Total Generation

The total Equivalent Operating Hours ("EOH") for each unit at TG since commercial operation are as below:

Generator	Total EOH up to 27th Feb 2023
GT1	170,799
GT2	171,078
ST	170,939

Total Starts

The total starts for each gas turbine at TG since commercial operation are as below:

Generator	Total Starts up to 27th Feb 2023
GT1	1,712
GT2	1,429
ST	196

Major Equipment

1.1 GAS TURBINE

The gas turbines are Siemens SGT5-4000F / V94.3A(2) units manufactured by Siemens, each having a nominal net site rating of approximately 230 MW. They are of the dual-fuel type (natural gas or distillate).

Type	Siemens SGT5-4000F / V94.3A(2)
Serial Number	800409 / 800411
Number of GT	2
Fuel	Gas / Liquid Fuel
Nominal continuous site rating	230 MW
Operating speed	3000 rpm
Number of compressor stages	15
Number of turbine stages	4
Compressor site pressure ratio	18:1
Gas turbine site exhaust temperature	601 °C
Type of combustion	Annular
Number of burners	24
Min. Natural gas pressure	23.3 bar
Liquid fuel type	Distillate
Starting system	SFC

- **Starting Equipment**

  The Gas turbine requires assistances to accelerate the gas turbine set up to its operating speed, as it can only generate the required torque once it has reached 50% of its rated speed. The generator is supplied from the starting frequency converter (SFC) during the initial starting phase and is operated as a closed-loop frequency controlled synchronous motor. The converter is shutdown as approx. 70% of the rated speed and the machine set accelerated by the turbine alone.

- **Turning Gear**

  The shaft turning gear is located within the compressor bearing housing. It comprises a hydraulic motor which is connected to a drive pinion. The drive pinion is permanently meshed with a swing pinion. Lifting oil is supplied to the hydraulic motor and the meshing gear to operate the turning gear.

- **Lubricating Oil System**

The lubricating requirement for the gas turbine power plant are furnished by a forced-feed lubrication system.

Major system components include:

- ✓ One Lube oil tank
- ✓ Two Main lube oil pump (AC driven)
- ✓ One emergency lube oil pump (DC driven)
- ✓ One Lifting oil pump
- ✓ Lube oil coolers (3 x 50%)
- ✓ Lube oil duplex filters
- ✓ Two oil vapor extraction fans

Lubrication oil cooling is achieved through a water cooling loop driven by 2 x 100% water pumps through an external water to air-fin fan-type cooler.

- **Air Intake System**

Inlet air filtration is achieved using 2-stage air filters (pre-filter and fine filter). The first stage uses M6- rated pre-filters and the second stage uses E11-rated fine filters.

- **Exhaust System**

Exhaust gas from each gas turbine can either be discharged through a bypass stack with diverter damper in closed position for open cycle operating mode or in opened position through the HRSG stack for combined cycle operating mode.

- **Gas Turbine Generators**

The gas turbine generators are air-cooled types TLR1 115/52. Each generator has a rated output of 303MVA and generator terminal voltage of 15.75 kV.

Technology	SIEMENS
Generator Type	TLRI 115/52 3 ~ YY
Year of Manufacture	2001
Rated Apparent Power	303.00 MVA
Rated Active Power	233.31MW
Rated Current	11,107A
Rated Voltage	15.75kV±5%
Speed	$50s^{-1}$
Frequency	50Hz
Power Factor	0.77
Inner Connection of Stator Winding	YY/48
Rated field current for rated output	1396A
Rated field Voltage	432V
Reference standards	IEC 34 / VDE 0530
Windings insulation Class	F
Excitation system type	Static Exciter
Cooling	Air Cooled

The generators are connected to the 15.75/275 kV transformers by insulated and pressurized bus bars via generator circuit breakers. Synchronizing of the generator output to the Grid System is via these generator circuit breakers.

The two-pole generator uses direct air cooling for the rotor and indirect air cooling for the stator winding. The cooling air is circulated in the generator interior in a closed circuit by two fans and recooled in single cooler sections arranges on the side of the generator.

The Stator is manufactured as a two-part structure; the horizontally split outer housing and the stator core and winding assembly. The outer housing is welded construction and the stator core and winding assembly is manufactured using the global-VPI process. The stator core is stacked with insulated electrical sheet steel laminations with a low loss index and flexibly supported in the lower half outer housing by means of insulated guide bars and rings.

