

NTPC Limited, Sipat

The most Energy efficient & Water efficient station of NTPC Limited, India.



Organization Profile / Business Case

Case Study Snapshot	
Industry	Power Generation
Product/Service	Electricity
Location	Sipat, Bilaspur, Chhattisgarh, India
Energy performance improvement percentage (over the improvement period)	0.9 % improvement
Total energy cost savings (over the improvement period)	USD 8.3 Million
Cost to implement Energy Management System (EnMS)	USD 0.55 Million
Total energy savings (over the improvement period)	6.04 Million GJ
Total CO₂- emission reduction (over last 4 years 2018-19 to 2021-22)	0.57 Million Metric Tons

NTPC Sipat (3 x 660 MW + 2 x 500 MW)

A unit of NTPC Limited, a Central Public Sector Enterprise under Govt. of India, is committed to generate power prioritizing three Es- Efficiency, Environment & Economy through Implementation of EnMS with ISO 50001:2018 certification.

Sipat Super Thermal Power Station of NTPC is one of the frontrunners in India adopting the supercritical technology for thermal power generation. Supercritical units operate at temperatures and pressures above the critical point of water. They are designed with higher grade of metallurgy to extract more work output, thereby giving higher efficiency. NTPC Sipat has been supplying the low cost power on sustained basis across the country maintaining high efficiency adopting various energy efficient technologies and practices. This station comprises three units of 660 MW (supercritical) and two units of 500 MW (subcritical), aggregating to installed capacity of 2980 MW, that contributes to approx. 4.5% of requirement of Western Region (major customers) as preferred supplier.

Station has ensured not only the generation of power adopting efficient technologies & practices, but has also been committed towards harnessing the green energy with installation of Solar PV plants. Sipat is having the Solar PV of 800 KW at present in its premises, and in line with NTPC’s long- term commitment to produce sustainable green energy, it has further planned for installation of 4.5MW of Solar PV in coming future. This foray will play a major role in lowering its carbon footprint by reducing GHG emissions.

NTPC Sipat is also in the process of installation of Emission Control Systems comprising De-Nox technology and Flue Gas Desulphurization (FGD) in all generating units for further betterment of environment and compliance of revised statutory norms. Apart from it, the station is committed to conserve the natural resources like water through its untiring efforts with the principle of ‘reduce, reuse and recycle’.

The station is Zero Liquid Discharge (ZLD) compliant with reuse of Ash water, drain water, effluent treated water, sewage water etc, with various recycle systems like Effluent Treatment Plant(ETP), Sewage Treatment Plant (STP), Ash Water Recirculation System (AWRS) etc.

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Apart from this, the station is increasing its evacuation of fly ash by dry evacuation technology, contributing to low land filling, ash brick manufacturing, providing input material to cement plants etc, thereby reducing usage of water for ash disposal. Moreover, the station is operating at higher Cycle of Concentration (COC) reducing the requirement of fresh water make up for cooling water system. The water system of the station is monitored on real time basis with a Water Dashboard devised with the inputs from various flow meters installed in the water system right from drawl point to consumption end, and corrective action is taken based on its input regarding any deviation observed on daily basis. This has ultimately helped reduce the specific water consumption of the station on year-on-year basis (as shown at fig2). In addition to the same, the station is moving ahead for rainwater harvesting, enhancement in Dry Ash utilization, reservoir lining etc for further conservation of water ensuring the ecological balance and sustainability.

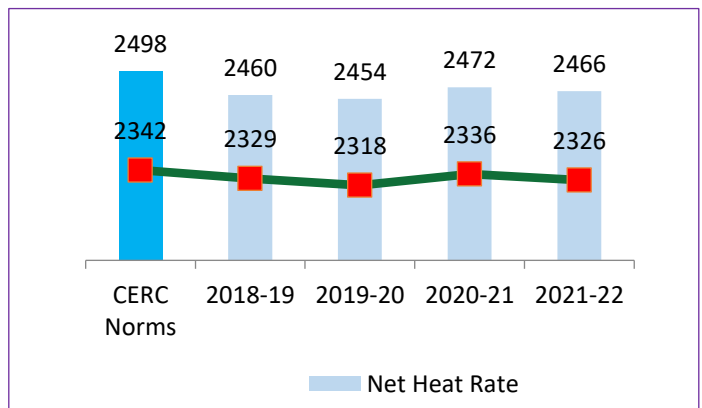
NTPC Sipat has shown appreciable reduction in its Net Heat rate adopting the EnMS, and it has succeeded to bring it down from 2472 Kcal/kwh in FY 20-21 To 2466 Kcal/Kwh in FY21-22 way below the norms of the Indian power regulator(CERC).

