Mandatory Energy Audit of

Namrup Thermal Power station (APGCL)

Dibrugarh, Assam

Submitted By

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Abbreviation

Abbreviation	Description	Abbreviation	Description
ACC	Air Cooled Condenser	LPH	Low Pressure Heater
ACW	Auxiliary Cooling Water	LT	Low Tension
AEA	Accredited Energy Auditor	MW	Mega Watt
BFP	Boiler Feed Pump	MWh	Mega Watt hour
CEA	Certified Energy Auditor	MOV	Motor Operated Valve
CEM	Certified Energy Manager	NCV	Net Calorific Value
CEP	Condensate Extraction Pump	NG	Natural Gas
CFM	Cubic Feet per minute	OEM	Original Equipment Manufacturer
CCPP	Combined Cycle Power Plant	TPH	Ton per Hour
CT	Cooling Tower	MU	Million Unit
CV	Control Valve	ROI	Return on Investment
CW	Cooling Water / Circulating Water	mmWC	Mili meter Water Column
DBT	Dry Bulb Temperature	MTOE	Million Tons of Oil Equivalent
DC	Designated Consumer	MVA	Mega Volt Ampere
DCS	Distributed Control System	NA	Not Available
DP	Differential Pressure	ON	Oil Natural Cooling
GCV	Gross Calorific Value	ONAN	Oil Natural-Air Natural Cooling
GSC	Gland Steam Cooler	PCC	Power Control Centre
GT	Gas Turbine / Generation Transformer	PF	Power Factor
HP	High Pressure	R&D	Research and Development
HRSG	Heat Recovery Steam Generator	RPM	Rotations Per Minute
HT	High Tension	SAT	Station Auxiliary Transformer
IEEE	Institute of Electrical & Electronics Engineers	SCM	Standard Cubic Meter
IGV	Inlet Guide Vane	S/D	Star-Delta
kCal	Kilo Calorie	ST	Station Transformer
kJ	Kilo Joule	STG	Steam Turbine Generator
KVA	Kilo Volt Ampere	THD-I	Total Harmonic Distortion in Current
KVAh	Kilo Volt Ampere-Hour	THD-V	Total Harmonic Distortion in Voltage
kVAr	Kilo Volt-Ampere Reactive	TR	Transformer
KW	Kilo Watt	UAT	Unit Auxiliary Transformer
KWh	Kilo Watt-hour	VFD	Variable Frequency Drive
LHV	Low Heat Value	Vunb	Voltage Unbalance
LP	Low Pressure	WBT	Wet Bulb Temperature

Acknowledgement

Energy Consultancy Services, Bhubaneswar (ECS) is thankful to the management of Namrup Thermal Power Station (NTPS), a gas-based power plant of APGCL at Namrup, Dist. Dibrugarh - Assam, for giving us the opportunity to carry out Mandatory Energy Audit Study of NTPS unit as per Bureau of Energy Efficiency Regulations 2010 . ECS team is also thankful to all other supporting Officers / Staffs of NTPS 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:

Mr. Tiken Ch. Basumatary-General Manager, NTPS

Md. Zakir- Dy General Manager (O & M), NTPS

Mr. Chiranjib Adhikary- Dy General Manager , NRPP

Mr. Krishanu Bikash Karmakar- Assistant General Manager, OPND

Mr. Rupjyoti Kalita- Deputy Manager/Energy Manager, NTPS

Mr.Abhijit Pathak-Assistant Manager, OPND, NTPS

We extend our sincere gratitude to Mr. Rupjyoti Kalita, (Energy Manager of NTPS) and all other officers, technicians and staffs for their keen interest shown in the study and the courtesy extended.

Following team members were engaged in this study and visited the NTPS unit from 24.02.2022 to 26.02.2022

- 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

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 has been carried out.

Chapter 1 INTRODUCTION

1.1 Background

Namrup is a small town situated close to the foothills of the Patkai Hills in the extreme southeastern part of Assam, India. The river Dihing or Disang flows through it. Namrup is situated in amidst wet-paddy fields, indigenous Assamese villages, orchards, large tea-gardens and densely forested hills. Administratively Namrup is located within Dibrugarh district and is today an important industrial town of Assam.[*citation needed*] Namrup is approximately 75 km from Dibrugarh by road towards south-east and approximately 50 km from Tinsukia (locally pronounced as Tinicukeeya) towards south. It is also a small railway station in Dibrugarh-Guwahati broad-gauge railway line. The nearest airport is Dibrugarh located at a distance of approximately 70 km. Other urban areas close to Namrup are Naharkatiya - 18 km, Duliajan - 35 km, Sonari - 20 km, Moran - 55 km, etc. by roadways. Namrup is located around 500 km east of Guwahati, the largest city in the North East Region.

Namrup is a place with three major industries viz. The B.V.F.C.L, the APL and the thermal power project.

The Dillighat in Namrup is a picnic spot in Upper Assam. During the winter and mostly during the New Year's Day Dillighat becomes a busy picnic spot, along with the jackwell situated near the BVFCL factory is a tourist attraction of this area. Clean water, river-bed rocks, green canopy of forests and tea gardens are attractions in Dillighat. Dillighat is situated on the banks of river dilli or disang (a tributary of mighty Luit or Brahmaputra) in Namrup and Borhat (a place adjoining to Namrup in Sivasagar District).

Other places of interest within the town include the Namrup Bagan, the ASEB-(world's largest baseload turbine station) colony,[2] Kheremeeya Village, Dilli Dowania Gaon, Rangagoraah, Dillighat, Naliapool, Jackwell, waterfalls in patkai range, railway station, and gandhi maidan.

Moreover, Namrup is centrally and closely located to several other attractions such as the Joy-Dihing Rainforest (10–15 km north), Coraideu - the ancient capital (25 km south-east), Tai-Phake village with traditional unique phake-life (13–14 km north). Moreover, it is closely located to many beautiful places in Arunachal Pradesh such as Deomali(a riverside picnic spot), Miao (picnic spot), Namdapha National Park, Khunsa (a small hill-town), etc.

Namrup Thermal Power Station having installed capacity of 134 MW combined cycle Gas Based power plant (GT 3x23 MW + 1x12.5 MW, Steam Turbine 1x30 MW & Steam Turbine with HRSG 1x22.5 MW) is Located at Namrup, Assam. First three Gas Turbines (3x23 MW) were commissioned on 1965. Gradually another Gas Turbine of 12.5 MW was commissioned on 1975. Steam Turbine (open cycle) 1x30 MW & Steam Turbine with HRSG (1x22.5 MW) were commissioned on 1976 & 1985 respectively. Due to ageing of the NTPS units as well as low performance/efficiency , APGCL takes steps to replacement of NTPS old units to new units. Hence unit-1,unit-4 and unit-5 has been decommissioned on 24th Oct-2017, 19th August-2020 and 19th August 2020 respectively and Namrup replacement power project (NRPP) (GTG-62.25 MW, STG-36.15MW) was commissioned on 16-07-2021. Present derated capacity of NTPS plant is. 64.5 MW(unit-2-21MW, unit-3-21MW and unit-6-22.5MW).

Per unit energy cost for financial year 2020-21 has been fixed by AERC as Rs.3.01 per kWh and this value is used for all the cost benefit calculation in this report.

Specific Gas consumption of NTPS in 2020-21 and 2021-22 (up to January 2022) is 0.481 scum/kwh and 0.669 scum/kwh respectively and Specific Gas consumption of NRPP is 0.220 kCal/kwh (up to January 2022)

In combination of NTPS and NRPP it is found that Specific Gas consumption for power generation decreases from 0.481 in 2020-21 to 0.467 SCM/kWh in 2021-22 (up to Jan 22)

Average gross heat rate (GCV basis) of NTPS in 2020-21 and 2021-22 (up to January 2022) is 4652 kCal/kwh and 5601 Kcal/kwh respectively and Average gross heat rate (GCV basis) of NRPP is 2030 kCal/kwh (upto January 2022).

In combination of NTPS and NRPP, it is found that average gross station heat rate (GCV basis) for the year 2020-21 is 4652 kCal/kwh and average gross station heat rate (GCV basis) for 2021-22 is 3815.5 kCal/kWh upto January 2022 .

Average auxiliary power consumption of NTPS for the year 2020-21 and 2021-22 (upto January 2022) is 5.82 % and 5.78 % respectively. And average auxiliary power consumption of NRPP for the year 2021-22(upto January-2022) is 4.76.

In combination of both NTPS and NRPP in the year 2021-22 (upto Jan 22) it is found that the Average auxiliary power consumption decreases from 5.82% to 5.27% in comparison with the year 2020-21.

Moreover, auxiliary power consumption for NTPS is very much at higher side in comparison to similar kind plants. APC has been reduced to commissioning of NRPP plant

I. In NRPP Based on data collected through onsite measurement and collection of process parameter from DCS, the performance of process as well as major equipment is assessed and reported in this report.

II. Overall gross heat rate (GCV basis) of combined cycle module is assessed as 2030 for the year 2021-22(upto Jan 22) for NRPP and Overall gross heat rate (GCV basis) of open cycle module is assessed 5601 kCal/kWh for NTPS .

III. All the motors were found with steady loading except AOP motor.

IV. NRPP Cooling tower effectiveness and condenser effectiveness is found satisfactory.

V. Insulation health of steam distribution line, GT exhaust duct and HRSG body was conducted by checking the skin temperature of the steam line, GT exhaust duct and HRSG body. In most of the cases skin temperature was found in the permissible range between 45 – 75 ^{0}C,

VI. Illumination level inside key areas of the plant need serious attention and augmentation is needed to improve illumination level. With same wattage or less wattage LED can be fitted for more lux.

VII. Some key observation and General Recommendation:

a. Preparation of detailed electrical SLD depicting the location of energy meters in plant area to access generation, auxiliary power consumption and ex-bus generation. IOT based EMS should be installed for monitoring & accounting energy.

b. Calibration of gas flow meter for individual Gas Turbine of NTPS is required.

c. Replacement of existing motor operated exhaust fans at turbine floor by turbo-ventilator andsave energy.

d. Install light pipe at turbine roof and save energy by switch off light in daytime.

e. Replace all rewinding induction motor with IE3 or more efficient motor.

f. Tailor made Turbine Inlet Air Cooling (TIAC) system may be adopted for improving GT efficiency.

g. 3 nos Air compressor of NRPP is of reciprocating compressor which may be replaced with energy efficient screw compressor

1.2 Summary of Recommendation:

					Simple Pay
	Measure	Annual Savings		Investment	back
Sl.No.	NRPP	KWH	Rs. Lakhs	Rs. Lakhs	Years
1	Installation of VFD in ONE NO. CEP PUMP	130680	3.93	8.00	2.03
2	COST Economics by improving pump efficiency by impeller and Casing coatings CW pumps	217800	6.56	5.00	0.76
3	REPLACMENT OF RECIPROCATING COMPRESSOR WITH NEW SCREW AIR COMPRESSOR	57816	1.74	6.20	3.56
4	Turbo ventilators for Natural Ventilation	181500	3.41	1.65	0.48
	TOTAL	**587796**	**15.64**	**20.85**	1.33

Sl.No.	Input Energy	**KWH**	**Rs. Lakhs**	**Rs. Lakhs**	**Years**
	NTPS				
1	Replacement of 37 KW Pump	132000	3.97	3.7	0.93
2	REPLACEMENT OF OLD 2X36WATT FTL WITH LED LAMPS	136555	4.11	1.05	0.26
3	REPLACEMENT OF 400WATT HPSV WITH 200WATT LED LAMPS	9636	0.29	0.88	3.03
	TOTAL	**278191**	**8.37**	**5.63**	0.67

1.3 Company's Profile:

Assam Power Generation Corporation Ltd. was constituted after unbundling of ASEB in Dec 2004 through State Power Sector Reform Programme under the provision of Electricity Act'2003. The certificate of commencement of business was obtained w.e.f. April 2004. The final Transfer scheme was implemented on Aug'2005 with a new Company Balance Sheet w.e.f April 2005. The company is mainly responsible for maximum energy generation to meet up the energy demand in the state.

