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Significance of Thermal Power in India - Energy for Economy

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Abstract:
Intent of this article is to deliberate Significance of Thermal Power in India for next couple of decades. Electricity is essential element for holistic growth. India has achieved swift progress in sustainable power generation, but Renewable Energy is not reliable due to limitations. At the same time, population rise, Economic & Industrial growth, lifestyle change etc. have led to enhance power demand.
To study this subject, data has been explored from authentic sources, Focus Group Discussion with Subject Matter Experts, Industry Leaders on different aspects. Ample of Government published reports & dashboards, International & National Journals have been examined. Study indicates that Thermal Power is vital contributor & will be backbone for couple of decades. Further study to be explored to review appropriate strategies to operate Thermal Power Station at the maximum capacity & performance within optimum cost to ensure affordable & acceptable energy for all.

Keywords: Energy for Economy, Thermal Power, Sustainable Energy, Generation Mix,

Introduction
Today, one of the most basic needs is LIGHTING UP LIVES. (Tamso Ma Jyotirgamaya) [1] It means "Lead us from Darkness to Light." Growing economies have set aspiring Renewable Energy (RE) installation enhancement aims to decrease power exportation on estimate of their growing economy [2]. In due course, Sustainable Energy development & technology modernization, Thermal Power Plants (TPP) in India are struggling with significant challenge like fuel crisis, environmental, international scenario etc. Further to this, Resource Planning, Water availability & process cost, other infrastructure & environment norms, cost affordability, old equipment's performance related challenges, huge O&M cost are critical hurdles being faced by Indian TPP. RE is not consistent at present, for energy security reliance on conventional source is essential. [3].

Objective
To ensure sustainable & affordable electricity to lighting up millions of lives and the growth of Nation, one of the crucial criteria is to run the installed Thermal Power Plants at the highest design capacity and benchmarking performance with optimum cost. The primary goal of this research is to study significance of Thermal Power Plant in the Green Energy Era.

Method
For this research, Interviews with relevant Senior industry Leaders, Focused Group Discussion with Subject Matter Expert have been done. Literature review of abundant Government published information and past research data have been examined. Country's current scenario – Energy Mix like Thermal, Solar, Wind, Nuclear, Hydro and other resources have been reviewed & data has been obtained, articulated from National Power Portal which indicates that Thermal Power is vital contributor to fulfil power demand.
Central Electricity Authority (CEA) Annual report (2021-22) presents that power demand supply gap is reduced but still it is around 4 % upto Dec 2022 which indicates deficiency in power supply. As per

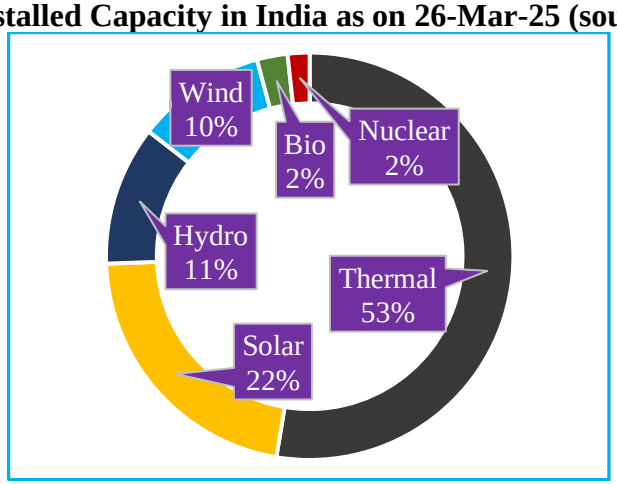
CEA, Per Capita Energy Consumption is constantly rising & as per CEA general review report 2022, major consumers are Industrial, Domestic, Agriculture, Commercial and others. As per CEA report "GROWTH OF ELECTRICITY SECTOR IN INDIA FROM 1947-2020", all consumers. Energy consumption is rapidly increasing on year-on-year basis. As per ministry of Statistics & Programme implementation (MOSPI), factories establishment is increasing which is direct indication of continual increase in power demand. Ministry of Environment, Forest and Climate Change Posted On: 03 AUG 2023 5:04PM by PIB Delhi (Release ID: 1945472) that target to achieve net zero by 2070.
Owusu & team. (2016) have published paper describing sustainability issues of RE. Research published by Ashok Upadhyay & team (2014) regarding Solar Energy Fundamentals and Challenges in Indian restructured power sector like bottlenecks like availability, High Capital Cost, Large amount of land requirement and energy storage etc. Also research paper on subject, Solar Energy - Challenges, Economics & Policies in India done by Arun Kumar Singh & team has been reviewed. Solar Projects Risk Analysis and Project delay related issues studied by SIDDHARTH GAURAV& team has been reviewed. Article on limitations of renewable energy by Halkos, George & Gkampoura, Eleni-Christina. (2020) has been studied.
As per National Electricity Plan (Volume 1) published by CEA in March 2023, during 2031-32 Generation contribution from Thermal shall be around 50 % means Thermal will be major contributor after decade. To manage grid with different contributor, flexible operation to be considered which is described in report on optimal generation mix 2030 version 2.0 published in April 2023 by Ministry of Power, Government of India, Central Electricity Authority. Niti Ayog has published analytical tools for managing climate change and exporing net zero pathways on 20th July 2023 (Release ID: 1941098) which is tool developed with the help of IIT Bombay for India Energy Security Scenarios (IESS) 2047.

