

**IJRAME**

ISSN (ONLINE): 2321-3051

INTERNATIONAL JOURNAL OF RESEARCH IN
AERONAUTICAL AND MECHANICAL ENGINEERING**MAXIMIZATION OF RENEWABLE ENERGY IN MEETING
COUNTRY'S ELECTRICAL DEMAND****Umeshkannan. P¹ , Dr. K.G.Muthurajan²**

- 1 *Assistant Professor, Department of Mechanical Engineering, Apollo Engineering College, Chennai, India. umeshkannanp@yahoo.co.in*
- 2 *Professor, Department of Mechanical Engineering, Vinayaga Mission University, Salem, TamilNadu, India. kgmuthurajan@gmail.com*

Abstract

In India, at any point of time the power shortage exists and is even higher during peak hours. In the absence of demand management, the country has to import energy as well as this has raised issues of long-term energy security for the country. The aim of this work is to find out how much can be supplied from different energy sources and to look into the alternatives available for sustainable energy development without compromising the overall objectives of economic and social improvement. This model is subjected to various constraints like potential, demand, running cost and Hydrogen / Carbon ratio, isolated load, emission and previously installed capacities/minimum share in maximizing the renewable shares is set as an objective. Tora package has been used to solve this linear program. This model shows that maximum 29% of total requirement can be met by renewable energy. Coal, Gas, Hydro and Nuclear sources are supplying around 63 % of power requirement with reduced role of coal as compared to ever before. We can conclude that power can be produced at an overall efficiency of 36% while meeting a huge demand of 9, 45,000 GWh of electricity with considerable supply from renewable.

Keywords: Electricity Demand & Supply, Indian power scenario, Optimization Model, Hydrogen/carbon ratio

1. INTRODUCTION

The power requirement for the country is increasing day to day. The rapid rate of growth of energy demand could be sustained primarily through increase in dependence on commercial energy sources such as coal, oil, natural gas and electricity. However, the energy supply system that has been developed over the years has intended to depend more and more on commercial energy resources, the availability of which is harshly limited. To some extent, subsidized prices of certain forms of energy also led to an increase in the gross energy demand.

This factor has 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. India has a large number of remote small villages and islands that lack in the electricity, and probability of connecting them with the high voltage gridlines in the near future is very poor due to

financial and technical constraints. Improving technologies of renewable resources and necessary capacity addition of them in regular intervals will enhance their role and existence against fossil fuels in future.

2 .Development of the Model

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. Based on the current generation, we are urged to install the power plants in huge level. Different sources which have ability to supply heavy requirements are to be identified and analyzed, for which the model has been proposed.

The electricity demand in the country for the year 2020 would be approximately 9,45,000 GWh [S Jebaraj 2007] is predicted by ANN forecasting model. This energy requirement should be met from the feasible sources. This model shows the appropriate energy options for power generations and optimized values that are selected based on factors such as cost, potential and demand, minimal value and efficiency with objective as maximizing the renewable sources. The additional targets in the Model are:

- ❖ To minimize cost.
- ❖ Preference will be given to gaseous fuels than solid fuels in future.
- ❖ To develop all feasible sources
- ❖ Improving overall efficiency of power generation

Possible 18 energy options have been considered to meet the electricity demand in preliminary stage and after hundreds of trials finally the following thirteen options are finalized for this Optimization Model. Several scenarios are developed by varying individual constraints one by one while keeping other constraints as constant.

