Ozone Layer.

- Identify areas and time periods sensitive to wildlife such as feeding and breeding locations and seasons and avoid them when possible;
- If sensitive wildlife species are located in the area, monitor their presence before the onset of noise creating activities, and throughout the seismic program. In areas where significant impacts to sensitive species are anticipated, experienced wildlife observers should be used. Slowly buildup activities in sensitive locations.

Terrestrial Impacts and Project Footprint

Project footprints resulting from exploration and construction activities may include seismic tracks, well pads, temporary facilities, such as workforce base camps, material (pipe) storage yards, workshops, access roads, airstrips and helipads, equipment staging areas, and construction material extraction sites (including borrow pits and quarries).

Operational footprints may include well pads, permanent processing treatment, transmission and storage facilities, pipeline right-of-way corridors, access roads, ancillary facilities, communication facilities (e.g. antennas), and power generation and transmission lines. Impacts may include loss of, or damage to, terrestrial habitat, creation of barriers to wildlife movement, soil erosion, and disturbance to water bodies including possible sedimentation, the establishment of non-native invasive plant species and visual disturbance. The extent of the disturbance will depend on the activity along with the location and characteristics of the existing vegetation, topographic features and waterways.

The visual impact of permanent facilities should be considered in design so that impacts on the existing landscape are minimized. The design should take advantage of the existing topography and vegetation, and should use low profile facilities and storage tanks if technically feasible and if the overall facility footprint is not significantly increased. In addition, consider suitable paint color for large structures that can blend with the background. General guidance on minimizing the project footprint during construction and decommissioning activities is provided in the **General EHS Guidelines**.

Additional prevention and control measures to minimize the footprint of onshore oil and gas developments may include the following:

- Site all facilities in locations that avoid critical terrestrial and aquatic habitat and plan construction activities to avoid sensitive times of the year;
- Minimize land requirements for aboveground permanent facilities;
- Minimize areas to be cleared. Use hand cutting where possible, avoiding the use of heavy equipment such as bulldozers, especially on steep slopes, water and wetland crossings, and forested and ecologically sensitive areas;
- Use a central processing / treatment facility for operations, when practical;
- Minimize well pad size for drilling activities and satellite / cluster, directional, extended reach drilling techniques should be considered, and their use maximized in sensitive locations;
- Avoid construction of facilities in a floodplain, whenever practical, and within a distance of 100 m of the normal high-water mark of a water body or a water well used for drinking or domestic purposes;
- Consider the use of existing utility and transport corridors for access roads and pipeline corridors to the extent possible;
- Consider the routing of access roads to avoid induced impacts such as increased access for poaching;
- Minimize the width of a pipeline right-of-way or access road during construction and operations as far as possible;

- Limit the amount of pipeline trench left open during construction at any one time. Safety fences and other methods to prevent people or animals from falling into open trenches should be constructed in sensitive locations and within 500 m of human populations. In remote areas, install wildlife escape ramps from open trenches (typically every 1 km where wildlife is present);
- Consider use of animal crossing structures such as bridges, culverts, and over crossings, along pipeline and access road rights-of-way;
- Bury pipelines along the entire length to a minimum of 1 m to the top-of-pipe, wherever this is possible;
- Carefully consider all of the feasible options for the construction of pipeline river crossings including horizontal directional drilling;
- Clean-up and fully reinstate following construction activities (including appropriate revegetation using native plant species following construction activities) the pipeline right-of-way and temporary sites such as workforce accommodation camps, storage yards, access roads, helipads and construction workshops, to the pre-existing topography and drainage contours;
- Reinstate off-site aggregate extraction facilities including borrow pits and quarries (opened specifically for construction or extensively used for construction);
- Implement repair and maintenance programs for reinstated sites;
- Consider the implementation of low impact seismic techniques (e.g. minimize seismic line widths (typically no wider than 5 m), limit the line of sight along new cut lines in forested areas (approximately 350 m));
- Consider shot-hole methods in place of vibroseis where preservation of vegetation cover is required and when access is limited. In areas of low cover (e.g. deserts, or tundra with snow cover in place), vibroseis machinery should be selected, but soft soil locations should be carefully assessed to prevent excessive compaction;
- Install temporary and permanent erosion and sediment control measures, slope stabilization measures, and subsidence control and minimization measures at all facilities, as necessary;
- Regularly maintain vegetation growth along access roads and at permanent above ground facilities, and avoid introduction of invasive plant species. In controlling vegetation use biological, mechanical and thermal vegetation control measures and avoid the use of chemical herbicides as much as possible.

