Mandatory Energy Audit of

Lakwa Thermal Power station (APGCL)

Charaideo, Maibela,Assam

Submitted By

ENERGY CONSULTANCY SERVICES

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Acknowledgement

Energy Consultancy Services, Bhubaneswar (ECS) is thankful to the management of Lakwa Thermal Power Station (LTPS), a gas based power plant of APGCL at Maibella Dist.. Charaideo - Assam, for giving us the opportunity to carry out Mandatory Energy Audit Study of LTPS unit as per Bureau of Energy Efficiency Regulations 2010 . ECS team is also thankful to all other supporting Officers / Staffs of LTPS for their whole-hearted support, hospitality and the courtesy extended to the Audit team during the course of the study. Details of officers extended courtesy and support during energy audit study are as below:

Name of Person	Designation	Name of Person	Designation
Sh. Pankaj Bikash Sharma	AGM(LOD)	Sh. Vikash Sharma	AGM(LRPP)
Smt. Ashrulima Borah	AGM(HR)	Sh Alik Das	DM
Shri Amit Ranjan Laskar	DM	Sh. Rajat Ghosh	DM

Following team members were engaged in this study and visited the AGBPS unit from 21.01.2022 to 24.01.2022

- Shri Amulya Kumar Mohini – BEE Accredited Energy Auditor, AEA-002
- Shri. Jitendra Kumar – Energy auditor
- Shri Ashok Nanda - Energy auditor
- Shri Upendra Patra - Electrical Engineer

Amulya Kumar Mohini
Director, ECS, Bhubaneswar

Abbreviation

Abbreviation	Description
ACW	Auxiliary Cooling Water
AEA	Accredited Energy Auditor
APGCL	Assam Power Generation corporation Ltd
BFP	Boiler Feed Pump
CEP	Condensate Extraction Pump
CCPP	Combined Cycle Power Plant
CT	Cooling Tower
CW	Cooling Water / Circulating Water
DBT	Dry Bulb Temperature
DC	Designated Consumer
DP	Differential Pressure
GCV	Gross Calorific Value
GT	Gas Turbine / Generation Transformer
HP	High Pressure
HRSG	Heat Recovery Steam Generator
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
kcal	Kilo Calorie
kVA	Kilo Volt Ampere
kVAh	Kilo Volt Ampere-Hour
kVAr	Kilo Volt-Ampere Reactive
kWh	Kilo Watt-hour
LP	Low Pressure
LRPP	Lakwa Replacement Power Project
LT	Low Tension
LTPS	Lakwa Thermal Power Station
MW	Mega Watt
MWh	Mega Watt hour
NCV	Net Calorific Value
NG	Natural Gas
TPH	Ton per Hour
MU	Million Unit
MTOE	Million Tons of Oil Equivalent
RPM	Rotations Per Minute
SCM	Standard Cubic Meter
STG	Steam Turbine Generator
STP	Slandered Temperature Pressure
THD-I	Total Harmonic Distortion in Current
THD-V	Total Harmonic Distortion in Voltage
VFD	Variable Frequency Drive
WBT	Wet Bulb Temperature

Executive Summary

As per the gazette notification issued by the ministry of Power, it has become necessary for all designated consumer to follow all the guidelines of PAT scheme based on the target assigned by BEE. One mandatory Energy audit to be conducted during PAT cycle of three years in which DC shall be recommended to follow the recommendation as per form 2 duly certified by the Accredited Energy auditor. MEA study will help to reduce the demand & supply gap to some extent and protect our ozone layer as well as our environment. In general, Energy Audit is identifying the areas where waste can occur, and where scope for improvement exists. Ultimately, it will reduce the energy demand at same level of outcomes.

In view of above , the Ministry of Power, Government of India has enacted the Energy Conservation Act, 2001 and in March 2007 (Under section 14 (e) of the Energy Conservation Act 2001,) National Mission for Enhanced Energy Efficiency has been designed and M.O.P. has further notified Nine Energy Intensive establishments i.e. industrial units / others, as Designated consumers, e.g. Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel, Aluminium and Railways. It defines the threshold Energy consumption limit for each designated consumer.

M.O.P has further notified regulations for Manner and Intervals of Time for Conduct of Energy Audit On 28th April 2010 vide Gazette Notification No. 02/11(6)/05BEE, & enacted S.O.1378 (E) Dated 27th May 2014, where in it has issued detailed guidelines for getting the energy audit conducted by each D.C once within three years. With this objective, mandatory Energy Audit of has been carried out.

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COMPANY PROFILE

LTPS is a unit of Assam Power Generation Corporation Ltd (APGCL). In 2004, APGCL came in existence after reform in power sector under electricity act 2003. Prior to this reform in power sector, generation, transmission and distribution of power was solely managed by Assam State Electricity Board (ASEB). But in due course of time as demand of electricity increased substantially in the State of Assam, ASEB was unbundled to diversify the management of board into three distinct sectors i.e. APGCL (generation), AEGCL (Transmission) & APDCL (distribution). One of the main reason for this unbundling was to improve the quality of service to the consumers and also to extend the supply of electricity to the for flung areas of Assam, which are still devoid of electricity power.

Foundation of Lakwa Thermal Power Station (LTPS) at Maibella was laid down in the district of Charaideo , Assam, on May 22, 1978 for installation and commission of 3X15 MW Gas Turbine under Phase-I program. LTPS was dedicated to nation with the commissioning of three gas turbine of total capacity 45 MW in 1981. The Gas turbines was supplied by Westinghouse Canada Ltd Canada, and M/S ONGC had agreed to supply natural gas to LTPS for generation of power. Fourth Gas turbine of same capacity was commissioned in 1986 and it was supplied by Mitsubishi Heavy Industries Japan after commitment of 0.17 MMSCMD additional gas supply from M/s ONGC was received.

LTPS further enhance their generation capacity by installing three additional BHEL/ GE Gas Turbine Units of capacity 20 MW each in 1994 under APGCL program Phase II.. Later on, BHEL commissioned the waste heat recovery boiler (HRSG) and steam turbine of capacity 1X37.2 MW, by converting open cycle system to closed cycle system in 2012.

LTPS had always tried to perform well and outshine as a leading gas based power generation station in North East. In this endeavor to move ahead in time and improve itself, LTPS had successfully completed the installation and commissioning of a 69.755 MW (7X9.965 MW) Gas Engine based power plant in April 2018 under APGCL project LRPP (Lakwa Replacement Power Plant). This project was completed through an EPC contract between APGCL and M/S Wartsila Finland OY jointly with M/S Wartsila India Pvt Ltd which is a replacement of the old Phase -I power house of LTPS. This is a step towards incorporating newer state of the art of technology and thereby moving ahead towards a better future.
LTPS pride themselves with operating almost 23 years old Gas Turbine successfully and commissioning of state of art new technology based gas engine
LTPS is equipped with a wealth of construction and operations experience, and their human resource is committed to harness the huge power potential of the country with minimal impact on the environment.

GOALS AND OBJECTIVES OF THE ENERGY MANAGEMENT PROGRAMME

Goal and Objectives LTPS is as follows,

- To generate cost effective power,
- To use Fossil fuel efficiently.
- To optimize CO_2 emission, for minimum environmental impact
- To identify energy conservation areas,
- To implement real time data monitoring system. (SCADA system)
- To reduce maintenance period and cost.
- To manage cogeneration Steam & Electricity
- To improve load factor of station
- To implement energy conservation focused outreach.
- To implement new and suitable energy conservation technology best available in world.
- To provide training to staffs to familiarize with latest & new Technology.

To achieve the objective of energy conservation program, LTPS has replaced old gas turbine of Phase I unit with new Lakwa Replacement Power Project (LRPP) to efficiently increase the power generation of the APGCL.

The salient feature of LRPP unit,

- Total power generation capacity = 69.755 MW
- No. gas engine installed = 7 no.
- Capacity of each gas engine = 9.965.MW.
- Total LRPP project cost =Rs. 267.50 Crore
- LRPP project commissioned =Apr 26, 2018

Gas Engine Generators

- Gas Engine Make =Wartsila Finland 0y
- Generator Make = ABB Finland 12.46 MVA, 750 rpm
- AVR make = ABB Finland

Gas Compressor

- Gas compressor make =Howden
  (supplied by Kirlosker Pneumatic Co. Ltd)
- Capacity of each gas compressor = 0.19MMSCMD
- Rated Discharge Presser = 6 bar

Transformer

- Station Unit Transformer =2X54 MVA 11/132 kV Schneider make.
- Station Auxiliary Transformer =2X2MVA Voltamp make
- 3.3 kV Station transformer =1X2MVA Voltamp make

Key Benefits of Gas engine

- High Efficiency of 45% and Low Heat rate
- Guaranteed Net Heat Rate of 1901 kcal/kWh & Gross Heat rate 1873 kcal /kWh
- Efficiency of plant remain unchanged at full load or part load
- Starting tine is less
- Suitable for lean natural gas
- Less project area (6.5 bigha) fewer auxiliaries, less water and chemical required as comparison to gas turbine.
- Due to module construction, maintenance is easier, less time consuming and not affect other gas engine power generation.

MAJOR CHALLENGE AND GOALS FOR THE UPCOMING YEAR

Major challenges and goals for upcoming years are as below,

- Availability of fossil fuel (natural gas). In last few years NG production remain almost constant, while demand of NG has been increased.
- Investment constraint in replacement of low energy efficient equipment with high energy efficient equipment.
- Raw water availability, depletion of water day by day will be a big challenge in future.
- Re-utilization of effluent generated in plant will be big challenge in future.
- Power sale price (tariff), cost of fuel is increasing faster than increase in tariff

EXECUTIVE SUMMARY

					Simple Pay
	Measure	Annual Savings		Investment	back
Sl.No.	LTPS	KWH	Rs. Lakhs	Rs. Lakhs	Years
1	Installation of VFD in one no. CEP Pump	190080	6.96	8.00	1.15
2	COST Economics by improving pump efficiency by impeller and Casing coatings CW pumps	297000	11.88	5.00	0.42
3	Cost Benefit Analysis for Reduction of Stages of BFP (1 No)	338580	12.39	5.00	0.40
4	Replacement of reciprocating compressor with new screw air compressor	57816	2.12	6.20	2.93
5	Repair of Insulations/refractories of HRSG	287151	4.24	5.00	1.18
6	Replacement of Fill Pack materials of Cooling Tower	524700	16.79	20.00	1.19
7	Replacement of old 2x36watt ftl with led lamps	136555	5.00	1.05	0.21
8	Replacement of 400watt hpsv with 200watt led lamps	9636	0.35	0.88	2.50
	TOTAL	1841518	59.73	51.13	0.86

CHAPTER 1. INTRODUCTION

INTRODUCTION AND PLANT ESTABLISHMENT

LTPS is owned by public sector Assam Power Generation Corporation Ltd (APGCL), which has now four power generation stations as below,

99.5-MW Namrup Thermal Power Project (NTPS);

167.2 MW Lakwa Thermal Power Station (97.2-MW Phase-II & 69.755 MW LRPP units),

100-MW Karbi Langpi Hydroelectric Project (KLHEP)

9 MW Stage-I & 4.5-MW Stage-II Myntriang Small Hydroelectric Project (MSHEP).

These projects generate between 57 per cent and 76 per cent of their installed capacities.

The Lakwa Thermal Power Station Project, which was conceived in the year 1981, is biggest power generation station among all four unites,

<u>Lakwa Thermal Power Station</u>

Description	Generator Unit	Rating at Base Load	Make	Module Output at Base Load*
Phase II	Gas Turbine # 5	20 MW	. BHEL.	97.2 MW
	Gas Turbine # 6	20 MW	. BHEL.	
	Gas Turbine # 7	20 MW	. BHEL.	
	Steam Turbine # 1	37.2MW	BHEL.	
LRPP	Gas Engine # 1	9.965 MW	Wartsila Finland	69.755 MW
	Gas Engine # 2	9.965MW	Wartsila Finland	
	Gas Engine # 3	9.965MW	Wartsila Finland	
	Gas Engine # 4	9.965MW	Wartsila Finland	
	Gas Engine # 5	9.965MW	Wartsila Finland	
	Gas Engine # 6	9.965MW	Wartsila Finland	
	Gas Engine # 7	9.965MW	Wartsila Finland	
Total Installed Capacity at Base Load				167 MW

The LTPS Project is fueled by Natural Gas from M/S GAIL & M/S Assam Gas Company Ltd (AGCL). The gas from the M/S OIL's off take point is transported through a pipeline laid, owned and maintained by M/S Assam Gas Company Ltd. The gas received at the Project, being at low pressure (4 - 5 kg/cm^2), is compressed to desire pressure for two different consumers i.e. Phase-II Gas Turbines and LRPP Gas Engines. LTPS has three GTs, three waste heat recovery boiler, One STG and seven numbers Gas Engine of total capacity.