3. Base Line Model

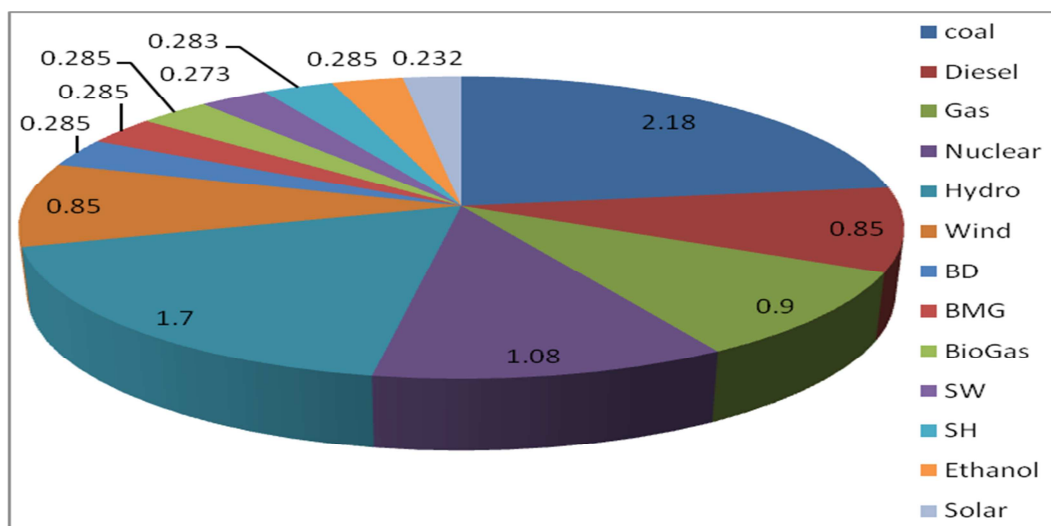


Figure 1 Base Line Solution

Coal is the major contributor with 23% of power supply which is followed by hydro (18%), Nuclear (11%), Gas (10%), Diesel (9%) and Wind (9%) that meets the country's future requirements. Other suppliers are Bio Diesel, Bio Gas, Solid Waste, Bio Mass Gasifier, Small Hydro, Solar and Ethanol are contributing 3% each. The supply from these minor sources needs a lot of focus on development of latest technologies on those and intention to install them in massive level. The renewable sources can meet 29 % of power requirements. By this given objective, overall power generation efficiency of 36 % can be reached. Even higher values can be achieved only by relieving some of the poor efficient technologies or increasing efficiencies of these renewable sources.

Coal is the major player. But this model shows the use of coal power that can be substituted by other sources like Gas. Coal contribution is always more than 50% in the last two or three decades. This trend can be suppressed by emission constraint. And also it should be noted that based on all restrictive strategies the coal will be a preferential choice.

4 .Discussions and Scenarios

Different scenarios are developed by changing the values of individual constraints. The constraints given in base line model are running at a cost of Rs 3.6 / KWh, emission of 0.6 Kg / KWh, H/C ratio of 1, minimum 2% of share from all sources in overall power supply.

4.1 Cost Constraint

We know that the power consumption cost is being collected from consumers with subsidy. But the same time, the production costs are increasing day by day. This constraint is substituted as compromise between production charges and consumer's electricity bill. Running cost is lowered up to Rs 3 / KWh in overall as strict condition. The renewable energy share is reduced from 29% in the base line solution to 20% when restriction is applied. Bio Diesel, Biomass Gasifier, Solid waste, Ethanol and solar values reduced to their lower boundary values as entered. Wind, Small hydro and Biogas shares maintain almost the same level as base line solution. Diesel share is reduced drastically from their maximum (9%) to minimum (1%) value when toughest condition is made as mandatory. It's experienced that below this cost we can't supply for the huge requirement