Research Gap Analysis

Research in the subject of Power Sector in India indicate that Renewable Energy is growing exponentially. Focus to achieve net zero target is visible. Aggressive expansion in Solar Energy is observed. Study is also indicating energy demand is rising due to Industrialization & Economic Growth. Research and Development is being carried out to mitigate technical challenges in RE.
Research gap is observed for significance of Thermal Power Contribution. Due to reliability issue of Solar & Renewable Energy, at present only Thermal Power is vital source of Power. Study for Thermal Power Sector Endurance is desirable.

Current Condition of Indian Power Sector

Fig – 1 Installed Capacity in India as on 26-Mar-25 (source: NPP)

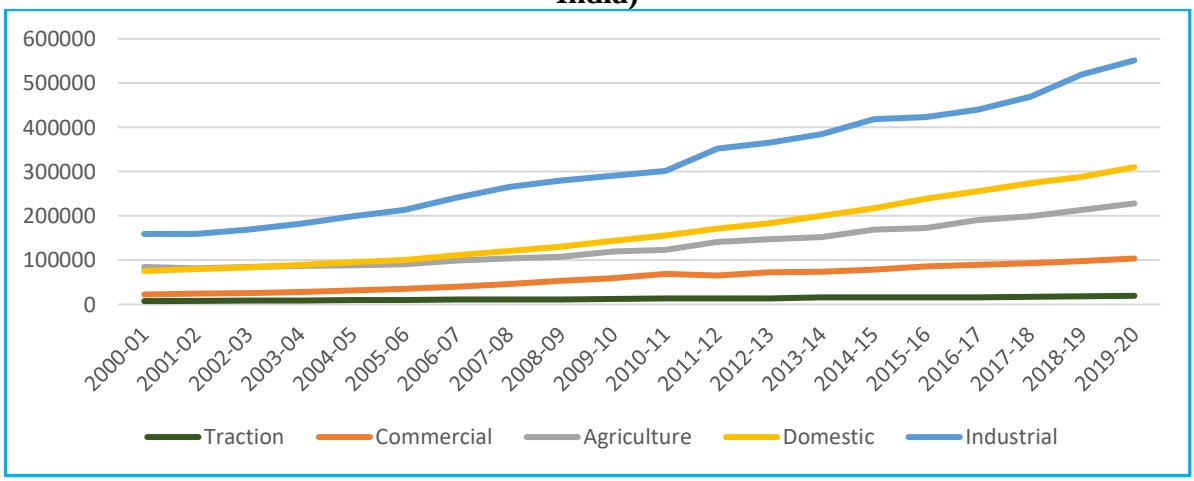


Thermal Power is contributing 52.62 % and balance 47.38/% by other generation sources [4]. It shows key contributor of power is Thermal in present situation. Peak supply vs demand difference is reducing, but still, it is approx 1.2 % in 2021-22 which is 2475 MW [5]. During 2022-23 (by Dec 22) it is seen 8657 MW which is 4 %. [6]. Further to this, Per capita energy consumption is constantly rising from 566.69 KWH in 2002-03 to 1255.14 KWH in 2021-22. Per Capita Consumption trend shows, power requirement is constantly increasing. [7]

