Design and Technical Specifications For Chilled Water Plant (with Option for an Integrated Power Plant) in Data Centre Park

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Dwg. No.	**Drawing Title**

ANNEX F: DESIGN AND TECHNICAL SPECIFICATIONS

2611239A-PLOT-S2-001	Layout of Chilled Water Plant (with Option for an Integrated Power Plant)
2611239A-PFD-S2-001	Flow Diagram of Chilled Water Plant (with Option for an Integrated Power Plant)
2611239A-SLD-S2-001	Key Single Line Diagrams (2 sheets)
P1203/CS/C601	Road Cross Section

ANNEX F: DESIGN AND TECHNICAL SPECIFICATIONS

Abbreviations:

A

AISI	:	American Iron & Steel Institute
AMSL	:	Above Mean Sea Level
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute or Application Programming Interface
ASME	:	American Society of Mechanical Engineers
ATC	:	Acceptance Test Code

B

BCA	:	Building & Construction Authority
BCC	:	Backup Control Centre
BoP	:	Balance of Plant
BS	:	British Standards

C

CAAS	:	Civil Aviation Authority of Singapore
C&I	:	Control and Instrumentation
CCR	:	Central Control Room
CCW	:	Closed Cooling Water
CEMS	:	Continuous Emission Monitoring System
CHWS	:	Chilled Water System
CoP	:	Coefficient of Performance
CTI	:	Cooling Tower Institute

D

DC	:	Data Center
DCMIS	:	Distributed Control Monitoring and Information System
DCP	:	Data Centre Park
DSTA	:	Defence Science and Technology Agency

E

EDB	:	Economic Development Board
EDG	:	Emergency Diesel Generator
EIA	:	Environment Impact Assessment
EMA	:	Energy Market Authority
EMC	:	Electromagnetic compatibility
EN	:	European Standard
ESD	:	Emergency Shutdown System
EWS	:	Engineering Work Station

F

FRP	:	Fiber Reinforced Plastic
FSSD	:	Fire Safety & Shelter Department

G

GEG	:	Gas Engine Generator
GHV	:	Gross Heating Value
GIS	:	Gas Insulated Switchgear
GPS	:	Global Positioning System
GRA	:	Gas Receiving Area
GT	:	Gas Turbine
GTG	:	Gas Turbine Generator

H

Ha	:	Hectare
HART	:	Highway Addressable Remote Transducer
HDPE	:	High Density Poly Ethylene

HRSG	:	Heat Recovery Steam Generator
HV	:	High Voltage
I		
IDA	:	Info-communications Development Authority of Singapore
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IES	:	Illuminating Engineering Society
ISO	:	International Organization for Standardization
J		
JTC	:	JTC Corporation
K		
kV	:	kilo Volt
kW	:	kilo Watt
L		
LHV	:	Lower Heating Value
LON Works	:	Networking Platform for Control applications
LNG	:	Liquefied Natural gas
LV	:	Low Voltage
M		
MB	:	Mixed Bed
MHA	:	Ministry of Home Affairs
MSSL	:	Market Support Services Licensee
MV	:	Medium Voltage
MW	:	Mega Watt
N		
NEA	:	National Environment Agency
NEMS	:	National Electricity Market of Singapore
NEWater	:	Treated Waste Water
NFPA	:	National Fire Protection Association
NLA	:	Net Lettable Area
O		
ONAF	:	Oil Natural Air Forced
ONAN	:	Oil Natural Air Natural
OPC	:	OLE for Process Control
P		
PLC	:	Programmable Logic Controller
PSCC	:	Power System Control Centre
PSO	:	Power System Operator
PUB	:	Public Utilities Board
PVC	:	Poly Vinyl Chloride
Q		
-		
R		
RO	:	Reverse Osmosis
RT	:	Refrigeration Ton (Cooling Capacity)
RTU	:	Remote Terminal Units
S		
SCADA	:	Supervisory Control and Data Acquisition
SEM	:	Sequence of Event Monitors
SF_6	:	Sulfur Hexafluoride
SRS	:	Safety Related System
SS	:	Spring Singapore
ST	:	Steam Turbine
STG	:	Steam Turbine Generator

T

TVRA	:	Threat Venerability Risk Assessment

U

UF	:	Ultra Filtration
UPS	:	Uninterrupted Power Supply
URA	:	Urban Redevelopment Authority

V

VSD	:	Variable Speed Drive

W

WHB	:	Waste Heat Boiler

X

XLPE	:	Cross Linked Poly Ethylene

Note: "Plant" or "Facility" means to "Chilled Water Plant (with Option for an Integrated Power Plant)"

1. General Project Requirements

1.1 Project Background

DCP is proposed to be located at Tanjong Kling and will occupy an estimated area of 13ha and can consist of approximately eight DCs buildings (refer to Annex A for location plan), providing at least 70,000 m^2 up to 105,000 m^2 of net rackable DC space. Investors will have a selection of various land plots to enable them to rapidly build their own DCs facility within the DCP, leveraging various supporting infrastructure to get to market quickly and reduce overall capital expenditure and operating costs. The Plant will be sited as shown in the Layout of Chilled Water Plant (with Option for an Integrated Power Plant), Dwg. No. 2611239A-PLOT-S2-001 in Annex 4.

The operating environment of the DCs in DCP will be similar to that of typical DCs. Typical ambient air temperature for DCs is 22˚C, with an allowable range of ±2˚C. Required relative humidity is 50%, with a range of ±5%. High end DCs also require at least N+2 redundancies for critical equipment and usually have ultimate load requirement of 20 to 30MW per building.

1.2 Chilled Water Plant (with Option for an Integrated Power Plant) Requirements

Developers can provide a Chilled Water Plant (with Option for an Integrated Power Plant) solution. As per the EMA regulations direct power connection to DCP are not allowed. The end users in DCP must buy the power from electricity retailers and their installation (DC building) must be connected to the power grid network to obtain power supply as their main or back-up source. To supply power to DCP, there will be two onsite 66kV sub-stations.

In the event that the plant is to export power to the grid, it shall comply with all prevalent regulatory requirements from the relevant authorities.

The range for chilled water requirement of the DCP is estimated to be at least 50,000RT to 74,000RT, which is expected to be achieved in a phased manner. Table below indicates the chilled water load requirements and shall be considered as reference by the Developer.

Year	Chilled Water Load requirement
2014	5,000RT
2015	10,000RT
2016	20,000RT
2017	28,000RT
2018	38,000RT
2019	46,000RT
2020	53,500RT
2021	59,000RT

Year	Chilled Water Load requirement
2022	61,500RT
2023	63,000RT

Table 1-1: Projected Cooling Load

The facility shall be completed and commercially operational 24 months from the date of award. Considering the above Chilled Water requirements of the end users, the Developer can propose an efficient, more cost-effective, scalable configuration for the proposed Plant.

The Developer shall propose a feasible and suitable plant and configuration to meet the requirements for the facility. The details of the Plant requirements are given in Annex 2. All schematics, flow diagrams, configurations etc provided within the specifications shall be taken as for reference only.

The information provided in the specifications is to be used for reference only. The use of this information does not relieve the Developer of his responsibility to meet the requirements of the proposed plant. Neither Stakeholders nor any of their advisors have any liability as to the completeness or correctness of the information contained herein.

1.3 Design conditions

The proposed plant shall be designed to achieve the design conditions as stated in this section.

1.3.1 Chilled water supply and return temperature at the primary side of CHWS customer station:

a) Supply temperature to DCP = 6˚C±0.5˚C
b) Return temperature to Chiller= 12˚C±0.5˚C

1.3.2 Chilled water supply and return temperature at the secondary side CHWS customer station:

a) Supply temperature = 7˚C±0.5˚C
b) Return temperature = 13˚C±0.5˚

1.3.3 Ambient air conditions to be maintained in Data Centre

a) Dry bulb temperature = 22 +/- 2˚C
b) Relative humidity = 50 +/- 5 %

1.3.4 Fresh water cooling tower temperature:

a) Supply temperature from Cooling Tower = Developer to decide

b) Return temperature to Cooling Tower = Developer to decide

1.3.5 Outdoor temperature:

a) Design Dry Bulb temperature = 32˚C
b) Design Wet Bulb = 28˚C

1.4 Site conditions

The Plant shall be designed to operate throughout the range of meteorological data as listed herein.

1.4.1 Site Location

The proposed site location of the Plant for DCP is at Tanjong Kling, Singapore. The proposed Power and Chilled Water Plant will be constructed on an area of 3.8hectare.

The site elevation will be approximately 5.0m above Admiralty Chart Datum. The finished level shall be determined by the Developer considering parameters such as flood level and regulatory requirements.

Site access will be via "Sunway View" as shown in the site layout drawing No 2611239A-PLOT-S2-001 in Annex 4.

1.4.2 Climatic Data

Singapore's climate is characterised by the monsoon, and is generally uniform in temperature, with high humidity and abundant rainfall due to the maritime situation of the island and its proximity to the equator.

Rainfall occurs throughout the year, but is heaviest from November to February during the Northeast monsoon. Much of the rain falls as sudden showers with precipitation of more than 50mm a day occurring more than nine times a year. Annual precipitation is about 2,375mm.

Reference Conditions for purposes of Plant Performance;
• Dry Bulb temperature : 32°C
• Wet Bulb temperature : 28°C

Statistics of Singapore's climate are summarized below for Developer's reference. The Developer shall obtain actual data from the relevant sources for the design.

Parameters	Unit	Data
Mean daily temperature	˚C	26.6

Parameters	Unit	Data
Mean daily maximum temperature	˚C	30.7
Mean daily minimum temperature	˚C	23.7
Highest maximum temperature	˚C	35.8
Lowest minimum temperature	˚C	19.6
Mean daily relative humidity	%	84.6
Mean daily maximum relative humidity	%	96.4
Mean annual rainfall	mm	2,375
Highest annual rainfall	mm	3,452
Lowest annual rainfall	mm	1,493
Highest daily rainfall	mm	512

Table 2-2: Overview of Singapore's Climatic Conditions

1.4.3 Soil Information

Borehole data near the proposed site is included in Annex 3 for preliminary information. Plan showing the position of the bore logs are shown in the same Annex 3. The soil information is provided for the Developer as reference only. The Developer shall carry out the detailed ground and subsoil investigations to be used for the eventual foundation design.

1.5 Fuels

1.5.1 Liquefied Natural Gas (LNG)

The Developer shall refer to the latest Network Code for the Singapore gas specification.

1.5.2 Diesel Oil

It is the responsibility of the Developer to arrange the Diesel Oil from the Fuel Supplier and to comply with NEA's latest emission requirement for the class of diesel to be used.

