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Crisis of Survival of Thermal Power Plants in India due to Consistently Falling Capacity Utilization – Factors Responsible and Future Outlook

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ABSTRACT

Thermal power plants in India are facing unprecedented crisis. Their capacity utilization (known as Plant Load Factor, PLF) has been consistently falling over the years. In the year 2019-2020 the national average PLF stood at 55.4%, down from 78.6% in 2007-2008. It is predicted that the national average PLF may fall to 48% by 2022. Many new thermal power plants, set up with substantial capital investment are staring at a bleak future. It is an irony that on one hand, the country is power deficit and on the other hand, a large amount of new, efficient and low-carbon- footprint thermal power remains grossly unutilised. Since considerable investment has gone into these thermal power assets, the falling PLF is a matter of concern for all the key stakeholders including the power producers, lenders, regulators and consumers. This paper identifies eleven major factors responsible for this situation and discusses future outlook of these factors. We find that urgent review of fresh thermal capacity addition, immediate phasing out of old inefficient plants and policy support to enable flexible operation of the thermal power generators are imperative to save the sector from imminent collapse.

Keywords: Thermal Power, Energy Economics, Plant Load Factor, Coal, Renewable, Flexible Operation

JEL Classifications: Q40, Q42, Q43, Q48

1. INTRODUCTION

1.1. Growth of Thermal Power Installed Capacity in India - Coal based Generation Played a Major Role in the Country's Growth Story

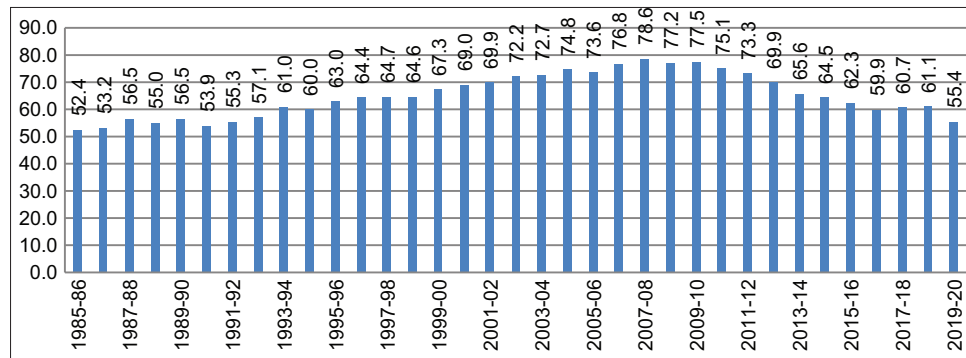
Indian power sector has seen robust growth in installed power capacity since independence of the country. Starting from a modest 1362 MW in 1947, the total installed capacity has risen to the level of 370106 MW by the end of March 2020. In this journey, the major contributor has been coal based capacity which is 205135 MW, making 55.4 % of the total capacity. Coal based capacity has grown from 756 MW to 205135 MW, registering a whopping 271 times growth in this period. This robust growth of installed capacity was propelled by the consistent demand and

supply gap of electricity in the country. In the year 2019-2020, energy shortage was 0.5% and peak shortage was 0.7% in the country.

1.2. Falling Plant Utilization Factor/Plant Load Factor (PLF) of Thermal Power Plants

For a properly maintained plant, the forced outage and planned outage together account for around 8-9%, which together should bring a reduction in PLF by 8-9% in a year. Therefore, a reasonably well-maintained power plant should be able to operate at 91-92% Utilization Factor (Hereinafter referred to as PLF in this paper) if other factors are favourable. However, the following figure (Figure 1) depicts the trend of actual PLF in the country. As can be seen, PLF of thermal power plants has been falling consistently

Figure 1: Bar chart showing plant load factor of thermal power plants in India 1885-86 to 2019-2020



Source: Central Electricity Authority Reports, Ministry of Power

in last 12 years. National average PLF in the year 2019-20 was mere 55.4 % down from 78.6% in 2007-2008.

1.3. PLF of Thermal Power Plants in the Country (Coal and Lignite based) from 1985 to 1986 to 2019-2020 – The Business Problem

It is pertinent to note that the drop in PLF of coal stations is happening across the sectors (Central, State and Private sector power plants). In 2009-2010 Central State and Private Sector recorded PLF of 85.5%, 70.9% and 83.9% which fell down to 65.36%, 50.26%, and 54.73% respectively in 2019-2020.