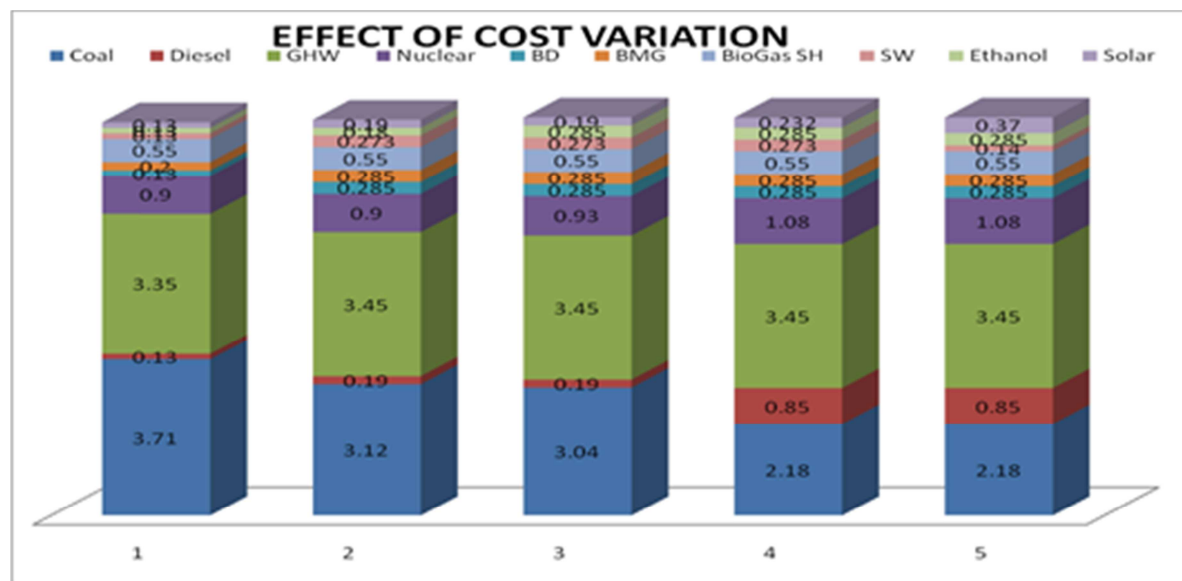


Figure 2. Cost variation versus power generated by individual source

Coal shows major variation for this overall cost value change. Importantly Coal shows big positive improvement for cost restriction while other sources fail to maintain its base line values. For 0.6 Rs / KWh cost restriction coal supply sharply arose to 3.71 lakh GWh from 2.18 lakh GWh. Based on current status, only Coal has an ability to increase its show when restriction is made while others suffer a setback. 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. When cost is relaxed to Rs 3.8/KWh the solar shows positive improvement by 1%. It's obvious that cost is one of the major issues in production of electricity.

4.2 Emission Constraint

This constraint is given for reducing pollution and an attempt to reach the international standard. The side effects of this are air pollution and global warming. It is planned for fixing reduced level of emission at 0.6 kg / kWh. During scenarios the emission values are reduced from 0.6 kg to 0.42 kg/KWh. Coal importance

has reached the lowest of all scenarios. Its share reduces from 22% to 18%. Diesel share is reduced to 62000 GWh from 85000GWh. Likewise Solid waste based power generation is reduced to 2.5% from 3%.

As coal shows big decline, almost all the other sources show their increasing role because coal is the major player. Gas shows major positive impact of 1.62 lakh GWh to compensate for the loss of coal. Remaining sources are maintaining their highest values as in base line. Once again it's proved that the renewable energy sources are eco-friendly. This constraint indicates how important the coal, if the emission is not followed. Indirectly emission constraint not only restricts the coal but also restricts the fossil fuel based technologies.

4.3 Efficiency Constraint

Efficiency of particular technology is a good indicator of technical advancement. Some sources are having low intense energy or not having good conversion techniques. But when they came across long path in efficiency improvement, it's a good sign of their role involvement. We know that renewable energy sources have the problem of higher power production cost. In addition to that the efficiency is low and these criteria which sidelines the presence of renewable.

Once again the Hydro, Nuclear, Wind, Gas, Small Hydro, Ethanol, Diesel values remains same as baseline solution when efficiency expectation raised from 36% to 39%. In the baseline model the renewable can supply 29%. But its supply reduces to 22% when 39% efficiency is aimed in overall. Especially solar which has huge potential is severely affected by increase in efficiency requirement. Their supply reaches the higher most of 45000 GWh when 35% efficiency is expected in overall.