1.6 Water

The Developer shall be responsible to arrange for the supply of water to the proposed plant.

1.7 Environmental requirements

1.8.1 General

The Developer shall design the Plant such that it meets all Singapore environmental legislation and regulations.

The Developer is obliged to comply with all applicable legal requirements concerning the protection of the environment. This includes preparing a site specific Environmental Impact Assessment (EIA) report and an Environmental Baseline Study that is based on the performance of the proposed plant.

Environmental emissions and impacts in Singapore are controlled under "Code of Practice on Pollution Control" (2000 Edition or latest edition)", Third Edition (with amendments) lists the allowable limits for air pollutants. It is the Developer's responsibility to comply with the latest requirements of the Code.

1.8.2 Visual and General Environment

The Developer shall design the plant and layout (including landscaping) such that it is both practical and fitting for the surrounding region. Consideration shall also be given to location and movement of plant, vehicles, material and people to avoid unnecessary congestion and obstruction.

1.8.3 Height Constraints at DCP

Stack height shall be determined by the Developer and be subject to the approval of the National Environment Agency. The criteria used to determine stack height are that Ground Level Concentrations of any pollutants shall not exceed the limits specified by all relevant authorities such as NEA, DSTA and CAAS. The Developer shall conduct dispersion modelling based on the performance of the plant to confirm that the proposed stack height will meet these criteria. Such modelling shall take into account existing background concentrations.

Developer to comply with NEA requirements on building height constraint of 85m AMSL but applicable to naturally ventilated building only. And, chimneys shall at all times be taller than the height of the building by at least 3m to prevent a downwash effect which alter the composition, humidity, temperature, dust concentration and in short impact adversely the air quality at the vicinity of the building.

If the Developer plans to increase the height of the building in future without having to increase the height of the chimneys, the height of the chimneys to be constructed shall take into account the future height of the building in order to comply with the requirements for chimney height in the Code of Practice on Pollution Control.

Developer to comply with DSTA requirements on building height control of 100m AMSL. All structures and fixtures such as TV antennae, water tanks, lift motor rooms, cranes, maintenance equipment, lightning conductors, lamp-posts,

maintenance equipment, cranes, etc. are subject to the same height limits. Please note that the same height limit is applicable to construction equipment and temporary structures, etc.

The lighting system must not affect aircraft in flight. The Developer shall ensure that any working / outdoor lightings must be pointed downwards and shielded to prevent causing glare and confusion to the pilots.

1.8.4 Vibration and EMC Limits

Vibration and Electromagnetic compatibility (EMC) Limits shall satisfy the Regulatory requirements such as Ministry of Manpower guidelines for Noise Control & Vibration, VDI guidelines, and IEC.

1.8.5 Security and Risk Requirements

The Developer is responsible to comply with the security and risk requirements from MHA. This would include TVRA study as well as other studies and measures arising from the TVRA study.

As the proposed plant will be serving data centres which could house financial institutes, the Developer is to consult MAS on any requirements that are required to be incorporate for the proposed plant.

1.8.6 Electricity Generation License

Should the Developer need to apply for "Electricity Generation License" from EMA, it is the Developer's responsibility to ensure that all of the EMA's latest requirements, as stated in the "Application for Electricity Generation License", shall be adequately met for the successful application of the electricity generation license. In the event that the shortlisted Developer could not obtain the electricity generation license after it has been selected, the Principal Agency reserves the right to award the concession for the Project to the next best Participant.
In the event that the Developer intends to use its existing generation license for this development, the Developer's shall submit all required documents to demonstrate that the existing generation license is able to cover the proposed development.

1.8 Terminal (Tie-in) Points

No.	Terminal point	Location
TP-1	Chilled water supply	Two connection points for each DCs building, but the interface connection with DCs building will be at the respective secondary side of the Heat Exchanger supply. The location of the connection points shall be further confirmed with JTC.
TP-2	Chilled water return	Two connection points for each DCs building, but the interface connection with DCs building will be at the respective

No.	Terminal point	Location
		secondary side of the Heat Exchanger return. The location of the connection points shall be further confirmed with JTC.
TP-3	Fuel Gas	The tie-in from the point of tapping off to the site should be mutually agreed between the Developer & Fuel Gas Supplier.
TP-4	Fuel Oil	To be mutually agreed between the Developer & Fuel Oil Supplier.
TP-5	Water	To be mutually agreed between the Developer & Water Supplier.
TP-6	Waste Water/Drainage	To be mutually agreed between the Developer & Local Authorities.
TP-7	Power for Chillers (in case of import from grid)	At the 66kV substation located adjacent to the project land.
	Export of power, if applicable	At the 66kVsubstation located adjacent to the project land.
TP-8	Access road to Plant	Main access to DCP would be via from Sun View Way.
TP-9	Telecommunication	To be mutually agreed between the Developer & telecommunication company.
TP 10	Chilled Water Reticulation Pipe Network	By Developer. Space shall be allocated by others for the Developer to lay the pipes.
TP 11	Heat Exchanger in DC	To be provided by the Developer.
TP 12	Meters	To be provided by the Developer.

1.9 Infrastructure provided by others

Infrastructures within the DCP would be provided by other parties. These infrastructures which are located outside of the Plant includes:

a) Main road leading into the DCP

b) Sewerage Network

c) Drainage Network

d) Street Lightings and associated cablings

e) Telecommunication network

f) Two numbers of 66kV substations and associated electrical cablings

The Developer shall note that there will be other Contractors who will be working within the DCP site during the construction of the proposed plant. This may include Contractors from the DC Developers as well as the Contractors for the infrastructure and substation works. Provisions shall be made by the Developer to accommodate and interface with the Contractors on site during the course of construction. It is deemed that the Developer has considered this in the proposal.

1.10 Performance requirements

1.10.1 General Design Considerations and Design Life

The Plant shall comprise well-proven major components, built to internationally recognized standards, and shall be designed to achieve high levels of operability, reliability, availability and maintainability stated under the conditions provided in Clause 1.4.2. This section documents the minimum performance requirements that the Developer shall comply.

The plant shall be designed for a minimum operating life of 30 years with minimum maintenance and minimal replacement of parts normally subject to wear and tear and deterioration in service.

Equipment and components normally subject to wear and deterioration shall be designed to have maximum practical life between overhauls. Equipment and components shall be designed to ensure plant operation at full load except for scheduled maintenance activities arranged in accordance with the operating and maintenance instructions. The Developer shall provide details of equipment subject to wear and deterioration together with anticipated periods of operation between replacements or overhauls.

Plant and equipment (including computers, control and telecommunication systems) shall be designed to minimize generation of unacceptable electromagnetic interference, or to be susceptible to such interference from such items during testing, commissioning and normal operation of the plant at Site. The Developer shall submit the expected electromagnetic levels during the proposal and after testing and commissioning to prove that the same electromagnetic levels are within range as intended.

1.10.2 Redundancy

The plant shall be designed to support Data Centres designed to have minimum Tier 2 classifications as per Uptime Institute's classification. However, minimum of N+2 redundancies shall be provided for all critical equipment at chilled water plant. Such equipment shall include;

a) Chillers
b) Pumps
c) Cooling towers
d) Heat exchangers

For chilled water reticulation pipe, minimum 2 x 50% capacity for supply ring mains and 2 x 50% capacity for return ring mains shall be provided in order to ensure chilled water supply to DCP at all times. Emergency power shall be provided to back up the critical equipment, including the chilled water distribution pumps and thermal storage system.

The design and configuration of the Plant shall be such that an outage or failure of any one single component shall not lead to failure of another unit or the loss of the total Plant output.

In addition, except as otherwise stated in this Specification, rotating auxiliaries shall be duplicated to provide standby redundancy such that failure of any rotating auxiliary shall not result in reduction of output.

Common services plant and electrical systems shall be provided with sufficient redundancy to allow plant output to be maintained on failure of a single plant item.

Standby equipment shall be configured to auto-start on failure of a running unit, and shall be supplied from a different switchboard or bus bar from the main / duty plant.

1.11 Regulatory, Codes of practice and Standards

Please refer to Annex 1.

1.12 Safety

The Developer shall design the Plant to enable it to be operated in a prudent and safe manner taking into consideration all anticipated faults that may occur on plant and control systems. It shall also include daily operational safety.

The Developer shall take into account any special requirements concerning the nature, handling and storage of all fuels, oils, gases and chemicals. Plant, equipment, buildings and other services shall be provided to ensure the safety and security of all plant and personnel. For flammable gases, areas shall be classified to an approved standard and the necessary certified equipment shall be provided.

2. Performance Guarantees

2.1 Chilled water plant

The following items of performance shall be guaranteed by the Developer in respect of the Chilled Water Plant.

a) Chiller performance (kW/RT)
b) CoP of the Chillers
c) Chilled Water Supply Temperature (on primary side of the heat exchanger)
d) Chilled Water Flow Rate

e) Availability of chilled water supply

2.2 Integrated Power Plant

The following items of performance shall be guaranteed by the Developer in respect of the integrated Power Plant solution at the specified design site conditions and when using the specified fuel gas / oil as indicated in the specification. These items shall be guaranteed during performance tests at site:

a) Gross Plant Output
b) Gross Plant Heat Rate (LHV Basis)
c) Steam flow rate to Chilled Water Plant (if absorption Chillers are envisaged)
d) Power export to the grid, if any
e) Fuel Gas/ Fuel Oil consumption
f) Emissions

2.3 Other Guarantees

a) Noise level at 1m outside the plant fence, when all equipment are running
b) Water Consumption for the Plant
c) Waste Water Discharge from the Plant
d) Compliance to Waste Water discharge limits

2.4 Conditions for Performance Guarantee

The Plant performance guarantees shall be stated at the following ambient conditions:

a) Dry Bulb Temperature : 32°C
b) Wet Bulb Temperature : 28°C

ANNEX 1: REGULATORY, CODES OF PRACTICE, AND STANDARDS

ANNEX F: DESIGN AND TECHNICAL SPECIFICATIONS

1. Regulatory

A comprehensive regulatory approval process involving planning and environmental issues is required to be followed for projects of this nature in Singapore.

The Developer shall be responsible for obtaining all regulatory approvals and permits for the Plant and payment of all relevant fees as required under the Law of the Republic of Singapore.

The Developer shall be responsible for any studies or engagement of Qualified Person (QPs) registered in Singapore in the course of obtaining regulatory approvals.

