
NTPC R&R Colony, Darlipali


NTPC Bhadla


NTPC Kudgi

ROLE OF FLEXIBLE GENERATION BY COAL BASED THERMAL PLANTS FOR ENERGY TRANSITION


NTPC Koldam


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Present Scenario

In November 2021, at COP26 summit, India presented Panchamrit (five nectar elements) of climate action, setting target of meeting 50% of its energy requirements from renewable energy sources by 2030, India aspires to achieve net-zero emissions by 2070.

With increasing integration of Renewable Energy into grid, it is expected supply side of grid will vary based on weather and time of day putting additional pressure on Thermal Power Plants to ensure grid stability, considering insufficient availability of Storage.

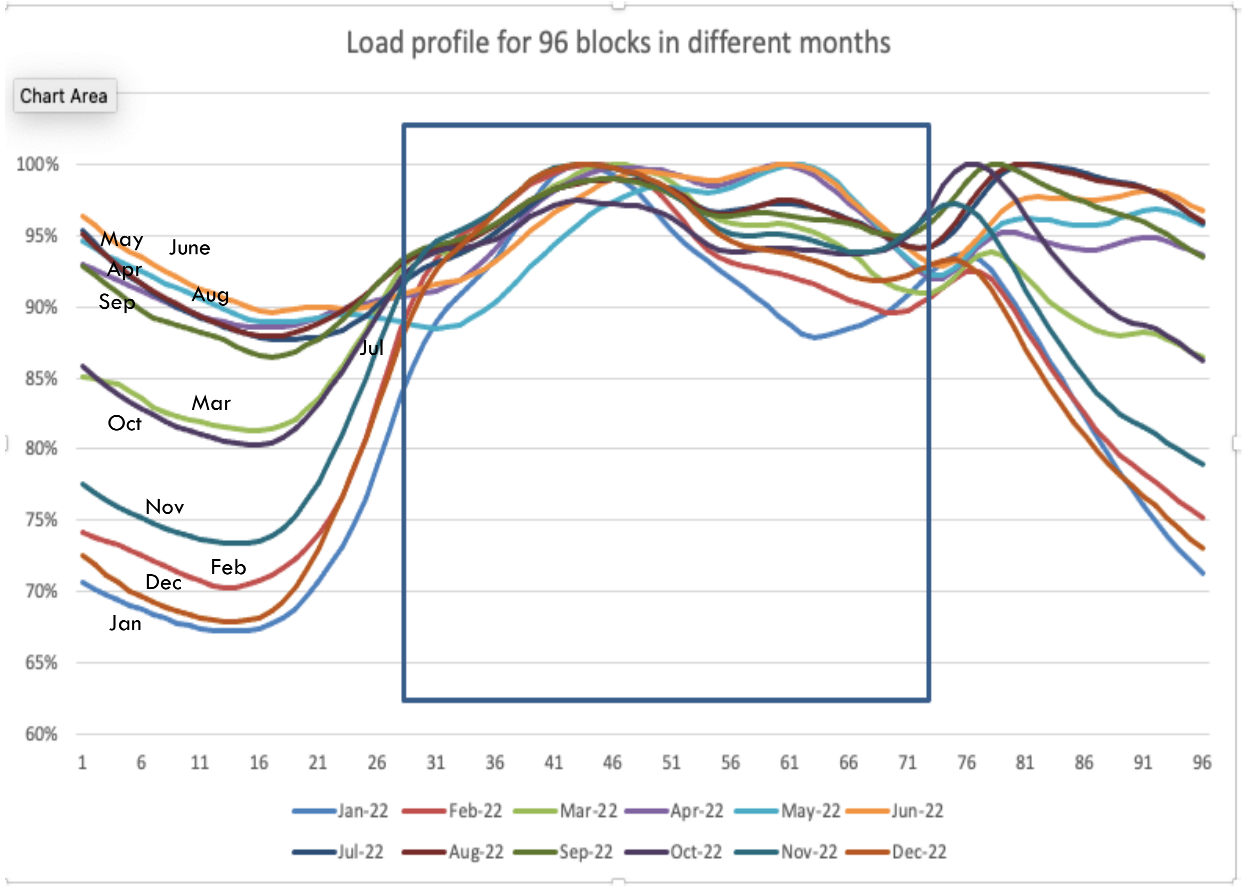
In FY’23 India produced 1616 BU of electricity with Thermal contributing ~75%, Renewables (incl. Hydro) – ~22.5% and Nuclear – ~3%. National grid is also witnessing a 6-7% rise in Peak load Y-o-Y (from 190 GW in FY 21 to ~216 GW in FY23). In future, India is projected to have an energy requirement exceeding ~2474 BU and Peak load of ~366 GW by FY’32.

FLEXIBLE OPERATION IMPACT

Cycling of thermal power plants also add costs to operation of thermal power plants viz.

- Increase in O&M charges and Overhaul expenses
- During RSD increased cost in startup of Thermal power plants
- Efficiency loss, heat rate changes
- Shortening of plant equipment life
- Higher probability of Forced outages due to running on partial load

Round the year Load Profile



Insights:

- Average monthly profile varies from month to month,
- Solar power is available from 26th Block to 76th Block, high load from thermal plants will be needed in non-solar blocks during April, May, June, August, and September.
- The same may not be required during Jan, November, and December.
- Needs detailed research on need of thermal power infrastructure which could be optimally utilized during the year.