Fig. 1

**Net Heat Rate: Heat rate on net energy sent out to grid*

“Our objective is to improve efficiency and reduce emission, thereby ensure sustainable growth through ISO 50001 EnMS implementation which strives to save every possible quantum of energy to create environmental synergy and become the most energy efficient unit in power industry.”

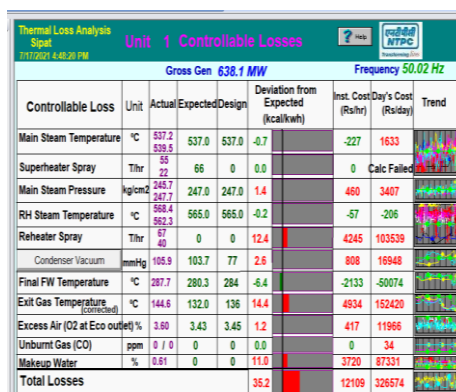
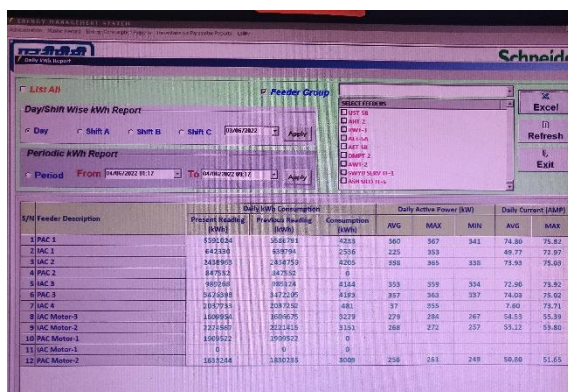
-Ghanshyam Prajapati, Head of Project, NTPC Sipat



(Fig. 2)



The station is committed to conservation of all form of energy like reduction in Auxiliary power consumption (APC) by augmentation of efficient drives, Heat rate improvements through process improvements and system modifications and water consumption reduction through sustainable actions. Keeping the consideration of sustainability, we have the Brighter Plan 2032 (Fig. 2) which also works as drivers for efforts. Station has a comprehensive energy management System (OLEMS) by Schneider Energy for real time Energy Consumption monitoring. Daily/ Monthly report of energy consumption for analysis and reporting is available in OLEMS system.



(Fig. 3) Multipronged approach of EnMS (Energy management system, Thermal Loss analysis, System Energy Efficiency Display(SEED)) at NTPC Sipat

NTPC Sipat has implemented Energy Management System in accordance with ISO 50001. The certification for the same has been done on 24.12.2021.

Business Benefits

Implementation of EnMS and ISO 50001 certification have paved the way for continual improvement in Energy Efficiency resulting into substantial reduction in generation cost, reduction in GHG emission, reduction in water consumption and reduction in pollutants disposal like ash. This all above creates a great satisfaction to management and increases the stakeholder confidence.

(i) Contributing to Sustainable Growth of business:

EnMS helps achieve the various objectives & goals pertaining to the complete business sphere, thereby providing the atmosphere for sustainable business development. The sustainable business always has the inclusive vision for the benefit of customer, for the benefit of country, for the benefit of society and ultimately for the benefit of all across the globe. This inclusive growth in turn pays to the business not only in terms of maximised returns, but also in earning reputation, trust and a reliable long tied relationship with all stake holders. EnMS is in fact a facilitator for a business to help it survive & grow in a long term time frame meeting its futuristic goals, addressing the efficiency, economy & ecology, and in turn getting evolved as the balanced business model.