Consultation, approvals and permits will be required to be obtained by the Developer from, but not necessarily limited to, the following authorities:

AUTHORITIES LIST	
Acronym	Name of the Authority
BCA	Building and Construction Authority
CAAS	Civil Aviation Authority of Singapore
CBPU	Central Building Planning Unit
EMA	Energy Market Authority
FSSD	Fire Safety and Shelter Department
IDA	Infocomm Development Authority of Singapore
LTA	Land Transport Authority
MEWR	Ministry of Environment and Water Resources (NEA & PUB)
MINDEF	Ministry of Defence
MOM	Ministry of Manpower
MPA	Maritime and Port Authority of Singapore
MSSL	Market Support Services Licensee
N Parks	National Parks Board
Power Gas	Power Gas
JTC	JTC Corporation
PSO	Power System Operator
SPPG	Singapore Power Grid
URA	Urban Redevelopment Authority

A copy of all documentation and correspondence relating to the regulatory approval process shall be made available to IDA and the Principal Agency, by the Developer.

The Developer shall be responsible for the certification of all pressure equipment, pipework, cranes, electrical works, fire safety works, air conditioning and mechanical ventilation systems, civil works including registration of construction worksites and factory premises, etc and shall employ the services of appropriately qualified Singapore Registered Professional Engineers including Accredited Checkers, Registered Inspectors, licensed electrical workers, registered plumbers and approved crane inspectors and/or third party agencies to achieve such certification or Regulatory Approvals, as required.

2. Codes of Practice and Standards

The Developer shall base the proposed plant design on the latest edition of all prevalent Singapore codes of practices, standards and regulations. In the absence of local codes of practice and standards, the Developer shall adopt internationally recognised codes of practices, standards and regulations that are accepted by local authorities.

The Developer shall allow for changes and variations in the regulations by the authorities during the performance of the Work.

Unless otherwise specified, the design, manufacture, fabrication, installation, Identification and testing of equipment covered by this Specification shall comply with, or be at least equal to the latest edition of the appropriate Standards of the following:

Plant shall also comply with the requirements of any Statutory and Local Authority having jurisdiction over the particular plant.

ACI	American Concrete Institute
ADC	Air Diffusion Council
AGMA	American Gear Manufacturer's Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BSI	British Standards Institution
CMAA	Crane Manufacturer's Association of America
CTI	Cooling Tower Institute
DIN	Deutscher Normenausschuiss
ES	European Standard
GNC	Gas Network Code, Singapore
HEI	Heat Exchange Institute
HIS	Hydraulics Institute Standards
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
ISO	International Organisation for Standardisation
MSS	Manufacturers Standardization Society
NACE	National Association of Corrosion Engineers

NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
SAE	Society of Automotive Engineers
SAMA	Scientific Apparatus Makers Association
SS	Spring Singapore
STC	Singapore Transmission Code (by EMA)
TEMA	Tubular Exchanger Manufacturers Association
TRD	Technical Rules for Steam Generators
UL	Underwriters Laboratories, Inc.
VDI	Association of German Engineers
WSHA	Workplace Safety and Health Act

Electrical installations in hazardous areas shall comply further with the requirements of requirements of applicable Singapore and International codes and regulations and shall permit safe working, as shall the electrical equipment used in these areas. A formal document defining any hazardous areas within the Plant shall be provided by the Developer along with a schedule of all the equipment installed within these areas.

ANNEX 2: CHILLED WATER PLANT (WITH OPTION FOR AN INTEGRATED POWER PLANT) CONFIGURATIONS

ANNEX F: DESIGN AND TECHNICAL SPECIFICATIONS

1. Chilled Water System

1.1 General

The Chilled Water System (CHWS) shall include, but not limited to, the major items of plant and equipment specified in this section, and also include all the incidental sundry components necessary to make the system complete.

a) Mechanical Chillers (motor or engine driven) and/or Absorption Chillers (steam fired or direct fired using LNG and/or oil)
b) Pumps
c) Thermal storage system
d) Heat rejection system (cooling water pumping system, cooling towers and condenser water circuit, etc)
e) Chilled water distribution system
f) Plate type heat exchanger in CHWS customer station
g) Make-up water system
h) Electrical supply and distribution, control & monitoring systems, metering and all necessary instrumentation, etc.

1.2 Performance and Criteria

This section briefly describes the high level performance criteria of the Chilled Water System.

1.2.1 Design Conditions

The design conditions shall be as per Section 2.3.

1.2.2 Design Cooling Capacity

The design cooling capacity shall be as per Table 2-1 “Projected Cooling Load” of Section 2.2, which shall be achieved in a phased manner. Number and capacity of chillers shall be selected suitably, considering suitable margin on the total cooling requirement and maintaining required reliability level of the system.

1.3 Chillers

The Developer can either provide Vapour Compression or Vapour Absorption Chiller or a combination of both Vapour Compression and Vapour Absorption Chillers to meet the cooling requirements of Data Centre Park as well as main control room/facilities of the power plant. Energy efficient chillers shall be provided. Each chiller shall achieve a temperature drop across the unit as specified in the design conditions and the design maximum cooling rate shall be achieved at the ambient conditions of 32°C Dry Bulb Temperature, and 28°C Wet Bulb Temperature.

Similarly, condenser water shall be pumped through the chillers, giving the same temperature increase across each chiller.

1.4 Pumps

The Developer shall design, supply, install and commission all the necessary pumps to satisfy all the liquid circuits.
The major pumps in the chilled water system are as follows:

a) Primary chilled water pumps
b) Secondary chilled water pumps (Chilled water distribution pumps)
c) Chillers' condenser water pumps

Constant or variable speed primary chilled water pumps shall be dedicated to each of the chillers (pair-up in small and large capacity flow) and variable speed secondary chilled water pumps shall be provided downstream. This arrangement allow operational flexibility for the system to cope with the cooling load variation in different phases, load variation between daytime and night time.

Condenser water pumps shall be provided to circulate the cooling water through the condensers and cooling towers.

Each chiller shall be served with individual primary chilled water pumps. The number and flow rates of the primary pumps shall match each chiller. They shall be designed with constant volume flow, low head which intended to provide constant flow through the chiller evaporator within the primary chilled water circuit. However, if variable speed /volume primary chilled water pumps are proposed, the chillers and control shall be designed to suit the application. All secondary chilled water pumps shall be operated at variable speed to match the varied load demand. It could be controlled by high voltage variable speed drive (VSD) for energy efficient performance in order to vary the pump speed and hence chilled water flow.

In order to cope with different operating conditions other than normal operation such as cases of low flow (low cooling load demand during night time period) and emergency (pipe burst or breakage), the secondary chilled water pumps are designed and selected with peak capacity overloading capability which it can carry overloaded chilled water flow without impairing overall performance. Under network burst and leakage conditions, the secondary chilled water pumps are required to operate under a higher system pressure than during normal operation.

However, the Developer shall analyse 'all possible' pumps configurations including variable primary flow system and variable condenser water flow system to optimise the design and achieve the optimum solution in terms of energy efficiency and running cost. If variable primary flow system and variable condenser water flow system are used, the chillers, cooling towers and control shall be designed to suit the application.

1.5 Thermal Storage System

Developer shall provide thermal storage system equivalent to one (1) hour of maximum chilled water supply/cooling capacity.

The calculation of availability of chilled water supply shall not take into account of the thermal storage system, i.e. thermal storage shall be considered as the additional backup to Tier II requirements.

1.6 Heat Rejection System

Heat rejection scheme with recirculating cooling water system employing cooling towers shall be adopted for the chilled water plant. The condenser water pumps and cooling towers shall be sized sufficiently to match the overall heat rejection capacity based on the design cooling capacity.

The cooling towers shall have ample heat rejection thermal capacities, minimal drift loss rates and ultra quiet sound power levels verified by field tests conducted in accordance with CTI acceptance test codes ATC-105 & ATC-140.

1.7 Chilled Water Distribution

The chilled water distribution system shall circulate the chilled water from the chilled water plant to the point of use within each of the development (CHWS customer station).

The distribution system consists of chilled water distribution pumps (secondary pumps) located at the chilled water plant and a network of distribution pipe work that connects to Chilled Water system Customer station in each development. The Developer shall design a central chilled water pipe networks to connect all Chilled Water system Customer stations.

The Developer shall undertake an economic evaluation (including both capital and running cost) of piping and pumping costs versus chiller power requirements to establish the most suitable and reliable distribution networks. When sizing piping and calculating pumping cost the heat load on the chiller generated by the frictional heating of the flowing fluid shall also be considered.

The Developer shall also take into consideration of the scalability of the chilling load. The Developer shall consider whether it would construct the chilled water network to cater for the ultimate chilling load of 74,000RT at the front end or construct the pipe network in parts and scale the network up according to the chilling load demand. If it is the latter case, the Developer shall demonstrate in the proposal that the duration required for the scaling up the piping network.

The total water flow in the piping must be pumped at a pressure sufficient to meet the requirements of the Customers with the largest pressure requirement. Consequently, all Chilled Water system stations should have their pressure differentials monitored and transmitted to the control panel, where pump speeds are adjusted to provide adequate pressure to the building with the lowest margin of pressure differential.

The Developer shall look into optimizing the design of pipe work distribution. This shall include pipe sizes and length, redundancy capacity, access for maintenance and pressure losses.

In laying out the main supply and return pipe work, redundancy of supply and return should be considered in all possible failure modes.

1.8 CHWS Customer Station

1.8.1 System Overview

a) The CHWS customer stations shall be built within the boundary of the Customer building to convey cooling energy from CHWS to the building chilled water system of the Customer. The CHWS Customer station is designed for indirect connection between the CHWS distribution network and the building chilled water system through multiple heat exchangers.

b) Chilled water pipes from the CHWS distribution network shall be connected to the plate type heat exchangers installed inside the CHWS customer station. Two intake connections (2x100%) to each customer building shall be provided. The heat exchanger together with the upstream pipe work, metering, etc inside the CHWS customer station shall be provided by the Developer. The building chilled water system provided by the Customer will interface with the CHWS developer at the secondary connection supply and return pipe outlets of the heat exchangers.

1.8.2 Building Interconnection

The Developer shall detail up all the interconnection requirements for the CHWS to ensure that:

a) Return temperatures from interconnections are maintained at the required level, thus maintaining chilled water plant efficiency.
b) Adequate space allowance is made for CHWS Customer stations.
c) Coordination between CHWS and DCP can be achieved.

Heat exchangers are one element of the CHWS Station and the space of CHWS station is based on the cooling requirements of the individual DCP. The secondary system downstream side of heat exchangers shall be provided by the Customer.

1.8.3 Heat Exchanger

The heat exchanger shall be of a plate type design with gasket clamped between plates. The framework shall be with at least 30% extra plate capacity for future expansion. The heat exchanger must be counter flow design. All connection shall be located at the same side.

