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Power Generation for India with Higher Efficiency

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Abstract:

The developed countries are consuming more amount of energy in all forms including electricity continuously with advanced technologies. Developing nation's energy usage trend rises quickly but very less in comparison with their population and their method of generating power is not seems to be as advanced as developed nations. The objective function of this linear programming model is to maximize the average efficiency of power generation inIndia for 2020 by giving preference to energy efficient technologies. This model is subjected to various constraints like potential, demand, running cost and Hydrogen / Carbon ratio, isolated load, emission and already installed capacities. Tora package is used to solve this linear program. Coal, Gas, Hydro and Nuclear sources can are supply around 87 % of power requirement. It's concluded that we can produce power at overall efficiency of 37% while meeting a huge demand of 13,00,000 GWh of electricity. The objective function shows the scenario of highaverage efficiency with presence of 9% renewables. Maximum value is restricted by low renewable source's efficiencies, emission constraints on fossil fuels and cost restriction on some of efficient technologies. This model shows that maximum 18% of total requirement can be met by renewable itself which reduces average efficiency to 35.8%. Improving technologies of renewable sources and necessary capacity addition to them in regular interval will enhance their role and existence against fossil fuels in future. The work involves conceptualizing, modeling, gathering information for data's to be used in model for problem solving and presenting different scenarios for same objective.

Keywords- Efficient Power Supply, Electricity Demand & Supply, Indian power scenario, Power Generation Options, Optimization Model

I. INTRODUCTION

International comparisons of the energy efficiency of power generation can be used to compare country's performance to that of other countries. Factors influencing energy efficiency of power generation are the type and age of power plants and the fuel types and technologies used. In general, the trend of energy intensity has risen in most developing countries due to increased industrialization, urbanization, a greater demand for the development of transport, infrastructure and the modernization of life styles. Such phenomena have altered our previous understanding of energy consumption and energy intensity patterns for developing countries. The sub optimal consumption of the commercial energy has adversely affects the productive sectors, which in turn hampers economic growth. Over the years, the rapid rate of growth of energy demand could be sustained primarily through increased dependence on commercial energy sources such as coal, oil, natural gas and electricity. Before the outlook of energy demand and supply is discussed, it may be constructive to understand the nature of physical resource endowments of the country and their present status of development.

The energy supply system that has developed over the years has tended to depend more and more on commercial energy resources, the availability of which is harshly limited. Progress of some of these energy resources is overwhelmed with serious environmental implications. To some extent, subsidized prices of certain forms of energy also led to end-use inefficiencies and, therefore, an increase in the gross energy demand. Kingdom and Ireland arefound to perform best in terms of fossil power generating efficiency. Australia, China and India perform 7%, 9% and 13% respectively below average. All these factors have raised questions about the long-term sustainability of such an energy supply system. Moreover, with the fast increase in demand for oil, the country has become a serious importer of oil.

Comprehensive energy planning for any country need a careful analysis of the present energy demand, a realistic prediction of its future growth and related long-term energy demand perspectives, which in turn will help in identifying the dimensions of the efforts needed to satisfy them. . A policy maker or planner must incorporate and analyze a wide array of information about technology, regulations, current policies, economics and political forces.

II. METHODOLOGY AND MODEL

The variables considered for this demand and supply situations are electrical demand for the country , already installed capacity of power generating station, maximum possible supply, emission associated during the power

generated, minimum share of renewable sources especially for rural electrification , efficiency, running cost incurred during generation and H/C ratio. The Model is created in aim of finding the optimum energy mix to meet the demand with objective as maximizing the average efficiency. With subjected to above said constraints. Possible sixteen energy options have been considered in the model to meet the electricity demand in first stage and after thousands of trials with considering the availability of sources /techniques; the twelve options are selected in the Model.

The model is formulated based on linear programming (with restricted variable) and is solved by using TORA Package. The baseline solution is obtained for efficiency objective. Different scenarios for same objective are developed by changing the value of single constraint while other constraints are maintained as same values in base line model. Possible eighteen energy options have been considered to meet the electricity demand in preliminary stage and after hundreds of trials finally the following thirteen options considered in the Optimization Model. Different objectives will be targeted during each phases are like minimizing the cost, maximization the renewable share, reducing the emission and efficient power generation. Reasonable energy options for power generations will be found out and optimized values will be selected. More than 15% Power supply from Renewable Energy will be focused.