If it is demonstrated that the use of herbicides is required to control vegetation growth along access roads or at facilities, then personnel must be trained in their use. Herbicides that should be avoided include those listed under the World Health Organization recommended Classification of Pesticides by Hazard Classes 1a and 1b, the World Health Organization recommended Classification of Pesticides by Hazard Class II (except under conditions as noted in IFC Performance Standard 3: Pollution Prevention and Abatement;[7]), and Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention.[8]

Spills

Spills from onshore facilities, including pipelines, can occur due to leaks, equipment failure, accidents, and human error or as a result of third party interference. Guidelines for release prevention and control planning are provided in the **General EHS Guidelines**, including the requirement to develop a spill prevention and control plan.

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[7] IFC Performance Standard 3: Pollution Prevention and Abatement (2006). Available at www.ifc.org/envsocstandards

[8] Stockholm Convention on Persistent Organic Pollutants (2001).

Additional spill prevention and control measures specific to onshore oil and gas facilities include:

- Conduct a spill risk assessment for the facilities and design, drilling, process, and utility systems to reduce the risk of major uncontained spills;
- Ensure adequate corrosion allowance for the lifetime of the facilities or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks;
- Install secondary containment around vessels and tanks to contain accidental releases;
- Install shutdown valves to allow early shutdown or isolation in the event of a spill;
- Develop automatic shutdown actions through an emergency shutdown system for significant spill scenarios so that the facility may be rapidly brought into a safe condition;
- Install leak detection systems. On pipelines consider measures such as telemetry systems, Supervisory Control and Data Acquisition (SCADA[9]), pressure sensors, shut-in valves, and pump-off systems,
- Develop corrosion maintenance and monitoring programs to ensure the integrity of all field equipment. For pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should be considered as required;
- Ensure adequate personnel training in oil spill prevention, containment, and response;
- Ensure spill response and containment equipment is deployed or available for a response.

All spills should be documented and reported. Following a spill, a root cause investigation should be carried out and corrective actions should be undertaken to prevent reoccurrence. A Spill Response Plan should be prepared, and the capability to implement the plan should be in place. The Spill Response Plan should address potential oil, chemical, and fuel spills from facilities, transport vehicles, loading and unloading operations, and pipeline ruptures. The plan should include:

- A description of the operations, site conditions, logistic support and oil properties;
- Identification of persons responsible for managing spill response efforts, including their authority, roles and contact details;
- Documentation of cooperative measures with government agencies as appropriate;
- Spill risk assessment, defining expected frequency and size of spills from different potential release sources;
- Oil spill trajectory in potentially affected surface water bodies, with oil fate and environmental impact prediction for a number of credible most-probable spill simulations (including a worst case scenario, such as blowout from an oil well) using an adequate and internationally recognized computer model;
- Clear demarcation of spill severity, according to the size of the spill using a clearly defined Tier I, Tier II and Tier III approach;
- Strategies and equipment for managing Tier I spills at a minimum;
- Arrangements and procedures to mobilize external resources for responding to larger spills and strategies for deployment;
- Full list, description, location, and use of on-site and off-site response equipment and the response time estimates for deploying equipment;
- Sensitivity mapping of the environment at risk. Information should include: soil types; groundwater and surface water resources; sensitive ecological and protected areas;

[9] SCADA refers to supervisory control and data acquisition systems, which may be used in oil and gas and other industrial facilities to assist in the monitoring and control of plants and equipment.

agricultural land; residential, industrial, recreational, cultural, and landscape features of significance; seasonal aspects for relevant features, and oil spill response types to be deployed;

- Identification of response priorities, with input from potentially affected or concerned parties;
- Clean up strategies and handling instructions for recovered oil, chemicals, fuels or other recovered contaminated materials, including their transportation, temporary storage, and treatment / disposal.

