Environmental and Social Impact Assessment Report (ESIA) – Part 7

Project Number: 51112-001
August 2018

INO: Jawa-1 LNG to Power Project

Prepared by ERM for PT Jawa Satu Power (JSP)

PLTGU Jawa 1 Independent Power Project

ANNEX F
WASTE REGULATORY REQUIREMENTS

Prepared for:

PT Jawa Satu Power (JSP)

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ANNEX F WASTE REGULATORY REQUIREMENT

Table F.1 List of Applicable Regulatory Documents

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
General Waste Management					
Act No 18 of 2008 regarding Waste Management	No	General	Republic of Indonesia	Waste management in general	General information on waste types and general implementation method
State Minister of Environment Regulation No 5 of 2009 regarding Waste Management at Port	Yes	Sea	Republic of Indonesia	• Prohibition to dispose waste from vessel routine operational or port supporting activities to sea; • Obligation to dispose waste to waste management facility at port; and • Facility permit and periodic reporting	The Project is responsible for their waste from routine ship operational activities and tank cleaning until it is received by the waste management company. Waste transmission must be reported by the Project responsible party for the ship to port administrator or head of port authority (Article 3)
State Minister of Transportation Regulation No PM 29 year 2014 regarding Pollution Prevention for Maritime Environment	Yes	Sea	Republic of Indonesia	Requirement for preventing pollution from operational activities conducted at Indonesian flagged ship and at port	Information for Project on pollution prevention from operating ship (Article 3)
Non Hazardous Waste - General					
Government Regulation No 81 year 2012 regarding Household and Household-Like Wastes (Garbage) Management	No	General	Republic of Indonesia	Waste minimisation program; Waste treatment hierarchy	The Project will need to prepare Plan/Program and perform waste minimisation, recycling, reuse and waste treatment (Article 12-16)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
State Minister of Environmental Decree No 112 year 2003 regarding Domestic Wastewater Quality Standard	No	Land	Republic of Indonesia	Quality standard for domestic wastewater generated	The Project will need to conduct domestic wastewater treatment to meet the required wastewater quality standard, provide closed and impermeable channel for wastewater disposal to prevent leakage to environment and provide sampling facility at the outlet of wastewater treatment system (Article 8)
State Minister of Environment Regulation No 12 year 2006 regarding Requirement and Procedure of Permit for Waste Water Discharge into Sea	Yes	Sea	Republic of Indonesia	Requirement and procedure of permit for wastewater discharge to sea and reporting	The Project will need to treat their wastewater to meet the requirement of this regulation and obtain wastewater discharging permit before this wastewater is discharged into the sea (Article 2-3)
State Minister of Environment Regulation No 19 year 2010 regarding Wastewater Quality Standard for Oil, Gas, and Geothermal Business and/or Activities	Yes	Water Media	Republic of Indonesia	• Applicable wastewater quality standard; and • Wastewater discharge management, including monitoring and reporting	The Project shall conduct wastewater discharge management, monitor wastewater quality at least 1 (one) time in a month, develop procedures in case of abnormal condition and/or emergency, record wastewater discharge rate daily, report wastewater discharge rate and quality at least every 3 (three) months to the relevant governmental agencies, report the occurrence of abnormal conditions within 2 x 24 hour and emergency situations within 1 x 24 hours to the relevant governmental agencies, and handle abnormal or emergency conditions by running a predetermined handling procedures (Article 10)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
State Minister of Environmental Regulation No 13 year 2012 regarding Implementation Guidelines for Reduce, Reuse and Recycle through Waste Bank	No	Land	Republic of Indonesia	This regulation is for reduce, reuse and recycle activities for Household and Household-Like Wastes (Garbage), through waste bank	Information for Project on the requirement, work mechanism, implementation and implementer of waste bank (Appendix I – III)
Hazardous Waste – General					
Government Regulation No 101 of 2014 regarding Hazardous and Toxic Waste Management	Yes	General	Republic of Indonesia	• Waste minimisation program; • Waste storage, storage period, permit, collection and disposal arrangement • Waste dumping; • Exclusion/delisting of hazardous waste; • By-products arrangement; • Environmental guarantee fund; • Transboundary movement; • Emergency response arrangement	The Project will need to minimise, submit a waste reduction implementation report, obtain hazardous waste temporary storage permit, and send the waste to licensed third party or utilise/process/dispose (if owning the permit) the hazardous waste (Article 10-12 and Article 28-29); and The Project can exclude some of their hazardous waste from specific source, after conducting the required characteristic test (LD50 and TCLP) (Article 192-195, and Attachment II)
Head of Environment Impact Management Decree No KEP-01/BAPEDAL/09/1995 regarding Procedures and Requirements for the Storage and Collection of Hazardous and Toxic Waste	Yes	Land	Republic of Indonesia	Procedures and requirement for storing and collection system	Information for Project on guidance and technical requirement of storage and collection of B3 waste (Article 5)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
Head of Environment Impact Management Decree No KEP-02/BAPEDAL/09/1995 regarding Hazardous and Toxic Waste Document	No	Other	Republic of Indonesia	Manifest and reporting	The Project shall ensure that the manifest shall be provided at the place of collection of hazardous and toxic waste by the generator of the waste for use when transporting it to a storage location outside the premises of generation or when collecting, transporting, treating, using, or disposing of the treatment products (Article 1)
Hazardous Waste – Transportation					
President Decree No 109 of 2006 regarding Emergency Response for Oil Spillage in the Sea	Yes	Sea	Republic of Indonesia	• Oil spill response, mitigation and reporting procedure; • Responsibility for cost caused; and • Levelling of oil spill emergency response (Tier 1 until Tier 3)	The Project will need to be responsible for responding the emergency condition on oil spill in the sea that come from their activities and to report the incident to the officer (Article 2)
State Minister of Transportation Decree No KM 69 of 1993 regarding Implementation of Goods Transportation	No	Land	Republic of Indonesia	• Permit for hazardous waste and material transporter; and • Requirement for vehicle equipment and operational method (loading/unloading, journey management)	Information for Project on the need of Government permit for the hazardous material and waste transporter and method of transporting hazardous material and waste (Article 12 and 15)
Director General of Land Transportation Decree No SK.725/AJ.302/DRJD/2004 regarding Implementation of Hazardous and Toxic Waste Transportation on Road	No	Land	Republic of Indonesia	• More detail requirement for hazardous and toxic waste's utilised vehicle; • Driver and helper of the vehicle Road path; and • How to operate the vehicle	The Project shall ensure that every vehicle must meet the general and specific requirements, relevant to the transported hazardous and toxic waste type and characteristic (Article 4)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
Circular Letter from Directorate General of Sea Transportation No UM.003/1/2/DK-15	Yes	Sea	Republic of Indonesia	Requirement for ship that transporting hazardous and toxic waste and format for the approval letter that need to be gained from the main harbour master	The Project shall ensure that the ship that they will use in hazardous and toxic waste transportation meet the requirement stated in this Circular Letter and have the approval from main harbour master prior to transporting the waste
International Convention for the Safety of Life at Sea (SOLAS), 1974	No	Water	International	• Minimum standards for the construction, equipment and operation of ships, compatible with their safety; • Fire Protection, Fire Detection and Fire Extinction; and • Carriage of Dangerous Goods	Information for Project on carriage of dangerous goods, including the requirement of packing, marking, labelling, placarding, documentation, storage, and to comply with International Bulk Chemical Code (IBC Code), International Gas Carrier Code (IGC Code), and International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code) (Chapter VII, Part A-D)
MARPOL - International Convention for the Prevention of Pollution from Ships (1973) consolidated Edition 2006	No	Water	International	• International convention covering prevention of pollution of the marine environment by ships from operational or accidental causes; • Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk; and • Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form	The Project shall not discharge residues containing noxious substances within 12 miles of the nearest land (Annex II)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
International Maritime Dangerous Goods (IMDG) Code Volume 1 (2006) and Volume 2 (2012)	Yes	Water	International	• Safe transportation or shipment of dangerous goods or hazardous materials by water on vessel; • List of harmful substances; and • Advice on the management of the materials including terminology, packaging, labelling, placarding, markings, stowage, segregation, handling, and emergency response	Information for Project on the implementation of IMDG code

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ANNEX G
VISUAL IMPACT ASSESSMENT

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1 INTRODUCTION

PT Pertamina (Persero), Sojitz Corporation and Marubeni Corporation (the Sponsors) have established a joint venture project company named PT Jawa Satu Power (JSP) to develop a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU), Combined Cycle Gas Turbine (CCGT) Power Plant, 500kV power transmission lines and Substation. Together, these elements comprise the PLTGU Jawa-1 Project (the Project).

The Project will be developed within the Karawang and Bekasi Regencies of West Java, Indonesia.

The construction of this Project is expected to commence in 2018. Operation of the 1,760 MW CCGT Power Plant and delivery of first power expected in 2021.

1.1 PURPOSE OF THIS REPORT

This report will determine visual impacts that might be brought about by the construction and operation of the Project. The assessment will establish the existing conditions of the Project area and where specific potential visual impacts or interactions with the environment are identified, provides suggested management recommendations to mitigate the potential visual impacts of the Project.

The Performance Requirements are incorporated into the Environmental Management Framework (EMF) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented within this report along with relevant suggested management and mitigation measures relating to the Project.

2 METHODOLOGY

The methodology used within this Visual Assessment is set out below.

Figure 2.1 Assessment Methodology

2.1 DEFINE THE VISUAL COMPONENTS OF THE PROJECT

Describe the key components of the Project that may contribute to visual impact during the construction and operation phases of the Project.

2.2 ESTABLISH STUDY AREA /VIEWSHED

The extent of the study area for visual assessment of the Project will be determined based on the Parameters of the Human Vision and the proposed visual changes that might be brought about by the project. This report will describe the extent of the study area as the Project viewshed.

The rationale behind the definition of the viewshed is appended to this report (Refer **Annex A**).

2.3 LANDSCAPE UNITS AND SENSITIVITY

This step seeks to determine areas of visual sensitivity within the view shed and the ability of those areas to accommodate the visual change of the project.

Landscape Units are underpinned by geology, soils, vegetation and drainage systems and statutory protection. However visually, Landscape Units often distil to predominant visual characteristics such as land-use, vegetation and topography, which have determined historical land management practices.

2.4 *SEEN AREA ANALYSIS*

Typically, a Seen Area Analysis is provided as part of a visual assessment to determine those areas from which key Project infrastructure may be screened from view by topography. This analysis utilises a GIS mapping study that is based on topography only. It does not consider the potential screening that may be afforded by vegetation and buildings.

The Project is located in agricultural plains of Karawang and Bekasi Regencies of West Java, Indonesia. The landscape surrounding the Project is flat with little topographical relief, which may afford screening of the Project.

It is therefore assumed that the Project is potentially visible throughout the viewshed the identified zones of visual influence.

2.5 *ASSESSMENT OF PUBLICLY ACCESSIBLE VIEWPOINTS*

The visual assessment of the Project will be undertaken from a selection of viewpoints, which provide for the range of view angles, distances and settings towards the Project.

Visual Impact Assessment (VIA) from the public domain is based on four criteria; visibility, distance, and landscape character & viewer sensitivity and viewer number. A description of influence of each of the four (4) criteria is outlined below.

Visibility: Project visibility can be affected by intervening topography, vegetation and buildings.

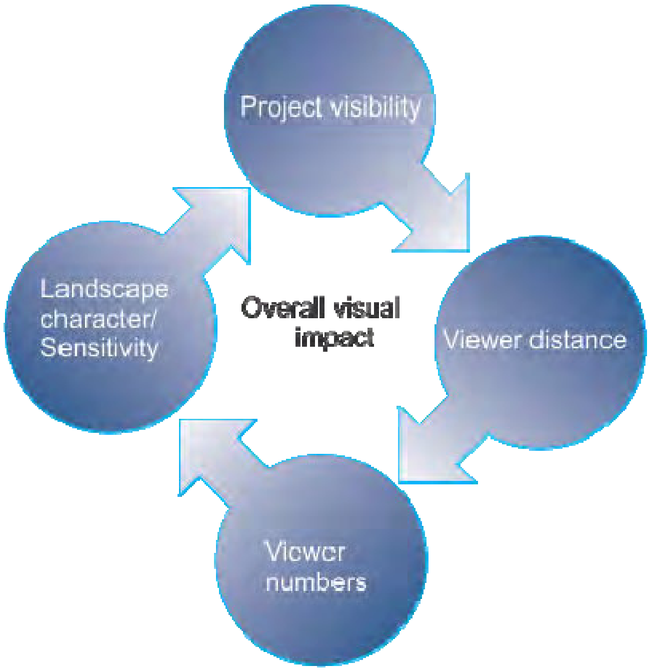
Distance: Visibility and scale of project infrastructure decreases as distance increases. This is considered by Zones of Visual Influence (ZVI) where an indication of impact based solely on distance is provided for.

Landscape character and viewer sensitivity: The character of the landscape around the site and adjacent to the viewing location will influence the ability of the project changes to be absorbed within existing change. That is, a landscape such as farmland is considered of low sensitivity, whereby a pristine landscape such as a national park is considered highly sensitive. Similarly, a greater sensitivity to visual change is afforded to a residential area or township than that of an industrial landscape.

Number of viewers: The level of visual impact decreases where there are fewer people able to view the Project. Alternatively, the level of visual impact may increase where views are from a recognised vantage point. Viewer numbers from a recognised vantage point would be rated as high.

The ratings of each criterion are not numerically based and cannot be simply added together and averaged to arrive at an overall rating. These four criteria need to be considered in the assessment of each viewpoint.

The overall effect of the Project at each viewpoint will be assessed by evaluating the value of each of those criteria, ranking those as being either low, moderate, or high, and subsequently making an assessment as to the overall effect by balancing each of those criteria.



2.6 SCALE OF EFFECTS

In a visual assessment, it is important to differentiate between a "visual impact" and a "landscape impact". Viewer numbers are important in the assessment of a visual impact, as if no one sees a particular development then the visual impact is nil, even though there may be a significant change to the landscape and hence a large landscape impact.

The overall visual impact of the Project when assessed from each viewpoints will use the following scale of effects:

- ***Negligible*** – minute level of effect that is barely discernible over ordinary day to day effects.
- ***Low adverse effect*** – adverse effects that are noticeable but that will not cause any significant adverse impacts.
- ***Moderate adverse effect*** – significant effects that may be able to be mitigated/remedied.

- ***High or unacceptable adverse effect*** – extensive adverse effects that cannot be avoided, remedied or mitigated.

A description of each of the effects is provided below:

Negligible Adverse effect: The assessment of a "*negligible*" level of impact is usually based on distance. That is, the Project is at such a distance that, when visible in good weather, it would be a minute element in the view across a modified landscape or screening afforded by vegetation can lead to a similar level of assessment.

Low adverse effect: The assessment of a "*low*" level of impact can be derived if the rating of any one of three factors, that is distance, viewer numbers and landscape sensitivity, is assessed as low. The reasoning for this "*low*" assessment is as follows:

- If the distance to the Project is great (i.e. towards the edge of the viewshed) then even if the viewer numbers and the landscape sensitivity were high, the overall visual impact would be minor because the Project would only just visible in the landscape.

- If viewer numbers were low, (i.e. few people can see the Project from a publicly accessible viewpoint); Project was close to the viewpoint and the landscape sensitivity was high, the overall visual impact would be low because the change would be seen by few viewers.

- If landscape sensitivity was low (i.e. within a highly modified landscape) then even if the Project was in close proximity to the viewpoint and it was visible to a large number of viewers, the overall visual impact would also be low because the viewpoint is not in a landscape of such sensitivity that further change would be unacceptable.

Moderate adverse effect: The assessment of a "*more than minor effect*" will depend upon all three assessment criteria (distance, viewer numbers and landscape sensitivity) being assessed as higher than "low"

High or Unacceptable adverse effect: The assessment of a "*high*" or "*unacceptable adverse effect*" from a publicly accessible viewpoint usually requires the assessment of all these three elements to be high. For example, a highly sensitive landscape, viewed by many people, with the development in close proximity would lead to an assessment of an unacceptable adverse effect. This assessment is also usually based on the assumption that such a view cannot be mitigated.

An example may be a well-frequented viewpoint in a National Park, that is in close proximity to the Project and that currently overlooks what appears to be a natural, pristine, un-modified landscape.

Landscape treatment would block this view and even though it would mitigate the view to the Reference Project such treatment would be unacceptable as it would also block the view from the lookout.

2.7 *MITIGATION MEASURES FOR PUBLICLY ACCESSIBLE VIEWPOINTS*

Where required, the ability for landscape mitigation to contribute to visual impacts will also be discussed at particular viewpoints or where required. For example, existing or supplementary roadside planting along a section of road or sensitive boundary may significantly reduce the visual impact of the Project.

2.8 *RESIDENTIAL VIEWPOINTS*

Visual impact from residential dwellings will be undertaken by way of representational view angles towards the edges within villages in proximity to the Project.

The assessment of visual impact from residences and villages is different to publicly accessible viewpoints in the following ways. An assessment of visitor numbers is not applicable and the landscape sensitivity is always rated as "high", as it must be recognised that people feel most strongly about the view from their dwelling and from their outdoor living spaces.

2.9 *MITIGATION MEASURES FOR RESIDENTIAL VIEWPOINTS*

Mitigation measures are also being considered and these will be evaluated to see how they may reduce the visual impact from residences.

2.10 *RECOMMENDATIONS*

Recommendations are based on the findings of this landscape and visual impact assessment.

3 PROJECT DESCRIPTION

The Project involves the development of a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU), Jetty and on-shore pumping, buried water and gas transfer pipelines, Combined Cycle Gas Turbine (CCGT) Power Plant, 500kV power transmission line and a Substation.

Figure 3.1 shows the location and layout of the key project components.

The following will describe the features of Project as relevant to assessing the visual impacts of the Project.

3.1 FLOATING STORAGE AND REGASIFICATION UNIT (FSRU)

The FSRU with a nominal capacity of approximately 82,000 metric tons at design draught (or 86,400 metric tons at summer draught) will be permanently moored offshore of Ciasem Bay within Subang Regency at a distance of approximately of eight (8) km off the north Ciasem Bay coast and at depth of 16 m of sea level.

The FSRU will receive LNG deliveries via Carriers, mainly from BP Tangguh Liquefaction Plant. The LNG transfer will occur between 19-27 times a year with a total capacity of 125,000 m^3 to 155,000 m^3. The onboard re-gasification system will process the LNG suitable for delivery to an Onshore Receiving Facility (ORF).

The key components of the FSRU relevant to visual assessment summarised below.

Table 3.1 FSRU Specifications

FSRU	Description
Dimensions	292.5 x 43.4 x 26.6 (m)
Draft	11.9 / 12.3 (Td summer)
Capacity	170,150 m^3

Figure 3.2 shows an FSRU of similar size and dimensions to that proposed by the Project.

Figure 3.1	*Project Layout*

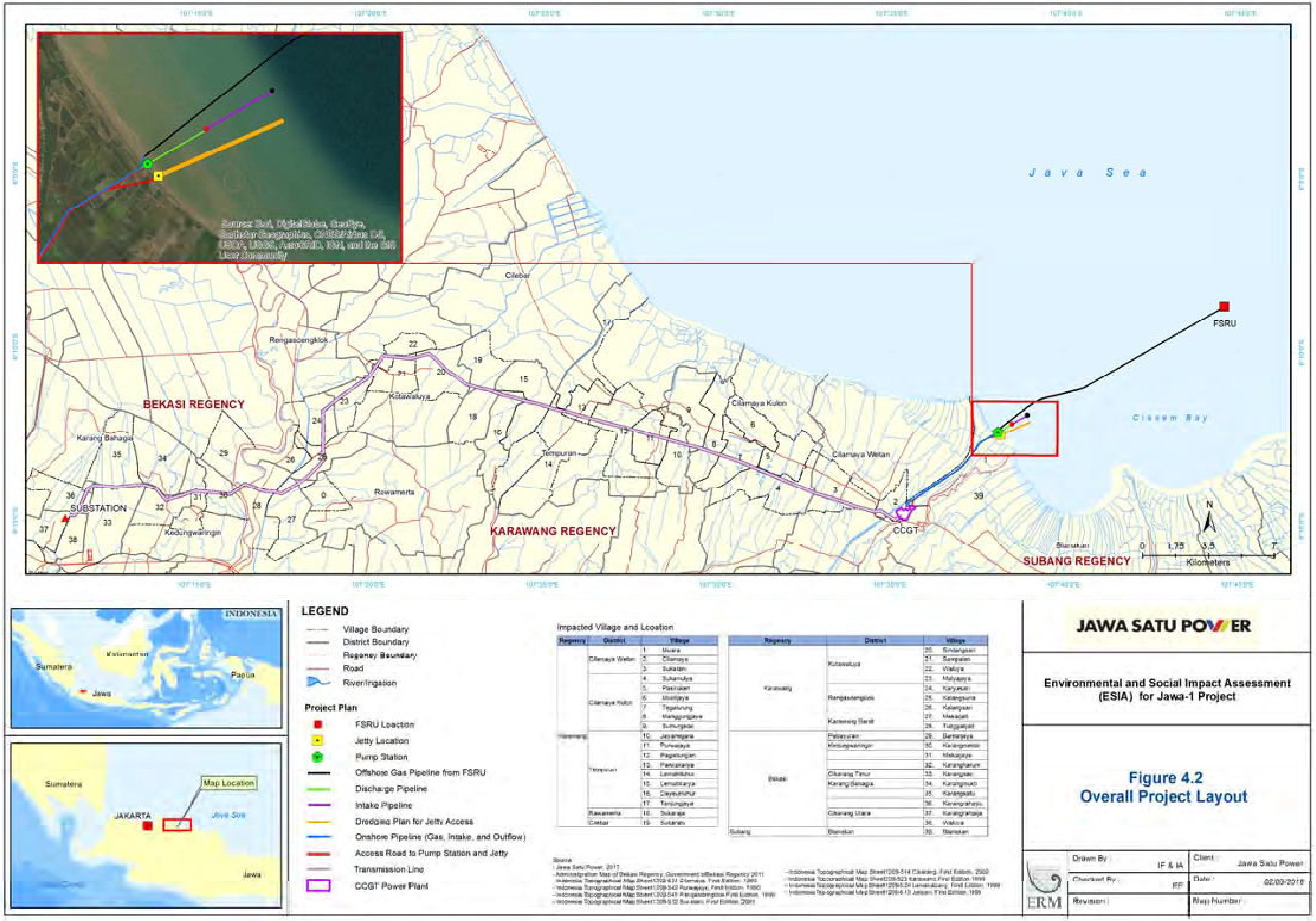


Figure 3.2 *Indicative FSRU*

Visually the FSRU will not be dissimilar to other ocean going vessels such as cargo ships and bulk material transporters and therefore commensurate and compatible with land based views towards the ocean.

Although the FSRU may be visible and potentially noticeable from the nearest land based viewing locations, because of the visual compatibility of the FSRU within ocean views, the visual change and impact would be minimal.

3.2 PIPELINES

The Project proposes to construct a gas pipeline for the purposes of transporting LNG between the FSRU and the power plant and water transfer pipes for cooling of power station.

3.2.1 *Gas Pipelines*

Gas transportation infrastructure will include approximately 14 km of sub-sea pipeline between the FSRU and shoreline and approximately seven (7) km of buried pipeline between the shoreline and the Onshore Receiving Facility (ORF) within the power plant site.

3.2.2 *Seawater Water Intake and Cooling Water Outfall Discharge Pipeline*

A seawater intake pipeline and pump station will be established close to shorefront. An offshore a cooling water discharge pipeline will also be established.

Figure 3.3 shows an existing buried pipeline corridor in close proximity to that proposed by this project.

Figure 3.3 Existing Pipeline Corridor

Once rehabilitated, the pipelines proposed by the Project would not be dissimilar to those that already existing in the area.

The majority of the onshore pipelines will be constructed within an existing easement. Following construction of the pipelines, the pipeline easements would be rehabilitated and returned to its current visual condition.

3.2.3 *Onshore Pumping station*

The onshore pumping station will deliver seawater the CCGT for various operational purposes including cooling and potable uses.

A pump station will be installed in a fenced enclosure at the Java Sea shoreline. The Pump station will be construed in a concrete basis approximately 25 m length x 7.8 m width x 12.7 m high. The floor of the basin will be approximately 9.6 m below the mean sea level (MSL) and the top of the basin approximately 3.1 m above MSL.

The site of the seawater pumping station (including electro chlorination plant, electrical building, etc.) will be elevated on the ground level of +2.6 m MSL, approximately two (2) m above high tide (+0.59m MSL).

An access road will be constructed beside the SKG Cilamaya ROW to connect the power plant to the Intake Pumping Station area. This road will be four (4) m wide.

With the exception of the on shore pump station for the cooling water system, all pipelines and associated infrastructure will be either under sea or buried and therefore not visible.

3.3 *JETTY*

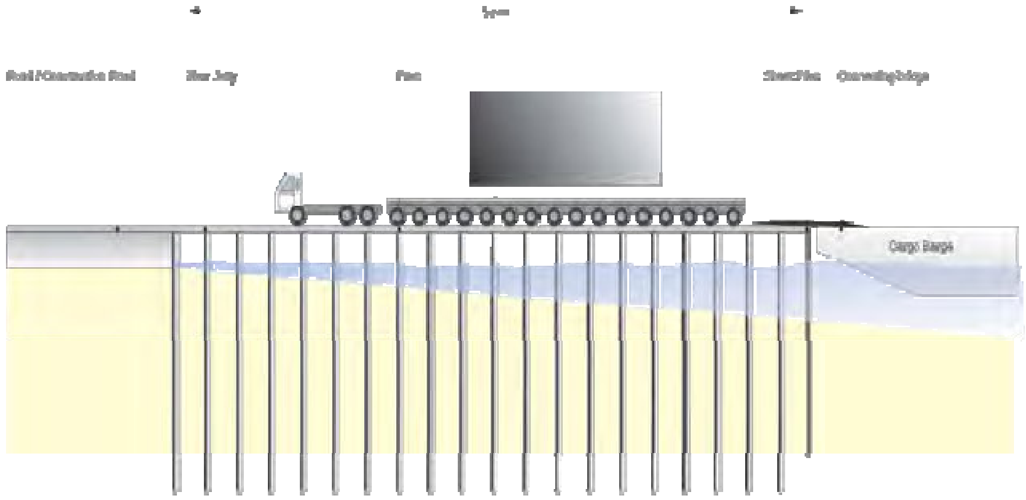
A new Jetty will be built to support mobilisation of heavy equipment and material. The jetty will be constructed at Muara Village, approximately 1.34 km from the mouth of the Cilamaya River. After the construction is complete, the jetty will remain to support emergency operations and CCGT maintenance.

Figure 3.4 shows the proposed location and layout of the Jetty in relation Muara Village, Cilamaya River, the surrounding land-use and other project infrastructure.

Figure 3.4 Jetty Location and Layout

The Jetty will be approximately 50 m L x 10 m w. Dredging is expected to be carried out during construction.

Figure 3.5 *Indicative Jetty Elevation*



The land take off point of the proposed Jetty is located amongst farming areas and the shoreline.

There are no nearby dwellings or roads, which would encourage visitors to the area or where people may see the Jetty. Visually the jetty would be similar to other Land/Sea supporting infrastructure found along the shoreline and in close proximity to the project.

3.4 CCGT POWER PLANT

The Combined Cycle Gas Turbine (CCGT) Power Plant will include the gas turbine buildings, cooling towers, noise walls, lighting, drainage works and associated infrastructure.

The CCGT development site is approximately 36.7 ha is area and lies to the north east of Cilamaya Village. The site was formerly part of a larger development site under the ownership of Pertamina (Persero). The site is currently undeveloped and used for agricultural purposes.

Site levels will be raised to 4.0m above mean sea level. A raised embankment with varying crest levels ranging from MSL+ 4.2 to MSL +6.0m MSL will surround the site to further flood proof the power plant.

The power plant complex will consist of five (5) main buildings supported by other infrastructure. The main buildings include the Onshore Receiving Facilities (ORF), two (2) turbine buildings, Heat Recovery Steam Generator (HRSG), Control and Electrical building (CEB), Cooling Towers, administration building and a workshop/warehouse building.

The key components relevant visual impacts is summarised below:

- Onshore Receiving Facility (ORF) will be located within a fenced compound to the north east of the power plant site. The ORF will be equipped with a control room and a meter room. A 70 m high vent stack and emergency flare.

- Two (2) turbine buildings, one (1) for each of the two (2) single shaft CCGT units. Each building has an area of 2,150 m^2 and will be 28 meters in height.

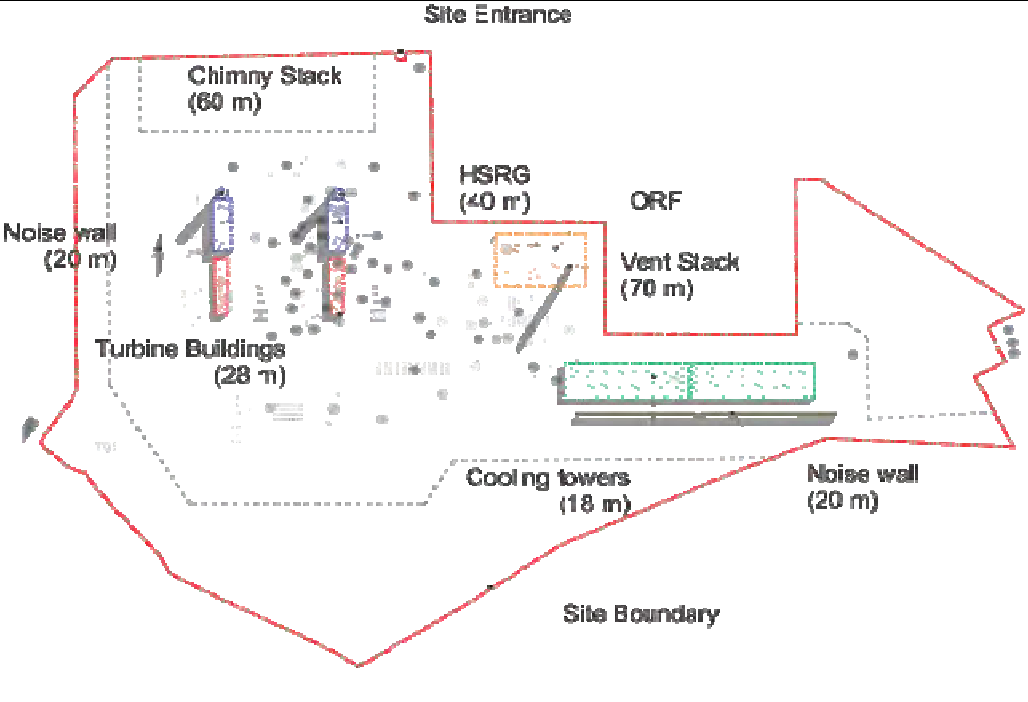
- Two (2) Heat Recovery Steam Generator (HRSG) will be housed in a building approximately 40 m in height with 60 m high, nine (9) m dia. Chimney Stack. Each will be equipped with a Continuous Emission Monitoring System (CEMS).

- Two (2) cooling tower blocks approximately 16 m L x 16 W x 18.7 m high will be constructed along the south eastern boundary of the site. The preliminary design includes 16 cells in each block. The final dimensions will be confirmed at the detailed design stage.

- A bank of cooling towers will be located in along the sites south eastern boundary. The Cooling Towers themselves are low level; however, a 20 m noise attenuation wall would be constructed along the length and to a height of 20 m.

Figure 3.6 shows the location and height of the key components relevant to visual impact.

Figure 3.6 *CCGT Key Visual Components*



Other buildings include:

- The Control and Electrical Building which houses the central control room, document room, kitchen/mess facilities, toilets, electronic and computer rooms, telecommunication room, MV and LV switchgear rooms and battery rooms.
- Administration Building will be constructed to include facilities such as a reception area, offices, meeting rooms and prayer room. The building will be not dissimilar is size and scale to others in the general area.
- The Workshop and Warehouse will contain machine tools, equipment, and storage of material required for routine maintenance.
- Service and Fire Water Storage system will comprise two (2) water storage tanks approximately 628 m^2.
- Chemical and Oil Storage Shelter (340 m^2) will store chemicals and lubricating oils for the operation and maintenance of the power plant.
- The Water Treatment Plant treat seawater for operational use throughout the plant including:
  - Cooling tower make up water;
  - Evaporative cooler make up water;
  - Process water (boiler make up, chemical dosing system dilution water, closed circuit cooling water make up etc.);
  - Service water (for cleaning and maintenance purposes);
  - Fire water; and
  - Potable water.

3.4.1 *Adjoining Boundaries*

Surrounding Land uses include paddy fields, and irrigation channel and linear village to the north, paddy fields to the east and south east, Cilamyan Village to the south west and the Pertagas Housing Complex to the west.

