

2 PROJECT DESCRIPTION AND ALTERNATIVES

2.1 INTRODUCTION

This chapter provides a description of the Sembcorp Utilities Pte. Ltd (the Sponsor or Sembcorp) Combined Cycle Gas Turbine (CCGT) Power Plant, including the facilities, equipment required and the associated activities to be undertaken throughout the Project cycle, including construction, operation and decommission phases. This chapter also provides an analysis of alternatives to the Project in **Section 2.8**.

The Sponsor has been selected by the Ministry of Electric Power (MOEP) of the Government of Myanmar (GOM) as a private sector independent power producer (IPP) to develop a 225MW CCGT power plant on a Build, Operate and Transfer (BOT) basis in Myingyan Township, in the Mandalay region in Myanmar. The Project comprises of the following Project facilities:

- 225MW CCGT Power Plant;
- Gas Supply Pipeline;
- 230kV Overhead Transmission Line; and
- Water Supply Pipeline, Wastewater Discharge Pipeline and Water Intake Pumping Station.

The Project will proceed to invest and establish a CCGT power plant with international financing provided by Asian Development Bank (ADB), International Finance Corporation (IFC), and other banks which have adopted the Equator Principles (EPs) as syndicates.

The technology of the Project is an efficient form of CCGT power generation which was designed for high reliability and efficiency operation with lower environmental impact. The Project will operate on natural gas as its only fuel.

The electrical capacity and electricity generated will be sold under a 22 year Power Purchase Agreement (“PPA”), as agreed with MEPE.

2.2 NAME OF PROJECT

Myingyan IPP Project – 225MW Gas-fired Combined Cycle Power Station.

2.3 PROJECT SPONSOR

Details of the main Project Sponsor are as follows:

Company Name: Sembcorp Utilities Pte. Ltd

Address: 30 Hill Street, #05-04

Singapore 179360

The Project site is located approximately 8km, south of Myingyan Township, Mandalay region in the Union Republic of Myanmar as shown in **Figure 2.1**.

The Power Plant will be located on a predominately green field site. The Project site is located adjacent to an existing steel mill (Myingyan Steel Mill No.4), owned by Ministry of Industry (MOI).

The Project site was acquired by the GOM, up to 18 years ago, and the registered land owner is MOI. The majority of this MOI-owned land is occupied by the existing steel mill infrastructure which was commissioned in 2007. The northern part was allocated for the Power Plant as shown in **Figure 2.2**. The Project site was cultivated farmland prior to acquisition of the land by the GOM and is currently dominated by sparse shrubby vegetation.

The following 5 villages are located in close proximity (3km radius from the Project site boundary), as shown in **Figure 2.2**:

- Sa Khar village;
- Hnan Ywa village;
- Hpet Taw village;
- Nyaung Kan village; and
- Gyoke Pin village.

In addition, there is 1 village located in close proximity to the proposed water intake pumping station, which is Tha Pyay Thar village.

The Ayeyarwady River is located approximately 14km west of the Project site boundary. There is an existing gas pipeline (Shwe Gas Supply Pipeline), approximately 18km in length which runs from the Taung Thar offtake point to an existing MOGE gas receiving station within the Project site boundary. The location of the Ayeyarwady River and Shwe Gas Supply Pipeline is shown in **Figure 2.2**. To the north, south and west of the Project site boundary is the agricultural area, to the east is an existing dirt road.

2.4.1

Existing Steel Mill Facilities

The existing Steel Mill produces approximately 200,000 tonnes per year of billets and slabs from recycled material such as scrapped metals and cars. It is currently undergoing expansion (Steel Mill Phase 2) to increase capacity with upgraded sub-station (to be connected to both the steel mill and the Power Plant), melt shop, direct reducing plant and rolling mill.

There are 913 workers at the steel mill, and their accommodation is as follows:

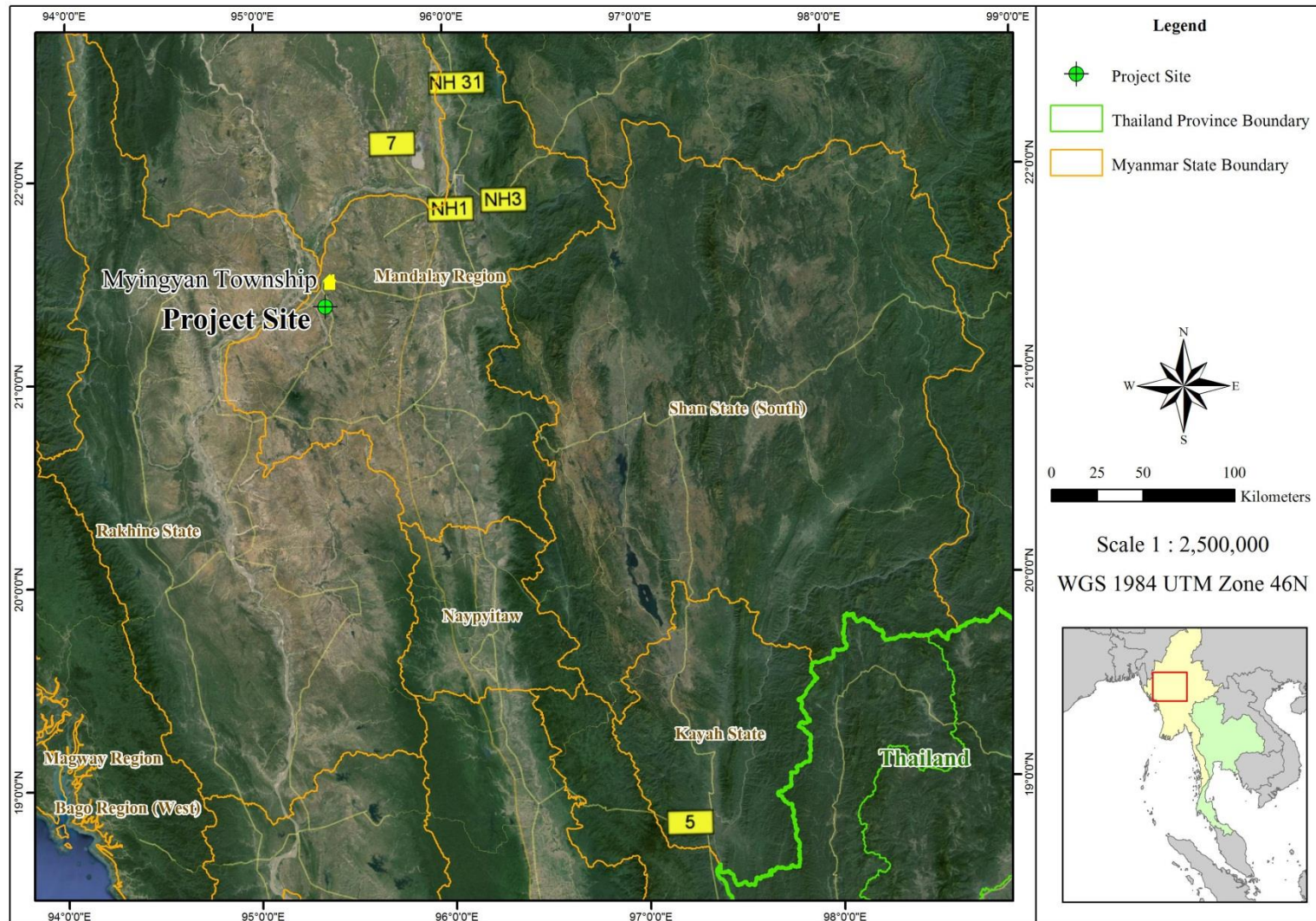
- Permanent worker's camp, housing approximately 880-900 workers. The permanent camp is located within the steel mill boundary, but is not near the Project site.
- Temporary worker's housing, for the remaining workers due to exceeded capacity at the permanent camp. The temporary accommodation consists of 15 households, and approximately 30 people in total. The temporary

accommodation is located outside the steel mill boundary, near the project site. Further details are provided in **Chapter 6**.

2.4.2 *Aggreko Temporary Gas-Fired Power Plant*

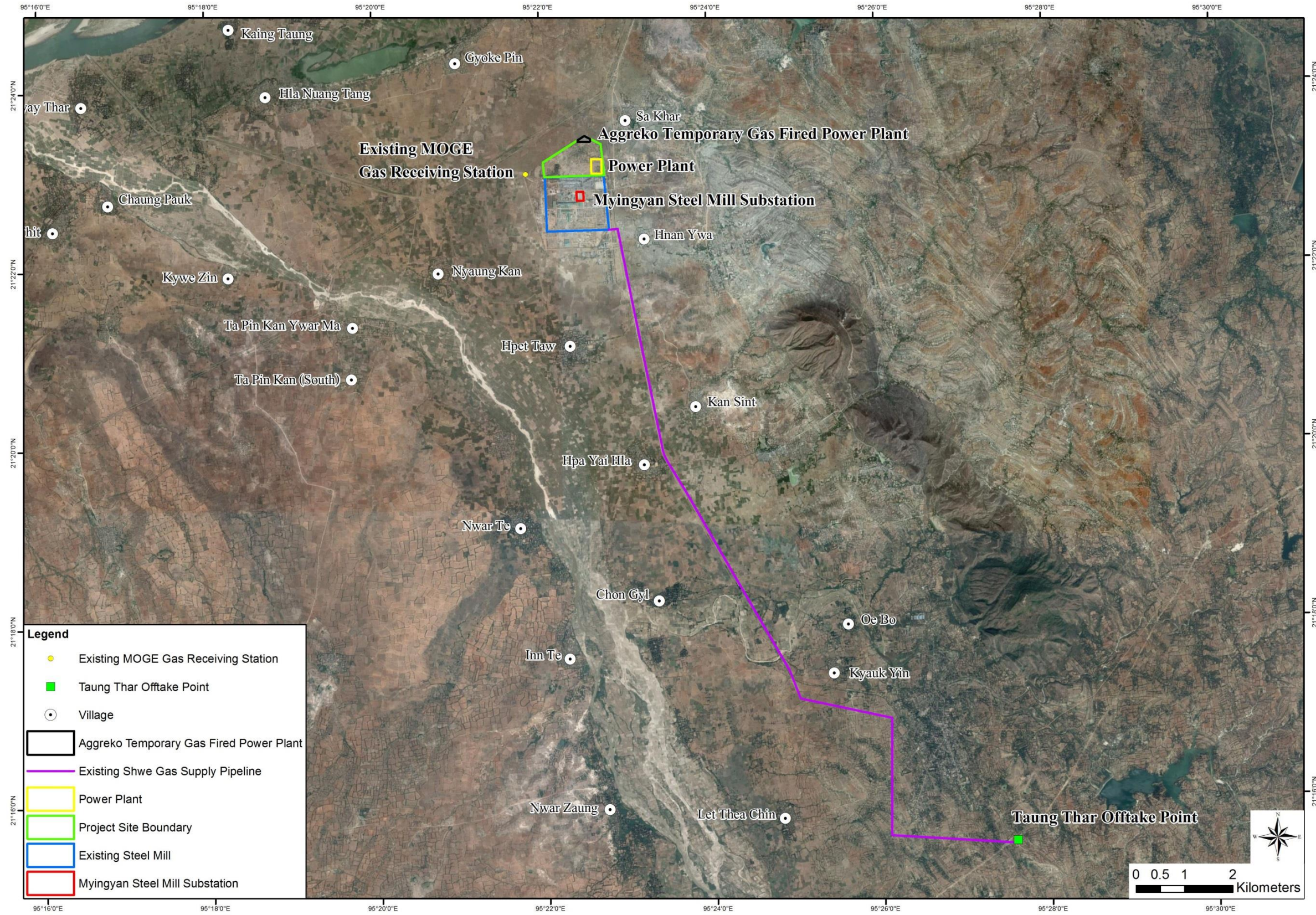
In addition, there is an existing 95MW temporary gas-fired power plant located within the Project site boundary (see **Figure 2.2**) operated by Aggreko. The temporary gas-fired power plant began operation in April 2015 and comprises 92 gas engines rated at 1.3MW each (119MW total). The generated power is supplied to Myingyan town substation via the existing 132kV overhead transmission line. The temporary gas-fired power plant will be decommissioned once the CCGT Power Plant is in operation.

Figure 2.1 Location of the Project Site within Myanmar



Source: Sembcorp, 2015 (modified by ERM)

Figure 2.2 Project Site Location



Source: Sembcorp, 2015 (modified by ERM)

2.5

PROJECT FACILITIES

The Project components are presented below and include Project Facilities (shown in **Figure 2.3**) and Associated Facilities. A total area of approximately 16 hectares (ha) is allocated for the Project facilities.

2.5.1

Project Facilities

- **225MW Combined Cycle Gas Turbine Power Plant** (approx. 9 ha) comprising of the following main components:
 - 2 sets of Gas Turbine (GT) units;
 - 2 sets of Heat Recovery System Generator (HRSG);
 - 1 steam turbine generating unit with associated auxiliary equipment;
 - Switchyard area;
 - Cooling Water System;
 - Demineralised Water System; and
 - Wastewater Treatment Facility.
- **Gas Supply Pipeline** (approx. 0.2 ha) connecting the new MOGE gas receiving station to the Power Plant (approximately 1km in length). MEPE/MOGE will build the new MOGE gas receiving station and the Sponsor will build new gas supply pipeline from delivery point at the outlet of the MOGE gas skid to the Power Plant.
- **230kV Overhead Transmission Line** (approx. 5 ha) connecting the Power Plant to the upgraded Myingyan Steel Mill sub-station located within the steel mill complex (approximately 2.5km in length).
- **Water Supply Pipeline and Wastewater Discharge Pipeline** (approx. 2 ha) connecting the Power Plant to the water intake point and new Pumping Station at the Ayeyarwady River. The water supply pipeline will be approximately 14km in length. The wastewater discharge pipeline will connect the Power Plant to the existing irrigation canal (approximately 3km in length). The wastewater pipeline will be run in parallel with the water supply pipeline. Both pipelines will share the 2m easement.