Decommissioning

Decommissioning of onshore facilities usually includes the complete removal of permanent facilities and well abandonment, including associated equipment, material, and waste disposal or recycling. General guidance on the prevention and control of common environmental impacts during decommissioning activities is provided in the **General EHS Guidelines.** Specific additional requirements to consider for oil and gas facilities include well abandonment and pipeline decommissioning options.

Wells should be abandoned in a stable and safe condition. The hole should be sealed to the ground surface with cement plugs and any known hydrocarbon zones should be isolated to prevent fluid migration. Aquifers should also be isolated. If the land is used for agriculture, the surface casing should be cut and capped below plow depth.

Decommissioning options for pipelines include leaving them in place, or removing them for reuse, recycling or disposal, especially if they are above ground and interfere with human activities. Pipelines left in place should be disconnected and isolated from all potential sources of hydrocarbons; cleaned and purged of hydrocarbons; and sealed at its ends.

A preliminary decommissioning and restoration plan should be developed that identifies disposal options for all equipment and materials, including products used and wastes generated on site. The plan should consider the removal of oil from flowlines, the removal of surface equipment and facilities, well abandonment, pipeline decommissioning and reinstatement. The plan should be further developed during field operations and fully defined in advance of the end of field life, and should include details on the provisions for the implementation of decommissioning activities and arrangements for post decommissioning monitoring and aftercare.

1.2 Occupational Health and Safety

Occupational health and safety issues should be considered as part of a comprehensive hazard or risk assessment, including, for example, a hazard identification study [HAZID], hazard and operability study [HAZOP], or other risk assessment studies. The results should be used for health and safety management planning, in the design of the facility and safe working systems, and in the preparation and communication of safe working procedures.

Facilities should be designed to eliminate or reduce the potential for injury or risk of accident and should take into account prevailing environmental conditions at the site location including the potential for extreme natural hazards such as earthquakes or hurricanes.

Health and safety management planning should demonstrate: that a systematic and structured approach to managing health and safety will be adopted and that controls are in place to reduce risks to as low as reasonably practical; that staff are adequately trained; and that equipment is maintained in a safe condition. The formation of a health and safety committee for the facility is recommended.

A formal Permit to Work (PTW) system should be developed for the facilities. The PTW will ensure that all potentially hazardous work is carried out safely and ensures effective authorization of designated work, effective communication of the work to be carried out including hazards involved, and safe isolation procedures to be followed before commencing work. A lockout / tagout procedure for equipment should be implemented to ensure all equipment is isolated from energy sources before servicing or removal.

The facilities should be equipped, at a minimum, with specialized first aid providers (industrial pre-hospital care personnel) and the means to provide short-term remote patient care. Depending on the number of personnel present and complexity of the facility, provision of an on-site medical unit and medical professional should be considered. In specific cases, telemedicine facilities may be an alternative option.

General facility design and operation measures to manage principal risks to occupational health and safety are provided in the **General EHS Guidelines**. General guidance specific to construction and decommissioning activities is also provided along with guidance on health and safety training, personal protective equipment and the management of physical, chemical, biological and radiological hazards common to all industries.

Occupational health and safety issues for further consideration in onshore oil and gas operations include:

- Fire and explosion
- Air quality
- Hazardous materials
- Transportation
- Well blowouts
- Emergency preparedness and response

Fire and Explosion

General guidance on fire precautions and prevention and control of fire and explosions is provided in the **General EHS Guidelines**.

Onshore oil and gas development facilities should be designed, constructed, and operated according to international standards[10] for the prevention and control of fire and explosion hazards. The most effective way of preventing fires and explosions at oil and gas facilities is by preventing the release of flammable material and gas, and the early detection and interruption of leaks. Potential ignition sources should be kept to a minimum and adequate separation distance between potential ignition sources and flammable materials, and between processing facilities and adjacent buildings[11], should be in place. Facilities should be classified into hazard areas, based on international good practice,[12] and in accordance with the likelihood of release of flammable gases and liquids.