The plant sites adjoining boundaries include:

- An existing ROW, Power and LNG plant to the north,
- Paddy Fields to the south east,
- Cilamayan Village to the south west, and

3.4.2 *Jalan Simpang Tiga Pertamina (Road) to the west.*

The power plant site is set within an area that comprises a range of uses from agricultural and farming to industrial. The sites boundaries and adjoining development area shown in **Figure 3.7.**

Figure 3.7 *Adjoining Boundaries and Layout*

The components of the CCGT that will contribute to visual impacts are the 70 m high vent stack in the ORF, the 40 m high chimney stacks and buildings associated with the turbine generators, and the cooling blocks.

It is expected that the two noise walls to the south and west of the project would be solid and would therefore assist to shield views to some of the direct light sources within the plant.

3.4.3 *Visual Plume*

The CCGT Power Plant options indicate that a visual plume associated with either options of the Power Plant is rare to unlikely.

A visual plume due to particulates is unlikely unless there is a major engine fault. If this was to occur, the plume would be brief due to on board engine management systems that are designed to shut the engines down should in such an event.

Visual plumes due to water vapour are also possible and would likely occur on engine start-up on cold, damp mornings and where the exhaust system is also cold. This would also be short term until the engines and exhaust reach operating temperature.

Visual plumes associated with the conversion of NO to NO^2 generally occur where temperatures in the exhaust stacks are in excess of 500°C. This results in a slightly brown to red visual plume.

The Gas Fired Power Station options operate on natural gas. The exhaust temperatures for natural gas are less than 400°C and therefore below the temperature range where NO to NO2 conversion takes place. There is unlikely to be a visual plume associated with NO to NO2 conversion.

There is the potential for visual plumes to be generated by the Gas Fired Power Station. The most regular instance of visual plumes will be on engine start-up on cold damp mornings. When these occur, they will be short in duration and until the engines and exhausts, temperatures reach operation temperatures. The visual impact of visual plumes associated with the Gas-Fired Power Station will be low.

3.5 500 KV TRANSMISSION LINE

A new 52.16 kilometre transmission line will be developed to transfer electricity from the Power Plant to the Cibatu Baru II/ Sukatani substation. The transmission will be approximately 34 m wide.

The transmission corridor will pass through two regencies; Karawang and Bekasi and near to 35 villages. The proposed transmission line route crosses mainly areas of land used for agricultural purposes (rice paddy fields) (*Spatial Planning, 2011*) therefore limiting any requirement to remove vegetation or trees.

Upgrades to the local electricity grid would also be required for the pumping station.

3.5.1 Tower Design

The transmission line infrastructure will comprise up to 118 lattice transmission towers with an overall height of 50 m to the catenary wire.

There are six (6) tower types proposed to be installed across the project. The reason for the different types is to allow for flexibility in design to accommodate minimum clearance heights above various land-uses, variabilities in spans to clear ground based features and layout or articulation in the line.

Table 3.2 *Tower types*

Tower Type	Angle (deviation)
AA	**0° -5°**
BB	**0°-10°**
CC	**10° - 15°**
DD	**30° - 60°**
EE	**60° - 90 °**
FF	**Terminal Towers**

The standard lattice tower height proposed by the project is 36 m. Similar to the reasons above; this height will vary depending on span width, clearance heights and topography. Typical tower heights range from 36 m-3 (33 m above ground) to 36 m+12 (48). The height difference will not be perceptible over most distances. **Figure 3.8** shows a typical lattice tower.

Figure 3.8 *Indicative Transmission Towers*

At close distances, the pylons will appear large. Their apparent size will diminish over distance.

Table 3.3 shows the specifications for lattice towers and steel poles, which have formed the basis for both the visual impact assessment in this report.

Table 3.3 *Lattice Tower*

Span length on level ground	390 – 530 m
Height range	33 – 48 m
Base dimensions	10 – 12 m square
Top dimensions	1.5 x 7.5 m diameter
Height to lower conductor at tower/pole	20 – 36 m
Easement width	34 m

Insulator arrangement	Conventional cross arms
Typical foundation dimensions	4 off 0.9 m diameter (above ground), or 0.9 m diameter x 6 m deep pile

Source: Land Procurement for 500 kV Transmission Line & Substation of Jawa 1 Combined Cycle Power Plant IPP Project, June 2017

To ensure that this assessment is based on a 'worse case' scenario, this report has assumed that the following dimensions apply to all lattice towers have a height of 48 m and a span length on level ground of 360 m

3.5.2 *Ancillary Power Infrastructure*

Sections of existing distribution power lines will be upgraded to provide power for pumping station and marine Structures. These upgraded power lines will be a combination of single 66kV and 22kV construction.

Indicative photographs of the poles associated with this type of infrastructure are shown in **Figure 3.9.**

Figure 3.9 ***(Left to right) Single Circuit 66 kV with Subsidiary (Wood poles), Double Circuit 66 kV with Subsidiary***

Electrical infrastructure and light poles are found in many locations within the project area and is not considered to have a high visual impact.

3.6 *CIBATU BARU II/SUKATANI SUBSTATION*

A new 500kV substation will be developed at the western end of the new 500kV transmission line to the Java-Bali grid.

The substation will be located within an area currently used as paddy fields and agriculture. An existing 500 kV power line to the east of the site runs between Muara Tawar to the northwest and Cibatu to the south east.

Figure 3.10 shows location and setting of the proposed substation.

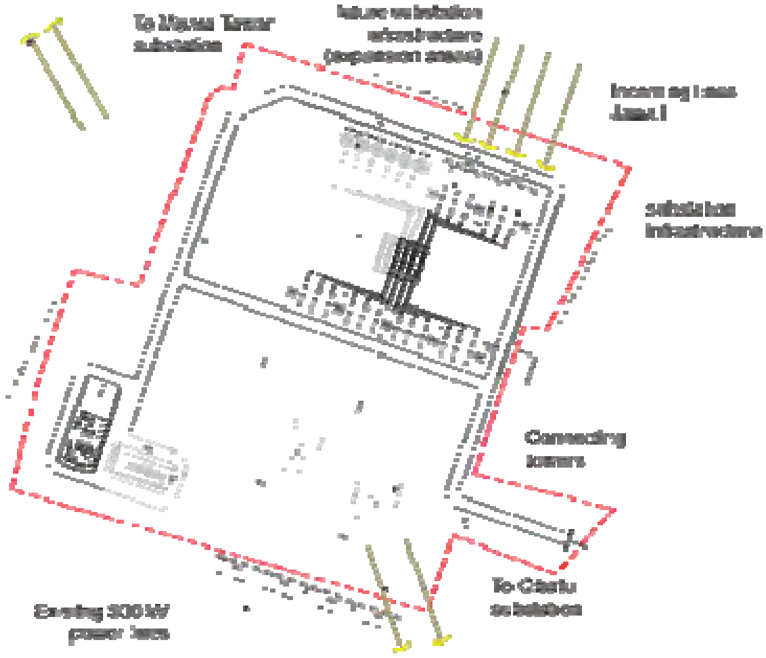
Figure 3.10 *Substation Location and surrounding area*

The existing 500 kV overhead power line and associated infrastructure are also located within agricultural land.

The 500kV Cibatu Baru II/Sukatani Substation will be an outdoor gas insulated design comprising:

- Two (2) outgoing lines to the 500kv Muara Tawar substation;
- Two (2) outgoing lines to the 500kv Cibatu substation; and
- Two (2) incoming lines from PLTGU Java-1 Power Plant.

Figure 3.11 Substation Layout



The substation area includes additional capacity for additional substation bays.

A small substation control building shall be provided which will consist of an office room, communications room, control room, and protection room.

Substation construction consists of control and switchyard building and:

- Transformer and assemblies;
- Filtering and internal wiring transformer equipment;
- Disconnecting Switch;
- Circuit Breaker;
- Lightning Arrester;
- Current Transformer;
- Positive Transformer;
- Neutral Current Transformer;
- Capacitor Voltage Transformer;
- Neutral Grounding Resistance;
- Panels and Cubicle Installation;
- Grounding System Installation; and
- Internal Wiring.

The substation and associated connecting infrastructure would be similar or at a lower scale to that of the existing 500 kV power line and the incoming lines from the Jawa1 Power Station.

3.7 CONSTRUCTION

This section will briefly describe the types of construction activities associated with the project as relevant to visual impact. This includes timeframes, material handling, plant, and equipment.

3.7.1 Pipelines

The onshore transfer Pipelines are approximately seven (7) km in length. The majority of the Transfer pipeline will be constructed using open trenching and backfilling. **Figure 3.12** shows the construction of a 1700 mm diameter steel pipe. Construction timeframes for open trenching allow for approximately 80 – 100 lineal meters per day within the construction area.

Figure 3.12 Typical Pipeline Construction

In addition, a seawater intake structure and pump station will be established in a fenced compound at the shoreline of the Java sea, close to the jetty and intake and discharge pipelines. The seawater will be abstracted using one (1) offshore intake pipe connected to a submerged intake head located in a dredged pit located at -4.5 meters MSL. The offshore intake pipe is preliminary sized at 1.3 meter diameter. The approximate length of the intake pipe is 2000 m.

The CCGT Power Plant process wastewater will be discharged using one (1) offshore discharge pipe connected to a submerged discharge diffuser located at -2.5m MSL. The offshore wastewater discharge pipe is preliminary sized at 0.9 meter diameter. The approximate length of the discharge pipe is 1000 m. The seawater intake pipeline and wastewater discharge pipeline will be made of HDPE material.

3.7.2 CCGT Power Plant

The construction of CCGT Power Plant is predicted to be completed within 36 months, which consists of material and heavy equipment mobilisations/demobilisation, installation of main building, supporting facilities and onshore gas pipes and commissioning test.

During the construction activities, it is expected that more than 4000 vehicles per year will be utilised for material transportation. This includes the mobilisation of the proposed construction equipment will include heavy equipment for land clearing and road construction such as bulldozer, loader, excavator, mobile crane, pile machine, molen, grader, scrapper, batching plant, asphalt mixing plant, and pile driver and gas turbine equipment transportation.

The majority of materials and heavy equipment will also be transported through temporary jetty for the CCGT construction.

3.7.3 500 kV transmission line

Tower foundation installation consists of land excavation, piling, setting, working floor making, stub shoes making, stub setting, crooked cut and supporting, formwork installation, cast preparation, earthing angle installation and grounding, cast foundation concrete, formwork disposal, filling and equipment demobilisation, and PLN boundary stacks installation.

Excavation to a depth of 3.5 m will be required where towers are located within the paddy fields or areas of soft ground. The excavated soils will be stockpiled for re-use following construction of foundations. The foundation of flooring will be constructed by drilling bore holes for the bored piers with a casing to prevent bore hole collapse prior to placing and shaping concrete.

Once the tower foundations are established, the lattice towers will be transported to site and assembled in place.

3.7.4 *Construction Camps*

Construction camps will be established at locations where accommodation is in short supply. Camps will be temporary only and used to shelter workers and storage of construction materials and equipment. Camp sites will be rented from the local community and rehabilitated following completion of construction.

There are no landscape techniques that can be employed to mitigate the visual impacts associated with the construction of the Project. However best practice construction management would be employed to maintain construction areas to the minimum required.

4 VIEWSHED

The viewshed is the area that can potentially be visually affected by a development or the zone of visual influence (ZVI). This report will use the term "viewshed". The viewshed extends to a distance at which the built elements are considered visually insignificant, even though they may still be visible.

The viewshed for the Gas-Fired Power Station has been based on an exhaust stack height of 70 m, which is the tallest proposed structure within the project.

The viewshed for the transmission lines and substation has been based on a tower height of 50 m.

No viewshed has been established for either the pipelines or on shore pumping station. This is because the pipelines will be buried and therefore not discernible once rehabilitated. The onshore pumping station would only be approximately 2 – 4 m above ground level and below the height of nearby and surrounding vegetation.

4.1 VIEWSHED DEFINITION

The extent of a viewshed for a development can be determined by an analysis based upon the parameters of human vision. For readers not familiar with the parameters of human vision these are set out in **Annex** A.

This analysis shows that a 70 m high structure becomes visually insignificant within this landscape at a distance of approximately 8.2 km.

This analysis shows that a 50 m high structure becomes visually insignificant within this landscape at a distance of approximately 5.7 km.

4.2 PROPOSED VIEWSHED FOR THE PROJECT

The extent of the viewshed and the ranges of visual impact are shown in **Table 4.1**. These tables also describe the levels of visual impact within the viewshed that will be used to assess the visual impact of the Project.

Table 4.1 *Viewshed and Zones of Visual Influence Gas-Fired Power Station*

Visual Impact	Vertical View angle	Distance CCGT	Distance 500 kV
Visually insignificant- A very small element in the viewshed, which is difficult to discern and will be invisible in some lighting or weather circumstances.	< 0.5°	<8.2 km	<5.7 km
Potentially noticeable, but will not dominate the landscape - The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer; however the wind turbines do not dominate the landscape.	0.5° - 1°	4.1 – 8.2 km	2.8 – 5.7 km
Potentially noticeable and can dominate the landscape - The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer	1°- 2.5°	1.6 - 4.1 km	1.2 - 2.8 km
Highly visible and will usually dominate the landscape - The degree of visual intrusion will depend on the wind turbines' placement within the landscape and factors such as foreground screening.	2.5° - 5°	800 m - 1.6 km	570 m – 1.2 km
Will be visually dominant in the landscape from most viewing locations - Unless screened by topography or vegetation, wind turbines will dominate the landscape in which they are sited.	>5°	800 m	570 m

Distance ranges are used as a guide to determine zones of visual impact. It is recognised that built form visibility does not dramatically change at each defined band. For example, visibility does not dramatically change when a viewer moves from 1.9 km to 2.1 km from the nearest proposed building, even though these locations are within different bands that, for the purposes of this analysis, show differing levels of impact. It must also be recognised that climatic factors such as rainfall, sea haze, cloudy skies and sun angle will also affect the visibility of development.

Figure 4.1 shows a view along an existing transmission line easement, west of the Project.

Figure 4.1 *Atmospheric Effects*

Here the atmospheric effects on the visibility of the existing transmission line can be seen. Where there is haze, fog or low visibility long views can be dramatically reduced.

5 THE SURROUNDING LANDSCAPE

This section of the report describes the physical characteristics of the existing landscape to determine the range of landscape units that exist within the viewshed.

5.1 TOPOGRAPHY

The Project is located within flat agricultural land and paddy fields. With the exception of villages and other community infrastructure, the area is primarily used for the rice growing. The predominant land management practise within the entire project area is flood irrigation.

Figure 5.1 shows the landscape at several locations the project viewshed.

Figure 5.1 Predominant Land Use

With the exception of developed urban and industrial areas and roads, the area is generally flat with little topographical variation.

5.2 VEGETATION

Vegetation plays an important role in determining landscape character, visibility and screening as well as landscape mitigation for sensitive uses such as villages and urban areas.

Based on the images shown in **Figure 5.2.** It is apparent that the majority of the land within the project area has been cleared for agricultural purposes. Canopy vegetation tends to be confined to road and track edges, along waterways, the margins of development and within private allotments. **Figure 5.2** shows vegetation at one such village within the project area.

Figure 5.2 *Vegetation around Villages*

The preceding sections have mapped those areas with existing vegetation and changes in topography. Other features that may determine landscape character are the presence of water. In the viewshed surrounding the Project.

The landscape units described in the following sections have been identified by a combination of the topographical and vegetative features as well as descriptions of the landscape character found within the Project viewshed.

6 *LANDSCAPE UNITS & CHARACTER*

Landscape units are based on areas with similar visual characteristics in terms of their ability to absorb visual change. Often the landscape units relate to areas with similar environmental, geological and land-use features. There are four predominant landscape units that have been identified within the Project viewshed. These are:

- Landscape Unit 1 – "Coastal";
- Landscape Unit 2 – "Agricultural";
- Landscape Unit 3 – "Townships/Residential"; and
- Landscape Unit 4 – "Industrial".

These landscape units are described in the following section.

6.1 *LANDSCAPE UNIT 1 – "COASTAL"*

The Landscape Unit 1 – "Coastal" runs along the coastline to the northeast of the Project. This landscape unit describes the narrow band of shoreline and mangroves, which runs along the ocean's edge.

Figure 6.1 shows a view of landscape unit 1 looking North West across proposed Jetty location.

Figure 6.1 View of the Coastline looking North West

Landscape Unit 1 is narrow and some sections are relatively inaccessible. The section of coast between the subject site and this landscape unit is well vegetated.

6.2 *LANDSCAPE UNIT 2 – "AGRICULTURAL"*

Landscape Unit 2 – "Agricultural" includes much of the area within the Project viewshed. These areas are low, lying with little topographical variation. Agricultural areas are typically covered with low vegetation, bisected by raised roads and tracks with canopy vegetation. Infrequently, Landscape Unit 2 contains trees and tall shrubs

Figure 6.2 shows the typical vegetation and landform characteristics of Landscape Unit 2.

Figure 6.2 Agricultural Land

This image demonstrates the flatness of landscape unit and fragmentation of views contributed to by vegetation along roadsides, track and within villages.

6.3 *LANDSCAPE UNIT 3 – "TOWNSHIPS"*

Landscape Unit 3 – "Townships" describes the urban areas, which include villages, residential areas, schools, businesses and places of worship as well as industrial and manufacturing precincts. There are 37 villages within the visual catchment of Project.

Figure 6.3 *Village Structures*

Housing and the landscape associated with residential areas generally tends to screen views to the surrounding rural areas. It is only on the periphery of townships that views across the adjacent agricultural areas are usually possible.

6.4 LANDSCAPE SENSITIVITY

Landscape sensitivity can be defined as the ability of a landscape to absorb visual change, and its visual influence thereof on the viewers. While change is an integral part of any landscape, development and infrastructure are significantly different to the natural processes that occur in a landscape. The sensitivity of viewers to change in the previously described landscape units will depend upon a number of factors, such as:

Location. The sensitivity of a viewer varies according to location. For example, visitors to a conservation reserves where the landscape appears untouched or pristine will be more sensitive to the imposition of new or modified elements within that landscape. The same viewer, travelling along roads in agricultural areas that contains highly modified landscape such as paddy fields or agricultural land, will be less sensitive to the presence of new elements.

Modifications or artificial elements are not confined to vertical structures or built-form. They also include removal of vegetation, visibility of roads, tracks, fences, power lines and other infrastructure - all of which decrease the sensitivity of a landscape to further change.

The rarity of a particular landscape. Landscapes that are considered rare or threatened are valued more highly by a particular community with an attachment to the particular landscape.

The scenic qualities of a particular landscape. Landscapes that are considered scenic because of dramatic topographical changes, the presence of water, coastlines, etc., may be extensive, however viewers have greater sensitivity to alterations within these scenic landscapes. As discussed above the presence of modifications or artificial elements including built form, roads, tracks, fences, silos and rail as well as farming practices including land clearing, cropping and burning, all decrease the sensitivity of a landscape's scenic qualities.

The landscape surrounding the Project has been extensively modified through agricultural practices. These practices include clearing of vegetation, levelling of land for cropping, construction of elevated roads and tracks and construction of irrigation and drainage infrastructure.

The resultant cleared landscape is interspersed with village, roads and agricultural buildings. Associated with these structures are plantings along roadsides or as shelter belts.

This landscape unit in which the Project is proposed to be located is not rare, nor is it high in scenic quality and for these reasons the landscape sensitivity is considered to be low.

However, it must be recognised that some people value the appearance of these areas, particularly paddy fields. For these viewers, the presence of the Project may be perceived as a high visual impact due to the presence of large-scale structures in a rural landscape.

Village and townships are also not an uncommon feature in the project area, nor are they of high scenic qualities. They often contain many forms of infrastructure and development including industrial areas, power and light poles as well as communication and other towers. However, given the concentration of housing which is a sensitive land-use, these have been given a moderate sensitivity rating.

Table 6.1 rates the sensitivity of the various landscape units within the visual catchment of the Project.

Table 6.1 Landscape Sensitivity

Landscape Unit	Sensitivity	Comments
Landscape Unit Type 1 "Coastal"	**HIGH**	Planning controls, strategies and guidelines all support the value of this coastal edge.
Landscape Unit Type 2 "Agricultural"	**LOW**	These areas contain many man-made modifications to a landscape type that has been largely cleared and, what vegetation is evident, is often planted wind breaks.
Landscape Unit Type 3 "Townships"	**MODERATE**	Views from residential townships are always important, so there is an increased sensitivity. However, urban areas are also able to accommodate change, as that is a regular occurrence within this type of landscape unit.

7 ASSESSMENT OF THE VISUAL IMPACT FROM PUBLICLY ACCESSIBLE VIEWPOINTS

The viewpoints selected to determine the extent of visual impact from publicly accessible locations is shown **Figure 7.1.**.

Figure 7.1 Map showing Viewpoint Locations

Each viewpoint is described in *Table 7.1* and will be discussed in detail in the following section.

As discussed in Section 4, this assessment will consider viewing locations within 1.6km of the Project, as this was determine that viewpoints within this distance have the greatest potential for visual impacts.

Views within this distance are also influenced by the benefit of screening afforded by existing vegetation.

Table 7.1 Viewpoint Locations

VP	Description	Distance to nearest Project boundary	VP	Description	Distance to nearest Project boundary
PPVP1	Jl. Raya Muara CIlamaya	480m NW	T20-30C	Unknown Road	860m NE
PPVP2	Jl. Simpang Tiga Pertamina	20m NE	T20-30D	Unknown Road	135m NE
PPVP3	Jl. Simpang Tiga Pertamina	10m E	T30-40A	Jl. Raya Junti	215m NW
PPVP4	Jl. Simpang Tiga Pertamina	25m SE	T30-40B	Unknown Road	150m SW
T0-10A	Jl. Singa Perbangsa Dusun Kostim	520m SW	T30-40C	Unknown Road	385m N
T0-10B	Jl. Singaperbangsa	870m S	T40-50A	Unknown Road	215m NW
T0-10C	Raya Tegal Urung	1.1km SW	T40-50B	Jl. Raya Pebayuran	75m SE
T0-10D	Raya Tegal Urung	1.2km SW	T40-50C	Jl. Kalenderwak Panjang	355m NW
T10-20A	Polo Cebang	485m SW	SVP1	Jl. Kampang Pisang Batu	835m N
T20-30A	Unknown Road	135m E	SVP2	Jl. Rawa Makmur	690m NE
T20-30B	Unknown Road	680m N			

7.1 *POWER PLANT VIEWPOINT 1 – JL. RAYA-MUARA CILAMAYA*

Power Plant Viewpoint 1 is located on Jl. Raya-Muara Cilamaya approximately 780m north west of the proposed CCGT Power Plant.

PPVP1 GPS (48M 787865E, 9309671S)

Figure 7.2 *Power Plant Viewpoint 1 looking South West*

Figure 7.2 shows the view looking south west towards the proposed CCGT Power Plant across rice paddies which has a low landscape sensitivity.

This view also shows existing vegetation located next to roadways and at the rear of villages and urban development. This vegetation will filter views for those users of the road when looking towards the project. In an urban setting or village location this vegetation will screen or filter views to the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Table 7.2 CCGT Power Plant VP 1 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed CCGT Power Plant	Approx. 780m south west	Low
Distance to proposed Pipeline	Approx. 480m north west	Low
Overall visual impact		**Low**

7.2 *POWER PLANT VIEWPOINT 2 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 2 is located on Jl. Simpang Tiga Pertamina approximately 20m south west of the proposed CCGT Power Plant.

PPVP2 GPS (48M 786343E, 9308724S)

Figure 7.3 Power Plant Viewpoint 2 looking North

Figure 7.3 shows the view looking north towards the proposed CCGT Power Plant across the school. **Figure 7.4** shows the existing vegetation located along the northern edge of the school and along the side of the roadway. This vegetation will assist in filtering or screening views towards the proposed development.

This vegetation will filter views for those within the school grounds and users of the roadwhen looking towards the project.

This view also shows existing infrastrucutre such as light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Figure 7.4 View of Vegetation along Northern Edge of School

Table 7.3 CCGT Power Plant VP2 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 20m north east	Moderate
Overall visual impact		**Moderate**

7.3 *POWER PLANT VIEWPOINT 3 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 3 is located on Jl. Simpang Tiga Pertamina approximately 10 m west of the proposed CCGT Power Plant.

PPVP3 GPS (48M 786233E, 9308975S)

Figure 7.5 *Power Plant Viewpoint 3 Looking East*

Figure 7.5 shows the view looking east towards the proposed CCGT Power Plant from the entry to the Pertagas housing complex. Views towards the project from the entry way are across a gap in roadside vegetation.

Figure 7.6 shows an aerial view of the complex. This aerial view shows that the extensive vegetation located within the complex would assist in filtering views to the Project.

Figure 7.6 Aerial view of Housing Complex

Table 7.4 CCGT Power Plant VP3 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 10m east	High
Overall visual impact		**Moderate-High (Prior to mitigation)**

7.4 *POWER PLANT VIEWPOINT 4 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 4 is located on Jl. Simpang Tiga Pertamina approximately 25m north west of the proposed CCGT Power Plant.

PPVP4 GPS (48M 786164E, 9309138S)

Figure 7.7 ***Power Plant Viewpoint 4 looking South East***

Figure 7.7 shows the view looking south east towards the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Figure 7.8 *View of Housing to North*

This view also shows existing vegetation located next to the ROW and within the villages and urban development. This vegetation will filter views for those users of the road when looking towards the Project. In an urban setting or village location this vegetation will screen or filter views to the Project.

Table 7.5 ***CCGT Power Plant VP 4 - Summary of Visual Impact***

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 25m south east	Moderate
Overall visual impact		**Moderate**

7.5 *VIEWPOINT T0-10 A – JL. SINGA PERBANGSA DUSUN KOSTIM*

Viewpoint T0-10A is located on Jl. Singa Perbangsa Dusun Kostim approximately 520m north east of the proposed Transmission Line.

Viewpoint T0-10A GPS (48M 784822E, 9309721S)

Figure 7.9 Viewpoint T0-10A looking South

Figure 7.9 shows the view looking south towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation and development that allows views towards the Project. Vegetation located along the roadside within the residential areas will filter views for those users of the road when looking towards the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.6 Transmission Viewpoint T0-10A - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 520m south west (T06C)	Low
Overall visual impact		**Low**

7.6 *VIEWPOINT T0-10 B – JL. SINGAPERBANGSA*

Viewpoint T0-10B is located on Jl. Singaperbangsa approximately 870m north of the proposed Transmission Line.

Viewpoint T0-10B GPS (48M 783501E, 9310473S)

Figure 7.10 Viewpoint T0-10B looking South

Figure 7.10 shows the view looking south towards the proposed transmission line across the canal between built form within the residential area. This landscape character has a moderate level of sensitivity to change.

Existing vegetation along the edge of the canal as well as built form either side of the image will block the majority of the view towards the Project. The canal allows for a small unobstructed view towards the Project.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.7 Transmission Viewpoint T0-10B - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 870m south (T09C)	Low
Overall visual impact		**Low**

7.7 *VIEWPOINT T0-10 C – RAYA TEGAL URUNG*

Viewpoint T0-10C is located on Raya Tegal Urung approximately 1.1km north east of the proposed Transmission Line.

Viewpoint T0-10C GPS (48M 781944E, 9311292S)

Figure 7.11 Viewpoint T0-10C looking South West

Figure 7.11 shows the view looking south west towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation and development that allows views towards the Transmission Line. Vegetation located along the roadside and within the residential areas will filter views for those users of the road when looking towards the Project.

Whilst this view is clear of any vegetation or infrastructure, at a distance of 1.1km the transmission line will form a small element in the view and is not inconsistent with the surrounding infrastructure in a view metres down the road.

Table 7.8 Transmission Viewpoint T0-10C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 1.1km south west (T13C)	Low
Overall visual impact		**Low**

7.8 *Viewpoint T0-10 D - Raya Tegal Urung*

Viewpoint T0-10D is located on Raya Tegal Urung approximately 1.2km north east of the proposed Transmission Line.

Viewpoint T0-10D GPS (48M 779413E, 9312433S)

Figure 7.12 Viewpoint T0-10D looking South

Figure 7.12 shows the view looking south towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a narrow gap in roadside vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

This view also shows existing infrastructure to the centre of the image. This infrastructure will appear in similar scale to the taller visible elements of the Project such as the transmission line.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.9 *Transmission Viewpoint T0-10D - Summary of visual impact*

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 1.2km south west (T19C)	Low
Overall visual impact		**Low**

7.9 *VIEWPOINT T10-20A – POLO CEBANG*

Viewpoint T10-20A is located on Polo Cebang on the outskirts of the township approximately 485m north of the proposed Transmission Line.

Viewpoint T10-20A GPS (48M 773675, 9313551)

Figure 7.13 Viewpoint T10-20A looking South East

Figure 7.13 shows the view looking south east towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

Figure 7.14 shows the vegetation within and along the southern edge of the township. This along with the buildings within the township will assist in filtering views.

Figure 7.14 View Along Back of Housing at Edge of Township

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.10 Transmission Viewpoint T10-20A- Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 485m south west (T31C)	Low
Overall visual impact		**Low-Moderate**

7.10 *VIEWPOINT T20-30A– UNKNOWN ROAD*

Viewpoint T20-30A is located on a local unknown road approximately 135m west of the proposed Transmission Line.

Viewpoint T20-30A GPS (48M 767744E, 9314682S)

Figure 7.15 *Viewpoint T20-30A looking East*

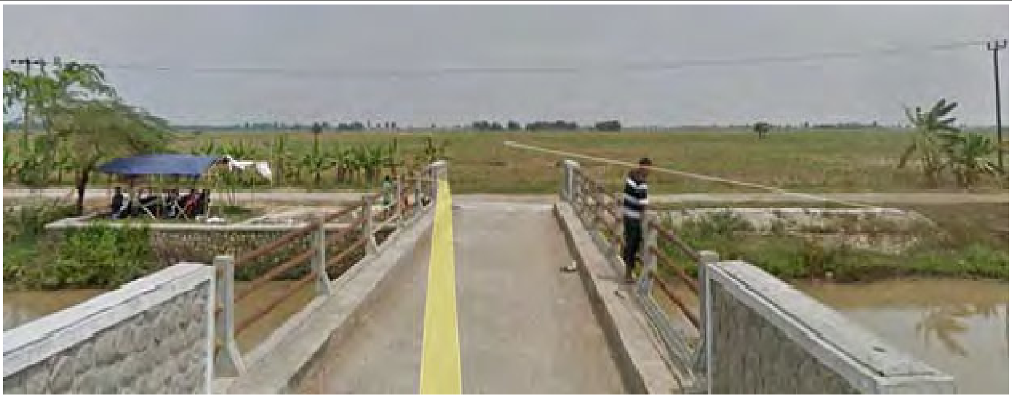


Figure 7.15 shows the view looking east along the alignment of the transmission line. This view is taken from the bridge near the T-intersection of the road and allows for a clear view of the Project.

This view also shows existing infrasturcutre such as electricity poles. From this location at only 135m away, the transmission line tower will be central to the view and will appear larger in scale to the existing infrastructure.

Table 7.11 ***Transmission Viewpoint T20-30A - Summary of visual impact***

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 135m east (T44C)	Low
Overall visual impact		**Low-Moderate**

7.11 *VIEWPOINT T20-30B– UNKNOWN ROAD*

Viewpoint T20-30B is located on a local unknown road approximately 680m south of the proposed Transmission Line.

Viewpoint T20-30B GPS (48M 766449E, 9314300S)

Figure 7.16 Viewpoint T20-30B looking North

Figure 7.16 shows the view looking north towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in roadside vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.12 Transmission Viewpoint T20-30B - Summary of visual impact

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 680m north (T47C/TS9)	Low
Overall visual impact		**Low**

7.12 *VIEWPOINT T20-30C– UNKNOWN ROAD*

Viewpoint T20-30C is located on a local unknown road approximately 860m south west of the proposed Transmission Line.

Viewpoint T20-30C GPS (48M 762305E, 9315609S)

Figure 7.17 Viewpoint T20-30C looking North East

Figure 7.17 shows the view looking north east towards the proposed transmission line across the canal between built form within the residential area. This landscape character has a moderate level of sensitivity to change.

Existing vegetation along the edge of the canal as well as built form to the right of the image will block the majority of the view towards the Project to the east. The canal allows for an unobstructed view towards the western section of the Project.

Table 7.13 Transmission Viewpoint T20-30C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 860m north east (T57C)	Low
Overall visual impact		**Low**

7.13 *VIEWPOINT T20-30D– UNKNOWN ROAD*

Viewpoint T20-30D is located on a local unknown road approximately 135m south west of the proposed Transmission Line.

Viewpoint T20-30D GPS (48M 761891E, 9316883S)

Figure 7.18 Viewpoint T20-30D looking North

Figure 7.18 shows the view looking north towards the proposed transmission line.

This view appears to be over local grave sites as shown in **Figure 7.19**. This would have a higher sensitivity to change that the agricultural land that surrounds it.