METHODOLOGY

LOAD PROFILE ANALYSIS – 2024-2030

National Grid Load Demand data collected from Jan 2019-Mar 2023 and an interactive model is generated, salient details of the model are as follows:

1. Load demand data is distributed block wise for all 96 Blocks*
2. Power Demand is Monthly average for each block
3. Installed capacity for each month is taken in the model from Executive Summary**
4. Contribution of Renewable in each month is provided based on data collected from SRLDC and NRLDC
5. Electricity Sources considered in the Model are:
   a) Wind
   b) Solar
   c) Nuclear
   d) Hydro
   e) Gas
   f) Coal

* Source: Energy Analytics Lab – IIT Kanpur

** Source: CEA Executive Summary

LOAD PROFILE ANALYSIS – 2024-2030

6. Peak Demand growth is as per NEP 2022 with FY'23 as reference Year

Year	Peak Demand (% Growth)
2021-22 to 2026-27	6.42
2026-27 to 2031-32	5.74

7. Load profile for 2030 is as per CEA document 'Optimal Generation Mix 2029-30 (Version 2.0)'. Capacity is increased proportionally till 2030.

8. PLF of Solar, Hydro, Wind, Gas etc. are taken as per FY'23

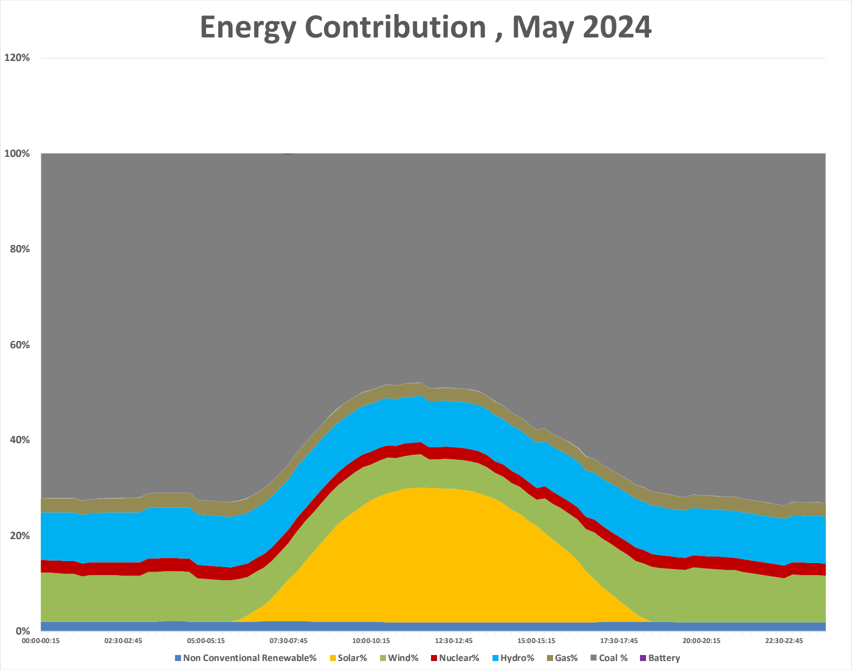
9. Solar and Wind day profile is calculated as average of SRLDC and NRLDC Plants

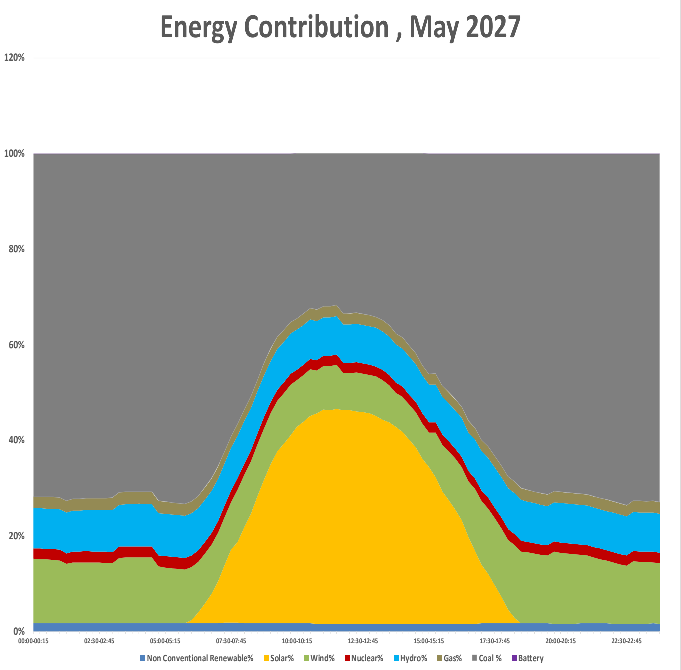
10. Coal Generation is used for Bucket filling in the Model