(ii) Energy performance improvement & cost saving:

Since 2018-19 we saved energy up to 2.7 million GJ which is equivalent to 750 GWh or 8.7 million USD with only capital investment for about 10 Million USD.

(iii) Efficiency improvement leading to operational profit:

EnMS guides to improve efficiency aspect of the plant leading to operational profit due to better efficiency parameters wrt the regulatory norms. Resulting into operational profit of 14.5 million USD in FY 2021-22.

(iv) Environmental benefits: Reduction in emission & water consumption with NHR improvement

On Implementation of EnMS since 2016-17, greatest impact towards greenhouse gas emissions (CO₂) reduction has been achieved. Around 0.6 million Metric Tons of CO₂ have been avoided from emission in last 6 years on improvement in energy efficiency.

Our EnMS has the wide coverage and guidance on water conservation. Govt. of India has tightened the norms of Specific water consumption (SpWc) to 3.5 cubic metre per MWh (applicable for NTPC Sipat). However, the station has achieved it with the efforts dealt before and is running at SWC much below the prescribed norm. Reduced requirement of water reduces the energy consumption for water pumping upto the power station, and helps conserve this scarce natural resource.

Sp Water Cons. – Litre/ KWh

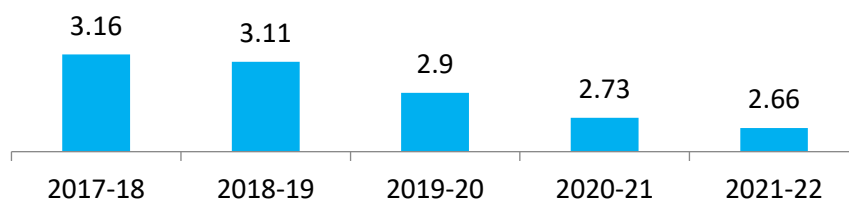


Fig. 4 *(SWC for 2021-22 corrected & normalized for reduced generation)

Through operational optimization, augmentation of additional ash water return, toe drain water recovery & thereby implementation of Zero Liquid Discharge (ZLD), our loading corrected Specific Water Consumption reduced to 2.66 lit/kwhr in FY 2021 as shown in fig.4 above. NTPC Sipat is one of the Lowest water consuming station of NTPC limited.

(v) **Benefit on Statutory compliance**

The Perform, Achieve and Trade (PAT) Scheme is a statutory instrument to reduce specific energy consumption in energy-intensive industries, with an associated market-based mechanism to enhance the cost-effectiveness through certification of excess energy saving which can be traded. It is the initiative of Ministry of Power, Govt. of India under Enhance Energy Efficiency Mission. Under this scheme the Energy Improvement Target for each PAT cycle (every three years) are set which has to be achieved during Assessment Year (AY). Due to implementation of EnMS, our station has surpassed the given target of both PAT cycles (Cycle I AY 2014-15 & Cycle II AY 2018-19) in terms of Oil equivalent savings and awarded 49,953 E certificates. One E certificate is equivalent to 1 MTOE (Heat value of one metric ton of oil with GCV 10000 kcal/kg). The E certificate thus achieved is being traded in National Power exchange. The monetary value of E certificate are 0.27 million USD.

(vi) **Improved thrust on solar power integration to reduce Emission:**

Our EnMS also guide us to utilize renewable energy in place of thermal power for drives which in turn reduce GHG equivalent emission. Station has taken initiatives toward scaling up its renewable capacity to 800KW

- 800 KW solar roof top plant (installed)
- 200 KW Solar roof top under plan
- 4.8 MW Solar (Ground mounted) under plan
- Electric Vehicle use & charging
- 50000 conventional light bulbs replaced with energy efficient LED lights
- Solar light pipes in offices & stores



(vii) **Awareness among employees**

The greatest benefit with the existence of Energy Management System is creating awareness at the company and its employees towards the importance of energy efficiency in life. Energy savings and emission reductions are always made to improve the electricity production process. Without a continuous improvement, the goal of the energy management system will never be achieved.