1.8.4 Control and Monitoring

a) General
Control and monitoring system shall include but not limited to energy meters, flow meters, motorized control valves, temperature sensors, and built in programmable logic controller with SCADA communications.

b) Programmable Logic Controller / Integrated Control Panel
The PLC controller shall be reprogrammed locally and providing signal output for monitoring the temperature, flow rate, energy consumptions, In/Out points to control user's pump status and motorized control valves status. Control panel shall be provided with auto / manual function.

c) Instrumentation
An ultrasonic in-line type thermal energy meter shall be provided to measure the cooling consumption with the overall accuracy within ±0.5% and shall comply with EN 1434 requirement.

1.8.5 Metering Equipment

a) General

- Thermal energy meter shall be applied for the purpose of billing. Therefore thermal energy meter shall contain requirements of tamper proof, reliable and accurate. A complete set of Thermal Energy Meter shall consist of energy calculator, flow meter and a factory matched high accuracy temperature sensors (if applicable temperature sensor pockets or thermo-wells). Flow meter shall be of Ultrasonic type with beam principle. Flow meters using the ultrasonic principle shall have a minimum metrological dynamic range of 1:200 for all sizes and flow rates. All thermal energy meters shall be sized based on the designed maximum flow rates.

- The accuracy in measuring data of the complete unit of thermal energy meter shall be within ±0.5% and complied with EN1434.

b) Chilled Water Flow Meter

- The chilled water flow meter shall be approved according to EN 1434 meteorological class 2 & 3 and Environmental class C.

- Chilled water flow meter shall be of Ultrasonic in-line type with beam principle. Chilled water flow meter shall not contain any mechanical moving parts. Electromagnetic, impeller and vortex are not acceptable.
- Chilled water flow meter shall be insensitive to sand particles in the water.
- All the chilled water flow meters with small flow rates up to 11.1l/s shall be moisture resistant to avoid condensation on the electronics.
- All critical electronics has to be situated in the calculator side and minimal electronics situated at the flow part has to be sealed with silica gel.
- Chilled water flow meter shall measure minimum 20% over the stated maximum flow.

c) Temperature Sensors and Stainless Steel Pockets

- Temperature sensors shall be direct immersion type or pocket type.

d) Thermal Energy Meter Communication Interfaces

- The thermal energy calculator shall have space for two independent plug-in communication modules to be used e.g. for Automatic meter reading system and Building management system simultaneously.
- Modules shall accomplish with following serial data transmittal standards; M-Bus, LON works, RF radio (Wireless Data), 0/4-20mA output/input.

2. Power Plant Equipment

2.1 Prime Mover

2.1.1 Gas Turbine Generator & Ancillaries

The Gas Turbine Generator (GTG) package shall be complete with ancillary plant, but not limited to the following;

- enclosures
- all skids
- air inlet filter system (including dust collection and disposal system) with ducts and silencers.
- compressor on-load and off-load washing system
- exhaust gas system
- lubrication system
- turning gear
- fuel compartments
- low NOx combustion systems for gas and distillate fuel (option for distillate fuel)
- fire fighting and alarm system
- I&C system
- protection system

- unit related electrical facilities, including excitation, voltage regulation and start-up facilities
- vibration monitoring system

The Gas Turbine Generator (GTG) package shall comply with the following requirements:-

a) The gas turbines shall be of dual fuel with auto switch-over, heavy duty or aero-derivative, single or multi shaft, indoor type directly coupled to a 50Hz generator. The turbine shall be suitable for extended operation while firing the back-up fuel, viz. distillate.

b) The gas turbines shall be provided with dry low NOx combustion systems for burning natural gas. When burning distillate oil, NOx emissions shall be controlled by water/steam injection, if required to meet the emission limits.

c) The Gas Turbine and Generator plant shall be installed in a machine hall which will be complete with an electric overhead travelling crane and with sufficient lay down area for inspections and maintenance.

d) The gas turbine control system shall incorporate an interface with the DCMIS to facilitate integrated control of HRSGs and steam turbines throughout all operational maneuvers.

e) Permanent equipment for both on-load and off-load compressor cleaning shall be provided for each gas turbine, allowing for the connection of common mobile washing equipment supplied. Permanent effluent disposal systems shall be provided, complying with the environmental requirements of Singapore. The compressor inlet plenum shall be complete with viewing window(s) to allow viewing of the on line compressor cleaning water spray pattern.

f) Means shall be provided for powered turning of the rotors for a sufficient period following normal or emergency shutdown to ensure satisfactory cooling of components. The turning gear shall be interlocked such that loss of lubricating oil shall immediately stop the gear. It shall not be possible to start the turning gear without adequate lubrication oil supplies.

g) As a backup to the powered system, means shall be provided for turning of rotors by hand during maintenance and for emergency use.

h) Gas turbines shall not exhibit screech/humming effect throughout its operating range, including full load operation at the rated firing temperature.

The Developer should give consideration to items necessary for installation in a coastal environment, including but not limited to materials of construction, corrosion protection, air inlet treatment, compressor section blading/ coating.

or

2.1.2 Gas Engine

The Duel Fuel Gas Engine Generator shall be provided complete with auxiliaries, but not limited to the following;

- Air intake and exhaust system
- Engine Cooling system
- Lubricating oil system
- Compressed air starting system
- Fuel system (Diesel and Regasified LNG)
- Enclosures
- Related electrical facilities

The Gas Engine Generator (GEG) package shall comply with the following requirements:-

a) GEG shall be of four-stroke compression ignition, heavy-duty type suitably designed and constructed for operation on natural gas and diesel oil.
b) The engine shall be continuously rated to give the stated generator output throughout the range of ambient conditions. High availability and reliability is of prime importance.
c) The engine shall be fitted with a governor capable of satisfying the limits laid down in ISO 8528-2 and ISO 8528-5, performance class G2.
d) An over speed protection device, independent of the governor control, shall be provided in accordance with ISO 3046-6, with shutdown latching and manual reset. Both mechanical and electrical over speed protection devices shall be provided.
e) The GEG set shall be provided with a self-contained and independent pressurized lubrication system operated by a positive displacement pump and serving all the lubrication requirements of the engine and generator, including generator bearings, crankshaft and connecting rod bearings, shaft gears, camshafts, pistons, valve gear, fuel injection pumps and turbocharger.
f) Radiators for cooling the engine jacket water and secondary cooling water shall be provided for the engine.
g) The engines shall be started by compressed air. For this purpose two alternating current motor driven air compressors, one duty and one stand-by, plus one diesel engine driven standby air compressor and multiple air receivers shall be provided.
h) Air intake system to meet the combustion air requirements of each engine shall be provided.
i) The exhaust gas system shall be complete with all the accessories and shall ensure safe disposal of the exhaust gases at a suitable point outside the engine room.
j) A Heat Recovery Unit/Boiler shall be provided to recover the waste heat from the exhaust gas and use the thermal energy in Absorption Chillers.

2.2 Heat Recovery Steam Generator (HRSG)/Waste Heat Boiler (WHB)

The HRSG package shall be complete with and include, but not be limited to, the following:

- HRSGs
- Chimney/stack
- Vent and drain systems
- Blow-down system
- Chemical dosing system
- Related piping and valves
- Stand-still preservation
- Deaerator & feed water storage tank
- Feed water pumps
- Locally mounted instrumentation and control devices
- Related electrical equipment

The HRSG shall comply with the following requirements:-

a) The HRSG shall be designed, constructed, inspected and tested, as a minimum, in accordance with the current requirements of ASME Boiler and Pressure Vessel Code. The HRSG shall also provide compliance with ASME code B31.1 and shall meet applicable Singapore regulatory requirements.

b) HRSG shall be of either natural circulation, or pump assisted circulation may be provided for use during start up only.

c) The design of the HRSG shall be considered in conjunction with the design of the steam by-pass system to ensure that the gas turbine will remain at base load operation even when the steam turbine is tripped on full load.

d) The design of the HRSG shall recognize the cyclic nature of the specified duty and shall minimize the effects of differential expansions and thermally induced stresses to ensure that the specified design life of the HRSG can be achieved.

e) The entire gas path from the turbine exhaust through the silencer and steam generator to the stack entry shall be designed to eliminate flow induced vibration or resonances throughout the operating range.

f) The HRSG shall be designed to accommodate the most rapid temperature variations that can be imposed by the gas turbine/gas engine.

g) The HRSG shall be chemically cleaned and suitably passivated before being put into service. The Developer is responsible for the safe disposal of the HRSG cleaning wastewater and chemicals in accordance with effluent discharge requirements.

2.3 Steam Turbine

The Steam Turbine Generator (STG) Package shall be complete with ancillary plant, and include, but not be limited to, the following:

- Steam turbines & generators
- Enclosures (if required)
- Bleed / extraction steam system to Chilled Water Plant
- Gland steam and sealing system

- Automatic draining system
- Lubrication and control oil system
- I&C system and turbine governor system
- Protection system
- Related electrical facilities, including excitation and voltage regulation

The Steam Turbine Generator (STG) package shall comply with the following requirements:-

a) The STG together with all associated components, shall be of proven design and shall be sized and rated for the operating regime specified, without limitation in output.

b) The STG and its ancillary plant and equipment shall provide continuous, safe, reliable and economical operation without undue heating, vibration, or noise. It shall be designed for ease of operation and maintenance and shall have rapid start-up and shut-down capability. Appropriate mitigation measures shall be included in the design so as to minimize blade erosion due to exhaust steam wetness.

c) The STG and its control system shall be suitable for all modes and conditions of operation. It shall incorporate an interface with the DCMIS to facilitate integrated control of HRSGs and STG throughout all operational maneuvers. The turbine governing system shall provide both upstream pressure and exhaust pressure control modes, in addition to speed and load control functions.

d) Each STG unit shall be capable of withstanding 100% load rejection without a unit trip. In addition, the STG shall also be capable of coming to rest without bearing or other damage on loss of cooling water or main alternating current power to its oil systems.

e) The STG unit shall be able to continue operation when one of the GTs trip. STG will need to maintain proportionate load when one GT trips, i.e. 50% during 1 GT full load operation.

f) The STG control system shall include all equipment and software necessary to monitor and record thermal stress levels in the high temperature turbine components.

2.4 Steam, Feedwater and Condensate System

2.4.1 Steam System

The steam generated in the HRSG shall be used to generate power in a steam turbine generator.

The Developer may extract the steam from HRSG and/or the steam turbine for use in the Vapor Absorption Chillers to generate chilled water. The condensate from the Vapor Absorption Chillers shall be returned to power plant Condenser.

The steam and feed water piping systems shall incorporate recognized features for rapid detection and prevention of water induction into the turbine from main steam lines, spray attemperators, gland sealing systems and turbine drain lines (to ASME Standard TDP-1-1980 requirements, or equivalent alternative code).