2.5.2

Associated Facilities

The new MOGE gas receiving station (see **Figure 2.7**) to be installed by MEPE/MOEP for connection of the gas supply pipeline to the Power Plant is regarded as an associated facility.

In addition, the transmission connection beyond the upgraded Myingyan Steel Mill sub-station will be GOM's responsibility and therefore is classified as associated facility. The connection beyond the Myingyan Steel Mill sub-station transmission line is not known at this stage.

The Project components are described in the below sections.

The Power Plant is designed to operate continuously, either in simple cycle mode or in combined cycle mode. During simple cycle operation, the flue gas from the gas turbine will exit via the bypass stack to the atmosphere. During normal combined cycle operation, the heat of exhaust gas will be admitted to the Heat Recovery Steam Generator (HRSG) where superheated steam will be produced which will drive the steam turbine to generate electrical power. The exhaust gas from the HRSG will be released from the main stack of the HRSG to the atmosphere.

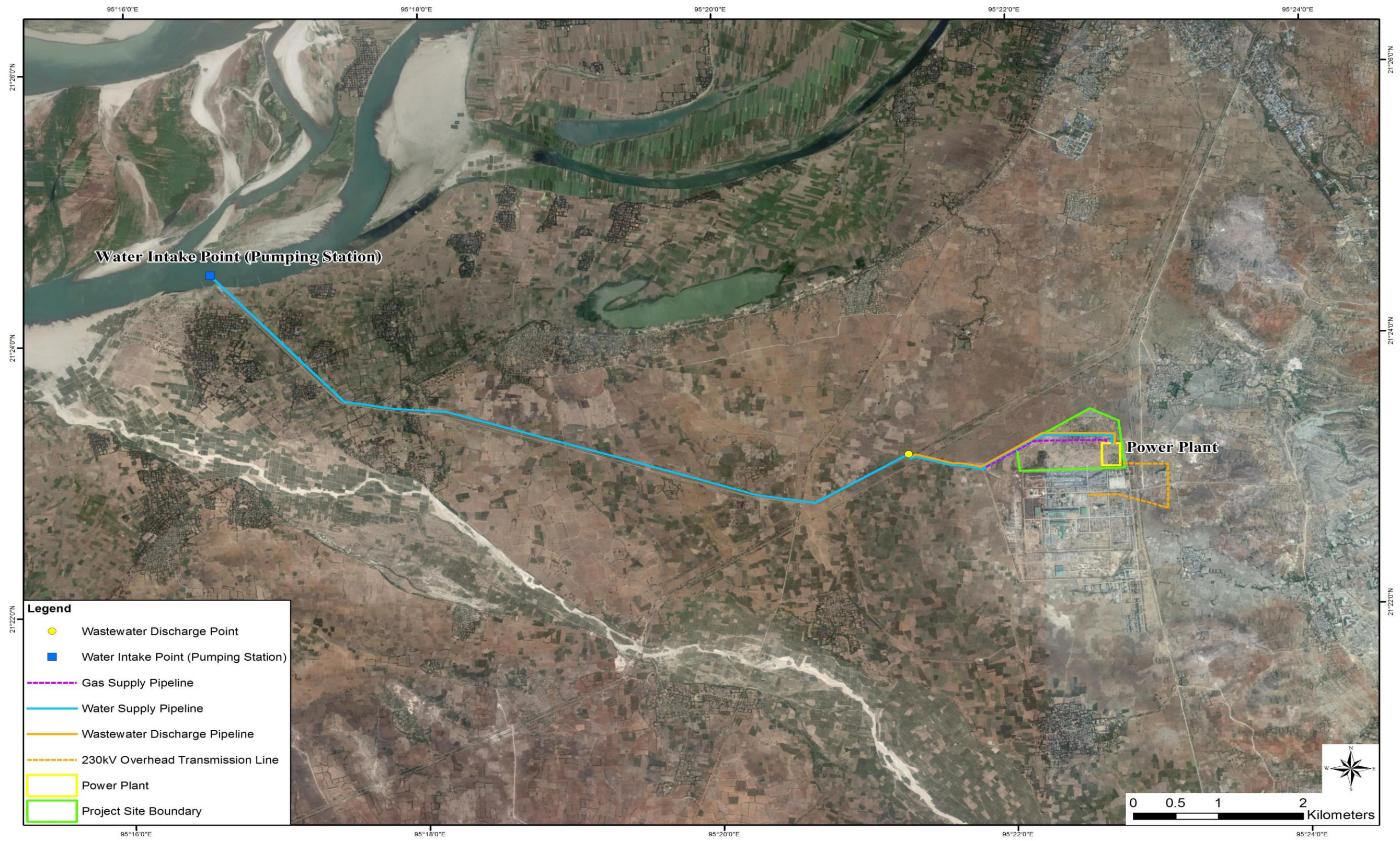
It is anticipated that the Power Plant will operate at full load for the majority of the time. Only one unit (either steam turbine or one gas turbine unit) will be down for maintenance. If the steam turbine is under maintenance, the gas turbines will be running in simple cycle mode, bypassing the HRSG. If one gas turbine is under maintenance, the other gas turbine will still be running.

The HRSG is designed for 3 pressures with reheat steam generation (High Pressure (HP), Intermediate Pressure (IP), Reheat (RH) and Low Pressure (LP)) used to maximize energy transfer from the exhaust gas of the gas turbine. The HP steam generated by the HRSG will be fed to the HP steam turbine and the reheat and LP steam will be fed to the LP steam turbine.

The power output is approximately 143MW during simple cycle and 225MW during combined cycle operation. The Power Plant will use natural gas as the only fuel.

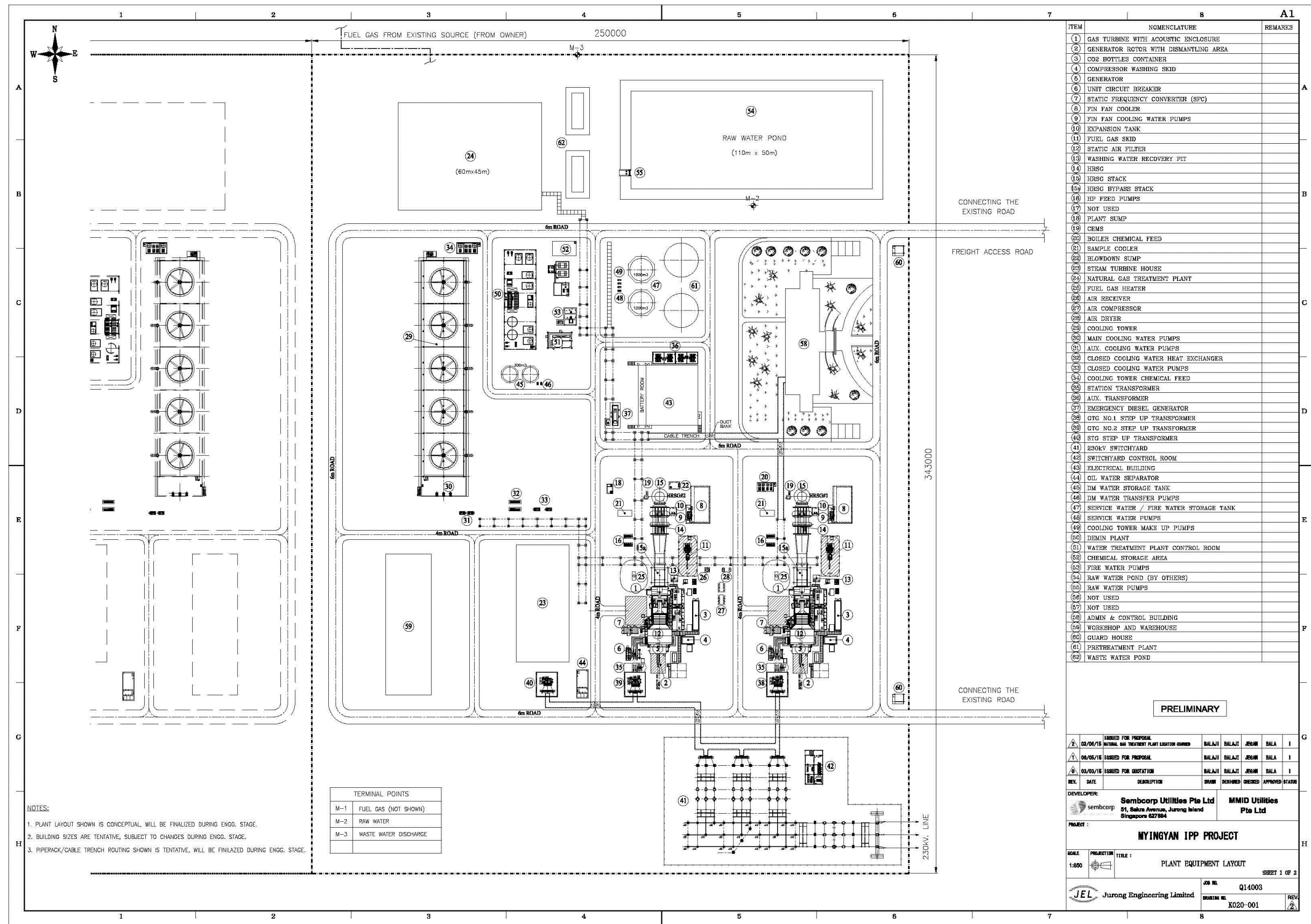
The indicative layout of the Power Plant is shown in **Figure 2.3**. In addition, the Process Flow Diagram of the Power Plant is shown in **Figure 2.5**.

Figure 2.3 Project Facilities



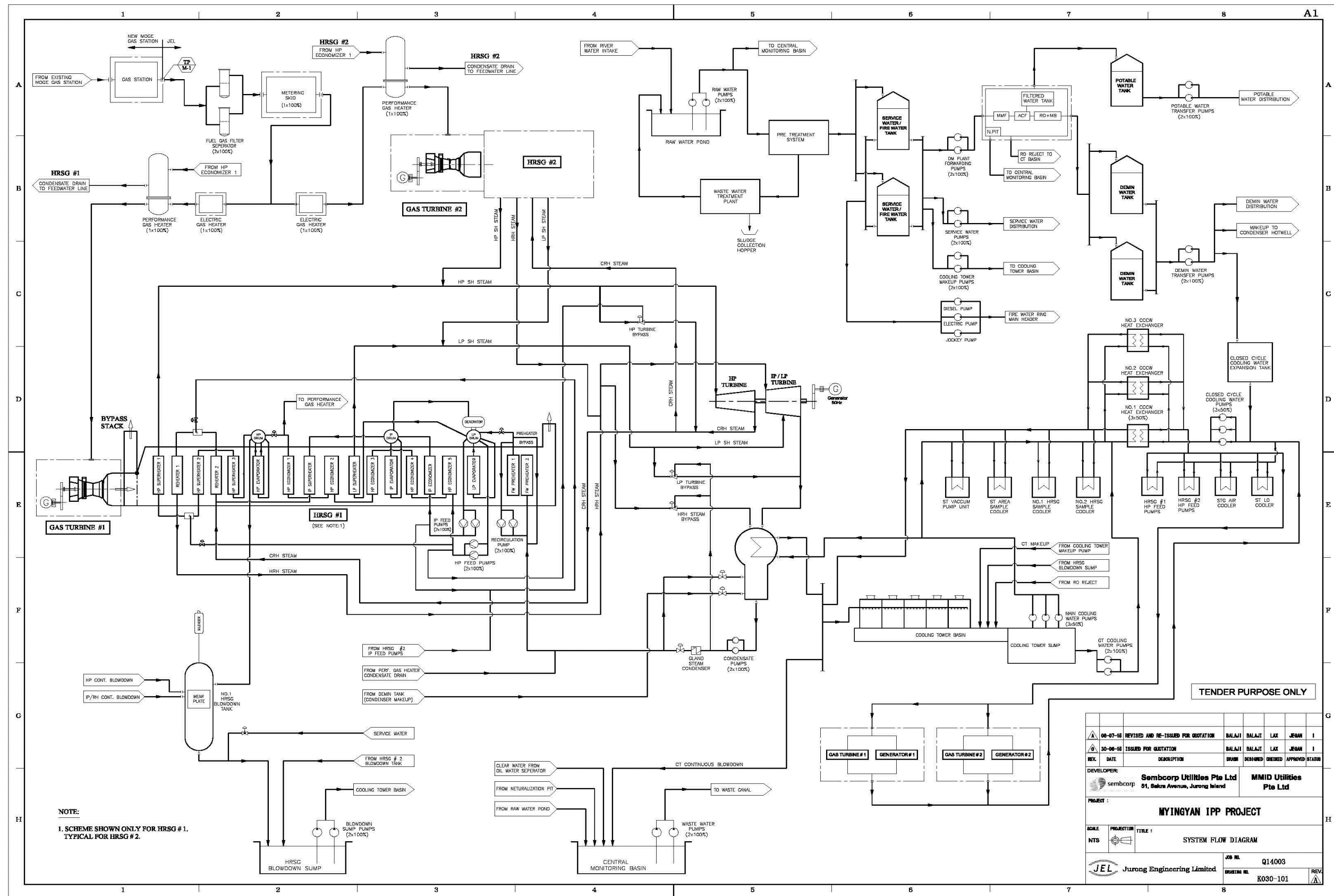
Source: Sembcorp, 2015

Figure 2.4 CCGT Power Plant Layout Plan



Source: Sembcorp, 2015

Figure 2.5 Process Flow Diagram of the CCGT Power Plant



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30-08-16	ISSUED FOR QUOTATION	BALAJI	BALAJI	LAX	JEAM	I
REV.	DATE	DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED/STATUS
DEVELOPER:		Sembcorp Utilities Pte Ltd		MMID Utilities Pte Ltd		
PROJECT:		MYINGYAN IPP PROJECT				
SCALE:	PROJECTION:	TITLE: SYSTEM FLOW DIAGRAM				
NTS		JOB NO. Q14003		REVISION NO. R030-101		
JEL		Jurong Engineering Limited		REV		

Gas Turbine

The GE 6F.03 heavy duty, multi-shaft gas turbine is selected for this Project. The configuration of this selected gas turbine is a multi-shaft, bolted rotor with the generator connected to the gas turbine through a speed reduction gear at the compressor or “cold” end. This feature provides for an axial exhaust to optimize the plant arrangement for combined cycle application.