(viii) **Recognition & Brand building**

- NTPC Sipat was conferred with Swarna Shakti Award from Govt of India for the best Thermal Power Station in the country including for the category “Best O&M Practices” during FY 2020-21.
- NTPC Sipat won the Energy Efficient unit award in the CII National Award for excellence in Energy Management 2021.
- Sipat was conferred with “Power plant Performer - 2021” award by Mission Energy Foundation.
- Sipat was adjudged runner up in TERI water sustainability award 2021 under Industrial water use category.
- NTPC Sipat has won the prestigious CII - ITC Sustainability award 2021 for outstanding accomplishment in Corporate Excellence.

(ix) **Non-Energy & other associated benefits**

EnMS also indirectly suggests improving the environment by total ash utilization, helping reduced ash generation with less fuel consumption, thereby reducing the pollution caused by ash. Station is also motivated for other innovative modes for ash utilisation . Presently we have **production of cement and fly ash bricks, Manufacturing of fly ash based Light Weight Aggregate (LWA) for potential application in masonry, Road and highway projects, Uses in mine back filling etc.**

(x) **Benefits to other stakeholders in value chain**

Continual improvement in Energy Efficiency results into improved marginal profit which is shared with the end consumers lowering their net power tariff. Moreover, the adoption of energy efficient measures, efficient use of water & innovative use of waste by product in turn contribute to ecological well being, which benefits the public at large.



Fig 5 (Highway construction, Light weight aggregate (LWA), Mine filling, Ash bricks)

Plan

Top Management Commitment towards EnMS:

The sustained Performance of Energy efficiency through EnMS is the journey of consistent passion, and with firm belief our team is committed to the continual improvement. For sustainable business operation, Energy Efficiency is the key factor which enhances operational profit margin with regulatory & statutory compliances. It goes without saying that the role of the top management is vital for actualization of EnMS. Our top management provides both the technical and financial support for improvement in energy efficiency as well as towards other relevant measures. For achieving the Energy efficiency improvement target, NTPC management guides the stations with knowledge enrichment, internal energy audits of the systems, facilitating through the sections like CenPEEP (Centre for power efficiency & environment protection) and CEETEM (Centre for Energy Efficiency & total energy management). Further, the management provides support with considerable Budget allocations needed for adoption of new technology, system improvement implementing new projects or through retrofitting & renovations etc.

Management also provides budget for procuring the advanced instruments for energy efficiency testing by EnMS team and for different Energy audits (Preliminary & detailed audits) and services like, As per ISO 50001 guidelines, management approves the Energy Policy for the station and form the EnMS team led by Certified Energy Auditor & Energy Managers with a coordinating members of other departments. Further a separate Energy conservation budget is allocated for each financial year to achieve energy savings.

The top management actively communicate with the middle and lower management about its energy performance through Various forums as mentioned below:

- Station level management meeting,
- Daily planning meeting,
- Monthly operational review meeting

Energy consumption pattern is reviewed thoroughly and Suggestions for improvement is implemented through special performance optimization group (POGs) and Process improvement projects (PIPs). The station has various POGs including Heat Rate & APC reduction, Water consumption optimization etc. for system improvement.

Process of Understanding Energy consumption:

Use of data & developing the appropriate approach:

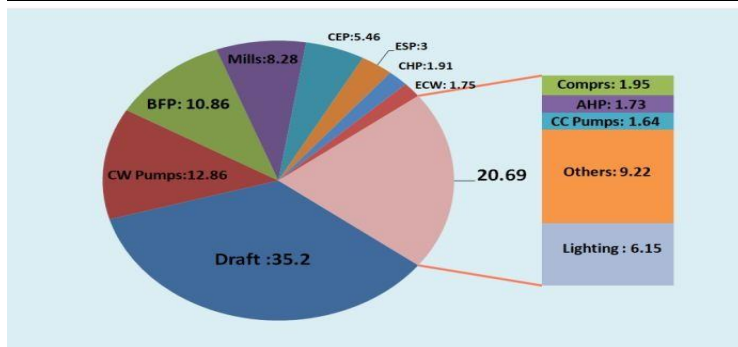
Thermal Power generation mainly uses coal as primary fuel and Electrical power for Auxiliary drives. Our steps for understanding the energy consumption mainly involve

Finding the attributes of losses in Turbine Heat rate & Boiler Efficiency: Sipat has 660MW and 500MW units. Design Parameter and loss in kcal/kwh for deviation from design parameters is as given below.