2.4.2 Feed Water System

The system shall include, but not be limited to, deaerator, feed pumps, attemperator supplies, spray water for the steam bypass systems, chemical dosing, feed water controls, piping, valves, fittings, etc.

a) Deaerator and Feedwater Storage Tank
A deaerating feed water heater consisting of a deaerating portion with section for cooling and collecting the incondensable gases and feed water storage tank shall be supplied.

The usable storage shall be a minimum of 10 minutes supply of feed water to the HRSGs when the unit GT load is 100%.

b) Feedwater Pumps
Dual redundant 100% feed water pumps shall be fitted that shall provide feed water at controlled rates.

The pump total head at rated capacity shall include a margin for wear in addition to normal design margins.

The pumps shall also incorporate rapid start-up features to ensure satisfactory start-up performance of a pump in standby mode.

2.4.3 Condensate System

The condensate systems shall supply condensate from condenser to the deaerator. The system shall include condenser, vacuum pumps, condensate extraction pumps, control valves, pipe work, etc.

a) Condenser
The condenser shall be designed in accordance with the codes and standards established by the Heat Exchange Institute for steam surface condensers including shell and tube side erosion allowances.

Vacuum pumps shall be provided for vacuum holding on the steam side. The equipment shall be designed to achieve maximum flexibility of operation.

b) Sizing Basis
- The condenser shall be sized to receive:
- Condense all steam for all operating ranges
- Accept the full steam turbine bypass steam when the steam turbine trips
- Condensate return from vapor absorption chillers, if applicable

c) Condensate Extraction Pumps
The main condenser shall be provided with 2 x 100% capacity extraction pumps of an approved type and construction, and of approved material.

The pumps shall be provided with a minimum flow protection system. The pumps shall operate under a controlled condensate level which will ensure cavitation free operation.

2.5 Cooling System

The cooling water system for the power plant (in the case of combined cycle power plant) shall consist of the following sub-systems namely;

- Main cooling water system
- Closed cooling water system & Auxiliary cooling water system.

2.4.4 Main Cooling Water System

A unitized main cooling water system shall be provided for each unit/block. The cooling water shall be recirculating type with induced draft cooling tower. The cold water collected in the cooling tower basin shall be routed to the pump fore bay through cooling water channel. Cooling water from the pump fore bay shall be circulated in the power plant condenser and shall be routed to the induced draft cooling tower. The system shall also receive return cooling water from the secondary side of closed cooling water system's plate heat exchangers.

The cooling water system shall consist of induced draft cooling towers, main cooling water pumps, stop logs and bar screens for each pump sump, condenser online tube cleaning system, chlorination system, cooling water chemical dosing & monitoring system, side stream filtration system (if required), interconnection pipe work, etc. The capacity and number of equipment shall be decided by the Developer based on the system requirement and considering adequate redundancy.

2.4.5 Closed Cooling Water System / Auxiliary Cooling Water System

A closed circuit cooling system, running on demineralised (DM) water, shall be supplied for each unit to provide high quality cooling water to various plant items, including turbine lubricating oil system, generator seal oil system and lubricating oil systems of major plant auxiliaries.

The closed cooling water pumps shall pump the required DM cooling water (primary side) to the HRSG, STG and BoP auxiliaries through CCW heat exchanger. The hot water returning from the auxiliary equipment shall be pumped again to the CCW heat exchanger where it shall be cooled by the auxiliary cooling water (recirculating cooling water from the cooling tower circuit) flowing on the secondary side. The auxiliary cooling water requirements (on the secondary side) shall be pumped by auxiliary cooling water pumps from fore bay. The hot water return line of auxiliary cooling water shall be connected to the condenser hot water return line of main cooling water system.

The closed cooling water system shall consist of closed cooling water pumps, plate heat exchangers, overhead expansion tank with accessories, chemical dosing system, piping, valves, fittings, etc. The auxiliary cooling water system shall comprise of auxiliary cooling water pumps with associated piping, valves, fittings, etc. The capacity and number of equipment shall be decided by the Developer based on the system requirement and considering adequate redundancy.

3. Mechanical System

3.1 Fuel System

The gas fuel and fuel oil systems shall be provided complete with all necessary plant and equipment including storage tanks, pumps, pipe work, valves, fittings, filters, vents, purging equipment, drains, drain tanks, metering, gas detection equipment, etc., to provide fuel supplies (natural gas and distillate oil) to the gas turbine units, or gas engine generators and emergency diesel generators.

Equipment within hazardous area classification zone shall be designed accordingly for explosion proof.

3.1.1 Gas Supply System

A gas supply system is required, complete in all respects, for the safe and reliable usage of gas as a main fuel, starting from the interface flange with the Gas supply system.

The Developer shall provide the complete fuel gas system, which shall include but not be limited to, the supply piping to all consumers, gas pressure reducing stations with stand-by streams, heating (if applicable), filter system, separator, condensate disposal system, flare station (if applicable), all pipelines, shut-off and safety valves, and inherent controls and instrumentation to allow full operation in accordance with the design philosophy set forth in this Specification.

The gas receiving and metering station shall be located within the Plant boundary. In addition, natural gas meters for the entire Plant shall be provided (complying with the Metering and Data Exchange Code, latest version), including the following: \\

- Flow indication, registration and settlement metering
- Check meter according to metering code and Data exchange code
- Pressure indication and registration
- Temperature indication
- The flow measurement shall be certified for billing purposes.

3.1.2 Back-up Fuel Supply System (Distillate oil)

The Developer shall supply a complete fuel oil system including fuel storage tanks, forwarding pumps, fuel treatment facilities, if any, and fuel pipelines to each individual gas turbine or gas engine generator and to the emergency diesel generator sets including all necessary vents, drains, meters, valves and instrumentation to allow full operation according to the design philosophy set forth in this Specification.

For safety and resiliency purposes, underground diesel storage is preferred and this must be in conjunction with current EMA's requirement of a Generation Licensee to provide fuel reserves to last at least 90 days for operation of the Licensee's authorized business.

Tanks shall be designed in accordance with API standards.

The piping / pumping systems from the day tanks to the GT's or GEG's or EDG's shall be sized to allow continuous full load operation. Metering equipment shall be provided for the tank filling system, and for each consumer i.e. at GTG, GEG, EDG.

3.2 Fire Fighting and Detection System

3.2.1 General

A fire fighting and detection system shall be provided and designed in accordance with Fire Safety Act administer by FSSD and applicable NFPA codes and standards and approved by an authorized insurance company.

Fire protection systems for the plant shall consist of:

a) Fire fighting water system (fire main)
b) High Velocity Water Spray Systems
   - Main and Auxiliary transformers
c) Medium Velocity Water Spray Systems
   - Steam Turbine lub oil storage
   - Steam turbine lub oil pipe work
   - Steam turbine bearings
   - Diesel generators
   - Diesel fire pumps / pipe work, etc
d) Automatic Spray deluge systems
   - Chiller enclosure
   - Cable flats
   - Workshop
   - Stores
   - Garage
e) Mobile foam units
f) CO_2 fire fighting system
g) Portable extinguishers

h) Fire Detection and Alarm System

3.2.2 Water Source

The supply of fire fighting water shall be taken from the dedicated fire water storage tank. The tank shall have filling connections from the PUB.

3.2.3 Fire Water Pumps

The fire pumps (electrical and diesel driven) shall be supplied and installed in the facility.

In addition, an electric motor driven jockey pump shall maintain the pressure in the fire water ring main. The pump shall have sufficient capacity to provide flow to two fire hose reels while maintaining the required pressure in the main.

3.2.4 Fire Main and Hydrants

a) Fire Main

All water based fire fighting systems shall be supplied from the fire fighting water ring main. The main shall be buried and arranged as a grid/ring system divided into sections by sufficient isolation valves to minimize the effect of pipe damage or maintenance.

b) Fire Hydrants

Fire hydrants shall be provided throughout the plant. All buildings, structures and equipment shall be within reach of hose streams from hydrants. The hydrants shall be compatible with the fittings and equipment used by the local fire authority.

All buildings shall be provided with hose reels suitable for use by untrained personnel. All buildings of more than one storey shall be provided with stand-pipe systems.

3.2.5 Portable Extinguishers

Portable extinguishers shall be provided on exit routes in accordance with FSSD requirements.

3.2.6 Fire Detection and Alarm Systems

A fire detection and alarm system shall be provided to protect life and property in all areas of the plant. The status of the system shall be displayed in the Central Control Room. The system shall monitor the status of all automatic and manual alarm devices, all extinguishing systems and the fire pumps. A mimic panel shall indicate the source of any alarm or fault.

Suitable detectors shall be provided for each area taking into account the type of fire likely to occur and the environment in which they are located.

3.3 Air Conditioning and Mechanical Ventilation System (ACMV)

3.3.1 General

The Plant buildings shall be provided with all necessary ACMV equipment including ductwork, pipe work, controls, instrumentation, interlocking and cabling systems designed to maintain appropriate environmental conditions for equipment/personnel. The outdoor ambient temperature for design shall be based on the ambient temperature range indicated in Section 2 of this specification and should cater for a marine salt laden environment.

The ACMV Systems shall generally be capable of maintaining inside design conditions under all Plant operating or non-operating conditions. The effects of solar gain shall be accounted for in the design of the HVAC Systems.

3.3.2 Air Conditioning System

Air conditioning system shall be, as a minimum, provided for the following areas. The chilled water required for the air conditioned area in the power plant shall be supplied from the chilled water facility.

- All Staff room
- Electrical and Control equipment rooms
- DCMIS equipment room
- All computer rooms and electronic rooms

Humidity control shall be provided in areas containing electronic or other equipment having specific humidity limitations imposed by the equipment manufacturer.

Outdoor ventilation air, for air conditioned areas, shall be provided with sufficient air change rate and fresh air supply in compliance to Singapore laws, codes, standards and regulations.

Control/electronic equipment rooms shall be supplied with filtered air at a rate which exceeds any applicable extract rate, in order to discourage ingress of dust and hazardous gas.

3.3.3 Ventilation System

Ventilation systems shall be, as a minimum, provided for the following Plant areas.

- Machinery spaces, as required
- Battery and battery charger rooms

Ventilation systems shall in general utilize powered roof or wall exhaust fans and sidewall intake louvers, as determined by physical arrangement of Plant ventilated.

The battery room ventilation shall be designed to prevent the build-up of explosive concentrations of gas as a result of battery charging. The system shall be backed up by the use of gas detection monitoring and the avoidance of locating HVAC electrical equipment in the hydrogen/air environment. Where necessary HVAC equipment electrical services in battery rooms shall be explosion proof. For seal type battery, explosion proof requirements may be waived.

The gas turbine modules shall be ventilated so as to prevent dangerous accumulation of explosive gasses. The ventilation system shall be supported by a gas detection system.

