Forecasting & Order Preparation of Energy Consumption in India

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Abstract:- *India is the seventh largest country in terms of area & second largest in terms of population. It is third largest economy in terms of GDP PPP & sixth largest in terms of nominal GD. India has become fastest growing major economy in the world. Since 1991 in its post 'liberalization' era policy it has undergone rapid industrialization. In order to maintain the pace of industrialization & economic growth rate, India needs to gain security in the energy sector. With many new climate change pacts & agreement in place India need to consider various factors while forecasting & order preparation of energy demands. While order preparation various factors such as efficiency, space, required, capital cost, etc. need to be considered. The paper discusses about the forecasting & order preparation of Energy Sector in India.*

Key Words: India, Forecasting, Order Preparation, Developing countries, Renewable sources, Electricity Demand

1. INTRODUCTION

India is the seventh largest country in the world in terms of area. It is the second largest country in terms of population. Following 'liberalization' of its economic policies in 1991, averaging a growth rate of 8 percent per year it has become the fastest growing major economy, surpassing China in 2015. Its per capita income has increased from $329 in 1991 to $1,723 in 2016. It is third largest economy in terms of GDP PPP (Purchasing Power Parity) & sixth largest economy in terms of nominal GDP.

India has the largest youth population in the world. It is set to become next manufacturing hub of the world. In order to maintain such a growth, India need to achieve energy security. Energy security is very essential for achieving a good rate of industrialization. To achieve a stable it is necessary to forecast the energy demands consumption & factors affecting order preparation.

2. FORECASTING

Forecasting has been defined by many people and associations such as:

According to *Allen*, "Forecasting is a systematic attempt to probe the future by inference from known facts".

In simple words, Forecasting is guessing future values based on past data, present conditions and future requirements.

Forecasting is done by two methods:

1. **Qualitative -** These depend on experience and knowledge of person who is forecasting.
2. **Quantitative -** These depend on actual values from past data.

2.1 Types of Forecasting

Short term-It is the forecast done for a period ranging from 1 day to several months. This type of forecasting can includes demand of electricity throughout the day.

Medium term-It is the forecast done for a period of 1 year to 3 years. This type of forecasting includes seasonal or quarterly forecasting of energy demands.

Long term-It is the forecast done for a period of more than years. This type of forecasting includes long term planning (five year plans). Such type of forecasts are important in planning energy security & setting up power plants.

2.2 Using Least square method to for forecasting energy consumption in India.

Table 1 - Least Square Method

YEAR	CONSUMPTION (GWh)Y	DEVIATIONX	X^2	XY
2012	785194	-3	9	-2355582
2013	824301	-2	4	-1648602
2014	881562	-1	1	-881562
2015	938823	0	0	0
2016	1001191	1	1	1001191
2017	1066268	2	4	2132536
2018	1130244	3	9	3390732
N=7	**∑Y=6627583**	**∑X=0**	**∑X^2 =28**	**∑XY=1638713**

Trend is,

$Y = a + bX$

$a = \sum Y/N = 946797.57$

$b = \sum XY/\sum X^2 = 58525.46$

Therefore, the trend becomes,

Y = 946797.57 + 58525.46X

Y_{2019} = 1180899 GWh

Y_{2020} = 1239424 GWh

Y_{2021} = 1297950 GWh

On average there is a growth of 6.25 percent per year in electricity consumption of India. [10]

3. ORDER PREPARATION

Order preparation is first step for manufacturing process on which while system depends. From collecting raw material for product to product's inspection. A Work Order is a task or job for a Customer that can be scheduled and assigned to someone. The term is commonly used in the Field Services Industry, where Work Orders or Jobs are assigned to Field Technicians. Usually, Work Orders are the result of a customer request. However, in many cases Work Orders may be a follow up action from an inspection or audit. The order preparation for a process depends upon products to be produced.

The order preparation of energy sector in India needs to be explored. Studying energy demands of world's fastest growing economy can help to get a perspective of developing nations & their energy sectors. Factors such as environment, space, efficiency need to be considered. The order preparation also needs to look into factors as reducing emissions by shutting down fossil fuel powered plants.