Figure 7.19 View of Graves

Table 7.14 Transmission Viewpoint T20-30D - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 135m north east (T59C)	Low
Overall visual impact		**Low**

7.14 *VIEWPOINT T30-40A– JL. RAYA JUNTI*

Viewpoint T30-40A is located on Jt. Raya Junti approximately 215m south east of the proposed Transmission Line.

Viewpoint T30-40A GPS (48M 758984E, 9316597S)

Figure 7.20 Viewpoint T30-40A looking North East

Figure 7.20 shows the view looking north east towards the proposed transmission line across the mosque development located within the residential area. This landscape character has a moderate to high level of sensitivity to change.

Existing built form of the mosque will block views to parts of the Project to the north.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.15 Transmission Viewpoint T30-40A - Summary of visual impact

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 215m north west (T67C/TS12)	Low
Overall visual impact		**Moderate**

7.15 *VIEWPOINT T30-40B–UNKNOWN ROAD*

Viewpoint T30-40B is located on a local unknown road approximately 150m north east of the proposed Transmission Line.

Viewpoint T30-40B GPS (48M 755813E, 9312406S)

Figure 7.21 Viewpoint T30-40B looking South West

Figure 7.21 shows the view looking south west towards the proposed transmission line across the canal between built form within the residential area to the right of the image and rice paddies to the left. This landscape character has a low level of sensitivity to change.

Existing vegetation as well as built form to the right of the image will block the majority of the view towards the Project to the north. The canal allows for an unobstructed view towards the south western section of the Project.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.16 Transmission Viewpoint T30-40B - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	150m south west (T81C)	Low
Overall visual impact		**Low**

7.16 *VIEWPOINT T30-40C–UNKNOWN ROAD*

Viewpoint T30-40C is located on a local unknown road approximately 385m south of the proposed Transmission Line.

Viewpoint T30-40C GPS (48M 753569E, 9309684S)

Figure 7.22 Viewpoint T30-40C looking North West

Figure 7.22 shows the view looking north west towards the proposed transmission line across the canal between built form or temple structure to the right of the image and extensive vegetation and residential development to the left. This landscape character has a low level of sensitivity to change.

Existing vegetation as well as built form to the right of the image will block the majority of the view towards the Project to the north east. The canal allows for an unobstructed view towards the north western section of the Project.

Table 7.17 Transmission Viewpoint T30-40C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 385m north (T88C) Nearest tower in view – 470m north west (T89C)	Low
Overall visual impact		**Moderate**

7.17 *VIEWPOINT T40-50A–UNKNOWN ROAD*

Viewpoint T40-50A is located on a local unknown road approximately 215m south east of the proposed Transmission Line.

Viewpoint T40-50A GPS (48M 752775E, 9309307S)

Figure 7.23 Viewpoint T40-50A looking North

Figure 7.23 shows the view looking north across the canal and weir structure towards the proposed transmission line.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.18 *Transmission Viewpoint T0-10A - Summary of visual impact*

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 215m north west (T90C/TS19)	Low
Overall visual impact		**Low**

7.18 *VIEWPOINT T40-50B– JL. RAYA PEBAYURAN*

Viewpoint T40-50B is located on Jt. Raya Pebayuran approximately 75m north west of the proposed Transmission Line.

Viewpoint T40-50B GPS (48M 751272E, 9309916S)

Figure 7.24 *Viewpoint T40-50B looking West*

Figure 7.24 shows the view looking west towards the proposed transmission line. This view is taken from a small gap in roadside vegetation and development that allows views towards the Project.

Bands of vegetation within the view will assist in filtering views towards the proposed transmission line.

Figure 7.25 shows the view looking south east along the roadway. The proposed transmission tower will be approximately 75 m away. The existing roadside vegetation being closer to the view will appear a similar or larger scale to the proposed transmission tower and will therefore assist in filtering views.

Figure 7.25 *View looking South East along Roadway*

This view also shows existing infrastructure such as electricity and light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.19 *Transmission Viewpoint T40-50B - Summary of visual impact*

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	75m south east (T93C/TS21), Nearest tower in view 240m west (T94C/TS22)	Low
Overall visual impact		**Low**

7.19 *VIEWPOINT T40-50C– JL. KALENDERWAK PANJANG*

Viewpoint T40-50C is located on Jt. Kalenderwak Panjang approximately 335m south east of the proposed Transmission Line.

Viewpoint T40-50C GPS (48M 744048E, 9309906S)

Figure 7.26 Viewpoint T40-50C looking North

Figure 7.26 shows the view looking north towards the proposed transmission line. From this section of residential development, existing development and vegetation will filter or screen the majority of views towards the proposed transmission line.

This view also shows existing infrastructure such as electricity and light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.20 Transmission Viewpoint T40-50C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 355m north west (T112C)	Low
Overall visual impact		**Low**

7.20 *SUBSTATION VIEWPOINT 1 – JL. KAMPUNG PISANG BATU*

Substation Viewpoint 1 is located on Jt. Kampung Pisang Batu approximately 835m south of the proposed Substation.

Substation VP1 GPS (48M 741824E, 9308317S)

Figure 7.27 *Substation Viewpoint 1 looking North*

Figure 7.27 shows the view looking north towards the proposed substation.

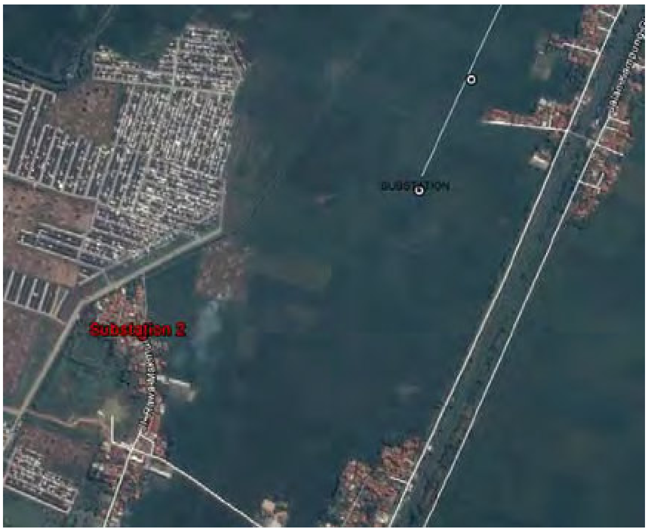
This view also shows existing infrastructure such as the existing transmission line. The proximity of this infrastructure to viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line towers and substation infrastructure.

Table 7.21 Substation Viewpoint 1 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Substation	Approx. 835m north	Low
Overall visual impact		**Low**

7.21 *SUBSTATION VIEWPOINT 2 – JL. RAWA MAKMUR*

Substation Viewpoint 2 is located on Jt. Rawa Makmur approximately 690m south west of the proposed Substation.



Substation VP2 GPS (48M 741500E, 9308775S)

Figure 7.28 Substation Viewpoint 2 looking North East

Figure 7.28 shows the view looking north towards the proposed substation at a gap in residential development.

This view also shows existing infrastructure such as the existing transmission line. The proximity of this infrastructure to viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line towers and substation infrastructure.

Table 7.22 *Substation Viewpoint 2 - Summary of visual impact*

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Substation	Approx. 690m north east	Low
Overall visual impact		**Low**

7.22 ASSESSMENT OF THE VISUAL IMPACT DURING CONSTRUCTION

Major construction activities will include:

- clearing of vegetation;
- excavation of the shafts and tunnels;
- general earthworks (including topsoil stripping, excavation, filling, topsoil spreading and rehabilitation works);
- building construction;
- drainage installation (including, where required, measures to protect water quality and groundwater flows);
- power connection;
- equipment fabrication and installation; and
- landscaping.

The major areas that will be visible would be the earthworks and temporary structures such which may include material stockpiles, laydown areas and concrete batching plant.

The operational lighting of the Project will be minimised where practical whilst maintaining light levels adequate for safety and security. The CCGT and substation site will be the only project elements that require night lighting.

The majority of critical equipment (that may require operational personnel at night) will be within and around the base of buildings. Some light will be expected to spill from the buildings through windows.

Plant lighting will be visible from roads and the margins of villages where vegetation does not currently screen or filter views to the project.

The area around the proposed CCGT and many of the villages located within the entire project area already contains many examples of night lighting either through street lighting, shops and business or form within dwellings.

Figure 8.1 shows existing lighting associated with the existing power plant to the north of the CCGT.

Figure 8.1 *Existing Power Plan*

Figure 8.2 Village Lighting

Existing vegetation found within the villages and roadsides that surround the CCGT site will assist to reduce the visual impact of night lighting over time to a moderate to low level of illumination.

8.1 LIGHTING DURING CONSTRUCTION

Extensive and intense lighting will be required consistently during the construction period. This lighting will have a much greater impact, as it will be more concentrated and an obvious change on the coastal plain.

However, given the existing lighting in the village and townships its addition, while noticeable, will not have a great visual impact.

9 LANDSCAPE MITIGATION

This section provides an overview of landscape mitigation strategies available to mitigation the predicted visual impacts of the Project.

Landscape planting is a mitigation option for residential properties or fixed viewpoints. Planting may be designed to either screen or significantly reduce the visual dominance through filtering. The effectiveness of landscape as a mitigation measure varies in accordance with landowner objectives and visibility of the Project.

9.1 REDUCING VISUAL IMPACT BY LANDSCAPING ALONG ROADS

Landscape mitigation is a proven method whereby even large existing structures, such as the 500 kV power line or 70 m vent stack can be screened from view.

Strategic landscaping may be installed in publicly accessible areas or along the boundaries of sensitive locations to assist with screening views to project features. For example, vegetation may provide screening of views if undertaken along sections of the rear of villages where breaks in vegetation permit views to the project from sensitive areas.

Figure 9.1 shows an existing view along a roadway within a village area.

Figure 9.1 ***Potential Mitigation along Roads***

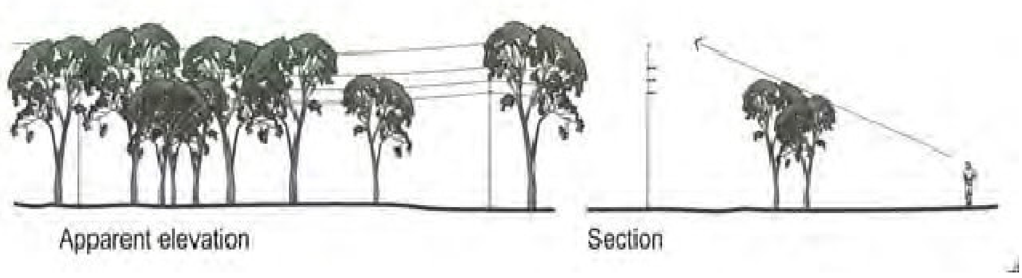
Planting such as that shown in **Figure 9.1** can easily screen views of large infrastructure even when in close proximity to a sensitive receptor.

A number of options are illustrated below which may be appropriate at different locations and for various Project infrastructure.

9.1.1 Tree Planting

It is clear from photographs in the preceding chapters that vegetation in this area can reach heights sufficient to screen or filter views to even the largest Project features. This screening can be achieved by planting large trees in front of power lines. Even though they might be smaller than that of the lattice towers, it is the effect of perspective that will afford the screening potential of the foreground vegetation.

Figure 9.2 Vegetation in the Foreground

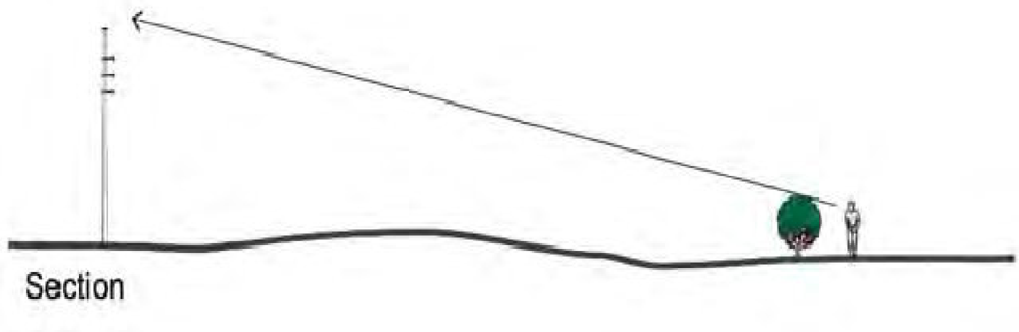


In **Figure 9.2**, trees planted between the power lines and the viewer. They have the potential to completely screen the poles and interconnecting wires.

9.1.2 Smaller planting near a viewer

When planted near the transmission towers and / or poles, trees need to reach almost the height of the poles to screen them from view. However if planting is located closer to an observer it needs to reach only 2-3 m before it forms an effective screen.

Figure 9.3 Foreground Planting



This example is particularly appropriate immediately adjacent to residential viewpoints where the owner does not like large trees or where there is insufficient space for their establishment.

10 CONCLUSION

This assessment has reviewed the likely landscape and visual impacts of the Project. The Project will be located within an "Agricultural Plain" that is flat and with little topographical variation. This landscape is one with low sensitivity to visual change and one that has the ability to absorb the visual change of such a proposal.

The landscapes within the project viewshed are not rare or unique. There are no protected areas or landscapes that would attract a high level of visual sensitivity in the region, particularly the beaches running along the water's edge.

The major impact may be on nearby adjacent residential properties; particularly those that lie along the edges of villages and that are oriented toward the project. For the majority or residential dwellings, it would appear that the visual impact would be minimal due to existing planting that screens views to the Project.

It is also clear that were visual impacts from sensitive locations may be experienced that landscape mitigation strategies that include new landscaping around either the proposed CCGT or in off-site locations such individual residential properties along the transmission corridor would be possible.

This is demonstrated by the existing vegetation in views and images contained within the assessment.

Annex A

Parameters of Human Vision

PARAMETERS OF HUMAN VISION

The visual impact of a development can be quantified by reference to the degree of influence on a person's field of vision. The diagrams on the following pages illustrate the typical parameters of human vision. These provide a basis for assessing and interpreting the impact of a development by comparing the extent to which the development would intrude into the central field of vision (both horizontally and vertically).

Horizontal Cone of View

The central field of vision for most people covers an angle of between 50^{O} to 60^{O}. Within this angle, both eyes observe an object simultaneously. This creates a central field of greater magnitude than that possible by each eye separately.

This central field of vision is termed the 'binocular field' and within this field images are sharp, depth perception occurs and colour discrimination is possible.

These physical parameters are illustrated in the figure opposite.

The visual impact of a development will vary according to the proportion in which a development impacts on the central field of vision. Developments, which take up less than 5% of the central binocular field, are usually insignificant in most landscapes (5% of $50^{O} = 2.5^{O}$).

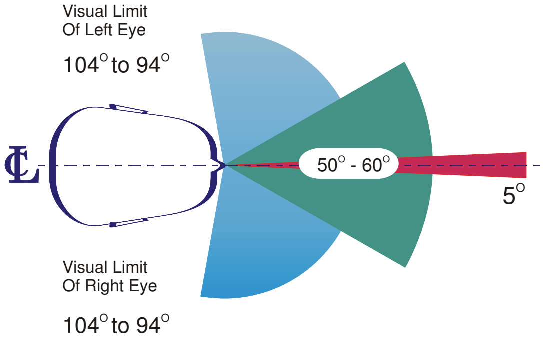


Figure A.1 Horizontal Field Of View

Table A.1: Visual Impact based on the Horizontal Field of View

Horizontal Field of View	Impact	Distance from an observer to a 500m wide built form
<2.5^{O} of view	Insignificant The development will take up less than 5% of the central field of view. The development, unless particularly conspicuous against the background, will not intrude significantly into the view. The extent of the vertical angle will also affect the visual impact.	> 11.5km
2.5^{O} – 30^{O} of view	Potentially noticeable The development may be noticeable and its degree of visual intrusion will depend greatly on its ability to blend in with its surroundings.	866m – 11.5km

>30° of view	Potentially visually dominant Developments that fill more than 30 percent of the central field of vision will always be noticed and only sympathetic treatments will mitigate visual effects.	< 866m

These calculations suggest that the impact of a built form stretching approximately 500m wide reduce to insignificance at 11.5km, as they would form less than 5% or 2.5° of the horizontal field of view.

Vertical Field of View

A similar analysis can be undertaken based upon the vertical line of sight for human vision.

The typical line of sight is considered to be horizontal or 0°. A person's natural or normal line of sight is normally a 10° cone of view below the horizontal and, if sitting, approximately 15°.

Objects, which take up 5% of this cone of view (5% of 10° = 0.5°) would only take up a small proportion of the vertical field of view, and are only visible when one focuses on them directly. However, they are not dominant, nor do they create a significant change to the existing environment when such short objects are placed within a disturbed or man-modified landscape.

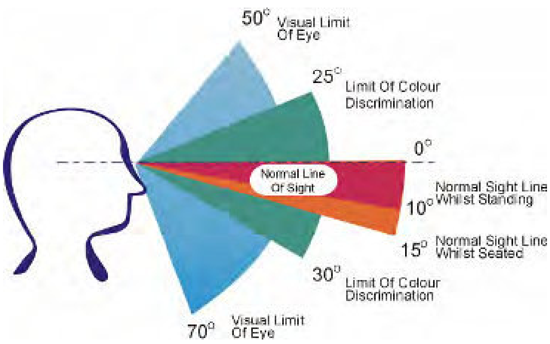


Figure A.2 Vertical Field Of View

The table below shows the relationship between impact and the proportion that the development occupies within the vertical line of sight.

Table A.2 Visual Impact based on the Vertical Field of View

Vertical Line of Sight	Impact	Distance from an observer to a 20m high built form
< 0.5° of vertical angle	Insignificant A thin line in the landscape.	>2,291 metres
0.5° – 2.5° of vertical angle	Potentially noticeable The degree of visual intrusion will depend on the development's ability to blend in with the	450 – 2,291 metres

	surroundings.	
> 2.5° of vertical angle	Visually evident Usually visible, however the degree of visual intrusion will depend of the width of the object and its placement within the landscape.	< 450 metres

These calculations suggest distances at which the magnitude of visual impact of the built form associated with the Project is reduced with distance.

At distances greater than 2.5 km, a fully visible 20 m high building would be an insignificant element within the landscape. At distances from 0.5 km to 2.5 km the built form would be potentially noticeable and at distances less than 0.5 km the built form (without intervening topography or vegetation) would be a dominant element in the landscape.

Proposed Viewshed & Zones of Visual Influence

The preceding analysis shows that a 500 m wide built form recedes into an insignificant element in the landscape at approximately 11.5 km. A building that is 20 m high recedes to an insignificant element in the landscape at approximately 2.5 km

Usually the extent of the viewshed is based on the lower number. This may seem counter intuitive, but one needs only to examine the visual impact of a farm fence. Whilst the fence may be many kilometres long, visible across the top of a ridgeline, the distance at which it recedes into an insignificant element in the landscape, is based on its height. A one metre high fence is indiscernible at a distance of a few hundred metres. Similarly, in this case the vertical field of view analysis is a better indicator of viewshed.

However to be conservative it is proposed that the viewshed extend out to 4km and that the zones of visual influence are also set at conservative levels. These are set out in **Table A.3**.

Table A.3 *Viewshed and Zones of Visual Influence*

Distance from an observer to the Project	Zones of visual influence
	Visually insignificant – outside the viewshed A very small element, which are difficult to discern and will be invisible in some lighting or weather conditions.
2-4 km	*Potentially noticeable, but will not dominate the landscape.* The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer; however, the wind turbines do not dominate the landscape.
0.5 – 2 km	*Potentially noticeable and can dominate the landscape.* The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer
<0.5 km	*Highly visible and will usually dominate the landscape* The degree of visual intrusion will depend on the buildings placement within the landscape and factors such as foreground screening.

PLTGU Jawa 1 Independent Power Project

ANNEX H
QUANTATIVE RISK ASSESSMENT

Prepared for:

PT Jawa Satu Power (JSP)

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1 INTRODUCTION

1.1 BACKGROUND

The PLTGU Jawa-1 Project ("Jawa-1 Project") involves the development of a Liquefied Natural Gas Floating Storage and Regasification Unit (FSRU), a Subsea Pipeline, an Onshore Pipeline, a Combined Cycle Gas Turbine (CCGT) Power Plant, a 500 kV power transmission lines and a Substation. These elements of Jawa-1 Project will be developed within the Karawang and Bekasi Regencies of West Java, Indonesia.

PT Pertamina (Persero), Sojitz Corporation and Marubeni Corporation (together, the "Sponsors") have concluded an agreement to develop Jawa-1 Project via a project company named PT. Jawa Satu Power (JSP).

Sponsors are seeking a financial investment from "Lenders" i.e. a consortium of Japan Bank for International Corporation (JBIC), Nippon Export and Investment Insurance (NEXI), Asian Development Bank (ADB) and a group of Equator Principles Financing Institutions (EPFIs). Jawa-1 Project is therefore required to comply with the applicable bank's health and safety policies, developed for managing the health and safety risks.

PT ERM Indonesia (ERM) is assisting the Sponsors and Lenders to develop a Quantitative Risk Assessment (QRA) Study to meet the requirements. This QRA Study is performed for the Jawa-1 Project facilities including FSRU, Subsea Pipeline, Onshore Pipeline and CCGT Power Plant which poses as major accident hazards to the surrounding off-site public.

Findings from this QRA Study will be incorporated in the Environmental and Social Impact Assessment (ESIA) from the community perspective along with the appropriate risk reduction measures where necessary.

1.2 SCOPE OF WORK

The scope of work for this QRA Study includes the following Jawa-1 Project facilities with potential major accident hazards to the surrounding off-site population:

- FSRU, including LNG storage, LNG regasification, high pressure natural gas send-out;
- LNG unloading operation from LNG CARRIER;
- Subsea Pipeline;
- Onshore Pipeline; and
- CCGT Power Plant.

1.3 *OBJECTIVE*

The objective of this QRA Study is to assess the risk levels associated with the operation of the Jawa-1 Project facilities including FSRU, Subsea Pipeline, Onshore Pipeline as well as CCGT Power Plant, and compare the risks against the risk criteria stipulated in the British Standard EN 1473: 2007 in terms of individual risk and societal risk for the surrounding off-site public if applicable.

2 *PROPOSED QUANTITATIVE RISK ASSESSMENT METHODOLOGY*

The elements of this QRA Study are depicted in **Figure 2-1**, and each of the elements is depicted as follows:

2.1 *HAZARD IDENTIFICATION*

This QRA Study concerns the fire and explosion hazards associated with the transport, storage and use of hazardous material (e.g. LNG, natural gas, hydrogen, diesel, etc.) for the Jawa-1 Project facilities, including the FSRU, Subsea Pipeline, Onshore Pipeline and CCGT Power Plant. The associated failures may be partial or catastrophic because of corrosion, fatigue, etc., and were taken into account for the detailed analysis in this QRA Study.

2.2 *FREQUENCY ANALYSIS*

This task involves the frequency analysis for each of the identified hazardous scenarios. Frequency analysis includes quantification of the frequency of the initiating events (e.g. pipework failure), and conducting Event Tree Analysis (ETA) to model the development of an event to its final outcomes (pool fire, flash fire, jet fire, fireball, vapour cloud explosion, etc.).

2.3 *CONSEQUENCE ANALYSIS*

Consequence analysis involves the modelling of the physical effects, and *PHAST* version 6.7 (*PHAST*), was adopted in this QRA Study. Consequence modelling results were used to establish levels of harm to critical equipment at varying distances from the identified hazards. Probit equations were used to relate levels of harm to exposure.

2.4 *RISK SUMMATION AND ASSESSMENT*

Risk summation was conducted using *SAFETI 6.7*, which calculates the risk based on different failure outcomes, failure event location, and weather conditions prevailing at the Jawa-1 Project facilities location. This step involves the integration of consequence and frequency data to give the risk results in terms of the required risk measures.

The products of the frequency and consequence for each outcome event above were summed and the total risk expressed in individual risk and societal risk terms. Individual risk results were presented as iso-risk contours overlaid on the Jawa-1 Project facilities plot plan. The acceptability of the risks for the surrounding off-site population was compared with risk criteria stipulated in the British Standard EN 1473 in terms of individual risk and societal risk.

2.5 *RISK MITIGATION*

The practical and cost-effective risk mitigation measures based on this QRA Study are recommended, if required, to demonstrate the risks are as Low As Reasonably Practicable (ALARP).

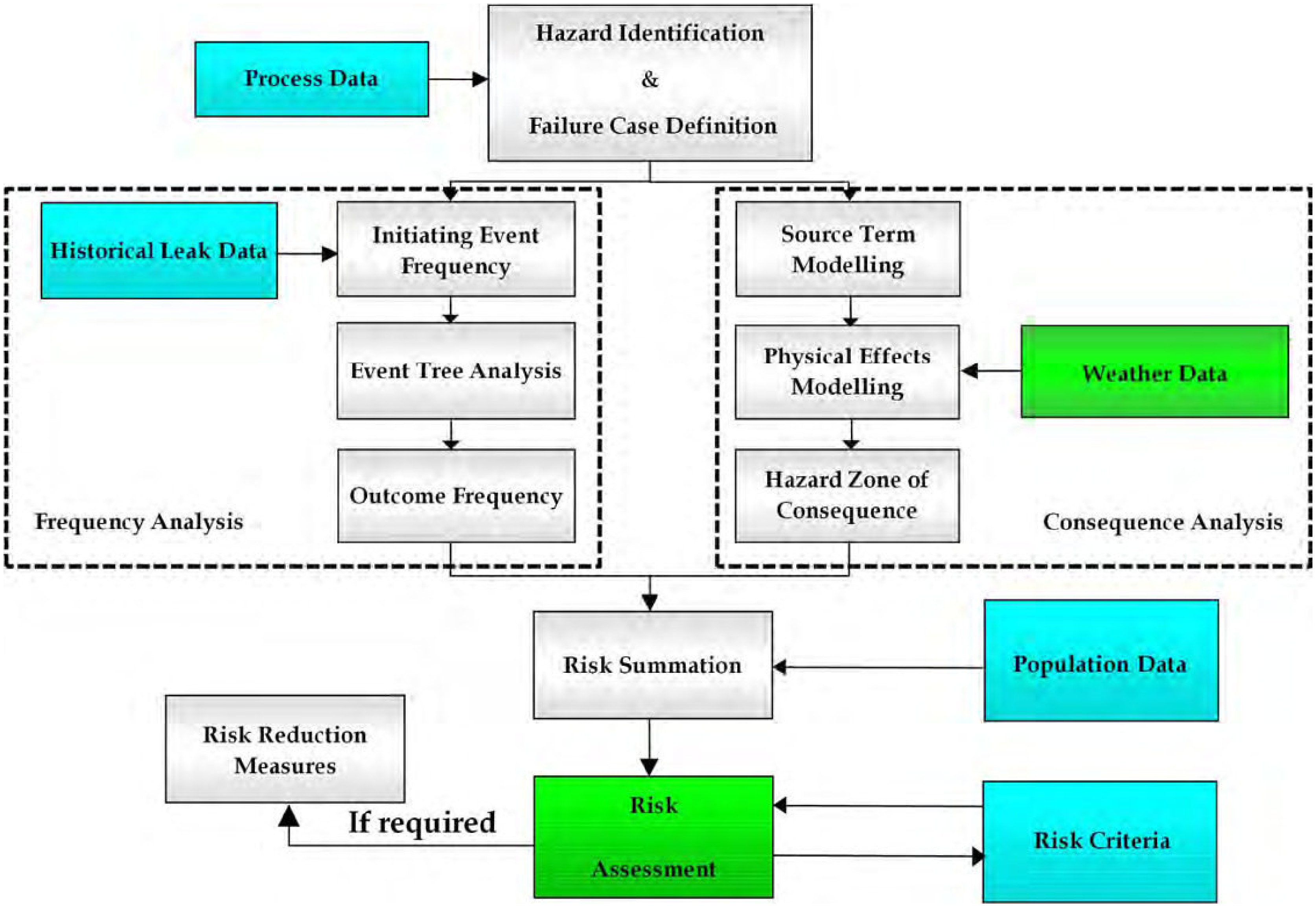


Figure 2-1 Proposed Quantiative Risk Assessment Methodology

3 DESCRIPTION OF SURROUNDING ENVIRONMENT

3.1 SURROUNDING OFF-SITE POPULATION IN VICINITY OF JAWA-1 PROJECT

3.1.1 Marine Population

The Indonesian Government Regulation No. 5 Year 2010 regarding Navigation, article 38 describes two (2) zones for navigational aids, which are:

- Prohibited zone within 500 m radius from the outermost point of a navigational aids installation or building; and
- Limited zone within 1,250 m radius from the outermost point from the prohibited zone.

These zones are set to protect the navigational aids from other activities. Furthermore, article 40 explains that marine ships/ vessels can only pass outside these two (2) zones.

Based on this regulation, the likelihood of having passing vessels in the vicinity of FSRU is deemed to be unlikely. In addition, generally the credible hazardous scenarios associated with the FSRU is not foreseen to reach outside 500 m. Nevertheless, it is conservatively assumed that about 100 fishing vessels per day passing through the 500 m radius from the FSRU.

The marine population for the fishing vessels is assumed as five (5) persons per one marine vessel and assumed as outdoor population without any protection.

3.1.2 Land-Based Population

Three villages including Muara, Cilamaya and Cilamata Wetan were identified in the vicinity of the onshore pipeline and CCGT power plant, the associated land-based off-site population for each village is summarised in **Table 3-1** and **Figure 3-1**.

Table 3-1 Land-Based Office LNG, Natural Gas and Other Dangerous Goods Associated with Onshore Jawa-1 Project Facilities

Village No.	Description	Total Population#	Area (km^2)	Population Density (per km^2)
1	Muara	4,759	14.12	337
2	Cilamaya	13,432	3.79	3,544
3	Cilamaya Wetan	137,047!	38.67	3,544*

Note *: The population density for Cilamaya Wetan village was conservatively assumed as high as that for Cilamaya, which is the highest among all villages in Karawang Regency as per ERM's survey.
Note #: It is conservatively assumed that 50% land-based population is within indoor.
Note !: Total population for Cilamaya Wetan is estimated using the assumed population density and the associated area.

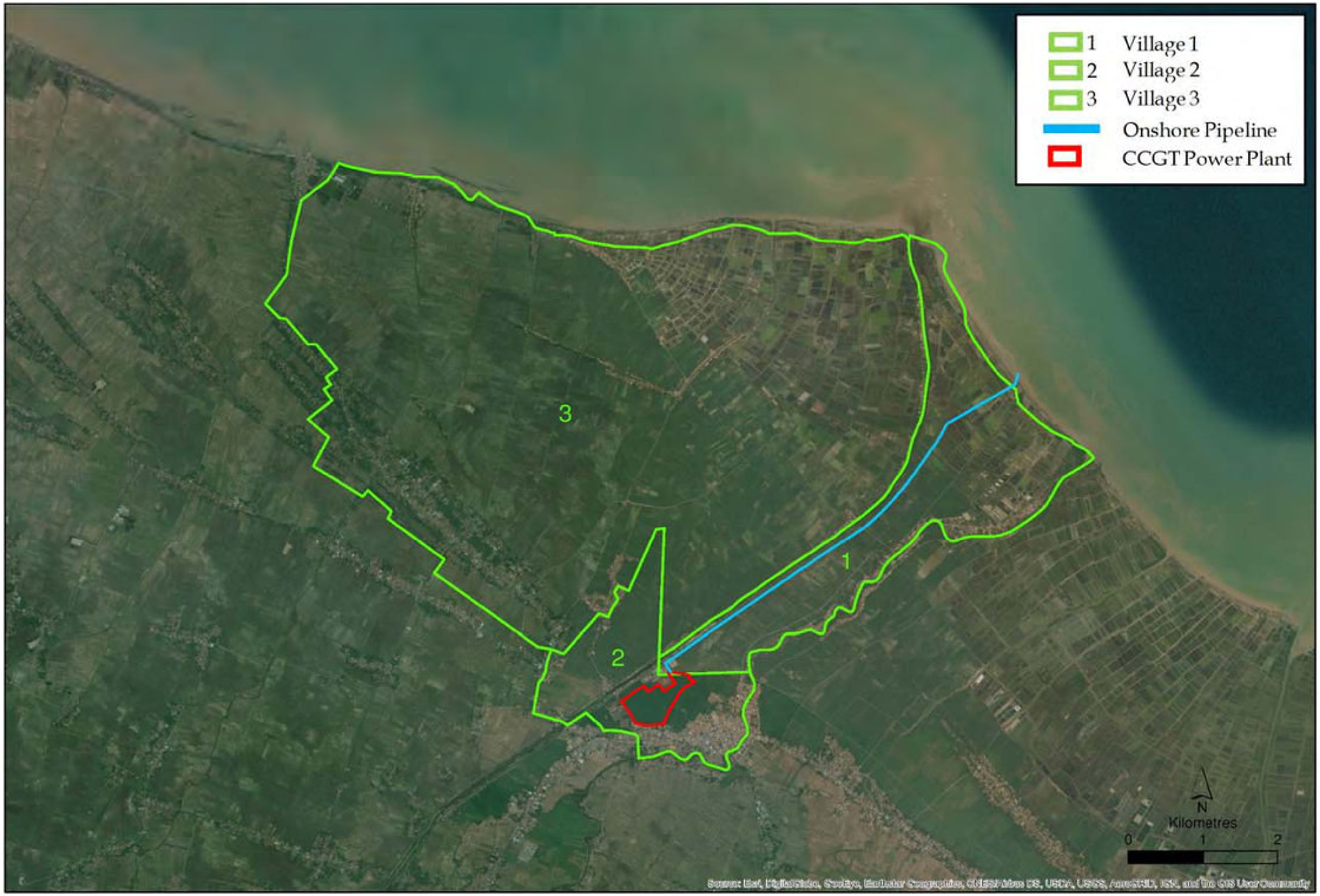


Figure 3-1 Land-Based Off-site Population in the Vicinity of Onshore Jawa-1 Project Facilities

3.2 *Environmental Conditions*

Based on the historical meteorological data, the average temperature and humidity for this QRA Study are summarised as below.