The rotor shaft is a single –piece solid forging manufactured from vacuum casting. Slots for insertion of the field winding are milled into rotor body. The longitudinal slots are distributed over the circumference so that two solid poles are obtained. The rotor winding consists of silver-alloyrd copper ensuring an increased thermal stability. The centrifugal forces of the rotor end windings are contained by single-piece rotor retaining rings are made of non-magnetic high strength steel.

The field current is supplied to the rotating rotor through carbon brushes and two steel sliprings arranged at the exciter end shaft end. The electrical connections between the sliprings and the rotor winding established by means of radial bolts and insulated semicircular conductors located arranged in the hollow bore of the rotor at the exciter end.

The air cooler is a shell and tube type heat exchanger which cools the air in the generator. The heat removed from the air is dissipated through the cooling water. The cooling water flows through the tubes, while the air is passed around the finned tubes. The cooler installed at the side of the generator stator frame housing and serves to direct the cooling air and the seal the ventilation system from the atmosphere. The cooler sections are parallel-connected on their water sides with equal flow to ensure an uniform cooling water supply to the cooler section.

The generator pedestal bearings with is support the generator rotor are provided with hydraulic shaft lift oil during startup and turning gear operation. All bearing insulated to eliminate shaft current. Thermocouples is embedded in the lower bearing sleeve to monitor bearing temperature.

- **Gas Turbine Generator Exciter**

The static exciter system is completely designed by SIEMENS. The Generator excitation system consists of a static generator excitation unit (SEE) and a starting frequency converter (SFC). The Gas turbine requires assistances to accelerate the gas turbine set up to its operating speed, as it can only generate the required torque once it has reached 50% of its rated speed. The generator is supplied from the starting converter during the initial starting phase and is operated as a closed-loop frequency controlled synchronous motor. The converter is shutdown as approx. 70% of the rated speed and the machine set accelerated by the turbine alone .

Technology	SIEMENS AG
Excitation Type	730/BAUS
Year of Manufacture	2017
Rated Field Voltage	468 Vdc
Max Field Current	1516 Adc
Ceiling Voltage	842 Vdc
Ceiling Current	2274 Adc
Incoming AC Voltage	415Vac
Frequency	50Hz
Voltage Transformer	15.75kV/110V
Current Transformer	13kA/1A
Number of AVR Channel	2

- **Gas Turbine Static Frequency Converter**

Static Frequency Converter	SIEMENS AG
SFC Type	4MW
Year of Manufacture	2017
Input Power	5100kVA
Rated Input Voltage	2.5kV
DC Link Current	1430 Adc
DC Link Voltage	2830 Vdc

- **Gas Turbine Generator Transformer**

Generator voltage is step-up from 15.75 kV to 275 kV via generator transformers and injected directly into the 275 kV busbars through circuit breakers.

The generator transformers shall be rated 160/305 MVA at ONAN/ODAF cooling type with on-load Tap changer having a tapping range of ± 12.6%.

Nominal ratio: 280kV/15.75 kV

Nominal rating	305 MVA
Number of Tx	2
Year of Manufacture	2001
Type	Oil – Nynas 10BN
Cooling Method	ONAN/ODAF
Vector group	YNd1
Rated Frequency	50Hz
Rated High Voltage (HV}	275 kV
Low Voltage (LV)	15 kV
On load tap Changer	MR R111 1200 Y-123/C10 191W
Rated Current OLTC	1200A
No Tap changer position	19

- **Unit and Station Electrical Auxiliary Supplies**

The power station unit and station auxiliary supplies is derived from two unit transformers connected to the generator 15.75 kV busbars of two gas turbine/generator units.

Two 20 MVA unit transformers are provided to step-down the generator terminal voltage to 6.6 kV to feed two 6.6 kV unit board (GT1 & GT2)

Nominal rating	20MVA
Number of Tx	2
Type	Oil
Cooling method	ONAN
High Voltage (HV)	15.75 kV
Low Voltage (LV)	6.6 kV
Off load tap Changer	ASPELEC
No Tap changer (off-load)	5
Service (Vector group)	Yynod11

Four 1750 MVA unit auxiliary transformers are provided to step-down 6.6 kV Unit Board voltage to 415 V to feed the 415 V Unit Auxiliary Boards for Gas turbine and steam turbine auxiliary power supply.

Nominal rating	1750 kVA
Number	4
Type	Dry
Cooling method	AN
High Voltage (HV)	6.6kV
Low Voltage (LV)	415V
Rated current (HV)	153.1A
Rated Current (LV)	2323A
No Tap changer (off-load)	5
Service (Vector group)	Dyn11

Three Excitation transformer are provided for each generator respectively to step down from the 6.6 kV Station Board to feed the Excitation power supply.