To describe the business problem more explicitly, we present here the data related to NTPC, (a Govt. of India Company and the largest power producer in India) in Table 1. The table shows the Declared Capacity (Declared Capacity or DC, represents the % capacity at which plant is ready to generate power) and Plant Load Factor (PLF, represents the actual capacity utilised) of NTPC over last 15 years. The difference between DC and PLF represents the gap between what the NTPC plants were capable of generating and what they could actually generate. The data depicts how NTPC plants ran much below their Declared Capacity.

As can be noticed above, the difference between declared capability and PLF for NTPC has increased from 2.22% in the year 2005 to 2006 to 21.16% in the year 2019 to 2020. This is staggering increase and is worrisome. The above situation indicates that considerable amount of electricity could not be sold/utilised thus resulting in Unrequisitioned surplus (URS). Un-requisitioned surplus (URS) happens when a power procuring utility does not requisition power from a generating station, which is ready to generate and supply power. URS is one of the indicators of low capacity utilization of power plants.

This is the condition with the country’s largest and premier thermal power generator which runs power plants at high efficiency, adheres to all environmental norms and produces relatively affordable power. Company’s average cost of power was around Rs 3.38 per unit (about 4.5 Cents/Kwhr) in year 2019, Mint (2019). In 2019-20 NTPC could not generate and sell about 74000 MUs (URS) of electricity. Other companies are facing even graver situation.

The lower capacity utilization not only affects the top line (due to less units of electricity sold) it also hurts the bottom line of thermal

Table 1: PLF and Declared Capacity of NTPC

Year	PLF (%) (coal stations)	Declared capacity (%)	Difference (DC-PLF) %
2005-2006	87.52	89.74	2.22
2006-2007	89.43	91.12	1.69
2007-2008	92.24	93.86	1.62
2008-2009	91.14	92.23	1.09
2009-2010	90.81	91.41	0.6
2010-2011	88.29	91.67	3.38
2011-2012	85.00	88.35	3.35
2012-2013	83.08	87.62	4.54
2013-2014	81.50	91.79	10.29
2014-2015	80.23	88.69	8.46
2015-2016	78.61	92.29	13.68
2016-2017	78.59	92.88	14.29
2017-2018	78.99	87.88	8.89
2018-2019	76.81	87.63	10.82
2019-2020	68.20	89.36	21.16

Source: Central Electricity Authority (CEA) Reports, NTPC data

generators. The price at which the generator sells power is regulated in India through two part tariff (Fixed Charges + Energy Charges). The energy charges that a thermal generator receives through tariff is based on certain normative operating conditions fixed by the regulator. Low PLF means that plants are operating at suboptimal level with operating parameters worse than design/normative limits, thus causing loss to the generator. For example, the electricity regulator fixes the normative heat rate (heat rate is a measure of thermal efficiency of the power station) for various power stations. The energy charges that the thermal power generator receives through tariff is based on presumption that the plant is running at the specified Heat Rate/Efficiency level (normative level). If the plant operates at low PLF with efficiency levels worse than this normative limit, it could incur losses. This, inter alia, means that the power producer will spend more on fuel per unit of electricity produced but will get less remuneration through energy charge. Every unit sold in this situation will be at loss.

Realising this difficulty, at the representation of thermal power generators, the regulator has permitted some allowance in the normative Heat rate so as to compensate the generators for such loss. However, the allowances are still not adequate as the PLF is going down day by day.

In this scenario, the thermal generators have been hit hard and there is seemingly no respite coming up on the horizon. The Economic

Times (2015) predicts that average national PLF may fall below 48% by 2022. In that situation, many coal-based projects will run into serious financial difficulty. These projects are financed mainly (75-80%) through loans. Interest on loans has to be paid even if plants remain idle. This can jeopardise many projects, hugely burdening the developers and lenders.

Under this already difficult situation, around 37 GW of new thermal power plants are still in the pipeline as on March 2020, reports PEI (2020). These pipeline projects, along with fast upcoming new renewable plants, which get preference in scheduling for being green energy, will push thermal generators to even more difficult situation at a time when demand growth in the country is not very robust. There is an imminent danger of collapse of the sector.

This requires that we urgently identify the factors responsible for falling Utilization Factor (PLF) of thermal power stations, so that policy makers, power producers, power purchasing companies, consultants and other key stakeholders can take appropriate action to manage the situation optimally. In this paper we explore various factors responsible for such situation and their future outlook.