Name of the Power Station	Description of Units	Total Capacity	Location
Namrup Thermal Power Station (NTPS)	2 nos of Gas Turbine units, 1 noWaste Heat Recovery unit.	GTG 21mw x 2 nos + STG 22.5 MW = TOTAL 64.5 MW	Namrup, PO-Namrup, Dist: Dibrugarh, Pin-786622
Namrup replacement power plant (NRPP)	1 nos of Gas Turbines, 1 no Waste Heat Recovery unit.	GTG 62.25 MW, STG 36.15 MW = TOTAL 98.4 MW	Namrup, PO-Namrup, Dist: Dibrugarh, Pin-786622
Total		**162.9 MW**	

1.4 DATA SHEET FOR GAS TURBINE MODEL NO. PG6111FA+e

COMPRESSOR

NO. OF STAGES	:	18
TYPE	:	AXIAL FLOW
DIRECTION OF ROTATION	:	COUNTER-CLOCKWISE WHEN FACING THE GAS TURBINE OUTPUT FLANGE.
CASING SPLIT	:	HORIZONTAL
COMPRESSION RATIO	:	1: 15.8
RATED SPEED	:	5231 RPM
MAXIMUM TIP SPEED	:	532 M/S
ROTOR CONSTRUCTION	:	DISCS AND THRU BOLTS
BLADE ATTACHMENT	:	DOVE TAIL
EXTRACTIONS	:	9TH, 13TH, 17TH STAGES & CDC.

MATERIALS OF CONSTRUCTION

INLET, MID COMPRESOR CASING	:	FERRITIC DUCTILE IRON
DISCHARGE CASING	:	2.25% Cr, 1% Mo ALLOY STEEL CASTING

BLADE MATERIAL

FIRST NINE STAGES	:	GTD450.
STAGES 10-16	:	AISI 403+Cb.
STAGE 17TH STATOR & EGV	:	IN 718.

S1, R1, S2, R2, S3	:	C-450S4 to
S8	:	C-450
R3 to R8	:	C-450
S9 to S17	:	AISI 403 Cb
R9 to R17	:	AISI 403 Cb

BLADE COATING	:	NONE.
WHEEL WEB COATING	:	CORROSION RESISTANT PAINT.
CASING BOLTS & NUTS	:	ASTM A193 OR EQUAL
COMPRESSOR DISCS	:	NI-CR-MO-V STEEL FORGINGS
VARIABLE INLET GUIDE VANES	:	C450 CARPENTER STEEL

COMBUSTION SYSTEM

TYPE	:	REVERSE FLOW, CAN ANNULAR
NO. OF COMBUSTORS	:	06
NO.OF BURNERS IN EACH	:	06
TYPE OF BURNERS	:	DLN 2.6
COMBUSTION CHAMBER		
MATERIAL OF OUTER CHAMBER	:	CARBON STEEL
MATERIAL OF INNER CHAMBER	:	HASTELLOY - X
MATERIAL OF TRANSITION PIECE	:	NIMONIC-263
TYPE OF SEAL	:	HULA SEAL (COMB CAN TO TRANS PIECE)
NO. OF IGNITORS	:	TWO
TYPE OF IGNITORS	:	AUTOMATIC RETRACTING TYPE SPARK PLUGS
NO. OF FLAME DETECTORS	:	FOUR
TYPE OF FLAME DETECTORS	:	ULTRA VIOLET

BEARINGS

NO. OF RADIAL	:	TWO (ELLIPTICAL)
NO. OF THRUST	:	ONE
TYPE OF THRUST BEARINGS	:	TILTING PAD (LOADED) TILTING PAD (UNLOADED)

VIBRATION DETECTORS

TYPE	:	SEISMIC (VELOCITY TYPE)
NUMBER	:	TWO PER BRG HSG
LOCATION	:	NO. #1 BEARING CAP AND NO. #2 BEARING CAP
SETTINGS	:	12 MM/SEC PK-PK (ALARM) 25.4 MM/SEC PK-PK (TRIP)

LUBE OIL SYSTEM

OIL TYPE : MINERAL OIL ISOVG 32 OIL
RESERVOIR CAPACITY (NOMINAL) : 23470 Liters (17245
LITERS)MAIN LO PUMP CAPACITY : 3600 LPM
RESERVOIR RETENTION TIME : 5 MINUTES MAIN
PUMP DISCHARGE PRESSURE : 5.30 BAR (G)LUBE
OIL HEADER PRESSURE : 1.72 BAR (G)
BEARING HEADER TEMPERATURE : 54.5 DEG C FOR OPEN COOLING
71.1 DEG C FOR CLOSED CW SYST
RESERVOIR COATING : EPOXY
APPROXIMATE LOSS OF LUBE OIL : 20 LITRES/100 OPERATING
HR(FROM LO TANK: LOSSER ARE IN THE FORM OF VAPOUR)

1.5 Summary and classification of energy

Following table represents the historical data collected from NTPS. Energy Performance Index data presented in the below table are calculated based on the data available with NTPS.

A		
Brief description of assignment	**:**	Mandatory Energy Audit of Namrup Thermal Power Station . Dibrugarh - Assam
Name & Address of Company	**:**	NTPS, **Namrup, Dibrugarh, Assam**
Address of communication of Auditor Firm	**:**	Energy Consultancy services
		Plot no- N4/182
		IRC village, Nayapalli
		Bhubaneswar -751015 (Odisha).
B		
Activity	**:**	Power Generation
C		
Working	**:**	24x7 days
No. of shifts	**:**	Three
Annual Working Days	**:**	365 days
D		
Total Power Generation Capacity of Station	**:**	**2*21MW)+1*22.5MW+98.4MW= 162.9 MW**
Power Export Voltage Level	**:**	220kV
Annual Power Generation	**:**	
Power Generation in 2020-21	**:**	**231079 MWH**
Tariff 2020.21	:	**Rs.3.01 per kWh***
Natural Gas consumption	:	Year 2019-20= **118823678**SCM
		Year 2020-21= **255344747** SCM
Average GCV of NG 2021-22 (upto Jan 22)	**:**	**9211* kcal/ SCM**
Station Gross Heat Rate 2021-22 (upto Jan 22)	:	3663 kcal/ kWh

1.6 Introduction about the plant/establishment

General plant/establishment details and Descriptions

Namrup Thermal Power Station (NTPS) was the biggest gas-based Power station for Base Load amidst South – East Asia in Sixties of 20th Century and was first installed & commissioned in 1965 under the electricity Act of 1948 as a step for formation of the state electricity boards all over the country. It was also the oldest and largest Thermal Power Plant(Gas Based) in India. Three no's of Gas Turbine were installed at 1965 of 23 MW each (Model - W-301). In 1975, another gas turbine having capacity of 12.5 MW (Model W-171) of Westinghouse was installed in NTPS. Again in 1976, for the first time in India, gas fired boiler by BHEL with Steam Turbine was also commissioned. In the year 1985, for the first time in India, a Heat Recovery Steam Generator of capacity 22.5 MW was installed by BHEL under Central Govt.'s R&D scheme for generation purposes. Since then all the units are running efficiently achieving milestones. The unit wise install & derated capacity of NTPS units are given below.

Unit	Generator	Capacity (MW)		Make	Commissioned on	Unit Transformer	Unit Aux. Transformer	Reserve Aux Transformer
		Installed	Derated					
	NRPP -Gas Turbine *	100		M/s BHEL	July 2021	11/220KV 100 MVA	11/0.415 , 1MVA	
2	NTPS Gas Turbine	23.0	21.0	M/s. Westinghouse Electric Corporation , Canada	16.04.1965	11/66. 30 MVA	11/0.415 , 1MVA	
3	Gas Turbine	23.0	21.0	M/s. Westinghouse Electric Corporation , Canada	16.04.1965	11/66. 30 MVA	11/0.415 , 1MVA	
6	Steam Turbine withwaste heat recovery boiler (combined cycle)	22.5	22.5	M/s BHEL	Nov., 1985	11/66. 30 MVA	11/0.415, 2MVA X 1	33/0.415, 2 MVA X 2

* GT-1 of NTPS was decommissioned from March, 2017.
GT-4 and ST-5 of NTPS was decommissioned 19th August-2020

The fuel used for generating power is NATURAL GAS, supplied by OIL (Oil India Limited), Duliajan and is transported to NTPS by AGCL (Assam Gas Company Limited), Duliajan. The Raw water required for running the plant as well as for providing drinking water to the residential quarters is fetched from the Dilli River Intake point situated at around 3 KMfrom NTPS.

NTPS is continuously achieving the generating target set by AERC from 2016 to 2018. Now with the passage of time all the units of NTPS being very old and are operating at a high cost due to high designed heat rate, it was decided to set up a 2 X 100 MW (Ph-I &Ph-II), CCGT at NTPS with low Heat rate machines to ensure high efficiency and reliability and to phase out existing G'T units gradually, once the project is completed.

The NRPP (Ph-1) will consist of One Gas Turbine Unit of capacity 62.25 MW and One Waste heat recovery unit of 36.15 MW with a capital cost including IDC of Rs. 694.00 Cr. The zero date of contract of NRPP is 09.02.2009. Project is completed and commissioned on 16th July 21

The specification of NRPP, Phase-I is detailed below:

Sl no	Generator	Capacity	Mak e	Unit Transformer
1	Gas Turbine Generator	62.25 MW	Turbine- GE(5231 RPM),Generator - BHEL(3000RPM)	100 MVA, 11/220 KV
2	Steam Turbine Generator	36.15 MW	BHEL(3000RPM)	55 MVA, 11/220 KV

1.7 Mode of Plant Operation

NTPS has 2 nos. of Gas turbines and 1 nos. of steam turbine with Waste heat Recovery . Gas Turbine units #2 and #3 each have a separate HRSG in its downstream. During closed cycle mode of operation steam produced by the HRSGs of the gas turbines operating in closed cycle mode is used to run a steam turbine i.e. unit #6. Steam produced by each HRSGs are supplied to common header for running the steam turbine (Unit# 6).Each gas turbine (unit #2 & #3) has 2 nos. of dampers at its exhaust. During closed cycle mode of operation of gas turbine, damper at the boiler input is kept open and the exhaust gas is used for running the HRSG, otherwise during open cycle mode damper at boiler inlet is closed and bypass damper iskept full open. During combine cycle mode of operation the bypass damper is kept in partial open condition to maintain gas turbine back pressure.

NRPP has commissioned one 62.25 MW Gas Turbine with Steam turbine of 36.15 MW total of 98.4 MW on 16th July 2021.

1.8 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 NTPS,Namrup, Dibrugarh. 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**.

Instrumentation Support

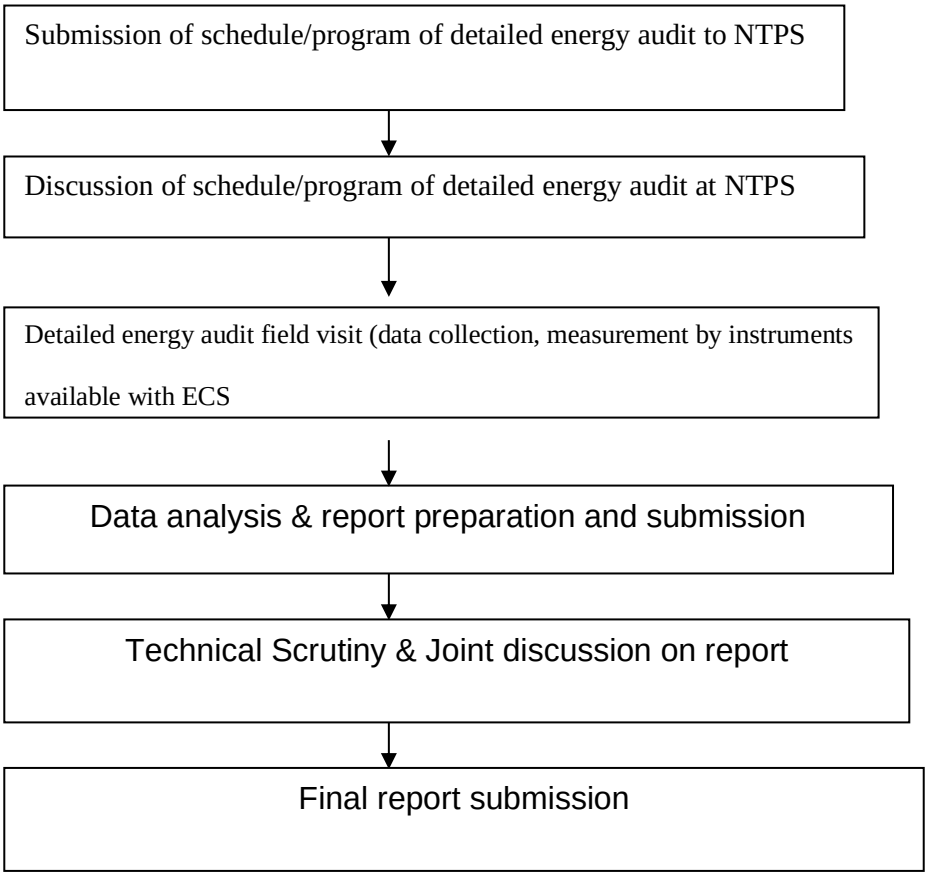
Some of the instruments used for undertaking the audit include the following:

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.