Parameter: 660MW / 500MW	Unit	Design Value	Deviation	Loss in Kcal/kwh
Load	MW	660 / 500	1 MW	0.11 / 0.48
Main Steam pressure before ESV	Kg/cm2	247 / 170	1 Kg/cm2	0.17 / 1.14
Main steam Temp before ESV	Deg. Celsius	537 / 537	1 Deg Celsius	1 / 0.68
Hot Reheat Temp before IV	Deg. Celsius	565 / 537	1 Deg Celsius	0.55 / 0.57
Superheat Attenuation	Ton/Hr	86.4 / 25	1%	0.23 / 0.68
Reheat Attenuation	Ton/Hr	0 / 0	1%	4.8 / 4.54
HP Turbine Efficiency	%	87.5 / 93.1	1%	4.5 / 4.6
IP Turbine Efficiency	%	92.5 / 94.2	1%	4.2 / 4.54

Finding the attributes of Boiler Efficiency Loss:

Parameter: 660MW / 500MW	Unit	Design Value	Test value
Dry Gas Loss	%	4.67 / 4.35	5.04 / 4.75
Loss due to Unburnt Carbon	%	1.5 / 1.5	0.42 / 0.34
Loss due to moisture in fuel	%	2.29 / 2.45	2.28 / 2.47
Loss due to Hydrogen in Fuel	%	4.17 / 5.29	4.16 / 5.31
Loss due to Carbon monoxide	%	0 / 0	0.00 / 0.00
Loss due to moisture in air	%	0.11 / 0.107	0.13 / 0.12
Radiation & unaccounted Loss	%	0.19 / 0.112	0.19 / 0.82
Other Losses	%	0.78 / 0.75	0.78 / 0.00
BOILER EFFICIENCY (660/500 MW)		86.29 / 85.84	86.99 / 86.17



Segmentation of electric power use system-wise and then equipment wise in the system to identify the gap in particular equipment.

This is being done on real time basis from remote. Offline monthly field tests of major equipments by EnMS team for finding energy use gap.

Fig 6.

Ensuring the EnMS Support in Strategy & Target:

By virtue of approved Energy policy EnMS team assess the energy use and gap vis-à-vis expected values & Baseline data and after review put up the observations and recommendations with the target improvements to the top management for approval. EnMS team is always a part of monthly strategic review meeting of top management.

Process of Review & Analyzing Energy Use, prioritizing resource & action:

- Significant Energy Use data collection, trending of past performance
- Performance gap analysis vis-à-vis design and comparison with baseline performance
- Comparison with similar equipment performance
- Identification of improvement potential & fixing the improvement target
- Preparation of action plan with responsibility for implementation
- Prioritization and recourse allocation are done from O&M and Energy conservation budget
- Energy Performance Review as below:

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“ISO 50001 is the true facilitator to improve system efficiency through EnMS ensuring economical product & enhanced operational profit with an eye on ecological balance, thereby leading to sustainable business growth.”

—Ramnath Pujari, GM(O&M)

In FY 2021-22

Efficiency Parameters	Operational Profit (Million USD)
Heat rate	2.38
Secondary fuel oil	3.58
Auxiliary power	2.39
Total	8.35

Energy Efficiency Performance Monitoring System			
Meetings	Frequency	Headed By	
Planning Meeting	Daily	O&M Head	Action plan is generated from the Review and Monitoring meetings is implemented in Operation & Maintenance practices
Operation Review Team Meeting	Monthly	Plant Head	
Regional Operational Performance Review	Half Yearly	Director	

Do, Check, and Act

Implementation Process & Involvement:

After fixing the action plan implementations are being done by responsible department within target date. The implementation of the identified projects is being taken up either in routine maintenance, short term planning, during Overhaul or renovations & retrofitting.