The Power Plant will be operated based on grid dispatch instructions. The Power Plant will be declared available for full load in normal case. If one gas turbine is offline the other gas turbine in full load and steam turbine (50%) will be declared available. The Power Plant is capable for house load operation. In case of any trip, the Power Plant could be started within 2 hours any one of the gas turbines.

Two gas turbine units will be installed for the Project. The gas turbines will be installed within an acoustic, ventilated enclosure with fire detection and protection systems. The gas turbines will have all associated ancillary equipment and systems required for the safe, efficient and reliable operation of the unit under simple and combined cycle operation.

The gas turbine generator (GTG) specification for each unit is shown in **Table 2.1**.

Table 2.1 *Gas Turbine Generator Specification*

Feature	Specifications
Model/Type	GE 6F.03
Fuel system	Gas only
Starting Means	Static Frequency Converter
Air filtration	Static type
Compressor/Turbine Cleaning	On and Off-line Compressor Water Wash
Exhaust System	Axial
Emissions Control	Gas – Dry Low NOx
Fire Detection	Heat Detectors
Gas Leak Detection	Gas detectors
Fire Protection	High pressure CO2 System
Off-Base Acoustic Enclosure	Turbine and Load Gear Compartments
On-Base Acoustic Enclosure	Lube oil and Gas module Compartments

Source: Sembcorp, 2015

The GTG’s will be installed outdoors as shown in **Figure 2.3**. The GTG’s will be capable of operation with their exhaust gases passing into the associated heat recovery steam generator, or as simple open cycle turbine generators, exhausting directly to atmosphere via an exhaust gas damper and the bypass stacks associated with each gas turbine (30m in height), located on the exhaust ducting upstream of the heat recovery boiler.

All cooling requirements for the turbine shall be met using heat exchangers, fed from the Closed Circuit Water (CCW) system.

Control of emissions of NOx will be achieved by Dry Low NOx (DLN) burners. The detailed of embedded emission controls are described in **Section 2.5.1**.

Audible and visual alarms will be located in the supervised areas in the Local Packaged Electrical and Electronic Control Compartment (PEECC). In addition, a Fire Detection System (FDS) will be installed at each gas turbine.

Heat Recovery Steam Generator (HRSG)

As one of the main units in a CCGT power plant, the two HRSG's (boilers) will be a natural circulation horizontal type HRSG with a three pressure with reheat system and an integral deaerator with no duct burners. The HRSG's will be combined with the gas turbines. The HRSG's are designed for exhaust gas conditions of the gas turbines fueled with natural gas.

Steam generated by the HRSG's will enter the steam turbine. The High Pressure (HP), Reheat (RH) and Intermediate Pressure (IP) steam from the HRSG's is sent to the steam turbine. Exhaust steam from the steam turbine will then enter into the condenser. The exhaust gas leaving the HRSG's will be routed to the HRSG stacks (40m in height).

The HRSGs will be sized to operate over the full range of ambient temperatures specified. The HRSGs consists of an economizer, evaporator, and super-heater tube bank section(s) with finned tubing, as appropriate, to maximize heat transfer. No supplemental firing facilities will be installed.

All pressure parts will be designed, manufactured and will be tested in accordance with "ASME Boiler and Pressure Vessel Code, Section 1, Power Boilers" or equivalent standards.

The HRSG specification is provided in **Table 2.2**.

Table 2.2 *HRSG Specification (at design condition)*

Feature	Specifications
HP steam rating	85.0 t/h
HP steam pressure	14.4 MPa(a)
HP steam temperature	568 °C
IP steam rating	17.0 t/h
IP steam pressure	2.27 MPa(a)
IP steam temperature	300°C
LP steam rating	10.4t/h
LP steam pressure	0.4 MPa(a)
LP steam temperature	290°C

Source: Sembcorp, 2015

Steam Turbine

The steam turbine is a separate High Pressure (HP) and Low Pressure (LP) cylinder structure. The selected steam turbines are:

- HP: multistage/bleeding/backpressure type; and
- LP: multistage/bleeding/condensing type.

Each rotor is composed with groups (drums) of reaction stages. Both turbines are equipped with 2 (two) inlet flanges positioned in the head. The live steam flows

through the emergency stop valves and the mass flow is regulated by control valves, which throttle all the steam flow; such valves are directly bolted to, and installed inside, the inlet section of turbine external casing for HP turbine, or installed separately on steam piping for LP turbine.

HP steam turbine has a downward radial exhaust flange, and LP steam turbine has an axial exhaust discharge flange. The steam turbine exhaust and condenser configuration will be in accordance to manufacturer’s standard design.

The Steam Turbine Generator (STG) will be of proven design and complete with all auxiliary oil and steam systems. The STG will be installed indoors for environmental protection (e.g., dust and rains) and to provide acoustic attenuation. The STG building will include an overhead travelling crane suitable for lifting the maximum heavy load for normal maintenance activities and suitable indoor laydown areas for plant maintenance. The STG specifications are outlined in **Table 2.3**.

Table 2.3 Steam Turbine Generator Specifications

Feature	Specifications
Rated out power	90 MW (to be determined)
Rated power factor	0.8 (lagging)
Rated rotation	3000 r/min
Rated frequency	50 Hz
Phase number	3
Cooling mode	TEWAC (Totally Enclosed Water-To-Air Cooled)
Insulation class	Class F (temperature rise as per Class B)
Exciting mode	Static Excitation System

Source: Sembcorp, 2015

Condensers and Auxiliaries

The condensate system is provided with a recirculation system to ensure there is a minimum condensate flow through the pump and gland steam condenser. The minimum flow protection is accomplished by recirculating the condensate back to the condenser via the Condensate Pump Recirculation Control Valve, based on the flow rate measured at the pump discharge header.

Feed Water System

The feed water system will provide sufficient and reliable feed water to the HRSG from the demineralization plant. The HP Feed water flow rate shall be approximately 29m³/sec and the quality shall be in accordance with STG and HRSG Original Equipment Manufacturer recommendations.

The feed water system will include necessary feed water heaters, de-aerators, feed water pumps, control valves and auxiliaries.

Cooling Water System

The mechanical draft cooling tower cooling water systems is selected for this Project. The main cooling water system will provide cooling water to the steam turbine condenser by means of cooling water pumps installed in the cooling tower basin. The warm water from the condenser is returned to the multi-cell mechanical draft cooling

tower, where it is cooled and collected in the cooling tower basin for return to cool the condenser. The induced draft cooling tower will be provided with the capacity for maximum heat rejection duty under all steam turbine operation conditions for the design conditions specified. The cooling tower shall have sufficient cells to allow for one cell to remain in standby under reference operating conditions.

The cooling tower will contain clarified raw water. A cooling tower chemical injection system will be provided to maintain the appropriate cooling tower chemistry. The Cooling water chemistry will be maintained at approximately 5 cycles of concentration (COC).

Closed Circuit Cooling Water (CCCW) System

The CCCW is a closed loop which provides cooling water flow to small duty plant heat removal and large duty plant heat removal devices which requires low fouling quality water during all modes of plant operation.

The CCCW system includes pumps, heat exchangers (plate-heat exchanger type), and a series of pipe runs complete with valves and controls necessary for the efficient distribution of cooling water from the pumps and heat exchanger to the various components of the cycle.

The CCCW system expansion tank maintains the required system head pressure and system water reserve storage. The tank is vented to the atmosphere and has a combined overflow and drain line. The tank also serves as a surge tank, accommodating flow variations in the system or thermal expansion of the water.

The chemical make-up water is a source of initial fill and make-up water for the CCCW system. The chemical composition of the CCCW will be constantly controlled.

A water sampling provision is located in the CCCW pump discharge line to periodically collect and sample the water and to monitor the water quality.

Cooling water from the CCCW pumps flows through a main header and then various small sub-headers and distribution lines to the heat removal devices picking up heat.

After passing through the heat removal devices, hot water flows from the individual equipment return lines to the main return header. At this point, hot water flow is directed through the CCCW heat exchanger. These heat exchangers reduce the coolant temperature approximately to 38°C. The CCCW heat exchangers utilize colder open cycle cooling water passing through the tubes as the cooling medium.

Raw Water System

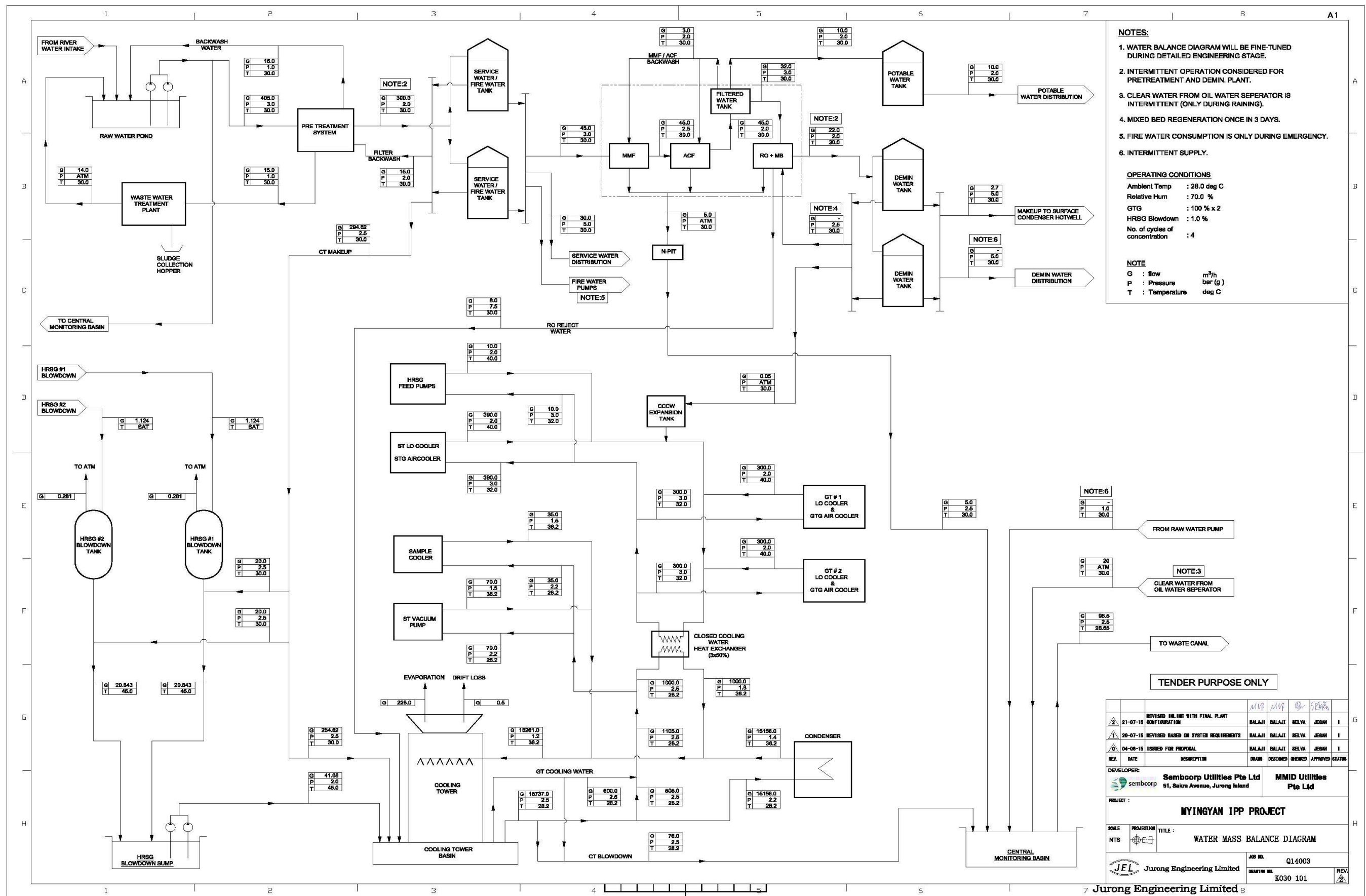
The raw water system includes the make-up water system, raw water storage pond and the pre-treatment system.

The raw water will be taken from Ayeyarwady River, using the water intake pumping station at the flow rate of approximately 405 m³/hour, via a 14km water pipeline and will be stored in the raw water storage pond. The water balance for the Power Project is shown in **Figure 2.6**.

The capacity of raw water storage pond is approximately 20,000m³, which can satisfy the water consumption of the plant for 2 days.

The pre-treatment system consists of 2 clarifier tank. The capacity of each clarifier is estimated at 240m³/hour approximately (2x60% capacity).

Figure 2.6 Power Plant Water Balance



Wastewater Treatment System

The wastewater system will collect and neutralize chemical wastes from the water treatment plant (regeneration waste) and the drainage from chemical containment areas.

Drains from all equipment containment drainage, spills, floor wash downs and fire protection discharges will be led to oil-water separator. One oil/water separator will be designed for outdoor, underground in RCC construction.