3.1 Capacity factor

The net capacity factor is the unit-less ratio of an actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period.

The capacity factor is defined for any electricity producing installation, such as a fuel consuming power plant or one using renewable energy, such as wind or the sun. The average capacity factor can also be defined for any class of such installations, and can be used to compare different types of electricity production. [1]

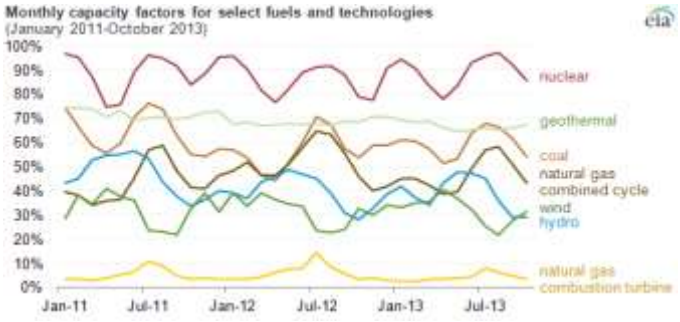

Fig 1 : US EIA monthly capacity factors 2011-2013

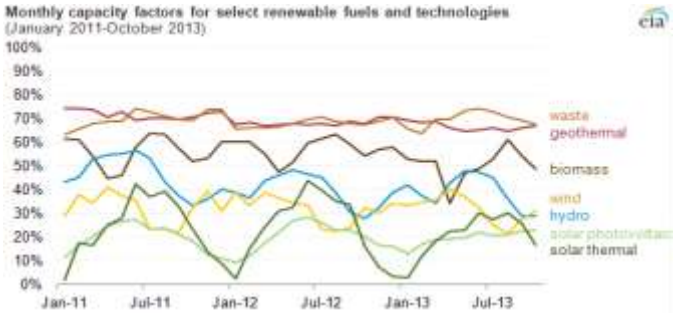

Fig 2 - capacity factor for renewable energy sources

3.2 Carbon Tax

A carbon tax is a tax levied on the carbon content of fuels. It is a form of carbon pricing. Revenue obtained via the tax is however not always used to compensate the carbon emissions on which the tax is levied (see implementation).

Carbon is present in every hydrocarbon fuel (coal, petroleum, and natural gas) and converted to carbon dioxide (CO_2) and other products when combusted. In contrast, non-combustion energy sources wind, sunlight, geothermal, hydropower & nuclear do not convert hydrocarbons to CO_2.

CO_2 is a heat-trapping "greenhouse" gas[2] which represents a negative externality on the climate system (see scientific opinion on global warming).[2][3][4] Since GHG emissions caused by the combustion of fossil fuels are closely related to the carbon content of the respective fuels, a tax on these emissions can be levied by taxing the carbon content of fossil fuels at any point in the product cycle of the fuel. [2][3]

While many remain apprehensive, a carbon tax is a step towards helping India meet their voluntary target to reduce the amount of carbon dioxide released per unit of gross domestic product by 25% from 2005 levels by 2020.

Environment Minister Jairam Ramesh told reporters in June 2010 that a domestic tax should come before a global carbon tax, and India has imposed one while others debate the issue.

With the new government in India under PM Narendra Modi, the carbon tax has been further increased form 100Rs per tonne to 200Rs per tonne in the Budget 2015-16. Currently the carbon tax stands at 400rs per tonne. [4]

With Paris Agreement's long term goal is to keep the increase in global average temperature to well below 2 °C above pre-industrial levels; and to limit the increase to 1.5 °C, since this would substantially reduce the risks and effects of climate change. Its implementation is expected to start by year 2020.

With targeting "shut-down" of all of its coal power plants by 2022. Norway & Netherlands have set deadline of banning sale of all petrol & diesel power automobiles by 2025 & 2030 respectively.

With developed countries aiming to cut down use of conventional sources of energy. The developing countries like India which produces 74 percent of electricity from coal might face pressure to reduce CO_x 's emission or increases carbon taxes.

3.3 Space

Republic of India is the second most populous country in the world having a population of 1.4 billion.. India is seventh largest country by area covering around 3.29 million square kilometer. Out of which 21.54 percent of area is covered by forest.