3.4 Compressed Air System

A compressed air facility shall be provided to supply instrument air and service air required throughout the power and chilling plant. The internal surfaces of all pipe work, air receivers, filter units, valves and other component parts of the system shall be resistant to corrosion by water entrained in the compressed air.

Instrument air shall be dry and oil free over the full range of ambient conditions. The instrument air distribution system shall normally operate independently, but to rationalise on the compressor installation, a valved and protected interconnection may be made upstream of the dryers, to allow the service air supply to supplement the instrument air supply, in the event of failure of more than one instrument air compressor.

An air distribution ring should be provided.

The service air system shall include hose stations and fixed connections for air tools.

All air vessels shall comply with the industrial safety requirement stipulated by the Ministry of Manpower.

3.5 Water Supply System

3.5.1 Raw Water System

The raw water requirements for the plant shall be supplied by the Public Utilities Board (PUB), NEWater. The raw water system shall consist of the following major equipment.

- Raw water reservoir
- Chlorine dosing system
- Raw water pumps to pump the raw water from reservoir to water treatment plant, fire water storage tank, cooling tower make-up of power plant and chilled water system, etc.
- Interconnecting piping complete with valves, fittings, supports and accessories

3.5.2 Water Treatment System

The raw water shall be treated in a water treatment plant to meet the quality requirements of HRSG make-up, closed cooling water system make-up, etc. The water treatment scheme to be followed shall be Ultra Filtration (UF) followed by Reverse Osmosis (RO) and Mixed Bed (MB) unit. The treated water from the mixed bed unit shall be stored in demineralised water storage tank, which shall be used as make-up to HRSG, closed cooling water system, etc.

3.5.3 Service Water System

The raw water shall be used to meet the service water requirements of power plant and chilled water system. Required number of service water pumps shall be installed near the raw water reservoir to pump the service water to the required consumer points.

3.5.4 Potable Water System

The source of potable water for this project is from the Public Utilities Board (PUB) of Singapore. The potable water from PUB shall be stored in potable water storage tank of suitable capacity and shall be distributed to all consumer points through potable water distribution network.

3.6 Waste Water Treatment and Disposal System

3.6.1 Waste Water Treatment & Disposal

The plant shall be designed with adequate drains, sumps and transfer pumps to permit the collection of all effluents. Streams to be collected shall include, but not limited to, the following;
All surface drains including roadways and access areas

- Flood and storm water drains
- Water treatment plant backwashes/rejects/regeneration waste

- Cooling tower blow down
- HRSG blow down
- Mechanical equipment drains

The effluents with the exception of storm or flood water shall be separated into "normal" and "abnormal" streams. In principle, normal streams shall be oil-free and discharged directly into PUB drainage system. All other drains shall be subject to oil separation treatment prior to discharge.

In general HRSG blow down, condenser, and water treatment plant areas may be considered oil free. Mechanical equipment drains, plant drains and runoffs, and wash areas shall be considered oil contaminated.

After oil separation the "abnormal" stream shall be discharged to the Effluent Collection Tank.

The waste water collected in the effluent collection tank shall be discharged to PUB drainage system in compliance with the discharge standards after appropriate treatment in the effluent treatment plant.

3.6.2 Sanitary Waste

The sanitary/sewage waste shall be discharged to the PUB sewage network, in compliance to the discharge standards.

3.7 Piping and Valves

All piping systems shall be designed to operate with normal maintenance for the entire plant service life and shall withstand the operating parameters, fluctuations and cycle variations which can normally be expected during this period.

3.8 Laboratory Equipment

The Developer shall provide all laboratory equipment, chemicals, furnishing, etc as necessary to make it an operational facility. The laboratory building shall be provided by the Developer.

4. Electrical System

4.1 Generator & Auxiliaries

4.1.1 Generator

The generators shall comply with the requirements of this specification, and the relevant parts of IEC 34. The generator shall be of an established design which has a proven record of reliability for similar applications. The rating of the generator shall

be selected to match, or exceed, the maximum continuous output of the turbine or gas engine across the ambient temperature range of this site, and shall not, under any condition, limit the possible output of the plant. The stator and rotor insulation shall be to Class F standards. The temperature rises and total temperatures shall not exceed the limits for Class B materials. Online condition monitoring equipment shall be provided for the stator winding and stator core insulation systems.

4.1.2 Generator Excitation

The generator excitation systems shall comply with the requirements of relevant IEC recommendations. Furthermore they shall comply with the requirements of the Singapore Transmission Code, along with the EMA. The excitation equipment shall be of double channel as to operate reliably and shall not impose restrictions on the availability of the generator due to excitation equipment faults or malfunctions. The excitation system rated output voltage and current shall be at least 110% of the corresponding generator field (rotor) voltage and current for generator rated output overexcited. The excitation system and equipment shall be complete with fast response continuously acting automatic voltage regulator, standby manual regulator, power system stabilizer, field suppression equipment and all control, monitoring and protection equipment to enable operation from the Central Control Room, using the DCMIS.

4.1.3 Synchronizing Equipment

A dual channel automatic synchronizing relay backed up with check synchronizing circuits shall be provided for operation of the generator circuit breaker and the 230kV switchgear breaker.

4.1.4 Generator Main Connections, Neutral Earthing & Switchgear

a) Generator Main Connection

The main busbar connections between generator to the generator transformers, including the generator circuit breakers, shall be of the phase isolated type with pressurized instrument-air having moisture traps. The installation shall generally comply with the requirements of BS 159 and IEC 105. The temperature rise of any part of the complete installation as installed shall not exceed the permissible values specified in BS 159 and IEC 105.

b) Neutral Connection and Earthing Equipment

A neutral earthing system shall be provided for each generator which shall comprise an earthing transformer with the secondary winding loaded with an appropriately rated resistor or alternatively neutral earthing reactor (if required by fault calculations). A suitable earth fault relay shall be provided in the path. The proposed design shall fall within the fault current allocation requirements.

c) Voltage Transformer Cubicles

Floor mounted cubicles shall be provided to accommodate the voltage transformers and associated fuses.

d) Generator Switchgear

A circuit breaker shall be provided for each generator. The generator switchgear shall be designed for incorporation into the phase isolated system of busbars in such a manner as to preserve the principle 'phase isolated' operation. The circuit breakers shall be SF_6 type designed, manufactured and tested for generator switching duty in accordance with the requirements of IEEE C37.013. Isolating and earthing switches shall be provided to permit adequate and safe maintenance of main plant and equipment to be carried out. The installation shall have moisture traps and be capable of operating satisfactorily at continuous maximum current when any pressurizing unit is not operating.

4.2 Motors

Motors shall comply with the requirements of IEC 34. All motors shall be of high efficiency design and construction. Motor enclosures shall be IP 54 for indoor application and IPW 55 for outdoor. In hazardous areas the motor design shall be ex-proof according to the zone classification. Motors rated above 200kW to be of MV design. Motor windings shall be insulated with materials having at least thermal classification F. The temperature rises shall not exceed the permissible limits for Class B materials. All motors above 3.7kW shall be fitted with anti-condensation heaters of appropriate rating.

4.3 Switchgear

4.3.1 MV Switchgear

a) General requirements

MV switchgears shall comply with the requirements of IEC 56 and IEC 298 and shall be type tested to an appropriate internationally recognized standard. Circuit breakers shall be of the fully with-drawable vacuum type or SF_6 type.

With each circuit breaker, contactor, isolating device and earthing device there shall be supplied all necessary auxiliary switches and mechanisms for indication, protection, control, interlocking, supervisory and other functions to meet the requirements of the Specification.

Safety interlocks to ensure correct system operation, to avoid unsafe switching conditions and to ensure safe isolation for maintenance shall be provided by mechanical or electrical means. The switchgear room shall be air conditioned, fire-fighting feature to be provided and the emergency exits shall comply with the local building code regulations. The MV loads should be allocated to the two bus bar sections and redundant drives to be connected on either side having main/stand-by change-over facility.

Motor feeders shall have protection relays model MICOM P220 or equivalent and shall be protected from excessive consecutive starts by the DCMIS.

b) 6.6kV Switchgear Arrangement and Requirements

Any 6.6kV switchgear shall be supplied from 2 Unit transformers.

A 6.6kV indoor, metal clad switchgear shall consist of two bus bar sections connected by a bus-coupler in normally open position and operated by an automatic quick transfer scheme, if one of the incomer connections should fail. Each bus bar section shall have its own supply voltage for the control circuits and protection relays with change over feature for emergencies.

4.3.2 LV Switchgear

It is envisaged the LV auxiliary power supply system shall comprise a number of main switchboards which will in turn supply motor control centers and distribution boards associated with the respective station and unit auxiliary loads (in case of a power plant). The switchgears (except the 4-wire Lighting and Power board) shall be of the free standing, fully withdrawable, cubicle pattern suitable for three phase, 3-wire operation, solidly earthed and shall be type tested to an appropriate internationally recognized standard.

The main LV boards shall consist of two bus bars connected by a bus-coupler operated by an automatic quick transfer scheme, if one of the incomer connections should fail. Each bus bar section shall have its own DC supply voltage (or alternatively from UPS system) for the control circuits and protection relays with change over feature for emergencies. The construction of the switchgear shall be such that the internal separation by barriers complies with form 3B (or above) separation in accordance with the requirements of BS EN 60439-1. Control will be on the same basis as for the MV switchgear. All “local control only” breakers and contactors must have padlock provisions. Redundant drives or loads shall be connected to different bus bars (if possible) and shall have main/stand-by changeover facility.

The DC distribution boards associated with the batteries and LV AC distribution boards shall preferably be equipped with miniature circuit breakers on outgoing circuits. Safety interlocks to ensure correct system operation, to avoid unsafe

switching conditions and to ensure safe isolation for maintenance shall be provided by mechanical or electrical means.

4.4 Transformers

4.4.1 Generator Step-Up Transformer

Two winding type generator transformers suitably rated to match the output of the prime movers over the entire ambient temperature range of the site and in every mode of operation, shall be provided. The transformers shall be ONAF cooling classification and comply with the requirements of IEC 76. They shall also have an ONAN rating. The transformers shall be located in an outdoor compound adjacent to the generators each having firewalls, fire sprinkler system, oil collecting pit and a common oil separator.

The transformer shall have an off-load tap changer. The tapping range shall be selected to meet the voltage and reactive power control and operating requirements of the transmission system. The transformer LV terminals shall be connected by phase isolated bus bars to the generator switchgear. The transformers shall be provided with online partial discharge and dissolved gas monitoring as well as with winding temperature indication and alarm devices and gas and oil actuated relays. The transformer secondary winding shall be connected to the Grid 66kV GIS switchgear.