Plant Wastewater Monitoring System

The Central Monitoring Basin will collect all the neutralized wastes, separated water from oil-water separator, and cooling tower blow down water for monitoring to ensure compliance to wastewater effluent quality before discharge. The wastewater will be discharged to the irrigation canal outside of the Power Plant shown in **Figure 2.3**.

Sewage Water System

Sanitary waste water collection and a package sewage treatment plant will be provided. The treated water will be discharged to the Central Monitoring Basin.

Rain Water Drainage System

The rain water drainage system will consist of buried pipelines. Rain water from the roofs and the ground will be collected to the rain gravity drainage pipe, and then sent to the Central Monitoring Basin.

Oily Water Treatment System

Drains from all equipment containment drainage, spills, floor wash downs and fire protection discharges will be led to oil-water separator.

The oily waste water treatment is designed to treat the oily water from the Power Plant. The treated water shall drain to the Central Monitoring Basin.

Emission Control

The Project will include emission control technologies to reduce air pollutant emissions to comply with applicable standards.

Dry Low NO_x burners

The proposed power plant will be equipped with Dry Low NO_x burners developed to achieve low NO_x emissions.

The Project will provide Dry Low NO_x burners which are Best Available Technology (BAT) for CCGT power plants to guarantee NO_x emission levels at the exhaust chimney of 25ppm by volume (dry) at 15% O₂ levels.

Continuous Emissions Monitoring Systems (CEMS)

In addition to the emission reduction technologies, the proposed power plant will be installed with a CEMS which shall monitor the concentrations of SO₂, NO_x, CO, O₂ and dust as well as temperature and flow; as summarised below:

- SO_x Analysers (0 – 25ppm)
 - Non Dispersive Infrared/UV technique;
 - Extractive type, microprocessor based; and
 - Analyser shall have features such as auto temperature compensation, auto zero and span calibration etc.
- NO_x Analysers (0 – 100ppm)
 - Non Dispersive Infrared detection technique;
 - Extractive type, microprocessor based; and
 - Analyser shall have features such as auto temperature compensation, auto zero and span calibration etc.
- O₂ Analysers (0 – 25%)
 - Extractive type, using paramagnetic detection technique.
- Dust Analysers /Particulate matter (0 – 20mg/m³)
 - In situ type, optical transmission meter type (electro optical type), microprocessor based;
 - Extractive type, microprocessor based; and
 - Analyser shall have features such as auto temperature compensation, auto zero and span calibration etc.
- CO Analysers (0 – 200ppm)
 - Extractive type; and
 - Non dispersive infrared detection technique.

The sample handling system shall be based on the Extraction technique, with complete sample transportation and condition unit, heat tracing (if required), sample probes and pressure regulators etc. The system shall provide the facilities for local data acquisition and transmission of system parameters and off-normal alarms to the central control room.

2.5.4

Gas Supply Pipeline

Currently, the existing Steel Mill facility offtakes the gas from the Shwe gas pipeline, which is a Government-built gas supply pipeline. The gas supply pipeline from Taung Thar offtake point (on Shwe gas supply pipeline) is approximately 18km in length and connects to an existing MOGE gas receiving station located to the northwest of the steel mill built by the Government. This existing MOGE gas receiving station has been used to receive and supply gas to the steel mill and the existing onsite Aggreko temporary gas-fired power plant.

MOGE will install a new gas receiving station adjacent to the existing MOGE gas receiving station to supply gas to the Power Plant. The Project will build a new gas supply pipeline approximately 1km in length from the outlet of the new MOGE gas receiving station to the Power Plant (see **Figure 2.7**).

Design of the gas supply pipeline will be as per ANSI B 31.8: Gas Transmission and Distribution Systems. The class rating will be as per the final discharge pressure from

MOGE new gas receiving station and will be either ANSI Class 300 or Class 600. Welding of pipeline will be as per API Standard 1104. The gas supply pipeline will be buried and have a minimum cover of 1.0m on top of it. Cathodic protection will be in place for the buried section of the pipeline and the design will be based on soil resistivity. A Quantitative Risk Assessment (QRA) has been prepared for the gas supply pipeline (refer to **Annex A**).

It is noted that the gas supply from the Shwe gas supply pipeline will be sufficient to meet the Project's requirements, and there is no need to expand or seek additional gas supply. The gas supply agreement between MOGE and MEPE states that there will be a gas supply of 47.546 mmscfd from January 2015 onwards. This gas supply infrastructure is already in place and awaiting offtake.

A natural gas supply and treatment system will be installed at the Power Plant to meet the required gas quality and pressure specified by the gas turbine manufacturer. The natural gas system will include backup metering equipment and all necessary, gas filter-separators, isolation and control valves, safety valves, and other equipment. The gas analysis is provided in **Table 2.4**.

Table 2.4 Shwe Gas (natural gas) Composition

Component	Mole Percent	BTU Gross	Relative Density
C6 + 47/35/17	0.0199	1.05	0.0007
Propane	0.0297	0.75	0.0005
i-Butane	0.0109	0.36	0.0002
n-Butane	32.2 ppm	0.11	0.0001
i-Pentane	49.7 ppm	0.20	0.0001
n-Pentane	0.0000	0.00	0.0000
Nitrogen	0.2218	0.00	0.0021
Methane	99.5529	1007.81	0.5514
Carbon Dioxide	0.0491	0.00	0.0007
Ethane	0.1073	0.00	0.0011
TOTAL	100.0000	1012.18	0.5570

Source: Sembcorp, 2015

2.5.5 230kV Overhead Transmission Line

The proposed 230kV overhead transmission line alignment is approximately 2.5km in length and will be located between the generator transformer at the Power Plant and the upgraded Myingyan Steel Mill sub-station located within the steel mill complex. The proposed alignment is to the east of the Project boundary shown in **Figure 2.8**.

Connection beyond the upgraded Myingyan Steel Mill sub-station is GOM's responsibility. The connection beyond the upgraded Myingyan Steel Mill is not known at this stage.

2.5.6 Water Supply Pipeline and Wastewater Discharge Pipeline

The proposed water supply pipeline alignment is approximately 14km in length and will run from the Power Plant along an existing irrigation canal connecting to the Ayeyarwady River for water intake (see **Figure 2.9**). The proposed alignment is surrounded by predominantly agricultural/modified land and some shrubs. The

proposed alignment is expected to go underneath several existing dirt paths and roads including the Nyaung U-Myingyan highway.

Land required for the water supply pipeline would be minimal as the majority of the water supply pipeline will be located along the existing irrigation canal.

There is an existing floating pump house for supply of water for irrigation, located at the irrigation canal intake on the Ayeyarwady River. Due to capacity requirements, this pump house is considered to be unsuitable insufficient for supplying water to the proposed Project and a new pump house will be constructed by the Sponsor. The pumps will be located on a floating pontoon with shed.

In terms of social features, the proposed alignment avoids crossing existing villages. Near the outlets on the Ayeyarwady River the water supply pipeline is expected to have several communities of the Tha Pyay Thar village on either side of the proposed alignment and pass through the south of Hla Naung Taung village (see **Figure 2.2**).

The proposed wastewater discharge alignment is approximately 3km in length and will run alongside the water supply pipeline from the Power Plant to the irrigation canal (see **Figure 2.9**). The wastewater discharge is anticipated to be approximately 70 to 100 m³/h.

Figure 2.7 Proposed Alignment of Gas Supply Pipeline from New MOGE Gas Receiving Station to the Power Plant

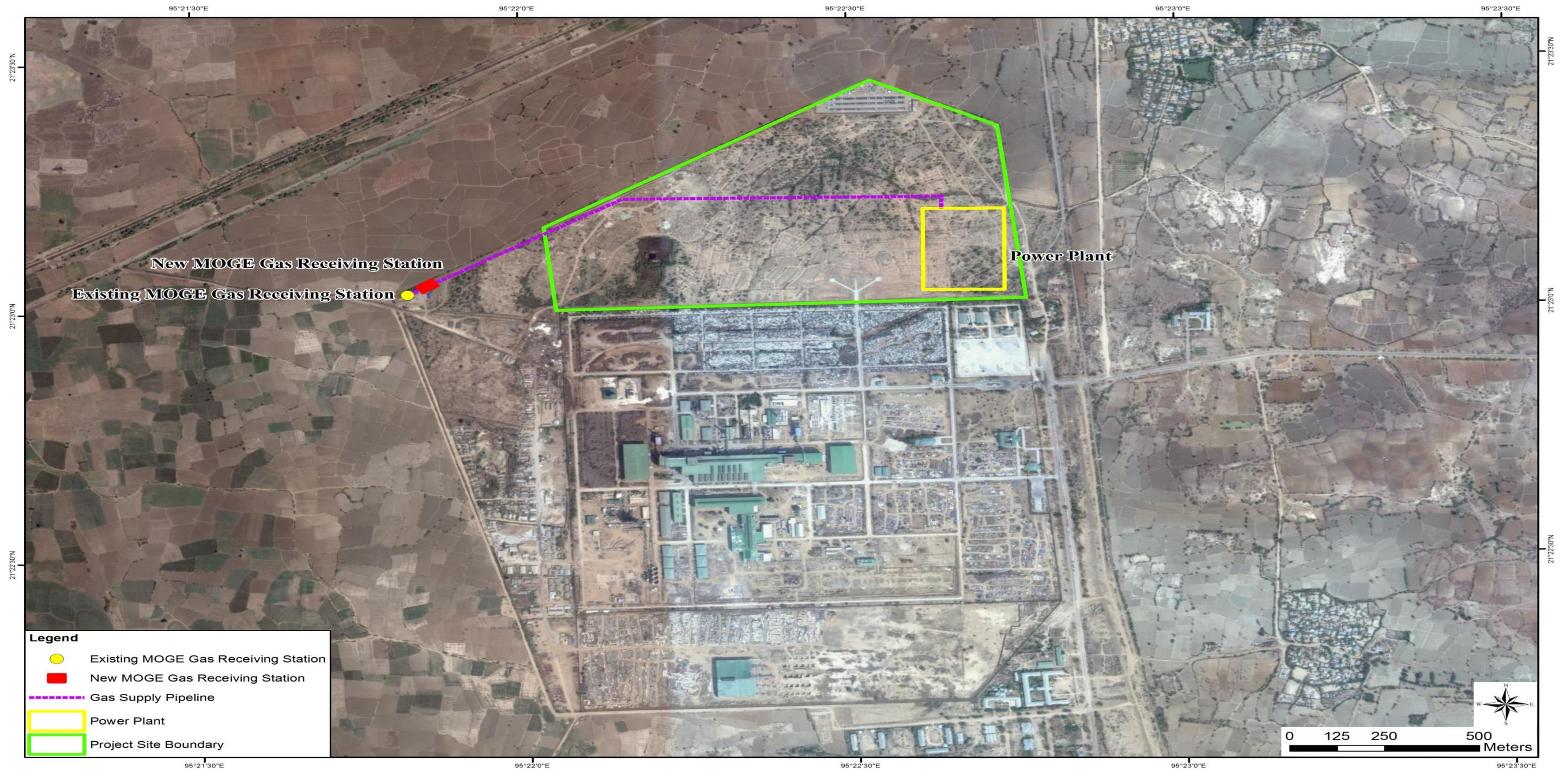


Figure 2.8 Proposed Alignment 230kV Overhead Transmission Line Route from Power Plant to Upgraded Myingyan Steel Mill sub-station



Source: Sembcorp, 2015 (modified by ERM)

Figure 2.9 Proposed Alignment of Water Supply Pipeline from the Power Plant to the Ayeyarwady River Water Intake Point and Wastewater Discharge Pipeline



Source: Sembcorp, 2015 (modified by ERM)

2.6

PROJECT LIFE CYCLE OVERVIEW

Project life cycle analysis identifies the key issues and concerns that are likely to evolve over the entire lifespan of a project.

In the case of the proposed Project, these issues may arise during the construction, operation and maintenance, and decommissioning. These issues have been considered in this ESIA, prior to any irreversible actions being undertaken by the Sponsor, Contractors and other Project associates. The following sub-sections identify the key activities to be completed and facilities to be constructed and operated over the lifetime of the Project.

2.6.1

Construction Phase

Construction Schedule

Construction is expected to start in the first quarter of 2016 and be complete in the region of 22.5 months with commercial operation targeted at the first quarter of 2018.

Construction activities of the Project will include: mobilisation, site clearance, onshore construction of all Project components, Nyaung Hla jetty reinforcement and commissioning. Heavy equipment such as bulldozers, excavators, dump trucks, compactors, etc. will be used at the Project site.

The normal construction hours are anticipated to be 10 hours per day, 6 days per week.

Mobilisation

Site construction work will start once civil design of site preparation is finalised. All work will be conducted in accordance with the detailed master construction schedule, provided by the EPC Contractor. Prior to commencement of work, all Contractors will be required to provide detailed site specific plans related to:

- Equipment use;
- Excavation and backfilling management;
- Soil erosion management;
- Traffic management;
- Storm water pollution prevention plan;
- Dust prevention plan;
- Environmental and Social Management Plan;
- Waste Management Plan; and
- Plan drawings of laydown, traffic flow, parking, trash storage, and recycling areas.

Earth Works

Earth works will include clearing of vegetation and grading of the Project site. It is anticipated that the subsoil, which will be stripped and removed from the Project site, will be utilised for levelling/ backfilling. It is anticipated that approximately 20,000m³ of soil will be removed due to excavation activities of the water supply pipeline and then backfilled.

Site Foundation

The foundation concept design for the Project has been prepared considering geotechnical information. It is proposed that lightly loaded structures with equipment not sensitive to settlement may be supported on spread footings and/or mat foundations, provided the sub grade is adequately compacted. Other structures and/or settlement sensitive equipment shall be supported on piles.

