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THEME:
Conventional & Non-conventional Energy:
Challenges & Opportunities

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Prof. T. Harinarayana is the Director of the Gujarat Energy Research and Management Institute, Gandhinagar, Gujarat. He also holds the position of an Independent Director, Gujarat State Petroleum Corporation Limited. Prof. T. Harinarayana has over 30 years of experience of working with CSIR-National Geophysical Research Institute as Scientist "G". He is a leading scientist, well recognized for his excellence in deep EM Technique-Magnetotellurics among the national and international scientists. His research publication record has crossed 100 recently.

Prof. T. Harinarayana holds two doctoral degrees in the field of Electromagnetics-one from Edinburgh University, UK & the other from Indian School of Mines, Dhanbad. He has guided 6 research students for their doctorate degree. His academic and research excellence created opportunities for him to serve as a visiting professor and scientist at the University of Tokyo, Japan and the University of Texas at Austin, USA respectively. He has also organized and chaired a large number of conference / seminars and technical sessions.

Prof. Harinarayana has done research studies at NGRI, Hyderabad for more than 30 years. At GERMI, Gujarat, Prof. Harinarayana has published innovative ways to develop Solar energy enhancement. This includes

AN INNOVATIVE SOLUTION FOR POWER PROBLEM IN INDIA

Abstract

Water, power & earth are the three most important items necessary for any country. Apart from water, power is utmost important for every person. India is now facing acute shortage of power by all, more specifically by our industry sector. Due to this problem, our economy is not growing as per our expectation. Earlier, for a similar situation related to food, we could overcome the problem through Green Revolution. Later, we could overcome the malnutrition for our younger children and babies through White Revolution. Now we are facing power shortage problem and the time has come now to bring out Energy Revolution. The economic growth of the country crucially depends upon the generation of power and also on the per capita consumption. As compared to many countries, India per capita consumption is far below. In such a situation, we need to make an advance plan for the future. In the present study, an innovative solution is suggested for our power problem.

GERMI is pushing many innovative ideas and has taken up renewable energy projects in many ways. Here the total power problem requirement for the next decade has been looked into in a holistic manner and suggested innovative and permanent solution. Hopefully, the suggested solution will make India more independent in power sector. If implemented, it helps our country to grow economically, generate more employment to the large technical human resource available in our country, helps environment and reduces the carbon dioxide and other toxic gases to the atmosphere.

national solar highways, solar panles on agricultural land etc. This helps to generate more power in small location.

Prof. Harinarayana has been involved in many innovative projects related to oil exploration, geothermal energy exploration, Solar energy generation etc in different regions of India.

Prof. T. Harinarayana is a member of the Russian Academy of Natural Sciences, Moscow. Became a Member of Governing Council of newly formed IIT-Vadodara. Recently, he has received ISCA-International Best Researcher Award-2013. He received the gold medal and a citation from Indian Geophysical Union (IGU) - Electroteck Endowment award during its 49th Annual Convention-2012. He has received the National Mineral Award-1991, the Andhra Pradesh Scientist Award-2008. While serving as Scientist and Head of the magnetotelluric Division, NGRI, Hyderabad he became a fellow and a member of national (IGU, AEG, APAS etc.) and international (IAGA, EMSEV etc.) scientific societies, academic forums and editorial boards of various techno-scientific journals of global importance.

1. Introduction

It is known to all that India is now facing shortage of power. Most of our industries and establishments in many states are facing major problems due to lack of power. There exists a large gap between power demand and production. We are not progressing well on par with other developed countries due to this problem. (Ref. 1, 2) Our economic growth is crucially depending on our power sector. Although, many plans are proposed earlier by the Planning Commission of Govt. of India, it was not effective. We are all facing acute shortage of power now. As the population is increasing more people started using the latest technologies with many comforts. The demand for power is increasing year after year. For example, citizen's life style is also changing fast. Persons travelling by bi-cycle earlier, wants to travel by motor cycle. Persons travelling by motor cycle want to travel by car. Persons using fans earlier, wants air-conditioning equipment. People use to wash their cloths earlier manually wants to use washing machines etc. All such things need more power. People's way of living is changing fast due to new electrical gadgets introduced with technological advancement for comfortable living. People living in under developed countries want to live like developing countries. People from developing countries want to have same comforts as that of the citizens living in developed countries. Of course, it is the right of every citizen in this planet to live the way they want to live. This driving force is one of the major factor for the present day energy demand in the whole world.

In the above scenario, it is the duty of the government to provide power to all our citizens with comfortable living. In any nation, provision of water and power to their citizens are the two major items. These two items are the utmost important. They are considered to be on top of their agenda and considered as priority items apart from housing, health and other aspects. Every nation need to find their own resources first and plan in such a way that it reaches to their citizens with ease. Once their own resources are not enough for them, then they need to plan to get from other countries as import items etc. In the above scenario, let us examine and plan our power sector in India in an innovative way.

