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A Study Of Analysis Of Cost Structure Of Select Power Generation Sources For Supplying The Electricity To Consumers At Economical Rate

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Abstract

Cost of the power is major cost element in the cost of the products & services. Consequently, analysis of cost structure of the various power generation sources in order to supply the electricity to consumers at economical rate have vital importance.

Keywords:
- Cost of the Generation per unit: Total cost of the Generation divided by the Generations of the Electricity in the Kilo Watt Hour.
- Capacity of the Power Plant: The capacity of the power is the capacity to produce the power in Mega Watt Hour.

Introduction:

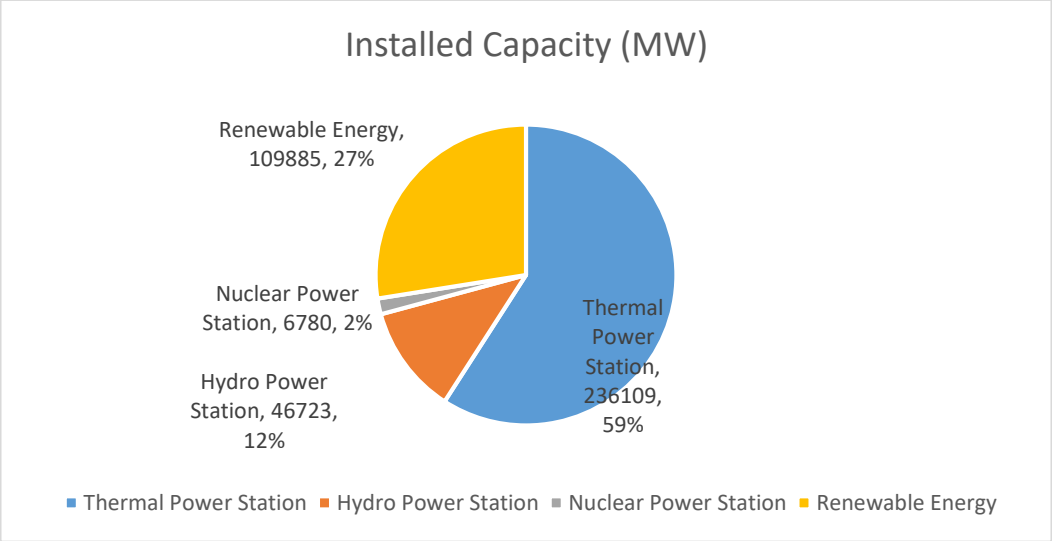
The power sector is backbone of the country's economic and social development. The tariff structure, which determines the price of the electricity, is an important aspect of the power sector and has significant implications for the consumers, investors, and the other stakeholders in this sector.

The purpose of the proposed study is to analyse the cost of the Generation from the various sources of the power generation & to analyse the load curve & suggest the mix of the power sources in the light of increasing solar power capacity addition in India.

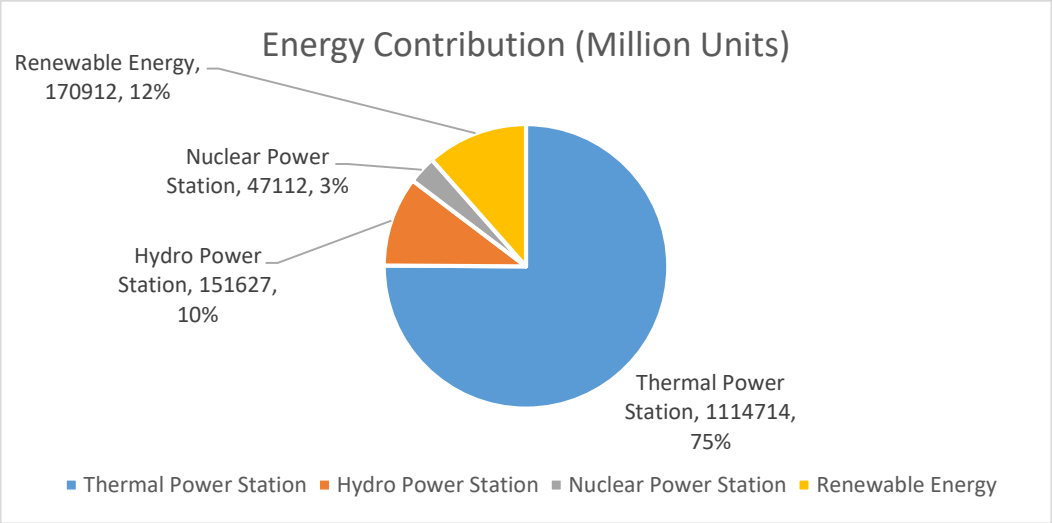
Sources of the Power Generation:

- Thermal (Coal based power Stations & Gas Based Power Stations)
- Hydro power Stations
- Nuclear Power Stations
- Renewable Power Stations (Solar, Wind, Tidal)

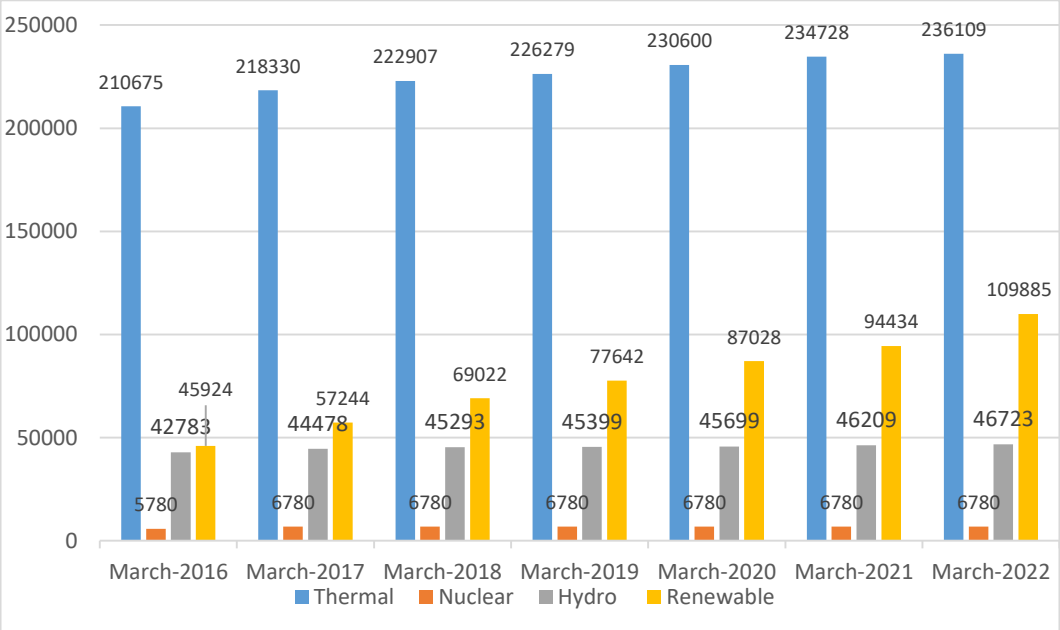
Installed Capacity in India:



Power Generation in India:



Incremental Capacity Addition in MW:



Types of Power Stations:

a) Coal Based Thermal Power Station:

In coal based thermal power station, coal is used as fuel in the steam boiler, & steam generated in the boiler is used for driving the turbine. The turbine is coupled with the rotor of the Generator & thus electricity is generated in the Generator.