Facility fire and explosion prevention and control measures should also include:

- Provision of passive fire protection to prevent the spread of fire in the event of an incident including:
    - Passive fire protection on load-bearing structures, fire-rated walls, and fire-rated partitions between rooms
    - Design of load-bearing structures taking into account explosion load, or blast-rated walls
    - Design of structures against explosion and the need for blast walls based on an assessment of likely explosion characteristics

[10] An example of good practice includes the United States (US) National Fire Protection Association (NFPA) Code 30: Flammable and Combustible Liquids Code. Further guidance to minimize exposure to static electricity and lightening is American Petroleum Institute (API) Recommended Practice: Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents (2003).
[11] Further information on safe spacing is available in the US NFPA Code 30.
[12] See API RP 500/505 task group on electrical area classification, International Electrotechnical Commission, or British Standards (BS).

- Specific consideration of blast panel or explosion venting, and fire and explosion protection for wellheads, safe areas, and living areas;
- Prevention of potential ignition sources such as:
    - Proper grounding to avoid static electricity buildup and lightning hazards (including formal procedures for the use and maintenance of grounding connections)[13]
    - Use of intrinsically safe electrical installations and non-sparking tools[14]
- A combination of automatic and manual fire alarm systems that can be heard across the facility;
- Active fire protection systems strategically located to enable rapid and effective response. The fire suppression equipment should meet internationally recognized technical specifications for the type and amount of flammable and combustible materials at the facility.[15] A combination of active fire suppression systems can be used, depending on the type of fire and the fire impact assessment (for example, fixed foam system, fixed fire water system, CO_2 extinguishing system, and portable equipment such as fire extinguishers, and specialized vehicles). The installation of halon-based fire systems is not considered current good practice and should be avoided. Firewater pumps should be available and designed to deliver water at an appropriate rate. Regular checks and maintenance of fire fighting equipment is essential;
- All fire systems should be located in a safe area of the facility, protected from the fire by distance or by fire walls. If the system or piece of equipment is located within a potential fire area, it should be passive fire protected or fail-safe;
- Explosive atmospheres in confined spaces should be avoided by making spaces inert;
- Protection of accommodation areas by distance or by fire walls. The ventilation air intakes should prevent smoke from entering accommodation areas;
- Implementation of safety procedures for loading and unloading of product to transport systems (e.g. ship tankers, rail and tanker trucks, and vessels[16]), including use of fail safe control valves and emergency shutdown equipment;
- Preparation of a fire response plan supported by the necessary resources to implement the plan;
- Provision of fire safety training and response as part of workforce health and safety induction / training, including training in the use fire suppression equipment and evacuation, with advanced fire safety training provided to a designated fire fighting team.

Air Quality

Guidance for the maintenance of air quality in the workplace, along and provision of a fresh air supply with required air quality levels, is provided in the **General EHS Guidelines**.

Facilities should be equipped with a reliable system for gas detection that allows the source of release to be isolated and the inventory of gas that can be released to be reduced. Equipment isolation or the blowdown of pressure equipment should be initiated to reduce system pressure and consequently reduce the release flow rate. Gas detection devices should also be used to authorize entry and operations into enclosed spaces.

Wherever hydrogen sulfide (H_2S) gas may accumulate the following measures should be considered:

- Development of a contingency plan for H_2S release events, including all necessary aspects from evacuation to resumption of normal operations;

[13] See International Safety Guide for Oil Tankers and Terminals (ISGOTT) Chapter 20.
[14] See ISGOTT, Chapter 19.
[15] Such as the US NFPA or equivalent standards.
[16] An example of good industry practice for loading and unloading of tankers includes ISGOTT.