2. LITERATURE REVIEW

We reviewed relevant papers in this arena and found that substantial work has been in the area of renewable energy integration in the grid and its consequent effect on thermal power. Many papers have dealt with merits of renewable energy and have looked into how these could be integrated into the grid and how this integration will impact coal based plants. Some papers have also dealt with isolated factors responsible for falling PLF of thermal power.

One of the most relevant work in this field comes from Wang and Li (2019). They have done scenario analysis in the electric power industry in China under the implementation of the electricity market reform and carbon policy in China. They have modelled four potential influencing factors of government policy: (1) the demand response mode; (2) power marketization process; (3) capacity adjustment of thermal power units; and (4) carbon taxes. Their model assesses the impact of these influencing factors on electricity generators. Two scenarios have been considered, business as usual (BAU) and Aggressive demand response (AG). The Business As Usual case predicts that utilization factor (UF or PLF) of thermal power shall drop considerably from 42% in 2020 to 28% in 2035. They predict that thermal power capacity addition will have negative growth of 0.004% during 2030-2035.

Min et al. (2020) have created an optimisation model for flexibility of grid in view of phasing out of coal and nuclear plants in South Korea. They observe that in view of rapid addition of renewables for flexibilization in the grid, the coal plants will still play a vital role.

Another important work comes from the USA. Robert (2019) has analysed the hourly generation patterns at large coal-fired units and the implications of transitioning from baseload to load-following electricity supplier. The paper states that several factors have led

to the decline of electricity generation from coal over the past decade, and the projections forecast high rates of growth for wind and solar technologies in coming years.

Luo et al. (2019) have brought out the effect of renewable energy on thermal power generation and have analysed the demand for flexibility improvement of thermal power units for accommodation of wind power under the situation of high-proportion renewable integration.

Liao et al. (2015) have done modelling and optimization of the medium-term units commitment of thermal power. They have created a scheme for thermal power plants under the name Medium-term Optimal Commitment of thermal units (MOCTU) to ensure that the generation process runs smoothly and minimizes the start-up and shut-down times of thermal units. This paper also therefore deals with effect of renewable energy on thermal power plants and how they should embrace the flexible operation regime.

Bhardwaj and Sharma (2020) have analysed the financial sustainability of Indian power sector, particularly in terms of poor financial health of the electricity distribution companies in India. They find that poor financial health of distribution companies will affect the thermal power generators.

Singh et al. (2013) have studied the changes in productivity for 25 state-owned coal-fired power plants (CFPPs) in India, over a period of 7 years (2003-2010). This study recommends specific policies that can be implemented to increase the productivity of power plants.

There are two very important reference works relevant for this research coming from the advisory bodies/agencies related to Govt of India. One is the Draft National Electricity Plan, Volume I; Central Electricity Authority, (CEA) (2016) and the other is Greening the Grid: Pathways to Integrate 175 Gigawatts of Renewable Energy into India's Electric Grid, Vol. I—National Study, a Joint Initiative by USAID and Ministry of Power (2017).

The Draft National Electricity Plan from CEA, (CEA is Govt of India policy body, vested with planning in the Power Sector) discusses the issue of Capacity Utilization of thermal power plants in India. It predicts that by 2022 many plants may get partial or no schedule of generation at all, meaning that many of these thermal power plants may have to be kept idle for lack of demand. Technical viability of thermal plants becomes dicey if they run under 55% capacity utilization.

Greening The Grid, a joint study by USAID and Ministry of Power is an extensive study covering operational challenges and cost saving opportunities for renewable energy using state-of-the-art power system planning tools. This paper discusses in detail the integration of renewable and also discusses flexibilization requirement of thermal power plants in India.

There are also many articles from prestigious news publications in India which have cited that the Utilization Factor (PLF) of thermal power plants in India is going down and likely to drop further.

They have also brought out some of the factors behind such drop in Utilization Factor.

Twesh, The Hindu Business Line (2018) reports that the coal “supply constraint” has affected thermal power plants, which are facing severe coal shortage and are running at $< \frac{1}{2}$ day’s stocks.

Anupam, Financial Express (2018) has pointed out that lower-than-expected growth in demand for electricity, coupled with the overcapacity of installed power projects, has precipitated a situation where more than 20,000 MW of under-construction coal-based power projects in the private sector are staring at an uncertain future.

Sengupta, The Economic Times (2016) predict that thermal power plants’ Capacity Utilization in India will drop to 48% by 2022. The report further adds that all coal-based thermal power plants need to brace for a drastic fall in capacity utilization by 2022, as additional non-thermal (renewable) electricity generation capacities come on stream. At that level of utilization, plants may lose the ability to run at a technically viable level and might find it extremely difficult to service debts turning into non-performing assets for lenders.