In Phase-II unit, Natural Gas is used as the main fuel. Gas turbine cycle comprises of Gas turbine, compressor and combustor. The compressor is the location where the air is decreased in volume and increased in pressure. Compressors come in several forms and use different methods to achieve compression. However, most industrial gas turbine uses an axial compressor. The term 'axial' is given to this type of compressor because in general air flows from the inlet to the outlet parallel to the compressor longitudinal axis. An advantage of this type of compressor is its continuous flow. This compressed air is sent for combustion with fuel in combustion chamber. The combusted flue gas is allowed to expand through a gas turbine, where the work is done by the gas turbine which is coupled with generator to generate electricity. The flue gas exits the gas turbine at a very high temperature. This high temperature flue gas is passed through Waste Heat Recovery Steam Generators (HRSG) where the heat is utilized to generate steam. This steam is used to generate power through steam cycle in a steam turbine.

In LRPP, again Natural gas is used as the main fuel. Gas engine comprises of GPS (gas pressure control system) gas engine and turbo charger. Compressed natural gas and compressed fresh air from turbo charger fed into gas engine to operate the respective generators coupled with engines. High pressure exhaust gas from engine moves turbo charger blades installed in the path of exhaust.

Power generated in both unit at 11 kV and step up to 132 kV level before export to grid.

GENERAL DATA

A		
Brief description of assignment	:	Mandatory Energy Audit of LTPS Maibella. Distt: Charaideo - Assam
Name & Address of Company	:	Assam Power Generation Corporation Ltd, Bijulee Bhawan Paltanbazar Guwahati - 781001- Assam
Address of communication of Auditor Firm	:	Energy consultancy Services, Plot no-n4/183, IRC village, Nayapalli, Bhubaneswa-751015(Odisha)
	B	
Activity	:	Power Generation
	C	
Working	:	24x7 days
No. of shifts	:	Four
Annual Working Days	:	365 days
	D	
Total Power Generation Capacity of Station	:	**167 MW**
Power Export Voltage Level	:	132kV
Annual Power Generation	:	
Import Power in 2017-18	:	Nil
In-house Power Generation through DG	:	Nil (2015 to 2018)

Tariff 2020-21	:	
LTPS	:	Rs. 3.66 per kWh*
NG Purchase Cost	:	Rs...6,043.25/ 1000SCM
Natural Gas consumption	:	Year 2020-21=230571499 SCM Year 2019-20= 246093320 SCM
Average GCV of NG 2017-18	:	9211* kcal/ SCM
Station Gross Heat Rate 2020-21	:	2296.87kcal/ kWh
Station NET Heat Rate 2019-20	:	2616.89 kcal/ kWh
Base Line Net Heat Rate 2014-15	:	3220.85 kcal/ kWh
Targeted Net Heat Rate 2019-20	:	3220.85 kcal /kWh
As per PAT 2 Cycle Net Generation 2014-15	:	873.31 MU

*Above power sale cost (tariff) of company and GCV of NG has been considered for all onward calculations.

SCOPE OF WORK

The Auditor shall carry out Mandatory Energy Audit (MEA) in accordance with S.O. 1378(E) dated 27.05.2014 (Ministry of Power Notification) and as per guidelines/ stipulations of Bureau of Energy Efficiency (BEE), Energy Conservation Act 2001 and relevant Gazette Notifications at LTPS, Maibella, Charaideo, Assam. The energy audit shall be carried out as per methodology specified in the Bureau of Energy Efficiency (Manner and Intervals of Time for Conduct of Energy Audit) Regulations, 2010 and shall submit the **energy audit report along with Form-2**.

METHODOLOGY

- The audit adopts the method of measuring field data using calibrated portable instruments and thermodynamic simulation-based analysis to evaluate the performance of individual major components in the plant and also to assess the overall plant efficiency. The performance assessment typically applied to:
- Comparing actual performance to reference Performance
- Comparing different conditions of the systems and subsystems
- Analyzing the impact of individual equipment performance's variation on overall plant efficiency
- Assessing different energy efficiency measures implementation options
- Measurements and monitoring with the help of appropriate instruments including continuous and/or time-lapse recording, as appropriate and visual observation was made to identify the energy usage pattern and losses in the system.
- Computation and in-depth analysis of the collected data, including utilization of computerized analysis and other techniques as appropriate were done to draw inferences, and to evolve suitable energy conservation plan/s for improvement/ reduction in net heat rate of station

- The methodology of conducting energy audit &energy conservation study at LTPS is given in the form of flow chart below.

Submission of schedule/program of detailed energy audit

↓

Discussion of schedule/program of detailed energy audit

↓

Detailed energy audit field visit (data collection, measurement by instruments available with ECS

↓

Data analysis & report preparation and submission

↓

Technical Scrutiny & Joint discussion on report

↓

Final report submission

INSTRUMENTATION SUPPORT

Instrumentation Support

Some of the instruments used for undertaking the audit include the following:

1. Testo flue gas analyzer: For temperature, CO (ppm) & O_2 % of flue Gas.
2. Digital anemometer: For measuring air flow
3. Hygrometer: For measuring temperature, humidity.
4. Power analyzer - KRYKARD ALM-31: Three phase power and harmonic analyzer
5. Portable clamp on multimeter: For measurement of V, I, kW, kVA, P.F. etc.
6. Lux meter: For measuring the illumination level.
7. Ultrasonic flow meter: For measuring flow of water

8. Digital temperature indicator: For measuring the temperature at boilers, turbine, condenser, economizer, air pre-heater, flue gas temperature. etc.
9. Non-contact infrared digital thermometer: For measuring surface temperature of boiler, steam lines during Insulation audit of Boiler & Turbine.
10. Digital tachometer: For measuring speed of shafts, motors.

ENERGY AUDIT TEAM

Sr No.	Name	AEA/ CEA/ Engineer	Qualification	Experience
1.	Shri. AMULYA KUMAR MOHINI	AEA-002	BE (Mechanical), BOE-Proficiency	30-year Exp in industries & BEE Energy conservation.
2.	Shri Jitendra Kumar	EA-18199	B.E (Mechanical l	10 years- Energy conservation Power Generation, Trans & Distribution, Energy Audit& M&V
3.	Shri. Ashoka Nanda	EA-14995	B Tech electrical	15 years- Energy Audit in all sector
4.	Shri Upendra Patra		Diploma Engineer (Electrical)	5 years in Energy Audit in Industry.

Major Fuel Uses Area

Natural gas is a major source of power generation. Auxiliary consumption is around **5.91 %.**

CHAPTER 2. PROCESS DESCRIPTION

Presently, there are three power units installed at LTPS i.e. Phase II, Phase III (WHRP) and Lakwa Replacement Power Plant (LRPP). In Phase-II unit, four no. gas compressor, three no. GTs installed. While in phase III unit, three no. HRSG and one steam turbine are installed beside other connected utilities. In LRPP unit, three no. gas compressors, seven no. gas engine and one no. GRU (gas regulating unit) are installed and each gas engine is a combination of one gas engine, one AC generator and one turbo charger.

PHASE II POWER GENERATION PROCESS DESCRIPTION

Gas Compressor Section

Natural gas is received from AGCL & GAIL at 3 - 6 kg/ cm2 g and compressed it to 18 kg/cm2 g in gas compressor station and fed to GTs.

Specifications Gas compressors-

Gas Compressor #6, #7, #8

Description	Value
Motor rating	1375 KW
Gas Compressor Type	4RDS2. Reciprocating
Gas Compressor Capacity	0.207mmscmd

Gas Compressor #9

Description	Value
Motor rating	1050 KW
Gas Compressor Type	4RDS2. Reciprocating
Gas Compressor Capacity	0.28mmscmd

Operation-

The natural gas is compressed in two stages. At first, in 1st stage cylinder, gas is compressed to 5 kg/cm^2 g, and then enters into the 2nd stage cylinder, where the it compressed to 18 kg/cm^2 g.

Gas Turbine Generator.

In a gas turbine generator (GTG), fresh air is compressed at about 7- 9 kg/ cm^2 g and mixes compressed NG in combustion chamber. Mixture of fuel & air is burnt in combustion chamber. Internal energy is converted into thermal energy in combustion chamber. A very high temperature & high pressure of flue gas moves through the gas turbine blades make them spin. The fast-spinning turbine drives a generator that converts kinetic energy into electricity.

Heat recovery steam generator.

Flue gas temperature after Gas Turbine remains very high (above 550^0 C) and contents large amount of thermal energy. Waste heat recovery steam generator (HRSG) captured thermal energy from flue gas that would otherwise escape through the exhaust stack.

HRSG is source of super heated High Pressure & Low Pressure steam. Condensate from condenser & make DM water pass through economizer installed in HRSG and then super heated HP & LP steam generates. Both HP & LP steam send to STG.

Steam turbine.

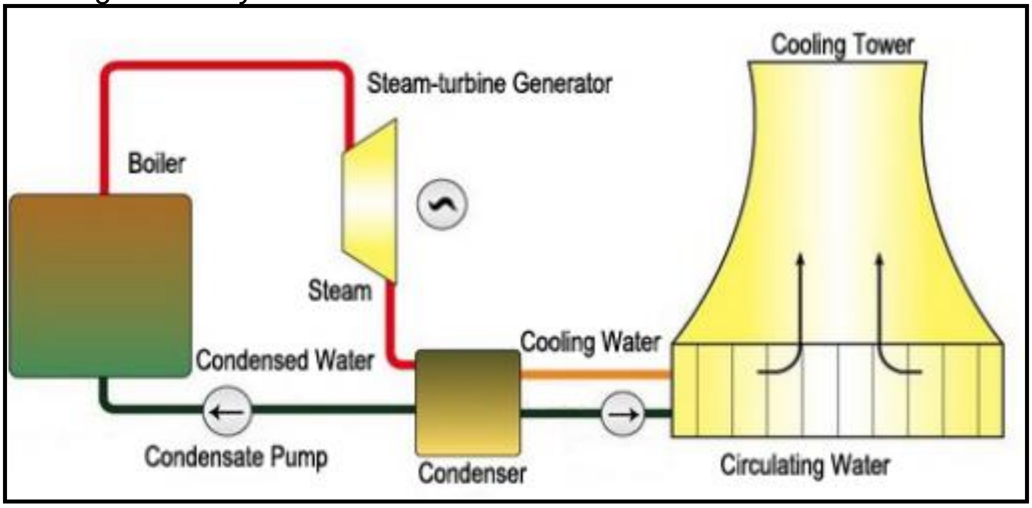
STG is dual cycle steam turbine, HP & LP. LP & HP super heated steams from HRSG enter into Steam Turbine Generator (STG), where kinetic energy of steam converted to mechanical energy and finally converted in electrical energy. Exhaust of steam from STG is condensed in condenser and condensate sends back to boiler.

Power generated by GTGs and STGs is exported to grid.

Cooling tower

Cooling water is supplied to plant from Cooling Tower. The cooling tower is induced draught type, having nozzles to spray hot water coming out from condenser and coolers into the fill packs and drift eliminator to reduce the drift losses. The induced draught is created by electrical motor driven fan attached with gear reducer.

Cooling Water Cycle



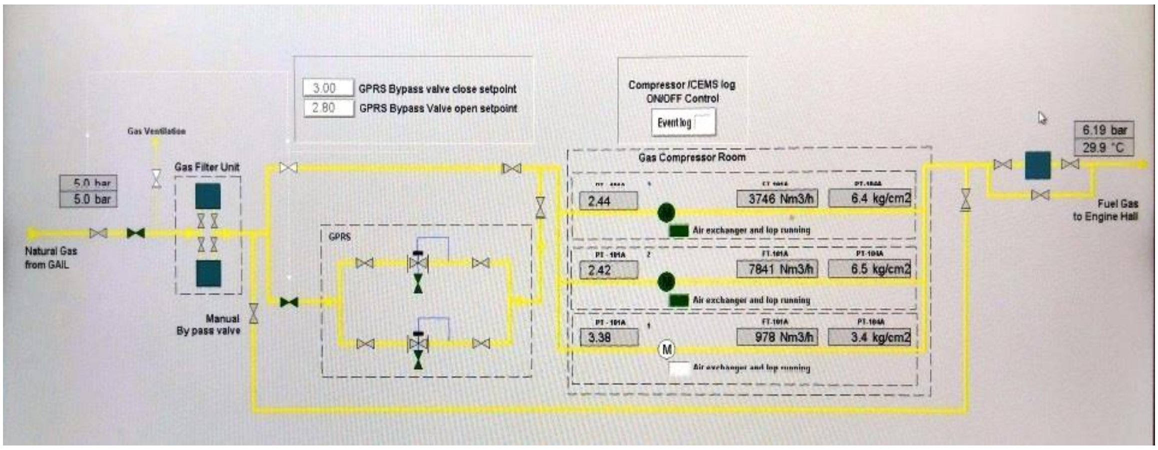
MAJOR FUEL INPUT, QUANTITY & COST

Natural gas is used as major fuel for power generation in Phase II.