1.9 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 NTPS is given in the form of flow chart below.



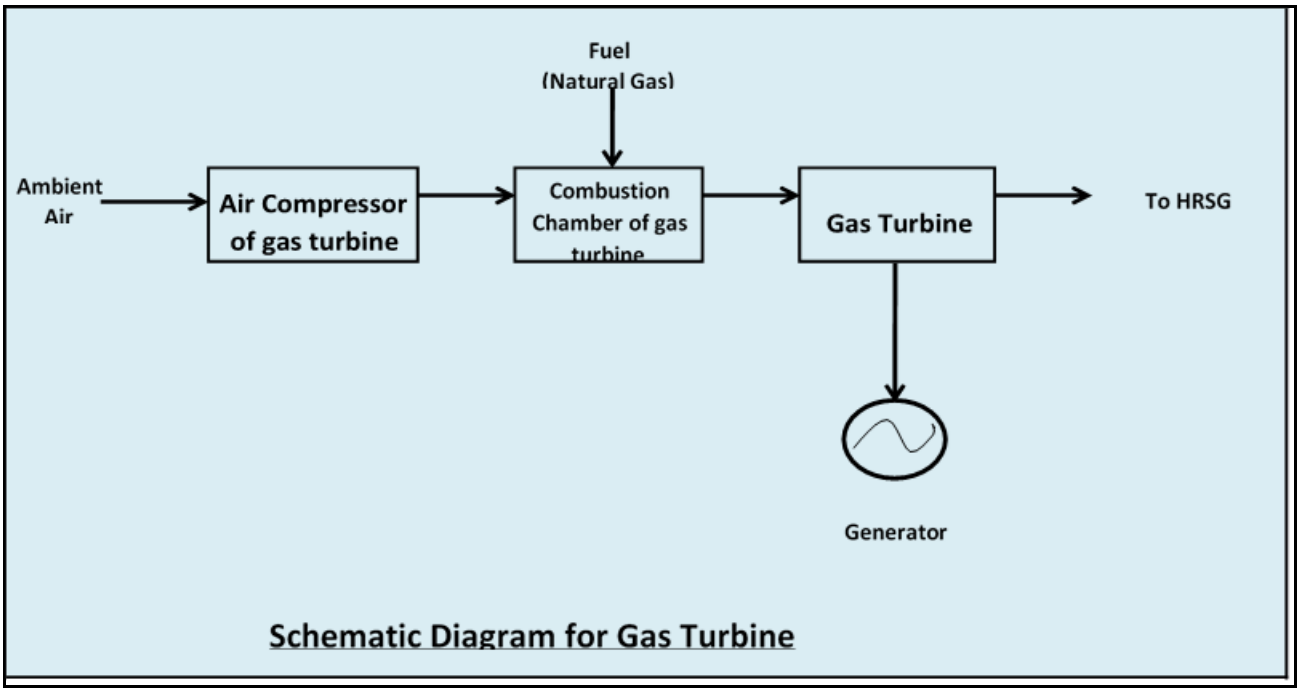
1.10 Energy Audit Team (onsite & off site)

ENERGY AUDIT TEAM

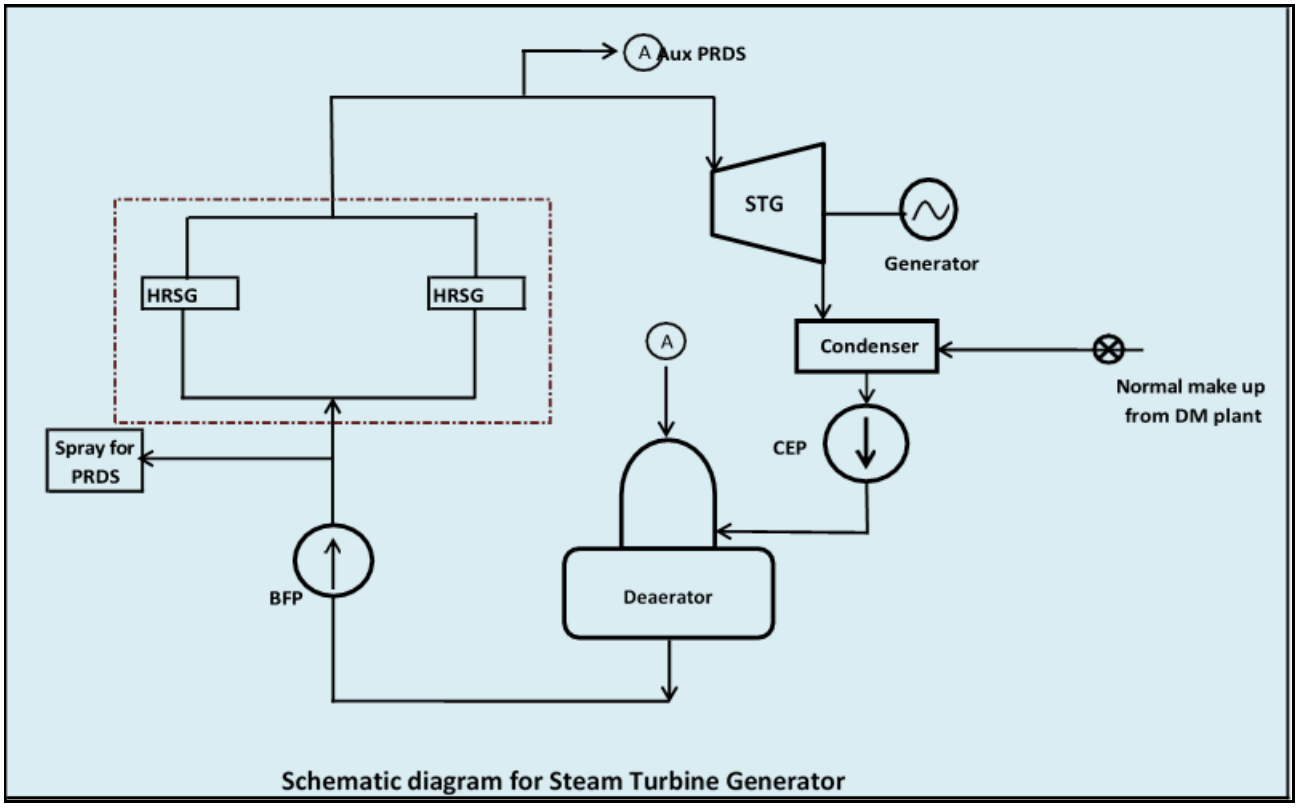
Sr No.	Name	AEA/ CEA/ Engineer	Qualification	Experience
1.	Shri. AMULYA KUMAR MOHINI	AEA-002	BE (Mechanical), BOE-Proficiency	30-year Exp in industries & BEE Energy conservation.
2.	Shri Jitendra Kumar	EA-18199	B.E (Mechanical l	10 years- Energy conservation Power Generation, Trans & Distribution, Energy 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)	ears in Energy Audit in Industry.

2.0 Generation process description

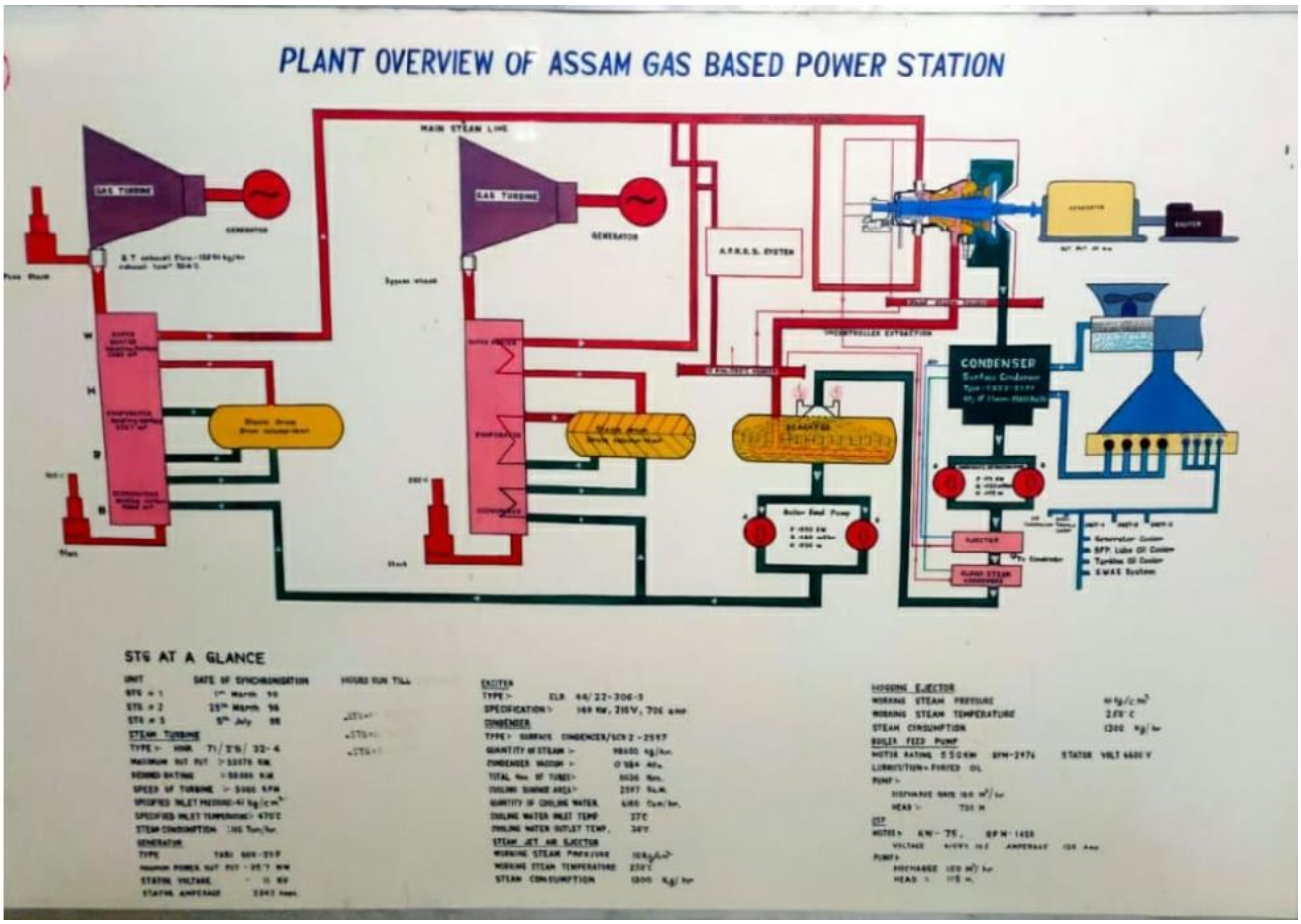
Process flow diagrams and major unit operations



Schematic Diagram for Gas Turbine



Schematic diagram for Steam Turbine Generator


PLANT OVERVIEW OF ASSAM GAS BASED POWER STATION
MAIN STEAM LINE
GAS TURBINE
GENERATOR
GAS TURBINE
GENERATOR
CONDENSER
STG AT A GLANCE

2.1 Major raw material inputs, quantity and costs

Parameters	Unit	2021-22(upto Jan 22)	2020-21
Fuel Consumption	SCM	132831895	143006489
Landed Cost of Fuel	Rs.	677470093	591207650
Tariff Rs/kWh	Rs./ SCM	5.10	3.01

Average Tariff has been increased from Rs 3.01 per SCM in the year 2020-21 to Rs 5.10 Per SCM in the year 2021-22 (upto Jan 22)

2.2 Energy and utility system description

List of utilities

- Gas Turbines and its Auxiliaries
- Gas Turbine Generator Transformers
- Gas Turbine Unit Auxiliaries Transformers
- HRSG & STG
- STG Generator Transformer (GT)
- STG Unit Auxiliaries Transformers
- Raw Water Pump
- Instrument Air Compressor
- Clutch Air Compressor
- Service Air Compressor
- Boiler Feed Pump
- Condensate Extraction Pump
- CW Pumps
- CT Fans
- Air Conditioning Plant

2.3 Brief description of each utility

Gas Turbine Units:

There are four Gas Turbines used with a total rating of 120.75 MW using Natural Gas as a fuel. 3 Gas turbines are supplied by Westinghouse, Canada while Gas turbine 4 was supplied by Bharat Heavy Electrical Ltd, India. Salient Technical Specifications of the GTs are as under:

Westinghouse (GT 2& GT3)	BHEL (GT NRPP)
Type – Single Cycle, Single Shaft No. of stages – Four(4) Compressor type – Axial flow Compressor no. of stages – 15 nosCompressor ratio – 1:6 Generator Cooling Type – Hydrogen Cooled Generator Rated Voltage – 11kV Rated Power Factor – 0.85 Rated r.p.m – 3000	Type – Single Cycle, Single Shaft No. of stages – Five(5) Compressor type – Axial flow Compressor no. of stages – 14 nosCompressor ratio – 1:6 Generator Cooling Type – Air CooledGenerator Rated Voltage – 11kV Rated Power Factor – 0.85

Waste Heat Recovery Boilers (WHRBs) for NTPS

There are three (3) Waste Heat Recovery Boilers (one for each GT-2 GT=3) of WHRBs producessteam at a time to run a steam turbine of 22.5 MW. Presently WHRB-1 is out of service as GT-1 was decommissioned.