- 25.0 °C and 90% for offshore Jawa-1 Project facilities; and
- 26.9 °C and 80% for onshore Jawa-1 Project facilities.

The surface roughness of 0.2 mm for open water and 10 cm for land-based were adopted for the detailed consequence analysis as part of this QRA Study.

3.3 *Meteorological Data*

The 10-year meteorological data from Year 2000 to Year 2009 at the FSRU location from Badan Meteorologi, Klimatologi, dan Geofisika (BMKG), the Indonesia Agency for Meteorology, Climatology, and Geophysic, has been selected to represent local meteorological conditions including wind speed, wind direction, atmospheric stability class, temperature, and relative humidity.

With reference to "Guidelines for Quantitative Risk Assessment, CPR 18E (Purple Book)", at least six (6) representative weather classes are recommended and used in this QRA Study, covering the stability conditions of stable, neutral and unstable, low and high wind speed. At least the following six (6) weather classes have to be covered in terms of Pasquill classes.

- "B" stability class, with medium wind speed (3 – 5 m/s);
- "D" stability class, with low wind speed (1 – 2 m/s);
- "D" stability class, with medium wind speed (3 – 5 m/s);
- "D" stability class, with high wind speed (8 – 9 m/s);
- "E" stability class, with medium wind speed (3 – 5 m/s); and
- "F" stability class, with low wind speed (1 – 2 m/s).

The probability of each weather state for each direction during the day and night are rationalised for analysis based on the requirements presented in "Guidelines for Quantitative Risk Assessment, CPR 18E (Purple Book". Based on the analysis on raw data, the summary of meteorological data for offshore and onshore Jawa-1 Project facilities are presented in **Table 3-2** and **Table 3-3**, which was used for this QRA Study.

The wind speeds are quoted in units of meters per second (m/s), while the atmospheric stability classes refer to:

- A – Turbulent;
- B – Very Unstable;
- C – Unstable;
- D – Neutral;
- E – Stable; and

- F – Very Stable.

Atmospheric stability suppresses or enhances the vertical element of turbulent motion. The vertical element of turbulent motion is a function of the vertical temperature profile in the atmosphere (i.e. the greater the rate of decrease in temperature with height, the greater the level of turbulent motion). Category D is neutral and neither enhances nor suppresses turbulence.

Table 3-2 Historical Meteorological Data at FSRU Location from BMKG (Year 2000 – 2009) for Offshore Jawa-1 Project Facilities

Wind Direction/ Wind Stability Classes	Day Time (%)						Night Time (%)						Total (%)
	1.5D	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	**1.5D**	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	
N	0.24	0.24	0.05	0.05	0.05	0.00	0.24	0.24	0.05	0.05	0.05	0.00	**1.26**
NE	0.28	0.28	0.11	0.11	0.11	0.05	0.28	0.28	0.11	0.11	0.11	0.05	**1.85**
E	0.57	0.57	1.88	1.88	1.88	9.18	0.57	0.57	1.88	1.88	1.88	9.18	**31.90**
SE	0.53	0.53	1.45	1.45	1.45	8.29	0.53	0.53	1.45	1.45	1.45	8.29	**27.38**
S	0.38	0.38	0.16	0.16	0.16	0.07	0.38	0.38	0.16	0.16	0.16	0.07	**2.63**
SW	0.49	0.49	0.44	0.44	0.44	0.37	0.49	0.49	0.44	0.44	0.44	0.37	**5.30**
W	0.65	0.65	1.24	1.24	1.24	5.28	0.65	0.65	1.24	1.24	1.24	5.28	**20.60**
NW	0.43	0.43	0.51	0.51	0.51	2.14	0.43	0.43	0.51	0.51	0.51	2.14	**9.08**
Sub-Total	**3.57**	**3.57**	**5.83**	**5.83**	**5.83**	**25.37**	**3.57**	**3.57**	**5.83**	**5.83**	**5.83**	**25.37**	**100.00**

Table 3-3 Historical Meteorological Data for Onshore Jawa-1 Project Facilities (Source: ERM, 2018b)

Wind Direction/ Wind Stability Classes	Day Time (%)						Night Time (%)						Total (%)
	1.5D	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	**1.5D**	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	
N	0.25	0.25	0.33	0.33	0.33	1.50	0.25	0.25	0.33	0.33	0.33	1.50	**6.00**
NNE	0.50	0.50	0.42	0.42	0.42	2.10	0.50	0.50	0.42	0.42	0.42	2.10	**8.70**
NE	0.25	0.25	0.33	0.33	0.33	1.05	0.25	0.25	0.33	0.33	0.33	1.05	**5.10**
ENE	0.38	0.38	0.33	0.33	0.33	1.25	0.38	0.38	0.33	0.33	0.33	1.25	**6.00**
E	0.50	0.50	0.50	0.50	0.50	2.25	0.50	0.50	0.50	0.50	0.50	2.25	**9.50**
ESE	0.63	0.63	0.58	0.58	0.58	2.00	0.63	0.63	0.58	0.58	0.58	2.00	**10.00**
SE	0.63	0.63	0.42	0.42	0.42	1.00	0.63	0.63	0.42	0.42	0.42	1.00	**7.00**
SSE	0.63	0.63	0.33	0.33	0.33	0.25	0.63	0.63	0.33	0.33	0.33	0.25	**5.00**
S	0.75	0.75	0.33	0.33	0.33	0.25	0.75	0.75	0.33	0.33	0.33	0.25	**5.50**
SSW	0.75	0.75	0.33	0.33	0.33	0.25	0.75	0.75	0.33	0.33	0.33	0.25	**5.50**
SW	0.75	0.75	0.42	0.42	0.42	0.25	0.75	0.75	0.42	0.42	0.42	0.25	**6.00**
WSW	0.50	0.50	0.42	0.42	0.42	0.50	0.50	0.50	0.42	0.42	0.42	0.50	**5.50**
W	0.38	0.38	0.42	0.42	0.42	1.25	0.38	0.38	0.42	0.42	0.42	1.25	**6.50**
WNW	0.25	0.25	0.25	0.25	0.25	1.00	0.25	0.25	0.25	0.25	0.25	1.00	**4.50**
NW	0.25	0.25	0.17	0.17	0.17	1.25	0.25	0.25	0.17	0.17	0.17	1.25	**4.50**
NNW	0.25	0.25	0.25	0.25	0.25	1.10	0.25	0.25	0.25	0.25	0.25	1.10	**4.70**
Sub-Total	**7.38**	**7.38**	**5.58**	**5.58**	**5.58**	**16.15**	**7.38**	**7.38**	**5.58**	**5.58**	**5.58**	**16.15**	**100.00**

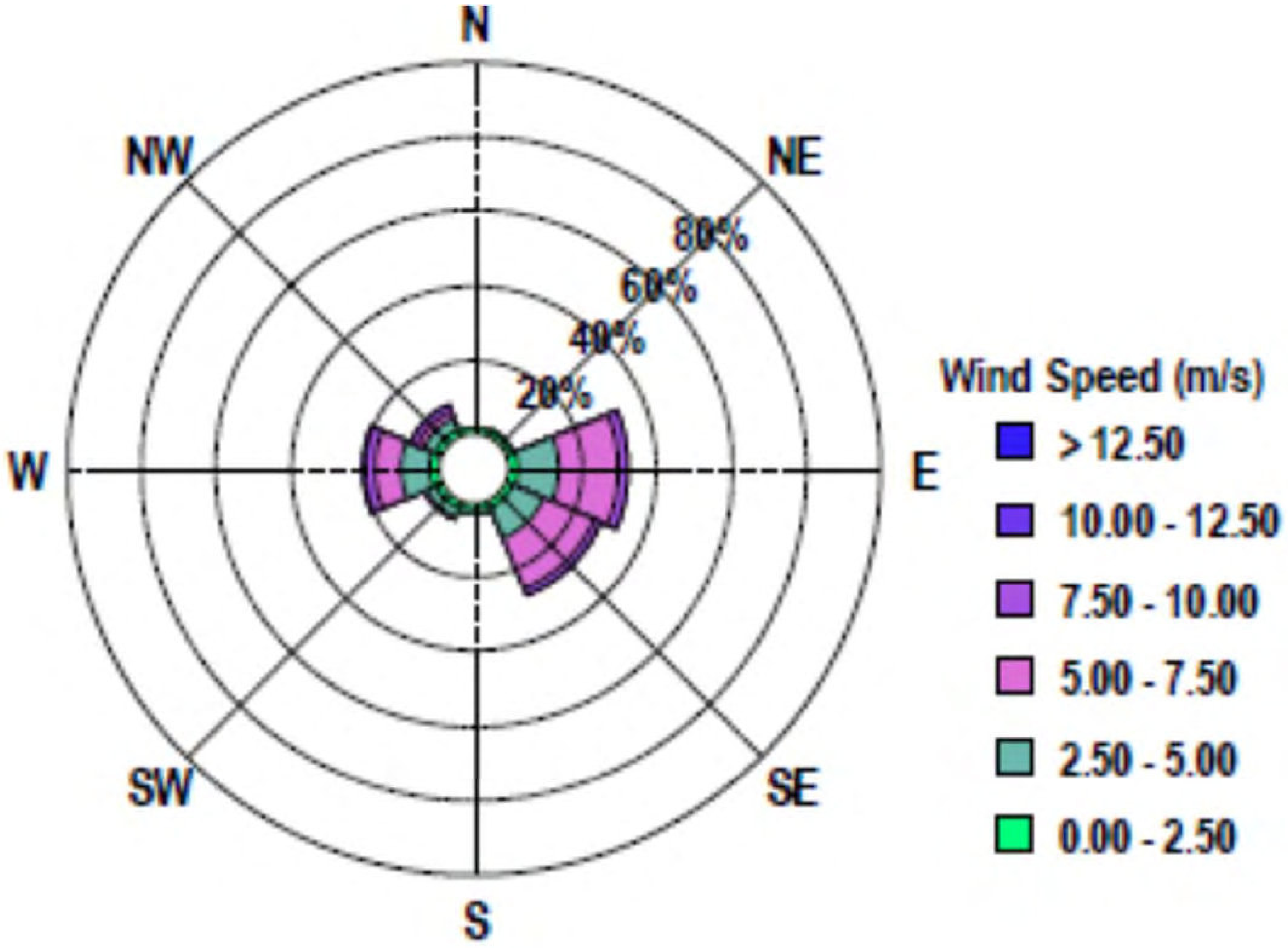


Figure 3-2 Wind Rose of Historical Meteorological Data at FSRU Location (2000 – 2009) for OffshoreJawa-1 Project Facilities

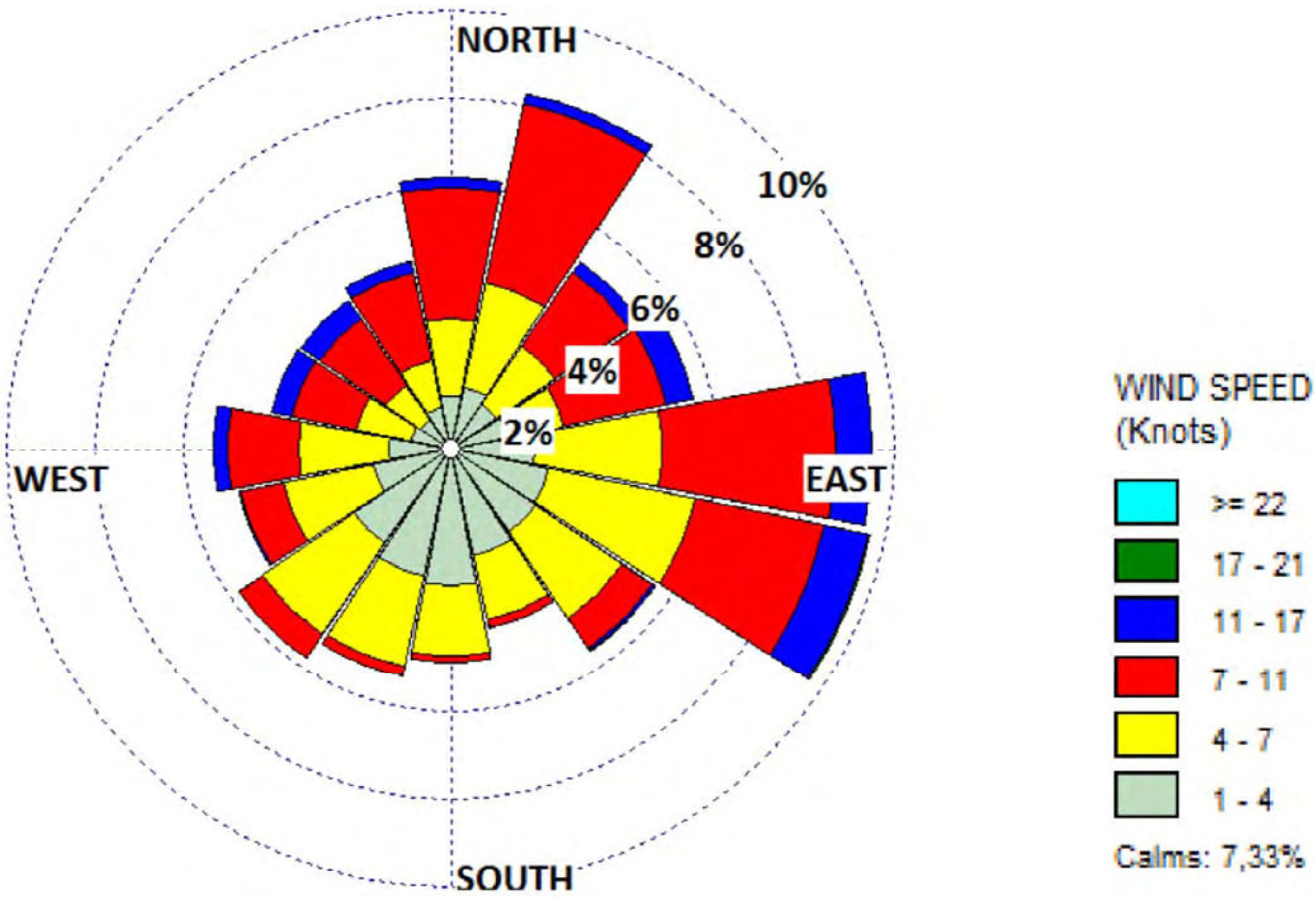


Figure 3-3 Wind Rose of Historical Meteorological Data Proximity to Onshore Jawa-1 Project Facilities

4 DESCRIPTION OF JAWA-1 PROJECT FACILITIES

4.1 FSRU PROCESS FACILITIES

4.1.1 LNG Storage and Loading System

The LNG storage capacity the FSRU is designed as 170,000 m^3 and its storage system is membrane type double containment system as per the requirement of the Class and Regulatory bodies concerned. The containment system will be provided with a full secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the ship structure to an unsafe level. The In-Tank LNG Storage Pumps load LNG to LNG regasification plant for regasification process.

4.1.2 LNG Booster Pump System

The LNG from the discharge of the In-Tank LNG Storage Pump is pumped at about 5 barg to the LNG Booster Pump Suction Drum, which acts as a buffer volume. The LNG inside the Suction Drum is then pumped via the LNG Booster Pumps, at a capacity of 210 m^3 for each Booster pump, to the Regasification System up to about 80 barg.

4.1.3 LNG Regasification System

Four (4) regasification trains are provided at the Regasification Module of the FSRU, with a maximum installed capacity of 400 mmscfd.

The LNG from the discharge of the LNG Booster Pumps is re-gasified and superheated to the required send-out temperature of 10 °C. The LNG is re-gasified by a simple heat exchange process using glycol water and seawater. Shell and tube type heat exchanger is used for Regas Vaporizer (LNG/glycol water) and plate type heat exchanger is used for Glycol Water Heater (Glycol water/ Sea water).

4.1.4 Boil Off Gas System

This facility aims to release BOG from the FSRU storage tank. As the LNG will be stored under a cryogenic saturated condition, BOG will form as a result of leakage and environmental heat. The BOG should be removed from the tank to prevent excess pressure. The excess of BOG in the tank will be siphoned via a compressor which will be channeled into a fuel gas system or a BOG recondenser.

4.1.5 Utility System – Power Generation System

The FSRU is provided with its own dedicated power generation system. The dual fuel type power generators can operate on both boil off gas (BOG) as fuel gas and marine diesel oil (MDO). Under normal circumstances, power generation will consume BOG as fuel gas. However, under start-up or special maintenance repair circumstances as well as under emergency conditions, the fuel gas may not be available and diesel oil will be the fuel supply to the power generator. In addition, a dedicated emergency diesel power generator is also provided on the FSRU for back-up power generation and black start-up.

4.1.6 Utility System – Diesel Oil Storage and Transfer System

Marine diesel oil (MDO) is used for dual fuel generator engines, pilot fuel of gas combustion unit, incinerator and auxiliary boilers while marine gas oil (MGO) is used for inert gas generator, emergency generator engine, main dual fuel generator engines, and pilot fuel of gas combustion unit, incinerator and auxiliary boilers.

MDO/ MGO storage tanks, settling tank and service tanks are provided for the FSRU, and the maximum capacity of the MDO/ MGO storage tank was considered as 1,000 m^3 respectively in this QRA Study.

Bunkering of diesel oil will be conducted within reach of the supply crane on the FSRU to handle bunker hoses. In this QRA Study, it was conservatively considered that the bunkering operation will be performed three (3) times a year with duration of six (6) hours for each operation.

4.1.7 Utility System – Lubricating Oil Storage and Transfer System

Lube oil storage and settling tanks are typically provided for the FSRU. Lube oil is used for the power generation prime movers and for major rotating equipment.

4.1.8 Utility System – Nitrogen Generation System

Nitrogen generators will be typically provided for the FSRU to generate nitrogen for the purpose of inert gas purging.

4.1.9 Utility System – Seawater System

Seawater will be used to vaporize LNG in the heat exchanger. The seawater will be filtered by intake screens, and pumped by seawater pumps. The seawater used from the LNG vaporisation system will return to the sea via gravity discharge off the FSRU.

4.1.10 Utility System – Instrument Air System

Redundant air compressors will be provided to generate the utility and instrument air for the FSRU. An instrument air receiver will also be provided for a specified hold up volume.

4.1.11 Utility System – Fuel Gas System

The BOG from the LNG storage tanks will be sent to BOG Compressor. Part of the compressed BOG will be used for fuel gas for power generation. In addition, LNG/ forcing vaporisers are also provided for forced BOG generation to provide fuel gas for the FSRU. Under normal circumstances, power generation will consume BOG treated by the fuel gas skid and delivered at approximately 6 barg.

4.1.12 Utility System – Fresh Water and Demineralised Water System

Fresh water generation system and sterilization system for domestic water will be provided for the FSRU.

4.2 FSRU OPERATIONS

4.2.1 LNG Unloading Operation

The LNG offloading process is carried out under cryogenic conditions (ambient temperature of -160 °C and pressure of about 3-5 barg) using unloading pump and channeled through loading arm or cryogenic expansion hose and LNG piping installed in mooring system and connecting LNG CARRIER to FSRU.

The LNG from LNG CARRIER is unloaded via three (3) standard 16-inch loading arms on the LNG CARRIER and FSRU (1 for LNG unloading; 1 for vapour return; 1 hybrid for spare). The maximum LNG unloading rate (5,000 m^3/hr) for each of LNG unloading arms was conservatively considered in this QRA Study. The LNG unloading time from LNG CARRIER to FSRU is about 25 hours.

To compensate for the depreciation of volume in the LNG CARRIER storage tank and to avoid the occurrence of the vacuum due to the LNG offloading process, a number of boil off gas (BOG) formed in the FRSU storage tank are returned to the LNG CARRIER storage tank via the vapour arm.

During the transfer process there is a potential of leakage on the LNG piping connection and loading arm. To overcome the damage to the ship wall path due to LNG leak, the ship wall around the loading arm is watered continuously (water curtain). However, in the practice, leakage is very rare due to strict preparation procedures before the operation of LNG transfers.

Loading arm and vapour arm integrated in the FSRU are also equipped with a security system that can stop the offloading process and release the loading connection automatically when hazard occurs. Emergency shutdown system is connected between FSRU and LNG CARRIER, so it can be activated from both sides.

At the end of unloading, pressurised nitrogen gas will be used to purge the unloading arms of LNG before disconnecting.

To maintain the balance of LNG CARRIER and FSRU drafts during offloading operations, ballast water and seawater are fed to the ballast tank and vice versa, ballast water removed from the FSRU ballast tank to the sea. Ballast water does not undergo processing or addition of chemicals.

After the offloading process is complete, the LNG CARRIER will be removed from the or LNG FSRU to then return to the loading port. The LNG that has been transferred to the FSRU storage tank will be stored in cryogenic saturation, at about -160 ˚C and about 0.5 barg, until later pumped into the vaporizer system. Once the LNG supply in the FSRU storage tank is low, the LNG CARRIER will come in for further offloading.

4.2.2 *LNG Regasification Operation*

The operation of the regasification unit installation consists of four (4) units of trains each having a maximum LNG regasification capacity of 100 mmscfd or a total of 400 mmscfd with an optimum regasification result of 300 mmscfd. The regasification unit working system is based on an open loop intermediate indirect regasification system, which uses seawater as a heat source in its regasification process.

The gas regasification process in FSRU consists of LNG feed system process, and regasification process.

4.2.3 *LNG Feed System*

The LNG send out system is used to pump LNG from the FSRU storage tank to the regasification unit. The LNG feed facility is integrated in the FSRU.

The send out process is still in cryogenic condition with temperature between -155 to -160 ˚C. The process of send out using two kinds of pump pressure levels are.

- Low Pressure Pump (submersible) to pump LNG from storage tank and send it to suction drum. The output pressure of this pump is about 85 barg; and
- High Pressure Pump (booster pump) is used to increase LNG pressure that can be adjusted to the needs of gas power plant pressure and overcome pressure drop on piping system. The pump output pressure is between 60- 98 barg.

During this process, the ballast water is pumped into the FSRU ballast tank to compensate for the LNG volume decrease in the storage tank.

4.3 FSRU KEY SAFETY FEATURES

4.3.1 *Emergency Shutdown System*

The emergency shutdown (ESD) system has two (2) mode, including LNG CARRIER mode and FSRU mode. The cause and effect for ESD (LNG CARRIER and FSRU) should be determined at detailed design stage.

In the event of fire or other emergency conditions, the entire cargo system, gas compressors and cutout valve to the engine room should be able to be shut downed by a single control to prevent major accident event.

4.3.2 *Fire Detection and Protection System*

Flammable gas and fire detectors are provided at the FSRU to detect leakage of natural gas and fire events respectively. The detectors will be positioned at strategic locations to provide adequate detection coverage for the FSRU.

4.3.3 *Fire Fighting System*

Firefighting system is provided in the FSRU as follows:

- High expansion foam in the Engine Room;
- Dry chemical powder in the cargo area, cargo manifolds, cargo tank domes & LNG regasification plant;
- Water spray system in the accommodation front wall, cargo machinery room wall, paint stores, chemical stores, oil/ grease store; and
- High pressure CO_2 in Electric Motor Room, Cargo Switch Board rooms, Emergency Generator Room, Main S/W Board Room, Engine Control Room Converter Room, Regas Switch Board Room, FWD Pump Room, and Cargo Machinery Room.

4.4 SUBSEA PIPELINE

The proposed subsea gas pipeline will be around 14 km long and 20 inches in diameter. The pipeline will run from the FSRU morning location to the coast of Cilamaya.

4.5 ONSHORE PIPELINE

The length of the proposed onshore pipeline running from the coast of Cilamaya to Onshore Receiving Facilities (ORF) located at close to the Jawa-1 CCGT Power Plant is approximately seven (7) km. As per IGEM/TD/2, the highest risk 1.6 km section of high pressure pipeline should be selected to compare with the IGEM/TD/2 Edition 2 F-N criterion envelope. A segment of the proposed onshore pipeline running from onshore receiving facilities located at close to the Jawa-1 CCGT Power Plant and with a total pipeline length of 1.6 km was selected for detailed analysis in this QRA Study.

4.6 *CCGT POWER PLANT*

4.6.1 *Onshore Receiving Facilities*

The ORF is the receiving and measuring station for natural gas to be used by the CCGT Power Plant. It houses the pig receiver, gas filters, pressure let-down skid, metering packages, in directed fired water bath heater, vent stack and flow computer building.

The vent stack will vent the natural gas during emergency conditions only. This includes sweet gas containing mostly methane (97%) and a small quantities of other hydrocarbons.

The amount of natural gas in energy units (MMBTU) will be calculated by measuring the gas volume and its composition. The gas volume rate is measured using mechanical and/ or electronic system and the measurement of gas composition will be measured using Gas Chromatography.

4.6.2 *Hydrogen Facilities*

Hydrogen gas is used to remove heat from the rotor and stator. The heat is removed via hydrogen/water heat exchangers within the casing. The stator casing is fully sealed to minimise hydrogen consumption. The water-cooling system in the stator winding is designed to provide optimum reliability. The deionized water flows through the stainless-steel cooling tubes to remove the heat dissipated by the stator winding.

A hydrogen storage system is provided to maintain the hydrogen pressure in the generators. The hydrogen system consists of standard pressurized hydrogen storage cylinders connected to a generator manifold supplied with the generator. An emergency shutoff valve shall be located downstream of the gas cylinders designed to shutoff hydrogen supply in the event of a supply pipe rupture.

4.6.3 *Carbon Dioxide Facilities*

A carbon dioxide system is provided to purge the hydrogen from the generators which is usually done before starting generators maintenance. The carbon dioxide system consists of standard pressurised carbon dioxide storage cylinders connected to a manifold supplied with the generator. The cylinders are housed in a heated enclosure that is sized and designed to prevent walk-in possibility.

4.6.4 *Other Associated Facilities*

CCGT power plant complex will consist of five (5) main buildings supported by other facilities. The main buildings include two (2) Turbine Building, the Control and Electrical Building (CEB), an Administrative Building and the Workshop/ Warehouse Building.

Other associated process facilities within the building complex includes the gas turbine, the steam turbine and a generator. In addition, equipment installed outside the main buildings includes the Heat Recovery Steam Generator (HRSG), ORF, Cooling Towers, Black Start Facility, Seawater Supply System, Service and Fire Water Storage Tank, a Fire Water Pump Shelter and a Chemicals and Lube Oil Storage Shelter. In addition, Water Treatment Plant and Wastewater Treatment Plant will also be located at the proposed Project area. Details of the proposed Jawa-1 CCGT Power Plant are summarised from **Section 4.4.5.1** to **Section 4.4.5.4** of the ESIA Report.

5 HAZARD IDENTIFICATION

Hazardous scenarios associated with the operation of the Jawa-1 Project facilities including FSRU with an LNG unloading from the LNG CARRIER and sending out high-pressure natural gas, Subsea Pipeline, Onshore Pipeline and CCGT Power Plant were identified through the following tasks:

- Review of hazardous materials;
- Review of potential MAEs;
- Review of relevant industry incidents; and
- Review of potential initiating events leading to MAEs.

5.1 *REVIEW OF HAZARDOUS MATERIALS*

LNG on board the LNG CARRIER and FSRU, and natural gas associated with the FSRU were the major hazardous material considered in this QRA Study, while the other dangerous goods including marine diesel oil, marine gas oil, lubricating oil, nitrogen, calibration gas, etc. were also taken into account in this QRA Study.

The details of LNG, natural gas and other dangerous goods associated with the Jawa-1 Project facilities are summarised in **Table 5-1**.

Table 5-1 LNG, Natural Gas and Other Dangerous Goods Associated with the Jawa-1 Project Facilities

Chemical	Location	Maximum Storage Quantity	Temperature (°C)	Pressure (barg)
LNG	FSRU	170,000 m^3	-163	0.7
Natural gas	FSRU	On-site generation	10	70
	Subsea Pipeline, Onshore Pipeline, CCGT Power Plant	Transportation	5	41.7
Marine Diesel Oil	FSRU	≤1,000 m^3	25	ATM
Marine Gas Oil	FSRU	≤1,000 m^3	25	ATM
Lubricating Oil	FSRU	≤ 200 m^3	25	ATM
Nitrogen	FSRU	On-site generation	-	-
Calibration Gas	FSRU	~2 Cylinders	25	-
Hydrogen	CCGT Power Plant	~2 Cylinders (11.1 m^3)	25	150

Chemical	Location	Maximum Storage Quantity	Temperature (°C)	Pressure (barg)
Carbon Dioxide	CCGT Power Plant	2 Cylinders (6.6 m^3)	25	150

5.1.1 *LNG*

LNG is an extremely cold, non-toxic, non-corrosive and flammable substance.

If LNG is accidentally released from a temperature-controlled container, it is likely to come in contact with relatively warmer surfaces and air that will transfer heat to the LNG. The heat will begin to vapourise some of the LNG, returning it to its gaseous state.

The relative proportions of liquid LNG and gaseous phases immediately following an accidental release depends on the release conditions. The released LNG will form a LNG pool on the surface of the sea in the vicinity of the FSRU which will begin to "boil" and vapourise due to heat input from the surrounding environment. The vapour cloud may only ignite if it encounters an ignition source while its concentration is within its flammability range.

Any person coming into contact with LNG in its cryogenic condition will be subjected to cryogenic burns.

5.1.2 *Natural Gas*

Upon the regasification of LNG, high pressure natural gas is formed. Natural gas is composed of primary methane gas with other fossil fuels such as ethane, propane, butane and pentane, etc. Natural gas is extremely flammable when mixed with appropriate concentration of air or oxygen in the presence of an ignition source.

Not only is the maximum surface emissive power of pure methane higher, but the consequence distances for both flash fire and jet fire hazardous scenarios associated with pure methane is larger than that of natural gas. As such, pure methane has been conservatively selected as representative material for the natural gas in the consequence modelling conducted using *PHAST*.

The major hazards arising from loss of containment of natural gas may lead to hazardous scenarios including jet fire, flash fire, fireball, and vapour cloud explosion (VCE) if congested area(s) is(are) in the vicinity of.

5.1.3 *Diesel (Marine Diesel Oil, Marine Gas Oil), and Lubricating Oil*

Diesel (marine diesel oil, marine gas oil) and lubricating oil have a relatively higher flash point (greater than 66 °C), which is above ambient temperature, and with a high boiling point. Thus, evaporation from a liquid pool is expected to be minimal.

5.1.4 *Nitrogen*

CAS number of nitrogen is 7727-37-9, nitrogen is a nontoxic, odourless, colorless, non-flammable compressed gas generated on board the FSRU. However, it can cause rapid suffocation when concentrations are sufficient to reduce oxygen levels below 19.5%.

The expected off-site impact associated with nitrogen is limited as nitrogen is generated for the purpose of inert gas purging after LNG unloading operation. Therefore, nitrogen was not further assessed in this QRA Study.

5.1.5 *Calibration Gas*

The volume of the compressed calibration gas inside the cylinders is limited, the associated hazardous impact upon loss of containment is considered localized. It is expected that the calibration gas does not pose any risk to the off-site population and hence is not further assessed in this QRA Study.

5.1.6 *Hydrogen*

CAS number of hydrogen is 1333-74-0, and hydrogen is a colourless and odourless gas at ambient temperature and pressure. It has a boiling point of -253 °C at 1 bar, a critical temperature of -240 °C and a critical pressure of 13 bara.

Hydrogen is extremely flammable in oxygen and air, and has the widest range of flammable concentrations in air among all common gaseous hydrocarbons. This range is between the lower limit of 4% to an upper limit of 75% by volume. Because of this wide range, a given volume of hydrogen release will present a large flammable volume, thus increasing the probability of ignition.

Also, when diluted with inert gas, hydrogen can still burn with only 5% oxygen. It can be ignited by low energy sources; hence it is easily ignited by static electricity.