LRPP PROCESS DESRIPTION

Gas Regulating Unit (GRU)

Pressure of NG is regulate in GRU, it has a facility to increase gas pressure are by pass the system fully are partial. It depends upon the intake natural gas pressure.



Gas Engine

The principle of operation of a gas engine power plant is similar to automobile. Its fuel, however, is natural gas. The natural gas is kept under pressure according to the demand of engine and it is supplied to the cylinder mixed with air necessary for combustion.
This is done by the turbo compressor. The gas engine works at constant speed after the ignition. The generator connected to the axis of the engine produces the electricity at 11kV. While producing power, the engine also warms up. In addition to this, engine also produces “waste heat”. Such “heat sources” are the heated out lubricating oil. Hot oil is then, cooled by water/ coolant though heat exchanger. Coolant is cooled in radiator installed outside the plant.
The heat rate of gas engine claimed by supplier is much lower than the heat rate combine cycle gas power station.

Radiator

Gas engine generates electric power with great efficiency and at the same time, the generated heat can also be used to a significant extent.
The water returning from the pipes of the district heating systems gets heated. The temperature of the water in the district heating is increased by the released heat from the oil cooler, the mixture cooler and from the very engine through a radiator. The hot water received from distinct heating system is cooled in force draft radiator.

Turbo Charger

The gas mixed with the preheated combustion air is compressed to the required pressure by the turbo compressor driven from the smoke gas side. The heated gas compound cools to the optimal temperature for the gas engine operation in the two-stage mixture cooler. The gas/air mixture burnt in gas engine and the drives the main axle connected to generator. The generator generates power. Hot flue gas again drives turbo charger and compressed inlet fresh air. Temperature of flue / smokes get reduced to 340 to 360 ^{0} C.

CHAPTER 3. ENERGY & UTILITY SYSTEM

ENERGY & UTILITY SYSTEM

List of utilities used in LTPS, Maibella is given as below,

- NATURAL GAS
- STEAM
- ELECTRICITY
- COMPRESSED AIR
- COOLING WATER
- RAW WATER

BRIEF DESCRIPTION OF EACH UTILITY

NATURAL GAS

Natural gas is received from Oil India Limited through pipeline under GTG (gate to gate concept). It is used as a fuel in GBS and GTGs to increase NG pressure and to generate power respectively. In gas booster station, NG is used as a fuel in gas engines to increase NG (raw material) pressure from 3.6 kg/cm^2 g pressure to 21.0 kg/cm^2 g. GBS discharge gas temperature is kept normal through heat exchanger cooling. After cooling, compressed NG is sent to GTG, where it is used in gas turbines to generate power. GCV/ NCV of supplied NG vary time to time along with change in its consumption.

STEAM

NG is burnt in combustion chamber of GTG with fresh compressed air. High temperature & pressure flue gas moves turbine blades and exits out at very high temperature & low pressure. Waste heat of GTG's exhaust flue is recovered in waste heat recovery steam generator (boiler), where flue gas temperature decreases from 550 ^{0} C to 200 ^{0} C (approx.) and generates super-heated steam. Super-heated steam is used in steam turbine for further power generation.

Electricity

Like Other industry, electricity plays an important role in this company also. LTPS is an electricity producer and besides its export, electricity is used in different utility sections e.g., Intake water supply, water treatment section, air compressors station, cooling Water section, HVAC, Office light etc, as an auxiliary including colony supply.

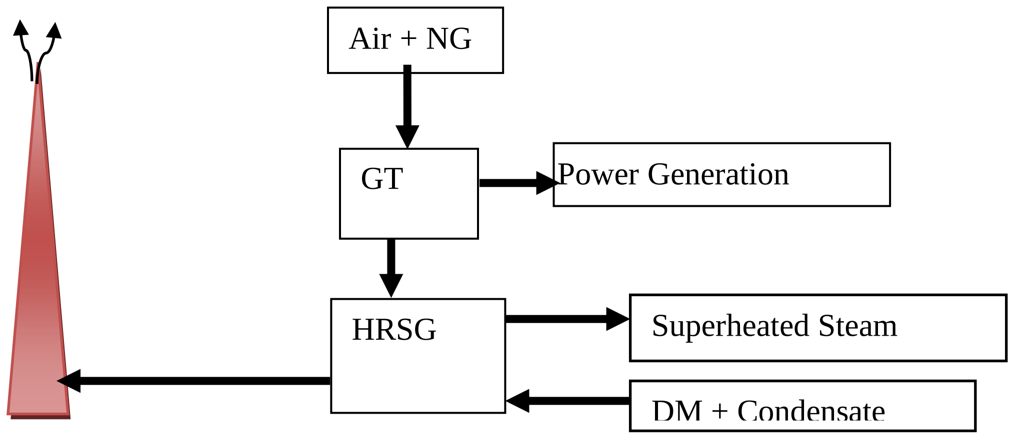
Cooling Water

Cooling water is supplied to plant from Cooling Tower. Hot water received from STG condenser is cooled in cooling tower. Cold water is collected in bottom basin of CT and recirculated again to plant through cooling water recirculation pumps or auxiliary cooling water pumps.

CHAPTER 4. DETAIL PROCESS FLOW DIAGRAM AND ENERGY & MATERIAL BALANCE

PROCESS FLOW DIAGRAM GT & HRSG

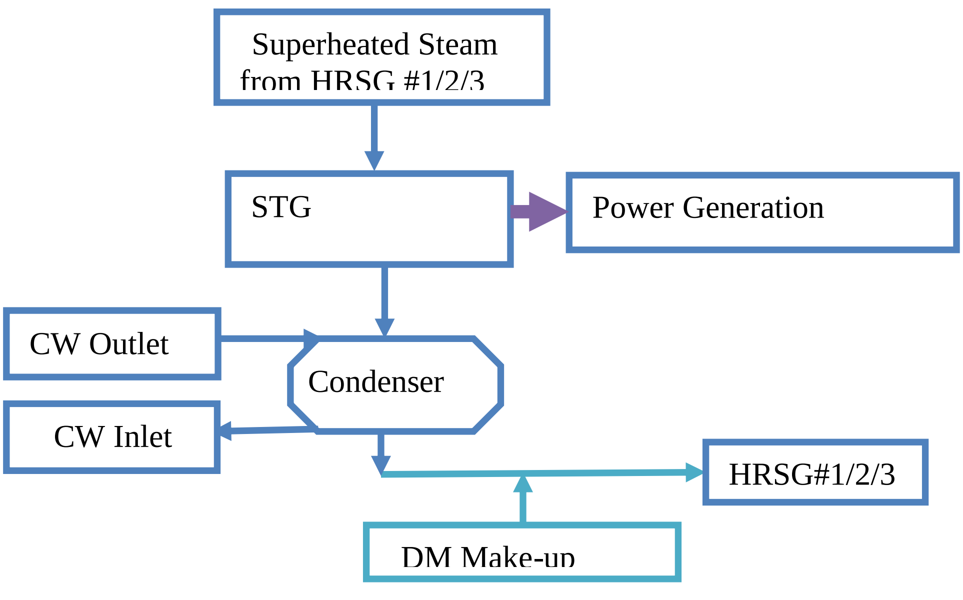
Process cycle for GTs. HRGS and STG adopted in LTPS is given below, value of each input & output entity is given in below table



GTG and Waste Heat Recovery Steam Generator

HRSG & STG SUPER HEATED STEAM

Detail parameter of GT Section



Steam Turbine and Condensate Recovery

GT No.	Description	Flow SCM/	Pressure kg/cm2 a	Temperature °C	Generation MW/ TPH	Remarks
5	Air inlet	-	1.019	25.2	-	
	Fuel inlet (NG)	7675	15.75	-	-	
	Generator output	-	-	-	20.6	
	Super heated Steam Generation	-	51.725	430.36	38.205	
	lp Steam		3.7856	186.56	9.6656	
6	Air inlet	-	1.019	29.2	-	
	Fuel inlet (NG)		15.64			
	Generator output				18.1	
	Super heated Steam Generation		52.575	460.3	38.347	
	lp Steam		3.798	210.96	8.928	
7	Air inlet	-				
	Fuel inlet (NG)					SHUTDOWN
	Generator output					
	Super heated Steam Generation					

STG	Description	Flow TPH	Pressure kg/cm2 G	Temperature °C	Generation MW/ TPH	Remarks
1	Super Heated HP Steam Inlet	76.552	52.15	445.33		
2	Super Heated LP Steam Inlet	18.5936	3.7918	198.76		
	Generator output				20.568	
	Condenser		-0.939	48.15		
	Average CW Inlet to condenser		2.497	21.1395		
	Average CW Outlet from condenser		1.7	32.9295		

ENERGY BALANCE PHASE II

GT#5 and connected waste heat recovery boiler was under shutdown during site visit, thus avoid for calculation.

ENERGY BALANCE OF GT& HRSG

	Energy balance of GT				
Sl No	Description	Unit	GT#5	GT#6	GT#7
Input					
1	Natural gas consumed during test	SCM/h	7675	7400	7496
2	GCV of NG (average)	Kcal/SC M	9211	9211	9211
3	Total Heat Input to GT	Kcal /h	**70694425**	**68161400**	**69045656**
Output					
4	Gross power generated during the test	MW	20.6	18.1	17.18
4i		Kcal/h	**17716000**	**15566000**	**14774800**
	HEAT RATE	Kcal/kwh	3431.77	3765.82	4018.96
	GT Efficiency		**25.06**	**22.84**	**21.40**
		kcal/hr	**17716000**	**15566000**	**14774800**
Losses in generator					
5	Generator efficiency	%	98	98	98
6	Loss in Generator	Kcal/h	361551.02	317673.47	301526.53
Radiation losses					
7	Radiation losses	%	2	2	2
	Radiation losses	Kcal/h	1413888.5	1363228	1380913.12
8	Unaccounted loss	%	2	2	2
		Kcal/h	1413888.5	1363228	1380913.12
9	Total loss (6+7+8)	Kcal/h	**3189328.02**	**3044129.47**	**3063352.77**

	Energy Balance of HRSG				
Energy available at GT exhaust			HRSG #1	HRSG #2	HRSG #3
10	Heat available to HRSG from GT exhaust (3-4i-6-7)	Kcal/h	**49789096.98**	**49551270.53**	**51207503.23**
	Energy available at GT exhaust				
	Heat available to HRSG from GT exhaust	Mcal/h	49789.10	49551.27	51207.50
11	**Energy available in Generated super Heated Steam at GT exhaust**				
	HRSG HP Steam Pr	kg/cm2	**51.79**	**52.643**	**51.375**
	HRSG HP Steam Temp	Deg C	**340.4**	**456.31**	**438.13**
	HRSG HP Steam Flow	TPH	**40.89**	**32.374**	**40.901**
	Heat in HP Steam Enthalpy	kcal/kg	725.908	795.112	785.171
	Heat available in HP steam		25320232.92	22287297.57	27750960.39
	HRSG LP Steam Pr	kg/cm2	**3.79**	**4.06**	**3.87**
	HRSG LP Steam Temp	Deg C	**198.76**	**204.27**	**181.58**
	HRSG LP Steam Flow	TPH	**8.66**	**8.92**	**8.50**
	Heat in LP Steam Enthalpy	kcal/kg	681.947	684.441	672.978
	Heat available in L P steam	KCAL	4979511.15	5155361.40	4815231.89
	Net Heat transfer to Steam	MCal	30299.74	27442.66	32566.19
	Heat in Feed Water	kcal/kg	106.68	106.68	106.68
12	HRSG Efficiency	%	60.86%	55.38%	63.60%
	Loss as Flue Gas	Mkcal	19489.35	22108.61	18641.31

Energy Balance of STG When GT5 & GT7 are on full load			
Sr No	**Description**	**Unit**	**STG#1**
	Input		
1	Heat added to water/steam in HRSG	Mcal/hr	**100996.6002**
	Output		
2	Gross power Generation	MW	20.403
	Heat rate	**Kcal/kwh**	**4950.09**
	STG Efficiency	%	17.37%
3	Heat converted to Power	Mcal/hr	**17546.58**
	Losses		
4	Loss in steam turbine cycle	kcal/hr	**83450.02**

Unit Heat Rate PHASE II When GT5 & GT7 are on full load			
Sr. No.	**Description**	**Unit**	**Value**
1	Net Power Generation	MW	37.78
2	Net Heat Used	Mcal/hr	139740.081
3	Heat Rate of Unit Open cycle	kcal/kWh	3698.78
4	Efficiency of Unit in Open Cycle		23.25%
5	heat Rate Close cycle	kcal/kWh	2401.73
6	Efficiency of Unit in Closed cycle		35.81%

