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LEAST COST ENERGY SUPPLY OPTIONS FOR INDIA

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ABSTRACT

At the time of independence, India had a very poor infrastructure in terms of energy production and supply, total installed electricity generation capacity was 1363 MWe. Electricity is the most important component of the primary energy. The average growth rate over the entire period thus has been an impressive. The economics of various modes of power generation depends on local conditions, discount rates and availability of cheap fuels. India is importing coal hydrocarbons as well as enriched uranium. Issues like comparative economics, effect on environment, security of supplies, future technological developments in India will dictate contributions of various energy resources.

The objective function of model is to minimize the cost associated with power generation from each resource. This Model is subjected to various constraints like potential, demand, efficiency, emission and H/C ratio, isolated load and minimum capacity existing. This model shows that 72% of total requirement can be met by Coal and Hydro power sources itself. From the renewable side, wind and bio gas can make up to 9% of total power requirement. Due to high running cost, solar importance maintains lowest in all scenarios. It's compulsory to find advanced technology to reduce the cost of solar based power generation.

INTRODUCTION

There are major changes taking place in the requirement of petroleum products, electricity and fuel wood in the energy demand over the years. Based on the data available energy intensity of GDP in India can be estimated and is the same as in OECD countries. During the 50 years that followed independence, the demand for energy, particularly for commercially energy, registered a high rate of growth contributed largely by the changes in the demographic structure brought about through rapid urbanization, need for socio-economic development and the need for attaining and sustaining self reliance in different sectors of the economy.

India has about 0.04% of the proven reserves of the hydrocarbon in the world. Hydro energy is clean and economically cheap source of energy and best for meeting peak demand. The nuclear program in India is based on natural Uranium and indigenous thorium resources, which is capable of producing two lakhs Megawatts. In power generation coal is the major contributor and coal reserves are about 5.7 % of the proven reserves of the coal in the world. Wherever fossil fuels are available at reasonable prices, setting up of thermal power plants is an option to be considered in any techno-economic analysis.

BASE LINE MODEL

The electrical demand in India would be approximately 945000 GWh [Iniyan 2006] by 2020 and it should be met with least cost options. Appropriate energy mix options for power generations are considered and optimized values are selected based on factors such as efficiency, potential, demand, pollution associated with each technique, minimal value and renewable constraint with objective as minimizing the cost by selecting least cost techniques first. Twelve energy sources considered are Coal, Oil, Gas, Nuclear, Hydro, Wind, Bio-diesel, Biomass-gasifier, Biogas, Solar PV, Ethanol and Mini hydel sources are considered for power generation.

Coal is the topmost electricity supplier 54% share and Hydro is next with 18%. Nuclear, Gas and Wind based power generation sources can take up the power demand of 7% each. Other suppliers are Bio Gas (BG) (2.5%), Diesel (1%) and Biomass Gasifier (BMG), Bio Diesel (BD), Small Hydro (SH), Solar and Ethanol based power are at the level of 0.75% each. The renewable energy supply can reach the level of 15%.we can view that most of renewable sources are at the level of their individual boundaries.
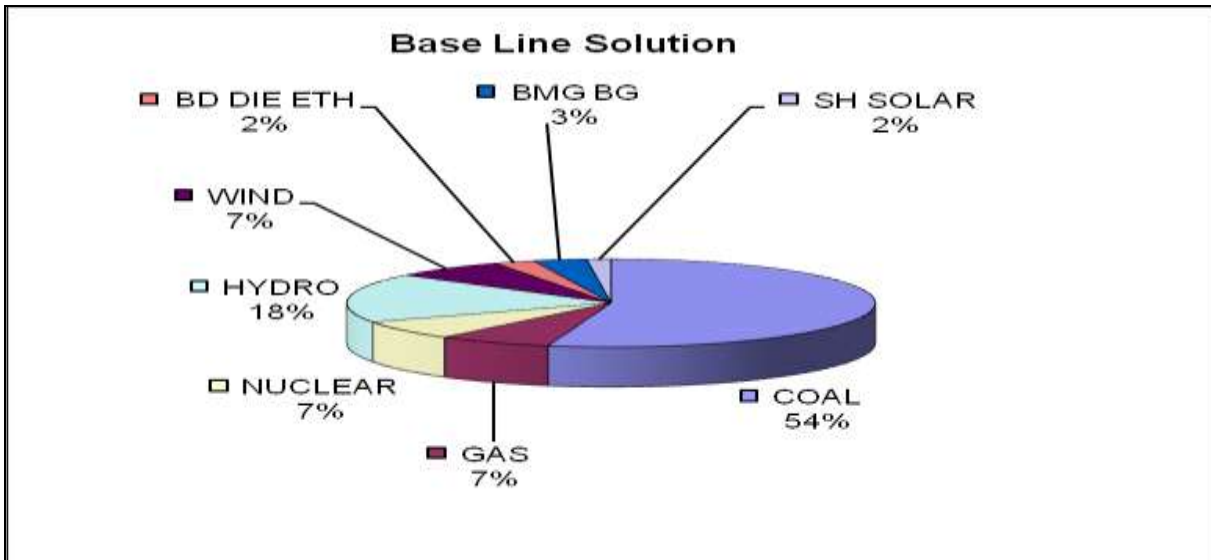
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Figure 1 Base line Solution