The major hazards arising from loss of containment of hydrogen may lead to hazardous scenarios, including jet fire, flash fire, fireball, and VCE.

5.1.7 *Carbon Dioxide*

CAS number of CO_2 is 124-38-9, and CO_2 is a colourless and odourless gas at ambient temperature and pressure.

At low concentration, carbon dioxide (CO_2) is odourless; while at high concentration, it has a sharp acidic odor. It is mainly due to dissolving of CO_2 in the mucous membranes and saliva, forming a weak solution of carbon acid. At very high concentration, apart from potential asphyxiation hazard, it is also considered toxic. Prolonged exposure to moderate concentration can cause acidosis and adverse effects on calcium phosphors metabolism resulting in increased calcium deposit on soft tissue.

At high CO_2 concentration, dissolved CO_2 will increase to lowering pH of the blood thus trigger effects on the respiratory, cardiovascular and central nervous systems. Also, too high level of CO_2 in tissues will lead to acidosis which is harmful for mammalian tissues, especially those with a high sensitivity (e.g. brain).

It is believed that at a CO_2 concentration of 10-15% will cause serious health effect and mortality may start to occur; while LC_{50} for rat is believed to be 45% for thirty (30) minutes exposure. However, no probit equation is available for CO_2 or human impact, and therefore CO_2 is only considered as asphyxiation effect and not further considered in this QRA Study.

5.2 REVIEW OF POTENTIAL MAEs

5.2.1 LNG

The possible hazardous scenarios considered in this QRA Study upon the release of LNG are:

- Pool fire;
- Flash fire; and
- VCE.

5.2.2 Natural Gas

The possible hazardous scenarios considered in this QRA Study upon the release of high pressure natural gas are:

- Jet fire;
- Flash fire;
- Fireball; and
- VCE.

Considering that the regasification unit on board the FSRU and the HRSG at CCGT Power Plant are relatively congested, a VCE may potentially occur if flammable gas cloud accumulate in these congested areas and is ignited, leading to damaging overpressure.

5.2.3 Hydrogen

The possible hazardous scenarios considered in this QRA Study upon the release of hydrogen are:

- Jet fire;
- Flash fire;
- Fireball; and
- VCE.

Considering that the HRSG at CCGT Power Plant is relatively congested, a VCE may potentially occur if flammable gas cloud accumulate in these congested areas and is ignited, leading to damaging overpressure.

5.2.4 *Other Dangerous Goods*

Considering the high flash point temperature of other dangerous goods such as marine diesel oil present in the FSRU, the possible hazardous scenarios considered in this QRA Study are a pool fire and flash fire.

5.3 *REVIEW OF RELEVANT INDUSTRY INCIDENTS*

To investigate further the possible hazardous scenarios from the Jawa-1 Project facilities including FSRU, and the LNG CARRIER unloading operation, Subsea Pipeline, Onshore Pipeline and CCGT Power Plant, a review of the applicable past industry incidents at similar facilities worldwide was conducted based on the following incident/ accident database:

- eMARS;
- Major Hazard Incident Data Service (MHIDAS) database
- MHIDAS database; and
- Society of International Gas Tanker and Terminal Operators (SIGTTO).

Details of the past industry incident analysis are presented in ***ANNEX H-1***.

5.4 *REVIEW OF POTENTIAL INITIATING EVENTS LEADING TO MAES*

The potential hazardous scenarios arising from the Jawa-1 Project facilities were identified as loss of containment of LNG, natural gas, hydrogen and other dangerous goods. The potential initiating events which could result in the loss of containment of flammable material including LNG, natural gas, hydrogen and diesel are listed below:

- Collision with other passing / visiting marine vessels;
- Mooring line failure;
- Dropped objects from crane operations on the FSRU;
- General equipment/piping failure (due to corrosion, construction defects etc.);
- Sloshing;
- LNG containment system failure; and
- Natural hazards.

5.4.1 *Ship Collision*

The Indonesian Government Regulation No. 5 Year 2010 regarding Navigation, article 38 describes two (2) zones for navigational aids, which are:

- Prohibited zone within 500 m radius from the outermost point of a navigational aids installation or building; and
- Limited zone within 1,250 m radius from the outermost point from the prohibited zone.

These zones are set to protect the navigational aids from other activities. Furthermore, article 40 explains that marine ships/ vessels can only pass outside these two (2) zones. Based on this regulation, the likelihood of having passing vessels in the vicinity of FSRU is deemed to be unlikely.

As such, the failures due to ship collision incidents is unlikely, nevertheless, the ship collision failure has been taken into account in the unloading arm failure frequency, as suggested in the UK HSE, which was incorporated and assessed in this QRA Study.

5.4.2 Mooring Line Failure

The mooring lines at the FSRU may fail due to various reasons such as extreme loads, fatigue, corrosion and wear, and improper selection of mooring lines etc. Upon failure of the mooring lines, drifting of LNG CARRIER or FSRU may occur leading to potential failure of unloading arms and collision impact with another vessel, with ultimately potential release of LNG or natural gas. Mechanical integrity program (including testing and maintenance) for the mooring lines, as well as tension monitoring system for the mooring lines are provided at the FSRU. The mooring line failure has been taken into account in the unloading arm failure frequency, as suggested in the UK HSE, which was incorporated and assessed in this QRA Study.

5.4.3 Dropped Objects from Supply Crane Operation

Supply cranes are provided at the FSRU for lifting operations. Swinging or dropped objects from crane operation may lead to potential damage on the LNG or natural gas pipework and subsequent loss of containment. Generally, lifting activity is not expected at FSRU during normal operation. However, during certain circumstances where lifting is required; safety management system will be in place to minimize the dropped object hazard.

Even with supply crane operation, the lifting equipment operation procedure will be in place to ensure that any lifting operation near or over live equipment should be strictly minimised. If such lifting operation cannot be avoided, lifting activities will be assessed. Also, adequate protection covers will be provided on the existing facilities in case the operation of lifting equipment has a potential to impact live equipment at the FSRU. Process isolation will also be achieved in case that live equipment protection becomes impractical.

A Job Safety Analysis should be conducted for the supply crane operation to identify and analyse hazards associated with the lifting operation. In addition, risk from lifting operation will be minimised through the work permit system, strict supervision and adequate protection covers on live equipment. The potential for a dropped object to cause damage on the live equipment and cause a release event is therefore considered included in the generic leak frequency in **Table 6-1**.

5.4.4 *General Equipment/ Piping Failure*

Loss of integrity of the equipment and piping may occur because of material defects, construction defects, external corrosion etc., and leading to loss of containment of LNG and natural gas. Material defect may occur due to wrong materials being used during construction. Construction defect may result from poor welding. The generic failure frequency of the equipment and piping for this QRA Study was obtained from the International Association of Oil and Gas Producers (OGP), which was subsequently incorporated and assessed in this QRA Study.

5.4.5 *Sloshing*

Under high wind or sea conditions, excessive motion while operating partially-filled LNG cargo tanks may lead to membrane damage and loss of membrane structural integrity. In addition, boil off gas will be vented to atmosphere, where safety impact may occur if the vent gas is ignited. The cargo tanks are generally either full (inbound voyage) or empty (outbound voyage), hence the chance of sloshing during transit is minimized. In case of the unforeseen need to depart the berth before fully unloading of LNG, the LNG CARRIER or FSRU can conduct an internal cargo transfer between tanks such that sloshing would not be a potential hazard. Annulus between membrane and ship structure is also monitored for hydrocarbon presence, with vent to safe location. Flame arrestors are also provided at vent location to minimize the chance of vent gas ignition. Therefore, considering adequate safety systems are in place to minimize the chance of sloshing, this scenario was not considered as a significant contributor to the overall risk and not further assessed in this QRA Study.

5.4.6 *Natural Hazards*

The natural hazards to FSRU, such as earthquake, tsunami, subsidence, lightning, etc. should be already taken into account in the design, as such, the historical failure database are in deem sufficient covering all possible failure modes into consideration for this QRA Study.

5.5 *IDENTIFICATION OF HAZARDOUS SECTIONS*

A total of twenty four (24) hazardous sections were identified from the Jawa-1 Project facilities, with consideration of the location of emergency shutdown valves and process conditions (e.g. operating temperature and pressure). The details of each hazardous section (including temperature, pressure, flow rate, etc.) are summarised in **Table 5-2**. These hazardous sections formed the basis for the development of loss of containment scenarios for this QRA Study.

Table 5-2 Identified Hazardous Sections Associated with Jawa-1 Project Facilities

Section Code	Description	Operating Temperature (°C)	Operating Pressure (barg)	Size/ Diameter (mm)	Inventory (kg)	
					IS Case[@]	IF Case[@]
OLNGT_01	LNG Loadout from LNG CARRIER to LNG Storage Tank in FSRU (including LNG unloading lines)	-160	5.0	406.4	3.42E+04	8.74E+04
OLNGT_02	LNG Storage Tanks	-160	0.7	-	-	1.81E+07*
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	-160	7.0	254.0	1.06E+05	1.49E+06
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure Pump)	-160	80	254.0	1.49E+04	1.96E+05
OLNGT_05	LNG Regasification Plant including four Regasification Trains	10	80	304.8	1.41E+04	1.80E+05
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	10	80	304.8	2.48E+04	3.57E+05
OLNGT_07	Natural gas in Loading Platform to Emergency Shutdown Valve of Riser for the Subsea Pipeline	10	70	508.0	2.63E+04	3.59E+05
OLNGT_08	Riser for Subsea Pipeline	5	41.7	508.0	2.35E+05	5.67E+05
OLNGT_09	Subsea Pipeline within the Vicinity of the FSRU (within 500 m from the FSRU)	5	41.7	508.0	3.13E+04	3.64E+05
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	-160	7.0	304.8	1.46E+04	9.19E+04
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	5	13	152.4	4.54E+02	6.69E+03
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	-160	0.5	508.0	1.45E+05	1.45E+05
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	40	6.0	304.8	3.70E+01	6.11E+01
OLNGT_14	BOG in Gas Combustion Unit/ Engine	-120	0.5	508.0	4.00E+01	5.31E+01
OLNGT_15	LNG CARRIER Vapour (BOG) return line during loudout operation	-120	1	406.4	7.60E+01	8.91E+01
OLNGT_16	FSRU Vapour (BOG) return line during loudout operation	-120	1	406.4	7.60E+01	8.91E+01
OLNGT_17	Marine Diesel Oil Storage &Transfer System	25	1.0	254.0	7.45E+05	7.45E+05
OLNGT_18	Marine Gas Oil Storage & Transfer System	25	1.0	254.0	7.45E+05	7.45E+05
OLNGT_19	Lubricating Oil Storage & Transfer System	25	1.0	254.0	1.49E+05	1.49E+05
OLNGT_20	Subsea Pipeline	5	41.7	508.0	-	5.67E+05*
OLNGT_21	Onshore Pipeline	5	41.7	508.0	-	4.62E+05*
OLNGT_22	Onshore Receiving Facilities	5	41.7	508.0	1.29E+05	3.71E+05*
OLNGT_23	Natural Gas Transfer System at CCGT Power Plant	30	41.7	508.0	3.88E+04	3.71E+05*
OLNGT_24	Hydrogen Storage and Transfer System at CCGT Power Plant	25	150.0	101.6	3.88E+04	8.74E+04*

Note @: IS stands for isolation success cases; while IF stands for isolation failure cases. Note *: Only isolation failure cases were considered for those hazardous sections

6 FREQUENCY ANALYSIS

6.1 RELEASE FREQUENCY DATABASE

The historical database from the International Association of Oil and Gas Producers (OGP) was adopted in this QRA Study for estimating the release frequency of hazardous scenarios associated with the Java-1 Project facilities. The release frequency in OGP is based on the analysis of the UK HSE hydrocarbon release database (HCRD) which collected all offshore releases of hydrocarbon in the UK (including the North Sea) reported to the UK HSE Offshore Division from 1992-2006. Considering that the FSRU is located around 14 km offshore, this database was considered adequate for purpose of this QRA Study.

The release frequencies of various equipment items are summarised in **Table 6-1**.

Table 6-1 Historical Process Failure Release Frequency

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Piping 2″	10 mm hole	Liquid/ Gas	7.30E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	7.00E-06	per metre per year	OGP
Piping 2″ to 6″	10 mm hole	Liquid/ Gas	3.45E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.70E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	6.00E-07	per metre per year	OGP
Piping 8″ to 12″	10 mm hole	Liquid/ Gas	3.06E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.70E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.70E-07	per metre per year	OGP
Piping 14″ to 18″	10 mm hole	Liquid/ Gas	3.05E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.70E-07	per metre per year	OGP
Piping 20″ to 24″	10 mm hole	Liquid/ Gas	3.04E-05	per metre per year	OGP

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.60E-07	per metre per year	OGP
Piping 26″ to 48″	10 mm hole	Liquid/ Gas	3.04E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.30E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.60E-07	per metre per year	OGP
Pressure Vessel - Large Connection (> 6″)	10 mm hole	Liquid/ Gas	5.90E-04	per year	OGP
	25 mm hole	Liquid/ Gas	1.00E-04	per year	OGP
	50 mm hole	Liquid/ Gas	2.70E-05	per year	OGP
	>150 mm hole	Liquid/ Gas	2.40E-05	per year	OGP
Pump Centrifugal - Small Connection (up to 6″)	10 mm hole	Liquid	4.40E-03	per year	OGP
	25 mm hole	Liquid	2.90E-04	per year	OGP
	50 mm hole	Liquid	5.40E-05	per year	OGP
Pump Centrifugal - Large Connection (> 6″)	10 mm hole	Liquid	4.40E-03	per year	OGP
	25 mm hole	Liquid	2.90E-04	per year	OGP
	50 mm hole	Liquid	3.90E-05	per year	OGP
	>150 mm hole	Liquid	1.50E-05	per year	OGP
Compressor Reciprocating - Large Connection (> 6″)	10 mm hole	Gas	3.22E-02	per year	OGP
	25 mm hole	Gas	2.60E-03	per year	OGP
	50 mm hole	Gas	4.00E-04	per year	OGP
	>150 mm hole	Gas	4.08E-04	per year	OGP
Shell and Tube Heat Exchanger - Large	10 mm hole	Liquid/Gas	1.20E-03	per year	OGP
	25 mm hole	Liquid/Gas	1.80E-04	per year	OGP

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Connection (> 6”)	50 mm hole	Liquid/Gas	4.30E-05	per year	OGP
	>150 mm hole	Liquid/Gas	3.30E-05	per year	OGP
Unloading Arm	10 mm hole	Liquefied Gas	4.00E-06*	per transfer operation	UK HSE
	25 mm hole	Liquefied Gas	4.00E-06*	per transfer operation	UK HSE
	>150 mm hole	Liquefied Gas	7.00E-06	per transfer operation	UK HSE
Riser	10 mm hole	Gas	7.2E-05	per year	OGP
	25 mm hole	Gas	1.8E-05	per year	OGP
	>150 mm hole	Gas	3.0E-05	per year	OGP
Diesel Storage Tank	10 mm hole	Liquid	1.6E-03	per year	OGP
	25 mm hole	Liquid	4.6E-04	per year	OGP
	50 mm hole	Liquid	2.3E-04	per year	OGP
	Rupture	Liquid	3.0E-05	per year	OGP
Unloading Hose	10 mm hole	Liquid	1.3E-05#	per hour	Purple Book
	25 mm hole	Liquid	1.3E-05	per hour	Purple Book
	50 mm hole	Liquid	1.3E-05	per hour	Purple Book
	Rupture	Liquid	4.0E-06	per hour	Purple Book
LNG Storage Tank	10 mm hole	Liquid	3.3E-06[!]	per year	OGP
	25 mm hole	Liquid	3.3E-06[!]	per year	OGP
	50 mm hole	Liquid	3.3E-06[!]	per year	OGP
	Rupture	Liquid	2.5E-08	per year	OGP
Metering	10 mm hole	Gas	2.45E-02	per year	UK HCR
	25 mm hole	Gas	2.15E-03	per year	UK HCR
	50 mm hole	Gas	2.69E-04	per year	UK HCR
Cylinder	Rupture	Gas	1E-06	per year	Purple Book

*Notes: The leak frequency of unloading arm, presented in the UK HSE, has been evenly distributed into 10 mm and 25 mm hole sizes.

#Notes: The leak frequency of unloading hose, presented in the Purple Book, has been evenly distributed into 10 mm, 25 mm and 50 mm hole sizes.
!Notes: The leak frequency of LNG storage tank, presented in OGP, has been evenly distributed into 10 mm, 25 mm and 50 mm hole sizes.

6.2 *Release Hole Sizes*

The release hole sizes presented in **Table 6-2**, which are consistent with the OGP database, were adopted in this QRA Study.

Table 6-2 Hole Sizes Considered in the QRA

Leak Description	Hole Size
Very Small Leak	10 mm
Small Leak	25 mm
Medium Leak	50 mm
Rupture	>150 mm

6.3 *Flammable Gas Detection and Emergency Shutdown Probability*

With reference to the Purple Book, the effect of block valve system is determined by various factors, such as the position of gas detection monitors and the distribution thereof over the various wind directions, the direction limit of the detection system, the system reaction time and the intervention time of an operator. The probability of failure on demand of the block valve system as a whole is 0.01 per demand.

Considering that the FSRU and the ORF at the CCGT Power Plant is provided with gas detection systems and automatic emergency shutdown systems, the probability of executing the isolation successfully when required was selected as 99% in this QRA Study.

6.4 *Ignition Probability*

The immediate ignition probability was conservatively estimated based on offshore ignition scenarios No. 24 from the OGP Ignition Probability Database. For flammable liquids with flash point of 55°C or higher (e.g. diesel, fuel oil etc.), a modification factor of 0.1 was applied to reduce the ignition probability as suggested in OGP.

It was conservatively assumed that the ratio between immediate ignition and delayed ignition as 50:50.

6.5 *Ignition Sources*

In order to calculate the risk from flammable materials, information is required on the ignition sources which are present in the area over which a flammable cloud may drift. The probability of a flammable cloud being ignited as it moves downwind over the sources can be calculated. The ignition source has three factors:

- Presence factor is the probability that an ignition source is active at a particular location;
- Ignition factor defines the "strength" of an ignition source. It is derived from the probability that a source will ignite a cloud if the cloud is present over the source for a particular length of time; and
- The location of each ignition source is specified. This allows the position of the source relative to the location of each release to be calculated. The results of the dispersion calculations for each flammable release are then used to determine the size and mass of the cloud when it reaches the source of ignition.

The ignition sources are site specific. The typical ignition sources are marine traffic and the population nearby.

Marine traffic are area ignition sources in *SAFETI 6.7*. The presence factor for a line source is determined based on traffic densities, average speed. The location of the line source is drawn onto the site map in *SAFETI 6.7*. Probability of ignition for a vehicle is taken as 0.4 in 60 seconds based on TNO Purple Book.

SAFETI 6.7 will automatically allow for people acting as ignition sources. These are based on the population data. The presence of such sources (e.g. cooking, smoking, heating appliances, etc.) is derived directly from the population densities in the area of concern.

6.6 PROBABILITY OF VAPOUR CLOUD EXPLOSION

The probability of explosion given an ignition was taken from the Cox, Lees and Ang model, as shown in **Table 6-3**. VCE occurs upon a delayed ignition from a flammable gas release at a congested area.

Table 6-3 Probability of Explosion

Leak Size (Release Rate)	Explosion Probability
Minor (< 1 kg s^{-1})	0.04
Major (1 – 50 kg s^{-1})	0.12
Massive (> 50 kg s^{-1})	0.30

6.7 EVENT TREE ANALYSIS

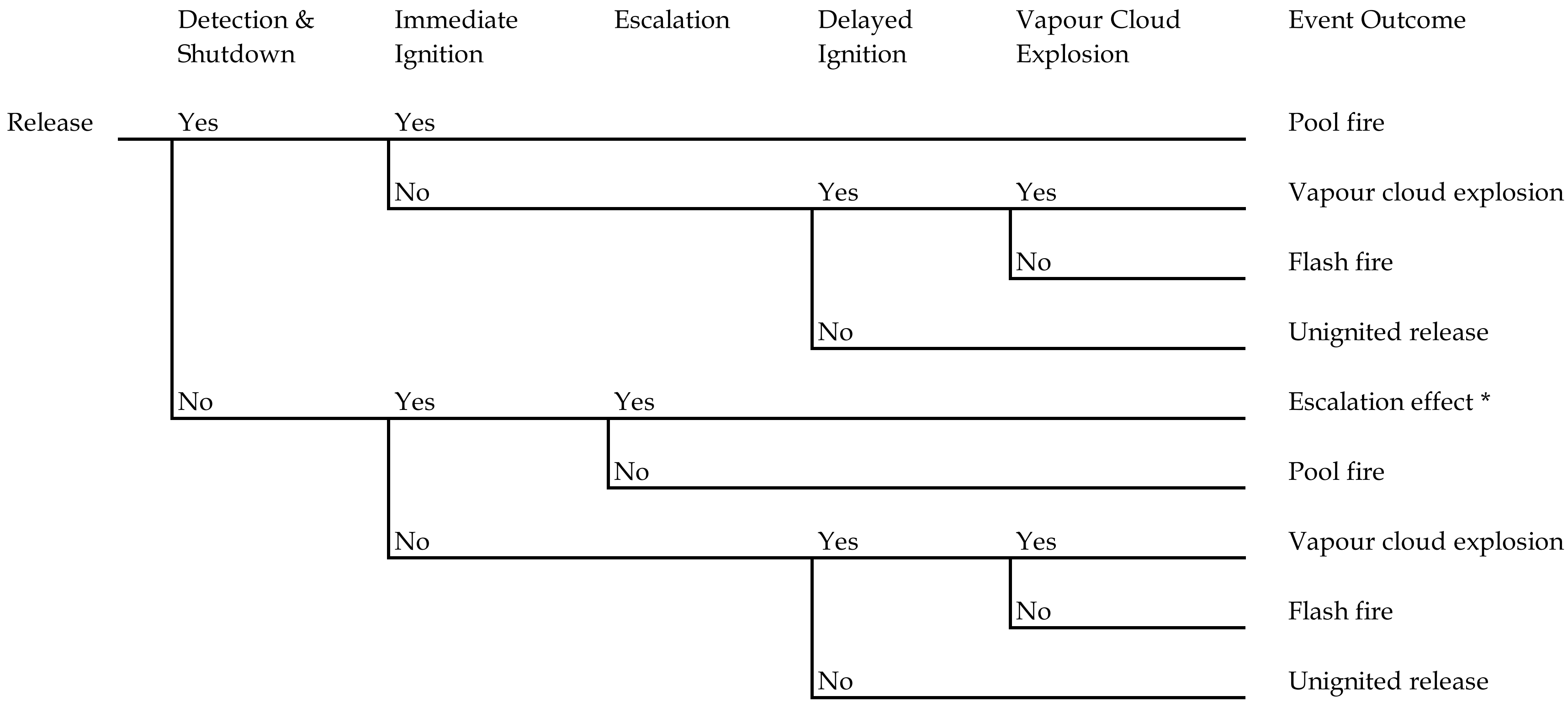
An event tree analysis was performed to model the development of each hazardous scenario outcome (jet fire, pool fire, flash fire, fireball and VCE) from an initial release scenario. The event tree analysis considered whether there is immediate ignition, delayed ignition or no ignition, with consideration of the associated ignition probability as discussed above. The development of the event tree is depicted at **Figure 6-1**, **Figure 6-2** and **Figure 6-3** for LNG, natural gas/ hydrogen, and diesel release scenarios respectively.

6.8 *ESCALATION ANALYSIS*

An initially small release may escalate into a larger, more serious event if a jet fire or pool fire by a high radiation level of 37.5 kW/m^2 or greater impinges on neighbouring equipment/ piping for an extended time (more than five (5) minutes for jet fire and more than ten (10) minutes for pool fire). This is taken into account in the modelling for isolation fail branch of the event tree, depicted in **Figure 6-1**, **Figure 6-2** and **Figure 6-3** for LNG, natural gas/ hydrogen and diesel release scenarios respectively.

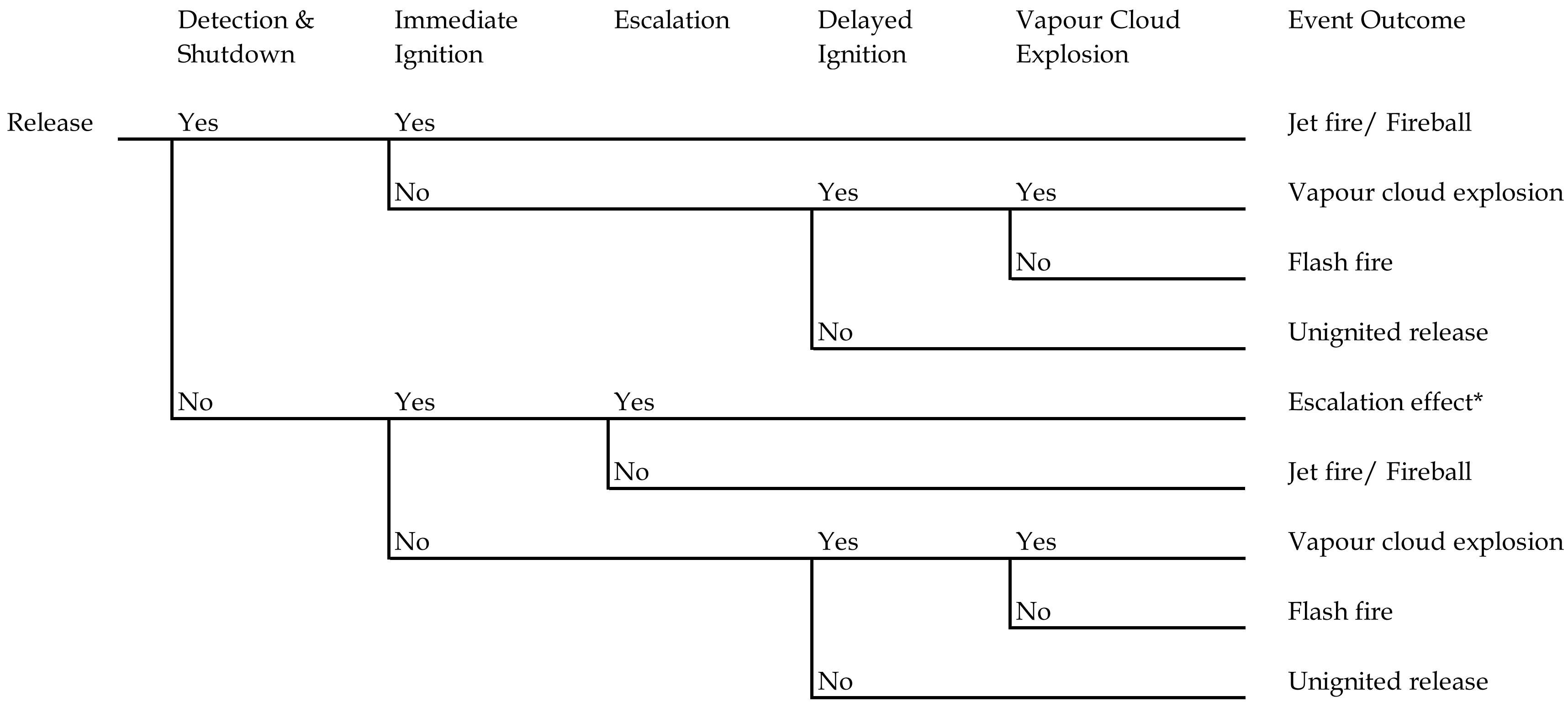
If neighbouring equipment/ piping is within range of the jet fire event flame zone, an escalation probability of 1/6 has been taken to conservatively estimate the directional probability and chance of impingement. In case pool fire events, the escalation probability was conservatively estimated without considering any directional probability.

Escalation has been assumed to cause only a full bore rupture of the affected equipment and piping, leading to fireball event as the worst-case scenario.



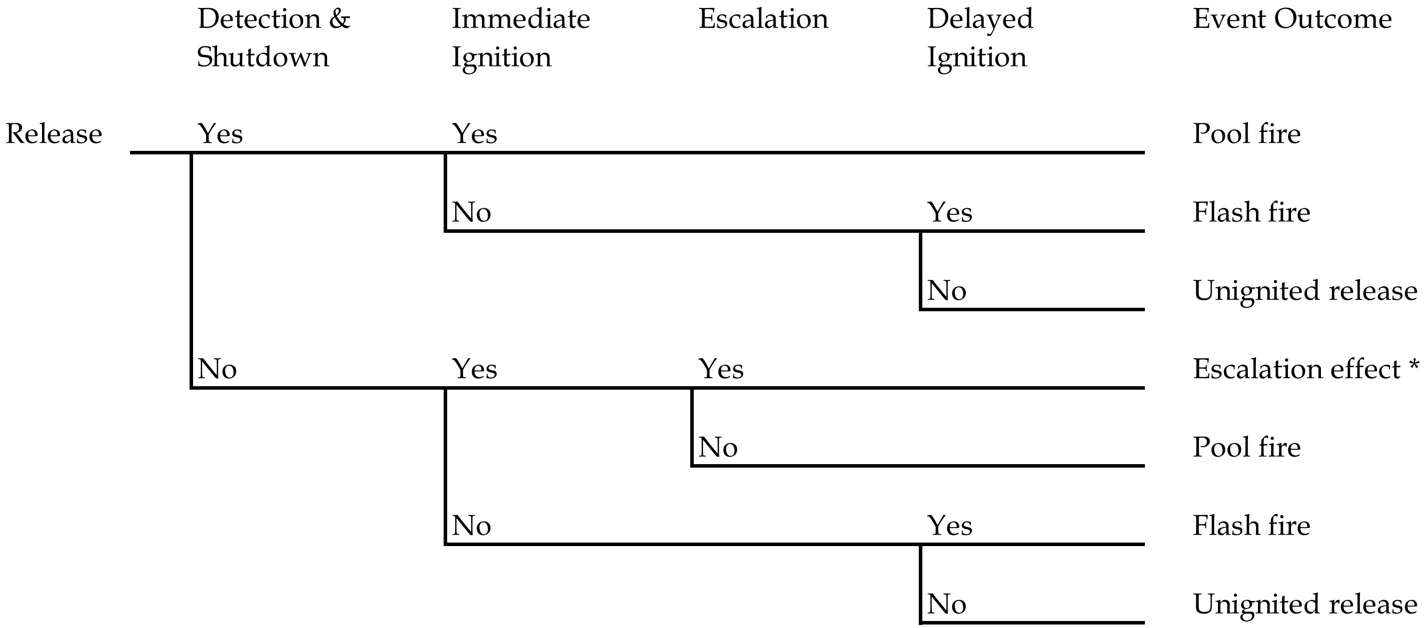
Note *: The escalation effect probability is estimated based on the location of release scenario and target equipment, as well as the associated consequence impact distance and duration. As such, the escalation probability for each hazardous scenario regardless different hole size and location are assumed as 1/6, and it is only applied if separation distance between release scenario and target equipment is within the associated consequence impact distance.

Figure 6-1 Event Tree Analysis for LNG Release from Offshore Jawa-1 Project Facilities



Note *: The escalation effect probability is estimated based on the location of release scenario and target equipment, as well as the associated consequence impact distance and duration. As such, the escalation probability for each hazardous scenario regardless different hole size and location are assumed as 1/6, and it is only applied if separation distance between release scenario and target equipment is within the associated consequence impact distance.

Figure 6-2 Event Tree Analysis for Natural Gas/ Hydrogen Release from Offshore and Onshore Jawa-1 Project Facilities



Note *: The escalation effect probability is estimated based on the location of release scenario and target equipment, as well as the associated consequence impact distance and duration. As such, the escalation probability for each hazardous scenario regardless different hole size and location are assumed as 1/6, and it is only applied if separation distance between release scenario and target equipment is within the associated consequence impact distance.

Figure 6-3 Event Tree Analysis for Diesel Release from Offshore Jawa-1 Project Facilities

7 CONSEQUENCE ANALYSIS

This section summarises the approaches to model the major hazardous scenarios from the continuous and catastrophic releases considered in this QRA Study. Consequence analysis comprises the following items:

- Source term modelling, which involves determining the release rate variation with time and thermodynamic properties of the released fluids;
- Physical effects modelling, which involves estimating the effect zone of the various hazardous scenarios;
- Dispersion Modelling for Subsea Release; and
- Consequence end-point criteria, which involves assessing of the impact of hazardous scenarios on the exposed population.

7.1 SOURCE TERM MODELLING

PHAST was used to estimate the release rates, which were used to determine the ignition probability. Source term modelling was carried out to determine the maximum (e.g. initial) release rate that may be expected should a loss of containment occur.

7.2 RELEASE DURATION

For LNG unloading arm failure at the LNG CARRIER and FSRU two (2) release durations were considered:

- 30 seconds release; and
- 2 minutes release.