The Developer shall connect the transformers to the Grid switchgear using XLPE insulated cables.

4.4.2 Auxiliary Transformers

Oil and liquid filled type transformers shall have natural cooling and shall be located in outdoor compounds with firewalls, fire sprinkler system, oil collecting pit and connection to the common oil separator. Other types of transformer maybe located inside the buildings. The transformers shall be adequately rated to provide the auxiliary power supply systems and to be provided with off-load tap-changers as well as with winding temperature indication and alarm devices and gas and oil actuated relays. The transformers shall comply with the requirements of IEC 76 and IEC 726.

4.4.3 Current Transformers

All current transformers shall comply with the requirements of IEC 44-1. For tariff metering class 0.2 is required.

4.4.4 Voltage Transformers

All voltage transformers shall comply with the requirements of IEC 44-2. For tariff metering class 0.2 is required. Primary windings shall be connected to the HV circuit through renewable fuses of approved type, generally to IEC 269 or IEC 282, and shall be readily accessible. Secondary fuses shall be provided on each voltage transformer and secondary windings shall be earthed at one point only through a link in an accessible position.

4.5 Direct Current System

The direct current switchboards shall comply as specified under LV switchgear clause 4.3.2 above. The direct current distribution boards shall be equipped with double pole circuit breakers for each incoming, interconnecting and outgoing circuit. It shall consist of a three phase rectifier/charger unit to be equipped with alternating current input and direct current output circuit breakers.

Batteries shall be selected from a cell type having a design life of at least 10 years. The battery system shall be 2x100% to provide a redundant power supply with preferred voltage to be 110V direct current and the sizing has to be designed for supply of emergency power, UPS, and as the case may be for a safe shut-down of the plant, barring of the turbines / generators as well as for emergency lighting for 4 hours. The casing of the batteries shall be fire retardant and the battery room(s) shall have air exhaust system, fire and gas detection as well as fire fighting system.

4.6 Emergency Power Supply System

All equipment which are necessary for emergency operation shall be supplied either from the direct current system. The Control and protection equipment which require a secure alternating current supply shall be supplied from the UPS system. All equipment requiring LV emergency power supply shall be connected to an emergency alternating current switchboard to which is connected the emergency diesel generator set.

4.7 Uninterruptable Power Supply (UPS) System

All alternating current equipment which cannot tolerate a disconnection of supply and are required to operate continuously such as a DCMIS or local control system shall be provided with dual supplies from a UPS system/s. The UPS voltage 230V alternating current shall be derived by one feeder from a 400/230V alternating current transformer and another feeder shall be from a dedicated battery, via a static inverter having a static bypass switch. The UPS equipment shall be provided with isolation facilities to permit full replacement without disrupting any part of the systems to which it is normally connected. The dual redundant UPS equipment shall be rated for a standby period of 4hours, when supplying 125% of the maximum continuous load of its associated distribution board.

4.8 Lighting and Small Power Installation

The lighting and small power installation shall be according to Singapore Standard and comprise the following:

- Permanent lighting installations, comprehensive system of battery powered emergency lighting systems, road lighting, and area floodlighting, utilizing energy efficient devices and light sensitive initiation controls and auto switch off timers in low manning areas.
- Small power, socket outlets, connection units for plant areas, equipment and control rooms, office areas, maintenance and testing areas, and domestic items.
- Secondary distributions of cables, distribution boards, supplies for transportable and fixed equipment, welding plant, environmental plant, and sump pumps.

Where areas are classified as hazardous areas due regard must be given to the requirements, limitations and classifications of equipment in accordance with IEC 79. The lighting installation shall be designed to give, under normal operating conditions and throughout the station's operational life, the Illuminating Engineering Society (IES) recommended minimum levels of illumination in such a manner as to ensure evenness and to avoid glare.

4.8.1 Emergency lighting

A section of the main lighting installation shall be operated as an emergency lighting scheme. The emergency lighting shall be supplied separately from the normal lighting and shall be kept energized from the emergency switchboard on failure of the electrical supply to normal lighting in the relevant area.

4.9 Cable System

4.9.1 General

The cable installation shall include all cables required for the supply, control, indication and monitoring of all plant. The installation shall be complete with all cable terminations, cable trays, cable ladder racks, junction boxes and accessories. For demin and chemical skids, corrosion resistant cable trays to be used (FRP preferred). Cable tunnels shall have fire fighting system and dedicated cable floors and chambers shall have deluge system.

4.9.2 Power Cables

a) HV Power Cables

66kV cables shall be single core, with copper conductor, XLPE insulation, copper wire screen, aluminum laminated sheath, halogen-free and flame retardant HDPE

sheath. The HV power cables shall comply with IEC 60840 or 62067 and ANSI S-108-720-2004, as applicable, supplied in the required length, straight-through joints are not permitted. Developer is responsible for complete supply of all required accessories. The cable shall be laid on cable trays, in cable tunnel or into the ground in such case the cable shall have aluminum armour.

b) MV power cables.

MV cables shall be single core or multicore, with copper conductor, XLPE insulated steel wire armoured, aluminum in the case of single core cables, and sheathed with flame retardant PVC. This MV cables shall comply with the relevant parts of IEC 502 and IEC 811.

c) LV power cables.

Cables shall be 600/1000V grade, single core or multicore XLPE insulated, steel wire armoured, aluminum in the case of single core cables, and served with flame retardant PVC. This LV cables shall comply with the relevant parts of IEC 502 and IEC 811.

4.9.3 Control Cables

a) Multicore Control Cables

The cables provided shall comply with the latest applicable IEC standards.

All cabling (except fiber optic cables) and wiring supplied shall have copper conductors, thermoplastic insulation and thermoplastic inner sheath. All cabling and wiring shall be of the flame retardant type and during combustion shall emit no halogen gases and produce minimal smoke.

b) Pilot Cables

Multicore pilot cables shall have copper conductors, thermoplastic insulation, thermoplastic inner sheath, galvanized steel wire armour and thermoplastic sheath overall.

4.9.4 Laying and Terminating of Cables

Where practical, cables shall be laid in cable subways, shafts, pipes, ducts and troughs. Cable trays should be filled by not more than 60% of their space and trays to be covered. It shall be noted that direct burial of cables is not permitted; PVC ducts shall be used. The ducts shall be designed and tested for 100% water removal.

4.10 Earthing and Lightning Protection System

4.10.1 Earthing System

The earthing system shall conform to the relevant sections of BS 7430, IEC 364-5-54, IEEE 80 and IEEE 665. There are to be separate direct connections to earthing rods and the station main earthing system from all low voltage, medium voltage and high voltage system neutrals.
The instrument earthing has to be a separate system.

4.10.2 Lightning and Surge Protection

A complete lightning protection system comprising a roof network and down conductors shall be installed to protect station buildings, chimneys and other important areas in accordance with the requirements of BS 6651 and the SS 555.

4.11 Back-up / Emergency Diesel Generator Set

An emergency diesel generator set shall be supplied to support the Plant during a black-out, or other emergency condition and as such shall be sized to keep critical equipment operating to supply chilled water to DCP.

5. Control and Instrumentation System

5.1 General

5.1.1 Design Philosophy

All Control and Instrumentation equipment necessary to allow the safe and efficient operation of the Plant shall be supplied. A consistent control, instrumentation and data acquisition philosophy shall be applied throughout the design. The objective shall be to standardize all equipment, wherever possible, throughout the plant in order to rationalize operation, maintenance and reduce spare parts. In general, all equipment shall be of modern compact design, latest to date incorporating well proven technology and supplied from one composite range as marketed by a reputable international manufacturer.

The Plant shall normally be controlled and monitored from a central control room (CCR) using a Distributed Control Monitoring and Information System (DCMIS). A PLC shall be supplied for chilled water plant control and operation, which shall be hooked up to the DCMIS for monitoring purpose. Local control equipment may also be installed; however these shall be equipped with local/remote selection, and used for commissioning and maintenance only. Equipment that are normally used for maintenance such as EWS, PMS, etc., shall be accommodated separately.

All C&I equipment shall be supplied by redundant uninterruptible power supply (UPS) systems, supplied by two independent UPS sources (i.e. totally separate power supplies), using two independent rack power supply cards.

5.1.2 Redundancy

The Developer shall provide control, interlock and protection systems including field sensors, drive equipment and accessory devices in accordance with requirements stated below:

No single failure of instrumentation, electronic module or communication link shall lead to facility trip. All transmitters and sensors, which directly or indirectly trip the facility, shall be in triplicate and arranged in two-out-of-three voting logic. Redundant control and protection systems shall be employed to ensure high availability. All trips shall have TMR (triple modular redundancy from instrument to control. DCMIS IOs are designed in such way that tripping on one panel should not lead to equipment or facility trip. All local panels shall have dual power supply units (24V) from UPS1 and 2. No single point failure for any equipment or communication paths. The system shall comply with EMA code for redundancy.

Dual redundancy shall be provided for all communication cables and channels.

5.2 Operation Philosophy

Control, in general, shall be from the Central Control Room (CCR) and shall be based on a DCMIS with redundant configuration. All functions will be performed via the DCMIS display screens with the minimum of conventional desk controls and displays. Therefore, other than emergency stop buttons, there will be no desk controls for the operation of the plant, and no alarm panels.

All plant operation will be through the DCMIS and plant history (chart records, sequence of events, etc) with DCMIS or OPC, if necessary, facilities for hard copy reports from the DCMIS or OPC printers shall be provided. All operator logs can be entered into the DCMIS and so these logs, alarm records and daily reports can be made available through the DCMIS displays or remotely by data communications (Ethernet) links to a remote computer system.

The Developer shall ensure no single failure of instrumentation, electronic module or communication link shall lead to plant trip.

5.3 Control and Monitoring of the Plant

5.3.1 General

Provision shall be made within the control, instrumentation and alarm equipment to allow the automatic control to be fully co-ordinated.

Control system shall be designed in such a way at any time the Plant should meet the rated demand without any major operator intervention in any condition.

5.3.2 Grid Frequency Response

The unit master control system shall be designed to be frequency sensitive and to control the unit output response in accordance to the Singapore Transmission Code and any other latest requirements or revisions specified by Power Grid to achieve grid frequency control.

5.3.3 Power System Control Centre Interface

The unit control system shall be designed to accept load demand signals from the Power System Control Centre (PSCC) and Backup Control Centre (BCC) of EMA/PSO. RTU shall be provided to communicate with PSCC, BCC and the signal exchange with Power System Operator (PSO) shall be as per the Transmission Code requirements.

5.3.4 RTU signal exchange with Gas Suppliers

The DCMIS shall be designed to carry out the signal exchange between DCMIS and the respective RTU of the Gas Suppliers.