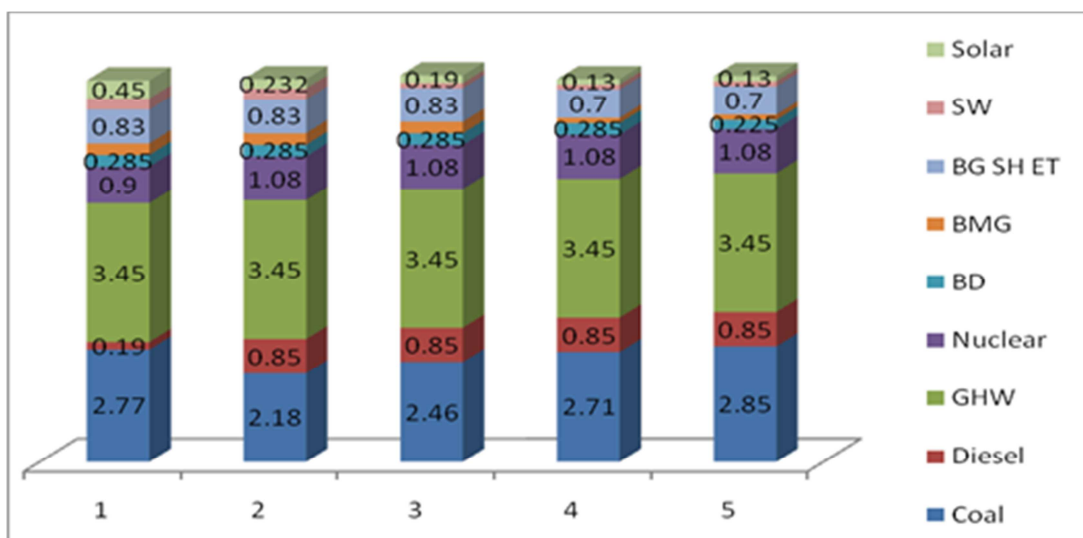


Figure 3. Efficiency variation versus power generated by individual source

4.4 Hydrogen / Carbon Ratio Constraint

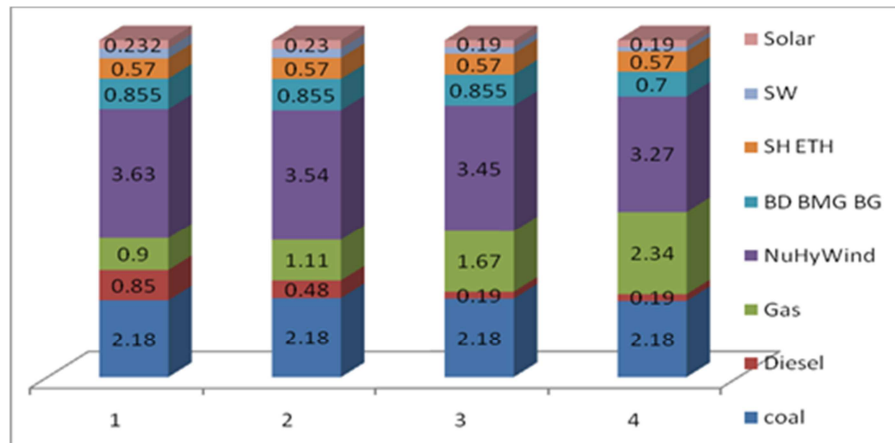


Figure 4. H/C variation versus power generated by individual source

This is newly introduced constraint ever to show the reality of hydrocarbon usages. When compared to olden days most of applications are shifted to gaseous mode [Ramachandran 1999] and also future trend in power generation. The H/C ratio of higher value is targeted in baseline model. Currently we are in the level of solid fuel (H/C=1) ie coal, lignite. The maximum target of using the fuel (H/C=2.5) higher than liquid has been tried. During this trial, Gas fuel supply has rise to 24%. The share of gas takes the lead than coal (20%).

This model shows Gas can take the main role in place of coal. So it is better to find better gasification methods from liquid and solid hydrocarbons. Power generation based on gas source is increasing uniformly. It has an advantage of less pollution when compared to other fossil fuel based technologies. In the absence of this constraint, gas will have poor show due to high cost and emission than fossil & non fossil fuel sources.

4.5 Minimum Supply Constraint

This constraint is involved to make the low efficient or high cost or high emission technologies to be part of base line solution. The technologies like solar and later developed methods will not be a part of solution, if this constraint is not incorporated. Minimum of 0.5 % from all sources is made compulsory on all technologies. Then attempt is made to increase their minimum role to 1%, 1.5%, 2 and 2.5 %. Forced introduction of higher values of these technologies affect the presence of coal and gas. Wind, hydro, nuclear and diesel maintain their base line shares. Minimum role by all low and new technologies can be improved by rectifying their deficiencies and installing required capacities which can reduce importance of coal to some extent.