- Installation of monitors set to activate warning signals whenever detected concentrations of H_2S exceed 7 milligrams per cubic meter (mg/m^3). The number and location of monitors should be determined based on an assessment of plant locations prone to H_2S emission and occupational exposure;
- Provision of personal H_2S detectors to workers in locations of high risk of exposure along with self-contained breathing apparatus and emergency oxygen supplies that is conveniently located to enable personnel to safely interrupt tasks and reach a temporary refuge or safe haven;
- Provision of adequate ventilation of occupied buildings to avoid accumulation of hydrogen sulfide gas;
- Workforce training in safety equipment use and response in the event of a leak.

Hazardous Materials

The design of the onshore facilities should reduce exposure of personnel to chemical substances, fuels, and products containing hazardous substances. Use of substances and products classified as very toxic, carcinogenic, allergenic, mutagenic, teratogenic, or strongly corrosive should be identified and substituted by less hazardous alternatives, wherever possible. For each chemical used, a Material Safety Data Sheet (MSDS) should be available and readily accessible on the facility. A general hierarchical approach to the prevention of impacts from chemical hazards is provided in the **General EHS Guidelines**.

A procedure for the control and management of any radioactive sources used during operations should be prepared along with a designated and shielded container for storage when the source is not in use.

In locations where naturally occurring radioactive material (NORM) may precipitate as scale or sludges in process piping and production vessels, facilities and process equipment should be monitored for the presence of NORM at least every five years, or whenever equipment is to be taken out of service for maintenance. Where NORM is detected, a NORM management program should be developed so that appropriate handling procedures are followed. Procedures should determine the classification of the area where NORM is present and the level of supervision and control required. Facilities are considered impacted when surface levels are greater than 4.0 Bq/cm^2 for gamma/beta radiation and 0.4 Bq/cm^2 for alpha radiation.[17] The operator should determine whether to leave the NORM in-situ, or clean and decontaminate by removal for disposal as described in Section 1.1 of this Guideline.

Well Blowouts

A blowout can be caused by the uncontrolled flow of reservoir fluids into the wellbore which may result in an uncontrolled release of hydrocarbons. Blowout prevention measures during drilling should focus on maintaining wellbore hydrostatic pressure by effectively estimating formation fluid pressures and strength of subsurface formations. This can be achieved with techniques such as: proper pre-well planning, drilling fluid logging; using sufficient density drilling fluid or completion fluid to balance the pressures in the wellbore; and installing a Blow Out Preventor (BOP) system that can be rapidly closed in the event of an uncontrolled influx of formation fluids and which allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained. The BOP should be operated hydraulically and triggered automatically, and tested at regular intervals. Facility personnel should conduct well control drills at regular intervals and key personnel should attend a certified well control school periodically.

During production, wellheads should be regularly maintained and monitored, by corrosion control and inspection and pressure

[17] US Environmental Protection Agency (EPA) 49 CFR 173: Surface Contaminated Object (SCO) and International Atomic Energy Agency (IAEA) Safety Standards Series No. ST-1, §508

monitoring. Blow out contingency measures should be included in the facility Emergency Response Plan.

Transportation

Incidents related to land transportation are one of the main causes of injury and fatality in the oil and gas industry. Traffic safety measures for industries are provided in the **General EHS Guidelines**.

Oil and gas projects should develop a road safety management plan for the facility during all phases of operations. Measures should be in place to train all drivers in safe and defensive driving methods and the safe transportation of passengers. Speed limits for all vehicles should be implemented and enforced. Vehicles should be maintained in an appropriate road worthy condition and include all necessary safety equipment.

Specific safety procedures for air transportation (including helicopter) of personnel and equipment should be developed and a safety briefing for passengers should be systematically provided along with safety equipment. Helicopter decks at or near to facilities should follow the requirements of the International Civil Aviation Organization (ICAO).

Emergency Preparedness and Response

Guidance relating to emergency preparedness and response, including emergency resources, is provided in the **General EHS Guidelines**. Onshore oil and gas facilities should establish and maintain a high level of emergency preparedness to ensure incidents are responded to effectively and without delay. Potential worst case accidents should be identified by risk assessment and appropriate preparedness requirements should be designed and implemented. An emergency response team should be established for the facility that is trained to respond to potential emergencies, rescue injured persons, and perform emergency actions. The team should coordinate actions with other agencies and organizations that may be involved in emergency response.