ENERGY BALANCE LRPP

Description	Unit	GE#1	GE#2	GE#3	GE#4	GE#5	GE#6	GE#7
Input								
Natural gas consumed during study	kg/hr	1372.67	1383	1425.35	1354.63	1383.07	1326.6	1300.94
Inlet gas temperature	Deg C	30	30	30	30	30	30	30
NG Density at STP	kg/scm	0.76	0.76	0.76	0.76	0.76	0.76	0.76
NG Density after temperature correction	kg/scm	0.722	0.722	0.722	0.722	0.722	0.722	0.722
NG consumption	scm	1900.214775	1914.6	1973.14	1875.24	1914.61	1836.5	1800.92
GCV	kcal/scm	9211	9211	9211	9211	9211	9211	9211
Total Heat Input to GE	Mcal /h	17503	17635	18175	17273	17635	16916	16588
Output								
Gross power generated during the study	kWh	8969	9288	9591	9262	9202	8488	9156
Heat Rate	kcal/kWh	1951.49	1898.70	1894.96	1864.92	1916.48	1992.90	1811.74
Efficiency of GE	%	44.07%	45.29%	45.38%	46.11%	44.87%	43.15%	47.47%
Heat Loss	Mcal/hr	9789.54	9647.43	9926.34	9307.53	9721.77	9616.02	8714.09

Overall Gross Heat Rate =1904.45 kcal/ kWh

CHAPTER 5. PERFORMANCE EVALUTION OF MAJOR UTILITIES

LIST OF MAJOR UTLITIES EQUIPMENT OF PHASE II STUDIES

Performance testing of major equipment has been done on the basis of onsite data measurement and analysis of the collected data. The list of major utilities equipment studies are depicted as below,

GAS TURBINE
HRSG
STEAM TURBINE
CONDENSER
COOLING TOWER
PUMPS
AIR COMPRESSOR
Lighting

CHAPTER 6. PERFORMANCE RESULT OF GTG

Performance of GTs evaluated on the basis of data collected on site

GT # 5 was under shut down. GT Efficiency is found low,

Description	Value	Unit
GT -5		
NG Flow	7675	Nm^3/hr
Power Generation	20.6	MW
Temperature of NG	34.8	^{0}C
GCV of NG	9211	kcal/SCM
Heat Rate of Turbine	3431.77	kcal/ kWh
GT Efficiency	25.06%	
Description	**Value**	**Unit**
GT 6		
NG Flow	7400	Nm^3/hr
Power Generation	98	MW
Temperature of NG	34.8	^{0}C
GCV of NG	9211	kcal/SCM
Heat Rate of Turbine	3765.82	kcal/ kWh
GT Efficiency	22.84%	
Description	**Value**	**Unit**
GT 7		
NG Flow	7496	Nm^3/hr
Power Generation	17.18	MW
Temperature of NG	34.8	^{0}C
GCV of NG	9211	kcal/SCM
Heat Rate of Turbine	4018.96	kcal/ kWh
GT Efficiency	21.40%	

HRSG PERFORMANCE

Heat available to HRSG from GT exhaust (3-4i-6-7)	Kcal/h	**49789096.98**	**49551270.53**	**51207503.23**
Energy available at GT exhaust				
Heat available to HRSG from GT exhaust	Mcal/h	49789.09698	49551.27053	51207.50323
Energy available in Generated super Heated Steam at GT exhaust				
HRSG HP Steam Pr		**29.61**	**30.04**	**28.05**
HRSG HP Steam Temp		**475.8**	**459.3**	**409.9**
Heat in HP Steam Enthalpy	kcal/kg	812.993	803.862	777.942
HRSG LP Steam Pr		**29.61**	**30.04**	**28.05**
HRSG LP Steam Temp		**475.8**	**459.3**	**409.9**
Heat in LP Steam Enthalpy	kcal/kg	812.993	803.862	777.942
Steam flow	TPH	53	58	45
Heat in Feed Water	kcal/kg	76.552	104	80
Net Heat transfer to Steam	Mcal/hr	39031.373	40591.996	31407.39
HRSG Efficiency	%	78.39%	81.92%	61.33%

HRSG # 1 & # 3 was on load during site visit, while HRSG # 2 was under shut down. However HRSG #2 datas were collected when it was on load

PERFORMANCE OF STG

Performance of Steam Turbine Generator was evaluated on the basis of site data collection and results are depicted as below,

	Energy Balance of STG when HRSG #1 & HRSG #2 are on load		
Sr No	**Description**	**Unit**	**STG#1**
	Input		
1	Heat added to water/steam in HRSG	Mcal/hr	**79623.369**
	Output		
2	Gross power Generation	MW	20.48
	Heat rate	**Kcal/kwh**	**3887.86**
	STG Efficiency	%	22.12%
3	Heat converted to Power	Mcal/hr	**17612.8**
	Losses		
4	Loss in steam turbine cycle	kcal/hr	**62010.57**

CONDENSER

Performance of condenser has been evaluated as per site data available.

Condenser Effectiveness = (CW outlet temperature- CW inlet temperature) / (condenser saturation temperature - CW inlet Temperature)

TTD Terminal temperature difference TTD=Saturation temperature at condenser pressure-CW water outlet temperature)
Results are depicted as below in table

Lakwa Thermal power plant		
Particulars	**Unit**	**GTS 1**
CW I/L temp.	˚C	18.242
CW O/L temp.	˚C	32.86
Temperature Difference across cooling water	˚C	14.618
Condenser Vacuum	kg/cm2	-0.939
Steam Saturation Temperature	˚C	44.27
Condenser TTD	˚C	11.41
Condenser Effectiveness		56.16%
Condenser ITD	˚C	26.028
Condenser LMTD		17.726

Higher TTD value indicate poor performance of condenser

CHAPTER 7. GAS BOOSTER STATION

PHASE - II
Four gas booster compressors are installed to raise NG pressure to 18.0 kg / cm^2 g in Phase II.

Description	Gas Compressor No.		Unit
	6,7 & 8	9	
Motor Rating	1375	1050	kW
Model	4RDS2	4RDS2	
Type	Reciprocating	Reciprocating	
Capacity	0.207	0.28	mmscmd

Gas Compressor Operation-

The gas is compressed in two stages. At first in the 1^{st} stage cylinder gas is compressed to 5 kg/cm^2. The gas then enters the 2^{nd} stage cylinder where the gas is compressed to 18 kg/cm^2.

Performance of Phase -II Gas Compressor

Description	Value	Unit
Power Consumption Gas compressor #6	1137	kWh
Power Consumption Gas compressor #7	1272	kWh
Total Power Consumption	2409	kWh
Gas Compressed Q	15403	SCM
Suction Pressure P1	6.03	kg/cm2 a
Discharge Pressure P2	18.53	kg/cm2 a
Actual Specific power consumption (SPC)	158.2	Watt/SCM
Design SPC (considering max power loading 90%)	143.5	Watt/SCM
Design Flow	8625	SCM/hr
Volumetric Efficiency	89%	

Combine volumetric efficiency of gas compressor no. 6 & 7 is found approx 90% and consuming around 10% extra from design parameter.

CHAPTER 8. PLANT AUXILIARIES

CONDENSATE EXPORT PUMP (CEP)

Two no. Condensate export pumps are installed, one no. pump is kept on load while other one kept as standby.

LTPS	CEP PUMP		
Particulars	**Units**	**Design**	**CEP-1A**
Flow rate	m3/hr	230	**142**
Net Head	mH	170	**165**
Temperature	DegC		**45**
Type of Fluid			**Water**
Density of Fluid	kg/m3		**1000**
Work Done (Hyd Power)	kW		**63.8**
Input Energy	Motor Rated		180
Voltage	kV		3.3
Current	Amps		34
Power Factor			0.85
Load	kW		165.2
Overall System Efficiency	%	74.9	39%

Efficiency of above CEP Pump is observed as 39 % . Thus, there is an opportunity to save energy by installing VFD .

8.2 BOILER FEED PUMP NO 3

Four no. BFP are installed, one no. pump is kept on load while other one kept as standby.

LTPS	BFP PUMP		
Particulars	**Units**	**Design**	**BFB-B**
LOAD , MW			
Flow rate	TPH	56	**32.11**
suction pr	Kg/cm2		**0.035**
discharge pr	Kg/cm2		**56**
Net Head	mH	1070	**559.65**
Temperature	DegC		**106.19**
Type of Fluid			**Water**
Density of Fluid	kg/m3		**954**
Work Done (Hydraulic Power)	kW		**51.3**
Input Energy			
Motor Rated	kW	3500	325
Voltage	kV		3.3
Current	Amps		55.3
Power Factor			0.9
Load	kW		284.5
Overall System Efficiency	%		18%

Observation :
Pumps efficiency observed at very lower side . It is suggested to overhaul or replace BFP pump in order to save the energy .

INTAKE WATER PUMP HOUSE

Intake water pump house is about 10 km away from power generation plant and two vertical self prime pumps are installed at river DISANG to supply raw water to plant. One number pumps remain in operation at a times, while other kept as standby.
Intak water pump are operates normally 14hrs in a day and supply raw water to plant through pipe lines P1 or P2. Performance of both pumps has been evaluated on the basis of site data measurement and results are depicted as below

LTPS	INTAKE WATER PUMP HOUSE		
Particulars	**Units**	**PUMP 1**	**PUMP 2**
Flow rate	m3/Hr	185	180
suction pr	Kg/cm2	**3.5**	**3.5**
discharge pr	Kg/cm2	**11**	**10.5**
Net Head	mH	**145**	**140**
Temperature	DegC	**35**	**36**
Type of Fluid		**Water**	**Water**
Density of Fluid	kg/m3	**1000**	**1000**
Work Done (Hyd Power)	kW	**73.1**	**68.7**
Input Energy			
Motor Rated	kW	180	180
Voltage	kV	0.427	0.427
Current	Amps	249.33	241.67
Power Factor		0.89	0.85
Load	kW	164.1	151.9
Overall System Efficiency	%	44.54%	45.21%

Observation : One NRV is observed is passing which needs to be attended, . huge water is getting leaked through gland which is wastage of energy

Efficiency of both pumps found below 50%, thus advised to keep both pipe lines in operation to reduce friction losses.

COOLING WATER CIRCULATION PUMP

There are three number (two no. running+ one no. standby) vertical pumps of rating 4815m3/hr installed to supply cooling water from cooling tower to condensers. Cooling water helps to remove heat from condenser and rejected in cooling tower.
Performances of CW pumps are depicted in below table.

LTPS	CW PUMP		
Particulars	**Units**	**CWP I**	**CWP 3**
Flow rate	M3/hr	**4283**	**4222**
suction pr	Kg/cm2	**0.3**	**0.3**
discharge pr	Kg/cm3	2.4	2.4
Net Head	mH	**21**	**21**
Temperature	DegC	**33**	**33**
Type of Fluid		**Water**	**Water**
Density of Fluid	kg/m3	**1000**	**1000**
Work Done (Hyd Power)	kW	**245.1**	**241.6**
Input Energy			
Motor Rated	kW	500	500

Voltage	kV	3.3	3.3
Current	Amps	97.02	93.16
Power Factor		0.85	0.85
motor shaft power	kW	471.3	452.6
Overall System Efficiency	%	52.00%	53.38%

Efficiency of these pumps found nearby 50%. Now more energy efficient centrifugal / turbine pumps are available in market, but investment cost is too high and simple payback period is more than 5 years. Thus, it is suggested here to apply Energy Efficient polymer coating on impellor and casing. It will reduce the friction and improve efficiency of pump.

ACW PUMPS

There are Two no. ACWP pumps installed to supply ACW in STG section for equipment cooling. Normally, one pumps remains on load, while other pumps kept as standby. The performance of ACW pumps has been evaluated and results are depicted in table as below,

LTPS	ACW PUMP	
Particulars	**Units**	**ACW 1**
Flow rate	m3/Hr	316
suction pr	Kg/cm2	**0.3**
discharge pr	Kg/cm3	**4.05**
Net Head	mH	**37.5**
Temperature	DegC	**35**
Type of Fluid		**Water**
Density of Fluid	kg/m3	**1000**
Work Done (Hyd Power)	kW	**32.3**
Input Energy		
Motor Rated	kW	
Voltage	kV	0.415
Current	Amps	102.47
Power Factor		0.84
Load	kW	61.9
Overall System Efficiency	%	52%

8.5 COOLING TOWER

Cooling tower (CT) is an important part of thermal power plant. The primary task of a cooling tower is to reject heat into the atmosphere and it is the biggest sink of heat rejection. Rejected heat from cooling tower is approx 30% total thermal energy in power generation. They represent a relatively inexpensive and dependable means of removing low-grade heat from cooling water. Make-up water source is used to replenish water loss due to evaporation. Hot water from STG section is sent to cooling tower. The cold water exit from the cooling tower is sent back to the STG section or to other units for further cooling of equipment .