The WHRBs are vertical forced circulation, single drum, single pressure unfired water tube boiler. It is designed to generate steam quantities as furnished in operating parameters as 20.5 atm (a) and 375°C of superheated steam at main steam stop valve outlet under specified modes of operation.

The technical features of the waste Heat Recovery Boilers are as follows:

Parameter	Technical Specification
Boiler Type	2X58.5 TPH, Vertical Forced circulation, Single drumwaste heat recovery boiler.
Super Heater	Convection, spiral frame, total heating surface 2000 m^2
Evaporator	Spiral finned, total heating surface 10,450 m^2
Economizer	Spiral finned, total heating surface 4000 m^2
Condensate pre heater	Spiral finned, total heating surface 1060 m^2
Steam temp at boiler outlet & Steam pressure at boiler outlet	382°C,21.8 atm(a)

Steam Turbine Generators of NTPS

The steam turbine used in unit no. 6 is driven by the steam produced by the two Heat Recovery Steam Generators. Salient Technical features are as under:

Maximum output = 22.5 MW
Speed = 3000 rpm
Trip Speed = 3200 rpm
Steam pressure at turbine inlet = 20.5 ata
Steam temperature at turbine inlet = 375°C
Exhaust pressure = 0.132 ata
Inlet steam flow = 117 TPH

Technical Specification of Major Auxiliaries of Unit # 6:

Boiler Feed Pumps

There are Three (3) Boiler Feed Pumps are used for HRSG, which one (1) are standby. Salient Technical specifications:

All Three pumps are supplied by BHEL and rated capacity 150 HP, nos of stage 10, working voltage 415 V, 175 A, rpm 2970, discharge head 336 mwc, discharge flow of 65 TPH and design efficiency 68%.

Condensate Extraction Pumps

There are two (2) nos. of pumps are used for condensate extraction, out of which one (1) no of pumps are used in operation and one (1) remain standby.

Technical Specification:

All Two (2) pumps are supplied by Siemens with a rated capacity of 55 kW, operating voltage 415, 90 amp, rpm 1480and AMB 45° C

Circulating Water Pumps

There are four (4) nos. of Cooling Water pumps. Out of these four (4) pumps one (1) pumps remains as standby.

Salient Technical Specifications:

All four pumps are supplied by NGEF, made in India. The rated capacity is 225 kW, with input voltage 415, 374 Amp and PF 0.8. The rpm of the motor is 994 rpm. Type AMW 35526 HI, 3 phase, 50 Hz at 45° C.

Boiler Circulating Water Pumps

There are six (6) nos. of Boiler Circulating Water pumps. Each module of HRSG is provided with two pumps, out ofwhich one (1) remains in operation.

Salient Technical Specifications:

Type – Centrifugal, capacity – 306 m^3/hr, sp. gravity – 0.83, total head in meters – 578 m , power 75 kW.

Cooling Tower Fans

There are 3 nos. of cooling tower fans used in three cells in cooling tower.

Technical Specification:

Make: Crompton Greaves, 3 Phase, 52 KW, 1460 RPM, 415 V, 90 A, 50 Hz.

Instrument Air Compressor

There are 2 nos. of reciprocating air compressors. Out of the two compressors one remains in service.

Technical specification:

Make: Siemens, 3 phase IM, 415 v, 78 A, 45 kW, 1475 RPM, p.f. 0.8

Key Auxiliaries

Sl. No.	Pumps / motors/ fan blowers	Rated kW	Total rated kW	Technical Specification
Unit #6 (STG)				
1	Vacuum pump motor (2 Nos)	30	60	3Ph. 415 volt. 55amps, 980rpm, NewmanElectric. made in England
2	Emergency oil pump	3.7	3.7	3 Ph, 415 volt_ 8 amps. 2850 rpm.,Kirloskar Electric Co. Ltd.
3	Auxiliary oil pump motor (1 nos)	30	30	3 Ph, 415 volt. 53 amps. 2900 rpm.,Kirloskar Electric Co. Ltd.
4	Dozing pump motor (6 nos)	0.37	2.22	3Ph, 415 volt, 1 amps, pf .69. 1380 rpm., Bharat Bijulee limited.
5	Sump pump motor (6 nos)	1.50	9	3Ph, 415 volt, 3.4 amps, 1410rpm., Crompton Greaves.
Gas Turbine				
6	Primary Oil pump (3nos)	37.5	112.5	3 Ph, 415 volt, 66amps, 2960rpm, Buffalo,USA
7	Seal oil pump (3nos)	2.3	6.8	3 Ph, 415 volt, 5amp, 1435 rpm, Westinghouse, USA
8	Vapour Extraction pump (3 nos)	0.75	2.25	415volt. 3.6amps, 960rpm. Roots Connersville, USA
9	Clutch air compressor (1 nos)	3.75	3.75	3 Ph, 415 volt, 7.9 amp, 1430rpm., IngersollRand

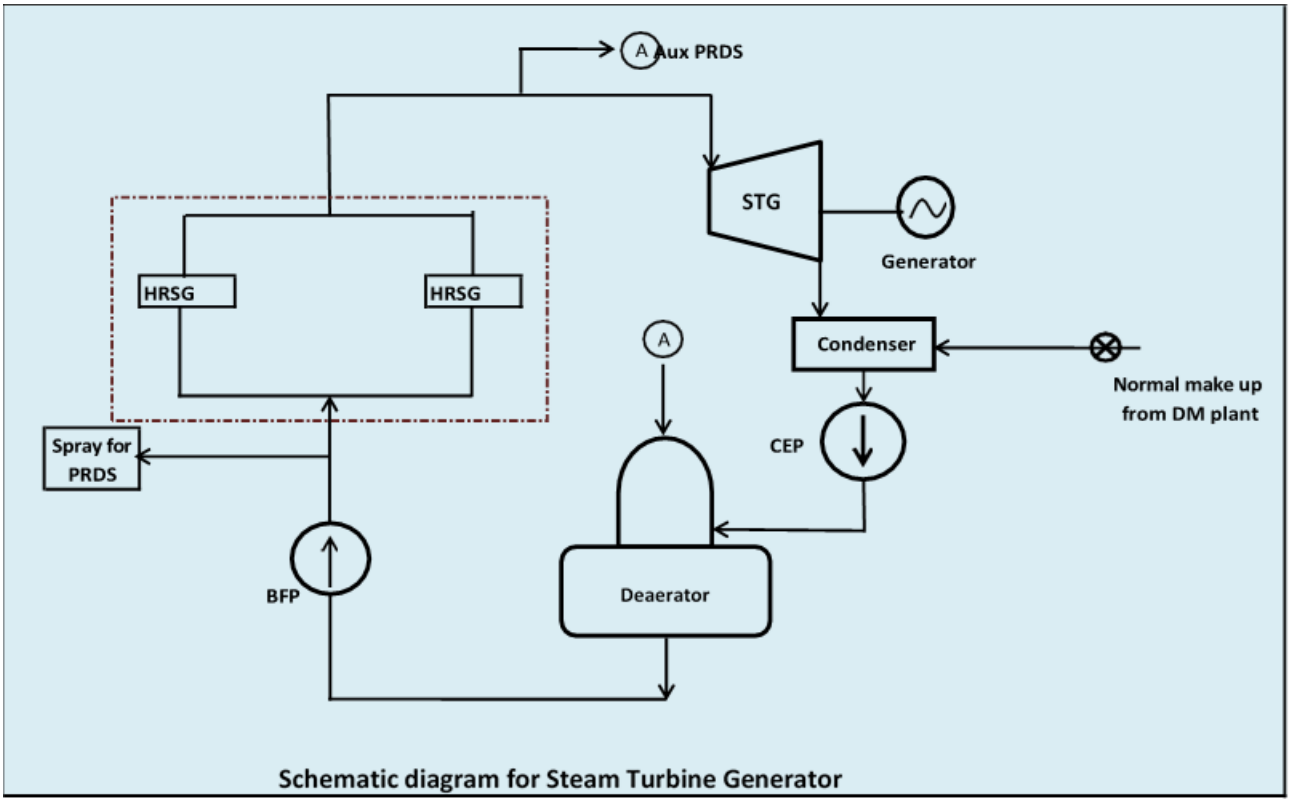
Sl. No.	Pumps / motors/ fan blowers	Rated kW	Total rated kW	Technical Specification
10	Instrument air compressor (1 nos)	3.75	3.75	3 Ph, 415 volt. 7.9 amp, 1430rpm., IngersollRand
	Instrument air compressor (1 nos)	5.60	5.60	3 Ph. 415 volt 10 amp, 1445 rpm., IngersollRand
11	Circulating water pump (6 nos)	37	222	3 Ph, 415 V +/- 10 %, 62 amp. 1472 rpm., eff 92%, Kirloskar, Electric Co. Ltd.
Total rated auxiliary power in kW			461.57	

3.0 Detailed Process flow diagram and energy and material balance

3.1 Flow chart showing flow rate, temperature, pressures of all input-output streams

Data collected during audit for energy balance is presented below along with the flow diagram:

Flow chart with Parameters for GT Unit #2 & #3 and Waste Heat Recovery Steam Turbine #6(During Combine Cycle Mode of Operation):



Schematic diagram for Steam Turbine Generator

ENERGY BALANCE

GT	Description	Flow	Pressure	Temperature	Generation
No.		SCM/	kg/cm2 a	°C	MW/ TPH
GT NRPP	Air inlet	-	1.019	19.85	-
	Fuel inlet (NG)	20649	16.189	-	-
	Generator output	-	-	-	66.88
	Super heated Steam Generation	-	84.1	531.4	105.1
	IP Steam		25.1	261.2	8.4
	LP Steam		4.6	206.2	8
GT #2 NTPS	Air inlet	-	**1.019**	**21.4**	**-**
	Fuel inlet (NG)	**8417**	**11**		
	Generator output				**16**
	Super heated Steam Generation				

STG	Description	Flow	Pressure	Temperature	Generation
		TPH	kg/cm2 G	°C	MW/ TPH
1	Super Heated HP Steam Inlet	105.1	84.1	531.4	
2	Super Heated IP Steam Inlet	8.4	25.1	130.6	
3	Super Heated LP Steam Inlet	8	4.6	103.1	
	Generator output				34.57
	Condenser		-0.939	48.15	
	Average CW Inlet to condenser		2.497	21.1395	
	Average CW Outlet from condenser		1.7	32.9295	

Observation : During field study it was found the Generation of NRPP was 66.88 MW and NTPS(GT2) was 16 MW. Generation in STG was 34.57 MW . total power generation during study was 117.45 MW