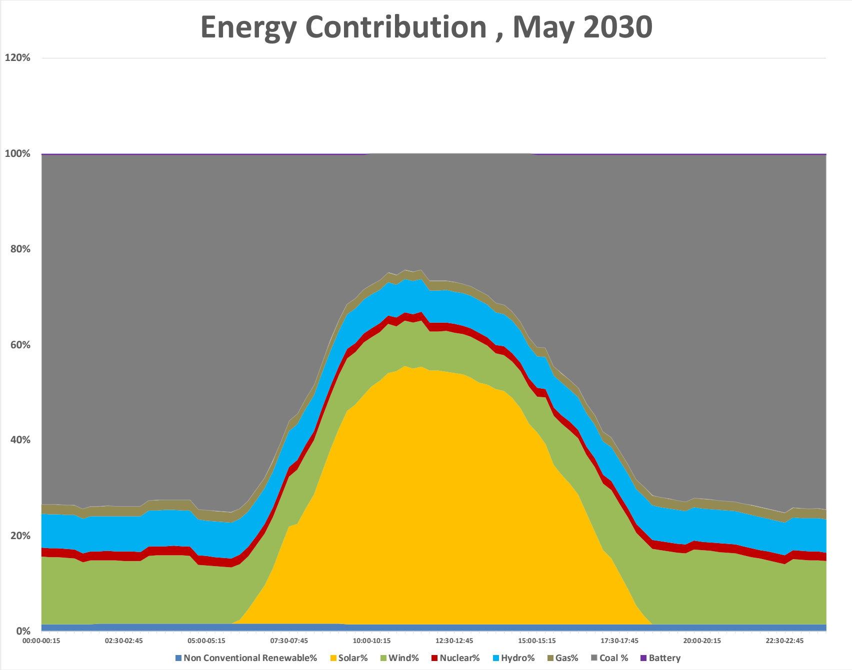
Fuel Type	Capacity as on 31.03.2023, MW	Capacity (Base) – Optimal Gen Mix (Apr 2023),MW
Hydro	42,104	53,860
PSP	4,746	18,986
Small Hydro	4,944	5,350
Coal+Lignite	211,855	251,683
Gas	24,824	24,824
Nuclear	6,780	15,480
Solar	66,780	292,566
Wind	42,633	99,895
Biomass	10,802	14,500
Total	415,469	777,144
BESS		41,650 MW / 208250 MWh

ANALYSIS

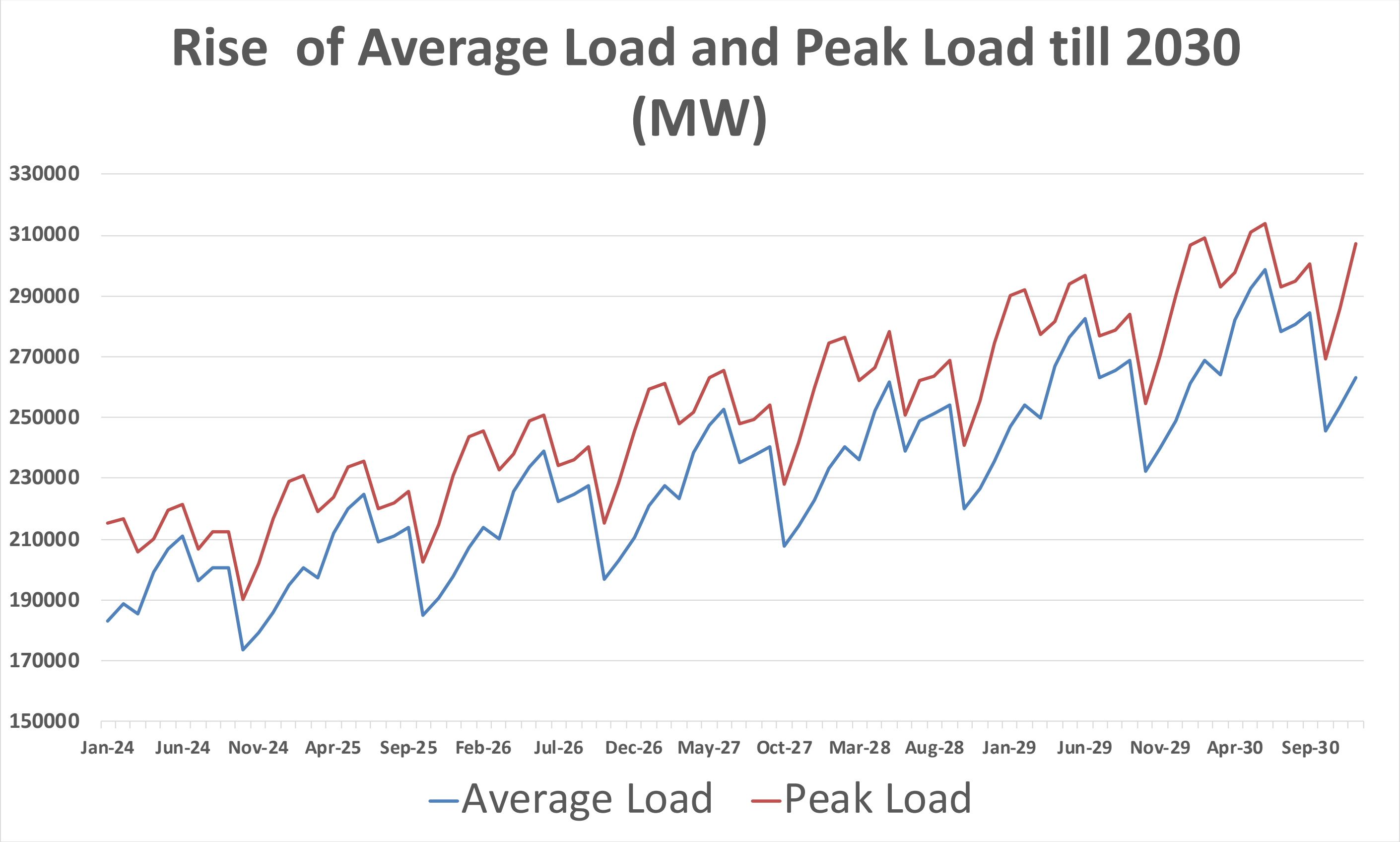
Variation of Fuel Mix Profile: 2024-2030