Cooling Tower has 6 nos. of cell and each cell have one CT fan. CT fan no. 5 was found in stop position and plant people quoted that they have stopped in to save power.
All five Cells were found in operation during audit visit.

Hot water cooling tower inlet temperature	= 30.90 ^{0} C
Cold water cooling tower outlet temperature	=21.12 ^{0} C
Wet bulb Temperature	= 16.56 ^{0} C
Dry Bulb Temperature	= 23.63 ^{0} C

Temperature difference between wet bulb temperature and cold water is almost 9.79^0 C, which is too high. One reason of higher Δ T is stop of one number CT fan and other reason is chocking of fill material.

Performance Analysis of Cooling Towers

Sl. No.	Particulars	Unit	
1	CW O/L Water Temperature	ºC	30.90
2	CW I/L Water Temperature	ºC	21.12
3	Ambient Wet Bulb Temperature	ºC	16.56
4	Range	ºC	9.79
5	Approach	ºC	4.56
6	CT Effectiveness	%	68%

OBSERVATION : Cooling Tower effectiveness is 68% and running satisfactory.

INSULATION, REFRACTORY AND STEAM / HOT AIR LEAKAGE

Thermography of GTG flue gas duct, HRSG, STG, steam line section of Phase II and heat engine of LRPP was carried out with the help of thermal imager, to find out heat loss particularly from GT duct skin, steam line & STG etc. The major heat loss areas have been identified with the help of thermography report and which are depicted as below in table.

Description	Insulation damaged	Joint Leakage	Average Surface Temperature	Area (approx) m^2
GTG-3 TG Outlet Right Side		√	250	0.50
GTG-3 TG Outlet Right Side		√	250	0.50
GTG-3 TG Outlet Right Side		√	250	0.50
GTG-3 TG Outlet Left Side		√	250	0.50
GTG-3 TG Outlet Left Side		√	250	1.00

Description	Insulation damaged	Joint Leakage	Average Surface Temperature	Area (approx) m^2
GTG-3 Right Side Before Boiler		√	250	0.25
GTG-3 Left Side Before Boiler		√	250	0.25
GTG-3 Left Side Before Boiler		√	175	0.50
GTG-2 Right Side Before Boiler	√		200	0.50
GTG-2 Right Side Before Boiler	√		225	0.25
GTG-2 Left Side Before Boiler			250	0.50
GTG-2 Outlet Right Side		√	250	0.50
GTG-2 Outlet Right Side		√	275	0.50
GTG-2 -Bottom	√		275	1.50
GTG-2 Outlet Left Side		√	275	2.00
GTG-2 Outlet Left Side		√	275	1.00
GTG-2 Outlet Left Side	√		275	0.50

AIR COMPRESSOR

<u>Air Compressor STG Section</u>

There are two no. reciprocating air compressors installed to meet the demand of compressed air in the HRSG plant. Normally, one compressor remains on line as per compressed air demand in plant and other one is kept as standby.

Description	Value	Unit
No. of Air Compressor Installed	2	no.
Compressor remains in operation	1	No.
Type of Compressor	Reciprocating	
No. of Stage	2	no.
No. of receiver	1	no.
Pressure Setting		
Unloading Pressure	6.0	kg/cm^2
Loading Pressure	4.6	rpm
Power	29.53	kW
Year of manufacturing	1995	
Motor Rating	37	kW
Measured FAD	237	cfm
Specific Power Consumption (SPC)	2.07	Watt/cfm

SPC of air compressor is found on higher side.
From above graph, air compressor remains off load most of the time.

Air Compressor GT Section

There are three no. reciprocating air compressors installed to meet the demand of compressed air in GT section. Normally, two compressors remains on line as per demand of compressed air in plant and other one is kept as standby.

Description	Unit	Comp 2	Comp 3
Type of Compressor		Reciprocating	Reciprocating
Year of manufacturing	no.	1990	1990
Motor Rating	kW	15	15
Rated cff@6.2 kg/cm^2	cfm	74	74
Pressure Setting			
Unloading Pressure	kg/cm^2	6.1	6
Loading Pressure	rpm	4.6	4.6
Power	kW	11.35	12.1
Measured FAD	cfm	62	65
Specific Power Consumption (SPC)	Watt/cfm	3.051	3.103

SPC of both air compressors found on higher side. Both compressors are very old and more energy efficient compressors are available in market.

CHAPTER 9. TRANSFORMERS AND DRIVES LOADING PATTERNS PHASE II

TRF / Drive	Hz	Voltage -U1	Voltage -U2	Voltage-U3	Uthd %	Current-1	Current-2	Current-3	Athd %	KW-Total	KVA-Total	PF-Total
CEP-1, 180 KW, 3.3kV												
AVG	49.89	3310.00	3310.00	3309.00	0.9	33.55	32.69	33.42	3.1	167.58	190.44	0.88
BFP-3, 325KW, 3.3kV												
AVG	49.78	3290.00	3292.00	3294.00	0.8	57.34	56.87	56.98	3.7	275.49	325.38	0.85
BFP-4, 325KW, 3.3kV												
AVG	49.99	3291.00	3294.00	3291.00	0.9	62.3	61.9	62.6	3.2	298.25	355.05	0.84
CWP-1, 500KW, 3.3kV												
AVG	49.88	3300.00	3299.00	3298.00	0.7	97.72	96.9	97.65	2.8	447.19	556.70	0.80
CWP-3, 500KW, 3.3kV												
AVG	49.89	3290.00	3299.00	3295.00	1.1	93.14	93.33	92.23	1.8	447.06	530.15	0.84
AOP (AUXILARY OIL PUMP), 75KW, 415V												
AVG	50.02	431.20	432.30	431.40	0.8	65	65.6	64.5	3.5	46.67	48.62	0.96
LP- BFP-2, 15KW, 415V												
AVG	49.99	430.3	431.30	430.50	0.8	20.01	20.15	20.62	3.1	14.66	15.11	0.97
LP- BFP-4, 15KW, 415V												
AVG	49.98	430.10	430.00	429.90	0.9	19.89	18.98	19.56	2.8	14.22	14.51	0.98
AIR COMPRESSOR MOTOR, 37KW, 415V												
AVG	50.4	429.40	428.90	429.60	0.9	27.67	27.49	27.69	3.2	19.51	20.54	0.95
RAW WATER PUMP-II, 37KW, 415V												
AVG	50.2	411.3	412.1	411.6	0.8	50.1	50.3	49.8	3.6	29.99	35.70	0.84

PHASE-2												
GAS COMPRESSOR UNIT #7, 1375KW, 3.3kV												
AVG	49.94	3411	3421	3398	1.3	262.9	264.6	264.1	3.4	1298.76	1558.52	0.83
GAS COMPRESSOR UNIT #8, 1375KW, 3.3kV												
AVG	50.02	3430	3423	3326	1.2	250.3	250.6	251.2	2.9	1237.48	1473.34	0.84
LOAD GEAR VENT FAN-1, 5.5KW, 415V												
AVG	50.03	426.2	426.5	426.9	1.5	8.25	8.26	8.19	2.3	5.11	6.08	0.84
LOAD GEAR VENT FAN-2, 5.5KW, 415V												
AVG	49.95	425.6	426.1	425.9	1.3	8.52	8.57	8.66	2.4	5.34	6.33	0.84
WATER PUMP MOTOR FOR GC#7, 7.5KW, 415V												
AVG	50.05	429.3	429.4	426.6	1.2	6.5	6.65	6.45	2.5	4.43	4.85	0.91
COOLING FAN-1 FOR GC#7, 11KW, 415V												
AVG	49.94	412.3	412.4	412.1	0.9	16.89	16.57	16.99	2.1	10.57	12.01	0.88
COOLING FAN-2 FOR GC#7, 11KW, 415V												
AVG	49.9	411.2	412.3	412.1	0.9	17.2	17.1	17.6	1.7	10.66	12.34	0.86
WATER PUMP MOTOR FOR GC#8, 7.5KW, 415V												
AVG	50.05	428.2	428.6	429.1	1.2	6.47	6.44	6.49	2.3	4.38	4.80	0.91
COOLING FAN-1 FOR GC#8, 11KW, 415V												
AVG	49.94	415.2	415.6	415.9	1	16.35	16.24	16.95	1.9	10.50	11.89	0.88
COOLING FAN-2 FOR GC#8, 11KW, 415V												
AVG	49.9	411.2	412.3	412.1	0.9	16.25	16.3	16.21	1.8	10.17	11.60	0.88
INSTRUMENT AIR COMPRESSOR-1, 15KW, 415V												
AVG	50	408.4	408.9	407.3	0.9	25.8	25.1	24.9	1.8	14.29	17.86	0.80
INSTRUMENT AIR COMPRESSOR-3, 15KW, 415V												
AVG	49.89	408.1	407.6	408.3	1.1	26	25.9	25.7	1.45	14.81	18.28	0.81

AUXILARY OIL PUMP (AOP) FOR GENERATOR #5, 37KW, 415V											
AVG	49.89	422.1	422.3	422	1.2	51.23	51.11	50.3	1.2	32.74	37.20	0.88
LOAD GEAR VENT FAN (TOP) FOR GENERATOR #5, 5.5KW, 415V												
AVG	49.89	411.3	410.6	411.3	1.7	8.25	8.68	8.19	1.5	5.19	5.96	0.87
LOAD GEAR VENT FAN (BOTTOM) FOR GENERATOR #5, 5.5KW, 415V												
AVG	50	410.9	411.2	411.3	0.8	9.2	9.3	9.45	1.9	5.84	6.63	0.88
AUXILARY OIL PUMP (AOP) FOR GENERATOR #6, 37KW, 415V												
AVG	49.89	421.05	421.3	420.9	1.6	52.24	52.06	52.98	1.9	33.65	38.24	0.88
LOAD GEAR VENT FAN (TOP) FOR GENERATOR #6, 5.5KW, 415V												
AVG	49.89	410.3	410.6	411.3	1.7	8.76	8.72	8.77	1.5	5.42	6.23	0.87
LOAD GEAR VENT FAN (BOTTOM) FOR GENERATOR #6, 5.5KW, 415V												
AVG	50	410.9	410.6	411.3	1.1	8.61	8.66	8.59	1.6	5.30	6.14	0.86
CT FAN NO-2, 30KW, 415V												
AVG	49.87	413.3	407.3	408.3	1.1	42.1	42.9	42.5	1.2	25.23	30.15	0.84
CT FAN NO-3, 30KW, 415V												
AVG	49	412.3	407.6	409.1	1.3	43.6	43.1	42.8	1.3	25.73	30.63	0.84
CT FAN NO-4, 30KW, 415V												
AVG	49.08	412.3	409.1	408.6	1.1	42.02	42.3	42.1	1.6	25.54	29.93	0.85
CT FAN NO-5, 30KW, 415V												
AVG	49.8	412.8	409.4	409.7	1.7	44.02	41.05	43	1.4	24.62	30.37	0.81
CT FAN NO-6, 30KW, 415V												
AVG	49.7	410.3	409.2	409.6	1.4	43.6	43.79	43.21	1.6	25.75	30.89	0.83
CT FAN NO-6, 30KW, 415V												
AVG	49.79	411.1	410.3	409.1	1.2	44.02	43.1	42.8	1.6	26.06	30.77	0.85

Observation: -

Power Factor of following Transformer / drives found below 0.7
Aux transformer no.2 5MVAkVA 3.3/0.433 kV
F Station Aux transformer no.1 2.5 MVAVA 3.3/0.433 kV
J Air Compressor 50 HP
Gas compressor no.2 460 kW 3.3 kV
Lower power factor increases distribution loss.

LRPP

Gas Engine

Sr. No.	Descriptions	Voltage	Current	KW	KVA	PF
1	GG-1, 9.965MW	11330	469	9113.52	9205.58	0.99
2	GG-2, 9.965MW	11320	480	9319.04	9413.17	0.99
3	GG-3, 9.965MW	11310	472	9155.62	9248.11	0.99
4	GG-4, 9.965MW	11270	477	9219.89	9313.02	0.99
5	GG-5, 9.965MW	11270	446	8620.69	8707.77	0.99
6	GG-6, 9.965MW	11270	471	9103.91	9195.87	0.99
7	GG-7, 9.965MW	11270	467	9026.60	9117.78	0.99

Power factor is maintained at generation point and generation Voltage is found slightly higher.