Power Plant Construction

Table 2.5 presents the key structures which will be constructed for the Power Plant. It is expected as a part of the mobilisation phase the Project site will be fenced. The construction area for the Power Plant will be adjacent to the Power Plant site as shown in **Figure 2.10**.

Table 2.5 Power Plant Key Structures

Item	Description
Steam Turbine Building	The Steam Turbine Building will consist of the following: <ul style="list-style-type: none"> • Steam Turbine Hall • Turbine Operation Platform • Crane Girder • Turbine Hall Gable Structure • Turbine Generator Pedestals
Main Control & Electrical System Buildings & Structures	The Control & Electrical System Buildings & Structures will consist of the following: <ul style="list-style-type: none"> • Central Control Room • Plant electrical room • Transformer oil pit • Outdoor power distribution equipment • Emergency diesel generator room / container • Switchyard control building
Main Chemical Water Treatment System Structures	The Main Chemical Water Treatment System Structures will consist of the following: <ul style="list-style-type: none"> • Boiler Make up Water Treatment Plant • Industrial Waste Water Treatment Plant
Auxiliary Buildings & Structures	The Auxiliary Buildings & Structures will consist of the following: <ul style="list-style-type: none"> • Administration building • Maintenance & Warehouse • Guard house • Air compressor house shelter • Cooling water pump house and associated equipment (outdoor) • Mechanical draft flow cooling tower (5 cells) • Water basin of cooling tower (1 set) • Mechanical acceleration clarifier (2 sets) (outdoor) • Foundation of service water cum firefighting watertank (2 sets) • Sewage water equalization tank • Oil water separator
Main HRSG Stacks (2 stacks)	<ul style="list-style-type: none"> • 40m height with a diameter of 3.7m
Bypass Stacks (2 stacks)	<ul style="list-style-type: none"> • 30m height with a diameter of 4.0m

Source: Sembcorp, 2015

Figure 2.10 Power Plant Construction Area



The construction of the buildings and structures in **Table 2.5** will typically be reinforced concrete structures or steel frame structures. Reinforced concrete shall be used for primary plant facilities and facilities exposed to an aggressive environment. These facilities are primarily low-rise buildings/structures that have a large footprint area relative to their height. Conversely, steel is used for large expansive structures.

A concrete batching plant will be located onsite during construction. The location of the concrete batching plant is located near the material storage yard and is shown in **Figure 2.10**. The concrete batching plant will produce 500m³ of concrete per day and will be operational for 12 hours per day. The loading/unloading areas during construction will also take place in the construction area shown in **Figure 2.10**.

Gas Supply Pipeline Construction

Construction of the gas supply pipeline will take approximately 4 months.

The site clearance activities for the gas supply pipeline will involve the clearance of shrubs and vegetation. The construction activities for the gas supply pipeline will require the use of crane truck, excavator, compactor and generator set. The machinery associated with the construction of the gas supply pipeline will be operated during daytime only (10 hours per day).

The waste associated with construction of the gas supply pipeline will comprise of steel pipes, steel plates, structural steel and wooden crates. Excavated soil will be used for backfilling and will be compacted and levelled. Opportunities for the disposal sale of the steel pipes and structural steel will be explored. The wooden crates will be disposed of by a licenced waste contractor.

230kV Overhead Transmission Line Construction

Construction of the 230kV overhead transmission line from the generator transformer at the Power Plant to the upgraded Myingyan Steel Mill sub-station located within the steel mill complex will take approximately 7 months.

The site clearance activities for the 230kV overhead transmission line will involve the clearance of shrubs and vegetation. The construction activities for the 230kV overhead transmission line will require the use of cranes, soil compactor, concrete truck, generator set and trucks. The machinery associated with the construction of the 230kV overhead transmission line will be operated during daytime only (10 hours per day).

The waste associated with construction of the gas supply pipeline will comprise of steel pipes, steel plates, structural steel and wooden crates. Opportunities for the disposal sale of the steel pipes and structural steel will be explored. The wooden crates will be disposed of by a licenced waste contractor.

Water Supply Pipeline Construction

Construction of the water supply pipeline from the Ayeyarwady River to the Project site will take approximately 11 months.

The water pipeline shall be led with floating barge water intake concept. The intake floating pontoon located on the river bed. A steel approach bridge will be adopted to connect the pontoon with the land. The bridge pier will be constructed on the bank of the river. Around the bridge, dry masonry will be used to protect the river bank, and the scope of slop protection will be approximately 40m.

The site clearance activities for the water supply pipeline will involve the clearance of shrubs and vegetation. The construction activities for the water supply pipeline will require the use of cranes, soil compactor, concrete truck, generator set and trucks. The machinery associated with the construction of the water supply pipeline will be operated during daytime only (10 hours per day). For the crossing of roads and the railway pipe jacking will be used.

The waste associated with construction of the water supply pipeline will comprise of steel pipes, steel plates, structural steel and wooden crates. Opportunities for the disposal sale of the steel pipes and structural steel will be explored. The wooden crates will be disposed of by a licenced waste contractor

Commissioning

After 75 to 80%, completion of the construction phase, priorities shall be shifted from the overall geographic area to that dictated by utilities and process completion. All major equipment will be installed, tested and commissioned under the supervision of the respective representatives.

Commissioning activities would involve the following activities:

Simple Cycle:

- First Fire;
- GTG Short-circuit and AVR testing;
- Synchronizing; and
- Dry Low NOx tuning.

Combined Cycle:

- Steam Blowing;
- STG no-load tests;
- STG Load Tests;
- Plant Fine-Tuning;
- Performance Test; and
- Reliability Run.

Transportation of Construction Material

Heavy Cargo

Heavy cargo will be transported by barge from Thilawa Port in Yangon to Nyaung Hla Jetty on the Ayeyarwady River. **Table 2.6** shows the heavy cargo to be transported.

Table 2.6 *Heavy Cargo to be transported from Thilawa Port in Yangon to Nyaung Hla Jetty*

Description	Quantity
Gas Turbine	2
Gas Turbine Generator	2
LP steam turbine	1
Steam Turbine Generator	1
HP steam turbine skid (with gearbox)	1
Main condenser	1
HRSB Module	12

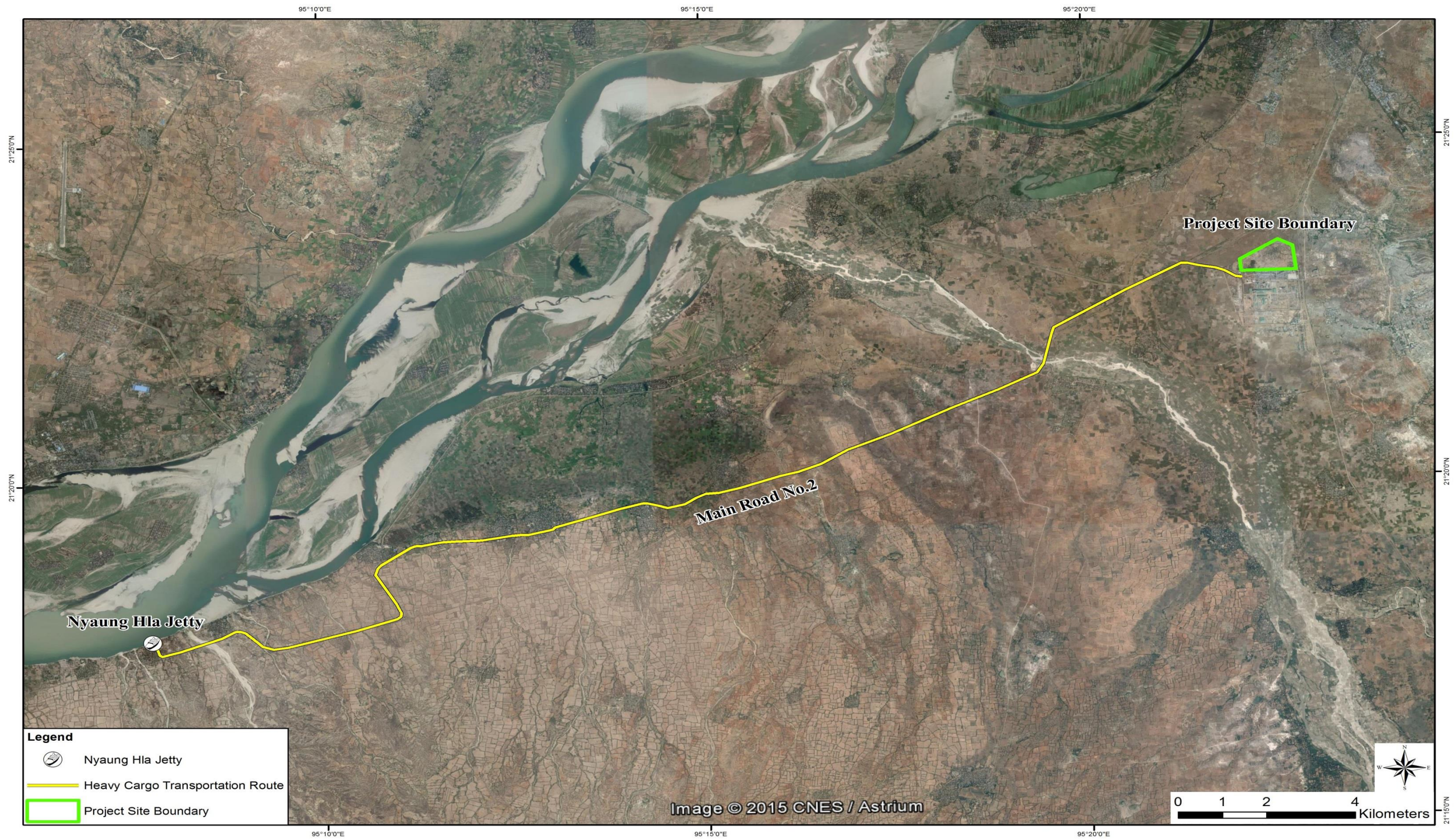
The inland transportation for the heavy cargo will start from Nyaung Hla Jetty place to the Project site using the Nyaung U-Myingyan Road. With approval from the Transport Superintendent, the cargo will be transported from the jetty to the Project site with necessary traffic escorts. The proposed transportation route from Nyaung Hla Jetty to the Project site is approximately 25km and is shown in **Figure 2.11**. On route to the Project site the heavy cargo will use the existing road to cross the Sintelwa River. This road will require reinforcement and backfilling underneath the existing I-beams.

The temporary landing place at the Nyaung Hla Jetty will require reinforcement for the roll off operation. The ground conditions will be prepared, levelled and compacted/strengthened appropriately.

Construction Materials

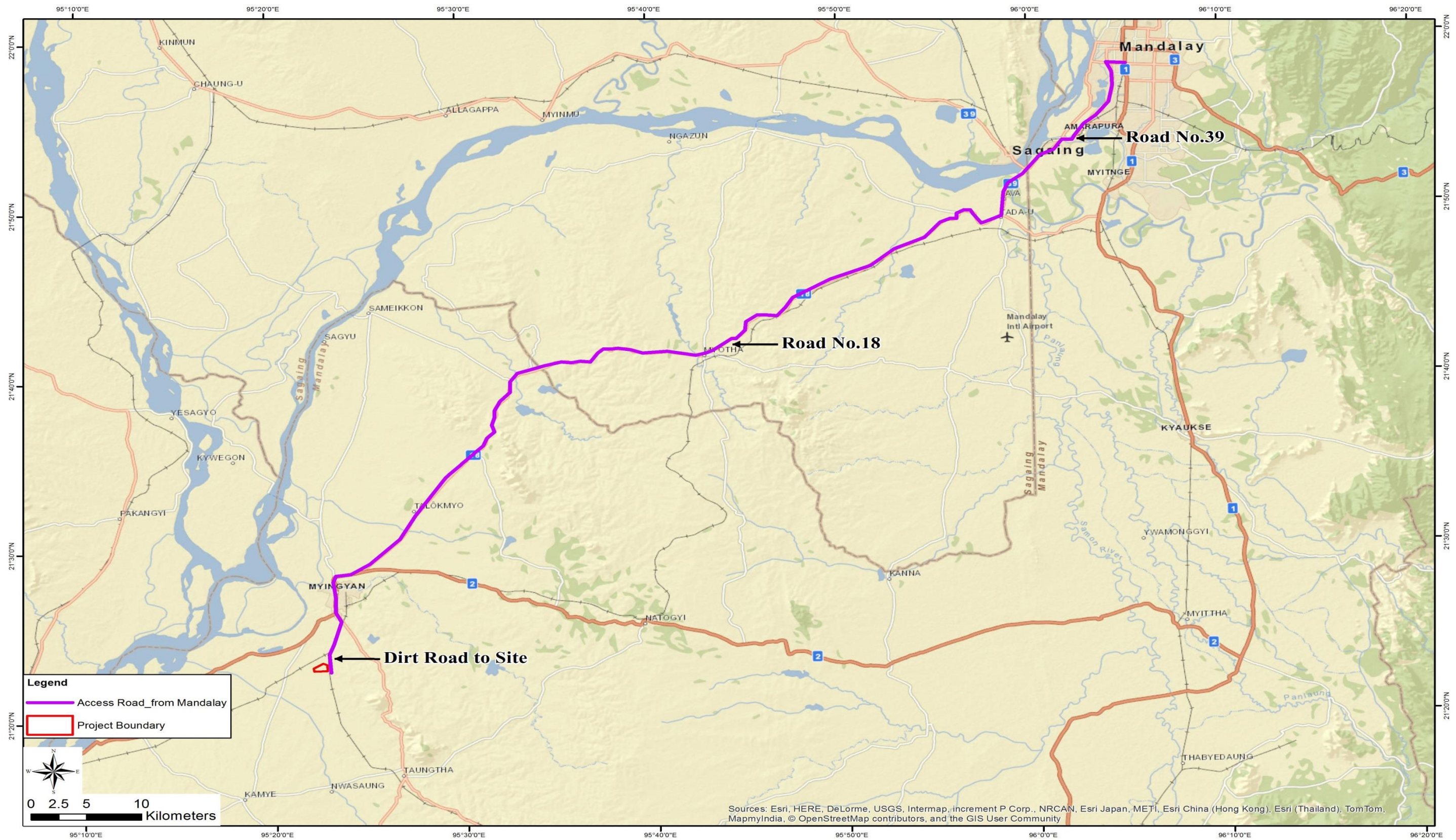
For other construction materials the proposed ground transportation route is from Mandalay to the Project site using existing roads no. 39 and road no. 18. Construction materials such as structure steel, piping, plant mechanical equipment, electrical and instrumentation equipment and other construction consumables will be used for this route. It is anticipated 2 to 10 trucks will use this route during the construction period. The ground transportation route is shown in **Figure 2.12**.