- Steam Turbine Excitation Transformer

Nominal rating	2530kVA
Number	1
Type	Dry -
Cooling method	AN
High Voltage (HV)	6.6 kV
Low Voltage (LV}	570V
Rated current (HV)	221A
Rated Current (LV)	2583A
Tap changer (off-load)	5
Service (Vector group)	Dy11

- Gas Turbine Excitation Transformer

Nominal rating	1650kVA
Number	2
Type	Dry
Cooling method	AN
High Voltage (HV)	6.6 kV
Low Voltage (LV}	730V
Rated current (HV)	144.3A
Rated Current (LV)	1305A
Tap changer (off-load)	5
Service (Vector group)	Dy11

Two Static Frequency Converter transformer are provided for each gas turbine generator respectively to step down from the 6.6 kV Station Board to feed the Static Frequency Converter Equipment.

Nominal rating	2570kVA
Number	2
Type	Dry
Cooling method	AN
High Voltage (HV)	6.6 kV
Low Voltage (LV}	2500V
Rated current (HV)	225A
Rated Current (LV)	594A
Tap changer (off-load)	5
Service (Vector group)	Dy11

An essential diesel generator of 900kVA capacity is provided and connected to the 415 V Station Auxiliary Board to feed the essential loads during shutdown. Interconnections are also provided between the 415 V Unit Auxiliary Boards and the 415 V Station Auxiliary Board.

- **GT Generator Circuit Breaker**

Maker	ABB
Type	HEC3
Serial Number	(GT1)- HA 1293-10 & (GT2) – HA1292-10
Year Of Manufacture	2001
Rated Maximum Voltage	25.3 kV
Rated Continuous Current	12 kA
Frequency	50 Hz
Rated Short-Circuit Current	100kA
Rated Operation SF6 pressure @20degC	620 kPa abs

- **Isolated Phase Bus (IPB) Duct**

The generator shall be connected to the 15.75/275kV transformers by insulated and pressurized busbars via generator circuit breakers. The specification of the IPB are as follow:

Make	Siemens
Type	3EK7240-4CL41-OB
Max Cont Operating Voltage	16.54kV
Rated Voltage	19.2kV
Rated frequency	50Hz
Nominal Discharge Current	10kA
High Current impulse	100kA
Short Circuit Current	20kA

- **Switchgears**

MV Switchgear

GT & ST	
Make	Natus
Rated Voltage	7.2kV
Operating Voltage	6.6kV
Frequency	50Hz
Rated Short time current	31.5kA/1s
Rated pulse Current	80kA
Rated Current	2500A
Type	NES (-H)

LV Switchgear

GT & ST	
Make	Siemens
Model/Type	SIVACON
Rated Voltage	3/PE/N 50Hz 415V
Control Voltage	DC 220V; DC24V

- **D.C and UPS Supply System**

Inverter 220VDC/240AC	
Manufacture	AEG SVS Power Supply System
Rating	20kVA
Serial Number	70050354/001 & 002

220V Battery Charger – Unit 00BTL10 & 10BTL10	
Manufacture	AEG SVS Power Supply System
Rating	71.8kVA
Battery Type	108 cell
Rating	220V/100A

220V Battery Charger – Unit11BTL10/12BTL10	
Manufacture	AEG SVS Power Supply System
Rating	54.6kVA
Battery Type	108 cell
Rating	220V/76A

- **Grounding and Lightning Protection**

The conventional type of lightning arrestor system is installed at the top of the HRSG stacks, GT and ST hall and Plant Buildings. The grounding and earthing system was designed according to the European harmonization document HD 637 S1/1/. The calculated ground potential rise which is based on the specific soil resistivity measured is Ue-1.53kV. The design of the earthing conductor according to the electrical equipment installed such as Generator, Transformer, and switchyard equipment.