Energy balance of NTPS (GCV basis) and Performances of GT

Energy balance of GT				
Sl No	**Description**	**Unit**	**GT# NRPP**	**GT#2 NTPS**
Input				
1	Natural gas consumed during test	SCM/h	20649	8417
2	GCV of NG (average)	Kcal/SCM	9211	9211
3	Total Heat Input to GT	Kcal /h	**190197939**	**77528987**
Output				
4	Gross power generated during the test	MW	66.88	16
4i		Kcal/h	**57516800**	**13760000**
	HEAT RATE	Kcal/kwh	2843.87	4845.56
	GT Efficiency		**30.24**	**17.75**
		kcal/hr	**57516800**	**13760000**

Observation : Heat Rate was observed in NRPP 2843.87 Kcal/kWh and 4845.56 Kcal/kWh .Similarly GT Efficiency for NRPP was found to be 30.24% and GT efficiency of NTPS(GT#2) was found to be 17.75 %

Performances of HRSG

Losses in generator				
5	Generator efficiency	%	98	98
6	Loss in Generator	Kcal/h	1173812.24	280816.33
Radiation losses				
7	Radiation losses	%	2	2
	Radiation losses	Kcal/h	3803958.78	1550579.74
8	Unaccounted loss	%	2	2
		Kcal/h	3803958.78	1550579.74
9	Total loss (6+7+8)	Kcal/h	**8781729.80**	**3381975.81**

Energy Balance of HRSG

	Energy available at GT exhaust		HRSG #NRPP	HRSG #NTPS
10	Heat available to HRSG from GT exhaust (3-4i-6-7)	Kcal/h	**123899409.20**	**60387011.19**
	Energy available at GT exhaust			
	Heat available to HRSG from GT exhaust	Mcal/h	123899.41	60387.01

11	Energy available in Generated super-Heated Steam at GT exhaust		
	HRSG HP Steam Pr	kg/cm2	84.1
	HRSG HP Steam Temp	Deg C	531.4
	HRSG HP Steam Flow	TPH	105.1
	Heat in HP Steam Enthalpy	kcal/kg	829.633
	Heat in HP FEED WATER Enthalpy	kcal/kg	299.8
	Heat available in HP steam		55685448.3
	HRSG IP Steam Pr	kg/cm2	25.1
	HRSG IP Steam Temp	Deg C	261.2
	HRSG IP Steam Flow	TPH	8.4
	Heat in IP Steam Enthalpy	kcal/kg	694.883
	Heat in HP FEED WATER Enthalpy		196.6
	Heat available in IP steam	KCAL	4185577.2
	HRSG LP Steam Pr	kg/cm2	4.6
	HRSG LP Steam Temp	Deg C	206.2
	HRSG LP Steam Flow	TPH	8
	Heat in LP Steam Enthalpy	kcal/kg	684.801
	Heat in HP FEED WATER Enthalpy		108.7
	Heat available in L P steam	KCAL	4608808
	Net Heat transfer to Steam	MCal	64479.83
12	**HRSG Efficiency**	**%**	**52.04%**
	Loss as Flue Gas	Mkcal	59419.58

Observation : During field study HRSG efficiency was found to be 52.04 % .and HRSG performance is satisfactory .

PERFORMANCE OF STG

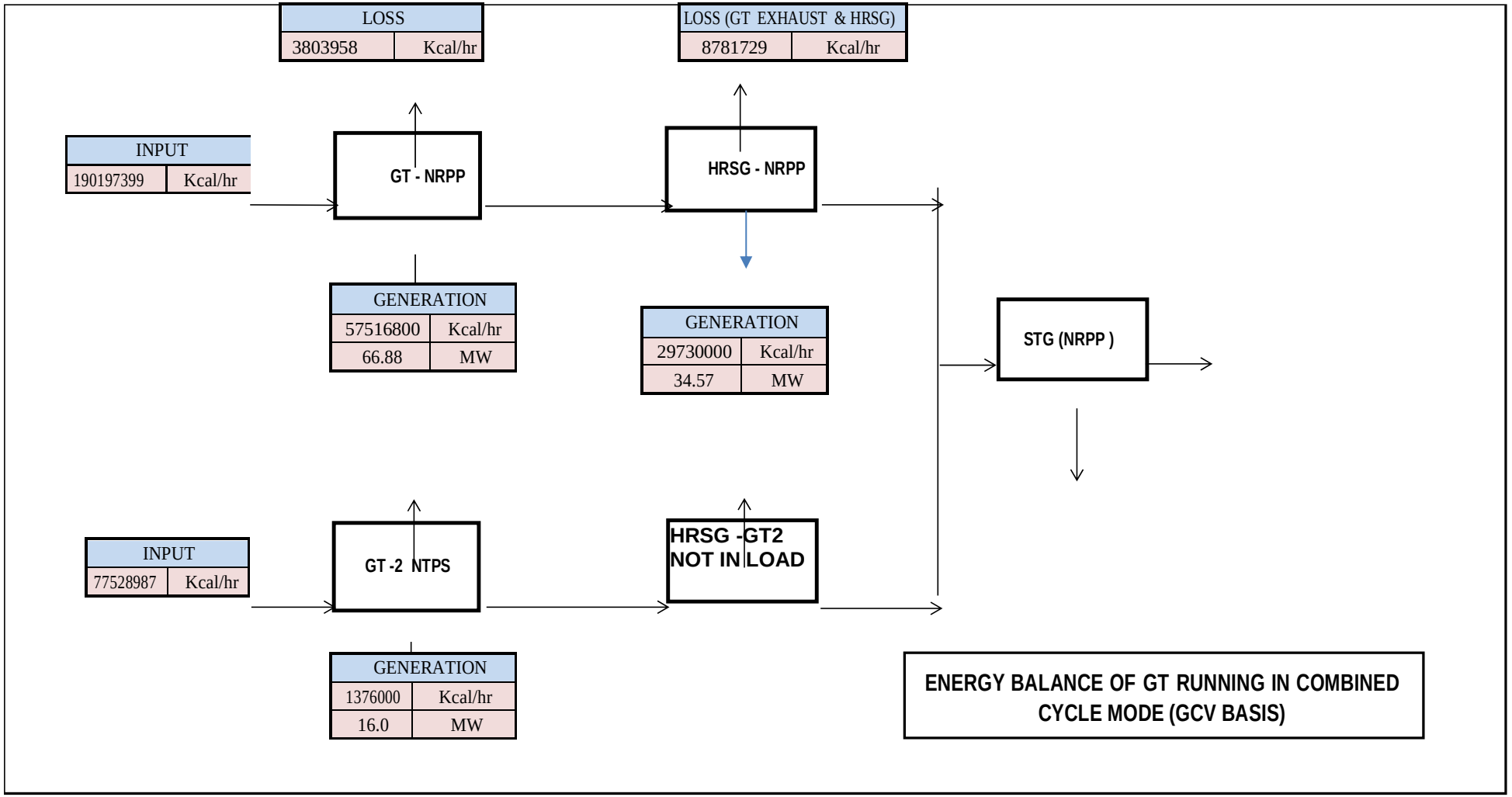
Energy Balance of STG OF NRPP is on full load			
Sr No	**Description**	**Unit**	**STG#1**
Input			
1	Heat added to water/steam in HRSG	Mcal/hr	**123899.41**
Output			
2	Gross power Generation	MW	34.57
	Heat rate	**Kcal/kwh**	**3584.02**
	STG Efficiency	%	24.00%
3	Heat converted to Power	Mcal/hr	**29730.2**
Losses			
4	Loss in steam turbine cycle	kcal/hr	**94169.21**

Unit Heat Rate of NRPP on full load			
Sr. No.	**Description**	**Unit**	**Value**
1	Net Power Generation	MW	101.45
2	Net Heat Used	Mcal/hr	190197939
3	Heat Rate of Unit Open cycle	kcal/kWh	2843.87
4	Efficiency of Unit in Open Cycle		30.24%
5	heat Rate Close cycle	kcal/kWh	1874.79
6	Efficiency of Unit in Closed cycle		45.87%

Unit Heat Rate of NTPS WHEN GT2 IS ON LOAD			
Sr.	**Description**	**Unit**	**Value**
1	Net Power Generation	MW	16
2	Net Heat Used	Mcal/hr	77528987
3	Heat Rate of Unit Open cycle	kcal/kWh	4845.56
4	Efficiency of Unit in Open Cycle		17.75%
5	heat Rate Close cycle	kcal/kWh	0.00
6	Efficiency of Unit in Closed cycle		0.00%

Observation : STG generation was observed to be 34.57 MW and its Heat Rate is 3584.02 kcal/kWh . STG efficiency was found to be 24.00% . The performance of STG is satisfactory .

Energy Balance with Flow Diagram (GCV Basis)

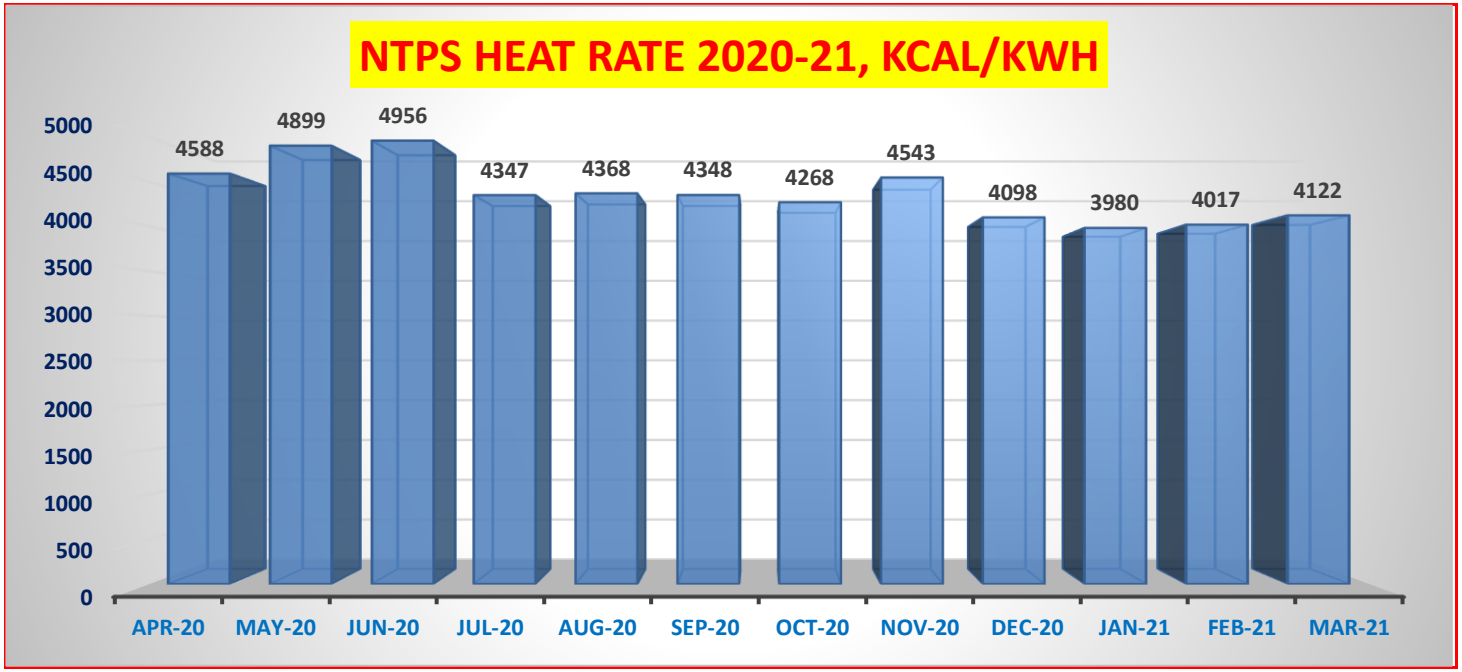


POWER GENERATION OF NTPS FOR THE YEAR 2020-21

MONTH	UNITWISE GENERATION DATA IN (MWH)				UNITWISE CUMULATIVE GENERATION DATA IN(MWH)			
	#2	#3	#6	TOTAL	#2	#3	#6	STATION
Apr-20	7510	8973	3872	20355	7510	8973	3872	20355
May-20	2721	6216	1723	10660	10231	15189	5595	31015
Jun-20	9712	7172	1328	18212	19943	22361	6923	49227
Jul-20	5139	6169	3051	14359	25082	28530	9974	63586
Aug-20	2502	7118	2449	12069	27584	35648	12423	75655
Sep-20	7406	3626	2233	13265	34990	39274	14656	88920
Oct-20	8946	8121	4752	21819	43936	47395	19408	110739
Nov-20	7746	8095	3105	18946	51682	55490	22513	129685
Dec-20	10623	9513	5453	25589	62305	65003	27966	155274
Jan-21	11352	9569	5781	26702	73657	74572	33747	181976
Feb-21	8814	9510	5279	23603	82471	84082	39026	205579
Mar-21	9903	9970	5627	25500	92374	94052	44653	231079
TOTAL	92374	94052	44653	231079				