III. RESULTS AND DISCUSSIONS

3.1 Baseline Scenario

Coal and Hydro are the major contributors with 56% and 12%can cater power supply requirement respectively. Followed by Nuclear (9%), Gas (9%) and Wind (5%) can feed country's future requirements. The other suppliers are Small Hydro and Diesel (2%) each. Rest of the sources such as Bio Diesel, Ethanol, Biogas, Biomass Gasifier and Solar are contributing only 1% each. By this given objective overall power generation efficiency of 37.3% can be reached. It clearly shows Renewable Energy sources are not in consideration when efficiency comes into matters while optimizing .Even higher values can be achieved but that is possible only by omitting some of poor efficient technologies.

Coal will be the major player for the next two decades. And also it indicates that instead of concentrating on only coal, the other major suppliers Gas, Wind, Nuclear and Hydro can be focused. The Nuclear and hydro projects are to be discussed in terms of political decisions than as technical or economic issues. Power supply from Renewable Energy will vary from 10 to 20% depends on intensity of work followed by Government and Private Sectors. We have to improve the energy conversion efficiency of techniques which generate power from the renewable sources.

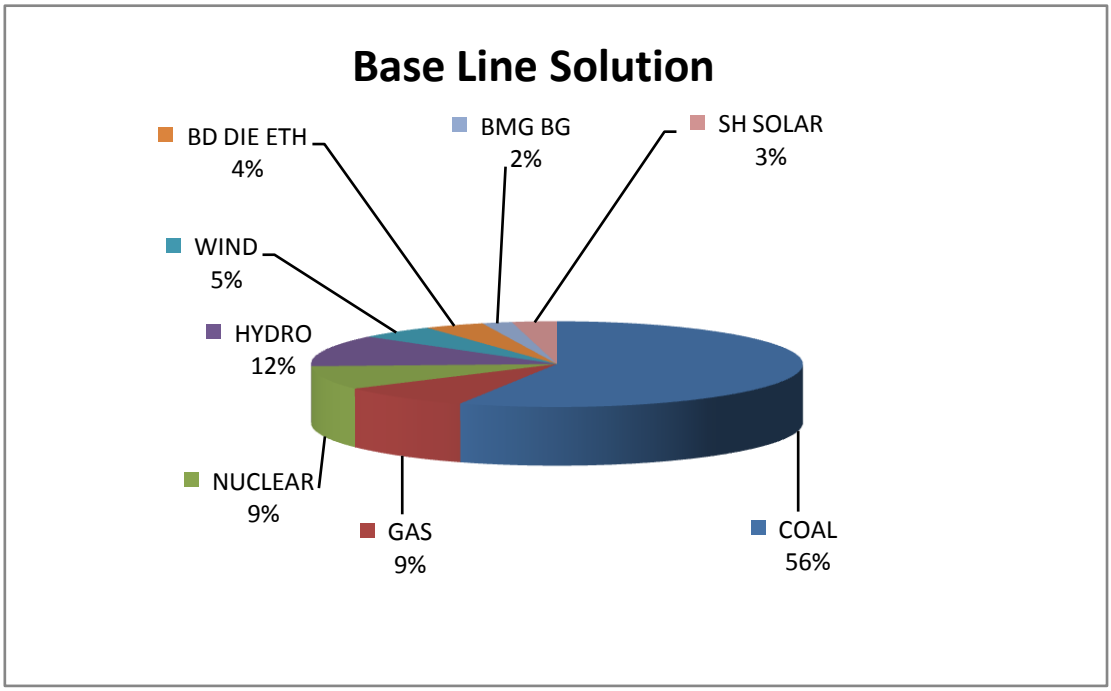

Figure 1 Base Line Solutions

3.2 Effect of cost constraint variation

This constraint is given for power generation at optimum cost between productions cost and supplying to huge Indian population at nominal rate. Running cost is lowered up to Rs 3.0 / KWh in overall as a strict condition from Rs 3.6 /KWh, which is substituted in the base line model. Coal shows major variation for this restriction. Importantly Coal shows positive improvement of 0.47 lakh GWh for cost restriction 0.6 Rs / KWh. Hydro and Small Hydro shares maintain theirs higher boundary values similar to base line solution. Nuclear energy importance reduced to 0.9 lakh GWh for reduction of cost in overall.