Ram, The Mint (2018), another prestigious newspaper dedicated to economic news, reports that Renewable Energy might be responsible for falling utilization Factor of thermal power plants.

Prasad, Economic Times, (2015) points out that addition of new capacities in the thermal power sector, lack of fuel and then low demand from buyers has forced thermal power generators to run below optimal capacity.

Nirbhay, Business Today (2020) quotes Honourable Union Minister for Power, New and Renewable Energy, Govt of India, saying that the country already (power) surplus and our thermal generation PLF is dropping because of renewable energy capacity that we have added. Thermal plants must be flexible to bring PLF down to 55%.

Xue and Xiao (2013) point out towards generalized congestion of power systems of India which affects the system adequacy and security. The researchers bring in a term called “generalized congestion.” They opine that the generalised congestion might be a constraint in effective and efficient utilization of generation assets.

It is found that most literature has identified or focussed on one or two factors that affect PLF of thermal power plants. Moreover, in terms of impact and projections about thermal power, most work is focussed on how to support and integrate renewables in the grid. There is no work to the best of our knowledge where attempt has been made to find out all the major factors affecting Utilization Factor of thermal power plants from thermal power plant perspective.

3. METHODOLOGY

To begin with, two step Exploratory Research was carried out. First step was the exploration of possible factors through Literature

Review. The aim was to the determine Factors/Areas which could be responsible for falling PLFs of thermal power plants. 94 journals papers, articles, news items were studied through which we created the first list of probable factors affecting the capacity utilization of power plants. It was followed by Focus Group discussions with selected experts (10 in total, each having experience of more than 30 years in thermal power sector). The Factors identified through literature review were discussed with experts in order to ensure that no significant factor is left out from the list. Finally the factors were shortlisted, clearly articulated and also divided in sub themes for easy comprehension and further research.

This two-step process (Literature Review + Focus Group Discussions) resulted in 25 factors being identified. A questionnaire was then created with 25 identified factors and responses were sought from respondents on a Likert Scale for each factor having impact on PLF of thermal power plants with choices as- (a) Very high impact (b) High impact (c) Neutral or undecided (d) Low impact and (e) Very low impact. There was also an open question available for respondents to add a new factor if they so wanted.

The questionnaire was administered to targeted power professionals from power companies in Central Sector, State Sector, Pvt Sector, Regulators, Consultants and Academicians. The respondents were experienced professionals in power sector. 75.18% of the total respondents who replied have more than 20-year experience in the sector. Questionnaire was sent to 400 respondents out of which 137 responded.

Analysis was then done using hypothesis testing for proportion. If majority ($>50\%$) of the respondents feel that a particular factor has very high or high impact on thermal power PLF-such factor shall be considered a major factor. We have done z statistic test of proportion to ascertain whether majority of the respondents have chosen a particular factor as having Very High or High impact (a+b) (Refer Table 2). Our sample size is. $n = 137$. Null hypothesis (H_0) is - population proportion P is 0.5 (i.e., only 50% respondents believe that this factor has very high or high impact. Alternate hypothesis is that P is significantly $>50\%$ (99 % confidence level).

(H_0 , $P = 0.5$ i.e., 50 %,

H_a , $P > 0.5$, a one tailed test)

{ $P_n > 5$ and $P(1-P)_n > 5$, both conditions are satisfied to run normal distribution test of proportion.}

A p-critical value corresponding to Z-critical value approach has been used. In order to do this, the Z critical value at 99 % confidence level (2.576) has been taken and applied in formula below to find p critical value for our sample size (137). Our approach is that if sample p is greater than p-critical, it can be concluded that the Null Hypothesis is rejected for that factor and there is evidence to believe that that majority of experts think that this factor is a major factor. This was done for all the factors.

Following calculation shows how p critical value (p-cut-off) has been calculated.

$$Z = (p-p_0)/\sqrt{p_0(1-p_0)/n}$$

$$1.576 = (p-0.5)/\sqrt{0.5(1-0.5)/137}$$

This gives,

$$P = 0.61$$

The p critical value (p-cut-off) comes to 0.61. This means that if p (proportion of respondents saying a particular factor as very high or high impact out of the total respondents) is more than 0.61 i.e., if more than 61% percent respondents (as opposed to >50%, if we were to consider a simple majority approach) say that a particular factor has high or high or very high impact, then we infer that this is majority opinion and is not a mere chance of random response.