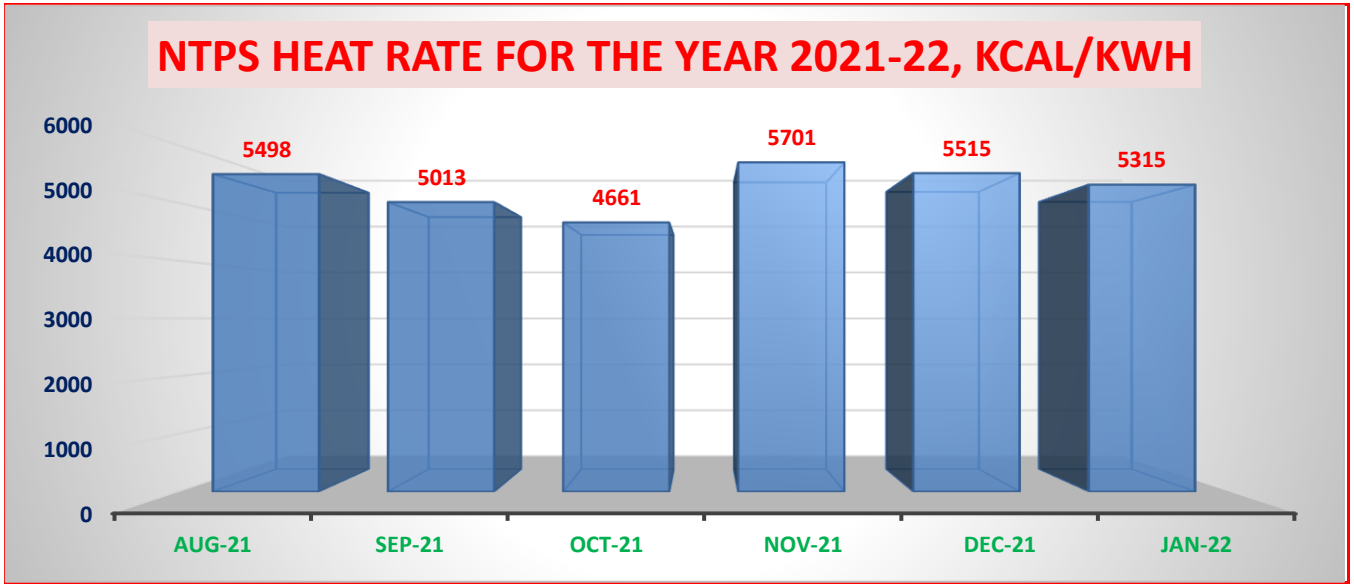
Observation : Unit wise Power generation for the year 2020-21 was tabulated as above table. Total power generation of NTPS 231079 MWH. The Power generation of GT#2 was found to be 92374 MWH, GT#3 was 94052MWH and unit#6 power generation was 44653 MWH .

HEAT RATE OF NTPS FOR THE YEAR 2020-21



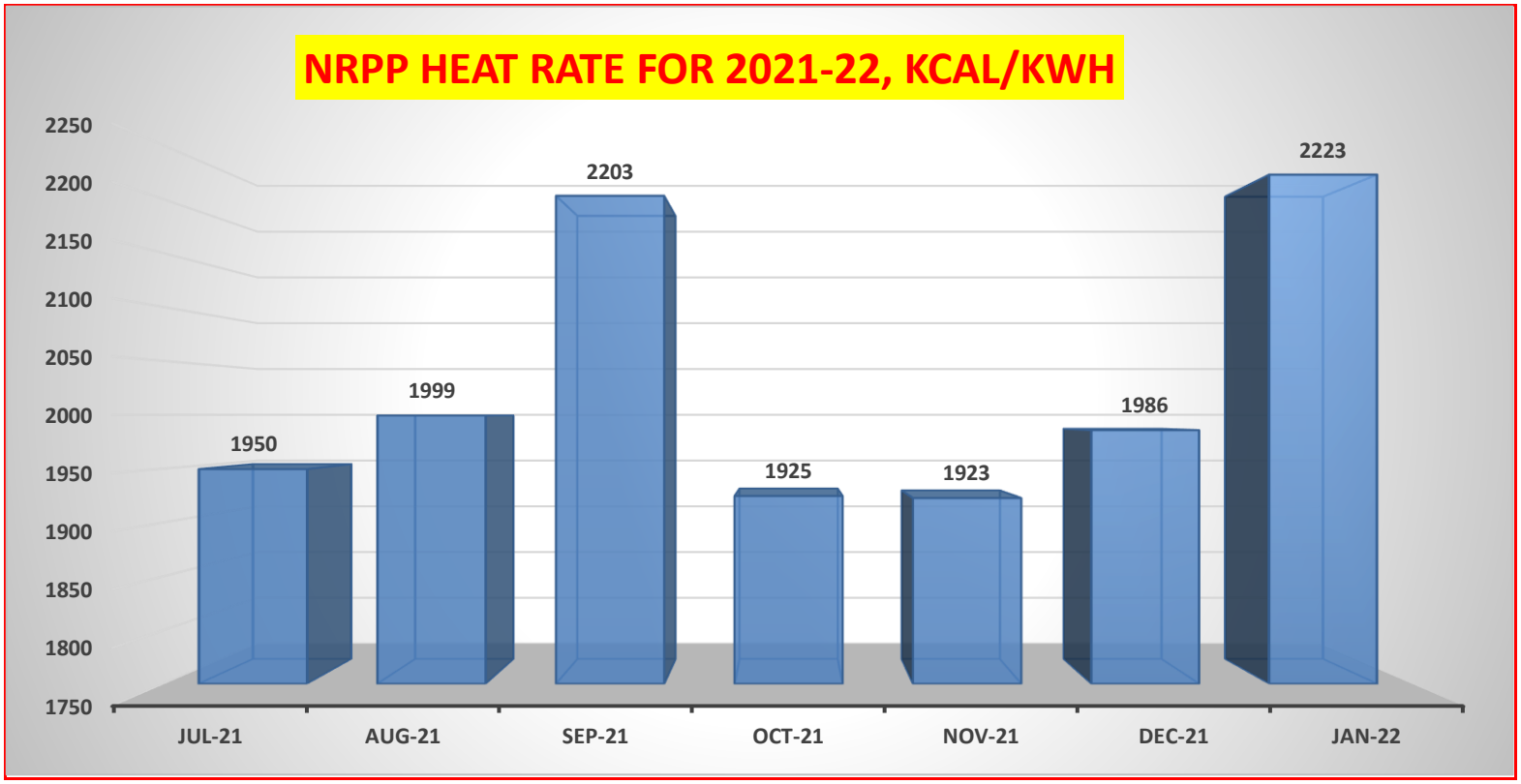
Observation : Heat rate for NTPS for the year 2020-21 is depicted in above chart. Heat rate is observed to be varying from 3980kcal/kWh to 4965 Kcal/kWh. Heat rate is found to be highest in the month of Jun 20 and lowest in the month of Jan 21 .

HEAT RATE OF NTPS FOR THE YEAR 2021-22(UPTO JAN 22)



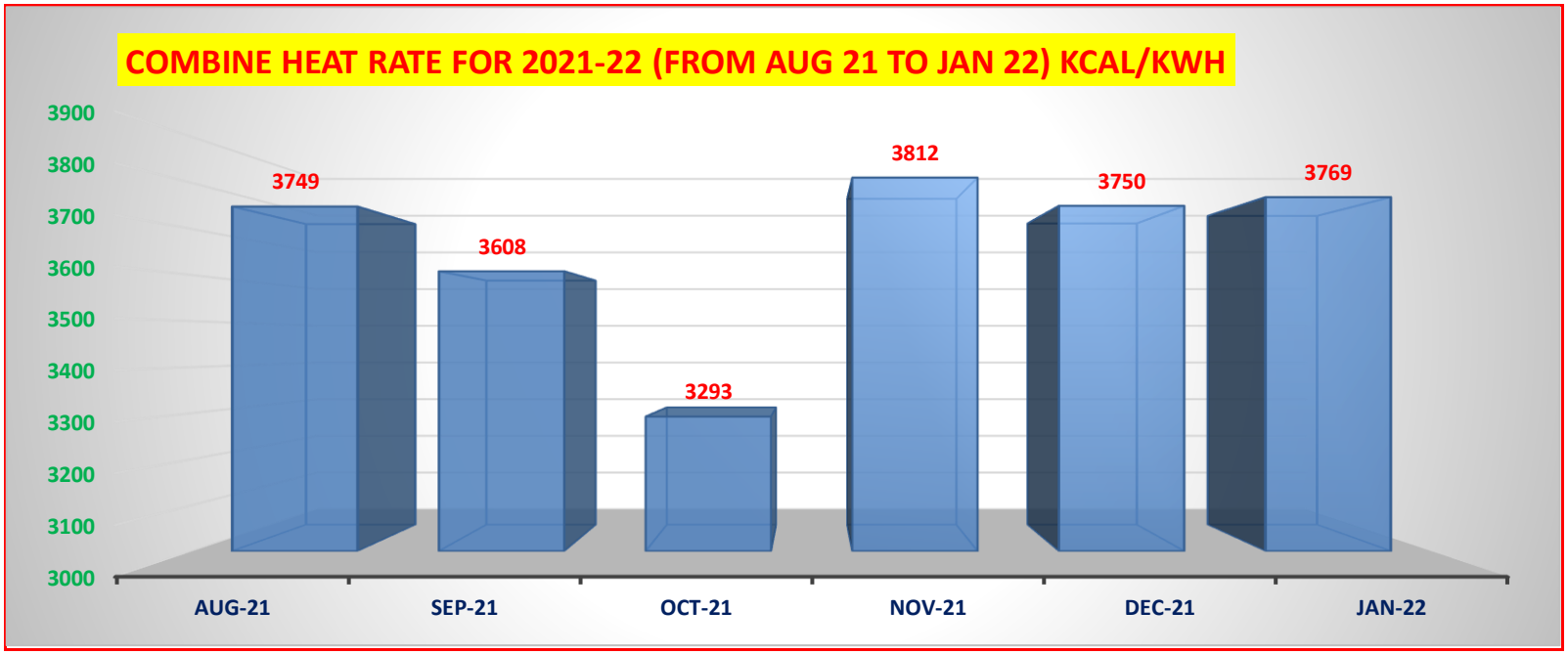
Observation : Heat rate for NTPS for the year 2021-22 (upto January 2022) is depicted in above chart. Heat rate is observed to be varying from 4661 kcal/kWh to 5701 Kcal/kWh. Heat rate is found to be highest in the month of November 2021 i.e., 5701 kcal/kWh and lowest in the month October 2021 i.e., 4661 kcal/kWh .

NRPP HEAT RATE FOR 2021-22 (upto January 2022)



Observation : Heat rate of NRPP for the year 2021-22 is depicted in above diagram. Heat rate is observed maximum in the month of January 2022 i.e., 2223 kCal/kWh and minimum in the month of November 21 i.e., 1923 kCal/kWh . the Average heat rate for the year 2021-22(Upto January 20220 is found to be 2030 kCal/kWh.

COMBINE HEAT RATE FOR NTPS AND NRPP FOR 2021-22(FROM AUG21 TO JAN 22)



Observation : combine Heat rate of NTPS and NRPP for the year 2021-22 (FROM AUG 21 TO JAN 22) KCAL/KWH is depicted in above bar chart. Combine Heat rate is observed maximum in the month of November 2022 i.e., 3812 kCal/kWh and minimum in the month of October 21 i.e 3293 kCal/kWh . the Average heat rate for the year 2021-22(Upto January 20220 is found to be 3663 kCal/kWh.