Building Ventilation FAN

Description	Rating	Voltage	Current-1	Power KW	Power KVA	PF
Fan 1	20 HP	408.00	26.50	14.24	18.73	0.76
Fan 2	20 HP	408.00	27.50	14.58	19.44	0.75
Fan 3	20 HP	408.00	27.30	14.47	19.30	0.75
Fan 4	20 HP	408.00	28.40	15.46	20.07	0.77
Fan 5	20 HP	408.00	28.30	15.60	20.00	0.78
Fan 6	20 HP	408.00	25.00	13.08	17.67	0.74
Fan 7	20 HP	408.00	26.40	14.18	18.66	0.76

Engine Ventilation Fan 5HP Each

Description	Voltage	Current-1	Power KW	Power KVA	PF
Engine 1, Fan1	408	6.30	3.70	4.45	0.83
Engine 1, Fan2	408	6.20	3.68	4.38	0.84
Engine 2, Fan1	408	6.40	3.85	4.52	0.85
Engine 2, Fan2	408	6.00	3.56	4.24	0.84
Engine 3, Fan1	408	5.90	3.46	4.17	0.83
Engine 3, Fan2	408	6.30	3.74	4.45	0.84
Engine 4, Fan1	408	6.00	3.52	4.24	0.83
Engine 4, Fan2	408	6.40	3.85	4.52	0.85
Engine 5, Fan1	408	6.20	3.68	4.38	0.84
Engine 5, Fan2	408	6.00	3.56	4.24	0.84
Engine 6, Fan1	408	6.10	3.62	4.31	0.84
Engine 6, Fan2	408	6.00	3.52	4.24	0.83
Engine 7, Fan1	408	6.60	3.97	4.67	0.85
Engine 7, Fan2	408	6.50	3.91	4.59	0.85

CHAPTER 10. LIGHTING

LTPS has taken energy efficient measures and start replacing of conventional light installed in plant and offices etc with energy efficient LED light fittings of equivalent or higher lumen lamp. Still, there are some areas where conventional light yet to be replaced with LED light fittings, which summaries as below in table are,

Sr. no.	Description	No.
1	70 W HPSV Lamp, 200-250 V SON (E), CM/L : 730596	44
2	70 W HPMV Lamp, 220 - 250 V,50 Hz	215
3	150 W, 11/11, 200-250 V, SON (E)	14
4	250 W HPSV Lamp (Tubular) , 200-250 V, CM/L-7305966	21
5	400 Watt HPSV Lamp (Tubular) , 200-250 V, CM/L- 7305966	11
6	PHILIPS-HPL-N, G/74/2, MBF-250W, 200-250 V, Made in India, E7 (H7) (EOT CRANE LAMP)	8
7	2×36 W INDUSTRIAL TYPE FLUORESCENT LUMINAIRE NORMAL/EMG. RESPECTIVELY	193
8	2×36 W RECESSED TYPE MIRROR OPTIC FLUOROSCENT LUMINAIRE NORMAL/EMG.	78
9	2×36 W INDUSTRIAL TYPE WALL MOUNTED FLUORESCENT LUMINAIRE TYPE FI FED FROM NORMAL/EMG. RESPECTIVELY	43
10	2×36 W INDUSTRIAL TYPE SURFACE MOUNTED FLUORESCENT LUMINAIRE TYPE FI FED FROM NORMAL/EMG. RESPECTIVELY	24
11	2×36 W RECESSED MOUNTED TYPE MIRROR OPTICS FLUORESCENT TYPE FM LUMINAIRE FED FROM NORMAL/EMG. RESPECTIVELY	12
12	BULK HEAD FIXTURE WITH 1×100 GLS LAMP SUITABLE FOR 220 V DC	20
13	BULK HEAD FIXTURE WITH 1×100 GLS LAMP SUITABLE FOR 220 V DC	18
14	WELL GLASS FIXTURE WITH 1×100 W GLS LAMP SUITABLE FOR 220V DC	6
15	RECESSED MOUNTED DECORATIVE FIXTURE WITH 100 W GLS LAMP SUITABLE 220 V DC	4

INSTALLED POWER GENERATION UNITES

Detail of power units installed is depicted in table below:

Description	Generator Unit	Rating at Base Load	Date of Commission	Make	Module Output at Base Load*
Phase II	Gas Turbine # 5	20 MW	03.01.94	Mitsubishi Heavy Industries.	97.2 MW
	Gas Turbine # 6	20 MW	26.07.94	Mitsubishi Heavy Industries.	
	Gas Turbine # 7	20 MW	24.05.99	Mitsubishi Heavy Industries.	
	Steam Turbine # 1	37.2 MW	17.01.12	BHEL.	
7 Gas Engine	Gas Engine # 1	9.965MW	26 May 2018	Wartsila Finland	69.755MW
	Gas Engine # 2	9.965MW	26 May 2018	Wartsila Finland	
	Gas Engine # 3	9.965MW	26 May 2018	Wartsila Finland	
	Gas Engine # 4	9.965MW	26 May 2018	Wartsila Finland	
	Gas Engine # 5	9.965MW	26 May 2018	Wartsila Finland	
	Gas Engine # 6	9.965MW	26 May 2018	Wartsila Finland	
	Gas Engine # 7	9.965MW	26 May 2018	Wartsila Finland	
	Total Installed Capacity at Base Load				167MW

MONTHLY GENERATION PATTERN

Power is generated at 11 kV and exported at 33 kV & 132kV level to grid.

Feeder Name	Voltage	Unit
Mariani Feeder	132	kV
Namrup feeder I	132	kV
Namrup feeder II	132	kV
Nazira Feeder I	132	kV
Nazira Feeder II	132	kV
Dibrugarh Feeder	132	KV
ONGC Feeder	33	kV
Sonari Feeder	33	kV
Colony feeder	33	kV

Monthly power generation pattern Phase II is depicted as below for last two years,

Power Generation in 2016-17

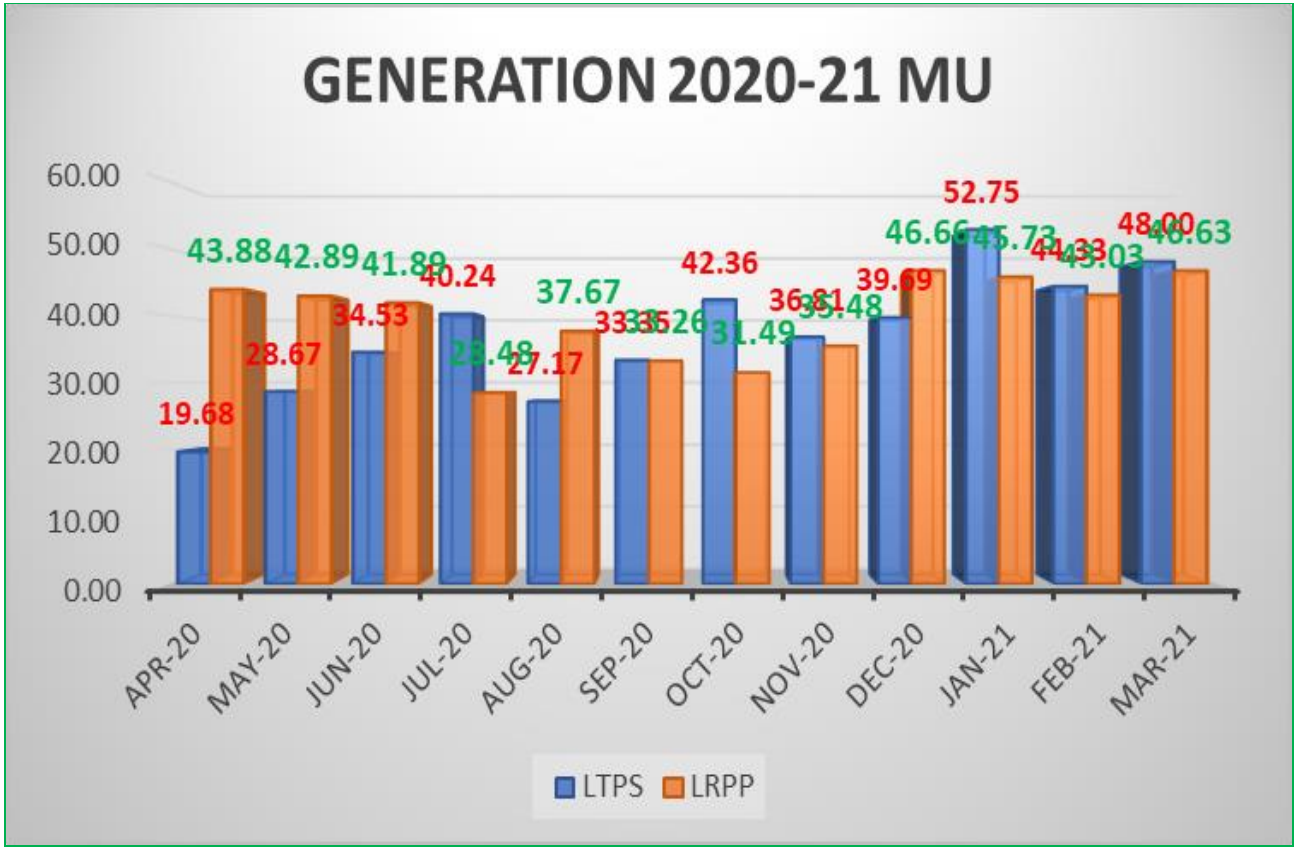
Unit =Million Unit (MU)4

LTPS							LRPP						Total			
Month	LTPS Generation (MU)	**LTPS PLF %**	Aux consumption (MU)	Aux consumption %	Gas Consumption (SCM)	LTPS HEAT RATE	LRPP Generation MU	LRPP PLF %	Aux consumption (MU)	Aux consumption %	Gross Heat Rate on GCV (Kcal/KWh)	Gas Consumption (SCM)	Total MU	Station (LTPS+LRPP) PLF %	Gas Consumption (SCM)	**Total HEAT RATE**
Apr-18	35.08	50.12	3.27	9.32	11107238	2914.82	8.10	16.12	0.14	1.78	2102.02	1,881,271	43.17459	35.92	12988509	2053.61
May-18	36.68	50.72	3.40	9.27	10600240	2660.49	45.57	87.81	0.66	1.45	2120.50	10,691,189	82.24761	66.21	21291429	2035.45
Jun-18	36.39	51.99	3.28	9.01	9631485	2436.61	38.60	76.86	0.75	1.93	2135.73	9,049,370	74.9852	62.38	18680855	1898.17
Jul-18	38.99	53.91	3.46	8.87	11761526	2776.89	40.11	77.30	0.78	1.95	2143.41	9,438,749	79.10235	63.68	21200275	2075.45
Aug-18	44.07	60.94	3.74	8.49	14307376	2988.66	9.73	18.75	0.24	2.49	2122.05	2,270,014	53.79822	43.31	16577390	2159.35
Sep-18	35.98	51.41	3.18	8.85	12173156	3114.32	36.33	72.33	0.72	1.97	2117.29	8,392,622	72.30907	60.15	20565778	2157.58
Oct-18	34.65	47.92	3.18	9.19	11499406	3054.81	42.77	82.41	0.80	1.87	2091.15	9,902,606	77.41817	62.33	21402012	2172.47
Nov-18	46.07	65.82	3.74	8.13	14412664	2879.95	36.31	72.30	0.68	1.88	2159.05	8,049,107	82.37796	68.53	22461771	2024.37
Dec-18	45.64	63.11	3.88	8.50	13295360	2681.52	43.83	84.46	0.78	1.78	2105.18	10,121,585	89.47347	72.03	23416945	2015.56
Jan-19	47.11	65.14	3.92	8.33	13620151	2661.51	41.00	79.01	0.77	1.88	2116.30	9,597,627	88.10828	70.93	23217778	2013.55
Feb-19	38.09	58.32	3.26	8.57	11155934	2695.76	41.38	88.29	0.73	1.76	2096.86	9,546,900	79.478	70.84	20702834	1911.35
Mar-19	33.36	46.13	3.06	9.18	11438991	3156.15	46.25	89.11	0.83	1.79	2116.49	10,630,363	79.60761	64.09	22069354	2199.08
Total/ Average	**472.09**	55.44	**41.39**	8.77	**145,003,528**	2827.33	**429.99**	70.37	**7.88**	1.83	**2118.84**	**99,571,403**	**43.17459**		**244574931**	