Figure 2.11 Proposed Transportation Route of Heavy Cargo from Nyaung Hla Jetty to the Project Site



Source: Sembcorp, 2015 (modified by ERM)

Figure 2.12 Proposed Transportation Route of Construction Materials to the Project Site Transportation Route



Source: ERM, 2015

Power and Water Supply

Approximately 16,000kW of electricity will be required during the peak construction period, with an average consumption rate of 800kwh/mth. The electricity will be sourced from the 11kV transmission line which is 2km from the Project site. The route of the transmission line is currently not known. The Contractor shall provide 11kV/380V box-type transformer and 300kW diesel generator for emergency.

During construction, water is required for construction worker activities and prefabricated concrete activities. The maximum number of workers onsite during construction is anticipated to be 900 persons and each worker is estimated to consume approximately 50 litres of water per day⁽¹⁾. Prefabricated concrete activities are estimated to consume 40m³ of water per day.

The average water consumption rate during construction is anticipated to be 700m³ per month (approximately 24m³ per day).

At the early stage, the raw water required during construction will be transported from underground tube wells. The final location of the tube wells are not known at this stage. The water from the tube wells will be treated and purified to supply for construction. At a later stage, when the water supply pipeline from the Ayeyarwady River is connected, the construction will change over to this water supply for construction purposes.

Construction Waste

Solid Waste during Construction

The solid waste generated during construction will include steel pipes, steel plates, structural steel and wooden crates. Opportunities will be explored for selling the steel plates and structural steel. The wooden crates will be disposed of by a licenced waste contractor.

There will also be biomass waste associated with the clearance of tree, shrubs and grass. Approximately 800m³ of biomass waste is anticipated during construction. Opportunities for providing biomass waste to the local community will be explored or biomass waste will be disposed of by a licenced waste contractor.

All excavated material will be backfilled with no surplus.

Hazardous Wastewater during Construction

Hazardous wastewater will be generated from chemical cleaning of the equipment during the precommissioning process. The hazardous wastewater from chemical cleaning will be treated in the neutralisation system.

⁽¹⁾ Metcalf & Eddy Inc. Wastewater Engineering: Treatment, Disposal, Reuse. 3rd Edition McGraw Hill, Network, 1979

Non Hazardous Wastewater during Construction

Non-Hazardous wastewater will be generated from the toilet facilities and workers accommodation (sewage). Non-hazardous wastewater will also be generated from the canteen. The sewage generated onsite will be collected through underground pipes into a holding tank, from where the sewage will be routed to an onsite sewage treatment plant or alternatively transported periodically by vacuum trucks and transferred to a septic tank or discharge to common drain.

Construction Workforce

The anticipated workforce during construction is shown in **Table 2.7**. The workers accommodation will be located to the north of the construction area shown in **Figure 2.11**.

Table 2.7 **Anticipated Workforce during Construction**

Workforce Origin	No. of Skilled Workers	No. of Semi-Skilled Workers	No. of Unskilled Workers	Total Average Workforce (per day)	Total Peak Workforce (per day)
Local Workforce	140	210	250	600	900
Migrant Workforce	50	10	0		

Source: Sembcorp, 2015

2.6.2 Operational Phase

The main features of the Project have been described in **Section 2.5.1**.

There will be no Operation and Maintenance (O&M) contract with any third party operator, as the Project will be owned and operated by the Sponsor. The O&M of the Project will be undertaken by the Sponsor with the support of a long term service agreement (LTSA) for the GT with the manufacturer. The LTSA will cover the supply of spare parts, supervision and specialized labour for inspections, major and minor overhauls.

O&M staff with relevant experience of operating similar plants and with adequate knowledge of comparable technology will be deployed prior to Simple Cycle commercial operation date (COD) to commission and take over the Project from the EPC Contractor.

The below sections will discuss further the key activities during Operation Phase.

Operational Schedule

The start of operation is anticipated for the first quarter of 2018. Simple cycle operation will occur during the first five months of operation before the combined cycle plant is complete.

Fresh Water Supply

The main freshwater supply source will be taken from Ayeyarwady River via the water supply pipeline which will be retained in the raw water pond.

The raw water will be passed through the pre-water treatment. The majority of the water will be supplied to meet the plant service water / cooling tower make-up and the balance will be taken to meet the plant potable water and demineralized water requirement.

Table 2.8 presents the water requirements and their volumes during operation.

Table 2.8 *Water Requirements during Operation*

Water Requirement	Volume
Cooling water system	405 m ³ /h (circulating)
Demineralised water system	22 m ³ /h
Domestic water	4m ³ /h

Source: Sembcorp, 2015

Operational Wastewater

As presented in **Section 2.5.1** the Project will be equipped treat all wastewater to comply with the discharge specification before discharge to the irrigation canal shown in **Figure 2.9**. A sewage treatment plant will also be installed.

Table 2.9 presents details of the wastewater and approximate capacities which will be generated during operation.

Table 2.9 *Wastewater during Operation*

Item	Timing of Wastewater Generation	Capacity
Wastewater from Power Plant		
Sludge from river water pre-treatment	Normal Operation	1 m ³ / hour
DM plant neutralized water	Normal Operation	5 m ³ / hour
Cooling tower blowdown	Normal Operation	70.5 m ³ / hour (continuous)
Stormwater	Normal Operation	Intermittent
Washing water from Main Block	Normal Operation	Intermittent
Fire protection system	Emergency	
Domestic Wastewater		
Kitchen	Normal operation	
Wash room	Normal operation	
Plant control room	Normal operation	
Condensate polisher / safety shower	Emergency	
Battery room/eye wash	Emergency	
Water treatment plant/safety shower	Emergency	
Sanitary/ Sewage Wastewater	Normal Operation	4 m ³ / hour

Wastewater from the plant process will be treated with pH control within a pH range 6 to 9 in the neutralisation treatment system and oil-water separator system. The treated wastewater will be stored in the Central Monitoring Basin before discharge to the existing irrigation canal shown in **Figure 2.9**. Sewage will be treated in a package sewage treatment and discharged into the wastewater discharge system. The sludge will be dewatered and disposed off-site by a licensed waste contractor.

Stormwater

The Power Plant perimeter drain for stormwater will be connected to an oil and grease pit (interceptor). The contaminants will be captured in the pit and removed manually.

Operational Solid Waste

Table 2.10 presents details of the solid waste and approximate capacities anticipated during operation.

Table 2.10 *Solid Waste during Operation*

Waste Type	Anticipated Quantity
Domestic Solid Waste	1.65kg per employee per week

The solid waste generated during the operation phase will be collected and segregated for recycle and non-recycle waste (i.e. paper, plastic). Solid waste will be disposed of and handled by Myingyan Municipality.

There will also be minimal other waste such as wood crates from maintenance activities which will be provided to the local community as fire wood.

Operational Hazardous Materials

The hazardous materials to be stored on site during operation are presented in **Table 2.11**. The chemicals will be transported appropriately to the Project site and Material Safety Data Sheets (MSDS) will be prepared from chemical suppliers in Myanmar.

Table 2.11 Hazardous Materials during Operation

Hazardous Material	Use of Hazardous Materials	Storage Location Onsite	Quantities to be Stored Onsite
Oxygen Scavenger	Chemical Dosing System	Chemical Storage House	1m ³
Phosphates	Chemical Dosing System	Chemical Storage House	1m ³
Fouling Agent	Chemical Dosing System	Chemical Storage House	1m ³
Anti-corrosion	Chemical Dosing System	Chemical Storage House	1m ³
Biocides	Chemical Dosing System	Chemical Storage House	1m ³
Hydrochloric Acid	Chemical Dosing System	Chemical Storage House	3m ³
Sodium Hydroxide	Chemical Dosing System	Chemical Storage House	3m ³
Sodium Hydroxide	Water Treatment System and Demineralised Water System	Chemical Storage House	10m ³
Hydrogen Chloride	Water Treatment System and Demineralised Water System	Chemical Storage House	10m ³
Diesel oil	Liquid fuel for emergency diesel engine generator, emergency diesel generator	Storage Tank	4,000 l/month

Operational Workforce

The anticipated workforce during operation is shown in **Table 2.12**.

Table 2.12 Anticipated Workforce during Operation

Description	Staff Number
Permanent Staff	48
Security (external)	12
Contract staff: Cleaners, Gardeners and helpers	10
Contract staff: Technical hands	10
Maintenance (once every 3 years)	90 for 30 days

Source: Sembcorp, 2015

The operational working hours / shift structures will be as follows:

- 12 hours per shift with 4 shift teams;
- 2 days shift 1 day off, 2 nights shift 3 days off (including sleeping off);
- 1 shift charge, 1 unit controller and 2 field technicians per shift; and
- 18 staffs will be in the shift roster.

Ancillary Structures

In addition to the main infrastructure on site, and as described above, the following ancillary buildings will be constructed:

- Administration building (incorporated of the Central Control Room);
- Gatehouse at the main gate of the site;
- Staff canteen; and
- Fire fighting pump house.

Emergency Diesel Generators

The Power Plant will have one emergency diesel generator with a capacity 800kWh that will only be used during plant safe shutdown. The diesel will be transported appropriately to the Project site from diesel suppliers in Myanmar. Material Safety Data Sheets (MSDS) will be completed for the diesel to ensure appropriate transportation. The diesel generator will be the stationary emergency type and will consist of control gear, lubricating oil system, fuel day tank, cooling system, direct current (DC) starting power and synchronizing equipment, and electrical protection system equipment. Following an emergency shutdown at the power plant, the diesel generators will provide electrical power to maintain the turbine generator unit and its auxiliaries in safe conditions. The diesel generator will not exceed operation for more than 2 hours which is considered to be sufficient.

Fire Protection System

The Power Plants fire protection system will provide personnel safety and plant protection through prompt detection, alarm and suppression of a fire. The system will be designed for any single design basis fire and will be in accordance with all local applicable codes and standards. The primary source of water for the system shall be from the plant's water system.

Power Plant Maintenance

During operation, maintenance will be associated with the following:

- Breakdown Maintenance;
- Planned Preventive Maintenance;
- Routine Maintenance; and
- Scheduled Preventive Maintenance.

2.6.3

Decommissioning Phase

The design life of the power plant is estimated to be 25 years. If the Power Purchase Agreement, Land Lease Agreement, Gas Supply Agreement and the other relevant agreements are not extended or renewed and an alternative economical fuel is available, the power plant may be retrofitted to support alternative power generation. This option would be possible, provided the required retrofits and new emission rates meet the applicable standards and guidelines.

If retrofitting is not feasible and the operational life of the Power Plant expires, the Power Plant will be decommissioned according to the requirements of the authorities at that time according to best industry practices.

2.7 PROJECT ALTERNATIVES

IFC Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts) (“PS1”) and the ADB Safeguard Policy Statement requires an assessment process that identifies the risk and potential impacts associated with a project. Specifically, “the process may comprise a full scale environmental and social impact assessment, a limited or focused environmental assessment or straight forward application of environmental siting, pollution standards, design criteria or construction standards”. PS1 states that for greenfield developments or large expansions with specifically identified physical elements, aspects and facilities that are likely to generate potential environmental or social impacts, the client will conduct a comprehensive ESIA, including an examination of alternatives, where appropriate.

This section presents an overview of the alternatives considered as part of the ESIA study. The main design criteria, plant technology, configuration and Project type were determined by MOEP and the selected IPP will have to comply with MOEP requirements and are therefore beyond the remit of this ESIA study and are not included in this review.

However, the decision on the final Project location has been considered and therefore this section presents a summary of the anticipated environmental and social impacts associated with each option.

In addition, 3 cooling options were initially explored by the MOEP, comprising once through cooling, cooling towers and dry/air cooling technologies. These alternatives are discussed further below.

2.7.1 Project Need

Myanmar adopted political and economic reforms in 2011 which resulted in a significant growth in Myanmar’s gross domestic product (GDP) to 6.3% in 2012 compared with an average of 5% in the previous 5 years (Asian Development Bank, 2013). According to a 2012 Asian Development Bank (ADB) study, Myanmar could follow Asia’s fast growing economies and expand at 7% to 8% per year and Myanmar’s economic growth is forecast to rise gradually to 6.7% in 2014.