4.0 List of equipment and process performances

During Mandatory Energy Audit, total process was studied and evaluated. Measurements and data were collected during the onsite audit visit for performance analysis of major equipment. The major areas of study were as follows:

a. Gas Turbines Units #2 & Unit #3 was kept standby.
b. Steam Turbines #6
c. Performance assessment of combined cycle as a whole
d. Transformers
e. Major motors
f. Cooling Tower of Steam turbine Unit # 6
g. Spray Pond #1 for Gas Turbine
h. Lighting
i. Insulation of Gas Turbines, HRSGs, and exhaust duct.
j. Condensers of ST-6

4.1 Performance of Gas Turbine

Gas Turbine Performance

			Value	
Sl No	**Description**	**Unit**	**NRPP GT**	**Remarks**
1	Generator Load	MW	67.02	
2	Ambient pressure	MMWC	108.4	
3	Suction DP	inwc	4.3	As per Local reading
4	Compressor suction pressure	KG/CM2 bar	1.14163	
5	Compressor discharge pressure	KG/CM2 G	13.9	
6	Compressor discharge pressure	KG/CM2 bar	14.933	
	Compression ratio		13.08	
	k =cp/cv		1.4	As per Local reading
7	Compressor inlet temperature	K	296	As per Local reading
8	Compressor outlet temperature	K	683.5	As per CR reading
9	Gas turbine inlet temperature	K	1579.7	As per CR reading
10	Gas turbine exhaust temperature	K	888.2	As per CR reading
11	Compressor inlet enthalpy	kj/kg	296.17	
12	Compressor outlet enthalpy	kj/kg	695.56	
13	Gas turbine inlet enthalpy	kj/kg	1732.8	
14	Gas turbine exhaust enthalpy	kj/kg	919.732	Air Standard basis
15	**Thermal efficiency**	**%**	33.92%	
16	Comp disch temp (isentropic)	K	617.06	
17	**Compressor isentropic efficiency**	**%**	**82.85%**	Cold air standard basis

Observation : Thermal efficiency of gas turbine has been found to be 33.92% and compressor isentropic efficiency is 82.85 % . Performance of Gas turbine is satisfactory .

4.1 Boiler Feed Pumps (BFPs) of NRPP

BFP 's are the key auxiliaries in terms of connected load as well as Consumption. All the BFPs for the units of NRPP, the design details are same, and the observation details are below.

NRPP		BFP PUMP
Particulars	**Units**	**HP BFP-B**
Flow rate	TPH	103.2
suction pr	Kg/cm2	0.5
discharge pr	Kg/cm2	94.5
Net Head	mH	940
Temperature	DegC	110.6
Type of Fluid		Water
Density of Fluid	kg/m3	1000
Work Done (Hydraulic Power)	kW	264.3
Input Energy		
Motor Rated	kW	507
Voltage	kV	6.6
Current	Amps	42
Power Factor		0.85
Load	kW	408.1
Overall System Efficiency	%	65%

Observation:

- Overall efficiencies of HPBFP Pumps are observed as 65 %
- **Comments:** It is recommended for de-stagging of HPBFP Pumping systems.

4.2 Condensate Extraction Pumps (CEPs) of NRPP:

To assess the performance of condensate extraction pumps (CEPs) the electrical as well as flow characteristics have been analysed. The performance of CEPs presented as below:

NRPP	CEP PUMP	
Particulars	**Units**	**CEP-1**
Flow rate	m3/hr	130
Net Head	mH	150
Temperature	DegC	45
Type of Fluid		Water
Density of Fluid	kg/m3	1000
Work Done (Hyd Power)	kW	53.1
Input Energy	Motor Rated	110
Voltage	kV	0.415
Current	Amps	172.73
Power Factor		0.85
Load	kW	105.5
Overall System Efficiency	%	50%

Observation:

- Overall efficiencies of CEP Pumps are observed as 50 %
- **Comments:** It is recommended for de-stagging of CEP Pumping systems.

4.3 INTAKE RAW WATER PUMP HOUSE

NTPS		INTAKE WATER PUMP HOUSE			INTAKE WATER PUMP HOUSE		
Particulars	Units	PUMP 1	PUMP 3	PUMP F	PUMP A	PUMP D	PUMP E
Flow rate	m3/Hr	357	312	148	184	187	166
suction pr	Kg/cm2	0.87	0.87	0.87	0.87	0.87	0.87
discharge pr	Kg/cm2	2.5	2.5	2.5	2.5	2.5	2.5
Net Head	mH	16.3	16.3	16.3	16.3	16.3	16.3
Temperature	DegC	35	35	36	37	38	39
Type of Fluid		Water	Water	Water	Water	Water	Water
Density of Fluid	kg/m3	1000	1000	1000	1000	1000	1000
Work Done (Hyd Power)	kW	15.9	13.9	6.6	8.2	8.3	7.4
Input Energy							
Motor Rated	kW	45	45	15	15	15	15
Voltage	kV	0.415	0.415	0.415	0.415	0.415	0.415
Current	Amps	63.00	62.67	24.5433	24.6333333	24.98	24.05
Power Factor		0.85	0.89	0.89	0.85	0.85	0.85
Load	kW	38.5	40.1	15.7	15.1	15.3	14.7
Overall System Efficiency	%	41.19%	34.56%	41.87%	54.12%	54.29%	50.16%

Observation:

- There are 2 pumps available at intake raw water pump house, only one is in operation and one is standby mode.

Comments:

- The combined efficiency (Motor + pump) of intake pump house are 41.19% and 34.56 %
- One of the options for Energy savings would be use of pump coating material to improve efficiency.
- One of the options for Energy savings would be remove the old pumps to replace new highly efficient Pump.
- There are 6 nos auxiliary pumps are available to draw water from low level.
- Combined efficiency of are found to be 41.87% for PUMP -F, 54.12% for PUMP -A, 54.29% for PUMP -D AND 50.16% for PUMP -E .

4.4 COOLING WATER PUMP HOUSE

NRPP	CW PUMP		
Particulars	Units	CWP 3	CWP 2
Flow rate	M3/hr	4385	4250
suction pr	Kg/cm2	0.3	0.3
discharge pr	Kg/cm2	2.2	2.2
Net Head	mH	19	19
Temperature	DegC	33	33
Type of Fluid		Water	Water
Density of Fluid	kg/m3	1000	1000
Work Done (Hyd Power)	kW	227.0	220.0
Input Energy			
Motor Rated	kW	650	650
Voltage	kV	6.63	6.63
Current	Amps	56.25	59.85
Power Factor		0.85	0.85
motor shaft power	kW	549	584.2
Overall System Efficiency	%	41.35%	37.67%

Observation:

- There are 3 pumps available at Cooling water pump house , only two is in operation and one is standby mode.

Comments:

- The combined efficiency (Motor + pump) of intake pump house are 41.35% and 37.67 %
- One of the options for Energy savings would be use of pump coating material to improve efficiency.

4.5 AUXILIARY COOLING WATER

NRPP		ACW PUMP	ACW PUMP
Particulars	Units	ACW 1	CT Make up
Flow rate	m3/Hr	1230	232
suction pr	Kg/cm2	0.3	0.3
discharge pr	Kg/cm2	4.05	2.3
Net Head	mH	37.5	20
Temperature	DegC	35	36
Type of Fluid		Water	Water
Density of Fluid	kg/m3	1000	1001
Work Done (Hyd Power)	kW	125.7	12.6
Input Energy			
Motor Rated	kW	250	30
Voltage	kV	6.6	0.415
Current	Amps	23.39	47.57
Power Factor		0.84	0.85
Load	kW	224.6	29.1
Overall System Efficiency	%	55.96%	43.45%

Observation:

- There are 2 pumps available at Cooling water pump house , only one is in operation and one is standby mode.

Comments:

- The combined efficiency (Motor + pump) of Cooling water pump house is 55.96%
- One of the options for Energy savings would be use of pump coating material to improve efficiency.
- The combined efficiency (Motor + pump) of circulating cooling water pump is 43.45 %

4.6 CIRCULATING COOLING WATER AT NRPP

NRPP	NRPP CCW	
Particulars	Units	PUMP 1
Flow rate	m3/Hr	1150
suction pr	Kg/cm2	0.3
discharge pr	Kg/cm2	6.02
Net Head	mH	57.2
Temperature	DegC	32
Type of Fluid		Water
Density of Fluid	kg/m3	1000
Work Done (Hydraulic Power)	kW	179.3
Input Energy		
Motor Rated	kW	280
Voltage	kV	6.66
Current	Amps	25.27
Power Factor		0.9
Load	kW	262.3
Overall System Efficiency	%	68.34%

Observation:

- There are 2 pumps available at Circulating Cooling water pump house of NRPP, only one pump is in operation and one is on standby mode.

Comments:

- The combined efficiency (Motor + pump) of circulating Cooling water is observed as 68.34 .
- Pumping system of circulating cooling water pumps are satisfactory

4.6 CIRCULATING COOLING WATER AT NTPS

NRPP		NTPS WATER PUMP HOUSE		
Particulars	Units	PUMP 1	PUMP 2	PUMP 6
Flow rate	m3/Hr	60	134	61
suction pr	Kg/cm2	0.3	0.3	0.3
discharge pr	Kg/cm2	4	4	4
Net Head	mH	37	37	37
Temperature	DegC	35	35	36
Type of Fluid		Water	Water	Water
Density of Fluid	kg/m3	1000	1000	1000
Work Done (Hydraulic Power)	kW	6.0	13.5	6.2
Input Energy				
Motor Rated	kW	37	37	37
Voltage	kV	0.415	0.415	0.415
Current	Amps	39.29	59.67	37.71
Power Factor		0.85	0.85	0.85
Load	kW	24	36.5	23
Overall System Efficiency	%	25.21%	37.02%	26.74%

Observation:

- There are 6 pumps available at Cooling water pump house , only three is in operation and three are on standby mode.

Comments:

- The combined efficiency (Motor + pump) of Cooling water pump house are observed as 25.21%, 34.02% and 26.74%
- One of the options for Energy savings would be use of pump coating material and also replace the pumps with energy efficient pump to improve efficiency.

4.7 Assessment of Transformer Performance

NTPS have generator-transformers, unit auxiliary transformer, reserve transformer and auxiliary transformer. The transformers that were accessible for measurement were studied during onsite audit and electrical parameters were measured. Based on the parameters measured, loading of transformer have been calculated. Summary of transformer performance is presented below (for details refer to annexure):

Summary of Transformers Loading of NTPS													
Name of Transformer	Rated Capacity(MVA)	Frequency (Hz)	Average Voltage(V)	THD V (%)	V unb (%)	Average Current(A)	THD I (%)	A unb (%)	PF	Active Power (kW)	Reactive Power (kVAr)	Apparent Power (kVA)	% Loading
Gas Turbine (Unit#2) Generator Transformer	30	50.06	67216.00	1.15	0.20	118.72	1.13	2.62	0.99	13793.06	1221.25	13870.15	46.23
Gas Turbine NRPP Generator Transformer	100	49.94	64924.44	0.56	0.49	167.31	1.17	8.67	0.99	18700.09	1965.12	18838.92	62.80

Observation:

- Loading of generator transformers is 46.23% & 62.80%.
- Power factor of the generator transformer of Gas Turbines Units #2 and NRPP GT is found between 0.99.

