IMPACT ON THERMAL POWER PLANT DUE TO RENEWABLE PENETRATION & WAY FORWARD

The energy requirements and growth of the civilisation flourished through fossil fuels since the Industrial Revolution era reaching its pinnacle at the end of the 20th century. Subsequently, fossil fuel usage in power generation started declining and expected to settle almost at the installed capacity levels globally. The depleting fuel sources, difficulty securing long-term fuel supply agreements and ever-growing concerns of emissions and its impact on global warming from the release of greenhouse gases have led to this movement.

The drive to shift from fossil fuel-based power generation increased when the entire global community agreed to commit for limiting the global warming to well below 2°C under Paris agreement, on December 12th, 2015. Experts and the policymakers believe that this can only be achieved with significant decarbonisation of energy system over the long run.

It is expected that the implementation of the Paris Agreement will lead to the retirement of 80 per cent of the thermal power plant, globally by 2030. Further, falling of renewable energy prices and rising public resistance to set-up thermal power plants have also led to increased renewable capacity additions, forcing existing plants to operate at lower plant load factors, leading to reduced profits, forcing the private sector (IPP) exit.

This has led to a substantial reduction in investment for thermal power plants. Due to cheaper renewable sources and rising climate concerns, globally, the thermal power plants (predominantly coal-based) are losing visibility.

The renewable penetration in the grid, five states of India (Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh and Gujarat) face significant system integration challenges, as solar and wind shares rise above 15%.

In India, renewable energies, especially wind and solar technology, efficiency improvement measures, and how the existing power plant operates, are playing a fundamental role in reaching this goal. To achieve these carbon-free energy targets, Government of India plans to install 175 GW renewable energy with a daily net load swing of up to 80 GW by March 2022.

As per NITI Aayog, the total primary energy will increase almost three times between 2017 and 2042, equivalent to an annual growth rate of approximately 4%. However, coal will continue to remain predominant among all other commercial sources of energy in India. Considering the scale of demand in the country and abundant availability coal, it will remain the primary source for generating electricity, followed by hydro, gas, nuclear, and renewable energy.

However, coal usage will gradually transition towards clean coal technologies like supercritical (SC), and ultra-supercritical (USC) power plants, which will reflect in higher efficiency, more considerable power from coal with lesser coal consumption. Moreover, as compared to other fuels like oil and natural gas, which are mainly imported due to limited domestic resource availability, coal is available domestically in abundance. The older and smaller thermal power plants will retire and get replaced by larger SC / USC thermal power plants.

Further with the renewable penetration in the grid, five states of India (Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh and Gujarat) face significant system integration challenges, as solar and wind shares rise above 15%.

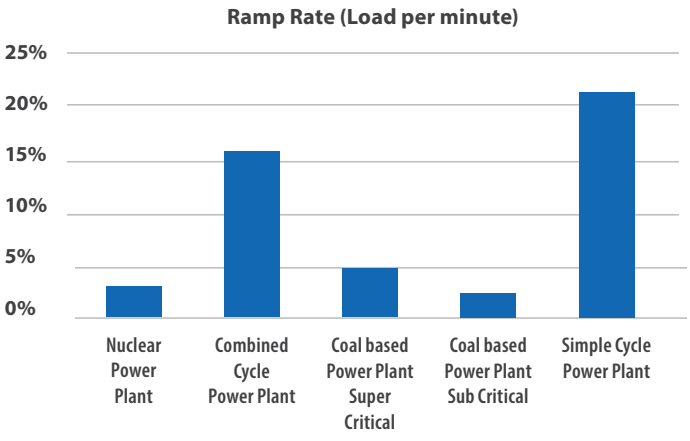
More states will experience higher shares of variable renewables, as solar power will be available during daytime and only when the sun is shining; and wind power is also dependent only when the wind blows. All these conditions create newer challenges and require significant change to the operation of the thermal power plants. This will create an opportunity for flexibility in the thermal power plant's operation and cleaner energy mix.

Considering the thermal power plant's percentage in the Indian power system, thermal power plants are the predominant source for the system flexibility. With its operating flexibility and lower loads and ramping rate, these plants can accommodate supply and demand variability and uncertainty.

There is a diverse range of strategies that can make existing conventional power plants more flexible. CEA has developed a road map for flexibilisation of thermal power plants, which underlines the importance of ramp rate (not a challenging factor, however, need to improve at least 1%/minute), financial framework (compensation for the increase in Capex and Opex due to change in the operating scenario) and revision of Grid Codes in terms of tariff structure. Considering this, there will be a considerable investment to develop thermal power plants to operate up to 30 to 40% load flexibly.

The other major factor for flexible operation of the grid is the operational philosophy (start-up and ramp-up characteristics) of the power plant. Gas-based combined cycle power plant with its high operationally flexible (high ramp rates & low start-up time) can suffice this requirement. The latest Indian grid code for RGMO (Restricted Governor mode of operation) mandates a speedy and sustainable response to the grid frequency fluctuations. Providing the primary frequency response will improve the grid stability, during daily load swing when renewables enter the grid. As per CEA, the required ramp rate in 2022 is 217 MW/min. (down) & 220MW/min (up).

The typical ramp rates of various type of units in India are depicted below.



Source: Gathered from various operating plant information

It may be noted that a simple cycle power plant has the highest ramp rate followed by a combined cycle power plant (CCPP) and oal-based power plant. The gas power plant in priority can support the daily swings as they possess higher ramping characteristics than the coal-based power plant.

The higher efficiency plants like supercritical units and advanced class combined cycle power plant would require operating at a baseload/maximum time. The subcritical power plant and stranded CCPP can take part in flexibilisation of the grid. The frequent load swings can be taken care of by the higher ramp rate turbines (Gas turbines/CCPP), while the steam turbine is used to operate at a fixed load condition.

Also, many R&D efforts are being deployed in developing hydrogen or hydrogen-based derived fuels viz., methanol/ammonia, and based combustion system for thermal power plants. The hydrogen generated from renewable power during lean power demand conditions can be stored and used in the thermal power plant when power demand peaks.

The capability to deliver a quick peak power is achievable through fuel combustion route. The hydrogen generated through renewable energy is termed as Green Hydrogen.

Further work around achieving Net Zero, without adding any more carbon to the atmosphere, is also underway. The carbon emissions, which is invariably generated through fuel combustion route presently, will be avoided. Using surplus renewable power, generating green hydrogen and synthesising with captured carbon from thermal power plants to make methanol or mix green hydrogen with nitrogen split from air to produce ammonia have all started. Small-scale testing of cofiring ammonia and coal is also being tried to reduce the existing power plant's carbon footprint.

While moving towards a cleaner energy mix, the following options are available for thermal power sector:

- Replacing the older thermal powerplant with new clean coal technologies like supercritical and ultra-supercritical power plants
- Operation of the stranded (8 GW) and stressed (16 GW) gas-based power plant to manage the Renewable energy variations, in India
- Shift to green hydrogen fuel or hydrogen-based derived fuels for use in thermal power plants, in future.

Having the dominant role in electricity supply, thermal power plants are critical for grid stability and economic growth. Due to stress on the environment impact, renewables may take over the larger share of power generation over the next few decades. However, this will not eliminate the addition of thermal power plant. The thermal power plants will continue to thrive in the grid, with its flexible nature and stabilising/sustaining the grid during the variation of renewable power generation.

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