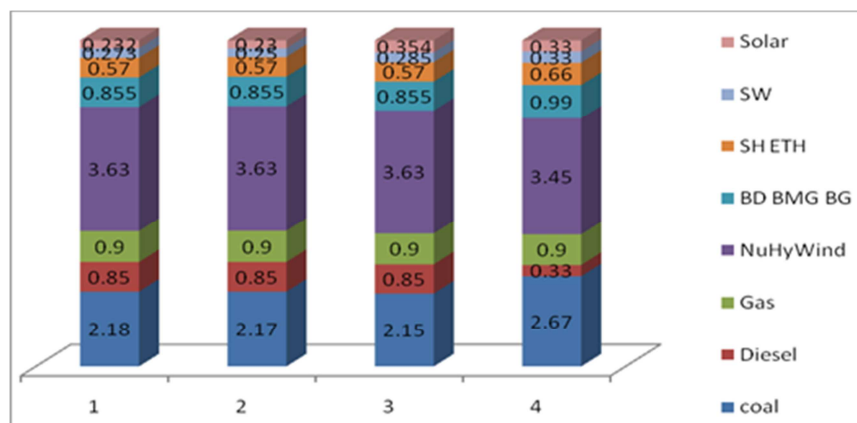


Figure 5. Minimum share participation versus power generated by individual source

4.6 Demand Constraint

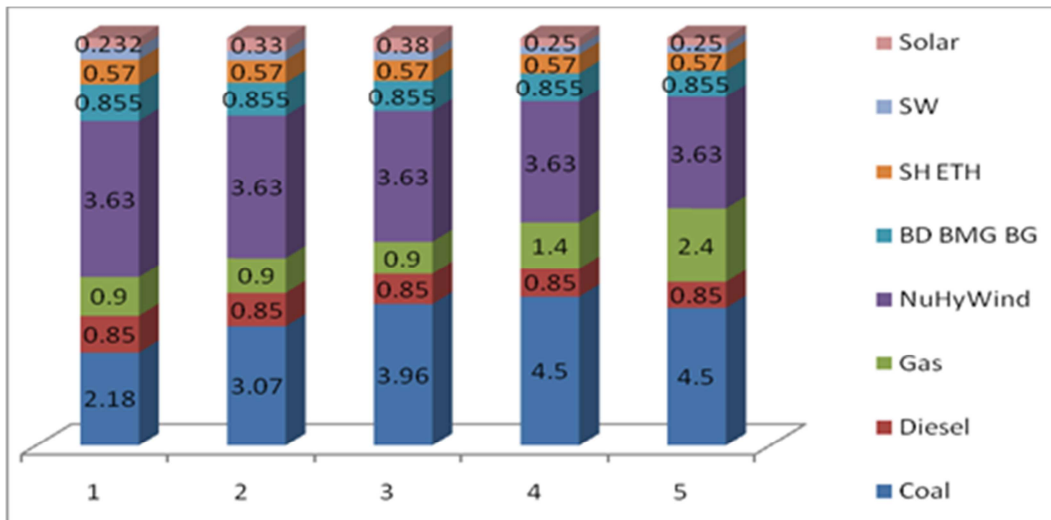


Figure 6. Demand variation versus power generated by individual source

We know that the demand trend for power supply may change as the years pass by. The scenarios are developed by considering if there is rise in demand than expected. Demand values are increased by 5%, 10%, 15% and 20% from current demand forecast. Coal and Ethanol are showing variation for change in additional requirement of power. Hydro, nuclear, wind, small hydro and diesel are already at their maximum capacity. Their supply will be heavily depending on fuel availability throughout the year and capacity building against political and environmental obstacles.