DISCUSSIONS AND SCENARIOS
Different scenarios are developed by changing the values of particular constraint while other constraints are maintained as same in base line model.
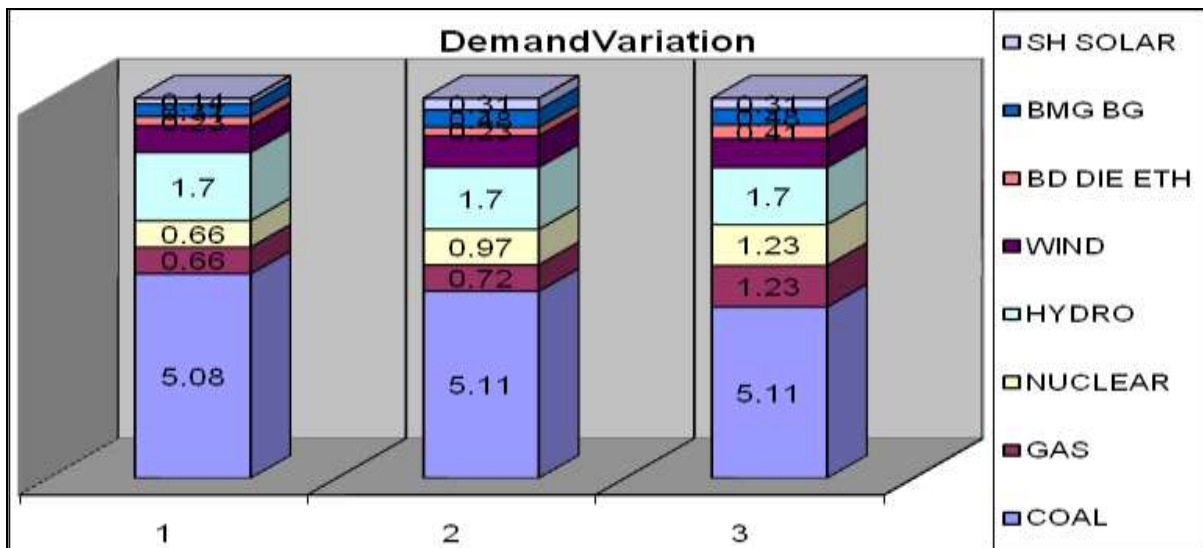
3.1 DEMAND VARIATION

Figure 2 Effect of demand variation on power supply options

There is more possibility of increase in requirement of power. There is necessity to find the possibility of how to supply that demand. Demand requirement values are increased by 20% from base line model and effect of requirement rise is studied. Gas, Nuclear, wind, Biomass gasifier, Small Hydro and Ethanol are showing positive variation for change in more requirement of power. Above said sources shares are changing from their lower boundary value in base line solution to maximum boundary for demand rise. Coal, Hydro and Biogas are remaining same as the base line solution, which are already at their maximum boundary conditions. Diesel and Bio Diesel are maintaining their lowest values due to emission parameter.

3.2 EFFICIENCY CONSTRAINT
The developing countries are not so effective in matching the demand for power and also unable to achieve the reasonable efficiency while generating power. So an attempt is made to raise the overall efficiency standard. This