A shorter release time (i.e. 30 seconds) was adopted in this QRA Study due to the presence of personnel in the vicinity who can initiate emergency shutdown successfully on top of the fire and gas detection system, and also due to the provision of detectors for excessive movement of the unloading arm which will initiate an automatic shutdown. The 2-minute release duration represents the case of failure of isolation of one unloading arm. Duration longer than two (2) minutes was not considered significant given that the transfer pumps on the LNG can be stopped, which will stop any further release.

For other offshore and onshore Jawa-1 Project facilities (e.g. FSRU, CCGT Power Plant), with reference to Purple Book, the closing time of an automatic blocking system is two (2) minutes, representing the release duration for isolation success case. Detection and shutdown system may however fail due to some reasons, also as per Purple Book, the release duration is limited to a maximum of thirty (30) minutes. The release duration of thirty (30) minutes was conservatively adopted for Offshore Pipeline, Onshore Pipeline and CCGT Power Plant in this QRA Study as the release duration for isolation failure case.

7.3 *RELEASE DIRECTION*

The orientation of a release can have some effects on the hazard footprint calculated by *PHAST*. The models take into account the momentum of the release, air entrainment, vaporization rate and liquid rainout fraction.

For a horizontal, non-impinging release, momentum effects tend to dominate for most releases giving a jet fire as the most serious outcome. If a release is vertically upwards, the hazard footprint will be significantly less compared to a horizontal release. In addition, if a release impinges on the ground or other obstacles, the momentum of the release and air entrainment is reduced, thereby reducing the hazard footprint but also increasing the liquid rainout fraction. In this scenario, a pool fire may become more likely.

Therefore, for all pool fire scenarios, the release orientation was set to "*downward impinging release*" in order to obtain the worst-case consequence pool fire, while "*horizontal non-impinging*" was representatively selected for modelling fire effects such as jet fire and flash fire as a conservative approach.

7.4 *PHYSICAL EFFECTS MODELLING*

PHAST was used to perform the physical effects modelling to assess the effects zones for the following hazardous scenarios:

- Jet fire;
- Pool fire;
- Flash fire;
- Fireball; and
- VCE.

7.4.1 *Jet Fire*

A jet fire results from an ignited release of the pressurised flammable gas. The momentum of the release carries the flammable materials forward in form of a long plume entraining air to give a flammable mixture. Combustion in a jet fire occurs in the form of a strong turbulent diffusion flame that is strongly influenced by the momentum of the release.

A jet fire was modelled for a pressurised flammable gas release. The default jet fire correlation model in *PHAST* was selected, and the release orientation was set as a horizontal non-impinging release.

7.4.2 *Flash Fire*

If there is no immediate ignition, the flammable gas such as natural gas and hydrogen may disperse before subsequently encountering an ignition source giving a jet fire or pool fire. The vapour cloud will then burn with a flash back to the source of the leak. A flash fire is assumed to be fatal to anyone caught within the flash fire envelope, although the short duration of a flash fire means that radiation effects are negligible. The fatality probability is therefore zero for persons outside the flash fire envelope.

Dispersion modelling was conducted by *PHAST* to calculate the extent of the flammable vapour cloud. This takes into account both the direct vaporisation from the release, and also the vapour formed from evaporating pools. The extent of the flash fire was assumed to be the dispersion distance to LFL in this QRA Study.

7.4.3 *Pool Fire*

In case of an early ignition of a liquid pool such as LNG pool, an early pool fire will be formed and the maximum pool diameter can be obtained by matching the burning rate with the release rate. Under such a condition, the size of the pool fire will not increase further and will be steady. In case of a delay ignition, the maximum pool radius is reached when the pool thickness at the centre of the pool reaches the maximum thickness.

The pool size of an early pool fire was taken into account for this QRA Study if available, otherwise, that of a late pool fire was considered.

7.4.4 *Fireball*

Immediate ignition of releases caused by a rupture in the pipeline may give rise to a fireball upon an ignition. Due to the transient nature of a release for high pressure condition, the mass of fuel entering the fireball for high pressure (> 40 barg) natural gas pipeline is difficult to estimate. A proposed alternative method was used to calculate at each time step the quantity of fuel that can be consumed in a fireball with the same burning time as the time since the start of the release. The size of the fireball is determined by equating these two (2) values.

Numerical modelling should be carried out to estimate the release rate and the mass released for different duration.

The discharge rate model for release from a high pressure natural gas pipeline is based on the equation for flow of an ideal gas through an orifice under isentropic conditions. If the ratio of the upstream pressure to that of the downstream pressure is sufficiently high, the flow is choked or sonic and the corresponding discharge rate will follow the critical flow relationship which is independent of downstream pressure as given below:

$$Q = c_d A_h \left[p\rho_0 \gamma \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}} \right]^{1/2}$$

Where

c_d Discharge coefficient

p Upstream pressure, N/m^2

ρ_0 Gas density in the pipeline, kg/m^3

γ Gas specific heat ratio, 1.31 for natural gas supplying to the Project facility

A_h Puncture area, m^2

For gas releases from pipeline ruptures, an empirical correlation developed by Bell and modified by Wilson **Error! Reference source not found.** is adopted which expresses an isothermal pipeline gas release as a 'double exponential' that decreases with time with two (2) important time constants. The model applies to mass of gas present in the pipeline of length L_p (m) and area A_p (m^2) (with the release isolated, i.e. upstream supply cut-off).

$$Q_t = \frac{Q_0}{(1+\alpha)} \left[e^{\frac{-t}{\alpha^2 \beta}} + \alpha e^{\frac{-t}{\beta}} \right]$$

where

Q_t Time dependent mass flow rate, kg/s

Q_0 Initial mass flow rate at the time of rupture, kg/s

t Time in seconds

α Nondimensional mass conservation factor

$$\alpha = \frac{M_T}{\beta Q_0}$$

M_T Total mass in the pipeline, kg

β Time constant for release rate in seconds

For small release:

$$\beta \approx \frac{L\sqrt{K_r}}{CK_A}$$

For large holes where $\frac{K_A^2}{K_F K_\gamma} > 30$

$$\beta \approx \frac{2L}{3C\sqrt{K_F}}$$

where

$$K_F = \frac{D_p}{\gamma f L_p} \;\; ; \; K_A = \frac{A_h}{A_p} \;\; ; \; K_\gamma = \left[\frac{\gamma+1}{2}\right]^{\frac{\gamma+1}{\gamma-1}}$$

D_p is diameter of pipeline, m

f is pipeline friction factor, dimensionless

The above equations have been used to model release rate with time for full bore ruptures.

The mass/duration correlation in the fireball model used in "TNO Yellow Book" is given as:

$t = 0.852M^{0.26}$

$r = 3.24M^{0.325}$

where:

M is the mass in kg

t is duration in seconds

r is the radius of the fireball in m

Based on the above, the fireball mass and duration was estimated as 2,000 kg for fireball consequence modelling, and the consequence analysis for a fireball scenario was conducted by Roberts (HSE) method in *PHAST* as the calculation method.

7.4.5 *Vapour Cloud Explosion (VCE)*

Explosions may only occur in areas of high congestion, or high confinement. An ignition in the open may only result in a flash fire or an unconfined VCE yielding relatively a lower damaging overpressure.

When a large amount of flammable gas is rapidly released, a vapour cloud forms and disperses in the surrounding air. The release can occur from the process facilities on the FSRU and CCGT Power Plant. If this cloud is ignited before the cloud is diluted below its LFL, a VCE or flash fire will occur. The main consequence of a VCE is damage to surrounding structures while the main consequence of a flash fire is a direct flame contact. The resulting outcome, either a flash fire or a VCE depends on a number of parameters.

Pietersen and Huerta (1985) has summarised some key features of 80 flash fires and AIChE/CCPS (2000) provides an excellent summary of vapour cloud behaviour. They describe four (4) features which must be present in order for a VCE to occur. First, the release material must be flammable. Second, a cloud of sufficient size must form prior to an ignition, with ignition delays of 1 to 5 minutes considered the most probable for generating VCEs. Lenoir and Davenport (1992) analysed historical data on ignition delays, and found delay times from six (6) seconds to as long as sixty (60) minutes. Third, a sufficient amount of the cloud must be within the flammable range. Fourth, sufficient confinement or turbulent mixing of a portion of the vapour cloud must be present.

The blast effects produced depend on whether a deflagration or detonation results, with a deflagration being, by far, the most likely. A transition from deflagration to detonation is unlikely in the open air. The ability for an explosion to result in a detonation is also dependent on the energy of the ignition source, with larger ignition sources increasing the likelihood of a direct detonation.

In order to calculate the distances to given overpressures, the Baker-Strehlow-Tang (BST) model, which is a congestion based model, was adopted in this QRA Study. The volume of flammable material in congested areas was estimated as well as the flame expansion characteristics, and then the BST model predicts the overpressures at a given distance. The BST model predicts the blast levels based on:

- Mass of flammable material involved in an explosion (determined based on dispersion modelling by *PHAST*);
- Reactivity of the flammable material (high, medium, or low)
- Degree of freedom for the flame expansion (1D, 2D, 2.5D or 3D); and
- Congestion level of a potential explosion site (high, medium, low).

To apply the BST model, the FSRU and CCGT Power Plant were identified with three (3) potential explosion sites based on the Jawa-1 Project facility layout. Leaks from the hazardous sections of the Jawa-1 Project facility were then modelled to cause explosion in the nearest potential explosion site.

Similar to thermal radiation levels, overpressure levels, corresponding to specific fatality levels, were taken from the data published by Purple Book for indoor/ outdoor population. The various overpressure levels considered in this QRA Study are presented in **Table 7-3**.

Table 7-1 summarises the input parameters, such as level of congestion, reactivity of material, etc., to the BST model performed by *PHAST*.

Table 7-1 Identified PES for Jawa-1 Project Facilities

Tag	PES Location	Reactivity of Material	Degree of Freedom for Flame Expansion	Level of Congestion	Length (m)	Width (m)	Height (m)	Estimated PES Volume (m^3)
PES 1	Regasification Plant on FSRU	Low	2D	Medium	30	20	10	6,000
PES 2	HRSG for CCGT-1	Low	2D	Medium	25	14	10	3,500
PES 3	HRSG for CCGT-2	Low	2D	Medium	25	14	10	3,500

7.5 DISPERSION MODELLING FOR SUBSEA RELEASES

In the event of a flammable gas release from the proposed subsea pipeline, the flammable gas will bubble to the surface of the sea and disperse. The simplest form of modelling applied to the subsea pipeline release is to assume that the dispersing bubble plume (driven by gas buoyancy) can be represented by a cone of fixed angle. The typical cone angle is between 10° and 12°. However, Billeter and Fannelop suggested that the "release area" (where bubbles breakthrough the sea surface) is about the twice the diameter of the bubble plume. Hence, an angle of 23° was recommended and used in this QRA Study for the subsea pipeline. The water depth is between 5 and 6 m. For this range of water depths, the cone model predicted the 'release area' to be in the range of 1.1 to 1.3 m diameter.

Any flammable gas will begin to disperse into atmosphere upon reaching the sea surface. The distance to which the flammable gas envelope extends will depend on ambient conditions such as wind speed and atmospheric stability as well as source conditions. *PHAST* was used to model the plume dispersion as an area source on the surface of the ocean.

7.6 CONSEQUENCE END-POINT CRITERIA

The estimation of the fatality/ injury caused by a physical effect such as thermal radiation requires the use of probit equations, which describe the probability of fatality as a function of some physical effects. The probit equation takes the general form:

$$Y = a + b \ln V$$

where

Y	is the probit
a, b	are constants determined from experiments
V	is a measure of the physical effect such as thermal dose

The probit is an alternative way of expressing the probability of fatality and is derived from a statistical transformation of the probability of fatality.

7.6.1 *Thermal Radiation*

The following probit equation is used to determine impacts of thermal radiation from a jet fire, pool fire or fireball to persons unprotected by clothing.

$$Y = -36.38 + 2.56 \ln (t\, I^{4/3})$$

where:

Y	is the probit
I	is the radiant thermal flux (W/m^2)
t	is duration of exposure (s)

The exposure time, t, is limited to maximum of twenty (20) seconds. The corresponding fatality probability estimated using Probit equation for specific thermal radiation are summarised in **Table 7-2**.

Table 7-2 Levels of Harm for 20-second Exposure Time to Heat Fluxes

Incident Thermal Flux (kWm^{-2})	Fatality Probability for 20-second Exposure Time
9.8	1%
19.5	50%
28.3	90%
35.5	99.9%

7.6.2 *Fireball*

The fatality rate within the fireball diameter is assumed to be 100%.

7.6.3 *Flash Fire*

With regard to a flash fire, the criterion chosen is that a 100% fatality is assumed for any person outdoors within the flash fire envelope. The extent of the flash fire is conservatively assumed to be the dispersion to its LFL

7.6.4 *Overpressure*

For an overpressure explosion, a relatively high overpressure is necessary to lead to significant fatalities for persons outdoor. Indoor population tends to have a higher harm probability due to the risk of structural collapse and flying debris such as breaking windows. **Table 7-3** presents the explosion overpressure levels from the Purple Book, which were adopted in this QRA Study.

Table 7-3 Effect of Overpressure - Purple Book

Explosion Overpressure (barg)	Fraction of People Dying	
	Indoor	Outdoor
> 0.3	1.000	1.000
> 0.1 to 0.3	0.025	0.000

8 RISK SUMMATION AND ASSESSMENT

8.1 OVERVIEW

The hazardous scenarios, the associated frequencies, meteorological data, population data, and suitable modelling parameters identified were input into *SAFETI 6.7*, and all risk summation was modelled using *SAFETI 6.7*. The inputs to the software comprise of:

- Release cases file detailing all identified hazardous scenarios, and their associated frequencies and probabilities;
- Release location of hazardous scenarios either at given points or along given routes;
- Weather probabilities file that details the local meteorological data according to a matrix of weather class (speed/stability combinations) and wind directions;
- Population data with the number of people and polygonal shape as well as indoor faction; and
- Ignition sources with ignition probabilities in a given time period.

8.2 RISK MEASURES

Two (2) type of risk measures considered in this QRA Study are individual risk and societal risk.

8.2.1 Individual Risk

Individual risk for fatality is defined as the frequency of fatality per individual per year due to the realisation of specified hazards. Individual risk may be derived for a hypothetical individual present at a location 100% of time or a named individual considering the probability of his/ her presence etc. (the latter case is known as personal individual risk). In this QRA study, the former type of individual risk is reported, considering that it gives an estimate of maximum individual risk.

8.2.2 Societal Risk

Societal risk is defined as the risk to a group of people due to all hazards arising from a hazardous installation or activity. The simplest measure of societal risk is the rate of death or potential loss of life (PLL), which is the predicted equivalent fatality per year. The PLL is calculated as follows:

$$PLL = f_1N_1 + f_2N_2 + f_3N_3 + \ldots\ldots + f_nN_n$$

where f_n is the frequency and N_n is the number of fatalities associated with n^{th} hazardous outcome event.

Societal risk can also be expressed in the form of an F-N curve, which represents the cumulative frequency (F) of all event outcomes leading to N or more fatalities. This representation of societal risk highlights the potential for accidents involving large number of fatalities.

8.3 *RISK CRITERIA*

The Annex L "Level of Risk" of the BS EN 1473 has given the risk criteria for the off-site population for LNG installations.

8.3.1 *Individual Risk Criteria*

As stipulated in EN standard, any scenario causing one (1) to ten (10) fatalities is categorised into Class 2, the associated risk levels corresponding Class 2, depicted at **Figure 8-1**, are selected for the individual risk criteria adopted in this QRA Study.

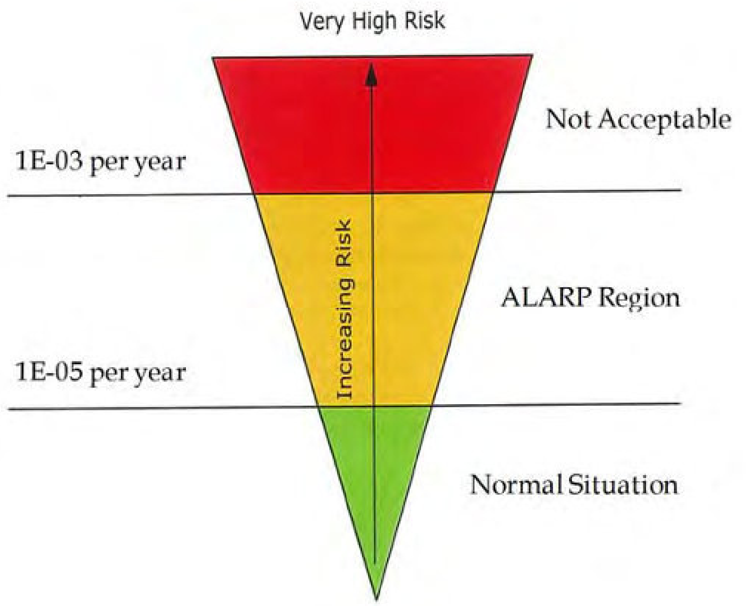


Figure 8-1 Individual Risk Criteria for Off-site Population

8.3.2 *Societal Risk Criteria*

As stipulated in EN standard, any scenario causing more than ten (10) fatalities is categorised into the most severe consequence Class 1, the associated risk levels corresponding Class 1, depicted at **Figure 8-2**, are selected for the societal risk criteria adopted in this QRA Study.

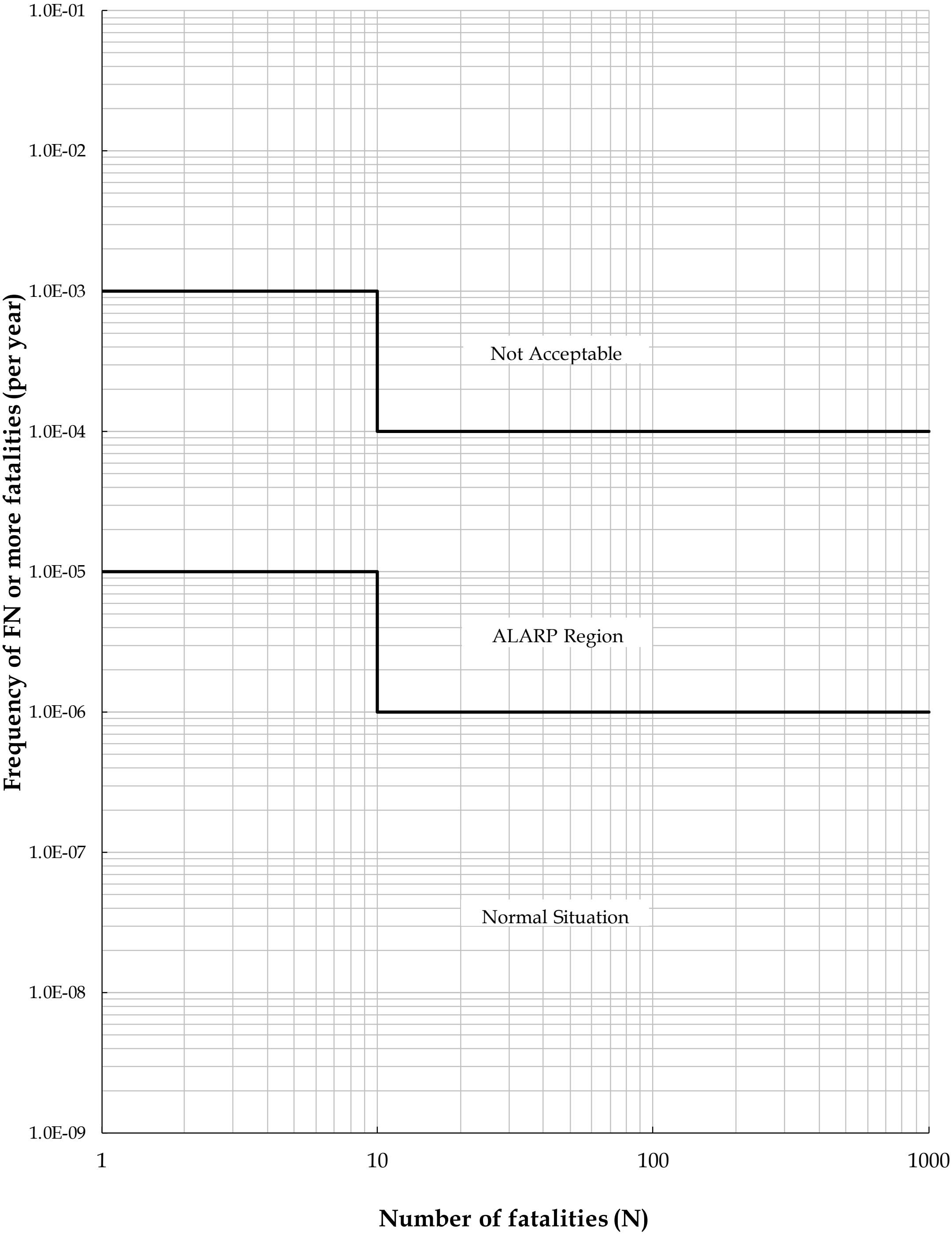


Figure 8-2 Societal Risk Criteria for Off-Site Population

8.4 *RISK RESULTS*

8.4.1 *Individual Risk Results*

The individual risk contours from 1E-04 to 1E-07 per year were depicted at **Figure 8-3** to **Figure 8-6**, and no individual risk contours from 1E-02 to 1E-03 per year were reached. As such, the individual risks for the off-site population are within the ALARP region as per EN standards.

8.4.2 *Societal Risk Results*

8.4.2.1 *Potential Loss of Life*

The total potential loss of life (PLL) to the off-site population in the vicinity of the Jawa-1 Project facilities are summarised from **Table 8-1** to **Table 8-3**.

The highest risk contributor for FSRU is from the fireball scenario of the line rupture of hazardous section "OLNGT_06 - Natural Gas from LNG Regasification Plant to Loading Platform" due to the associated relative larger consequence impact area and higher failure frequency.

The highest risk contributor for Onshore Pipeline is from the fireball scenario of the line rupture of hazardous section "OLNGT_21 – Natural Gas Onshore Pipeline" due to the associate relative larger consequence impact area.

Similar to the CCGT Power Plant, the highest top two risk contributors are from the fireball scenarios of the line rupture of hazardous sections "OLNGT_22 – Onshore Receiving Facilities" and "OLNGT_23 – Natural Gas Supply Line to CCGT Turbines" due to the associated relative larger consequence impact area.

Table 8-1 Potential Loss of Life to Off-site Population in vicinity of FSRU

Hazardous Scenario Code	Description	PLL
FB_OLNGT_06_L	Fireball scenario from the line rupture of natural gas from LNG Regasification Plant to Loading Platform	2.63E-04
OLNGT_03_L	Flammable effect scenarios (pool fire and flash fire) from large hole size release of LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	1.84E-05
FB_OLNGT_08_L	Fireball scenario from the line rupture of Riser for Subsea Pipeline	1.30E-05
FB_OLNGT_05_L	Fireball scenario from the line rupture of LNG Regasification Plant including four Regasification Trains	1.14E-05
FB_OLNGT_07_L	Fireball scenario from the line rupture of natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	2.72E-06
Others		1.01E-05
Total		3.19E-04

Table 8-2 Potential Loss of Life to Off-site Population in vicinity of Onshore Pipeline

Hazardous Scenario Code	Description	PLL
FB_OLNGT_21_L	Fireball scenario from the line rupture of onshore natural gas pipeline	1.09E-05
FF_OLNGT_21_L	Flash fire from the line rupture of onshore natural gas pipeline	6.78E-10
Total		1.09E-04

Table 8-3 Potential Loss of Life to Off-site Population in vicinity of CCGT Power Plant

Hazardous Scenario Code	Description	PLL
FB_OLNGT_22_L	Fireball scenario from the line rupture of onshore receiving facilities	3.12E-05
FB_OLNGT_23_L	Fireball scenario from the line rupture of natural gas supply line from onshore receiving facilities to CCGT turbines	1.45E-05
FF_OLNGT_22_L	Flash fire scenario from the line rupture of onshore receiving facilities	1.17E-05
FF_OLNGT_23_L	Flash fire scenario from the line rupture of natural gas supply line from onshore receiving facilities to CCGT turbines	1.40E-06
Others		2.82E-06
Total		6.16E-05

8.4.2.2 F-N Curves

The societal risk result, in terms of F-N curves, for the and off-site population is depicted at Figure 8-7Error! Reference source not found., demonstrating that the associated social risks are not in "Not Acceptable" region EN standards even a conservative assumption was made for off-site population.