Areas for Significant energy Performance improvement	Involvement as per EnMS
Heat loss issues in Boiler	Additional General Manager (AGM) - Boiler Maintenance
Air Preheater Exit Temperature High – Seal Issues	(AGM) - Boiler Maintenance (Rotary)
Turbine Heat Rate Gap	AGM-Turbine Maintenance
Air Compressor performance	AGM-Offsite Maintenance
Cooling Tower Performance	AGM-Offsite Maintenance
Monitoring Maintenance & Overhauling activities	AGM-Maintenance Planning
Monitoring Energy Conservation activities	AGM-Energy Management

Activities Identified and Implemented: All figures in Million USD

Activities	Investment	Savings/year	Remarks
Air Preheater Basket replacement in Unit 2 Overhauling	1.1 million	0.6 million	Gain of 10 degC in Flue Gas outlet temp. Heat rate improvement 13kcal/kWh (Payback period-2 years)
Turbine driven boiler feed pump(TDBFP) mechanical seal upgradation in Stg 1	0.28 million	0.06 million	TDBFP downtime reduced by 300 hours, MDBFP (11MW) (Payback period-4 years)
TDBFP RC valve actuator replaced with modified higher capacity actuator	0.09 million	0.47 million	Steam flow reduction by 10 TPH

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Activities	Investment	Savings/year	Remarks
Stage-I, Cooling Tower fill pack replacement of 2 towers (27 cells)	0.57 million	0.30 million	Heat rate Improvement of 6.50 Kcal (Payback period-2 years)
Both TDBFP cartridge replaced	0.10 million	1.3 million	Steam Flow reduction by 26 TPH.



Energy Performance Improvement(EPI) Validation:

ISO 50001 gives a recognized framework for EPI validation through Internal & external Audits.

- Ensuring the availability of Data Acquisition System (DAS) and instruments calibration for recording the indices under test
- Data collections like design data, PG test data, efficiency curve and actual performance data,
- Balancing of station Energy flow based on Online Energy Metering System (OLEMS)
- Analysis of data captured and validation of reported data by auditors and reporting
- Making further improvement action plan

Our Baseline and Reporting Period:

The baseline period & reporting period are fixed as per Govt. of India Gazette Notifications and covered under Perform Achieve & Trade (PAT) Cycle. The first PAT Cycle was 2012-15 with baseline period of 2012-13 based on past three years data. The target assessment period was FY 2014-15. The baseline data for second cycle was the achieved value of first cycle. The second cycle assessment period was 2018-19.

<u>PAT Cycle 1 : FY 2012-15</u>	<u>PAT Cycle 2 : FY 2016-19</u>
Baseline Net Heat Rate : 2491 KCAL/kWh	Baseline Net Heat Rate : 2438 KCAL/kWh
NET HEAT RATE TARGET : 2484 KCAL/ kWh	NET HEAT RATE TARGET : 2430 KCAL/ kWh
NET HEAT RATE ACHIEVED : 2438 KCAL/ kWh	NET HEAT RATE ACHIEVED : 2417 KCAL/ kWh
Achievement wrt baseline : 2.12 %	Achievement wrt baseline : 0.9%
Over achievement from target: 1.9 %	Over achievement from target: 0.53 %

Since implementation of EnMS in 2016, Govt of India notified NTPC Sipat in PAT cycle 2, wherein a percentage improvement of 0.9% wrt baseline NHR was achieved.

Transparency:

- Publication of integrated annual sustainability report as per GRI by NTPC Ltd
- Online Environment Management monitoring screen to local State Government
- Submission of audit reports to Government

What We Could Have Done Differently

- Advance Budget allocation for EnMS and speedy implementation
- Display of management instructions regarding EnMS in strategic locations
- Display of financial impacts on parametric variations affecting the EnPI
- Minimum Man-days training on EnMS processes & its benefits to all employees in advance
- Development of professional expertise through advance training on EnMS