Month	LTPS							LRPP						Total			
Month	LTPS Generation (MU)	**LTPS PLF %**	Aux consumption (MU)	Gross Heat Rate on GCV Open cycle (Kcal/KWh)	Gross Heat Rate on GCV Combined cycle (Kcal/KWh)	Gas Consumption (SCM)	LTPS HEAT RATE	LRPP Generation MU	LRPP PLF %	Aux consumption (MU)	Gross Heat Rate on GCV (Kcal/KWh)	Gas Consumption (SCM)	LRPP HEAT RATE	Total MU	Station (LTPS+LRPP) PLF %	Gas Consumption (SCM)	TOTAL HEAT RATE
Apr-19	23.37	33.40	2.51	5461.53	4094.35	10458161	4118.70	44.28	88.18	0.81	2206.73	10679591	2219.85	67.65817	56.28	21137752	2875.82
May-19	32.55	45.02	3.26	5489.07	3906.65	13411441	3792.17	45.08	86.85	0.81	2176.09	10343688	2112.32	77.629922	62.50	23755129	2816.77
Jun-19	32.34	46.21	3.22	6055.52	4069.01	13172828	3749.46	44.49	88.58	0.83	2095.29	9331379	1930.74	76.82774	63.91	22504207	2696.31
Jul-19	27.61	38.18	3.13	5820.23	4178.88	12396752	4133.12	46.25	89.11	0.85	2160.83	10737457	2137.17	73.85651	59.46	23134209	2883.30
Aug-19	31.53	43.60	3.00	5929.38	4133.21	14071460	4108.21	43.79	84.38	0.82	2155.42	10192564	2142.39	75.32254	60.64	24264024	2965.25
Sep-19	32.65	46.65	3.37	5549.51	3760.68	13169253	3713.30	42.86	85.34	0.81	2136.89	9824755	2109.96	75.50744	62.81	22994008	2803.17
Oct-19	39.55	54.68	3.35	4520.93	2898.83	12230376	2846.82	41.12	79.23	0.79	2131.84	9351547	2093.59	80.66246	64.94	21581923	2462.88
Nov-19	41.35	59.08	3.21	4548.10	2944.31	12965115	2886.43	42.92	85.45	0.78	2099.70	9596971	2058.42	84.26304	70.10	22562086	2464.71
Dec-19	44.57	61.63	3.72	3817.00	2540.31	12092142	2497.63	38.40	73.99	0.73	2136.05	8761167	2100.16	82.96565	66.79	20853309	2313.66
Jan-20	4.98	6.89	0.68	3937.39	2683.05	1438988	2657.28	34.37	66.22	0.68	2126.00	7861389	2105.58	39.35245	31.68	9300377	2175.47
Feb-20	13.51	20.68	1.29	4518.54	3200.42	4679040	3188.10	37.84	80.73	0.73	2109.69	8639397	2101.57	51.35088	45.77	13318437	2387.42
Mar-20	38.00	52.55	3.08	3949.36	2681.05	10877705	2634.86	42.81	82.48	0.83	2146.51	9810154	2109.53	80.8087	65.06	20687859	2356.57
Total/ Average	**362.01**	42.40	**33.82**	**4966.38**	**3424.23**	**130963259**	3330.11	**504.2**	82.29	**9.46**	**2140.09**	**115130061**	2101.89	**67.65817**		246093320	33481.38

Month	LTPS					LRPP					Total			
	LTPS Generation (MU)	**LTPS PLF %**	Aux consumption (MU)	Gas Consumption (SCM)	LTPS HEAT RATE	LRPP Generation MU	LRPP PLF %	Aux consumption (MU)	Gross Heat Rate on GCV (Kcal/KWh)	Gas Consumption (SCM)	Total MU	Station (LTPS+LRPP) PLF %	Gas Consumption (SCM)	TOTAL HEAT RATE
Apr-19	23.37	33.40	2.51	10458161	4118.70	44.28	88.18	0.81	2206.73	10679591	67.65817	56.28	21137752	2875.82
May-19	32.55	45.02	3.26	13411441	3792.17	45.08	86.85	0.81	2176.09	10343688	77.629922	62.50	23755129	2816.77
Jun-19	32.34	46.21	3.22	13172828	3749.46	44.49	88.58	0.83	2095.29	9331379	76.82774	63.91	22504207	2696.31
Jul-19	27.61	38.18	3.13	12396752	4133.12	46.25	89.11	0.85	2160.83	10737457	73.85651	59.46	23134209	2883.30
Aug-19	31.53	43.60	3.00	14071460	4108.21	43.79	84.38	0.82	2155.42	10192564	75.32254	60.64	24264024	2965.25
Sep-19	32.65	46.65	3.37	13169253	3713.30	42.86	85.34	0.81	2136.89	9824755	75.50744	62.81	22994008	2803.17
Oct-19	39.55	54.68	3.35	12230376	2846.82	41.12	79.23	0.79	2131.84	9351547	80.66246	64.94	21581923	2462.88
Nov-19	41.35	59.08	3.21	12965115	2886.43	42.92	85.45	0.78	2099.70	9596971	84.26304	70.10	22562086	2464.71
Dec-19	44.57	61.63	3.72	12092142	2497.63	38.40	73.99	0.73	2136.05	8761167	82.96565	66.79	20853309	2313.66
Jan-20	4.98	6.89	0.68	1438988	2657.28	34.37	66.22	0.68	2126.00	7861389	39.35245	31.68	9300377	2175.47
Feb-20	13.51	20.68	1.29	4679040	3188.10	37.84	80.73	0.73	2109.69	8639397	51.35088	45.77	13318437	2387.42
Mar-20	38.00	52.55	3.08	10877705	2634.86	42.81	82.48	0.83	2146.51	9810154	80.8087	65.06	20687859	2356.57
Total/ Average	**362.01**	42.40	**33.82**	**130963259**	3330.11	**504.2**	82.29	**9.46**	**2140.09**	**115130061**	**67.65817**		246093320	33481.38

Month	LTPS					LRPP						Total			
	LTPS Generation (MU)	**LTPS PLF %**	Aux consumption (MU)	Gas Consumption (SCM)	LTPS HEAT RATE	LRPP Generation MU	LRPP PLF %	Aux consumption (MU)	Gross Heat Rate on GCV (Kcal/KWh)	Plant Efficiency %	Gas Consumption (SCM)	Total MU	Station (LTPS+LRPP) PLF %	Gas Consumption (SCM)	TOTAL HEAT RATE
Apr-20	19.68	28.12	2.24	5,946,522	2781.07	43.88	87.36	0.83	2121.67	40.5341	10227540	63.55857	52.87	16174062	2342.44
May-20	28.67	39.64	2.64	8,106,456	2602.85	42.89	82.64	0.80	2133.71	40.3054	9993077	71.55932	57.61	18099533	2328.23
Jun-20	34.53	49.34	3.09	9,277,451	2473.22	41.89	83.40	0.77	2147.12	40.0537	9787163	76.41543	63.57	19064614	2296.52
Jul-20	40.24	55.64	6.29	12,141,066	2777.42	28.48	54.87	0.63	2142.09	40.1477	6604877	68.7169	55.32	18745943	2511.12
Aug-20	27.17	37.57	2.51	8,285,277	2807.41	37.67	72.58	0.77	2135.54	40.2709	8664995	64.8313	52.19	16950272	2406.67
Sep-20	33.35	47.65	5.77	10,830,955	2989.63	33.26	66.22	0.69	2130.61	40.3641	7635128	66.60611	55.41	18466083	2552.02
Oct-20	42.36	58.57	6.27	11,182,100	2429.95	31.49	60.68	0.67	2097.96	40.9922	7241699	73.853323	59.46	18423799	2296.32
Nov-20	36.81	52.59	2.85	8,947,428	2237.62	35.48	70.64	0.69	2108.81	40.7814	8113307	72.283876	60.13	17060735	2172.60
Dec-20	39.69	54.89	3.01	9,616,604	2230.10	46.66	89.90	0.82	2094.24	41.0650	10551034	86.351602	69.52	20167638	2149.85
Jan-21	52.75	72.95	3.76	12,812,113	2235.58	45.73	88.11	0.82	2108.23	40.7925	10506967	98.48187	79.28	23319080	2179.61
Feb-21	44.33	67.86	3.39	11,204,197	2326.62	43.03	91.79	0.80	2103.93	40.8759	9898664	87.35666	77.86	21102861	2223.66
Mar-21	48.00	66.37	3.66	12,066,500	2314.13	46.63	89.86	0.93	2130.38	40.3685	10930330	94.63045	76.18	22996830	2236.97
Total/ Average	**447.57**	52.56	**45.47**	**120,416,671**	2476.55	**477.07**	78.07	**9.21**	**2121.19**		**110154779**	**924.64541**		230571450	2295.38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34.53
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27.17
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MAY-20
JUN-20
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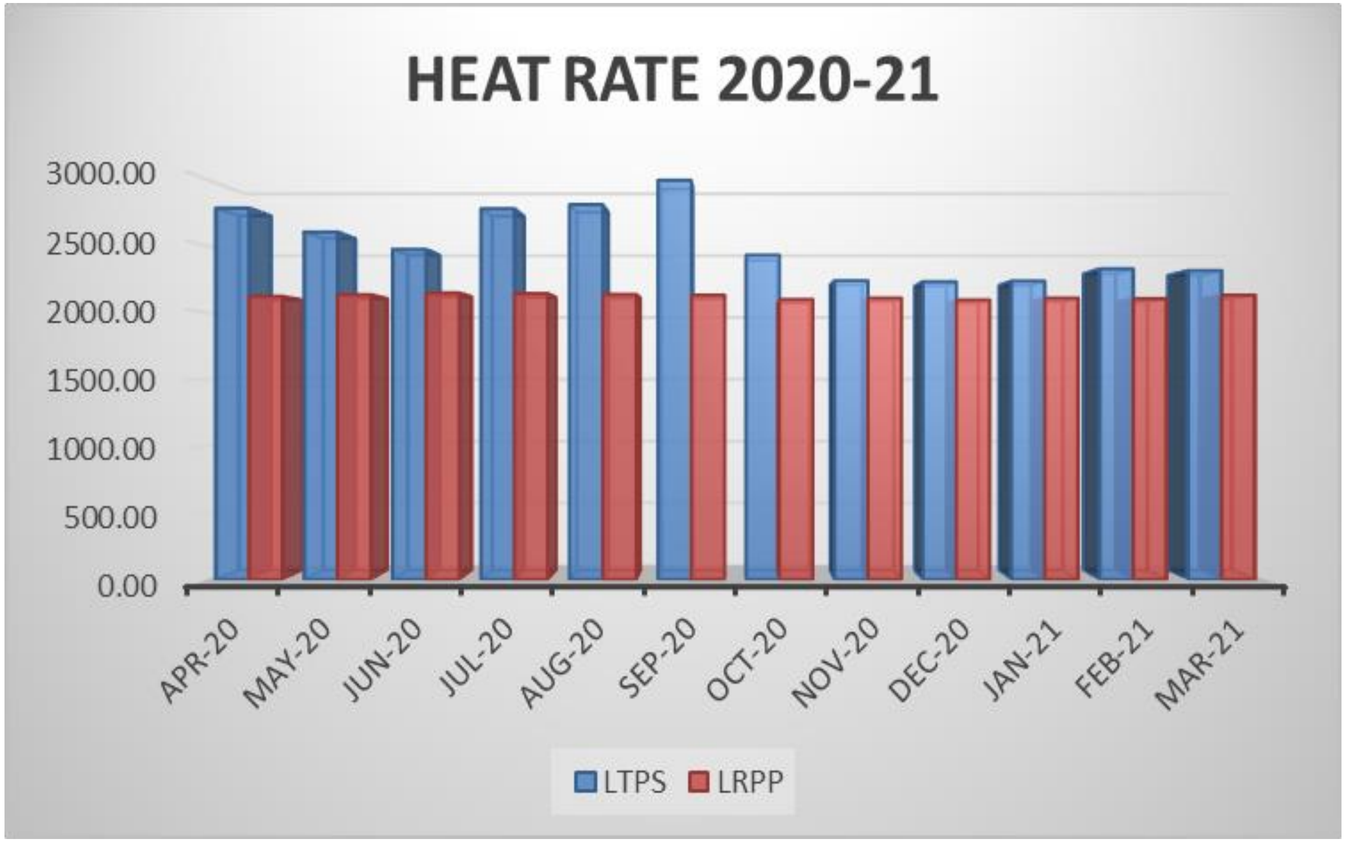
DEC-20
JAN-21
FEB-21
MAR-21
LTPS
LRPP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SEP-20
OCT-20
NOV-20
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LTPS
LRPP

CHAPTER 11.
ENERGY CONSERVATION MEASURES & RECOMMENDATION

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Encon 1: Cost Benefit Analysis by Installation of VFD in ONE NO. CEP

Background:

VFD on CEP

Recommendation

The pressure drop across the control valve is high due to the low opening of the D/A feed actuator valve. The deaerator valves are kept on throttle position. Thus, the throttling losses can be reduced effectively by employing variable speed option. Hence, install a variable frequency drive on the condensate extraction pumps with feedback from de aerator level sensors.

Energy and financial saving

The following parameters and assumptions are considered to estimate the energy savings and financial viability of this option.

Installation of VFD in ONE NO. CEP PUMP		
Average Power consumption in a CFP pump	160	kW
power saving after installation of 180 kVA VFD @15%	24	kW
Operating hours (considered 24 hr for 330 days)	7920	Hr
Annual power saving	190080	kWh
Tariff	3.66	Rs/ kW
Annual Energy Saving	6.96	Rs. In Lakh
Investment		
Installation cost three VFD	8	Rs. Lakh
simple Payback period	1.15	YRS

Based on onsite data measurement, observation and historical data, following energy conservation recommendation will help to reduce heat rate further and also to reduce auxiliary power consumption.