Major Power Consumers:

In India, Key Power users are Industrial (41.36%), Domestic (26.89%), Agriculture (17.99 %), Commercial (7.07 %) and others (6.69 %) [8]. Last 20 years, utilization study indicates that all category, power consumption has increased, Industrial power consumption is highest and risen rapidly [9].

Fig – 2 Energy Consumption in India (Source: CEA report, Growth of electricity sector in India)



In India, factories establishment is going up which is direct indication of continual growth in power demand. [10]. It means, major power users (Industries) are increasing which implies, continuous rise in Power Demand in future too.

Wind & Solar Generation Capacity addition in India:

At the 26th session of the UN Framework Convention on Climate Change (COP 26) in November 2021, Indian has announced its target to achieve net zero by 2070. [11]

The return-to-renewables is an exceptional direction but desires to be sustainable in order to confirm a sustainable future for generations to comply power requirements. [12]

In India, as on 31st March 2022, contribution from Solar (34%) and Wind (26%) was 60% [13].

During 2017-22, newly added RE, major segment is from Solar (76%) and Wind (15%). It indicates 91 % are from Solar & Wind which is not reliable sources due to limitation at present.

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Table: 1 – RE Installed Capacity & addition from 2017 – 22 (31.03.2022) (Source: NEP [13])

RE Source	Installed RE Capacity 31.03.2022		RE Capacity addition 2017 – 22 (31.03.2022)	
Solar	53996.54 MW	34 %	41707.72 MW	76 %
Large Hydro	46722.52 MW	30 %	2138 MW	4 %
Small Hydro	4839.39 MW	3 %	469.04 MW	1 %
Biomass	10682.36 MW	7 %	2386.58 MW	4 %
Wind	40357.58 MW	26 %	8077.81 MW	15 %

Bottlenecks of RE is availability, climate dependence, huge investment, land constraint & power storage [14]. Efficiency of Solar Cell and Per capita land requirement is also critical barrier for solar energy [15]. While the use of RE has been regarded as a solution to the mounting problems of climate change and people's current heavy dependence on fossil fuels, some significant hurdles (like Political Risk, Financial Risk, Technical Risk, Social Risk) must be mitigate so that RE aims are achieved in the near future [16].
A comprehensive policy framework on RE, Research and Technology Development Programme is in place to support R&D in new and renewable energy sector, including associating and supporting R&D earned out by industry for market development [17].
Developed countries that have economic resources to invest in R&D, education, and promotion of sustainable development and renewables' usage should help other developing countries [18]

Future prediction of power generation:
To meet power demand, Government is planning to add power generating capacity through various sources. In 2026-27, projected installed capacity for Thermal (Coal+ Lignite) shall be 39 % and Solar (30%) + Wind (12%) shall be 42 % of total installed capactiy. Whereas Gross Generation contribution from Thermal shall be 59 % and Solar (17%) + Wind (8%) shall be 25 % only [13].
Projected installed capacity for Thermal In In 2031-32, (Coal+ Lignite) shall be 29 % & Solar (40%) + Wind (13%) shall be 53 % of total installed capactiy. Whereas Gross Generation contribution from Thermal shall be 50 % and Solar (25%) + Wind (10%) shall be 35 % only [13]. It indicates, Gross Generation from Thermal Power Source shall be 50% in 2031-32. Thermal Power Source will be major contributor for next 10 years.