- **HV Motors**

Cooling Water Pump Motor 10PAC11 & 10PAC12	
Maker	Alstom
Rated Speed	426 RPM
Motor Type	AC Induction
Frequency	50 Hz
Rated Power	1723 kW
Rated Current	217 A
Rated Voltage	6600 V
Insulation	Class F

Boiler Feed Pump Motor 10LAC11,10LAC12 & 10LAC13	
Maker	Ansaldo
Rated Speed	2981 RPM
Motor Type	AC Induction
Frequency	50 Hz
Rated Power	2000 kW
Rated Current	201.2 A
Rated Voltage	6600 V
Insulation	Class H

Condensate Extraction Pump Motor 10LCB11,10LCB12 & 10LCB13	
Maker	Ansaldo
Rated Speed	2981 RPM
Motor Type	AC Induction
Frequency	50 Hz
Rated Power	420 kW
Rated Current	45.6 A
Rated Voltage	6600 V
Insulation	Class F

Deaerator Pump Motor 10LAC05	
Maker	ELIN EBG
Rated Speed	1489 RPM
Motor Type	AC Induction
Frequency	50 Hz
Rated Power	315 kW
Rated Current	35 A
Rated Voltage	6600 V
Insulation	Class F

- **275kV power cables**

There are 3 sets (GT1, GT2, ST) of 3 x 630mm2 stranded compacted plain annealed copper 275kV XLPE Lead Alloy sheathed (2.5 minimum average wall), helical copper screened (87 x 2.5mm) power cables of maximum length 700m connecting between the generator transformer and TNB 275kV switchyard.

- **Ancillary Plants**

Gas station is provided at the gas tie-in point with the gas receiving station installed by Petronas next to the Facility. Below the equipment at the gas station :

a. Gas Filtering station consists of three filters (3 x 50%)
b. Gas Reducing Station consists of two pressure regulator lines, slam shut off valves and safety valves (2 x 100%)
c. Gas Preheater consists of two fire tube water boiler (830 kW) – Logano SK 725 Buderus
d. Main Gas Compressor (1 x 100%). Details of main gas compressor as below.
e. Pilot Gas Compressor. Details of pilot gas compressor as below.
f. Fuel Gas Consumption Meter
g. Final Gas Filtering Skid
h. Air Compressor (Atlas Copco GA11CHAV)
i. N2 Production Station (INMATEC Type 1150/446)
j. Gas Cooler
k. Oil Cooler

Main Gas Compressor (complete with Lube oil system and cooler):

Manufacturer	Atlas Copco
Model	GT 032 T1D1
Type	One single stage geared turbo compressor
Auxiliary	1 hydraulic system with pumps
Quantity	1

Pilot Gas Compressor (Single stage screw compressor) (complete with Lube oil system and cooler);

Manufacturer	MAN Turbo
Type	CP100SK/A18
Turbine No.	One single stage screw compressor
Machine Number	270253, 270254
Auxiliary	1 hydraulic system with pumps

A compressor washing skid is provided for the washing of the compressor in case of fouling.

1.2 HEAT RECOVERY STEAM GENERATOR (HRSG)

The exhaust gas from each gas turbines is being used to produce steam through 2 units of HRSGs:

Manufacturer	Doosan Heavy Industries
Type	Horizontal gas flow with natural circulation
HP Section	HP Boiler Drum HP Economizer I HP Economizer II HP Evaporator HP Superheater HP Reheater
IP Section	IP Boiler Drum IP Economizer IP Evaporator IP Superheater
LP Section	LP Boiler Drum LP Superheater LP evaporator Condensate Preheater
HP working pressure	135.2 barg
IP working pressure	32 barg
LP working pressure	7.3 barg
Designed to	ASME Boiler & Pressure Vessel Code Section 1

1.3 STEAM TURBINE (ST)

The steam turbine is a Siemens two casing condensing turbine with reheat as per data below:

Manufacturer	Siemens
Type	K Series / SST5-5000
Turbine No.	10292/2
Nominal continuous site rating	260 MW
Operating speed	3000 rpm
Blade stages (Double flow)	HP Turbine : 22 stages IP Turbine : 15 stages LP Turbine : 6 stages
Steam Pressure	124.9 bar
Steam Temperature	565 °C
Exhaust steam pressure	0.069 bar

- **Steam Turbine Generator**

The steam turbine generators is hydrogen-cooled type THRI 108/44. The generator has a rated output of 343MVA and generator terminal voltage of 15.75kV.

Technology	SIEMENS
Generator Type	THRI 108/44 3 ~ YY
Year of Manufacture	2001
Rated Apparent Power	343.00 MVA
Rated Active Power	267.54MW
Rated Current	12,573A
Rated Voltage	15.75kV±5%
Speed	$50s^{-1}$
Frequency	50Hz
Power Factor	0.78
Inner Connection of Stator Winding	YY/54
Rated field current for rated output	2947A
Rated field Voltage	364V
Reference standards	IEC 34 / VDE 0530
Windings insulation Class	F
Excitation system type	Static Exciter
Cooling	Hydrogen Cooled

The generators are connected to the 15.75/275 kV transformers by insulated and pressurized bus bars. Synchronizing of the generator output to the Grid System is via 275kV HV circuit breaker at the 275kV switchyard.