5.4 Distributed Control Monitoring & Information System (DCMIS)

5.4.1 General

The DCMIS shall obtain plant data from a set of nodes interfaced to the local control and instrumentation for plant area. The Developer shall submit the proposed DCMIS architectural drawing along with the proposal.

The DCMIS shall be designed to have an availability of 99.98% by the inclusion of built-in redundancy for both hardware and software. This shall include redundant control processors, communication modules, data highway and power supplies with automatic changeover to the standby unit upon detection of a fault or failure of the operating unit. Where appropriate, I/O cards shall also be redundant. The failure of any single element shall not affect the operation of any item of operating unit. In particular, the redundant control processors, communication modules and power supplies shall be capable of fail over without any change to the unit status, sequence status or control actions, at any stage of Plant operation.

An OPC server shall access data point plant wide from DCMIS using client/server technologies and shall provide capability to retrieve, display and store the information from the DCMIS and historical data storage systems. The system shall be an independent system connected to DCMIS with security protection to avoid unauthorized usage. The communication shall be one way and shall not affect any of the DCMIS functions. The Developers proposal shall fully explain the security methods.

The system design shall be such that failure of the DCMIS shall not affect the safe operation of the plant.

5.4.2 Proprietary Package systems and DCMIS interfaces

For proprietary package systems, the Developer shall utilize control and monitoring equipment from the same manufacturer that will supply the DCMIS. The Developer shall fully integrate these proprietary subsystems into the DCMIS.

5.4.3 Sequence of Events

A sequence of events monitoring system (SEM) shall be supplied to allow analysis of the causes of trips or plant disturbances. The SEM recorder shall be integrated within the DCMIS on a dedicated processor.

5.4.4 Plant Metering and Monitoring

In addition to metering for process control, operation and trending there shall be metering for performance monitoring and for emissions monitoring. The data shall be actual values and integrated values and shall be available for display, logging and transmission over a communication link to an off-site computer system and as printing on a regular basis as logs for performance monitoring and integrated pollution control purposes.

5.5 Emergency Shutdown System (ESD)

The Safety Related System (SRS) shall be an emergency shutdown system that shuts automatically discrete equipment, a system, or the Plant, in a safe and controlled manner, in the event of abnormal operating conditions which could cause permanent damage to the plant endangering human safety or exceed operating limits to the detriment of plant life. The SRS shall include all the sensors, logic, and final elements needed for the safety function.

The SRS system shall fulfill the requirements of EN 61508 and IEC 61511 or equivalent.

5.6 Central Control Room (CCR)

The Developer shall propose the control room layout diagram in the Proposal clearly showing the location of operator station and engineering station of DCMIS and other peripherals.

5.7 GPS Master Clock System and Time Synchronization

A Global Positioning System (GPS) master clock system with slave clock shall be provided to synchronize the DCMIS and other plant control systems.

5.8 Continuous Emission Monitoring System (CEMS)

A CEMS shall be provided to monitor the emission levels at the stack outlet of the pollutant parameters. Indication and recording of O_2, CO, SO_x, NO_x, opacity and flue gas temperature shall be provided to the DCMIS. Monitor fault alarms shall be raised on the DCMIS to indicate failure of each individual monitor.

CEMS shall have facility to communicate with authorities such as NEA.

5.9 Gas Metering

A metering system shall be supplied at the main Gas Reception Area for gas supply sources.

Each metering system of the gas supply source shall consist of two full metering trains. Each metering train shall comprise of one ultrasonic flow measuring instruments. Gas supply source shall have one sampling line for Caloric Value measurement. Sampling lines of gas supply source shall be connected to two (Main and Check) Gas Chromatograph meters.

The following transmitters suitable for Gas monitoring shall be provided:

- Volumetric flow rate (instantaneous & total), corrected to Normal Conditions. The principle of Ultrasonic Flow Meter with Flow computers shall be used for gas mass flow measurements at the Gas Reception Area. USM flow meters shall be capable of accuracy to within ±0.3%.
- Flow Computer complete a flow/energy computing system with live temperature and pressure compensation and volume correction in accordance with ISO 12213 and from Calorific Value meter for computation of energy flow and compressibility shall be provided. The flow meter shall be provided with a pulse/analogue interface to enable remote monitoring at DCMIS
- The GC to measure the Calorific Value shall be located in a suitable housing located adjacent to the gas sample point to reduce gas sampling pipe run to a minimum. All materials exposed to the sample shall be stainless steel. Calibration and carrier gas

bottles shall be provided together with all accessories and fittings. The process controller shall be located remote from the GC meters in a non-hazardous area (local control room.

5.10 Programmable Logic/Process Controllers (PLC'S)

PLC based controllers may be provided for packages that only have a small number of inputs/outputs. They shall be interfaced to the DCMIS in a manner appropriate to the intention of control and monitoring of the Plant from the CCR using the DCMIS. PLCs shall be provided with redundant processers, power supply and communication.

Portable PC type programming tools with color monitors and printers shall be provided.

5.11 Field Instruments

5.11.1 General

All parameters (e.g. flow, level, pressure, temperature, analysis) for indication on local control panels or control panels remote from the point of measurement shall utilize SMART transmitters (4-20mA with superimposed HART signal) with local indication, which convert the measured parameter into a standard direct current electrical signal.

The allowable accuracy for meter to meter validation shall be ±1.0% for check meters measurements and systems that involve commercial issues like GRA gas flow measurement, chilled water metering, etc.

5.11.2 Analytical Instruments

Analytical instruments monitoring chemical or physical properties of process fluids and substances may be installed either directly in the process line or vessel or at a distance and connected by means of sampling systems.

5.11.3 Vibration Monitoring and Analysis System

Provision shall be made within the C&I to monitor and analyze the vibration of gas turbine/gas engines, steam turbine and generators, chiller compressors, etc.

Vibration sensors, monitors and analyzers shall be provided for all large pumps/motors.

Display vibration levels with alarm and trip level shall be indicated in CCR via DCMIS.

6. Civil and Structural Works

6.1 General

All civil, structural and architectural work, systems, buildings, facilities, equipment, tools, materials, etc., required to complete the works shall be provided, unless otherwise specified.

All civil, structural and architectural design shall be carried out in accordance with the latest edition of the relevant codes, standards and all applicable statutory regulations and shall meet the requirements of the Local Authorities.

The Developer shall ensure that during the design of facilities, proper provision is made to facilitate:

- Economical and efficient operation and maintenance;
- Easy and unrestricted access with appropriate equipment and transport to all locations;
- Sufficient lay-down areas near all equipment to facilitate disassembly and removal;
- Escape routes for personnel from all areas of the Plant and in particular the CCR and electrical rooms, and,
- These escape routes shall permit and ensure direct egress from the buildings without the necessity to pass through the plant equipment areas.

6.2 Site Survey Requirements

The Site Survey shall cover all surveys required for design, planning, work in progress and "work as executed" (this shall include permanent benchmarks) in accordance with locally approved systems.

The developer shall establish the grid coordinate system and transfer the coordinates from a known benchmark to set up coordinate system with ground levels by approved methods of survey.

6.3 Ground Conditions

It is the responsibility of the Developer to make investigations to determine the geotechnical conditions at the Site and shall design and construct the foundations and substructure to suit the actual ground conditions. Whatever information provided in this regard by Stakeholders is for indicative purposes only. Refer Annex 3 for initial indicative borehole details from adjacent site.

6.4 Earthworks

The Developer shall provide all earthworks necessary both for the establishment of the site and for the completion of all the Works, including all services.

Formation level of the area shall be established by developer with reference to the HFL (High Flood Level). The levels shown in the Layout of Power and Chilled Water Plant drawing are indicative only.

6.5 Civil and Structural Engineering Design Requirements

Design loads and load combinations for all buildings, structures, structural elements and components, handrails, guardrails, and connections shall be determined in accordance with SS/BS codes, as applicable.

6.6 Concrete Works

All concrete work shall be carried out in accordance with applicable Singapore Standard Code of Practice.

6.7 Structural Steelwork

All structural steelwork shall be carried out in accordance with BS/SS Code of practice acceptable to local Singapore authorities; where migration to Euro Codes are acceptable to local Singapore authorities, applicable Euro Codes shall be applied.

6.8 Underground Services

All underground piping and services required to support the facility shall be provided. Where practical, pressurized water pipes, gravity drains and electrical and communications cables, Chilled water reticulation pipes, Earth grid rods and straps outside of the main plant buildings shall be placed underground to give the least disruption to plant access during construction, operation and maintenance.

Within the main plant buildings these services can be reticulated above ground to more readily interface with associated plant.

6.9 Drainage

Storm water drainage system shall be designed to comply with PUB, NEA and other local regulations. Maximum rainfall intensity shall be in accordance with NEA's latest available data.

6.10 Electrical Conduits and Pits

Cable pits shall be precast concrete or similar approved material. Pit covers shall be rated to sustain the expected loading from pedestrians and Site traffic applicable to their location. Cable pits shall be designed with appropriate drainage to prevent the accumulation of water within them. All conduits shall be encased in mortar with the remainder of the trench filled as applicable to resist external loads.

6.11 Plant and Equipment Foundations and Sub-Structure Systems

Substructures, including basins, pits, and foundations for buildings, machines and equipment shall be of a quality and rigidity fit for the intended service and environmental

conditions. The structures shall be founded in such a way that settlements of any kind are limited or avoided.

Developer shall analyze (including sub-soil reactions), design and construct the equipment foundation so that no vibration problems occur during operation. The main equipment foundation shall be isolated from adjacent construction in order to minimize transmission of vibrations to surrounding structures.

6.12 Building Works

The Developer is responsible to provide complete plant buildings solutions including infrastructure within the allocated area of 3.8Ha (maximum). It includes superstructure, substructure, foundation, architectural work, roads, landscaping, cooling water inlet and outlet, pump house, etc.

The buildings shall satisfy structural and functional requirements and facilitate efficient operation, handling and maintenance activities.

Structures, systems and operations shall be planned, designed and constructed in such a manner that no single failure can lead to hazard or accident. The buildings shall be designed to reduce noise and heat transfer to the environment.

Penetrations by block-outs for cables between hazardous and non-hazardous areas shall be gas tight sealed with non-flammable composites or purpose made cable transits. The transits shall not reduce building construction or class.

6.13 Architecture

The exterior architectural systems shall provide a durable, weather tight enclosure to protect systems and personnel and allow for a controlled interior environment.

The architectural design of buildings, sound attenuation, and all associated facilities shall seek to balance functional, aesthetic, and economic considerations; and minimize the visual impact on the surround area.

ANNEX 3: INDICATIVE SOIL INVESTIGATION REPORT

ANNEX 4: DRAWINGS