Personnel should be provided with adequate and sufficient equipment that is located appropriately for the evacuation of the facility and should be provided with escape routes to enable rapid evacuation to a safe refuge. Escape routes should be clearly marked and alternative routes should be available. Exercises in emergency preparedness should be practiced at a frequency commensurate with the project risk. At a minimum, the following practice schedule should be implemented:

- Quarterly drills without equipment deployment;
- Evacuation drills and training for egress from the facilities under different weather conditions and time of day;
- Annual mock drills with deployment of equipment;
- Updating training, as needed, based on continuous evaluation.

An Emergency Response Plan should be prepared that contains the following measures, at a minimum:

- A description of the response organization (structure, roles, responsibilities, and decision makers);
- Description of response procedures (details of response equipment and location, procedures, training requirements, duties, etc.);
- Descriptions and procedures for alarm and communications systems;
- Precautionary measures for securing the wells;
- Relief well arrangements, including description of equipment, consumables, and support systems to be utilized;
- Description of on-site first aid supplies and available backup medical support;
- Description of other emergency facilities such as emergency fueling sites;

- Description of survival equipment and gear, alternate accommodation facilities, and emergency power sources;
- Evacuation procedures;
- Emergency Medical Evacuation (MEDIVAC) procedures for injured or ill personnel;
- Policies defining measures for limiting or stopping events, and conditions for termination of action.

1.3 Community Health and Safety

Community health and safety impacts during the construction and decommissioning of facilities are common to those of most other industrial facilities and are discussed in the **General EHS Guidelines**.

Physical Hazards

Community health and safety issues specific to oil and gas facilities may include potential exposure to spills, fires, and explosions. To protect nearby communities and related facilities from these hazards, the location of the project facilities and an adequate safety zone around the facilities should be established based on a risk assessment. A community emergency preparedness and response plan that considers the role of communities and community infrastructure as appropriate should also be developed. Additional information on the elements of emergency plans is provided in the **General EHS Guidelines.**

Communities may be exposed to physical hazards associated with the facilities including wells and pipeline networks. Hazards may result from contact with hot components, equipment failure, the presence of operational pipelines or active and abandoned wells and abandoned infrastructure which may generate confined space or falling hazards. To prevent public contact with dangerous locations and equipment and hazardous materials, access deterrents such as fences and warning signs should be installed around permanent facilities and temporary structures. Public training to warn of existing hazards, along with clear guidance on access and land use limitations in safety zones or pipeline rights of way should be provided.

Community risk management strategies associated with the transport of hazardous materials by road is presented in the **General EHS Guidelines** (refer specifically to the sections on "Hazardous Materials Management" and "Traffic Safety"). Guidance applicable to transport by rail is provided **EHS Guidelines for Railways** while transport by sea is covered in the **EHS Guidelines for Shipping.**

Hydrogen Sulfide

The potential for exposure of members of the community to facility air emissions should be carefully considered during the facility design and operations planning process. All necessary precautions in the facility design, facility siting and / or working systems and procedures should be implemented to ensure no health impacts to human populations and the workforce will result from activities.

When there is a risk of community exposure to hydrogen sulfide from activities, the following measures should be implemented:

- Installation of a hydrogen sulfide gas monitoring network with the number and location of monitoring stations determined through air dispersion modeling, taking into account the location of emissions sources and areas of community use and habitation;
- Continuous operation of the hydrogen sulfide gas monitoring systems to facilitate early detection and warning;
- Emergency planning involving community input to allow for effective response to monitoring system warnings.

Security

Unauthorized access to facilities should be avoided by perimeter fencing surrounding the facility and controlled access points (guarded gates). Public access control should be applied. Adequate signs and closed areas should establish the areas where security controls begin at the property boundaries. Vehicular traffic signs should clearly designate the separate entrances for trucks / deliveries and visitor / employee vehicles. Means for detecting intrusion (for example, closed-circuit television) should be considered. To maximize opportunities for surveillance and minimize possibilities for trespassers, the facility should have adequate lighting.2.0

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Table 1 presents effluent and waste guidelines for onshore oil and gas development. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. The guidelines are assumed to be achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guidelines**.

Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the **Thermal Power EHS Guidelines**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. Performar

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

Table 1. Emissions, Effluent and Waste Levels from Onshore Oil and Gas Development	
Parameter	**Guideline Value**
Drilling fluids and cuttings	Treatment and disposal as per guidance in Section 1.1 of this document.
Produced sand	Treatment and disposal as per guidance in Section 1.1 of this document.
Produced water	Treatment and disposal as per guidance in Section 1.1 of this document. For discharge to surface waters or to land: o Total hydrocarbon content: 10 mg/L o pH: 6 - 9 o BOD: 25 mg/L o COD: 125 mg/L o TSS: 35 mg/L o Phenols: 0.5 mg/L o Sulfides: 1 mg/L o Heavy metals (total)[a]: 5 mg/L o Chlorides: 600 mg/l (average), 1200 mg/L (maximum)
Hydrotest water	Treatment and disposal as per guidance in section 1.1 of this document. For discharge to surface waters or to land, see parameters for produced water in this table.
Completion and well work-over fluids	Treatment and disposal as per guidance in Section 1.1 of this document. For discharge to surface waters or to land: : o Total hydrocarbon content: 10 mg/L. o pH: 6 – 9
Stormwater drainage	Stormwater runoff should be treated through an oil/water separation system able to achieve oil & grease concentration of 10 mg/L.
Cooling water	The effluent should result in a temperature increase of no more than 3° C at edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 m from point of discharge.
Sewage	Treatment as per guidance in the General EHS Guidelines, including discharge requirements.
Air Emissions	Treatment as per guidance in Section 1.1 of this document. Emission concentrations as per General EHS Guidelines, and: o H_2S: 5 mg/Nm^3

Notes:
[a] Heavy metals include: Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[18] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[19] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[20] Indicative Occupational Exposure Limit Values published by European Union member states,[21] or other similar sources.

Particular attention should be given to the occupational exposure guidelines for hydrogen sulfide (H_2S). For guidelines on occupational exposure to Naturally Occurring Radioactive Material (NORM), readers should consult the average and maximum values published by the Canadian NORM Waste Management Committee, Health Canada, and the Australian Petroleum Production and Exploration Association or other internationally recognized sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[22].

Occupa

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[23] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[18] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/
[19] Available at: http://www.cdc.gov/niosh/npg/
[20] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
[21] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/
[22] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm
[23] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

The primary products of the oil and gas industry are crude oil, natural gas liquids, and natural gas. Crude oil consists of a mixture of hydrocarbons having varying molecular weights and properties. Natural gas can be produced from oil wells, or wells can be drilled with natural gas as the primary objective. Methane is the predominant component of natural gas, but ethane, propane, and butane are also significant components. The heavier components, including propane and butane, exist as liquids when cooled and compressed and these are often separated and processed as natural gas liquids.

Exploration Activities

Seismic Surveys

Seismic surveys are conducted to pinpoint potential hydrocarbon reserves in geological formations. Seismic technology uses the reflection of sound waves to identify subsurface geological structures. The surveys are conducted through the generation of seismic waves by a variety of sources ranging from explosives that are detonated in shot-holes drilled below the surface, to vibroseis machinery (a vibrating pad lowered to the ground from a vibroseis truck). Reflected seismic waves are measured with a series of sensors known as geophones laid out in series on the surface.

Exploration Drilling

Exploratory drilling activities onshore follow the analysis of seismic data to verify and quantify the amount and extent of oil and gas resources from potentially productive geological formations. A well pad is constructed at the chosen location to accommodate a drilling rig, associated equipment and support services. The drilling rig and support services are transported to site, typically in modules and assembled.