India has a high population density of 398.7 people per square kilometer. For comparison United States of America has a population density of 85 people per square kilometers. People's Republic of China has a population density of 145 people per square kilometers. While the French Republic has a density of 116 people per square kilometers.

Space, location, topology are determining factors production, distribution & consumption of electricity.

3.4 Sources of Energy and Cost per unit

Economic, Environmental & Social factors must also be considered in democratic country like India.

Solar Energy

Solar Energy has the greatest potential of all sources of renewable energy. Therefore all out efforts are made to harness this source of energy. The solar energy includes like technologies like solar heating, photovoltaics, artificial photosynthesis, solar thermal energy, etc. The solar energy is clean & environment friendly source of energy. This makes it a ideal candidate to replace coal fired power plants.

India is relatively closer to the equator making it favorable for production of solar energy. India has around 300 clear days favorable for solar energy production. The solar energy incidence on the India's land area is about 5000 trillion kilowatt-hours (kWh) per year. The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserves in India. [6]

India is said to have planned the world's largest renewable energy expansion program. Ministry of New & Renewable Energy has targeted addition of additional 175 GW of renewable energy by 2022. India's solar capacity has increased by 370 percent in last 3 years from 2.6 GW to over 12.2 GW. India has shown its commitments towards solar energy on domestic as well as international level. India initiated the founding of International Solar Alliance (ISA), an alliance of over 121 countries with primary objective efficient exploitation of solar energy sources.

Due to high population density, land is scarce in India. To completely power a city of 140 blocks, it would take around 110 blocks dedicated to solar energy. [7]

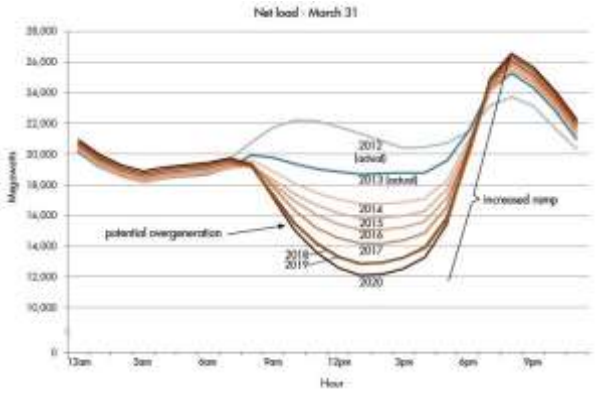

Fig 3 – "Duck Curve"

A average conversion efficiency for a photovoltaic cell is around 15 percent. Solar energy has a low capacity factor.

Solar energy however has one serious disadvantage. The maximum solar energy production occurs between 9 AM & 4PM, the demand for electricity during the period is comparatively lower. After sunset the electricity demands soars and the out of solar power plants nearly drop to zero, this leads to problem of destabilization of grid. This problem is represented by the "duck curve". Hence to stabilize the grid, battery storage facilities need to be provided. With increasing maintenance and initial cost, it increases cost per unit of solar energy.

Wind Energy

Wind is indirect form solar energy, as it is caused due to uneven heating of earth crust. It is potential alternative to fossil fuels, as it is plentiful, widely distributed & causes negligible effects on environment.

Wind also consumes very less land resources like solar energy sources. Its emission during operations are negligible.

Offshore wind turbine have proven to be a great success story in Europe due to Gulf Stream, A warm & swift Atlantic ocean current that flows along the coast of Europe, all round the year.

Wind power generation in India has increased significantly. The cost associated with wind power are decreasing rapidly in India. The wind power's tariff reached a record low of ₹2.44 in December 2017.

Electricity production from wind energy has increased from 6,270 MW in 2005 to 34,046 MW in 2017. India ranks fifth in the world in terms of electricity produced from wind power. India produced about 42.8 TWh of electricity from Wind energy. It is estimated that there is potential of around 65,000 MW of energy that can be harnessed. [8]

However wind has some drawbacks, To power a city of 140 blocks, it would take 19 blocks dedicated to wind energy. [7] Wind direction in many locations in India is unsteady, ie changes according to season. Especially during May – September (monsoon winds) tend to move towards the north-east, while during October – January (retreating monsoon winds) tend to move in the south-west.