Load Profile Analysis: Peak Load



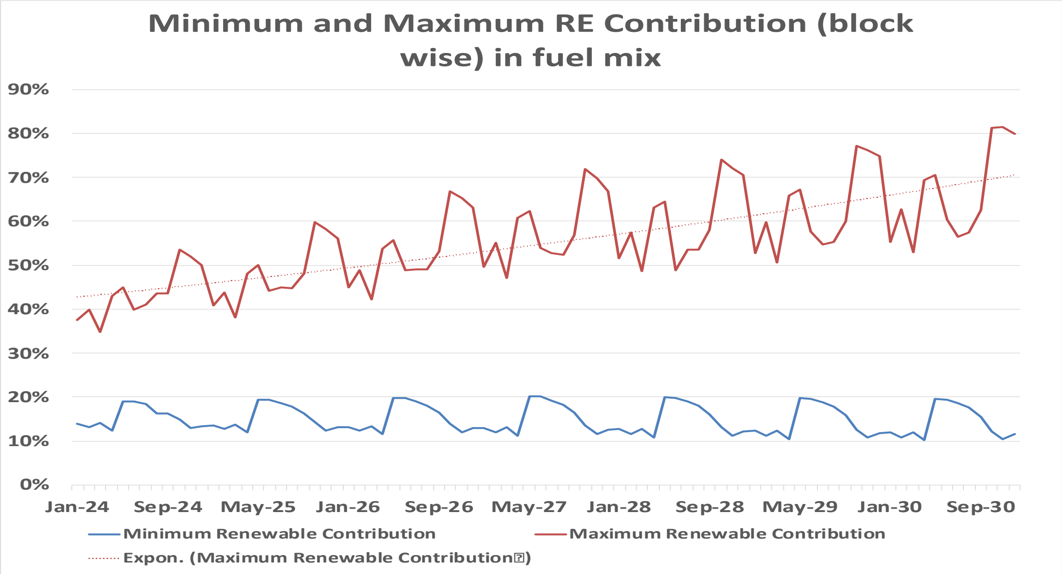
Peak Demand Variation

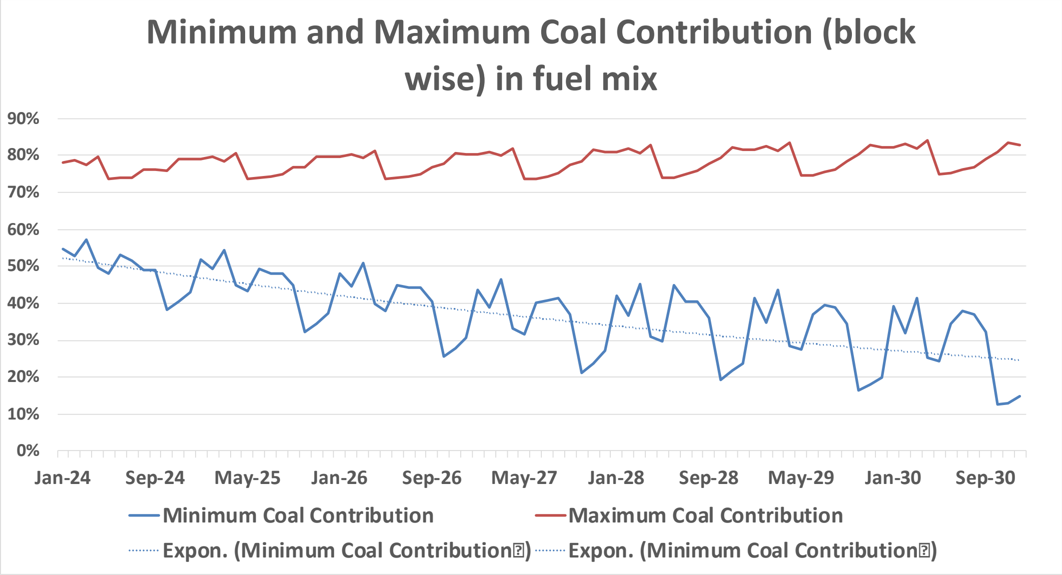
Insights:

- Peak Load exhibits seasonal pattern, characterized by diminished demand during the winter season, followed by gradual upswing in March, reaching its zenith in June.
- Subsequently, demand experiences gradual decline during rainy season, reaching its nadir in October-November.
- Average load is expected to cross 300 GW by 2030
- We have assumed a GDP increase of 7% at present elasticity of 0.76. If growth is higher then load may increase at faster rate

Load Profile Analysis: Fuel MIX

- **Insights:**
  - Average minimum coal contribution in the fuel mix is consistently falling below 30%. Projections indicate that renewable energy (RE) contribution may surge to as much as 70% for certain blocks by the year 2030. Furthermore, during select high RE months, the absolute coal contribution is anticipated to dip below 20%.
  - This trend suggests a substantial shift towards renewable sources. The potential for RE to dominate specific periods emphasizes a dynamic and evolving energy landscape, showcasing a significant transition towards cleaner and more sustainable power generation.

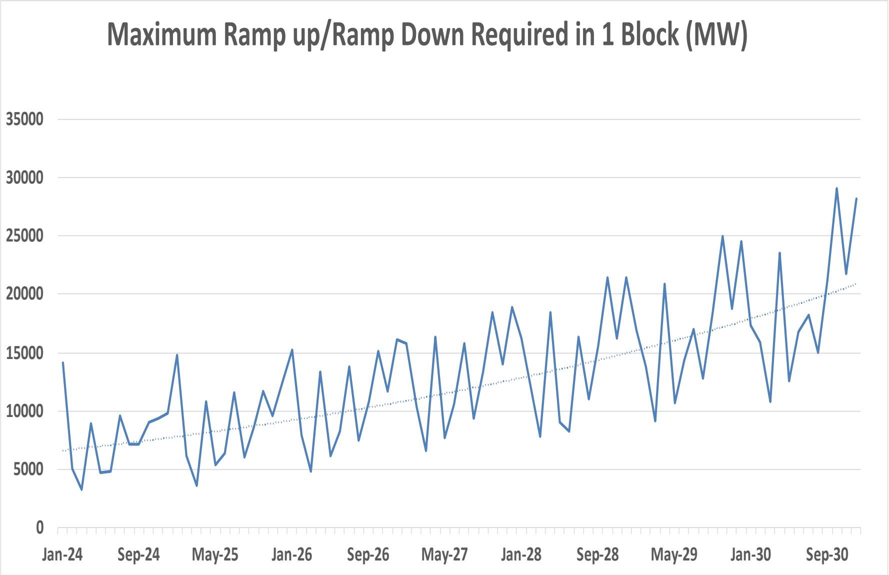


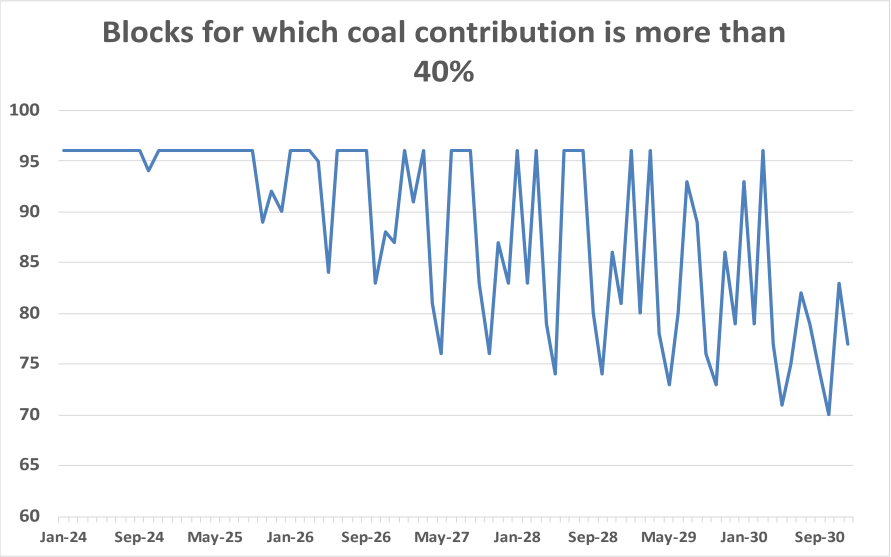


Load Profile Analysis: Flexible Opn

Insights:

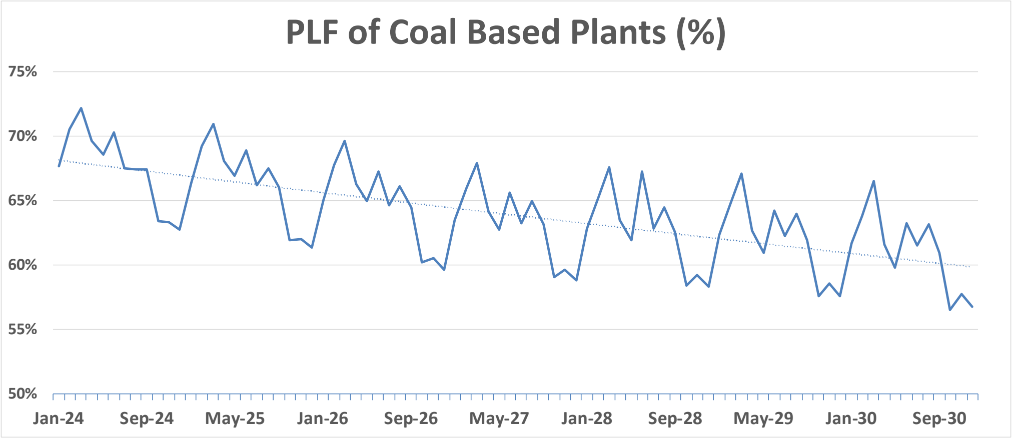
- Flexible operation is poised to exhibit a pronounced seasonality, with a noteworthy twofold variation throughout the year. Moreover, there is a projected fourfold increase in flexible operations between 2024 and 2030.
- The expedited integration of storage into the grid emerges as a potential mitigating factor, capable of curbing this rate by enabling a more even distribution of renewable energy across the day.
- Anticipated changes in the energy landscape include a decrease in blocks with coal contributions exceeding 40%, particularly after 2026. This shift signifies a move towards a more diversified and cleaner energy mix.
- By 2030, it is foreseen that approximately 20% of blocks will have coal contributions below 40%, potentially leading to more frequent reserve shutdowns. This underscores the evolving nature of energy generation, indicating a growing reliance on flexible operations and a diminishing role for coal in the overall energy portfolio.

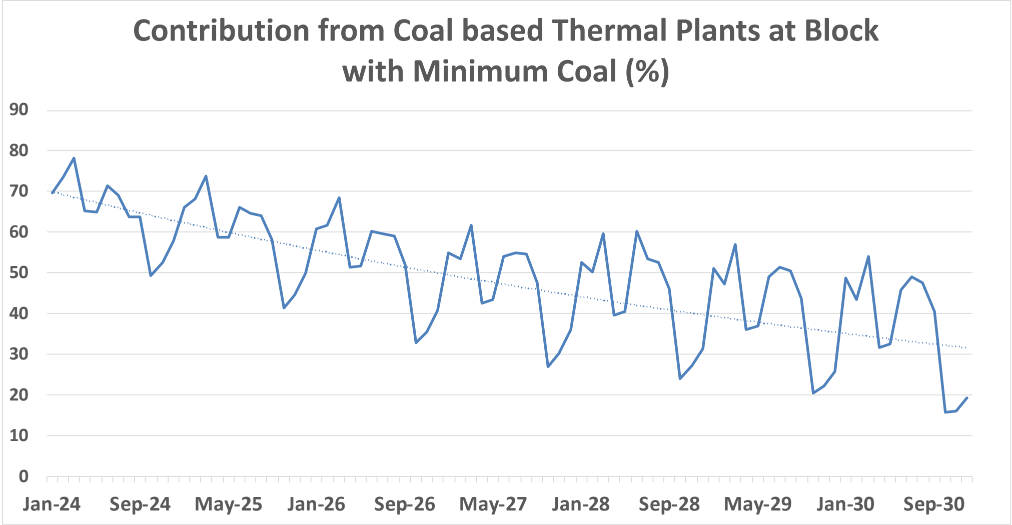




Load Profile Analysis: Coal based PLF

- **Insights:**
- The coal-based Plant Load Factor (PLF) is projected to persist above 60%, primarily driven by a combination of high load demand and the comparatively lower Capacity Utilization Factor (CUF) of solar power. This underscores the ongoing challenges in transitioning away from coal as a significant contributor to the power generation mix.
- However, a notable transformation is expected in the contribution from coal-based thermal plants, particularly at blocks where the minimum coal usage occurs. By the fiscal year 2029, the coal contribution in these blocks is anticipated to dip below 40%, reflecting a gradual reduction in coal dependence.
- Looking ahead to 2030, a more significant shift is forecasted, with some blocks witnessing a substantial decrease in coal contribution to as low as 19%. This suggests a notable stride towards diversification and cleaner energy sources, signaling a significant evolution in the energy landscape. It also highlights the potential acceleration of the transition away from coal in certain regions.





Load Profile Analysis: Flexible OPN

Insights:

Ramp Rate Projection (2030):

- Coal-based Thermal plants facing a projected ~1% ramp rate requirement by 2030 (presently 0.15%).
- Highlights the imperative for rapid adjustments to power output to accommodate dynamic demand shifts.