The major cost elements in the Coal based power stations are:

I) Variable cost element:

a) Coal
b) Furnace oil
c) Light Diesel oil

II) Fixed cost element:

a) Employee expenses
b) Repairs & Maintenance expenses
c) Admin & General expenses
d) Finance charges
e) Depreciation

Type of coals used in coal based thermal power station:

1) **Anthracite:** Anthracite is a dark black form of coal and the highest quality coal. It is very hard, has a low moisture content, and a carbon content of nearly 95%.
2) **Bituminous coal:** Bituminous coal is the second highest quality of coal, with a carbon content that ranges from 76-86%. It is the most abundant type, and one of the longest buried fossil fuels with an age of approximately 300 million years old. Therefore, its energy density is relatively high at 27 Million Jules/Kg. The highcarbon and low moisture content of this particular type of coal makes it ideal in the production of steel and cement, as well as in electricity generation and coke production.
3) **Lignite:** Lignite or brown coal is brown in colour and the lowest quality of coal. The carbon content of lignite ranges from 65-70%, therefore, compared to other types of coal it contains the greatest amount of compounds other than carbon—such as sulfur and mercury. Lignite is the youngest fossil fuel produced, with an age of approximately 60 million years. Its relatively short lifespan means it exhibits quite a low energy density at 18 Million Jules/kg.
   The prices of the coal ranges from 12000 per tonne to 1600 per tonne based on the calorific value i.e. quality of the coal.
4) **Gas based Power Station:** In Gas based power station Natural Gas or Naphtha is burnt is combustion chamber & flue gases generated in the combustion chambers drives the Gas turbine which in turn drives the rotor of the Generator & thus electricity is generated in the Generator.

The major cost elements in the Gas based power stations are:

I) Variable cost element:

a) Natural Gas or Naphtha

II) Fixed cost element:

a) Employee expenses
b) Repairs & Maintenance expenses
c) Admin & General expenses
d) Finance charges
e) Depreciation

C) Hydro Power Station:

In hydro power station, the water impinges the hydro Turbine, which in turn rotates the Rotor of the Generator. Hydro Power station do not have any variable cost, entire expenses are fixed in nature. The elements of the fixed cost are:

a) Employee expenses
b) Repairs & Maintenance expenses
c) Admin & General expenses
d) Finance charges

e) Depreciation

D) Photovoltaic based Solar Power Station:

In this type of the power station the photovoltaic solar cells converts solar energy into Direct Current voltage, which in turn is converted into Alternate Current voltage through the Inverter & which, is ultimately fed to the grid. Solar Power station also do not have any variable cost, entire expenses are fixed in nature. The elements of the fixed cost are:

a. Employee expenses
b. Repairs & Maintenance expenses
c. Admin & General expenses
d. Finance charges
e. Depreciation

Literature Review:

a) REPORT ON OPTIMAL GENERATION CAPACITY MIX FOR 2029-30 Published by Central Electricity Authority, Governement of India.

Central Electricity Authority (CEA) had conducted the study on "Optimal power generation capacity for the year 2029-30". The aim of the said report is to find out the most cost effective capacity mix of power generation, which may be essential to cater the peak demand of power amounting to 340 Giga Watt and electrical energy requirement of 2400 Billion Units by the year 2029-30. In order to achieve the objective of carbon free energy, India has updated its Nationally Determined Contributions (NDCs) according to which it stands committed to reduce Emissions Intensity of its GDP by 45 percent from 2005 level by 2030, and to achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

b) How different power plant types contribute to electric grid reliability, resilience, and vulnerability: a comparative analytical framework Published by IOP Publishing Ltd. https://iopscience.iop.org/article/10.1088/2516-1083/abf636

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This work explores the dependability trade-offs provided by the most common types of central power plants in the United States. Historically, the electricity sector has lacked consensus on how reliability, resilience, and vulnerability differ and how those metrics change depending on the power plant fleet composition. The authors have proposed distinct definitions for these metrics and an analytical framework to evaluate power plant fleet dependability. Using data analysis and literature review, the authors have identified fifteen dependability attributes across which they have ranked eleven power plant types relative to natural gas combined-cycle (NGCC) plants. The authors have find out that assuming all attributes that contribute to grid dependability are equally important and additive, electric grid dependability is best supported when power plant fleets include a mixture of power generation technologies.

c) Committee Report: Optimal Energy Mix in Power Generation on Medium and Long Term Basis published by PRS Legislative Research Institute for Policy Research Studies 3 rd Floor, Gandharva Mahavidyalaya, 212, Deen Dayal Upadhyaya Marg, New Delhi.