The two-pole generator uses direct hydrogen cooling for the rotor and indirect air cooling for the stator winding. The hydrogen is circulated in the generator interior in a closed circuit by two axial-flow fans arranged on the rotor shaft journals. Cold gas is drawn by the fans from the cooler compartments.

The Stator is manufactured as a two-part structure; the horizontally split outer housing and the stator core and winding assembly. The outer housing is welded construction and the stator core and winding assembly is manufactured using the global-VPI process. The stator core is stacked with insulated electrical sheet steel laminations with a low loss index and flexibly supported in the lower half outer housing by means of insulated guide bars and rings.

The rotor shaft is a single –piece solid forging manufactured from vacuum casting. Slots for insertion of the field winding are milled into rotor body. The longitudinal slots are distributed over the circumference so that two solid poles are obtained. The rotor winding consists of silver-alloyrd copper ensuring an increased thermal stability. The centrifugal forces of the rotor end windings are contained by single-piece rotor retaining rings are made of non-magnetic high strength steel.

The field current is supplied to the rotating rotor through carbon brushes and two steel sliprings arranged at the exciter end shaft end. The electrical connections between the sliprings and the rotor winding established by means of radial bolts and insulated semicircular conductors located arranged in the hollow bore of the rotor at the exciter end.

The hydrogen cooler is shell and tube type heat exchanger which cools the hydrogen gas in the generator. The heat removed from the hydrogen is dissipated through the cooling water. The cooling water flows through the tubes, while the hydrogen is passed around the finned tubes.

The sleeve bearings are provided with hydraulic shaft lift oil during start-up and turning gear operation. To eliminate shaft currents, all bearings are insulated from the stator and base plate respectively. Both bearings of the generator are connected to the turbine lube oil supply for the lubrication

The shaft seals are supplied with seal oil from the seal oil system. The seal oil is drawn from the seal oil tank by the seal oil pump in service and passed to the shaft seals via coolers, filters and differential pressure regulating valve.

Steam Turbine Generator Exciter

The static exciter system is completely designed by SIEMENS. The Steam Turbine Generator excitation system design with Double bridge with "stand by" redundancy. The power line side converter with 6 thyristors in three-phase bridge configuration single bridges and up to 4 bridges parallel connected with semiconductor fuses. SEE equipped with bridge rectifier redundant fans. The open-loop and closed-loop control section installed 2 sub racks with SIMADYN D can be switched over with Auto/Manual operation and redundancy controller.

Technology	SIEMENS AG
Excitation Type	SEE 750/4000
Year of Manufacture	2002
Rated Field Voltage	750 Vdc
Max Field Current	3636 Adc
Ceiling Voltage	900 Vdc
Ceiling Current	4000 Adc
Type of Thyristor	BSt T66 166
Frequency	50Hz

- **ST Generator Transformer**

Generator voltage is step-up from 15.75 kV to 275 kV via generator transformers and injected directly into the 275 kV busbars through circuit breakers.

Nominal rating	345 MVA
Number of Tx	1
Year of Manufacture	2002
Type	Oil – Nynas 10BN
Cooling Method	ONAN/ODAF
Vector group	YNd1
Rated Frequency	50Hz
Rated High Voltage (HV}	275 kV
Low Voltage (LV)	15 kV
On load tap Changer	MR R111 1200 Y-123/C10191W
Rated Current OLTC	1200A
No Tap changer position	19

- **ST lube Oil System**

The ST lube oil system is used to supply lubricating oil to the steam turbine and generator bearings. This system consists of:

- ✓ Two AC Lube Oil pumps
- ✓ One Emergency DC Lube Oil Pump
- ✓ Two Lifting oil pumps
- ✓ One double change over filter with ball valve
- ✓ Duplex lifting oil filter
- ✓ Hydromatic turning gear motor.
- ✓ One lube oil reservoir tank
- ✓ Two vapor extractors
- ✓ One double plate heat exchanger

- **ST Generator Seal Oil System**

The seal oil system is used to supply pressurized oil to generator shaft seal to prevent hydrogen which is used for cooling escapes from the generator housing. This system consists of:

- ✓ Three seal oil pumps
- ✓ One vacuum pump
- ✓ One double change over filter
- ✓ One seal oil tank
- ✓ One double seal oil cooler
- ✓ One seal oil storage tank

1.4 BALANCE OF PLANT

- **Boiler Feedwater System**

To feed and control Demin water level in HP & IP boiler drums and provides injection water to HP & IP desuperheater, the following major components were used:

- ✓ 3 Boiler Feed Pumps
- ✓ HP Feedwater control valves on each HRSG with inlet and outlet manual valves
- ✓ IP Feedwater control valves on each HRSG with inlet and outlet manual valves
- ✓ Various instruments to monitor drum levels, temperature, and pressure.
- ✓ Inlet strainer for each pump
- ✓ ARCV for each pump (recirculation valve)

Boiler Feed Pump Motor Specifications

Maker	Flowserve
Model Number	6 x 14 WXH-9/8
Rated Speed	2985 RPM
Motor Type	AC Induction
Stages	9
Rated Power	1786 KW
Rated Voltage	6600 V

Each feed water pump has its own lubrication system with oil tank.

- **Circulating Water System**

Circulating water system supplies sea water as the cooling medium to the surface condenser to remove heat from the steam turbine condenser by means of the circulating water pumps. This system also provides the service cooling water with cooling water to remove heat from the closed cooling water heat exchanger. Sea water is also fed to electrochlorination systems by means of seawater feed pump. This system consists of:

- ✓ Two circulating water pumps
- ✓ Two wash water skid pumps
- ✓ Two drum screens
- ✓ Two seawater feed pumps
- ✓ Two debris filters
- ✓ Two ball collectors
- ✓ Two Butterfly valve (Pump outlet)
- ✓ One debris disposal pump

Circulating Water Pump Motor Specifications

Maker	Sulzer South Africa Ltd
Model Number	BSm 1150 – 1s/001
Rated Speed	426 RPM
Motor Voltage	6.6 kV
Shut off head	36m
Rated Power	1548 KW
Flow	26190 m3/h
Mass	15000kg

Debris Filter Specifications

Maker	E Beaudrey Cie
Model Number	WA type 1850
Diameter	DN 2000
Length	1800 mm
Weight	4 t

Drumscreen Specifications

Maker	Brackett Green
Model Number	2802/1
Type	Shaftless double entry drum
Washwater Pump	Ingersoll Dresser 65-40 CPX 125
Debris Disposal Pump	Vaughan Pump STV4P
Bar Screen	2 unit
Stop Gate	2 unit. Provided with lifting beam.

Ball Collector Specifications

Maker	E Beaudrey Cie
Model Number	B8011
Weight	6000 kg
Diameter	DN 2000

- **Electrochlorination system**

This system provides protection for the Circulating Water System against biological fouling and growth. A sodium hypochlorite solution is generated in seawater by electrolysis and is fed to the circulating water intake structure, circulating water drum screen inlet, and circulating water pumps discharge piping. This system consists of:

- ✓ Two 100% capacity seawater strainers
- ✓ Two 100% capacity seawater booster pumps
- ✓ Two 100% capacity sodium hypochlorite generators
- ✓ One open top hypochlorite degasifier tank
- ✓ Two 100% capacity hypochlorite injection pumps
- ✓ Three hypochlorite solution diffusers
- ✓ Two transformer/rectifier power supplies
- ✓ One cell wash system
- ✓ One control cabinet

- **Instrument Air System**

The Instrument Air System provides dry compressed air at the required pressure and capacity to various consumers. This system consists of the following major equipment:

- ✓ Two screw compressor type air compressor
- ✓ Refrigeration dryer
- ✓ Micro filters
- ✓ Two receivers
- ✓ Two dryers

- **Close Cycle Cooling Water System (CCCW)**

The close cycle cooling water system transfer heat rejected from various plant equipment heat exchangers to the Circulating Water System via closed cooling water heat exchangers. The system consists of the following:

- ✓ Two cooling water pumps (Apollo KRC-200/400-108/CN)
- ✓ One expansion tank
- ✓ Two Heat Exchangers (Alfa Laval, Model M20 – MFD)
- ✓ Interconnecting pipes, valves, and instrumentations.

- **Condenser Air Extraction System (PUE & MAJ)**

The condenser Air Extraction System removes non-condensable gases such as air, ammonia, and carbon dioxide from the condenser steam space during normal steam turbine operation. The system is also used to remove air from the condenser prior to the admission of steam during unit start-up. If allowed to remain in the condenser, the non-condensable gases will blanket the condenser tubes and decrease the heat transfer capability to the circulating water, raising steam turbine exhaust pressure and reducing efficiency. The MAJ system removes air from condenser to create vacuum. The system consists of vacuum pump, tank, check valve, heat exchanger, separator, and valves.