Rest of all sources importance reduced to their lower boundary like base line solution. It is clear that based on cost and efficiency Coal is the best choice for huge power requirement though restriction is made by emission constraint. Gas and Nuclear's role are suppressed most in turn reduces the average efficiency to 36.6%.

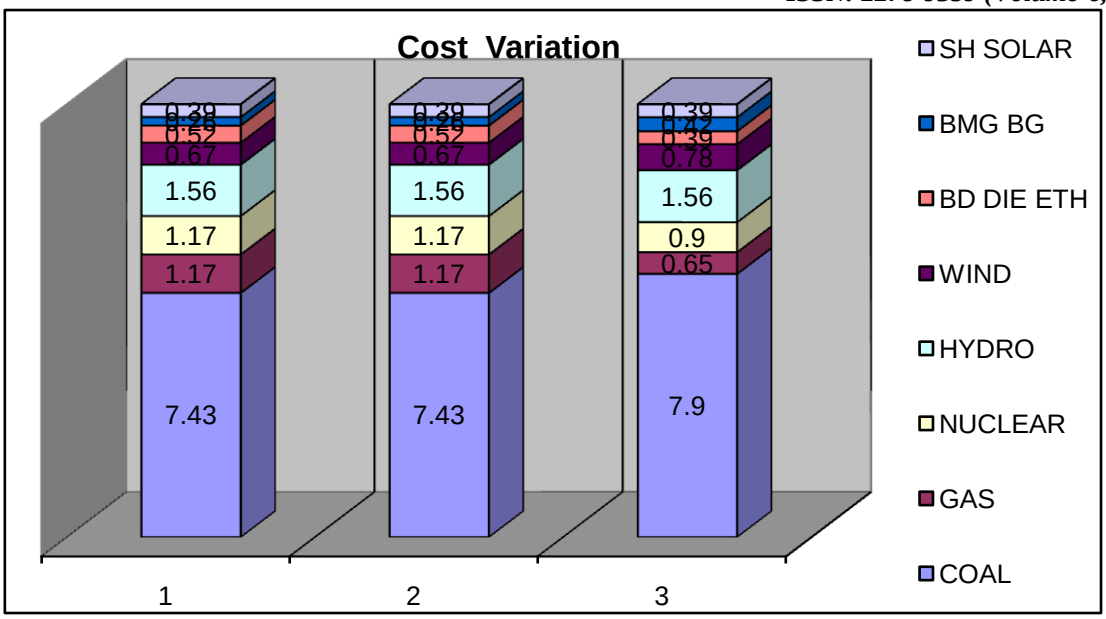

Figure 2Effect of cost variation on power supply options

3.3 Effect of Renewable share constraint variation

In the model minimum it's designed for 10% of total requirement should be met by renewable sources. This will enhance the reduction of emission, availability of sources for long time and reduction of fossil fuel usage to some extent. It also helps to connect the remote load comparatively easier and economically. In general renewable based Power Generations having low conversion efficiency. When renewable requirement is raised, maximum 20% of load can be supplied by renewable energy sources / sources which supports meeting of remote loads.

The Coal, Gas, Nuclear and Diesel presences are reduced by 0.15, 0.5, 0.2 and 0.13 lakh GWh respectively due to rest of sources reached their maximum limit. Solar importance increased to maximum (4%). Maximum 20% of total requirement can be met by renewable itself which reduces average efficiency to 35.8%.