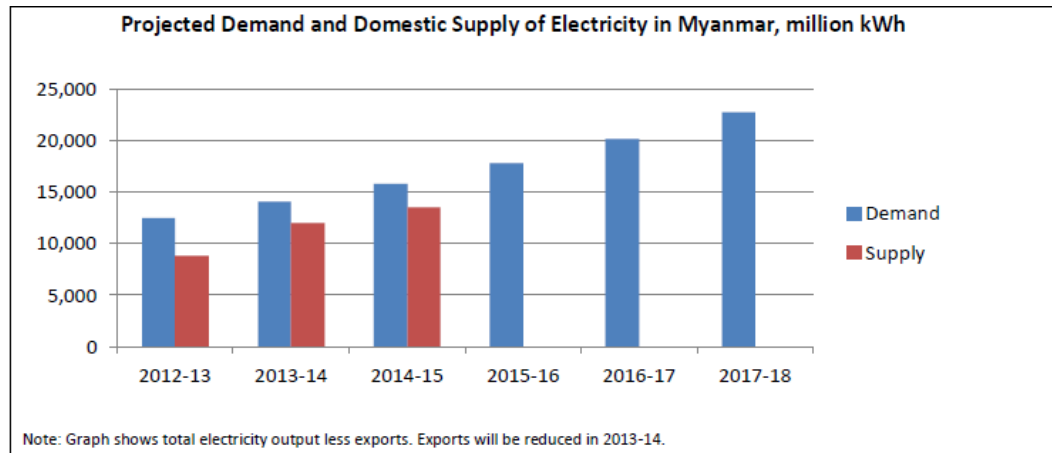
Parallel to the growth in GDP, electricity demand in Myanmar has increased dramatically. ADB released a report on Myanmar’s energy sector in October 2012 in which the future power demand was estimated to be doubling from 12,459 million kWh in 2012-2013 to 25,683 million kWh in 2018-2019 (ADB, 2012). Total system installed capacity in 2012 consists of 76.1% hydropower capacity, 20.5% gas-fired capacity, and 3.4% coal-fired capacity (ADB, 2013).

However, the actual power production in 2012 appears to be approximately 10,000 gigawatt-hours (GWh) with only 3,659 GWh available for domestic use (David Dapice,

2012). In 2012, total electricity consumption was 8,434 GWh. With a population of approximately 60 million, Myanmar per capita electricity consumption was only 140 kilowatt-hours (kWh) per year, which was the lowest among the 10 Association of Southeast Asian Nations (ASEAN) countries. The low national average per capita electricity consumption is due to the low electrification rate, low industrial development and lack of investment.

Figure 2.13 shows the estimated electricity demand and supply in Myanmar (ADB, 2012).

Figure 2.13 *Estimate of Electricity Demand and Supply in Myanmar, million kWh*



Source: David Dapice, 2012

There is a big medium-term problem with electricity supply in Myanmar. There will be only modest additions to hydroelectric capacity in the period from 2014 to 2019 and very little net new natural gas for domestic use will come on line.

Meanwhile, some hydro that is now exported may be switched to domestic use and some old gas-fired units will get more efficient new equipment and so be able to produce more electricity from the same amount of gas. However, these additions will fall short of new demand growth during 2014-2019. The more than 1,400MW of new gas units officially projected to be come on line in 2015-2016 will be forced to use, in part, LPG or even expensive liquid fuels if the official reports of limited additional supplies of natural gas for domestic use are correct. If world wholesale diesel or kerosene prices continue at their recently lower levels, the cost of electricity would be higher than current prices charged but much less than diesel electricity has cost in the past – over 400 kyat per kWh.

ADB (2012) estimated that demand in 2012 was 12.5 million kilowatt-hours, while supply available for consumption in that year was only 8.3 million kWh. In addition, a growing economy at this low development stage has a high growth of electricity relative to real output growth. The ADB growth cited from the MEP was 12.8% a year for electricity consumption. Therefore, even if supplies doubled every five to six years it would still not fully allow for closing the gap between demand and available supply that existed in 2012 or for increasing the coverage of households with grid connected power. Increasing thermal capacity to balance the dry season hydroelectric shortfalls would help to reduce blackouts.

Given that the new gas supply will become available from the Shwe Gas Supply pipeline, the proposed development of a combined cycle gas turbine power plant in Myingyan Township, Myanmar will contribute towards a power source for adding capacity required to cover the shortfall.

The 'No Project Scenario' is likely to have a negative effect on opportunities for employment, both directly from the Project and its dependent sectors such as agriculture, industries and manufacturing that require stable power supply in order to operate and be competitive.

2.7.2 *Alternatives of Different Power Generation Options*

Overview

Electricity generation may be achieved from renewable and non-renewable sources. Renewable sources include solar, wind, hydroelectric sources, and biomass while non-renewable sources include fossil fuels such as coal and natural gas. The following section describes the energy mix in Myanmar.

Hydroelectric

Myanmar has 20 grid-connected hydroelectric power plants; all operated by Hydropower Generation Enterprise (HPGE). Their installed capacity is 2,780MW accounts for 76.1% of national capacity. Off-grid supply from mini hydropower stations is provided by ESE and IPPs and contributes 33MW.

Table 2.13 shows the existing hydroelectric power plant in Myanmar (> 50MW).

Table 2.13 *Existing Hydroelectric Power Plant in Myanmar (> 50 MW)*

Station	Installed Capacity (MW)
Yeywa	790
Shweli-1	600
Paunglaung	280
Dapein-1	240
Baluchaung-2	168
Thauk-ye-khat	120
Mone	75
Shwegyin	75
Kyee on Kyee wa	74
Kun	60
Kinda	56
Keng Taung	54
All Others	188
Total	2,780

Source: Vikas Sharma, 2013

During the wet season (June-September), the power plants are able to generate at optimum capacity. However, in the dry season, insufficient water storage leads to production drops that necessitate significant load-shedding.

The exploitation of hydroelectric sites has been a top-down affair with little consultation with local communities. This is changing and affected communities,

especially in ethnic areas, now expect and should get a role in planning or even investing in their projects. Because this is tied into the peace negotiations, this participation often slows down the pace of investment. For example, an investor will often prefer a high dam as this has a better rate of return, but a high dam will displace more area and people with its reservoir. It is also more of a risk downstream if the dam fails. Local groups often prefer dams of medium height or even run of the river dams that do not store large amounts of water.

In addition, hydrology studies (how much water flows through the proposed dam site – not just on average, but maximum and minimum flows over many years) and environmental assessments can take several years. This is required to ensure that the maximum flow of the dam is not underestimated. This could lead to large releases of water and poor management of the reservoir level. These assessments can take 3 to 5 years to complete. Even then, the influence of water pressure on rock formations causing earthquakes in the region or of downstream sediment deposition may not be fully understood.

Once the design and studies and assessments are completed, large dams can take 5 to 10 years to come online. While hydroelectricity is a low cost source of power with no ongoing carbon or particulate emissions, it is not costless and without risks.

There are significant amounts of potential hydroelectric capacity and some estimates exceed 40,000MW. This is ten times the current capacity of Myanmar from all sources. Alternatively, if demand needs to double every six years for eighteen years, the capacity in 2032 would need to be 32,000MW. This suggests a significant amount and is above the high estimate of the MEP, however it would amount to approximately 2,000kWh per capita, less than the current Thai usage and equal Vietnam’s per capita generation in a few years. Given the long lags in building these dams, it is important to negotiate the ability to purchase significant amounts of power for domestic use, even from dams invested with foreign capital and initially destined for export.

Currently, the MEP is developing 20 hydroelectric power projects, 14 of which involve investments from China and Japan. The MEP also estimates the hydroelectric power plant projects to be completed during 2013-2016 with the total installed capacity of 472MW as shown in **Table 2.14**.

Table 2.14 *Expected Hydroelectric Power Plant Projects to be completed during 2013-2016*

Station	Installed Capacity (MW)
Thaukyekhat-2	120
Phyu	40
Namcho	40
Upper Paunglaung	140
Baluchaung No.3	52
Kyaukphyu	50
Upper Baluchaung	30
Total	472

Source: MEPE, 2013.

Gas-fired

Myanmar has 10 gas-fired power plants; all operated by Myanmar Electric Power Enterprise (MEPE). Their installed capacities of 996MW account for 20.5% of national grid capacity. Ahlone is the biggest plant with a capacity of 275MW. These plants use gas produced in the offshore fields of Yadana and Yetagun, and onshore fields operated by the Ministry of Energy. The output from these plants has been below expectations owing to low calorific value of local gas (high Nitrogen content) and low pressure without compression.

Table 2.15 shows the existing gas-fired power plants in Myanmar.

Table 2.15 *Existing Gas-fired Power Plants in Myanmar*

Station	Installed Capacity (MW)
Kyungchaung	54.3
Mann	36.9
Shwedaung	55.3
Mawlamyaing	12.0
Myanaung	34.7
Hilawga	208.7
Ywama	122.3
Ahlone	275.2
Thaketa	145.6
Thaton	51.0
Total	996

Source: Vikas Sharma, 2013

The gas-fired power plants in Myanmar use both liquefied petroleum gas (LPG) and liquefied natural gas (LNG) as fuels, however, the differences between LPG and LNG are not always clear. LPG is propane or butane gas under slight pressure which turns into a liquid at normal temperatures. It is often used for household cooking and delivered in small cylinders, but can be used in place of natural gas in many generators. It currently sells for 15 to 16 USD per million BTU (import price) and can be delivered in small ships of 10-30 thousand tons. It does not require elaborate or costly ports or handling equipment. LPG is a plausible transition fuel for gas-fired generators that will be commissioned in 2015-2018 but not able to use domestic natural gas until a few years later when extra domestic gas supplies should become available. LPG is also cheaper than kerosene or diesel alternatives.

LNG is super-cold natural gas which has turned into a liquid. It is typically delivered in specialized ships which are essentially floating thermos bottles, specially designed to handle the very cold liquid. Recently, most LNG tankers have been very large – up to 12 meters (39 feet) in draft and require costly specialised storage facilities on shore, which take several years to build. Due to the cost of the ships and the onshore facilities that need to be repaid over an extended period, most LNG contracts are for many years, usually at least twenty. If Myanmar will produce more domestic natural gas for its own use starting in 2020, the cost of domestic natural gas would be less than that of LNG. This would make the large onshore investment in equipment unattractive. Besides this, there are not deep water ports capable of handling large LNG ships close to population centers where electricity is needed.

However, MEP intends to focus on gas-fired power plant to reduce reliance on hydroelectric power plant projects. In its official five-year-plan, MEP has set an ambitious target to increase capacity to 2,500MW capacity by 2015-2016. One key upcoming development is a 500 MW plant set for completion by the end of 2014. It will supply power to Thilawa Special Economic Zone (SEZ) that is jointly developed by Myanmar and Japan. In addition, the World Bank lent 140 million USD in September 2013 to upgrade and add 125MW capacity to Thaton station. The MEP estimates the gas-fired power plant projects to be completed during 2013 to 2016 with a total installed capacity of 1,720MW as shown in **Table 2.16**.

Table 2.16 *Expected Gas-fired Power Plant Projects to be completed during 2013 to 2016*

Station	Installed Capacity (MW)
Hlawga (Zeya Co., Ltd.)	50
Ywama (MyanShwePyay Co., Ltd.)	50
Thaketa (CIC Co., Ltd.)	50
Ahlone (Toyo Thai Co., Ltd.)	100
Ywama (Transferred from Thailand)	240
Thaketa (BKB Co., Ltd. Korea)	500
Hlawga (Hydrolancang Co., Ltd. China)	530
Mawlamyaing (Myanmar Lighting Co., Ltd.)	50
Kyunchaung (Extension)	70
Shwedaung (Extension)	80
Total	1,720

Source: MEP, 2013.

Coal-fired

Currently, Myanmar has one coal-fired power plant named Tigyt with an installed capacity of 120MW. Efficiency of the power plant is low, generating power at an average capacity factor of approximately 30%.

There has been public skepticism concerning new coal generating plants. Historically, coal-fired power plants in the emitted significant amounts of soot and sulfur. Sulfur led to acid rain downwind. In addition, certain specifications of coal are also high in mercury, a toxic metal that can pollute watercourses. However, technology has evolved considerably and new coal-fired power plants can be designed to use low-sulfur coal and catch almost all of the ash particles generated from burning. Processing of coal before burning can also remove over half of the mercury.

A single coal unit has a usual capacity of 400 to 600MW and most coal stations have at least two units. A typical station has a capacity of 1,000MW (1 million kilowatts) and operates for 6,000 hours a year, producing six billion kWh a year. Since a ton of good steam coal produces approximately 3,000kWh, the annual coal consumption of one station is in the order of two million tons a year or 5-6 thousand tons a day. If the coal is of lower thermal quality, even larger amounts must be used. Handling such large amounts of coal requires ocean transport on large ships that need deep channels and ports with specialised unloading facilities. These are major investments and there is the potential for significant impact on the area in which they operate.

MEPE aims to add 300MW capacity by 2015-2016. In a key development, World Bank sanctioned a 165 million USD loan in early 2013 to develop coal-fired power plants.

It should be noted that coal-fired plants in general have higher CO₂ emissions compared to gas turbines. Gas turbines have relatively low CO₂ compared with other fossil fuel energy generation technologies. The Project has employed a CCGT technology which was designed for high reliability and efficiency operation with lower environmental impact. CCGT plant offer half as much CO₂ per kWh compared to other power generation technology. Natural gas provides more efficiency than coal because of higher operating temperatures, and when used together with the more efficient combined-cycle results in even higher efficiencies (IEA, 2006)¹.

Non-hydro Renewable Sources

Using non-hydro renewable sources for power generation is still in its infancy in Myanmar and constitutes a small percentage of total installed capacity and generation. While Myanmar is rich in renewable resources, the development remains severely limited by availability of funds to support the research and development, lack of a clear renewable energy policy and lack of talented manpower.

The following provides a brief summary of the limited publically available information concerning non-hydro renewable projects in Myanmar.

Biomass

There are 174MW of biogas power projects in operation.

Geothermal

Approximately 90 geothermal locations have been identified to date. Of these, 43 are being tested by the MEP along with Electrical Power Development Company of Japan, as well as Union Oil Company of California.