4. RESULTS AND ANALYSIS

Our literature survey resulted in identification of following 7 factors which could be affecting capacity utilization (PLF) of thermal power plants.

1. Effect of renewable energy
2. Low growth of demand as against projected
3. Overcapacity (excess installed capacity)
4. Financial health of discoms
5. Fuel availability (low availability of coal)
6. Transmission/evacuation constraints
7. Policy issues discouraging the thermal power generation.

These factors were then discussed with experts in the power sector in focus group discussion mode (10 in total, each having experience of more than 30 years in thermal power sector). As a result of the discussion, the factors got enhanced, refined and re-categorised. Finally, total 25 factors were identified which were clustered in ten sub themes. Table 2 lists all the ten sub themes, all

Table 2: (Factors identified, responses and analysis, total 137 responses)

Factors	Very high or high impact (a)	Proportion of very high and high versus Total (a/137)	Proportion at Z cut off value 2.576 (at 99% confidence level)	H0 Accepted/Rejected	Major factor (Yes/No)
1. Financial health of key players and cost related factors					
(1) Poor financial health of power procuring companies (Discoms) is forcing them to reduce power procurement even if while demand exists	108	0.79	0.61	Rejected	Yes
(2) The power utilities of state sector (State Gencos) are in financial distress and are unable to maintain their own power plants in good condition	101	0.74	0.61	Rejected	Yes
(3) The power utilities of private sector (IPPs) are in financial distress and are unable to maintain their own power plants in good condition	79	0.56	0.61	Not rejected	No
(4) Due to large number of thermal power loans becoming NPA, banks have reduced lending creating fund crunch for power producers	73	0.53	0.61	Not rejected	No
(5) Generating electricity from coal is no longer attractive business due to rising costs, forcing the thermal generators to cut down generation	87	0.63	0.61	Rejected	Yes
2. Emission and environmental pollution related factors					
(6) New emission norms set by Govt in 2015 for thermal power plants	93	0.68	0.61	Rejected	Yes
(7) Society's growing concern about environment is forcing power stations to reduce production	75	0.55	0.61	Not rejected	No
3. Generation mix related factors					
(8) Disproportionately high share of thermal power in Indian grid (63.7% of total installed capacity as on 31.03.2019)	70	0.51	0.61	Not rejected	No
(9) Substantial addition of renewable energy (solar and wind) having must-run status in the grid	108	0.79	0.61	Rejected	Yes
4. Grid evacuation constraint related factors					
(10) Grid evacuation constraint (line loading limitations) in some areas causing reduction in power generation	60	0.44	0.61	Not rejected	No

(Contd...)

Table 2: (Continued)

Factors	Very high or high impact (a)	Proportion of very high and high versus Total (a/137)	Proportion at Z cut off value 2.576 (at 99% confidence level)	H0 Accepted/Rejected	Major factor (Yes/No)
5. Technical problem related factors					
(11) The thermal power plants are experiencing forced outages//technical problems (like boiler tube leakages etc) and are unable to generate to full capacity	64	0.47	0.61	Not rejected	No
(12) Many thermal power plants in India are ageing and are unable to reach full load capacity	77	0.56	0.61	Not rejected	No
(13) The thermal power plants were designed as base load (full load) operation whereas the grid conditions today demand flexible operation that coal plants are unable to cope up	102	0.74	0.61	Rejected	Yes
6. Demand and supply related factors					
(14) Low growth of power demand in the country as compared to projected is resulting in underutilization of thermal power	102	0.74	0.61	Rejected	Yes
(15) India has reached a stage of being power surplus (on most days in a year)	79	0.58	0.61	Not rejected	No
(16) Although India is power deficit on totality basis, many regions have actually become power surplus	87	0.63	0.61	Rejected	Yes
7. Competition related factors					
(17) Large number of players in power generation is resulting in fierce competition	82	0.60	0.61	Not rejected	No
(18) After opening up of power sector, many new and inexperienced players jumped without understanding the electricity market	67	0.49	0.61	Not rejected	No
8. Fuel related factors					
(19) Low fuel (coal) availability forcing thermal power generators to reduce power generation	94	0.69	0.61	Rejected	Yes
(20) Poor quality of coal having very high ash is forcing thermal power generators to reduce power generation	82	0.60	0.61	Not rejected	No
9. Policy related factors					
(21) The tariff/policies are un-supportive of thermal power generators	82	0.60	0.61	Not rejected	No
(22) Renewable energy is getting promoted at the cost of thermal generators because thermal plants are supposed to generate when nobody else is able to generate and then back down when others are available	115	0.84	0.61	Rejected	Yes
(23) There is lack of policy clarity on whether and how old thermal power plants are to be retired, which creates a dilemma whether to invest in their R&M	89	0.65	0.61	Rejected	Yes
(24) The ultra mega power scheme did not bear desired results because of policy issues (projects risks were not addressed properly)	73	0.53	0.61	Not rejected	No
10. General perception related factors					
(25) There is a general perception that coal based thermal power will be entirely phased out in the medium/long run which is inhibiting new and modern technology infusion in thermal plants	79	0.58	0.61	Not rejected	No