Nuclear Energy

Nuclear energy is basically of two type - Nuclear fusion & nuclear fission. Nuclear fusion reactions involve fusing of two or more lighter nuclei like hydrogen, helium etc. Nuclear fusion occurs mainly in stars & few experimental reactors on earth. Nuclear fission involves splitting of heavier nuclei like Uranium-235, Plutonium-239 etc.

Nuclear Energy is the safest, cleanest & one the most economical sources of energy. It takes up very less space, In a city consisting of 140 blocks it would only take 3.5 blocks to power the entire city.[7] A fission single atom of Uranium-235 releases about 202 MeV of energy. Uranium-235 contains about two to three million times the energy equivalent of coal or oil.

In India Nuclear fission is used to produce electricity. India has 22 nuclear reactors across 7 power plants spread across the country. Total installed capacity is 6,780 MW, accounting for 3.22 percent of total electricity produced in India. India has planned to build 9,000 MW power plant at Jaitapur & 2,000 MW power plant at Kundankulam.[9]

Uranium reserves in India are limited, India exports a large amount of Uranium in order to fuel its reactors. However supply of Uranium is controlled by Nuclear Suppliers Group (NSG). India being not a member of NSG has caused many problem in its nuclear program. India is however developing a indigenous Thorium fuel cycle to power its power plants. India has largest reserves of Thorium. Thorium superior physical & nuclear properties as compared to Uranium & Plutonium.

The disadvantage of Nuclear Energy is that it is in many unacceptable source of energy due risk of radiation contamination & proliferation of nuclear weapons.

Hydroelectric Energy

Hydroelectric power plants employ a simple principle of converting potential, kinetic energy or sometimes both into electrical energy.

Hydroelectric power is a clean source of energy, it has negligible amount of emission during its operation. Hydroelectric power plants have the highest efficiency as compared to efficiency of all other sources. Hydroelectric power plants have average efficiency range between 86 percent to 95 percent. Thermal power plants have average efficiency of 33 percent. While nuclear power plants have efficiencies between 41 to 48 percent. India is endowed with economically exploitable and viable hydro potential assessed to be about 125,570 MW at 60% load factor. [10]

Hydroelectric power plants can be classified into two types – Large hydropower plants & Micro/Small hydropower plants.

Large hydropower plants – Hydroelectric power plants having operational heads greater than 70 meters are termed as hydroelectric power plants. Large hydropower plants produce around 10 percent of electricity produced in India. Hydroelectricity has a relatively stable capacity factors & are very suitable for replacing moderate capacity thermal power plants.

However due to flooding of basin by construction of dam results in large scale environmental damage, mass rehabilitation of people. Damage caused sometimes does not justify the economics of the grid.

Small/Micro hydropower plants – Small hydroelectric power plants operate under low heads. Technology for lower head turbine is still under development. However micro hydropower plants can operative under ultra-low head of around 10 meters.

Such plants are environmentally, economically & socially viable. They do not cause any rehabilitation of people. Such power plants can help to decentralize the power-grids. Micro hydroelectric power can provide help to reduce the burden of rural housing on the power-grids. Currently small hydropower plants generate about 5000 MW of electricity in India

4. CONCLUSIONS

India's heavy dependence on coal as major energy source is a very serious problem. India imports coal in order to fuel its thermal power plants. Therefore it's not viable economically & environmentally. Hence India needs proper forecasting & order preparation to reduce its dependence on coal, replace thermal power with energy sources which have a lower carbon footprint & also to meets the annual growth in electricity consumption.

Solar can supply about 15 percent, Wind can supply another 10 to 15 percent of the total energy consumption. While nuclear energy has tremendous potential its contribution depends on the development of fuel cycles example - Thorium fuel cycle. Micro hydroelectric power plants are extremely promising for the rural electrification, providing endless cheap energy on a small scale. However impact of large hydroelectric projects needs to be carefully studied before implementation in order to avoid large scale damage to environment & local inhabitants

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