MAJ Pump Specifications

Maker	ELMO
Model	2BW4303-0BL4-Z
Medium	Vacuum
Quantity	2

PUE Pump Specifications

Maker	ELMO
Model	2BV5 121 – 0HH03 – 1S-Z
Quantity	2

- **Auxiliary Boiler**

The auxiliary boiler provides process steam to ST sealing system and deaerator system. This is a package boiler with its own ancillary equipment.

Ball Collector Specifications

Maker	Vickers Hoskins
Model	WB 700
Type	3 pass fire tube
Design Code	ASME Section 1 - 2001
Evaporation Rate	6000 kg/hr saturated steam
Fuel	Natural gas
Working pressure	7 bar

- **Service Water System**

The service water system designed to absorb heat from the closed cooling water system which cools individual components of the ST and the water steam cycle using the closed cooling water heat exchangers. The system consists of:

- ✓ Two service water pumps (Apollo KRC-250/315-999/CN)
- ✓ Interconnecting pipes, valves, and instrumentations.
- ✓ Small Debris Filter (E Beaudrey Cie, Model WE type DN 400)

- **Chemical Waste Drainage and Treatment System**

The chemical waste drainage and treatment system collects and treats all plant wastewater (which may be acidic, alkaline, or subject to contamination from other corrosive chemicals used in the plant. The wastewater is transferred to the neutralization tanks, treated on a batch basis, and discharged to the plant wastewater disposal system. The system consists of:

- ✓ Two neutralization tanks
- ✓ Two 100% capacity chemical waste pumps
- ✓ Two chemical waste sump pumps
- ✓ One neutralization tank blower
- ✓ Two electrochlorination are sum pumps.
- ✓ Two HRSG blowdown transfer pumps
- ✓ Two drains transfer pumps

- **Cycle Make-up and Storage System**

The cycle makeup and storage system receive and stores demineralized water and distributes it to various plant systems. This system consists of:

- ✓ One demineralized water storage tank
- ✓ One reserve feedwater tank
- ✓ Two demineralized water transfer pumps

- **Flue Gas Emission Monitoring**

The Facility is equipped with Continuous Emission Monitoring System (CEMS) for Unit GT1 and GT2 stacks.

- **Water Treatment Plant**

Water treatment plants are used to produce Demin water necessary for the steam production. There are 2 trains of water treatment plant with each consists of:

- ✓ One activated carbon vessel
- ✓ One anion bed exchanger vessel
- ✓ One cation bed exchanger vessel
- ✓ One mixed bed exchanger vessel

- **Fire Fighting System**

The firefighting and protection systems provided at the Facility (including the Interconnection Facilities) consist of the following:

- ✓ 4 pumps to supply water to fire hydrants around the station (1 jockey pump, 1 electric pump and 2 diesel engine driven pumps)
- ✓ Heat and smoke detectors for all rooms;
- ✓ Linear heat detection cable for cable trenches and main transformer bays;
- ✓ fixed C02 systems for indoor switchboard and instrument/electrical equipment rooms;
- ✓ fixed water spray systems for main transformer bays;
- ✓ fixed foam monitor system for the fuel tank farm;
- ✓ Sprinkler systems for the gas turbine hall, administration building and workshop;
- ✓ Portable fire extinguishers at all buildings; and
- ✓ Fire hydrants at suitable locations within the boundary of the Facility.
- ✓ Liquid CO2 tank for each Gas Turbine to flood GT compartment with CO2

- **Deaerator System**

The deaerator system function is to remove non condensable gases like CO2 and oxygen from the condensate during start up and normal operation of the plant if required by the conductivity of the condensate. It also heats up the cold condensate during oil firing of the GT. The system helps to reduce the start-up time to reach the required steam quality for the ST.

The system mainly consists of multi stage pump, a deaerator tank, automatic recirculation valve, valves, and piping.

Deareator Pump and ARCV Specifications

Pump Maker	Apollo
Pump Model	GPH – 200C/4 – 999/CN
Pump Type	High Pressure Centrifugal Pump
Pump Quantity	1
ARCV Maker	Schroedahl GmBH
ARCV Model	SUL155UV-CS / K01-0508.1
ARCV Quantity	1

- **HRSG Drain Systems & Condensate Circulating System**

Drain Pump Specifications

Drain Pump Maker	Apollo
Pump Model	KRC – 80/400-308/CN
Pump Number	1255566/10-1
Quantity	2

Condensate Circulating Pump Specifications

Drain Pump Maker	Apollo
Pump Model	KRH-125/250-308/CN
Quantity	2

1.5 CONTROL AND INSTRUMENTATION SYSTEM

The automation system for the plant is achieved by the Siemens Teleperm XP - control system. The system comprises of modular hardware and software which handles process control and instruments, engineering system , diagnostics, and plant automation system.