Fig-3 Projected Installed capacity 2031-32

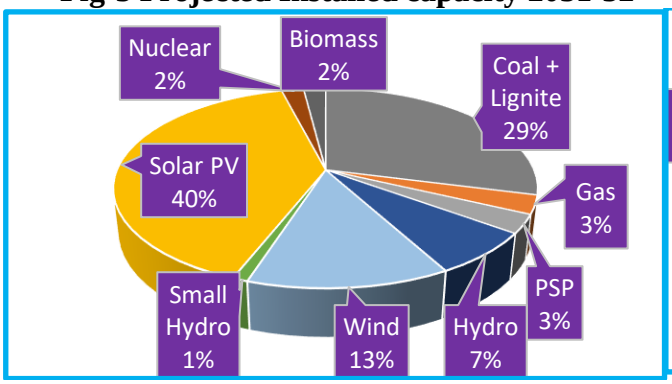
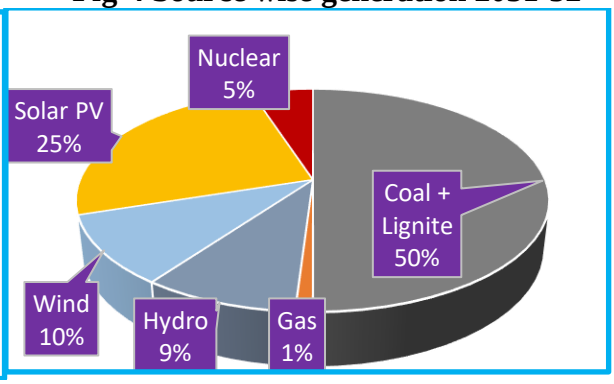


Fig-4 Source wise generation 2031-32



Although Solar & Wind installed capacity will be increased, base load will be from Thermal Sector which may vary from day & night schedule & shall be operated on flexible operation mode to ensure power grid stability. To integrate RE, flexible operation of Thermal & Hydro has been initiated as per CEA guideline [19]. As per report on optimal generation mix 2030 [20], coal capacity is running at

55% Minimum Power Load during the hours when full solar generation is available. The battery is getting charged during the solar hour and dispatched during non-solar hours. RE generation is seen to be almost fully absorbed during this day. The likely solar & wind CUF is 22.97% and 40.8% respectively while the gross PLF of the coal-based capacity is likely to be 65.90% on this day. The gross coal capacity on bar on this day is likely to be 192 GW.
Electricity supply from coal source will be continually increased from 994.2 TWh in 2022 to 3212.71 TWh in 2047 [21, 22], Volume of Thermal Power Generation will increase.

Table 2 Sourcewise energy supply projection IESS 2047 V3.0

Source	Projection Year (Trillion-watt hours TWh)				
	2027	2032	2037	2042	2047
Gas	50.09	51.24	52.39	53.54	54.69
Coal	1303.75	1657.39	1984.84	2454.98	3212.71
CCS	0	8.59	17.18	25.77	34.36
Nuclear	72.7	106.82	156.96	230.62	338.86
Hydro	183.68	206.07	226.59	230.57	234.56
Solar	176.34	349.09	593.51	873.98	1143.87
Wind	126.85	237.66	464.8	770.11	1097.43
Bioenergy	20.41	22.13	24.26	26.96	29.39
Electricity trade	0.4	5.68	13.72	17.51	22.35
Total	1934.22	2644.67	3534.24	4684.06	6168.23

Conclusion

At present, Power contribution from Thermal sector is around 52.62 % which is projected around 52.08 % in 2047. In current scenario, Peak demand-supply gap in electricity is 4 % (till Dec 22) which is 8657 MW. On the other side, continual increase in per capita electricity consumption, continual growth in all power consumers – Industrial, domestic, agriculture, commercial etc., indicates persistent raise in power demand. Power Supply from coal source prediction is around 52 % in year 2047 which indicates backbone will be Thermal Power. RE Installation is increasing but due to limitations like Technical, Political, Financial, Social, still it is not reliable. It shows that backbone of energy source shall be from Thermal Generation at least for next couple of decades, flexible operation to be ensured for Power Grid management to balance Generation Mix. It is essential for Economic Growth and holistic development.
Further in-depth study and Research in other source of energy to mitigate issues to be explored. Strategies for sustainability of Thermal Power Plant, Innovative approach for optimum generation cost, Innovative strategy to enhance efficiency & reliability, Strategy to meet Generation Flexibilization to be explored which can provide reliable & affordable power to LIGHTING UP LIVES.

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