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makes reduction of fuel usage and directs to choose more efficient technologies used in country. The rise in efficiency requirement makes the Nuclear, Wind and SH to reach their upper boundary conditions. Coal and Hydro are already at their highest in base line solution. There is no change in Gas, Diesel, Solar, Ethanol, Bio Diesel and BMG which are at lower levels of individual boundary as their individual efficiencies are less than 35%. Nuclear and Hydro can take more challenge on efficiency up gradation. Its need of the Governments to focus on power plant installation of these two and also making sure of availability of working fuels / fluids. Maximum overall average efficiency is only 40% can be reached because low efficient renewable sources.
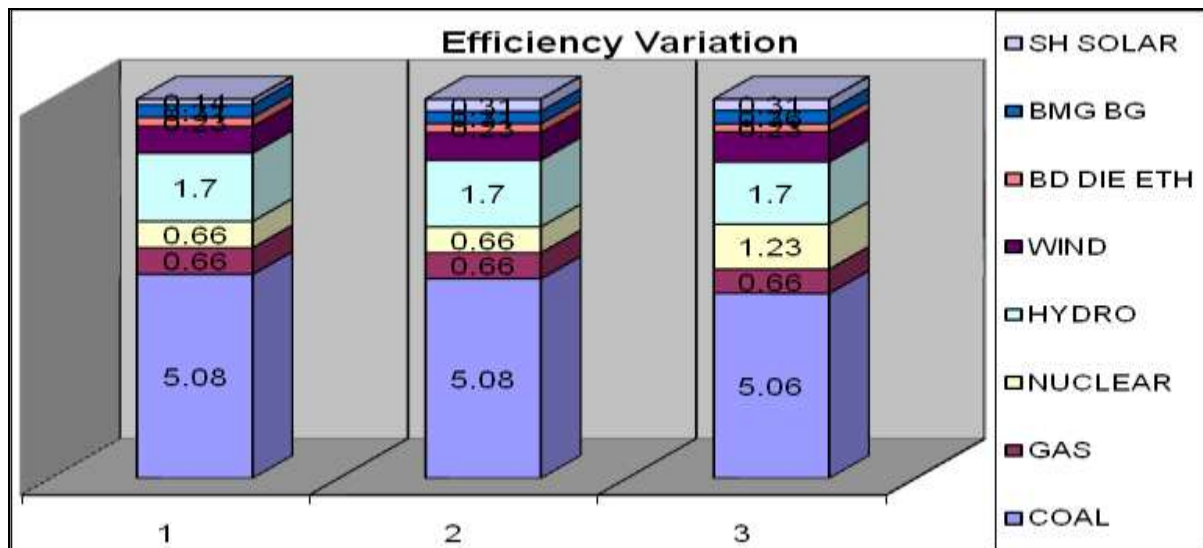

Figure 3 Effect of efficiency variation on power supply options

3.3 ISOLATED LOAD /RENEWABLE CONSTRAINT

Model is designed to have minimum 10% of total power supply should be from renewable sources. This will support the availability of conventional sources for long time and reduction of fossil fuel usage to some extent. It also helps to connect the remote loads easier than conventional one. Based on model constraints maximum of 22% of load can be supplied by renewable energy sources. Almost all renewable sources are changed from lowest (0.75%) to Maximum (2.5%) when 24% from renewable side is enforced. It's necessary for governments to take serious steps to implement this. As it led to reduction of Coal share to lowest value of 4.3 lakh GWh and Hydro supply reduced by 0.2 lakh GWh.
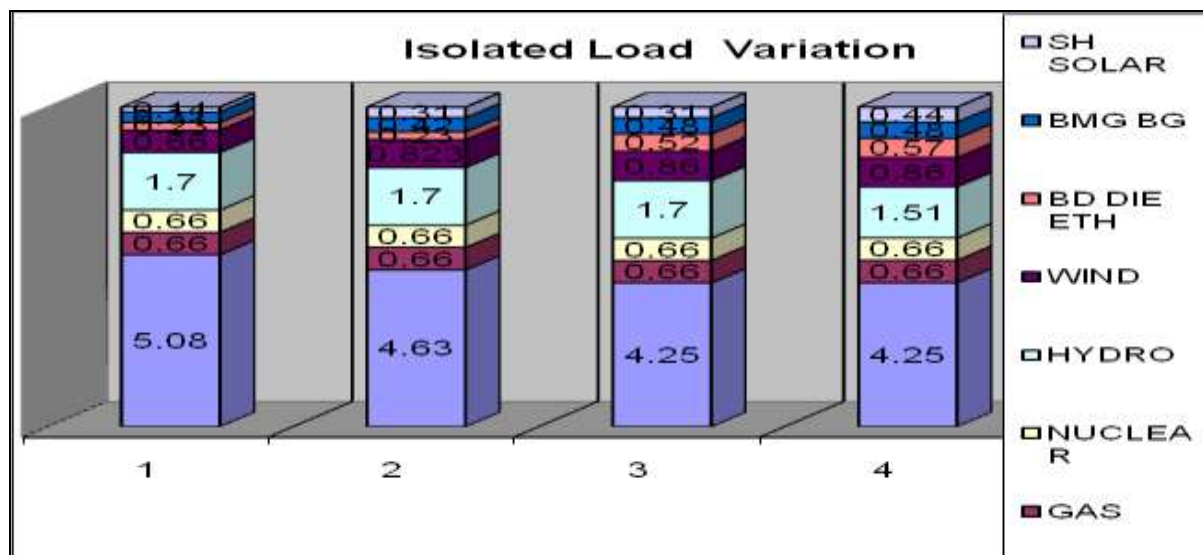

Figure 4 Effect of renewable share variation on power supply options

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3.4 MINIMUM SUPPLY CONSTRAINT &EMISSION CONSTRAINT

Supply from all sources is preferred in the model. So 0.75 % values are entered as low boundary value for many less effective sources. This constraint supports all the sources which in turn reduce the too much dependence on particular sources. When minimum of 2.25% of all sources are tried Diesel, Solar, BD, SH and Ethanol role improved, which in turn led to reduction of Coal usage to 4.3 Lakh GWh. It's comparatively easy to develop all sources to least extent even against their demerits.