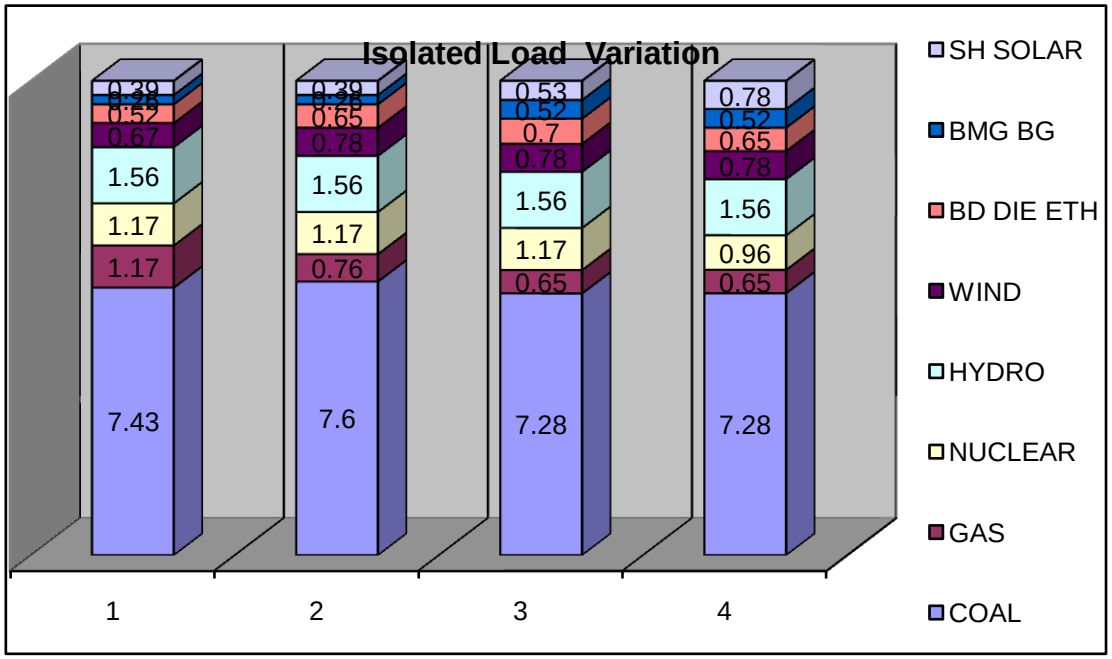

Figure 3Effect of renewable share variation on power supply options

3.4 Effect of Minimum Supply Constraint and Emission Variation

This constraint is involved to make the low efficient or high cost or high emission technologies to be part of base line solution. Minimum of 0.75 % from all sources is made compulsory on all technologies. Then attempt is made to increase their minimum role to 1.5% and average efficiency of 36.54 can be achieved. The technologies like Solar and later developed methods will not be part of solution if this constraint is not maintained.

Minimum role all low and new technologies can be improved by rectifying their deficiencies and installing required capacities which can reduce dependence of coal to some extent. Based on highest restriction of 0.58 Kg of emission / KWh, the Coal will be major supplier which will be affected most followed by Gas, Diesel, Ethanol having similar pattern and possible to have only 36% average efficiency only can be achieved.

3.5 Effect of demand constraint variation

Demand values are changed to 90% and 110%. Coal value changes heavily from 7.43 to 8.19 lakh GWh for the requirement addition. Diesel, BD, Gas, Nuclear, Hydro, SH and Wind values are maintained /slightly increased to their individual maximum limit. Remaining source's contributions maintained at their lowest (1%).

Coal is able to adapt the rise in demand within maximum limit constraint and other restrictions. This shows how model objective restricts coal even though it's more reliable in terms of cost, efficiency and rise in demand. Hydro and Nuclear supply will be heavily depending on fuel availability throughout the year and capacity building against political and environmental obstacles.