The Committee on Optimal Energy Mix in Power Generation on Medium and Long Term Basis (Chair: Chairperson, Central Electricity Authority) submitted its report on January 1, 2018. The Committee was constituted by the Ministries of Power, and New and Renewable Energy in October 2017. Power is generated through various sources of energy such as coal, hydro, natural gas, and renewables (solar, wind). An optimal energy mix is one that uses a mix of these generation sources in the most efficient manner.

Key observations and recommendations of the Committee include: Optimal generation mix: As per the National Electricity Plan, for the period 2017-2022, the committed capacity addition for various energy sources is: (i) hydro - 6.,823 MW, (ii) gas - 406 MW, (iii) nuclear - 3,300 MW, (iv) renewables - 1,17,756 MW, and (v) coal – 47,855 MW (with a retirement of 22,716 MW of coal based capacity). The Committee noted that only 6,445 MW of additional coal based capacity would be required during 2017-2022, to meet the peak

demand and energy requirement in the year 2021-22, as compared to the 47,855 MW that is currently at various stages of construction. The overall efficiency (or plan load factor) for coal based capacity is likely to be 56.5% during 2021-22. The Committee noted that considering all these factors such as: (i) existing and under construction power projects, (ii) targets for renewable energy generation, (iii) energy requirement in 2021-22, and (iv) the availability of domestic gas, there is not much scope in optimizing the generation mix by the year 2021-Integration of renewable energy: The Committee noted that, to accommodate the variability in renewable generation, the conventional generating plants (coal based) will need to be flexible (provide energy when the renewable plants are unable to). This will help with the balancing and ramping up of grid (when more capacity is required). States can also use a combined cycle gas based capacity for providing peaking and balancing support. Coordinated scheduling and utilisation of hydro generation for providing secondary and tertiary services would also help in integrating renewable generation resources into the grid.

Statement of the Problem:

The cost of capital equipment's of Solar Power Station has been reduced drastically in recent year; however, the availability of Solar Power is variable depending on the time of the day & seasons. In such situation, in order to supply the electricity to consumers at affordable rate, it is essential to define the optimum mix of the power generation sources.
This mix of the power generation sources will be variable based on the time of the day & seasons. As the Generation from the Solar Power is based on the radiation of the sun & which are variable based on the time of the day & seasons.

Need of the Study:

I) Survey of work done in the research area:
The addition of the Solar Capacity in such magnitude is recent phenomenon; hence, its impact on the tariff structure of the electricity is also not fully assessed. Consequently, this area is new, moreover, I haven't come across the documentation of the research on this subject.

II) Need of the Study:
There is vast difference between the cost of the generation from the sources like Coal based thermal power stations, Gas based power stations, Hydro power stations, Solar power stations, etc.
As the Solar Capacity addition has been increased multifold in recent years, the impact of this addition on grid & thereby on the tariff structure of the electricity needs to be analysed in order to define the best mix of the power generation sources, this will aim to reduce the cost of the electricity to the consumers.

Significance of the Study:

Government is planning for the carbon free country & thereby promoting the sources of the green energy. This will promote further addition in the Solar capacity in coming years. However, the generation from the Solar power station is not available through out the day & the generation from the Solar power station is also dependent on the season. Further, the level of the radiation of the sun is different in different regions of the country. Hence, the study of this Solar addition on the tariff structure of the power sector is very important.

Objectives of the Study:

The objective of the study is to determine the optimum mix of the sources of the power generation like Coal based Thermal power stations, Gas Based power stations, Hydro power stations & Solar Power stations, in order to supply the electricity to the consumer of the state of the Maharashtra at most competitive rates.

Justification of the Objectives:

The electricity is vital component in the human life & industrial growth. Consequently, supply of the electricity at the reasonable rate is very important & to achieve this the selection of the optimum mix of the sources of the power generation is very crucial at any particular time.

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