Wind Energy

Wind power projects are either in experimental phase or undergoing feasibility studies. There are some very small operational projects off the grid (Dattaw Mountain in Kyauske, and Government Technical High School in Ahmar, Ayeyarwaddy). Gunkul Engineering Public Company Limited and China Three Gorges Corporation, both foreign, signed a MOU with the MEP in 2011 to conduct feasibility studies for the development of 4,032MW of wind energy in Myanmar.

Solar Energy

Some pilot PV cell projects financed by the MEP and university research departments are underway in rural areas; being used to charge batteries and pump water for irrigation. Another example is the installation of 3KW PV systems in remote schools by Mandalay Technological University. Overall, however, at current costs, solar energy is unaffordable.

¹ IEA, 2006a: Energy Technology Perspectives 2006: Scenarios and strategies to 2050. International Energy Agency, Paris, 484 pp.

Three (3) power plant locations were considered by MOEP; location 1 – adjacent to the steel mill in Taung Thar Township (preferred location); location 2 – Thi Gon Site and location 3 – Taung Thar Site. The three (3) locations are shown in **Figure 2.14**.

Location 1 (adjacent to the steel mill in Taung Thar Township)

The preferred site is located adjacent to the existing steel mill on a plot of MOI-owned land which is approximately 27 hectares in size. An electricity sub-station is currently being constructed on the steel mill site to accommodate the capacity expansion of the steel mill and the Project. The 230 kV bay in use at present by the transmission line from ThPyWa, will be made available for the Project once the existing 230kV transmission line termination is relocated to one of the new bays under construction. River water is currently being abstracted for the steel mill by tube wells, expected to increase from 4 to 12 tube wells to accommodate the expansion of the steel mill (currently under construction). This site would require abstraction of freshwater from the Ayeyarwady River for cooling water system. It is also noted that there is currently no municipal sewage discharge connection to the steel mill site, and septic tanks are used instead.

The construction of the connecting gas pipeline from the interconnection point to the Project is in progress, with completion expected in 2015. Exact details of the gas reception area are not yet available and it is not yet confirmed whether the gas pipeline will access the receiving station from the east or west of the site.

There are at least 5 villages within 5km of the steel mill and Project site. The nearest villages are:

- Sa Ka Village 0.7km to the north;
- Hnan Ywa village 1.7km to the south east;
- Pet Taw village 3.7km to the south;
- Nyaung Gan village 3.8km to the south west; and
- Gyo bin village 3.2km to the north west.

Note that each village has its own pagoda. There is also a pagoda complex (i.e. shrines, courtyards and garden) located approximately 2km to the north. Some of these villages are considered as sensitive receivers for potential air and noise impacts.

A key reason for selecting Location 1 as the preferred site is that the site is located adjacent to the steel mill, which is already in operation, and therefore the proposed Project is in keeping with the existing industrial use. This would minimise the significance of the potential visual and aesthetic impact of the development of the Project. The infrastructure is also in place, or in the process of being installed, at this site and thus has advantages in relation to land availability, gas supply pipeline and connection to the national grid. The availability of cooling water is also an important factor, with the site at Location 1 being the closest of the three sites to the Ayeyarwady River. However, a disadvantage of the site being in close proximity to the steel mill is the potential for cumulative air quality and noise impacts on the existing Air and Noise Sensitive Receivers (ASRs and NSRs). It is also located quite far

(about 10km) away from cooling water source from the Ayeyarwady River, meaning construction of long pipelines are required for cooling water intake.

Location 2 (Thi Gon Site)

Location 2 is located approximately 5km south west of the preferred site at Location 1 (i.e. the steel mill site). GOM owns 8 hectares of land at this location, but this is not considered to be sufficient for the CCPP Project (which requires a minimum of 16 hectares). The connecting gas pipeline would need to be extended from the steel mill gas reception area for a further 5 km; however, at this early stage, the RoW for the gas pipeline is not considered to pose a constraint (although there would be additional costs in extending the gas connecting pipeline to the electricity substation).

The discussions have not been held with the Ministry of Gas (MOG) who would be responsible for the construction of the gas pipeline extension. Initial findings indicated that an electrical connection to the 230kV system is possible, but an additional 230kV substation would be required, in addition to the 5 km transmission line, to be constructed by the IPP developer.

Cooling water could also be extracted from the Ayeyarwady River, but the RoW from the river to the Project site would be considered a constraint as the RoW would traverse agricultural land (which could involve multiple owners) to connect to this location. Hence, this location would have additional land acquisition consideration. For once through cooling, the water pipelines are expected to be approximately 1.5m in diameter and the land for the RoW corridor would be sizeable (8-10m in width).

There are at least 8 village settlements within a 5km radius of the site at Location 2. Those closest would be considered as sensitive receivers for potential air quality and noise impacts. The nearest villages adjacent to Location 2 are Ta Pin Kan Ywar (0.3 km from Location 2) and Ta Pin Kan (South) within 1.1km of Location 2.

Location 3 – Taung Thar Site

The site at Location 3 is located on the opposite side of the road to the Taung Tha gas offtake station. The site is currently vacant and is bound by the railway line to the north west. A 230kV electrical interconnection would be available within 6.5km, but a new 230kV interconnection sub-station would need to be constructed by the IPP developer as well as the additional 6.5km transmission line. At the time of undertaking this ESIA study, there was no information available on the size of the land available at Location 3.

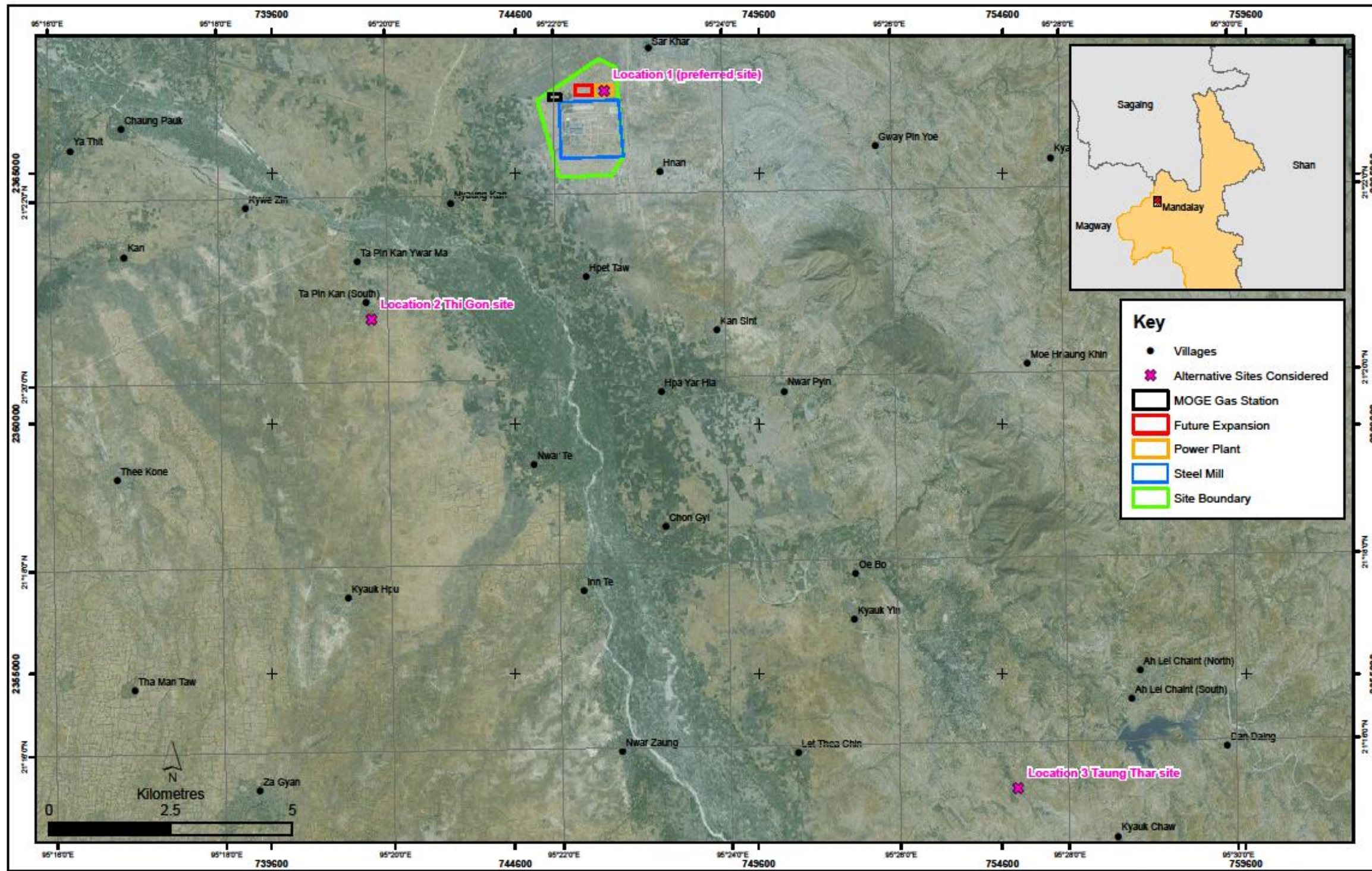
Given the inland location and distance from the Ayeyarwady River, the use of cooling water (i.e. cooling towers) is not considered feasible at this site.

There are at least 10 villages located within 5km of the site at Location 3, with the town of Taung Thar being the closest.

Location 3 is advantageous as the site is located directly opposite the Taung Thar gas offtake point; however, there is no information available at present regarding the availability of connection points. There is no water available within vicinity of the site

and so the plant would need to be air cooled, which has an associated penalty on the plant heat rate through decreased efficiency as well as potential visual and aesthetic impacts.

Figure 2.14 Alternatives of the Project Location



Source: ERM, 2015

2.7.4

Alternatives of Configuration on Site

As Location 1 is the preferred site for the Project, the following discussion refers to the options being considered regarding the plant configuration at Location 1.

MOGE has indicated that the new gas receiving station would be constructed adjacent to the existing one within the existing steel mill site and therefore no additional land take is required. The connecting Taung Thar gas offtake line may connect to the gas receiving station either from the west.

Sembcorp as the selected IPP developer will connect the power plant to the existing electricity substation within the steel mill site only.

Two (2) routes were considered for overhead transmission, either directly through the steel mill or adjacent to the Project Site in the steel mill complex. The route running alongside the Project Site is preferred as this would avoid the need to pass through the scrap yard. No additional land to be acquired and therefore there are no additional land acquisition issues to be considered.

2.7.5

Alternatives of Technological Options

The power plant technology was determined as part of the competitive tender process, by MOEP. However, the cooling mechanism for the Project; with open loop cooling water intake, closed loop with cooling towers and dry/air cooled condenser options are considered by the IPP developer. The main considerations for these options are outlined below.

Open Loop / Once Through Cooling

This system will take water from the Ayeyarwady River, circulate it through the pipes to absorb heat from the steam in the condensers and then discharge the water back to the river. This option is considered fairly simple and low cost to maintain, however it also requires a large reliable source of withdrawal water, which in turn can have potential water availability impacts on the river ecology and downstream river users (e.g. for irrigation and domestic users). It has been estimated that for once through cooling, a flow of approximately 4.5m³/s would be required and that this would be piped to the Project through pipelines, assumed to be subsurface, 1.5m in diameter.

The total RoW corridor would be between 8 to 10m in width to allow for maintenance access. Initial designs indicate that the RoW for the cooling water pipe would run alongside the existing irrigation canal, although this may pose issues in some locations regarding land rights/availability. There will also be pipeline crossings across the irrigation canal which would need to be considered for construction activities and long term stability of the pipeline.

Due to capacity limitations, the existing pumping station, maintained by the MOAI would not be suitable for the Project and new infrastructure would need to be developed or the existing pumping station upgraded to support the Project. Should piling or dredging works be required, this has the potential to impact on existing water quality and the freshwater ecology.

In addition to water availability, once through cooling can have significant negative impacts on the aquatic ecosystem and river users caused by the discharge of water which has absorbed the excess heat from the power plant. The continuous discharge creates a thermal plume, which gradually mixes with the river water.

Closed Loop System

The closed loop system uses cooling towers to expose water to ambient air to cool the water. As some of the water would evaporate, make-up water would be taken from the Ayeyarwady River to replace the evaporated water. These systems have lower water withdrawal requirements than once through systems. Water pipeline would also be required to supply water to the Project Site; however, these would likely be narrow in diameter (less than 30cm) and can be buried. Therefore, the RoW corridor will be narrower in comparison to the once through cooling system RoW.

The closed loop system has been selected for this Project.

Dry/ Air Cooling

The dry/air cooling system uses ambient air to cool the steam instead of water and thus the water withdrawal requirements are negligible on comparison with open loop and closed loop systems. There is an associated penalty on the plant heat rate through decreased efficiency and this will be an important consideration for the Project given the high ambient air temperatures experienced in the Mandalay region.

2.7.6

Alternatives of Temporary Landing for Heavy Cargo

The following temporary landing locations for heavy cargo were surveyed during the initial pre-development stage.

- Semeikhon Port at Mandalay Myotha Industrial Park (MMIP);
- Let Htode at the Ayeyarwady River; and
- Nyaung Hla at the Ayeyarwady River.

Semeikhon Port

The survey determined that the slipway jetty at Semeikhon Port is not suitable for roll off operation as the water level is too low and the slope level is very steep. The road conditions from the MMIP gate to the Project site is in good condition, however there is a suspension bridge that is not passable. There is no alternative road to avoid the suspension bridge.

Let Hrode Riverbank

The ground conditions at the Let Hrode Riverbank are considered suitable for heavy cargo. There is a steep slope at this location which would require levelling. This location is also accessible to the public.

Nyaung Hla Riverbank

The ground conditions at the Nyaung Hla Riverbank would require reinforcement. There is no steep slope onsite and the landing location is owned by a private company. Following reinforcement of the ground conditions the Nyaung Hla Riverbank is considered as the appropriate location.