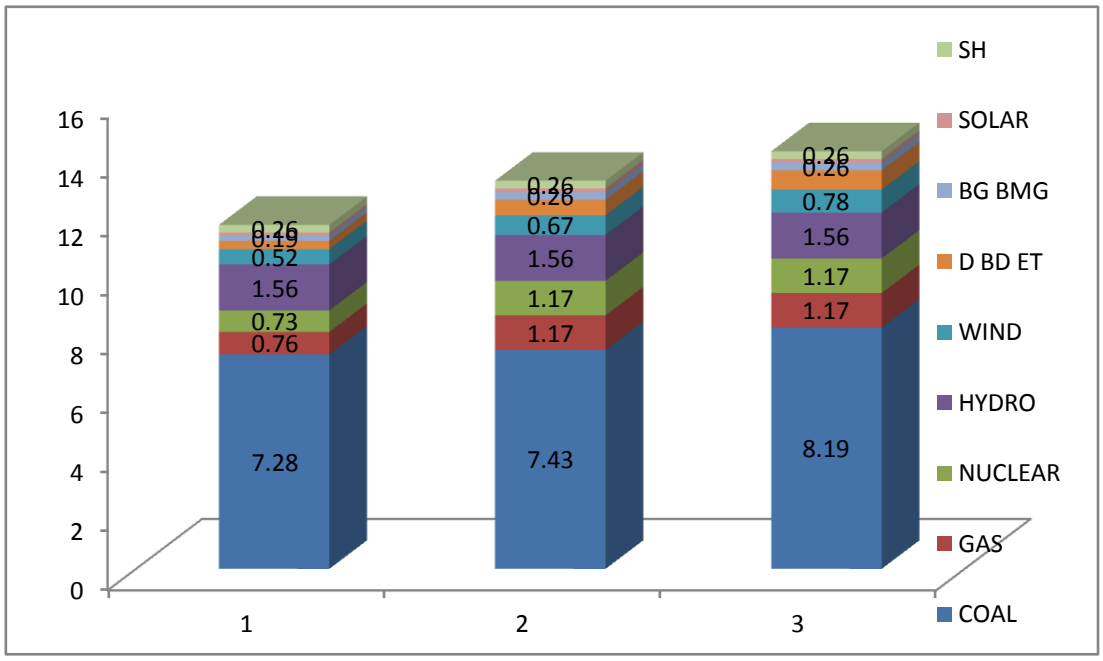

Figure 4Effect of demand variation on power supply options

IV. CONCLUSIONS

Table No 1 Supply from Sources for Demand Variation

OBJECTIVE	90% Demand	100% Demand	110% Demand	Above if possible (based on installation)
COAL	7.28	7.43	8.19	√
DIESEL	0.097	0.26	0.13	
GAS	0.76	1.17	1.17	√
NUCLEAR	0.73	1.17	1.17	
HYDRO	1.56	1.56	1.56	
WIND	0.52	0.65	0.78	
BIODIESEL	0.097	0.13	0.26	√
BIOMASS GASIFIER	0.097	0.13	0.13	
BIOGAS	0.097	0.13	0.13	
SMALL HYDRO	0.26	0.26	0.26	
ETHANOL	0.097	0.13	0.26	
SOLAR	0.09	0.13	0.13	√

For example 5000 MW of nuclear plant is installed which can generate Minimum of 0.3 lakh GWh and another 4000 -7000 MW installation is possible before 2020. So the achievable assumed will be 0.72 lakh GWh maximum. Similarly it's assumed for all sources. For coal already 200000 MW is already installed that's why always higher values are chosen.

Table No 2Possibility of Power Supply from Sources

	Possible share $*10^{5GWh}$	**Running Hours considered**	**Minimum required capacity required(MW)**	**InstalledStatus on 30/4/2017**
COAL	8.19	4000	200000	200000
GAS	**0.763**	3500	22000	25000

NUCLEAR	**0.73**	7000	11000	7000
HYDRO	**1.56**	2500	52000	45000
WIND	**0.78**	2000	39000	29000
DIESEL	0.097	2500	11000	1000*Installation period for power plant is smaller
BIODIESEL	0.097			
ETHANOL	0.097			
BIOMASS GASIFIER	0.097	2000	10000	9000*Installation period for power plant is smaller.
BIOGAS	0.097			
SMALL HYDRO	**0.26**	2000	13000	5000
SOLAR	**0.13**	2000	6500	10000

The comparison between developed and developing nations is widely based on the amount of electrical energy generated, consumed by them and how efficiently it is achieved. . Model was developed for energy allocation in India for the year 2020 depends on long term availability of energy from sources that are affordable, accessible and environmentally friendly

Coal continues to be the major source for energy use through electricity generation. Intensive efforts made in exploration and development of hydrocarbons has led to a significant step up in the production of oil and natural gas. Currently 50-60% of power supply for the country's requirement is supplied by coal only. In the coming decade's coal usage cannot be spared for next thirty years. However, in the recent years, the production of crude oil has been stagnating. It's better to find the technology with higher efficiency or more gasification method should be used to meet the demand.

Poor hydrocarbon resource base have forced an increased reliance on energy imports. The rising oil import bill has been the focus of serious concerns. The depleting nature and the accelerated demand of conventional energy had also forced planners and policy makers to look for alternate sources.

Power supply from Renewable Energy will vary from 10 to 20% depending on intensity of work followed by Government and Private Sectors. But most of renewable energies are having low efficiency. We have to improve the energy conversion efficiency of techniques which generate power from the renewable sources. Otherwise most of renewable energies will be out of focus when efficiency is considered as main criteria for selection.

Hydro and nuclear are at their maximum capacity for all scenarios because of combined advantage of cost and efficiency. There have been additions to nuclear power generation capacity as well as power generation from nuclear power plants. The availability of hydro-electricity has also decreasing. To meet the energy requirements policy decisions to speedily develop and utilize all types of energy resources.

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