Source: Results of this research

the 25 factors and also tabulates the responses of 137 respondents against all the factors.

5. MAJOR FACTORS IDENTIFIED THROUGH THE QUESTIONNAIRE ANALYSIS

Analysing the results of the survey (Table 2), we find that there are 11 factors out of the 25 factors which can be categorised under major factors affecting thermal power capacity utilization in India. They are listed below:

1. Poor financial health of power procuring companies (Discoms) is forcing them to reduce power procurement even if demand exists
2. The power utilities of state sector (State Gencos) are in financial distress and are unable to maintain their own power plants in good condition
3. Generating electricity from coal is no longer attractive business due to rising costs, forcing the thermal generators to cut down generation
4. New emission norms set by Govt in 2015 for thermal power plants
5. Substantial addition of renewable energy (solar and wind) having must-run status in the grid

6. The thermal power plants were designed as base load (full load) operation whereas the grid conditions today demand flexible operation that coal plants are unable to cope up
7. Low growth of power demand in the country as compared to projected is resulting in underutilization of thermal power
8. Although India is power deficit on totality basis, many regions have actually become power surplus
9. Low fuel (coal) availability forcing thermal power generators to reduce power generation
10. Renewable energy is getting promoted at the cost of thermal generators because thermal plants are supposed to generate when nobody else is able to generate and then back down when others are available
11. There is lack of policy clarity on whether and how old thermal power plants are to be retired, which creates a dilemma whether to invest in their R&M.

6. FUTURE OUTLOOK OF THE IDENTIFIED FACTORS

In Table 3 below we present the future outlook on all the 11 identified major factors.

Table 3: (Future outlook of identified factors)

Factor	Future outlook/comments
1. Poor financial health of power distribution entities	Bloomberg Quint (2020) reports that India's distribution companies (known as Discoms) lose around 360 Indian Rupees (\$4.63) on every megawatt-hour of electricity they deliver — equivalent to roughly 10% of the retail price. The Discoms are also debt ridden. Total debt in the sector amounts to 4.3 trillion rupees (\$56.4 billion), according to a recent report by the Asian Development Bank Institute done by Gopal et al. ADB (2019) Despite Govt's effort to revitalise the distribution sector, the financial position of Discoms remains a matter of worry for the next 5 year horizon. This situation is likely to continue unless decisive reforms are undertaken in the distribution sector supported with strong social and political will to make the Discoms profitable. With central government making some serious efforts in recent years including privatisation of distribution areas and strengthening the Ujjwal Discom Assurance Yojana (UDAY) scheme, some improvement is expected in this area. However, looking at the huge scale and complex nature of Discom's business, any major respite in this area which might support capacity utilization of thermal power plants appears unlikely in next 4-5 years
2. The power utilities of state sector (State Gencos) are in financial distress and are unable to maintain their own power plants in good condition	State Gencos' fate is tied with the Discoms. Unless the financial condition of Discoms improves, the State Gencos are also likely to remain in difficulty. They will not be able to invest in modern technology and pollution control equipment thus forcing the capacity utilization factors remain low. Mint (2020) reported that as on November 2019, the Discoms owed Rs 81085 Cr (nearly 11 Billion USD) to the Gencos. This creates a huge strain on Gencos Some state Gencos are putting up new supercritical units, which might run at high PLFs if other factors are favourable. However, for the older existing plants we do not see any improvement in Utilization Factor in next 5 years' horizon
3. Generating electricity from coal is no longer attractive business due to rising costs, forcing the thermal generators to cut down generation	Reuters (2019) reports that the main reason coal may have to face battle to fuel India's future energy needs is that it's simply becoming too expensive relative to renewable energy alternatives such as wind and solar. In recent trends, power supply auctions have shown that renewables can be offered at <3 rupees (4 U.S. cents) per kilowatt hour, a tariff that coal-fired generators have difficulty matching. It further opines that there is zero chance that new coal generators can produce electricity at rates competitive to renewables, given higher capital and operating costs. We anticipate that this trend will continue and will keep on putting negative pressure on capacity utilization of thermal power in future Gencos are trying to cope up with the new environment norms but are finding it very hard. However, they must get ready to adopt the new norms. Regulators, courts and public at large is likely to have zero tolerance towards noncompliance. Unless they become fully compliant with environmental norms they cannot survive. Installation of new equipment for pollution control, necessitating unit stoppages is likely to adversely affect the PLF during the implementation phase i.e., next 1-1.5 years, however it shall help the thermal power plant capacity utilization in positive way thereafter
4. New Emission Norms set by Govt in 2015 for thermal power plants is affecting capacity utilization	