From the base line solution it's clear that coal is major supplier which is associated with heavy emission. When overall restriction of 0.52 Kg of emission / KWh is permitted, the coal importance is reduced to 4.3 lakh GWh. The loss of coal share is replaced by Nuclear, BMG and Small Hydro.
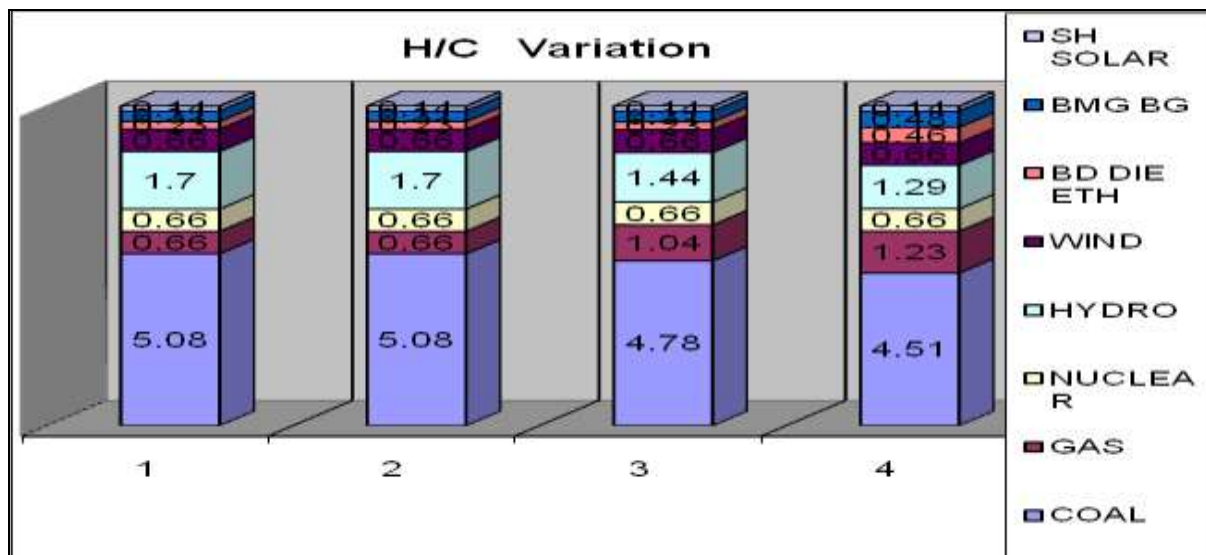
3.5 H/C CONSTRAINT

Figure 5 Effect of H/C variation on power supply options

This is the newly introduced constraint (Solid hydrocarbon fuel H/C=1, Liquid fuel H/C=2 and Gas Fuel H/C=4) ever to show the reality of hydrocarbon sources. Like most of applications power generation also trends towards to gaseous mode. The H/C constraint value increased by 20% and impact on base line solution is noted. The gas importance will increase to 1.23 GWh from 0.66 GWh in base line model. Bio diesel and Ethanol shares importance also changes from 0.75% to 2.5%.Bio Gas maintains its base line value because already it's have maximum boundary value. The increase in Gas share drastically reduces the role of Coal and Hydro by 0.57 and 0.31 Lakh GWh respectively. Nuclear, Solar, SH and Diesel are maintained at lower boundaries like in base line model.

CONCLUSIONS

In the coming decade's coal usage cannot be spared for next thirty years. . Issues to be considered in case of coal based plants include local of coalmines, transportation, sulphur and ash content of fuel associated environmental impact. Plants based on imported coal are to be set up at coastal sites. Tap all option including using the known fossil reserves efficiently, looking for increasing fossil resource base, competitive import of energy, wherever permitted based on geo-political considerations and found feasible from techno-commercial point of view. To keep the energy import at an affordable level and to have diversity of supply sources, it is necessary that share of nuclear energy be substantially increased from the present level. As the constraint to nuclear fuel is more, the capacity should be increased continuously in uniform rate. Gas price sector are subject to fluctuations due to market forces and form a sizable fraction of electricity cost produced from gas fired plants**.**

It is desirable that in future also the import content is kept limited to about the same level. If we targets low pollution then it's necessary to consider sources other than Coal to deliver the power requirement.   Harnessing full hydro potential for generation of electricity and increasing use of non-fossil resources have the potential of meeting the gap in the demand and supply of energy. Power generation based on renewable source is installed in lesser level which is of huge resources.

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