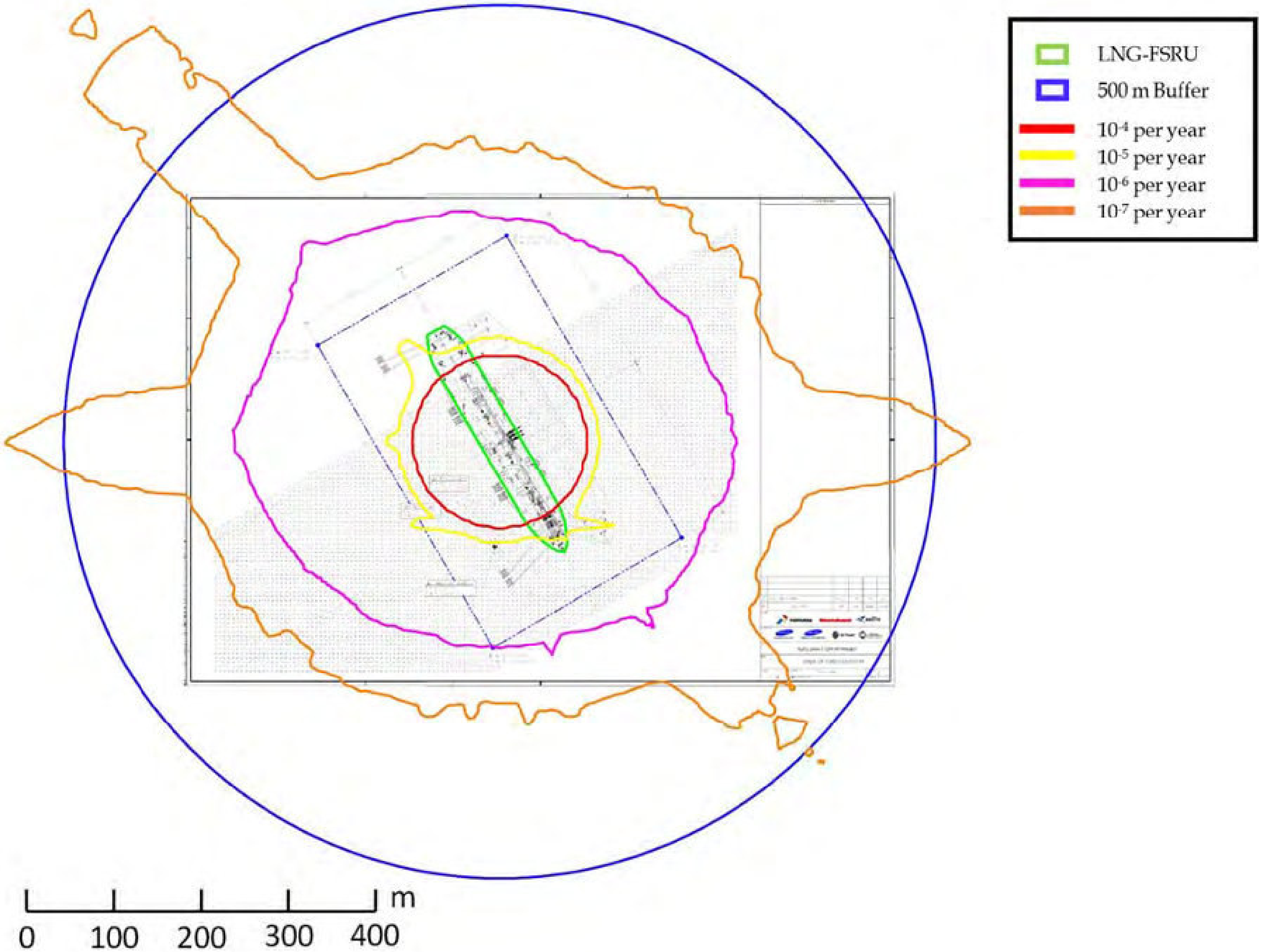


Figure 8-3 Individual Risk Contours for FSRU

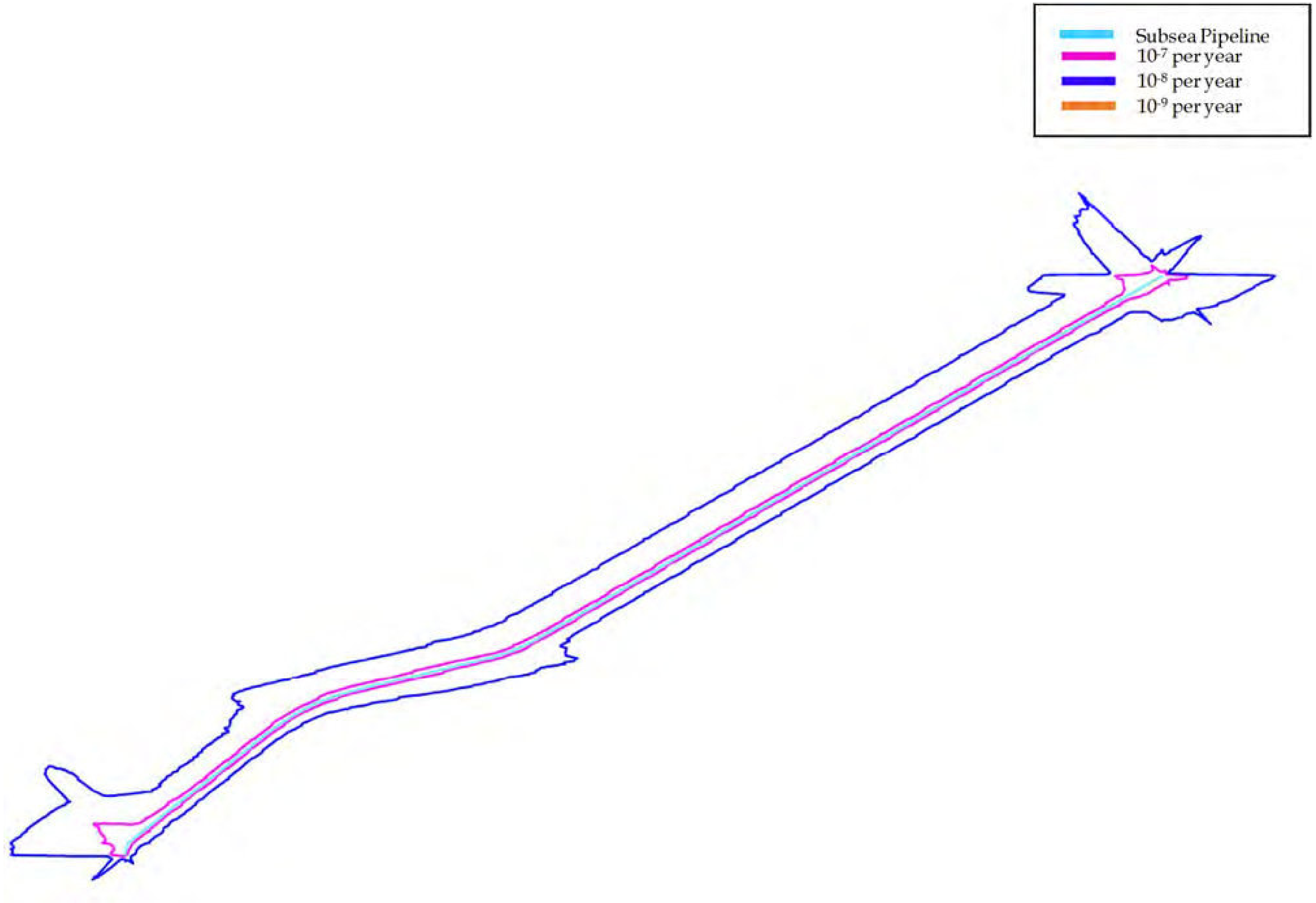


Figure 8-4 Individual Risk Contours for Subsea Pipeline

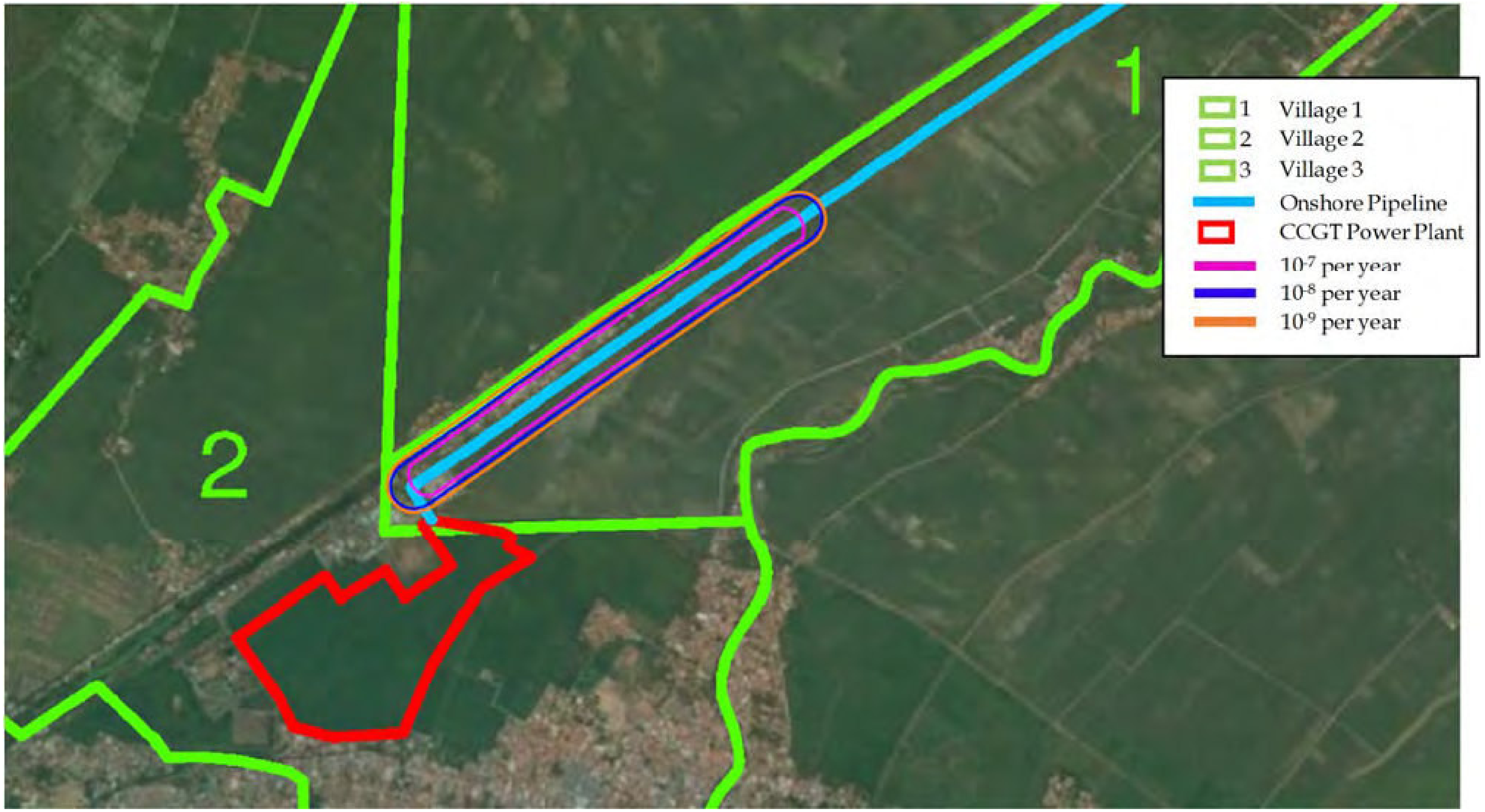


Figure 8-5 Individual Risk Contours for Onshore Pipeline

Figure 8-6 Individual Risk Contours for CCGT Power Plant

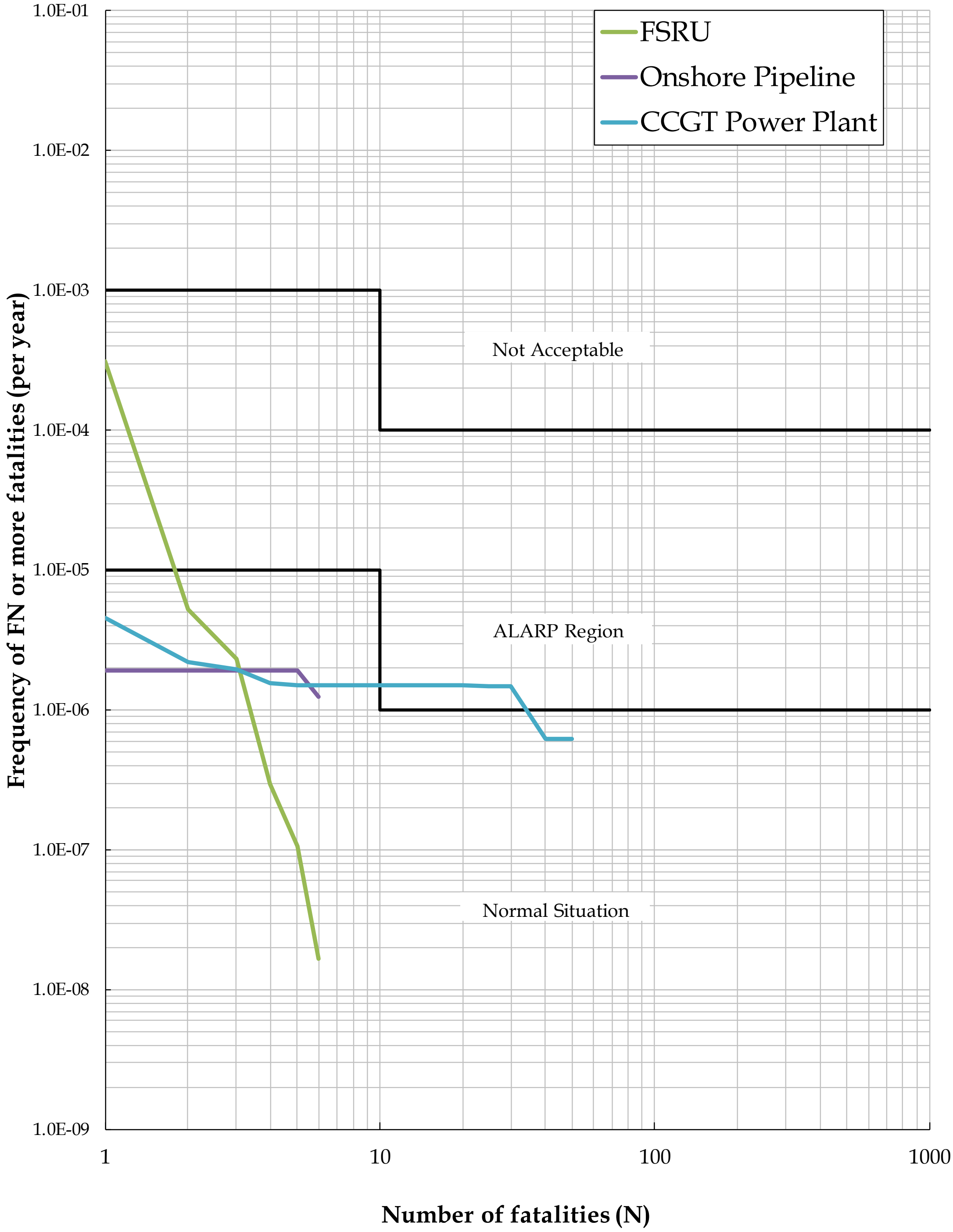


Figure 8-7 F-N Curve for Off-Site Population in vicinity of Jawa-1 Project Facilities

9 *CONCLUSION & RECOMMENDATIONS*

A Quantitative Risk Assessment Study has been conducted to evaluate the risk level associated with the transport, storage and use of LNG, natural gas, hydrogen and other dangerous goods (marine diesel oil, etc.) associated with the Jawa-1 Project facilities during the operational phase.

Risk Analysis Findings

Both individual risks and societal risk to the off-site population in the vicinity of the Jawa-1 Project facilities are not exceeding to "Not Acceptable" region as per EN standards, in order to manage the risk levels associated with the Jawa-1 Project facilities so that the risk levels will not exceed to the "Not Acceptable" region as per EN standards.

Recommendation

The following recommendations are made to further consideration:

- A Safety Zone covering the individual risk contour of 1E-06 per year should be considered to manage the off-site population in the vicinity of the FSRU;

- Emergency response plan should be implemented to evacuate the community in the vicinity of the Jawa-1 Project facilities and minimise the impact on the community in case major accident events associated with the Jawa-1 Project facilities occurred;

- Formal Safety Studies such as Hazard and Operability (HAZOP) Study etc., should be conducted for the Jawa-1 Project facilities during the detailed engineering stage to make sure process hazards are well controlled; and

- QRA Study for the Jawa-1 Project facilities should be considered to be regularly updated (such as update per 5 years) to assess potential off-site population and marine traffic growth.

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ANNEX H-1

Summary of Industry Incidents Review

H1 SUMMARY OF INDUSTRY INCIDENTS REVIEW

A review of the past industry incidents at similar facilities worldwide has been conducted to further investigate the possible hazards from the Jawa-1 Project's facilities. This annex summarises the findings on the past industry incidents based on the review of comprehensive incidents/ accidents database.

H1.1 INCIDENTS RELATED TO LNG CARRIER AND FSRU VESSEL

Incidents/ accidents related to LNG CARRIERS are summarised in **Table H1.1**.

Based on the listed sources in the table below, no safety incident has been recorded for the FSRU since the world's first FSRU began operation more than 10 years ago.

Table H.1 Summary of Incident Review for LNG CARRIER

Date, place	Cause	Description	Source
Negeshi, Japan (1970)	External Event	A few hours out of Japan heavy seas caused sloshing of cargo tanks in LNG ship steaming from Japan to Alaska. A thin membrane wall bent in four places and a half inch crack formed in a weld seam.	MHIDAS
Boston, Massachusetts, USA (1971)	Mechanical-Failure	LNG ship "Descartes" had gas leak from tank, faulty connection between tank dome and membrane wall, crew reportedly tried to conceal leak from authorities.	MHIDAS
Terneuzen; Algeria (1974)	Collision	LNG ship "Euclides" sustained contact damage with another vessel, causing damage to bulwark plating and roller fairlead.	MHIDAS
Canvey Island; Essex; UK (1974)	Collision	The coaster "Tower Princess" struck the "Methane Progress" as it was tied up at the LNG jetty tearing a 3 ft gash in its stern. No LNG was spilled & no fire	MHIDAS
El Paso Paul Kayser (1979)	Grounding	While loaded with 99,500 m^3 of LNG, the ship ran at speed onto rocks and grounded in the Straits of Gibraltar. She suffered heavy bottom damage over almost the whole length of the cargo spaces resulting in flooding of her starboard double bottom and wing ballast tanks. Despite this extensive damage, the inner bottom and the membrane cargo containment maintained their integrity. Five days after grounding, the ship was refloated on a rising tide by discharge of ballast by the ships' own pumps and by air pressurisation of the flooded ballast spaces.	SIGTTO (Society of International Gas Tankers Terminal and Operators Ltd.)

Date, place	Cause	Description	Source
Libra (1980)	Mechanical Failure	While on passage from Indonesia to Japan, the propeller tail shaft fractured, leaving the ship without propulsion. The Philippine authorities granted a safe haven in Davao Gulf to which the ship was towed. Here, with the ship at anchor in sheltered water, the cargo was transferred in thirty two (32) hours of uneventful pumping to a sister ship moored alongside. The LNG Libra was then towed to Singapore, gas-freeing itself on the way and was repaired there. In this casualty, there was, of course, no damage to the ship's hull and no immediate risk to the cargo containment.	SIGTTO (Society of International Gas Tankers Terminal and Operators Ltd.)
Taurus (1980)	Grounding	Approaching Tobata Port, Japan to discharge, the ship grounded in heavy weather with extensive bottom damage and flooding of some ballast tanks. After off-loading some bunkers and air pressurising the ruptured ballast spaces, the ship was refloated four days grounding. Despite the extent of bottom damage, the inner hull remained intact and the spherical cargo containment was undistributed. After a diving inspection at a safe anchorage, the ship proceeded under its own power to the adjacent LNG reception terminal and discharged its cargo normally.	SIGTTO (Society of International Gas Tankers Terminal and Operators Ltd.)
Thurley, United Kingdom (1989)	Human Error	While cooling down vaporisers in preparation for sending out natural gas, low-point drain valves were opened. One of these valves was not closed when pumps were started and LNG entered the vaporisers. LNG was released into the atmosphere and the resulting vapor cloud ignited, causing a flash fire that burned two operators.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR
Bachir Chihani (1990)	Mechanical Failure	Sustained structural cracks allegedly caused by stressing and fatigue in inner hull.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR
BOSTON, MASSACHUSETTS, USA (1996)	External Fire Event	Loaded LNG carrier sustained electrical fire in main engine room whilst tied up alongside terminal. Fire extinguished by crew using dry chemicals. Cargo discharged at reduced rate (over 90 h instead of 20 h) & vessel sailed under own power.	MHIDAS
SAKAI SENBOKU, Japan (1997)	Collision	LNG tanker sustained damage to shell plating on contact with mooring	MHIDAS

Date, place	Cause	Description	Source
		dolphin at pier. No spillage or damage to cargo system.	
BOSTON, MASSACHUSETTS, USA (1998)	Human Factor	LNG carrier was discharging cargo when arcs of electricity shorted out two of her generators. The US coast guard removed the vessel's certification of compliance as this incident was the latest in a series of deficiencies on the vessel.	MHIDAS
POINT FORTIN, TRINIDAD (1999)	Collision	A LNG carrier collided with a pier after it suffered an engine failure. There was no pollution or any injuries. The pier was closed for 2 weeks. $330,000 of damage done.	MHIDAS
EVERETT, MASSACHUSSETTS, USA (2001)	Mechanical	Suspected overpressurisation of No. 4 cargo tank resulted in some cracking of the outer tank dome. A minor leakage resulted in offloading being temporarily suspended. The tank itself was not damaged and offloading was completed. Vessel not detained.	MHIDAS
East of the Strait of Gibraltar (2002)	Collision	Collision with a U.S. Navy nuclear-powered attack submarine, the U.S.S Oklahoma City. In ballast condition. Ship suffered a leakage of seawater into the double bottom dry tank area.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR

H1.2 *INCIDENTS RELATED TO SUBSEA PIPELINE*

The representative incidents/ accidents related to the subsea pipelines are summarised in **Table H.2**.

Table H.2 Summary of Incident Review for Subsea Pipeline

Date, place	Cause	Description	Source
2006, St. Mary Parish, Louisiana	Dropped object	In a recent accident, a ruptured high-pressure natural gas pipeline was struck by a 5-ton mooring spud, dropped from a towing vessel Miss Megan. The uninspected vessel was pushing two barges, a construction barge, Athena 106, and the unmanned deck barge, IBR 234, through the West Cote Blanche Bay oil field in St. Mary Parish, Louisiana. The aft spud on Athena 106 was released from its fully raised position and struck the buried gas pipeline in the northwest area of the oil field. (Spuds were used to keep the barges stationary and hold them in place during marine construction work). The released gas was ignited and the subsequent fire engulfed both the towing vessel and the two barges. Five out of eight people onboard, including the master and four barge workers were killed and one barge worker was reported missing. Following the investigation conducted by NTSB, the cause of the accident was ascribed to the failure of the owner of Athena 106, Athena Construction and the master and owner of Miss Megan, Central Boat Rentals to ensure the spuds were pinned securely on its barges before getting under way	National Transportation Safety Board (2007)
1996, Tiger Pass, Louisiana	Dropped object	On 23 October 1996, in Tiger Pass, Louisiana, the crew of the dredge Dave Blackburn dropped a stern spud (a spud is a large steel shaft that is dropped into the river bottom to serve as an anchor and a pivot during dredging operations) into the bottom of the channel in preparation for continued dredging operations. The spud struck and ruptured a 12" diameter submerged natural gas steel pipeline. The pressurised (about 930 psig) natural gas released from the pipeline enveloped the stern of the dredge and an accompanying tug. Within seconds of reaching the surface, the natural gas ignited and the resulting fire destroyed the dredge and the tug. All 28 crew members from the dredge and tug escaped into water or onto nearby vessels. No fatalities resulted. The incident occurred due to incorrect information on the location of the gas pipeline that was passed on by the gas company to the dredging operator. The investigation report on the incident (by the NTSB) recommended that all pipelines crossing navigable waterways are accurately located and marked permanently.	National Transportation Safety Board (1998)

Date, place	Cause	Description	Source
1989, Sabina Pass, Texas,	Dropped object	The menhaden vessel Northumberland struck a 16″ gas pipeline in shallow water near Sabina Pass, Texas. The vessel was engulfed in flames; 11 of the 14 crew members died. The pipeline, installed in 1974 with 8 to 10 feet of cover, was found to be lying on the bottom, with no cover at all.	National Research Council (1994)
1987, Louisiana	Unknown	In July 1987, while working in shallow waters off Louisiana, a fishing vessel, the menhaden purse seiner Sea Chief struck and ruptured an 8″ natural gas liquids pipeline operating at 480 psi. The resulting explosion killed two crew members. Divers investigating found that the pipe, installed in 1968, was covered with only 6″ of soft mud, having lost its original 3-foot cover of sediments.	National Research Council (1994)

H1.3 INCIDENTS RELATED TO ONSHORE PIPELINE AND CCGT POWER PLANT

The representative incidents/ accidents related to the Onshore Pipeline and CCGT Power Plant are summarised in **Table H.3**.

Table H.3 Summary of Incident Review for Onshore Pipeline and CCGT Power Plant

Date, place	Cause	Description	Source
25/06/2001, Kazakhstan	Corrosion	Six metres of a one metre diameter pipe was thrown forty metres in the blast. Corrosion of the pipeline is thought to have led to the leak that caused the blast. Fire quickly extinguished and supplies resumed through an alternative pipe after three hours.	MHIDAS
10/04/2001, USA	Mechanical failure	Residents were evacuated for about three hours after a volatile gas cloud formed over a natural gas facility. The source of the leak was tracked down to a section of pipe, which was repaired.	MHIDAS
28/12/2000, Canada	Unknown	Explosion at a natural gas pumping station rattled windows 1.5 miles away. There was no rupture of the pipeline itself and the cause of the incident remains unknown. One man severely injured and gas pressure to customers affected	MHIDAS
28/05/2000, Canada	Mechanical failure	A section of the forty two inches pipeline ruptured during pressure-testing of the pipe.	MHIDAS
18/11/1998, UK	Impact	Workmen caused a main gas pipeline to fracture, sending a 30 ft plume of gas into the air. Local residents were evacuated and roads sealed off. It was several hours before the pressure had dropped enough for the pipe to be sealed off. No one was injured.	MHIDAS
14/08/1998, USA	External events	Lightning strike set fire to a natural gas compressor station. The resulting explosions sent a fireball 600 ft into the air. Five people were injured. Gas supplies to the whole of the Florida peninsula were shut off. Residents within two miles were evacuated.	MHIDAS
02/04/1998, Russia	Unknown	The metering unit of the natural gas distribution station was rocked by an explosion. A fire also occurred.	MHIDAS
27/06/1997, USA	Human factor	Gas escaped from a pipeline when equipment being used to take a metering station out of commission fractured a valve.	MHIDAS

Date, place	Cause	Description	Source
		No injuries were reported. People within a mile of the rupture were evacuated. No fire or explosion occurred.	
18/12/1995, Russia	Mechanical failure	Section of pipeline exploded due to high pressure in pipe.	MHIDAS
19/03/1995, USA	Unknown	Thirty six inches gas pipe ruptured. Leak caught fire & damaged reported 300 ft section. Gas rerouted to two parallel lines	MHIDAS
29/07/1993, UK	Impact	1,000 workers were evacuated as building contractors ruptured a mains pipe sending 40 ft gas into the air. Roads were sealed off for about an hour while the leak was brought under control.	MHIDAS
18/05/1989, Germany	General maintenance	Repairs to product pipeline possibly caused explosions/fires which destroyed refinery pumping/mixing station. Blaze burned for four hours as fire fed by 100 tonnes of fuel leaking from broken pipe system.	MHIDAS
10/10/2012, EU	Operation Error	The explosion occurred on 10 October 2012, just before midday, when the unit was being restarted. Earlier that morning, we had switched over to oil fuel in order to scan for defective non-return valves on the water-injection purging circuit. A transfer from natural gas to oil fuel takes place every 15 days in the period mid-October to March to prevent problems with fuel solidifying in ducts due to colder external temperatures. After the test we switched back to natural gas and proceeded to restart the unit at approximately 11:48. During each start-up, the gas valves (regulating valve SRV and on-off valves VS4, GCV1, GCV2 and GCV4) are tested for tightness. The test did not detect any problems. We therefore proceeded with the start-up by opening the gas supply and activating the spark plugs. At approximately 11:58, excessive vibrations were detected, corresponding to the time of the explosion (methane deflagration) in the boiler. This triggered the shutdown of the gas turbine and the whole unit.	eMARS
13/10/2008, EU	Operation Error	Explosion and fire caused by an unexpected and incidental flow of unburned Syngas in the room	eMARS

Date, place	Cause	Description	Source
		of the waste-heat boiler of the "Module 1" unit, for a wrong operation during the procedures of stop and purging for the maintenance of the turbogas (TG) of “Module 1”. The operation was controlled by subcontracted person and directed and coordinated by a shift head in the control room.	
15/11/2007, USA	Unknown	An explosion occurred at around 11.30 am in a natural gas treatment facility. It resulted in four injuries, two of them were severe.	ARIA
23/09/2002, USA	Unknown	In a natural gas treatment facility, a flash fire like event occurred in the central part where the raw natural gas is washed to remove impurities. Four of the nearby employees are injured, three suffered severe burns and intoxication.	ARIA
28/05/2000, Canada	Overpressure	A forty two inches pipe transporting natural gas ruptured during a pressure test. Authorities indicated that the gas inlet was promptly shut down; environmental effects were therefore assumed to be zero.	ARIA
04/01/1999, USA	Unknown	In a substation of a natural gas pipeline, a leakage led to an explosion and a fire destroying a house and workshop. The incident, visible from thirty kilometres was taken care of by firemen and controlled within four hours. Two firemen suffered mild injuries.	ARIA
08/02/1997, USA	Unknown	A leakage occurred on a natural gas pipeline of 660 mm diameter. The gas cloud exploded and a 100 m high flame occurred. Nearby houses were shaken by the deflagration.	ARIA
01/01/1997, Turkey	Human error	A natural gas leak occurred on a badly closed valve on a pipe (pressure= 20 bar). This incident led to death by asphyxiation of the two employees who entered in the room, one equipped with an inappropriate mask and the other without equipment.	ARIA
22/11/1995, Russia	Corrosion	An explosion followed by a fire occurred on a 0.5 m diameter natural gas pipe. Corrosion is at the origin of the accident. 240 m of pipes were destroyed.	ARIA

ANNEX H-2

Summary of Frequency Analysis Results

Section		Phase	Leak Size (mm)	Frequency											
				Isolation Success Case						Isolation Failure Case					
				JF[1]	PF[2]	FF[3]	VCE[4]	FB[5]	Total	JF	PF	FF	VCE	FB	Total
OLNGT_01	LNG Loadout from LNGC to LNG Storage Tank in LNG-FSRU (including LNG unloading lines)	L	10	3.14E-07	-	3.01E-07	1.26E-08	-	4.84E-04	3.14E-07	-	3.01E-07	1.26E-08	-	4.84E-04
			25	2.99E-07	-	2.63E-07	3.59E-08	-	5.18E-05	2.99E-07	-	2.63E-07	3.59E-08	-	5.18E-05
			50	1.44E-07	-	1.27E-07	1.73E-08	-	4.64E-06	1.44E-07	-	1.27E-07	1.73E-08	-	4.64E-06
			Full bore	-	2.75E-06	1.92E-06	8.25E-07	-	3.67E-05	-	2.75E-06	1.92E-06	8.25E-07	-	3.67E-05
OLNGT_02	LNG Storage Tanks	L	10	-	-	-	-	-	-	-	2.42E-09	2.32E-09	9.66E-11	-	4.00E-06
			25	-	-	-	-	-	-	-	7.01E-09	6.17E-09	8.41E-10	-	4.00E-06
			Full bore	-	-	-	-	-	-	-	4.95E-07	3.47E-07	1.49E-07	-	6.60E-06
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	L	10		-	6.52E-06	8.90E-07	-	9.67E-03		-	6.52E-06	8.90E-07	-	9.67E-03
			25	5.75E-06	-	5.06E-06	6.90E-07	-	8.12E-04	5.75E-06	-	5.06E-06	6.90E-07	-	8.12E-04
			50	5.21E-06	-	4.58E-06	6.25E-07	-	1.37E-04	5.21E-06	-	4.58E-06	6.25E-07	-	1.37E-04
			Full bore	-		3.90E-06	1.67E-06	-	7.43E-05	-		3.90E-06	1.67E-06	-	7.43E-05
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure	L	10	4.01E-05	-	3.53E-05	4.81E-06	-	2.05E-02	4.01E-05	-	3.53E-05	4.81E-06	-	2.05E-02
			25		-	2.21E-05	3.01E-06	-	1.39E-03		-	2.21E-05	3.01E-06	-	1.39E-03
			50		-	1.00E-05	4.30E-06	-	1.91E-04		-	1.00E-05	4.30E-06	-	1.91E-04
			Full bore		-	4.00E-06	1.72E-06	-	7.62E-05		-	4.00E-06	1.72E-06	-	7.62E-05
OLNGT_05	LNG Regasification Plant including four Regasification Trains	V	10	1.04E-05	-	9.95E-06	4.14E-07	-	1.69E-02	1.04E-05	-	9.95E-06	4.14E-07	-	1.69E-02
			25	3.87E-06	-	3.40E-06	4.64E-07	-	1.66E-03	3.87E-06	-	3.40E-06	4.64E-07	-	1.66E-03
			50	3.96E-06	-	3.49E-06	4.76E-07	-	3.17E-04	3.96E-06	-	3.49E-06	4.76E-07	-	3.17E-04
			Full bore	-	-	1.04E-05	4.46E-06	1.49E-05	1.98E-04	-	-	1.04E-05	4.46E-06	1.49E-05	1.98E-04
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	V	10	5.51E-06	-	5.29E-06	2.20E-07	-	8.85E-03	5.51E-06	-	5.29E-06	2.20E-07	-	8.85E-03
			25	9.41E-06	-	8.28E-06	1.13E-06	-	3.27E-03	9.41E-06	-	8.28E-06	1.13E-06	-	3.27E-03
			50	1.13E-06	-	9.98E-07	1.36E-07	-	7.33E-05	1.13E-06	-	9.98E-07	1.36E-07	-	7.33E-05
			Full bore	-	-	2.40E-04	1.03E-04	3.43E-04	4.58E-03	-	-	2.40E-04	1.03E-04	3.43E-04	4.58E-03
OLNGT_07	Natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	V	10	5.21E-06	-	5.00E-06	2.09E-07	-	8.38E-03	5.21E-06	-	5.00E-06	2.09E-07	-	8.38E-03
			25	1.75E-06	-	1.54E-06	2.10E-07	-	6.09E-04	1.75E-06	-	1.54E-06	2.10E-07	-	6.09E-04
			50	1.44E-06	-	1.27E-06	1.73E-07	-	9.33E-05	1.44E-06	-	1.27E-06	1.73E-07	-	9.33E-05
			Full bore	-	-	2.48E-06	1.06E-06	3.55E-06	4.73E-05	-	-	2.48E-06	1.06E-06	3.55E-06	4.73E-05
OLNGT_08	Riser for Subsea Pipeline	V	10		-	3.23E-07	1.34E-08	-	5.41E-04		-	3.23E-07	1.34E-08	-	5.41E-04
			25		-	3.42E-07	4.67E-08	-	1.35E-04		-	3.42E-07	4.67E-08	-	1.35E-04
			Full bore	-	-	1.18E-05	5.07E-06	1.69E-05	2.25E-04	-	-	1.18E-05	5.07E-06	1.69E-05	2.25E-04
OLNGT_09	Subsea Pipeline within the Vicinity of the LNG-FSRU (within 500 m from the LNG-FSRU)	V	10	-	-	8.99E-06	-	-	8.99E-06	-	-	8.99E-06	-	-	8.99E-06
			25	-	-	3.01E-06	-	-	3.01E-06	-	-	3.01E-06	-	-	3.01E-06
			50	-	-	2.43E-06	-	-	2.43E-06	-	-	2.43E-06	-	-	2.43E-06
			Full bore	-	-	4.16E-06	-	-	4.16E-06	-	-	4.16E-06	-	-	4.16E-06
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	L	10		-	6.09E-06	8.30E-07	-	9.03E-03		-	6.09E-06	8.30E-07	-	9.03E-03
			25		-	4.45E-06	6.06E-07	-	7.13E-04		-	4.45E-06	6.06E-07	-	7.13E-04
			50	-	4.08E-06	3.59E-06	4.89E-07	-	1.07E-04	-	4.08E-06	3.59E-06	4.89E-07	-	1.07E-04
			Full bore	-	3.56E-06	2.49E-06	1.07E-06	-	4.75E-05	-	3.56E-06	2.49E-06	1.07E-06	-	4.75E-05
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	V	10	3.14E-06	-	3.02E-06	1.26E-07	-	5.79E-03	3.14E-06	-	3.02E-06	1.26E-07	-	5.79E-03
			25	3.87E-07	-	3.71E-07	1.55E-08	-	6.24E-04	3.87E-07	-	3.71E-07	1.55E-08	-	6.24E-04
			50	2.30E-07	-	2.03E-07	2.76E-08	-	1.45E-04	2.30E-07	-	2.03E-07	2.76E-08	-	1.45E-04
			Full bore	1.50E-06	-	1.32E-06	1.80E-07	-	6.53E-05	1.50E-06	-	1.32E-06	1.80E-07	-	6.53E-05