(Contd...)

Table 3: (Continued)

Factor	Future outlook/comments
5. Substantial addition of renewable energy (solar and wind) having must-run status in the grid is causing coal based PLF to fall down	Going ahead, Govt of India has ambitious plans to establish 175 GW renewable energy by 2022. Honourable Prime Minister Shri Narendra Modi has further upped this commitment recently by announcing that India will attain 450 GW renewable capacity by 2030. Amidst such substantial renewable capacity addition, the electricity buying entities (Discoms) have been put under obligation to buy from renewable sources under a provision called renewable purchase obligation (RPO). Indian government has stipulated that by FY22 the states must procure minimum 21% quantity of their overall power purchases through renewable energy, as reported by Financial Express, (2018) This factor, therefore is also going to severely affect coal generation. Thermal generators will have to increasingly face this brunt. We feel that it is one of the most significant factor that will push down thermal power capacity utilization consistently in future
6. The thermal power plants were designed as base load (full load) operation whereas the grid conditions today demand flexible operation that coal plants are unable to cope up	To remain in existence, the thermal power plants must become ready for flexible operation. If done properly, it will help in better utilization factor and if not done, it will lead to the plants being shut down. This will be one of the important factors for improving capacity utilization of thermal power plants for the next 5 years horizon
7. Low growth of power demand in the country as compared to the projected demand is resulting in underutilization of thermal power	It appears that there has been substantial error in demand forecasting. Financial Express (2020) reports that the system of aggregate demand projection has not been robust in the country. The aggregate power demand is directly connected with the growth rate of the gross domestic product (GDP). The GDP growth rate of 8-10% was used in demand projection of the 18 th Electric Power Survey (EPS; 2012-17) and, consequently, the actual demand remained much below the projected one. A more scientific, multi input, realistic, iterative and agile demand forecasting is required in the country. It should use multiple factors like GDP growth, growth in industry, regional imbalances, and energy efficiency in the demand side etc., and should use realistic figures for such factors. This will help planning of new capacities and inadvertent overcapacity will be avoided
8. Although India is power deficit on totality basis, many regions have actually become power surplus	India has power deficit on national basis. However, there are regional disparities. Some regions have actually become surplus. Seamless power flow between deficit and surplus areas has not yet become reality due to techno economic constraints. New regulations called real time market (RTM) and security constrained economic dispatch (SCED) have come as breather in this situation. Faster implementation and training of personnel are required to harness the benefits fully
9. Low fuel (coal) availability forcing thermal power generators to reduce power generation	Govt of India has taken several steps including auction/re-allocation of coal mines so that production is given a push. The State-run Coal India (The largest and nearly the monopoly coal producer in India) has set itself an ambitious annual production target of 1 billion tonnes till 2024, reports Economic Times, (2020).Based on the ambitious plans of the main coal producer in India (Coal India) and auction of new mines by Govt of India for commercial mining (over 200 coal blocks are to be auctioned in the next 5 years), coupled with relative slowdown of thermal capacity addition, we do not foresee any negative impact on PLF of thermal power plants due to coal shortages in next 5 years
10. Renewable energy is getting promoted at the cost of thermal generators because thermal plants are supposed to generate when nobody else is able to generate and then back down when others are available	Since migration to renewable is inevitable, addition of renewables will continue to put heavy pressure on capacity utilization of thermal power plants. Most thermal generators are also likely to switch to renewable portfolio. However, the problem will be their midterm survival for which special fiscal and policy support needs to come fast
11. There is lack of policy clarity on whether and how old thermal power plants are to be retired, which creates a dilemma whether to invest in their R&M	There must be policy clarity on when and how the old plants should be phased out. Govt has already made some announcements about this. India's Honourable Finance Minister Ms Nirmala Sitharaman has said in her budget this year (2020) that "Utilities running thermal power plants that are old and where the carbon emissions are higher will be advised to close down and that land will be used for alternative energy purposes" reported Koundal and Joshi, ET Energy World (2020) Detailed guidelines with firm timelines needs to be given in this area so that thermal power generators take decisions to phase out old plants