Storage Augmentation as Solution:

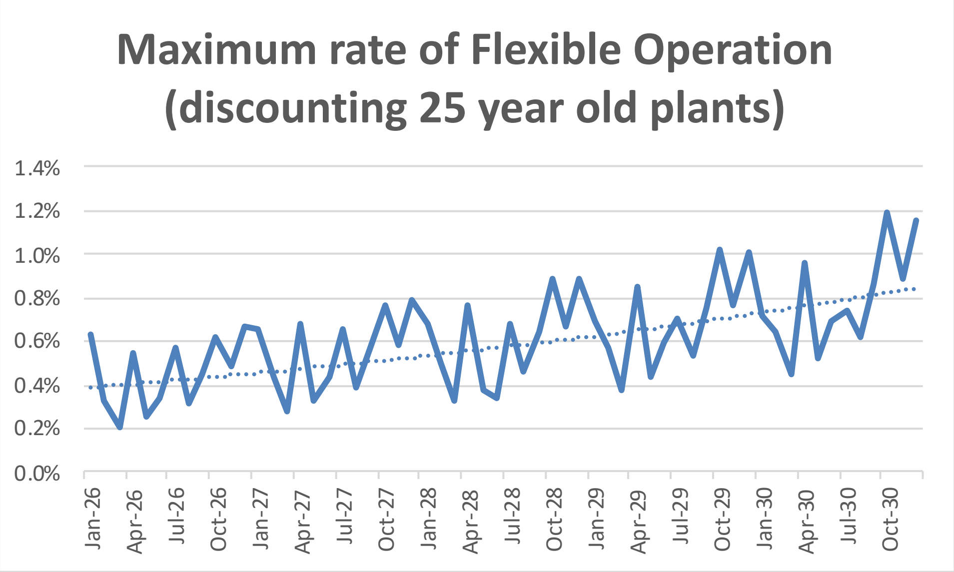
- Increasing storage capacity within the power grid identified as a key strategy.
- Enhanced storage capabilities can absorb and distribute energy more effectively.
- Alleviates the demand for swift adjustments from coal-based thermal plants.

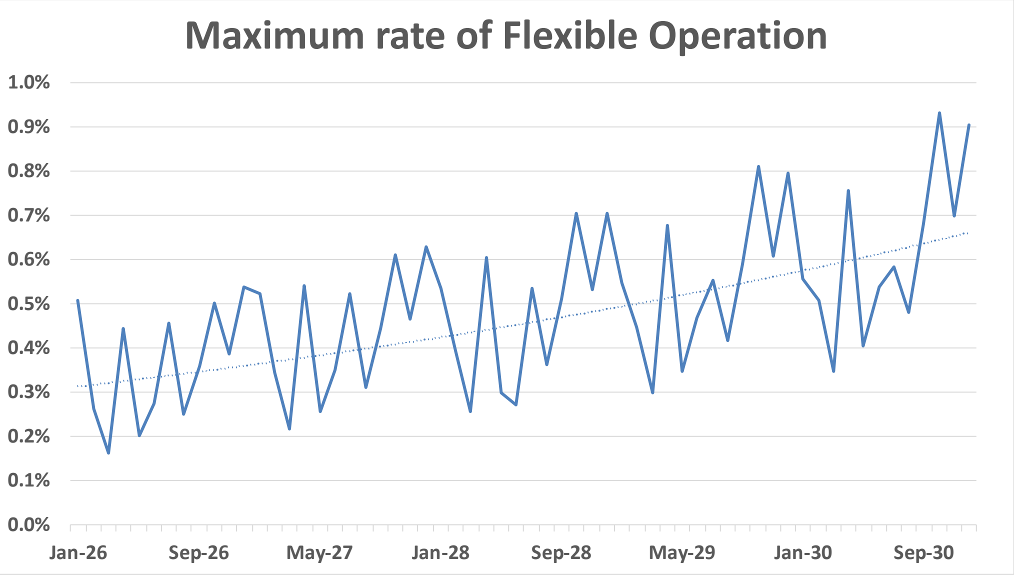
Age Distribution Insights:

- Coal fleet to include ~51 GW from plants over 25 years old by 2030.
- Discounting older plants reveals a flexibilization rate surpassing 1% for the remaining coal fleet.
- Suggests a nuanced relationship between plant age and flexibility.

Strategic Considerations:

- Findings emphasize the importance of both technological enhancements and age distribution considerations.
- Insightful for strategic planning in the ongoing evolution of the energy system.





Load Profile Analysis: Flexible OPN

Insights:

Load Profile Parameters:

- Thermal load, considering an 85% availability factor, and Nuclear load, with an 80% availability factor, were factored out. Hydro load was adjusted based on seasonal availability.

Additional Load Requirement (2030):

- A significant observation is that the additional load requirement is projected to exceed 60 GW in 2030.
- This heightened demand signifies evolving energy needs during non-solar hours, reflecting potential challenges in meeting the increasing load.