Hydro and nuclear can play the roles of coal and gas if excess power generating capacities installed and making availability of fuel required. Ethanol value changes from lowest level (2%) in base line model to 3% for the same condition mentioned above. Coal value changes heavily from 3.24 lakh GWh to 5.49 lakh GWh for additional requirement of 20%. Coal is able to adapt the rise in demand within maximum limit constraint. This shows that how the model objective restricts coal even though it's more reliable in terms of cost, efficiency and rise in demand.

4.7 Isolated Demand & Renewable Supply Maximization

Thousands of villages in India are yet to be electrified after sixty years of independence. Economically and technically there is lot of problems associated in supplying electrical power from centralized power generation to these villages. In this model, objective is designed to have maximum power supply from renewable sources amidst their limitations. Renewable energy shares can reach 29% of total power supply excluding hydro power plant. It also indirectly helps in supplying power to remote areas where centralized power generation cannot reach. The poor people in one lakh villages will get electricity through these sources.

Surprisingly 36% overall efficiency can be maintained even at this high level of renewable share. Bio Diesel, Bio Mass Gasifier, Ethanol, Biogas, solid waste and Small Hydro reaches the level of 2% each which is set as maximum limit for these sources. Solar reaches only 1.5% in base line model even though it is set as maximization category. If it's not designed as objective then the role of renewable energy will find it difficult to reach even 10%. Inference from this constraint is solar and other latest renewable technologies will be neglected because of their poor efficiency and cost. Their roles moves up only if heavy requirement on renewable is demanded. We know that it's possible to develop good technology in renewable side with better efficiency and installation of required capacity. Result is based on how fast it is achieved.

5. CONCLUSIONS

Due to the problems associated with the development of conventional sources of energy, the focus is now shifted to renewable energies. India has a huge potential of renewable energy source in abundance, which if developed properly can support the growing demand of the energy. The Model was developed for energy allocation in India for the year 2030 depends upon long term availability of energy from sources that are affordable, accessible and environmentally friendly. The main electrical load in remote villages is domestic. The infrastructure would need the availability of assured and reliable power at affordable price through reliable and adequate generation, transmission and distribution facilities. The energy deficit can be met by renewable energy sources as India has a high solar energy.

On a combined role of Coal, Diesel, Bio Diesel and Gas supply of 4.1 lakh Gwh can be supplied by installation of just 80000 MW. But on individual the gas power generation set up to be increased. The hydro power plant supplies 1.7 lakh Gwh which is possible by installing 80000 MW and nuclear power plant capacity is to be raised to 18000 MW. In this majority is installed already and in running condition but fuel availability is the problem. The renewable sources can supply around 2.7 lakh GWh which needs around 1, 80,000 MW capacity of installation. Surprisingly large amount of power can be generated even at the rate of 0.45 kg of emission / KWh in overall. Base line solution clearly shows that renewable energy sources can play a vital role if seriously developed.

REFERNCES

- Grover RB, Subash Chandra, "Scenario for growth of electricity in India", Energy Policy (2006) - Vol 34- issue 17, 2834-47.
- [Jebaraj S](#), "synopsis of PhD work on Formulation of forecasting model artificial neural networks" under the guidance of Dr Iniyar S at CEG, Anna University.
- Graus WHJ, Voogt M, Worrell E, "International comparison of energy efficiency of fossil power generation", Energy Policy 35 (2007) 3936–3951
- Dinesh Sharma .C, "Transforming rural lives through green power", Futures 39 (2007) - (583-596)
- M. Asif, T. Muncer, "Energy supply, its demand and security issues for developed and emerging economics", Renewable and Sustainable Energy Reviews (2007) 1388–1413
- Apergis, James Payn Nicholas, "Renewable energy consumptions and economic growth", Energy policy 38 (2010) 656-660
- S.K. Singal, Varun, R.P. Singh, "Rural electrification of a remote island by renewable energy sources", Renewable Energy 32 (2007) 2491–2501
- Lund Mathiesen B H, "Energy system analysis of 100% renewable energy system", energy (2007)
- <http://www.mnre.nic.in>, Ministry of non-conventional and renewable energy sources, Govt. of India, 2011.
- <http://www.powermin.nic.in>, Ministry of power, Govt. of India, 2011.
- Arcot Ramachandran, 86th session of Indian Science Congress (1999), Chennai, India