Section		Phase	Leak Size (mm)	Frequency											
				Isolation Success Case						Isolation Failure Case					
				JF[1]	PF[2]	FF[3]	VCE[4]	FB[5]	Total	JF	PF	FF	VCE	FB	Total
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	V	10	5.39E-06	-	5.17E-06	2.15E-07	-	9.03E-03	5.39E-06	-	5.17E-06	2.15E-07	-	9.03E-03
			25	1.02E-06	-	8.96E-07	1.22E-07	-	7.13E-04	1.02E-06	-	8.96E-07	1.22E-07	-	7.13E-04
			50	8.22E-07	-	7.23E-07	9.86E-08	-	1.07E-04	8.22E-07	-	7.23E-07	9.86E-08	-	1.07E-04
			Full bore	3.56E-06	-	2.49E-06	1.07E-06	-	4.75E-05	3.56E-06	-	2.49E-06	1.07E-06	-	4.75E-05
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	V	10	3.84E-06	-	3.68E-06	1.53E-07	-	7.07E-03	3.84E-06	-	3.68E-06	1.53E-07	-	7.07E-03
			25	2.27E-07	-	2.18E-07	9.08E-09	-	3.66E-04	2.27E-07	-	2.18E-07	9.08E-09	-	3.66E-04
			50	7.33E-08	-	6.45E-08	8.79E-09	-	4.65E-05	7.33E-08	-	6.45E-08	8.79E-09	-	4.65E-05
			Full bore	4.38E-07	-	3.85E-07	5.25E-08	-	1.93E-05	4.38E-07	-	3.85E-07	5.25E-08	-	1.93E-05
OLNGT_14	BOG in Gas Combustion Unit/ Engine	V	10	1.51E-06	-	1.45E-06	6.06E-08	-	3.03E-03	1.51E-06	-	1.45E-06	6.06E-08	-	3.03E-03
			25	1.32E-07	-	1.27E-07	5.29E-09	-	2.38E-04	1.32E-07	-	1.27E-07	5.29E-09	-	2.38E-04
			50	2.25E-08	-	2.16E-08	9.02E-10	-	3.66E-05	2.25E-08	-	2.16E-08	9.02E-10	-	3.66E-05
			Full bore	6.30E-08	-	5.55E-08	7.57E-09	-	1.68E-05	6.30E-08	-	5.55E-08	7.57E-09	-	1.68E-05
OLNGT_15	LNGC Vapour (BOG) return line during loadout operation	V	10	4.96E-06	-	4.77E-06	1.99E-07	-	9.68E-03	4.96E-06	-	4.77E-06	1.99E-07	-	9.68E-03
			25	4.82E-07	-	4.62E-07	1.93E-08	-	8.22E-04	4.82E-07	-	4.62E-07	1.93E-08	-	8.22E-04
			50	8.85E-08	-	8.49E-08	3.54E-09	-	1.37E-04	8.85E-08	-	8.49E-08	3.54E-09	-	1.37E-04
			Full bore	8.04E-07	-	7.08E-07	9.65E-08	-	9.15E-05	8.04E-07	-	7.08E-07	9.65E-08	-	9.15E-05
OLNGT_16	LNG-FSRU Vapour (BOG) return line during loadout operation	V	10	4.63E-06	-	4.45E-06	1.85E-07	-	9.04E-03	4.63E-06	-	4.45E-06	1.85E-07	-	9.04E-03
			25	4.24E-07	-	4.07E-07	1.69E-08	-	7.23E-04	4.24E-07	-	4.07E-07	1.69E-08	-	7.23E-04
			50	6.92E-08	-	6.65E-08	2.77E-09	-	1.07E-04	6.92E-08	-	6.65E-08	2.77E-09	-	1.07E-04
			Full bore	5.69E-07	-	5.01E-07	6.83E-08	-	6.48E-05	5.69E-07	-	5.01E-07	6.83E-08	-	6.48E-05
OLNGT_17	Marine Diesel Oil Storage &Transfer System	L	10	-	2.02E-06	1.94E-06	8.07E-08	-	3.21E-02	-	2.02E-06	1.94E-06	8.07E-08	-	3.21E-02
			25	-	1.09E-06	9.61E-07	1.31E-07	-	3.21E-03	-	1.09E-06	9.61E-07	1.31E-07	-	3.21E-03
			50	-	1.89E-06	1.67E-06	2.27E-07	-	1.04E-03	-	1.89E-06	1.67E-06	2.27E-07	-	1.04E-03
			Full bore	-	6.68E-07	4.68E-07	2.00E-07	-	8.91E-05	-	6.68E-07	4.68E-07	2.00E-07	-	8.91E-05
OLNGT_18	Marine Gas Oil Storage & Transfer System	L	10	-	1.92E-06	1.84E-06	7.67E-08	-	3.05E-02	-	1.92E-06	1.84E-06	7.67E-08	-	3.05E-02
			25	-	9.37E-07	8.24E-07	1.12E-07	-	2.76E-03	-	9.37E-07	8.24E-07	1.12E-07	-	2.76E-03
			50	-	1.48E-06	1.30E-06	1.77E-07	-	8.09E-04	-	1.48E-06	1.30E-06	1.77E-07	-	8.09E-04
			Full bore	-	4.46E-07	3.12E-07	1.34E-07	-	5.94E-05	-	4.46E-07	3.12E-07	1.34E-07	-	5.94E-05
OLNGT_19	Lubricating Oil Storage & Transfer System	L	10	-	5.63E-06	5.41E-06	2.25E-07	-	8.97E-02	-	5.63E-06	5.41E-06	2.25E-07	-	8.97E-02
			25	-	1.85E-06	1.63E-06	2.22E-07	-	5.45E-03	-	1.85E-06	1.63E-06	2.22E-07	-	5.45E-03
			50	-	3.05E-06	2.69E-06	3.66E-07	-	1.67E-03	-	3.05E-06	2.69E-06	3.66E-07	-	1.67E-03
			Full bore	-	1.34E-06	9.36E-07	4.01E-07	-	1.78E-04	-	1.34E-06	9.36E-07	4.01E-07	-	1.78E-04
OLNGT_20	Subse Pipeline	V	10	-	-	-	-	-	-	-	-	2.54E-05	-	-	2.54E-05
			25	-	-	-	-	-	-	-	-	8.51E-06	-	-	8.51E-06
			50	-	-	-	-	-	-	-	-	6.87E-06	-	-	6.87E-06
			Full bore	-	-	-	-	-	-	-	-	1.18E-05	-	-	1.18E-05
OLNGT_21	Onshore Pipeline	V	10	-	-	-	-	-	-	3.03E-06	-	2.90E-06	-		5.93E-06
			25	-	-	-	-	-	-	1.11E-06	-	9.73E-07	-		2.08E-06
			50	-	-	-	-	-	-	8.92E-07	-	7.85E-07	-		1.68E-06
			Full bore	-	-	-	-	-	-	-	-	1.34E-06	-	1.92E-06	3.26E-06
OLNGT_22	Onshore Receiving Facilities	V	10	2.11E-06	-	2.02E-06	8.43E-08	-	3.39E-02	2.13E-08	-	2.04E-08	8.51E-10	-	3.42E-04
			25	8.49E-07	-	7.47E-07	1.02E-07	-	2.95E-03	8.58E-09	-	7.55E-09	1.03E-09	-	2.98E-05
			50	6.37E-07	-	5.61E-07	7.65E-08	-	4.10E-04	6.44E-09	-	5.67E-09	7.73E-10	-	4.14E-06

Section		Phase	Leak Size (mm)	Frequency											
				Isolation Success Case						Isolation Failure Case					
				JF[1]	PF[2]	FF[3]	VCE[4]	FB[5]	Total	JF	PF	FF	VCE	FB	Total
			Full bore	-	-	4.31E-07	1.85E-07	6.16E-07	8.09E-05	-	-	4.36E-09	1.87E-09	6.23E-09	8.18E-07
OLNGT_23	Nagatural Gas Transfer System at CCGT Power Plant	V	10	7.13E-07	-	6.84E-07	2.85E-08	-	1.15E-02	7.20E-09	-	6.91E-09	2.88E-10	-	1.16E-04
			25	2.42E-07	-	2.13E-07	2.90E-08	-	9.02E-04	2.44E-09	-	2.15E-09	2.93E-10	-	9.12E-06
			50	2.00E-07	-	1.76E-07	2.41E-08	-	1.39E-04	2.03E-09	-	1.78E-09	2.43E-10	-	1.40E-06
			Full bore		-	3.36E-07	1.44E-07	4.80E-07	6.30E-05	-	-	3.39E-09	1.45E-09	4.85E-09	6.36E-07
OLNGT_24	Hydrogen Storage and Trnasfer System at CCGT Power Plant		10	1.37E-06	-	1.32E-06	5.49E-08	-	2.19E-02	1.39E-08	-	1.33E-08	5.54E-10	-	2.21E-04
			25	4.58E-07	-	4.03E-07	5.50E-08	-	1.71E-03	4.63E-09	-	4.07E-09	5.55E-10	-	1.73E-05
			50	5.48E-07	-	4.82E-07	6.57E-08	-	3.79E-04	5.53E-09	-	4.87E-09	6.64E-10	-	3.83E-06
			Full bore	-	-	1.04E-08	4.46E-09	1.49E-08	1.95E-06	-	-	1.05E-10	4.50E-11	1.50E-10	1.97E-08

Note:

1: JF stands for Jet Fire

2: PF stands for Pool Fire

3. FF stands for Flash Fire

4. VCE stands for vapour cloud explosion

5. FB stands for Fireball

ANNEX H-3

Summary of Consequence Analysis Results

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
OLNGT_01	LNG Loadout from LNGC to LNG Storage Tank in LNG-FSRU (including LNG unloading lines)	L	10	Jet Fire	35.35 kW/m^2	23	23	20	20	20	18	23	23	20	20	20	20
					28.3 kW/m^2	24	24	21	21	21	18	24	24	21	21	21	21
					19.5 kW/m^2	26	26	22	22	22	20	26	26	22	22	22	22
					9.8 kW/m^2	28	28	25	25	25	22	28	28	25	25	25	25
				Flash Fire	LFL	17	21	13	18	19	20	17	21	13	18	18	19
			25	Jet Fire	35.35 kW/m^2	52	52	44	44	44	39	52	52	44	44	44	44
					28.3 kW/m^2	54	54	46	46	46	41	54	54	46	46	46	46
					19.5 kW/m^2	57	57	49	49	49	44	57	57	49	49	49	49
					9.8 kW/m^2	63	63	55	55	55	50	63	63	55	55	55	55
				Flash Fire	LFL	78	79	67	76	78	71	78	79	67	76	76	78
			50	Jet Fire	35.35 kW/m^2	95	95	81	81	81	72	95	95	81	81	81	81
					28.3 kW/m^2	98	98	84	84	84	75	98	98	84	84	84	84
					19.5 kW/m^2	104	104	89	89	89	80	104	104	89	89	89	89
					9.8 kW/m^2	115	115	101	101	101	91	115	115	101	101	101	101
				Flash Fire	LFL	172	165	196	200	185	216	172	165	196	200	200	185
			Full bore	Pool Fire	35.35 kW/m^2	114	113	137	137	137	159	132	132	156	156	156	174
					28.3 kW/m^2	132	132	156	156	156	174	165	164	186	186	186	199
					19.5 kW/m^2	165	164	186	186	186	199	232	230	247	247	247	257
					9.8 kW/m^2	232	230	247	247	247	257	329	458	403	449	552	513
				Flash Fire	LFL	325	462	320	449	444	437	114	113	137	137	137	159
OLNGT_02	LNG Storage Tanks	L	10	Pool Fire	35.35 kW/m^2	-	-	-	-	-	-	2	2	2	2	2	2
					28.3 kW/m^2	-	-	-	-	-	-	2	2	2	2	2	2
					19.5 kW/m^2	-	-	-	-	-	-	7	6	7	7	7	6
					9.8 kW/m^2	-	-	-	-	-	-	7	6	7	7	7	6
				Flash Fire	LFL	-	-	-	-	-	-	5	5	6	7	7	6
			25	Pool Fire	35.35 kW/m^2	-	-	-	-	-	-	9	9	10	10	10	10
					28.3 kW/m^2	-	-	-	-	-	-	10	10	11	11	11	11
					19.5 kW/m^2	-	-	-	-	-	-	12	12	14	13	13	13
					9.8 kW/m^2	-	-	-	-	-	-	15	15	16	16	16	15
				Flash Fire	LFL	-	-	-	-	-	-	48	73	7	7	7	7
			Full bore	Pool Fire	35.35 kW/m^2	-	-	-	-	-	-	46	46	57	57	57	57
					28.3 kW/m^2	-	-	-	-	-	-	53	53	65	65	65	65
					19.5 kW/m^2	-	-	-	-	-	-	67	67	77	77	77	77
					9.8 kW/m^2	-	-	-	-	-	-	94	94	101	101	101	101
				Flash Fire	LFL	-	-	-	-	-	-	189	303	141	215	215	271
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	L	10	Jet Fire	35.35 kW/m^2	25	25	21	21	21	19	25	25	21	21	21	21
					28.3 kW/m^2	26	26	22	22	22	19	26	26	22	22	22	22
					19.5 kW/m^2	27	27	23	23	23	21	27	27	23	23	23	23
					9.8 kW/m^2	30	30	26	26	26	24	30	30	26	26	26	26
				Flash Fire	LFL	22	24	16	22	23	23	22	24	16	22	22	23
			25	Jet Fire	35.35 kW/m^2	55	55	47	47	47	42	55	55	47	47	47	47
					28.3 kW/m^2	57	57	49	49	49	43	57	57	49	49	49	49
					19.5 kW/m^2	60	60	52	52	52	46	60	60	52	52	52	52
					9.8 kW/m^2	67	67	58	58	58	53	67	67	58	58	58	58
				Flash Fire	LFL	82	82	72	83	83	83	82	82	72	83	83	83
			50	Jet Fire	35.35 kW/m^2	101	101	86	86	86	76	101	101	86	86	86	86
					28.3 kW/m^2	104	104	89	89	89	79	104	104	89	89	89	89

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					19.5 kW/m^2	110	110	95	95	95	85	110	110	95	95	95	95
					9.8 kW/m^2	122	122	107	107	107	97	122	122	107	107	107	107
				Flash Fire	LFL	171	166	192	196	182	225	171	166	192	196	196	182
			Full bore	Pool Fire	35.35 kW/m^2	130	130	153	152	151	173	147	146	170	168	168	187
					28.3 kW/m^2	147	146	170	168	168	187	175	175	197	195	194	209
					19.5 kW/m^2	175	175	197	195	194	209	235	234	251	249	248	261
					9.8 kW/m^2	235	234	251	249	248	261	1,112	1,089	862	905	905	977
				Flash Fire	LFL	1,253	1,058	1,056	1,069	1,118	851	130	130	153	152	151	173
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure Pump)	L	10	Jet Fire	35.35 kW/m^2	31	31	26	26	26	23	31	31	26	26	26	26
					28.3 kW/m^2	32	32	27	27	27	24	32	32	27	27	27	27
					19.5 kW/m^2	33	33	29	29	29	26	33	33	29	29	29	29
					9.8 kW/m^2	37	37	32	32	32	29	37	37	32	32	32	32
				Flash Fire	LFL	30	30	27	30	29	28	30	30	27	30	30	29
			25	Jet Fire	35.35 kW/m^2	69	69	59	59	59	52	69	69	59	59	59	59
					28.3 kW/m^2	71	71	61	61	61	54	71	71	61	61	61	61
					19.5 kW/m^2	75	75	64	64	64	58	75	75	64	64	64	64
					9.8 kW/m^2	82	82	72	72	72	66	82	82	72	72	72	72
				Flash Fire	LFL	84	83	79	89	86	97	84	83	79	89	89	86
			50	Jet Fire	35.35 kW/m^2	128	128	108	108	108	96	128	128	108	108	108	108
					28.3 kW/m^2	131	131	112	112	112	100	131	131	112	112	112	112
					19.5 kW/m^2	137	137	118	118	118	106	137	137	118	118	118	118
					9.8 kW/m^2	152	152	133	133	133	121	152	152	133	133	133	133
				Flash Fire	LFL	177	176	178	190	186	208	177	176	179	190	190	186
			Full bore	Jet Fire	35.35 kW/m^2	532	532	455	455	455	406	532	532	455	455	455	455
					28.3 kW/m^2	547	547	470	470	470	422	547	547	470	470	470	470
					19.5 kW/m^2	575	575	499	499	499	452	575	575	499	499	499	499
					9.8 kW/m^2	639	639	564	564	564	519	639	639	564	564	564	564
				Flash Fire	LFL	621	606	707	710	684	902	926	928	915	911	911	908
OLNGT_05	LNG Regasification Plant including four Regasification Trains	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	7	7	7	7
					9.8 kW/m^2	9	9	10	10	10	10	9	9	10	10	10	10
				Flash Fire	LFL	7	7	6	7	6	6	7	7	6	7	7	6
			25	Jet Fire	35.35 kW/m^2	19	19	20	20	20	22	19	19	20	20	20	20
					28.3 kW/m^2	20	20	21	21	21	22	20	20	21	21	21	21
					19.5 kW/m^2	22	22	23	23	23	24	22	22	23	23	23	23
					9.8 kW/m^2	25	25	26	26	26	27	25	25	26	26	26	26
				Flash Fire	LFL	17	17	16	16	16	16	17	17	16	16	16	16
			50	Jet Fire	35.35 kW/m^2	37	37	39	39	39	43	37	37	39	39	39	39
					28.3 kW/m^2	38	38	41	41	41	45	38	38	41	41	41	41
					19.5 kW/m^2	42	42	44	44	44	47	42	42	44	44	44	44
					9.8 kW/m^2	49	49	50	50	50	52	49	49	50	50	50	50
				Flash Fire	LFL	36	36	35	37	36	37	36	36	35	37	37	36
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	119	120	118	122	121	129	119	120	118	122	122	121
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	22
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	23
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	25
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	28
				Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	18
			50	Jet Fire	35.35 kW/m^2	40	40	42	42	42	47	40	40	42	42	42	42
					28.3 kW/m^2	41	41	44	44	44	49	41	41	44	44	44	44
					19.5 kW/m^2	46	46	48	48	48	51	46	46	48	48	48	48
					9.8 kW/m^2	53	53	54	54	54	57	53	53	54	54	54	54
				Flash Fire	LFL	40	40	39	41	40	41	40	40	39	41	41	40
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	134	133
OLNGT_07	Natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	22
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	23
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	25
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	28
				Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	18
			50	Jet Fire	35.35 kW/m^2	40	40	42	42	42	47	40	40	42	42	42	42
					28.3 kW/m^2	41	41	44	44	44	49	41	41	44	44	44	44
					19.5 kW/m^2	46	46	48	48	48	51	46	46	48	48	48	48
					9.8 kW/m^2	53	53	54	54	54	57	53	53	54	54	54	54
				Flash Fire	LFL	40	40	39	41	40	41	40	40	39	41	41	40
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	134	133
OLNGT_08	Riser for Subsea Pipeline	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	22
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	23
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	25
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	28
				Flash Fire	LFL	18	18	17	17	17	17	18	18	17	18	18	18
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	134	133
OLNGT_09	Subsea Pipeline within the Vicinity of the LNG-FSRU (within 500 m from the LNG-FSRU)	V	10	Flash Fire	LFL	-	-	-	-	-	-	1	1	1	1	1	1
			25	Flash Fire	LFL	-	-	-	-	-	-	2	1	1	1	1	2
			50	Flash Fire	LFL	-	-	-	-	-	-	3	3	3	3	3	4
			Full bore	Flash Fire	LFL	-	-	-	-	-	-	8	9	7	9	8	11
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	L	10	Jet Fire	35.35 kW/m^2	25	25	21	21	21	19	25	25	21	21	21	21
					28.3 kW/m^2	26	26	22	22	22	19	26	26	22	22	22	22
					19.5 kW/m^2	27	27	23	23	23	21	27	27	23	23	23	23
					9.8 kW/m^2	30	30	26	26	26	24	30	30	26	26	26	26
				Flash Fire	LFL	22	24	16	22	23	23	22	24	16	22	22	23
			25	Jet Fire	35.35 kW/m^2	55	55	47	47	47	42	55	55	47	47	47	47
					28.3 kW/m^2	57	57	49	49	49	43	57	57	49	49	49	49
					19.5 kW/m^2	60	60	52	52	52	46	60	60	52	52	52	52
					9.8 kW/m^2	67	67	58	58	58	53	67	67	58	58	58	58
				Flash Fire	LFL	82	82	72	83	83	82	82	82	72	83	83	83
			50	Jet Fire	35.35 kW/m^2	26	25	31	26	25	2	101	101	86	86	86	86
					28.3 kW/m^2	27	26	33	27	26	2	104	104	89	89	89	89
					19.5 kW/m^2	29	28	37	29	27	2	110	110	95	95	95	95
					9.8 kW/m^2	33	31	41	32	30	2	122	122	107	107	107	107
				Flash Fire	LFL	171	165	191	195	182	225	171	166	192	195	195	182
			Full bore	Pool Fire	35.35 kW/m^2	109	108	128	127	126	143	149	149	175	174	174	173
					28.3 kW/m^2	122	121	141	140	138	154	168	168	194	193	193	192
					19.5 kW/m^2	144	144	162	161	159	171	201	201	226	224	224	223
					9.8 kW/m^2	190	190	204	202	201	211	271	270	289	288	288	287
				Flash Fire	LFL	550	533	684	702	656	814	1,466	1,372	1,062	1,281	1,281	1,490
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					28.3 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					19.5 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					9.8 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			50	Jet Fire	35.35 kW/m^2	17	17	17	17	17	19	17	17	17	17	17	17

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					28.3 kW/m^2	17	17	17	17	17	19	17	17	18	18	18	18
					19.5 kW/m^2	18	18	18	18	18	20	18	18	19	19	19	19
					9.8 kW/m^2	22	22	22	22	22	23	22	22	22	22	22	22
				Flash Fire	LFL	14	14	14	14	14	13	14	14	13	14	14	14
			Full bore	Jet Fire	35.35 kW/m^2	46	46	46	46	46	54	46	46	48	48	48	48
					28.3 kW/m^2	47	47	47	47	47	56	47	47	51	51	51	51
					19.5 kW/m^2	53	53	53	53	53	59	53	53	55	55	55	55
					9.8 kW/m^2	62	62	62	62	62	66	62	62	63	63	63	63
				Flash Fire	LFL	48	48	48	48	48	50	48	48	47	49	49	48
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	V	10	Jet Fire	35.35 kW/m^2	15	15	13	13	13	12	15	15	13	13	13	13
					28.3 kW/m^2	15	15	13	13	13	12	15	15	13	13	13	13
					19.5 kW/m^2	16	16	14	14	14	13	16	16	14	14	14	14
					9.8 kW/m^2	19	19	16	16	16	14	19	19	16	16	16	16
				Flash Fire	LFL	5	4	5	6	5	9	5	4	5	6	6	5
			25	Jet Fire	35.35 kW/m^2	31	31	28	28	28	26	31	31	28	28	28	28
					28.3 kW/m^2	33	33	30	30	30	27	33	33	30	30	30	30
					19.5 kW/m^2	36	36	32	32	32	28	36	36	32	32	32	32
					9.8 kW/m^2	41	41	35	35	35	32	41	41	35	35	35	35
				Flash Fire	LFL	5	74	6	6	6	8	5	74	6	6	6	6
			50	Jet Fire	35.35 kW/m^2	57	57	51	52	52	47	57	57	51	52	52	52
					28.3 kW/m^2	60	60	53	54	54	48	60	60	53	54	54	54
					19.5 kW/m^2	65	65	56	57	57	51	65	65	56	57	57	57
					9.8 kW/m^2	73	73	64	65	65	58	73	73	64	65	65	65
				Flash Fire	LFL	220	166	128	158	152	97	220	166	128	158	158	152
			Full bore	Jet Fire	35.35 kW/m^2	107	107	94	95	96	88	107	107	94	95	95	96
					28.3 kW/m^2	112	112	97	99	99	91	112	112	97	99	99	99
					19.5 kW/m^2	120	120	104	105	106	97	120	120	104	105	105	106
					9.8 kW/m^2	134	135	117	119	119	110	134	135	117	119	119	119
				Flash Fire	LFL	199	161	188	236	213	200	200	161	188	236	236	213
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					28.3 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					19.5 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					9.8 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			50	Jet Fire	35.35 kW/m^2	17	17	17	17	17	19	17	17	17	17	17	17
					28.3 kW/m^2	17	17	18	18	18	19	17	17	18	18	18	18
					19.5 kW/m^2	18	18	19	19	19	20	18	18	19	19	19	19
					9.8 kW/m^2	21	21	22	22	22	22	21	21	22	22	22	22
				Flash Fire	LFL	14	14	13	14	14	13	14	14	13	14	14	14
			Full bore	Jet Fire	35.35 kW/m^2	46	46	48	48	48	54	46	46	48	48	48	48
					28.3 kW/m^2	47	47	50	50	50	56	47	47	50	50	50	50
					19.5 kW/m^2	53	53	55	55	55	59	53	53	55	55	55	55

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					9.8 kW/m^2	61	61	63	63	63	65	61	61	63	63	63	63
				Flash Fire	LFL	47	48	47	48	48	50	47	48	47	48	48	48
OLNGT_14	BOG in Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	2	2	2	2	2	2	2	2	2	2	2	2
			25	Jet Fire	35.35 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					28.3 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					19.5 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					9.8 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
				Flash Fire	LFL	5	5	5	5	5	5	5	5	5	5	5	5
			50	Jet Fire	35.35 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					28.3 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					19.5 kW/m^2	8	8	11	11	11	13	8	8	11	11	11	11
					9.8 kW/m^2	11	11	12	12	12	14	11	11	12	12	12	12
				Flash Fire	LFL	9	9	9	9	9	8	9	9	9	9	9	9
			Full bore	Jet Fire	35.35 kW/m^2	22	22	26	26	26	33	22	22	26	26	26	26
					28.3 kW/m^2	24	24	27	27	27	33	24	24	27	27	27	27
					19.5 kW/m^2	26	26	29	29	29	34	26	26	29	29	29	29
					9.8 kW/m^2	32	32	34	34	34	36	32	32	34	34	34	34
				Flash Fire	LFL	31	31	30	30	31	31	31	31	30	31	31	31
OLNGT_15	LNGC Vapour (BOG) return line during loadout operation	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					28.3 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					19.5 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					9.8 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
				Flash Fire	LFL	6	6	6	6	6	6	6	6	6	6	6	6
			50	Jet Fire	35.35 kW/m^2	13	13	13	13	13	13	13	13	13	13	13	13
					28.3 kW/m^2	11	11	13	13	13	15	11	11	13	13	13	13
					19.5 kW/m^2	13	13	14	14	14	16	13	13	14	14	14	14
					9.8 kW/m^2	15	15	16	16	16	18	15	15	16	16	16	16
				Flash Fire	LFL	11	11	10	11	11	10	11	11	10	11	11	11
			Full bore	Jet Fire	35.35 kW/m^2	32	32	12	12	12	41	32	32	12	12	12	12
					28.3 kW/m^2	33	33	36	36	36	42	33	33	36	36	36	36
					19.5 kW/m^2	36	36	39	39	39	44	36	36	39	39	39	39
					9.8 kW/m^2	44	44	45	45	45	48	44	44	45	45	45	45
				Flash Fire	LFL	38	38	38	39	38	40	38	38	38	39	39	38
OLNGT_16	LNG-FSRU Vapour (BOG) return line during loadout operation	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
			25	Jet Fire	35.35 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					28.3 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					19.5 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					9.8 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
				Flash Fire	LFL	6	6	6	6	6	6	6	6	6	6	6	6
			50	Jet Fire	35.35 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					28.3 kW/m^2	11	11	13	13	13	15	11	11	13	13	13	13
					19.5 kW/m^2	13	13	14	14	14	16	13	13	14	14	14	14
					9.8 kW/m^2	15	15	16	16	16	18	15	15	16	16	16	16
				Flash Fire	LFL	11	11	10	11	11	10	11	11	10	11	11	11
			Full bore	Jet Fire	35.35 kW/m^2	32	32	12	12	12	41	32	32	12	12	12	12
					28.3 kW/m^2	33	33	36	36	36	42	33	33	36	36	36	36
					19.5 kW/m^2	36	36	39	39	39	44	36	36	39	39	39	39
					9.8 kW/m^2	44	44	45	45	45	48	44	44	45	45	45	45
				Flash Fire	LFL	38	38	38	39	38	40	38	38	38	39	39	38
OLNGT_17	Marine Diesel Oil Storage &Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	11
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	13	12
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	15	14
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	18	17
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	6	5
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	14
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	15	14
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	19
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	27
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	32
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	8	7
			Full bore	Pool Fire	35.35 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					28.3 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					19.5 kW/m^2	261	268	261	264	279	272	261	268	261	264	278	272
					9.8 kW/m^2	264	271	273	276	291	297	264	271	273	276	291	297
				Flash Fire	LFL	47	54	47	50	65	58	47	54	47	50	50	65
OLNGT_18	Marine Gas Oil Storage & Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	11
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	13	12
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	15	14
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	18	17
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	6	5
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	14
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	15	14
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	19
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	27
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	32
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	8	7
			Full bore	Pool Fire	35.35 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					28.3 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					19.5 kW/m^2	261	268	261	264	279	272	261	268	261	264	279	272
					9.8 kW/m^2	264	271	273	276	291	297	264	271	273	276	291	297
				Flash Fire	LFL	47	54	47	50	65	58	47	54	47	50	50	65
OLNGT_19	Lubricating Oil Storage & Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	11
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	13	12
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	15	14
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	18	17
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	6	5
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	14
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	15	14
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	19
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	27
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	32
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	8	7
			Full bore	Pool Fire	35.35 kW/m^2	114	114	114	114	114	114	114	114	114	114	114	114
					28.3 kW/m^2	114	114	114	114	114	114	114	114	114	114	114	114
					19.5 kW/m^2	118	121	118	120	125	123	118	121	118	120	125	123
					9.8 kW/m^2	121	124	130	131	137	145	121	124	130	131	137	145
				Flash Fire	LFL	26	29	27	28	34	32	26	29	27	28	28	34
OLNGT_20	Subsea Pipeline	V	10	Flash Fire	LFL	-	-	-	-	-	-	1	1	1	1	1	1
			25	Flash Fire	LFL	-	-	-	-	-	-	2	1	1	1	1	2
			50	Flash Fire	LFL	-	-	-	-	-	-	3	3	3	3	3	4
			Full bore	Flash Fire	LFL	-	-	-	-	-	-	8	9	7	9	8	11
OLNGT_21	Onshore Pipeline	V	10	Jet Fire	35.35 kW/m^2	-	-	-	-	-	-	1	1	1	1	1	1
					28.3 kW/m^2	-	-	-	-	-	-	1	1	1	1	1	1
					19.5 kW/m^2	-	-	-	-	-	-	1	1	1	1	1	1
					9.8 kW/m^2	-	-	-	-	-	-	1	1	1	1	1	1
				Flash Fire	LFL	-	-	-	-	-	-	1	1	1	1	1	1
			25	Jet Fire	35.35 kW/m^2	-	-	-	-	-	-	3	3	3	3	3	3
					28.3 kW/m^2	-	-	-	-	-	-	3	3	3	3	3	3
					19.5 kW/m^2	-	-	-	-	-	-	3	3	3	3	3	3
					9.8 kW/m^2	-	-	-	-	-	-	3	3	5	5	5	5
				Flash Fire	LFL	-	-	-	-	-	-	1	1	1	1	1	1
			50	Jet Fire	35.35 kW/m^2	-	-	-	-	-	-	5	5	5	5	5	5
					28.3 kW/m^2	-	-	-	-	-	-	5	5	5	5	5	5
					19.5 kW/m^2	-	-	-	-	-	-	5	5	5	5	5	5
					9.8 kW/m^2	-	-	-	-	-	-	5	5	15	15	15	15
				Flash Fire	LFL	-	-	-	-	-	-	1	1	1	1	1	1
			Full bore	Fireball	FB Radius	-	-	-	-	-	-	36	36	36	36	36	36

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					35.35 kW/m^2	-	-	-	-	-	-	94	94	94	94	94	94
					28.3 kW/m^2	-	-	-	-	-	-	106	106	106	106	106	106
					19.5 kW/m^2	-	-	-	-	-	-	127	127	127	127	127	127
					9.8 kW/m^2	-	-	-	-	-	-	178	178	178	178	178	178
				Flash Fire	LFL	-	-	-	-	-	-	10	10	10	10	10	10
OLNGT_22	Onshore Receiving Facilities	V	10	Jet Fire	35.35 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					28.3 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	22	21	21	22	22	22	22
					28.3 kW/m^2	22	22	23	23	23	23	22	22	23	23	23	23
					19.5 kW/m^2	24	24	25	25	25	25	24	24	25	25	25	25
					9.8 kW/m^2	27	27	28	28	28	28	27	27	28	28	28	28
				Flash Fire	LFL	18	18	17	18	18	18	18	18	17	18	18	18
			50	Jet Fire	35.35 kW/m^2	40	40	42	42	42	42	40	40	42	42	42	42
					28.3 kW/m^2	41	41	44	44	44	44	41	41	44	44	44	44
					19.5 kW/m^2	46	46	48	48	48	48	46	46	48	48	48	48
					9.8 kW/m^2	53	53	54	54	54	54	53	53	54	54	54	54
				Flash Fire	LFL	40	40	39	41	41	40	40	40	39	41	41	40
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	173	175	170	179	179	176	173	175	170	179	179	176
OLNGT_23	Nagatural Gas Transfer System at CCGT Power Plant	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					28.3 kW/m^2	21	21	22	22	22	22	21	21	22	22	22	22
					19.5 kW/m^2	23	23	24	24	24	24	23	23	24	24	24	24
					9.8 kW/m^2	27	27	27	27	27	27	27	27	27	27	27	27
				Flash Fire	LFL	18	18	17	17	17	17	18	18	17	17	17	17
			50	Jet Fire	35.35 kW/m^2	39	39	41	41	41	41	39	39	41	41	41	41
					28.3 kW/m^2	40	40	43	43	43	43	40	40	43	43	43	43
					19.5 kW/m^2	45	45	46	46	46	46	45	45	46	46	46	46
					9.8 kW/m^2	52	52	53	53	53	53	52	52	53	53	53	53
				Flash Fire	LFL	39	39	38	39	39	39	39	39	38	39	39	39
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	165	166	158	169	169	167	165	166	158	169	169	167

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
OLNGT_24	Hydrogen Storage and Trnasfer System at CCGT Power Plant	V	10	Jet Fire	35.35 kW/m^2	7	7	13	13	13	13	7	7	13	13	13	13
					28.3 kW/m^2	13	13	16	16	16	16	13	13	16	16	16	16
					19.5 kW/m^2	15	15	17	17	17	17	15	15	17	17	17	17
					9.8 kW/m^2	18	18	19	19	19	19	18	18	19	19	19	19
				Flash Fire	LFL	17	16	18	19	19	18	17	16	18	19	19	18
			25	Jet Fire	35.35 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					28.3 kW/m^2	21	21	22	22	22	22	21	21	22	22	22	22
					19.5 kW/m^2	23	23	24	24	24	24	23	23	24	24	24	24
					9.8 kW/m^2	27	27	27	27	27	27	27	27	27	27	27	27
				Flash Fire	LFL	18	18	17	17	17	17	18	18	17	17	17	17
			50	Jet Fire	35.35 kW/m^2	39	39	41	41	41	41	39	39	41	41	41	41
					28.3 kW/m^2	40	40	43	43	43	43	40	40	43	43	43	43
					19.5 kW/m^2	45	45	46	46	46	46	45	45	46	46	46	46
					9.8 kW/m^2	52	52	53	53	53	53	52	52	53	53	53	53
				Flash Fire	LFL	39	39	38	39	39	39	39	39	38	39	39	39
			Full bore	Jet Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	18	18	18	18	18	18	18	18	18	18	18	18
					19.5 kW/m^2	28	28	28	28	28	28	28	28	28	28	28	28
					9.8 kW/m^2	54	54	54	54	54	54	54	54	54	54	54	54
				Flash Fire	LFL	165	165	158	169	166	177	165	165	158	169	166	177