Once on location, a series of well sections of decreasing diameter are drilled from the rig. A drill bit, attached to the drill string suspended from the rig's derrick, is rotated in the well. Drill collars are attached to add weight and drilling fluids are circulated through the drill string and pumped through the drill bit. The fluid has a number of functions. It imparts hydraulic force that assists the drill bit cutting action, and it cools the bit, removes cuttings rock from the wellbore and protects the well against formation pressures. When each well section has been drilled, steel casing is run into the hole and cemented into place to prevent well collapse. When the reservoir is reached the well may be completed and tested by running a production liner and equipment to flow the hydrocarbons to the surface to establish reservoir properties in a test separator.

Field Development and Production

Development and production is the phase during which the infrastructure is installed to extract the hydrocarbon resource over the life of the estimated reserve. It may involve the drilling of additional wells, the operation of central production facilities to treat the produced hydrocarbons, the installation of flowlines, and the installation of pipelines to transport hydrocarbons to export facilities.

Following development drilling and well completion, a "Christmas tree" is placed on each wellhead to control flow of the formation fluids to the surface. Hydrocarbons may flow freely from the wells if the underground formation pressures are adequate, but additional pressure may be required such as a sub-surface pump or the injection of gas or water through dedicated injection wells to maintain reservoir pressure. Depending on reservoir conditions, various substances (steam, nitrogen, carbon dioxide, and surfactants) may be injected into the reservoir to remove more oil from the pore spaces, increase production, and extend well life.

Most wells produce in a predictable pattern called a decline curve where production increases relatively rapidly to a peak, and then follows a long, slow decline. Operators may periodically perform well workovers to clean out the wellbore, allowing oil or gas to move more easily to the surface. Other measures to increase production include fracturing and treating the bottom of the wellbore with acid to create better pathways for the oil and gas to move to the surface. Formation fluids are then separated into oil, gas and water at a central production facility, designed and constructed depending on the reservoir size and location.

Crude oil processing essentially involves the removal of gas and water before export. Gas processing involves the removal of liquids and other impurities such as carbon dioxide, nitrogen and hydrogen sulfide. Oil and gas terminal facilities receive hydrocarbons from outside locations sometimes offshore and process and store the hydrocarbons before they are exported. There are several types of hydrocarbon terminals, including inland pipeline terminals, onshore / coastal marine receiving terminals (from offshore production), barge shipping, or receiving terminals.

Produced oil and gas may be exported by pipeline, trucks, or rail tank cars. Gas-to-liquids is an area of technology development that allows natural gas to be converted to a liquid. Gas is often exported as liquefied natural gas (LNG). Pipelines are constructed in a sequential process, including staking of the right-of-way (ROW) and pipeline centerline; ROW clearing and grading; trenching (for buried pipeline); pipe laying, welding, and bending; field coating of welded joints; testing; lowering; trench backfilling; and ROW reinstatement . Pumps or compressors are used to transport liquids or gas from the oil and gas fields to downstream or export facilities. During commissioning, flowlines, pipelines, and associated facilities (e.g. block valves and meters, regulators and relief devices, pump stations, pigging stations, storage tanks) are filled with water and hydrotested to ensure integrity. Pipeline operation usually requires frequent inspections (ground and aerial surveillance, and facility inspections) and periodic ROW and facility maintenance. Production and pipeline operation is usually monitored and controlled from a central location through a supervisory control and data acquisition system (SCADA) which allows field operating variables to be monitored such as flow rate, pressure, and temperature and to open and close valves.

Decommissioning and Abandonment

The decommissioning of onshore facilities occurs when the reservoir is depleted or the production of hydrocarbons from that reservoir becomes unprofitable. Parts of the onshore facilities, such as the aboveground facilities located in the oil or gas field area and along the transmission lines, are treated to remove hydrocarbons and other chemicals and wastes or contaminants and removed. Other components, such as flowlines and pipelines, are often left in place to avoid environmental disturbances associated with removal. Wells are plugged and abandoned to prevent fluid migration within the wellbore or to the surface. The downhole equipment is removed and the perforated parts of the wellbore are cleaned of soil, scale, and other debris. The wellbore is then plugged. Fluids with an appropriate density are placed between the plugs to maintain adequate pressure. During this process, the plugs are tested to verify their correct placement and integrity. Finally, the casing is cut off below the surface and capped with a cement plug.