Encon 2: Cost Benefit Analysis by Reduction in Stages in Boiler Feed Pump.

Background:

Each unit has One HPBFP & One LPBFP and the rating of each HPBFP is 325 KW and LPBFP is 15 KW is 550 KW. The present load of BEP is around 76%. The discharge pressure of HPBFP's is 80 Kg/cm2. The Drum pressure is 42 Kg/cm2. The pressure drops from BFP to Drum may be considered for energy saving. The best option would be Reduction in Stages in Boiler Feed Pump.

Recommendation:

It is recommended to reduce the stages of BFPs. It can be used to reduce the flow and head to actual conditions resulting in power consumption of the order of 15 %.

The practical estimated savings would be 15% in BFP's input power. The expected annual energy savings would be 496584 kWh worth lakhs annually. Annual cost saving per annum is 16.75 Lakh. The estimated investment would be Rs. 8 Lakhs. The investment would be recovered within 1-year time. The cost benefit details are furnished below.

Cost Benefit Analysis for Reduction of Stages of BFP (1 No)		
Particular	**Units**	**Value**
No. of BFP's for each unit	**Nos**	1
Rating of each BFP's	**KW**	325
No. of BFP's running per each unit	**Nos**	1
Power Consumption by BFP	**kW**	285
Total Load	**kW**	285
Avg. running hours	**hrs**	24
Avg operating days/yr	**days**	330
Present Discharge pressure	**Kg/cm²**	56
Expected Savings	**%**	15%
Annual Savings	**kWh**	338580
Electricity Cost	**Rs/kWh**	3.66
Annual Cost Savings	**Rs. Lakhs**	12.39
Investment	**Rs. Lakhs**	5
Simple payback Period	**years**	0.40

Encon 3: Cost Economics by improving pump efficiency by Polymer Coating in Cooling Water Pumps

Background:

All these pumps generally handle muddy and polluted water. Thus, the impellers are subject to high degree of corrosion and pitting, so also the valves, pipes, bend, etc. This factor reduces pump efficiency substantially. The efficiency of pumps can be improved by application of strong coating to the impeller. Recently such coating has been developed from glass flake which when applied, the impellers become very smooth, less corrosive and more efficient.

Recommendation:

It is recommended to apply Corrocoat coating which is the glass flake filled polyester based resin to the impeller of cooling water pump. The advantage of impeller coating is as follows.

- It improves efficiency & save energy
- It reduces surface roughness
- The coating is hydrophobic in nature

The Cost Benefit Analysis:

Energy consumption can be reduced in the process of Polymer Coating in Cooling Water Pumps. The total annual Energy saving with Polymer Coating is 297000 kWh. Total investment of the project was Rs 500000. The saving is Rs 10.01 lakhs after use of polymer coating with payback period of 0.5 years.

COST Economics by improving pump efficiency by impeller and Casing coatings in CW pumps		
Plant	**Units**	**Value**
No. of CW Pumps	Nos	4
No of pumps normally operated	Nos	4
Rating of each CW pump	KW	550
Power Consumption by CWP 1	KW	500
Power Consumption by CWP 2	KW	500
Power Consumption by CWP3	KW	500
Total Load	Kw	1500
Avg. running hours	hrs	24
Avg operating days/yr	days	330
Expected Savings		2.50%
Annual Savings	kwh	297000
Electricity Cost	Rs/kwh	3.373
Annual Cost Savings	Rs. Lakhs	10.018
Investment	Rs. Lakhs	5
Simple payback Period	years	0.50

Encon 4: Cost Economics by INSTALLATION OF NEW SCREW AIR COMPRESSOR

There are three reciprocating air compressors installed in LTPS in GT section to supply compressed ait to GT Section and they are operating inefficiently. They consumed around 40% power during off load. New energy efficiency variable drive-based screw type air compressors are available in the market and supplier claims 30% save energy. These compressors are maintaining air pressure with control of rpm of compressor. New screw air compressor produced same FAD & pressure with drive rating 11 kW instead of old air compressor rating 15 kW.

Thus, it is advised to installed One new screw air compressor with variable drives and FAD=150 cfm compressor. Annual energy saving has been worked out as below.

REPLACMENT OF RECIPROCATING COMPRESSOR WITH NEW SCREW AIR COMPRESSOR		
Power consumption Two Air Compressor at full load	22	kW
Power saving after installation of one new air screw compressors (30%) having motor rating 22 kWh	6.6	kW
Number of Compressor operated at a time	2	no.
Operating hours (considered 24 hr for 365 days)	8760	Hr
Annual power saving	57816	kW
Tariff	3.66	Rs/ kW
Annual Energy Saving	2.12	Rs. In Lakh
Investment		
New Air compressor cost @ Rs. 5.00 lakh	6.2	Rs. Lakh
simple Payback period	2.93	YRS

Encon 5: Repair and overhauling HRSG Refractories: It has been observed that the outside surface of HRSG temperature is around 90 Deg C. Some places it has been observed around 200 deg also. Hence it is recommended to change the insulation refractories of HRSG in order to save energy. Details of energy savings are as below.

Thermography GT & HRSG was conducted during site audit. Heat loss has observed from various locations as per thermography report. It is suggested here to repair refractory and insulation of area as mentioned in below table and prevent/ reduce heat loss.

Energy consumption by repairing of refractories will yield the total annual Energy saving 2.87 Lakh kWh. Total investment of the project was Rs 500000. The saving is Rs 4.2 lakhs with payback period of 1.2 years.

Repair of Insulations/refractories of HRSG		
Surface Temperature IN DEG C	200	C
Surface Temperature IN DEG K	473	K
Ambient temperature IN DEG C	31	0C
Surface Temperature IN DEG K	304	K
WIND VELOCITY	3.5	m/s
AREA OF AFFECTED PORTION	10.0	M2
SURFACE AREA HEAT LOSS S	3118.05	
"[10+(TS-TA)/20]X(TS-TA)"		
HEAT LOSS HS = SXA	31180.5	kcal/hr
HOURS OF OPERATION 24X330	7920.0	HR
EQ FUEL LOSS HF	246949560.0	kcal
EQ FUEL LOSS in KWH	287150.7	KWH
Average HRSG Efficiency	60%	
Average GCV of NG Feb 2019	9211	kcal/scm
Annual equivalent NG loss as a Heat Loss	44683.8128	SCM
Average Cost of NG	9.5	Rs/SCM
Total cost	4.2	Lakh
Refractory / Insulation repairing cost	5.0	Lakh
Payback	1.2	Year

Encon 6: REPLACEMENT OF COOLING TOWER FILL PACK MATERIAL

Background:

During field study it has been observed that fill pack materials were damaged.

It has been recommended to replace the damage fill pack materials at Cooling tower in order improve the effectiveness of Cooling tower

Cost Benefit Analysis:

In this project, the annual energy saving was 5.247 lakh kwh approx. with annual cost of saving of Rs 16.79 Lakh. The total cost of the project was Rs 20 Lakh and its payback period was 1.19 years.

Replacement of Fill Pack materials of Cooling Tower		
Particulars	**Unit**	**Value**
Average Annual Gross Generation Before Implementation	**MU**	477
Average Annual Gross Generation after Implementation by Considering 0.1 % of Improvement	**MU**	0.5247
Difference	**MU**	0.5247
Energy Saving	**kWh**	524700
Annual Cost of Savings @ Rs 3.5	**Rs. Lakh**	16.790
Total Investment of fill pack material	**Rs. Lakh**	20
Simple Pay Back Period	**Year**	1.19

Encon 7 REPLACEMENT OF 2X36W FLUORESCENT TUBE WITH 20 W LED TUBE

It is advised to replace 2X36 Watt fluorescent with 20W LED Tube of equivalent lumen. Annual saving has been worked out as below.

Description	plant	office	Unit
Number of conventional 2x36 Watt Tube fittings	250	50	no.
Power consumption in 2x36 W fluorescent tube fitting (including 15 Watt choke with each lamp)	102	102	Watt
Power consumption in 2X20 Watt LED	40	40	Watt
Difference in Power consumption	62	62	Watt
Annual Operating Hours (considered 24 hours for 365 day)	8760	250	Hr
Annual Energy Saving	135780	775	kWh
Total Annual Power saving	136555		kWh
Tariff	3.66		Rs./kWh
Annual Energy Saving	4.998		Rs. In Lakh
Investment 20 Watt LED Cost @ Rs. 350 per fitting including retrofitting cost	1.05		Rs. In Lakh
Simple Payback Period	0.21		yrs

Encon 8 REPLACEMENT OF 400W HPSV WITH 200W LED LAMP

It is advised to replace 400W HPSV with 200 LED luminaire of equivalent lumen. Annual saving has been worked out as below.

REPLACEMENT OF 400WATT HPSV WITH 200WATT LED LAMPS		
Number of 400 W HPSV	11	no.
Power consumption in single 400 W HPSV Fitting	440	Watt
Power consumption in single 200 Watt LED (equivalent lumen)	200	Watt
Difference in Power consumption	240	Watt
Annual Operating Hours (considered 10 hours for 365 day)	3650	Hr
Annual Energy Saving	9636	kWh

Tariff	3.66	Rs./kWh
Annual Energy Saving	0.3527	Rs. In Lakh
Investment	0.88	
Cost of 200 Watt LED @ Rs. 8000 per fitting including retrofitting cost	0.88	Rs. In Lakh
Simple Payback Period	2.50	YRS

CHAPTER 12. EVOLUTION OF ENERGY MANAGEMENT SYSTEM

ENERGY MANAGEMENT POLICY

LTPS has produce power in the most efficient, cost-effective, and environmentally responsible manner possible.

LTPS has made efforts to reduce carbon emission from plant. It will also support govt commitment in international forum.
LTPS has made efforts to enhance utilization of renewable energy resources.
It is advised to develop energy management policy.

ENERGY MANAGEMENT MONITRING SYSTEM

Company has established Energy Management Department (EMD) headed by Senior Manager to look after all concerned related to energy conservation, energy data storage, etc. EMD provides energy data to different Govt. Departments for implementation of energy conservation schemes in industries. Daily meeting held with HODs to monitor previous day data and to decide future action planning.

BENCH MARKING

Net Station Heat rate is depicted in table as below,

Year	Net Station Heat Rate kcal/kWh
2020-21	2309.50

*Plant was operated in Open cycle from Jul 2018 to Nov 2018

TRAINING OF STAFF RESPOSIBLE FOR OPERATION

LTPS/ APGCL provides training to operators / maintenance staff in view of operation of GTs, HRSGs, STG, Gas compresses, gas engine and their auxiliary equipments etc. LTPS / APGCL organized in house and third party training program to their management, officers and staffs time to time as per state/ central Government norms and policy.

GENERAL AUDIT REVIEW

LTPS has made efforts to bring down heat rate and they have phase-out energy inefficient PH I Unit. In view of power demand, availability of & infrastructure, APGCL has installed highly energy efficient LRPP unit (7 no. gas engines) in LTPS. To continuous monitoring of equipment performance, LTPS has installed scada system at HRSG, STG and LRPP.
In view of auxiliary equipments, there have good energy saving opportunities particularly replacement of reciprocating air compressor with screw type air compressor with VFD, replacement of conventional lighting luminaire with LED lamps, recovery waste heat from gas engine exhaust flue gas in LRPP and to implement energy efficient measures in pumps.

STRENGTH AND WEAKNESSES OF DC

- **Strength of DC**
    - LTPS has highly qualified and experienced technician, engineers, and management staff.
    - LTPS has own workshop and repairs most of damaged machine parts.
    - Held daily monitoring meeting on plant performance.
    - Preventive maintenance and annual shutdown planning
    - Implementation of energy conservation schemes on priority basis.
    - Continuous effort to reduce plant heat rate.

Weaknesses DC

- Equipment/ machines are commissioned around 20 years back.
- Unavailability of spare parts.
- Limitation of NG supply to DC.
- Being PSU, financial constraint.

Certification

This is to declare that,

a) *The data collection has been carried out diligently and truthfully;*

b) *All data monitoring devices are in good working condition and have been calibrated or certified by approved agencies authorized and no tempering of such devices has occurred;*

c) *All reasonable professional skill, care and diligence had been taken in preparing the energy audit report and the content thereof are a true representation of the facts;*

d) *Adequate training provided to the personals involved in daily operations after implementation of recommendations; and*

e) *The energy audit has been carried out in accordance with the Bureau of Energy Efficiency (Manner and intervals of time for the conduct of energy audit) Regulations, 2010*

Signature:

Name of the accredited energy auditor : **Amulya Kumar Mohini**

Accreditation details : **AEA-002**

Seal

Energy Consultancy Services ★ Bhubaneswar ★