Source: Results of this research

7. CONCLUSION

- Urgent review of all new thermal power capacity addition (other than those in pipeline) seems to be an imperative
- Existing plants must invest in flexibilization technologies. Urgent action is required in this area. Thermal power producers must invest and train people to run plants on flexible operation. All original equipment manufacturers (OEMs) should also support the power producers in tiding over this critical challenge. Since it will add additional
- burden on already stressed thermal sector, flexibilization should be incentivised through separate policy and fiscal incentives. Such support should be given to the power generator considering that the ramp-up and ramp-down is an ancillary service. By participating in ramp-up ramp-down, thermal power is helping the renewable integration in Grid
- Another step that needs to be taken is phasing out old thermal power stations. The power stations which have completed their life and are running at high Heat Rates (Low efficiency)

must be phased out fast. Phasing out of old inefficient plants will reduce carbon emission from inefficient plants and will also enable the new generation, high efficiency, supercritical technology plants to be utilised at higher capacity utilization (PLF) levels

4. Techno commercial mechanisms like real time markets (RTM) should be implemented fast and on a large scale. There is need for training the people across the power generation sector on using RTM effectively
5. With rising concern about pollution in the society, it is felt that the challenges for thermal generators on environment front are likely to be even more stringent. Thermal power generators must embrace the changes and install pollution control equipment quickly. Those who do such changes must be rewarded, those who do not do should be discouraged and penalised through some mechanism built-in in the tariff
6. Fast and strong reforms in the distribution sector are also need of the hour. Distribution sector must be modernised and privatised fast. New technology, IT based solutions should be implemented in the sector. There is need for training across the distribution sector in areas like modern IT driven methods, automation and controls, metering, business acumen, transparency, accountability and change management. UDAY scheme should be monitored and implemented in letter and spirit. Since the sector is complex and has problems that are typical to the sector, a separate regulator for Distribution sector may also help in recovery of the system. Distribution sector is already open to private participation. But response from private entities has not been very encouraging. More territories should be opened up for private participation
7. Coal production is expected to rise to sufficient level to sustain demand. Coal India has increased its production targets sharply. As planned by the Indian Govt, more commercial mining is expected to start when auctioned mines allocated to other private companies and PSUs start functioning. The coal production is therefore expected to cover the coal requirement of the thermal power stations in the country and we feel that coal shortage would not be affecting coal based generation PLF negatively
8. Coal based generation shall face more cost hikes both due to input costs and costs for abatement of carbon footprint. Cost parity between coal and renewable based generation is already a reality. Thermal power must acknowledge this fact and review its long term plans
9. If above steps are taken, at least the efficient, environment compliant thermal power plants will be able to operate at PLF levels of around 50% + and shall be able to survive and service debt
10. As reduction and eventual phasing out of large number of thermal power plants is almost a writing on the wall, electricity storage technologies should be supported (along with renewable energy) with intensive R&D, policy push and incentives so that renewable energy can sustain the grid when coal based generation is reduced or phased out. Coming up of battery storage will also relieve the coal based stations from ramp-up ramp-down duties
11. Existing thermal power players must diversify in other areas including renewables to ensure business continuity.

These steps are necessary to optimally utilise the thermal power plants. Otherwise many of the new, efficient thermal power assets created with large capital investment may face unsustainably low level of utilization and may become unavailable very soon.

8. LIMITATIONS

1. Being a relatively new phenomenon in India, there is lack of data and understanding about the impact of various factors on capacity utilization (PLF) of thermal power plants in India. Some survey responders may therefore have used their intuition in deciding the factors
2. It is assumed that electricity storage techniques would become cost effective in next 5 years and renewable energy coupled with storage cost per unit of electricity would be competing with thermal power cost
3. All the major factors affecting capacity utilization (PLF) of power plants identified through this study cannot be modelled in regression for future prediction of PLF because some factors are uncertain or qualitative in nature and their degree cannot be determined, viz, Financial health of power distribution companies, environmental norms
4. This paper has not considered the impact on environmental emission due to falling PLF of the thermal power stations
5. This paper has not considered the financial impact on generating companies due to falling PLF
6. Time is the essence of this article/paper. If the publication is delayed it will lose value and utility.

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