Storage Capacity vs. Load Requirement:

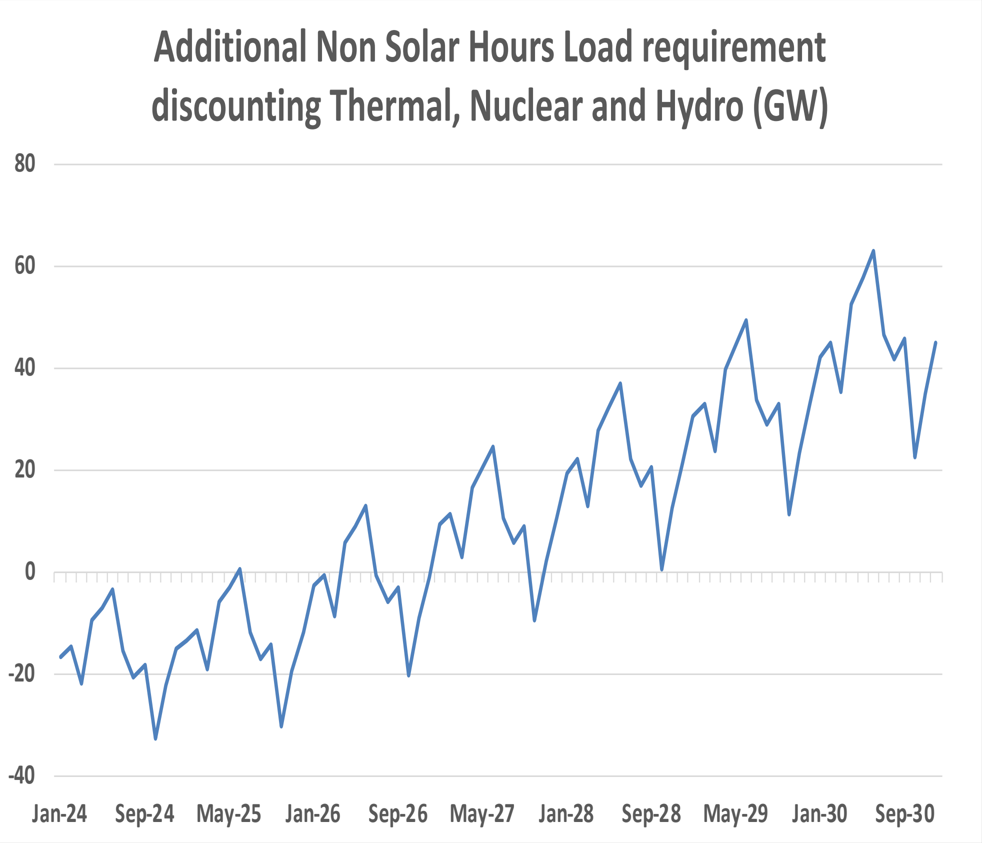
- Notably, the identified additional load surpasses the available storage capacity, which is represented by a 5-hour battery with a capacity of around 65 GW.
- This incongruence underscores a potential imbalance between load demands and the current storage infrastructure during non-solar hours in 2030.

Strategic Implications:

- The analysis implies a need for strategic planning to bridge the gap between load requirements and storage availability during non-solar hours.
- Consideration of additional storage infrastructure or alternative solutions may be crucial to align capacity with the growing demand.

System Resilience and Adaptability:

- The findings emphasize the importance of enhancing system resilience and adaptability, especially in managing load requirements beyond the capabilities of existing storage solutions.
- Strategic investments in advanced energy storage technologies or alternative load management strategies may be warranted.



INSIGHTS

INSIGHTS for NTPC

Challenges in the Electricity Sector:

- Balancing reliability, affordability, and security during the transition to cleaner energy sources.

Storage Integration for Flexibility:

- Pumped Hydro, Lithium-ion batteries, etc., expected to reduce the need for flexible operations.
- Digitalization crucial for achieving desired flexibility in coal-based thermal plants.

Flexible Operation Necessity:

- ~1% flexible operation expected for all coal-based thermal plants (presently 0.15%).
- Some plants may require 2-3% if fleet-wide flexibility is challenging.

Gas-Based Power Contribution:

- Increased contribution from gas-based power plants to reduce flexible operation in coal-based plants.

Revenue Generation through Ancillary Services:

- Implementation of primary, secondary, and tertiary services through flexible operations can yield significant revenue.

Electricity Load Seasonality:

- Current high seasonality with lower demand from industrial loads.
- Potential decrease in seasonality as industrial loads increase, leading to a more stable trend in electricity demand throughout the year.

Dynamic Nature of the Sector:

- Emphasizes the need for continual adaptation to emerging trends and demands in the electricity sector.

INSIGHTS for NTPC

Future Actions towards Coal-Based Thermal Plants:

Assumption in Analysis:

- All thermal plants assumed to perform flexible operation.

Aging Thermal Plants (2023-2030):

- As of 2023, 39 GW of thermal plants are over 25 years old.
- By 2030, 52 GW (20% of total) will surpass 25 years.
- If older plants can't adapt to flexible operation, ramp rate requirement may exceed 2-3%.

Utilizing Excess Storage Capacity:

- Battery Energy Storage Systems (BESS) can be leveraged to address challenges posed by aging plants.
- Integration of energy storage mitigates ramp rate challenges and provides essential system flexibility.

Research and Development (R&D) Focus:

- Higher ramp rates necessitate R&D efforts on boiler response time improvement.
- Faster boiler responses contribute to achieving desired ramp rates and enhancing overall system flexibility.

Key Takeaways:

- Strategic adaptation for aging thermal plants is essential for meeting flexibility demands.
- Energy storage solutions, particularly BESS, play a vital role in mitigating challenges associated with older plants.
- R&D efforts on boiler systems are crucial for enhancing responsiveness and achieving desired ramp rates.