4.8 Motor Loading Assessment:

Details of Electrical Motors Measurement at NRPP							
Sl. No.	**Particulars**	**Rated in KW**	**Volt**	**Amp.**	**PF**	**KW**	**%Motor Loading**
GT-MCC							
1	AOP-2	75	429.5	75	0.99	55.23	73.65
2	Cooling Air Motor BT-2	18.5	430.3	26.7	0.89	17.71	95.73
3	Cooling Air Motor BT-1	18.5	430.1	26.3	0.88	17.24	93.19
4	LO Mist Fan Motor QV-1	15	429.4	15.7	0.95	11.09	73.95
5	Hydrulic Pump Motor HQ-1	15	430.2	12.1	0.92	8.29	55.30
6	GBC (Cooling Water Pump-2)	15	431.2	14.5	0.97	10.50	70.03
7	Exhaust Frame Blower Motor	30	426.2	30	0.91	20.15	67.17
8	GFD Seal Air Motor-1	15	429.3	12.3	0.91	8.32	55.48
STG-MCC							
9	Condensate Recirculation Pump-2	55	428.6	44.35	0.97	31.93	58.06
10	Lop#1	75	429.6	73.8	0.94	51.62	68.82
11	CEP #1	110	428.4	174.4	0.84	108.70	98.82
12	IP BFP-1	37.5	428.6	56.1	0.89	37.06	98.84
BOP-MCC							
13	Air Compressor System-2	75	425.6	46	0.97	32.89	43.85

Sl. No.	**Particulars**	**Rated in KW**	**Volt**	**Amp.**	**PF**	**KW**	**%Motor Loading**
SST-4							
1	HP-BFP-3	610	6.6	42.3	0.88	425.51	69.76
2	GBC-2	930	6.75	99.04	0.78	903.14	97.11
3	CWP-3	650	6.58	60.74	0.87	602.24	92.65
4	ACWP-2	250	6.6	24.4	0.88	245.45	98.18
5	CW-2	650	6.64	65.7	0.84	634.69	97.64
6	CCWP-1	280	6.58	24.5	0.89	248.50	88.75
7	HP-BFP-1	610	6.59	40.8	0.91	423.77	69.47

4.9 Cooling Tower Performance:

In NRPP there are 1 nos. of separate cooling tower having 6 nos . of cells with one CT fan for each cell. During onsite audit only 5 CT fans were in service and one cell is under maintenance Details of observations were presented below:

	NRPP							
Sl. No.	**Parameter**	**UNITS**	**CELL-1**	**CELL-2**	**CELL-3**	**CELL-4**	**CELL-5**	**CELL-6**
1	CW FLOW TO CT AS A WHOLE	m^3/Hr	8635	8635	8635	8635	8635	8635
2	NO.OF CELLS		6	6	6	6	6	6
3	CW FLOW PER CELL	m^3/Hr	1439.17	1439.17	1439.17	1439.17	1439.17	SHUT
4	CT INLET TEMP (Common)	0_C	29.9	30.4	31	29.8	30.5	DOWN
5	CT OUTLET TEMP(Common)	0_C	25.3	25.8	26	25.2	25.5	
6	DRY BULB TEMP(Common)	0_C	23.92	23.92	23.92	23.92	23.92	
7	RH %	%	52.47	52.47	52.47	52.47	52.47	
8	WET BULB TEMP(Common)	0_C	17.34	17.34	17.34	17.34	17.34	
9	DENSITY OF AIR (Common)	kg/m3	1.135	1.135	1.135	1.135	1.135	
10	CT RANGE	0_C	4.6	4.6	5	4.6	5	
11	CT APPROACH	0_C	7.96	8.46	8.66	7.86	8.16	
12	EFFECTIVENESS		36.62%	35.22%	36.60%	36.92%	37.99%	
13	CT HEAT LOAD	Mkcal/Hr	39.72	39.72	43.18	39.72	43.18	
14	CT HEAT DUTY	TR	13135	13135	14277	13135	14277	
15	CT FAN MOTOR AMPERE	AMPS	83.53	85.27	87.93	75.83	85.37	
16	CT FAN MOTOR VOLT	VOLT	420	420	420	421	418	
17	CT FAN MOTOR POWER	Kw	51.65	52.72	54.37	47.00	52.53	
18	Fan Funnel Xn Area	m2	50.24	50.24	50.24	50.24	50.24	
19	Fan Air Velocity	m/sec	2.90	3.18	2.95	3.05	3.32	
20	(Avg of All cells)	m^3/Hr	524506	575148	533549	551635	599866	
21	CT FAN FLOW / CELL	kg/hr	642519	704556	653597	675753	734835	
22	**L/G RATIO**	**kgw/kgair**	2.24	2.04	2.20	2.13	1.96	

5.0 Insulation Survey:

Insulation health of GT body, GT exhaust duct and HRSG body was conducted by checking the skin temperature of GT body, GT exhaust duct and HRSG body. In many areas skin temperature was found very high. The insulation survey conducted during onsite audit is presented below:

Particulars	Temperature in °C							Average Temperature (°C)
1st side								
3rd Floor	140.3	60.6	42.3	42.5	42.6	45.6	38.6	59
2nd Floor	36.7	34.1	35.6	42.9	43.4	56.6	63.2	45
1st Floor	71	51.5	52.6	47.7	105	44.5	63	52
	43	70.7	35.1	40.7	34.2	29.8	40	
Ground Floor	50.4	42.3	41	35.8	38	49.7	56.6	46
	50.3	49.5	49.5	42.6	48.5			
2nd Side								
3rd Floor	35.6	39.6	34.5	36.6	49.6	42.5		40
2nd Floor	45.9	48.6	52.6	45.2	41.3			47
3rd Side								
3rd Floor	30.2	30.6	34.3	34.3	34.6	30.4		32
2nd Floor	49.9	41.2	39.7	47.5	49.7	46.6		46
Dum-1	60.6	53.53	181.1	177	27.9	60.06	49.4	87
Dum-2	34.5	37.5	38.5	41.5	140	45.5	139	68
Dum-3	125.5	42.5	43.5	42.6	43.5	43.6	129.5	67

OBSERVATIONS : SURFACE TEMPERATURE OBSERVED IN GT AREA AND HRSG AREA ARE SATISFACTORY.

6.0 Illumination Survey

During site audit illumination level of key operation area of the plant was checked at evening with Lux meter. Average illumination levels found are presented below:

Table No - 40

Illumination Survey at NTPS				
Sl No.	**Area**	**No. of Lamp**	**Type of Lamp**	**Avg. Lux**
Turbine Floor				
1	Gas Turbine -1	18	HPMV	20
2	Gas Turbine -2			25
3	Gas Turbine -3			20
4	Gas Turbine -4	7	CFL	18
5	STG (Unit-5)	11	HPMV	15
6	Waste Heat STG (Unit-6)			14
Control Room				
7	Electrical Control Room (ECR)	32	FTL	170
8	Mechanical Control Room (MCR)	21	FTL	120
Other				
9	Compressor Area	3	CFL	45
10	Gas Turbine Spray Pond CW Pump	1	FTL	25
11	Unit-5 CW Pump House Area	4	FTL	19
12	Unit-6 CW Pump House Area	5	FTL	20

7.0 Steam Turbine NRPP Condenser

NRPP		
Particulars	**Unit**	**STG 1**
Condenser Vacuum	ATM	0.058
Condenser Vacuum	kg/cm2 abs	0.059
CW I/L temp.	˚C	25.3
CW O/L temp.	˚C	29.9
Temperature Difference across cooling water	˚C	4.6
Steam Saturation Temperature		35.49
Condenser TTD	˚C	5.59
Condenser Effectiveness		45.14%
Condenser ITD	˚C	10.19
Condenser LMTD		7.661

Comments:

The effectiveness of condensers of NRPP is 45.14% and it is operating satisfactory.

8.0 Energy conservation measures and Recommendations

RECOMMENDATION
ENERGY CONSERVATION MEASURES & RECOMMENDATION

Encon 1: Cost Benefit Analysis by Installation of VFD in one nos CEP of NRPP

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	110	kW
power saving after installation of 180 kVA VFD @15%	16.5	kW
Operating hours (considered 24 hr for 330 days)	7920	Hr
Annual power saving	130680	kWh
Tariff	3.01	Rs/ kW
Annual Energy Saving	3.93	Rs. In Lakh
Investment		
Installation cost two VFD	8	Rs. Lakh
simple Payback period	2.03	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 Economics by improving pump efficiency by Polymer Coating in Cooling Water Pumps in CWP pump of NRPP

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 2.178 lakh kWh. Total investment of the project was Rs 500000. The saving is Rs 6.56 lakhs after use of polymer coating with payback period of 0.76 years.

Particulars	Units	Value
No.of CW Pumps	**Nos**	4
No of pumps normally operated	**Nos**	2
Rating of each CW pump	**KW**	650
Power Consumption by CWP 1	**KW**	550
Power Consumption by CWP 2	**KW**	550
Total Load	**Kw**	1100
Avg. running hours	**hrs**	24
Avg operating days/yr	**days**	330
Expected Savings		2.50%
Annual Savings	**kwh**	217800
Electricity Cost	**Rs/kwh**	3.01
Annual Cost Savings	**Rs. Lakhs**	6.55578
Investment	**Rs. Lakhs**	5
Simple payback Period	**years**	0.76

Encon 3: Cost Economics by INSTALLATION OF NEW SCREW AIR COMPRESSOR

There are three reciprocating air compressors installed in NRPP in GT section to supply compressed air 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	3.01	Rs/ kW
Annual Energy Saving	1.74	Rs. In Lakh
Investment		
New Air compressor cost @ Rs. 5.00 lakh	6.2	Rs. Lakh
simple Payback period	3.56	YRS

Encon 4 Turbo ventilators for Natural Ventilation in NRPP

Background

The turbo ventilator is recognized by its inherent nature to utilize the natural force of wind to draw heat and moisture out of the roof . This system uses the speed of wind for spinning of vanes.

The vanes move at the slightest push and continue even when the breeze has stopped due to the flywheel effect using the dynamic body weight . This facilitates the exhaust system to work round the clock without any expenditure on electricity.

In NRPP there are 11 nos of Exhaust fans are available which is running continuously. This may be replaced with energy saving turbo ventilators to save the energy

Recommendation

It is recommended to replace the existing motor driven ventilators with natural ventilators. The estimated savings would be 1.815 lakh kWh worth, Rs. 5.46 lakhs. The investment would be Rs. 1.65 Lakhs, would be recovered in 0.30 year. The cost benefit analysis is as below

Calculation :

	Turbo ventilators for Natural Ventilation		**Existing**	**Proposed**
	Description	**Unit**		**New**
1	Present no. of exhaust fans	No's	11	11
2	Rating	Kw	5.5	0
3	No. of days of operation / year	days	365	300
4	No of Hours Running	Hr	10	10
5	energy savings with natural ventilators	Kw/hr		5.5
6	Energy annual saving	kwh		181500
7	Avg. cost of electricity	Rs/kwh	1.88	3.01
8	Annual cost saving	Rs. Lakhs		5.46
9	cost of Natural Ventilator	Rs. Lakhs		1.65
	Pay Back	years		0.30

Encon 5 Replacement of 37KW cooling water pumps at NTPS

Background

During field survey, it has been observed that the [performance of cooling water pumps of NTPS are inefficient . These pumps may be replaced with energy efficient pumps .

Recommendation

It is recommended to replace the existing cooling water 3 nos pumps in order to save energy.. The estimated savings would be 1.32 lakh kWh worth, Rs.3.97 lakhs. The investment would be Rs. 3.70 Lakhs, would be recovered in 0.93 year. The cost benefit analysis is as below

Replacement of 37 KW Pump		
NTPS		
a	Flow, M3/Sec	0.0167
b	Differential Head, M	45.00
c	Output Power, KW (a x b x 9.8)	7.35
d	Expected Pump Operating Efficiency, %	70%
e	Motor Efficiency, %	90%
f	Input power, KW (c / d / e)	11.67
g	Present Average power	30.00
h	energy saving per day Savings, KWH (g-f)	18.33
i	Savings per annum, KWH)	66000
j	Savings per annum for 2 Nos pumps, KWH)	132000
k	Savings per annum, Rs	198660
l	Savings per annum, for 2 Nos pumps, RS)	397320
m	Cost of Replacement & Installation,	370000
n	Simple Pay Back, Yr.	0.93

Encon 6 REPLACEMENT OF 2X36W FLUORESCENT TUBE WITH 20 W LED TUBE at NTPS

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

REPLACEMENT OF OLD 2X36WATT FTL WITH LED LAMPS			
Description	**plant**	**office**	**Unit**
Number of conventional 2x36 Watt Tube fittings	250	50	no.
Power consumption in 2x36 W fluorescent tube fitting (including 12-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	3.01		Rs./kWh
Annual Energy Saving	4.110		Rs. In Lakh
Investment 20-Watt LED Cost @ Rs. 350 per fitting including retrofitting cost	1.05		Rs. In Lakh
Simple Payback Period	0.26		yrs.

Encon 7 REPLACEMENT OF 400W HPSV WITH 200W LED LAMP at NTPS

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	3.01	Rs./kWh
Annual Energy Saving	0.29	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	3.03	YRS

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