Overall supervision and control of the Facility is achieved through a Siemens proprietary network, the plant bus connected to all automation processors which located at site. All connections to the automation processors are dual linked, with redundant hardware for reliability.

Computerized equipment by Siemens-Fujitsu (HMI operator stations, data server, engineering station etc.) are linked with a dual Siemens industrial communication (known as terminal bus) running throughout the Facility and collecting information through all automation processors which are geographically distributed.

In the control room the operator shall have necessary means to supervise and control the Facility in normal operation, on start-up or on shutdown, and to master any abnormal operating condition by means of clear and immediate presentation of alarms and ready selective access to all processes displays he/she may require. There are also Alarm management systems embedded in the HMI including the high-resolution event loggers and process trends.

- **Control and Monitoring of the Facility**

The plant is controlled by a Siemens Teleperm XP Distributed Control System which interfaces with the Siemens V94.3A2 gas turbine and Steam turbine control systems and other proprietary control systems for sub-system equipment. The system has extensive control and protection interlocks to ensure safe operation of the plant, and these are subject to regular test and controlled operation.

- **Distributed Control System**

The control, protection and supervisory functions required for the central operation of the plant are implemented in an integrated control system in the form of a Teleperm XP –OM650 Distributed Control System. The TXP OM650 is specifically designed for power plant applications. The technology microprocessor is based utilizing proven hardware, firmware, and software. The architecture of the system shall allow for the control functions to be economically distributed within system modules of low functional content to satisfy the system design criteria.

Scheduled Maintenance History

Year	Maintenance Carried Out
2003	GT1 – Minor Inspection GT2 – Minor Inspection
2004	GT1 – Minor Inspection GT2 – Minor Inspection
2005	GT1 – Major Inspection GT2 – Major Inspection ST – Minor Inspection
2006	GT1 – Minor Inspection GT2 – Minor Inspection
2007	GT1 – Minor Inspection GT2 – Minor Inspection
2008	GT1 – Major Inspection GT2 – Major Inspection ST - Medium Inspection
2009	GT1 – Minor Inspection GT2 – Minor Inspection
2010	GT1 – Minor Inspection GT2 – Minor Inspection
2011	GT1 – Major Inspection GT2 – Major Inspection ST – Minor Inspection
2012	GT1 – Minor Inspection GT2 – Minor Inspection
2013	GT1 – Minor Inspection GT2 – Minor Inspection
2014	GT1 – Major Inspection/LTE GT2 – Major Inspection/LTE ST – LP turbine Major Inspection, HP turbine Medium Inspection
2015	GT1 – Minor Inspection GT2 – Minor Inspection
2016	GT1 – Minor Inspection GT2 – Minor Inspection
2017	GT1 – Major Inspection GT2 – Major Inspection ST – HP turbine Major Inspection
2018	GT1 – Minor Inspection GT2 – Minor Inspection
2019	GT1 – Minor Inspection GT2 – Minor Inspection
2020	GT1 – Minor Inspection GT2 – Minor Inspection
2021	GT1 – Major Inspection GT2 – Major Inspection ST –Minor Inspection

Major Plant Upgrades

No	Date of Modification	Description	Reason for Upgrade	Cost (RM)
1	29/12/2009	HIGH-PRESSURE GT COMPRESSOR CLEANING SYSTEM	GT compressor cleaning used for improvement of Daily online washing and periodically offline washing to increase the performance of GT compressor efficiency	1,437,948.33
2	24/11/2011	GT Power Upgrade	Upgrade CMF+ by Siemens. Gas Turbine Compressor Upgrade for power increased.	26,941,421.62
3	13/09/2014	GT HCO Upgrade	An efficiency improvement and power output increase achieved by shifting the GT rotor against the direction of the flow which reduces the clearances between the turbine blade and casing.	EUR 1,137,366.12 (parts) RM 36,589,243.49 (services price includes MO)
4	6/12/2017	ST Bearing Sprinkler Installation	To design and install sprinkler system for ST Bearings due to requirement from Insurance company.	216,862.00
5	23/04/2018	GT1 &GT1 SFC/SEE Control Upgrade to THYRIPOL SPPA-E3000	To upgrade SFC/SEE system due to the parts, equipment's and system obsolescence.	RM4,452,000.00