2. Power sector – the present scenario

If one can examine our country's power production scenario, we are generating 255 GW of power during the year 2014. This generation of power can be divided into two different fuel types, namely, the renewable fuels and non renewable fuels. Figure -1 provide these details. (Ref. 3 wikipedia website) Accordingly, 72% of power being generated using non-renewable sources such as coal, diesel,

nuclear etc. and 28% of power being generated using renewable sources such as hydro, small hydro, wind, solar, biomass etc. The total power production from non-renewable sources is close to 184 GW and from renewable sources it is 71 GW (numbers rounded off for clarity).

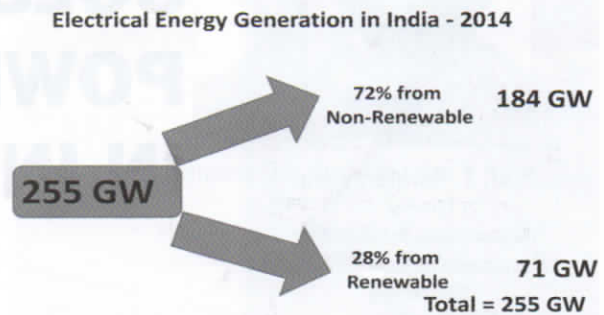


Figure 1 : Electrical power production in India from all types of fuel sources.

Although this number is very high as compared to several other countries, since our population has crossed more than a billion, our per capita consumption is very low. It is much lower than all developed countries like US, UK, Japan, Germany etc. and it is less than developing countries like China, Brazil etc. For comfortable living, we need to grow in power sector in an aggressive manner and work towards this direction from now. Let us say, we want to grow in all the sectors at an annual rate of 7% or 8% or 9% for the next 10 years or so, then our power sector also need to grow at the same rate. Following this logic, by the year 2024 we are expected to generate 603 GW of electricity. Unless we plan now and work aggressively, this number cannot be reached. Figure 2 provide these details.

3. Power sector – Future Demand

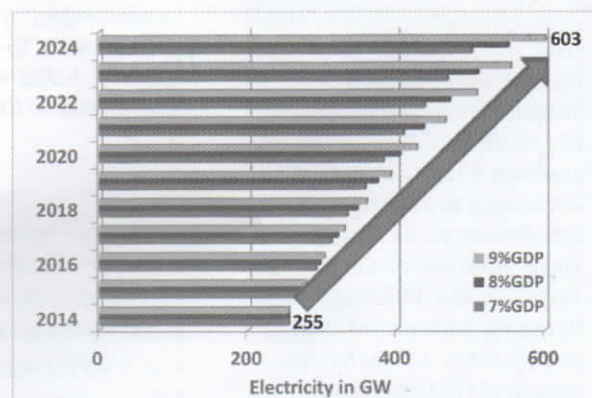


Figure 2 : Power generation and the expected demand for power in different years from the year 2014 until 2024 with expected annual growth rate of 7, 8 and 9%

As one can see, the target to be reached is a huge number (603 GW). This means we need to increase

our power production 2.4 more times within 10 years. Reaching this target needs meticulous planning with careful funding. However, one can find a simple solution to reach this target. Now let us examine, the present day power generation using different fuels. As of now, we are generating 5GW from nuclear, 25 GW from Oil and gas, 154 GW from Coal, 21 GW from Wind, nearly 2 GW from solar, 41 GW from hydropower, 7 GW from biomass totalling to 255 GW. If we multiply all these power generation units from different fuels with 2.4, then we have 12 GW from nuclear, 60 GW from Oil and gas, 370 GW from Coal, 50 GW from Wind, nearly 5 GW from solar, 98 GW from hydropower, 17 GW from biomass totalling to 612 GW, which is close to our target of 603 GW. This is a simple solution for our future target. But we need to decide whether such a simple solution is useful and beneficial to our country or not. If one critically analyze this, major portion of the fuels need to come from other countries. We used to think that we have plenty of coal for 100's of years for our use. But this found to be not true. As we all know, presently we are importing even coal for our power plants. Additionally, this type of solution makes our country always depend on other countries and need to spend our foreign currency. This in turn make our rupee value at a low level compared to other currencies. Thus this is not a better solution for our country.

4. Power sector – Smart plan

In such a scenario, let us find a smart plan. To do this let us examine the strengths of our country. Fig.4 shows the details. One can see that we have 6 major strengths with as our resources us. We are a tropical country and thus we have 300 sunny days nearly at all the locations, regions of our country. We have regular seasons like summer, winter and rainy seasons. These seasons with undulating topography of the landmark and many other factors provide more heat at one location, less heat at another location. Such a variation drives the air from one area to the other, which in turn provide lot of wind blows at many locations. We have many rivers flowing in our country like Ganga, Sindhu, Narmada, Tapti, Mahanadi, Godavari, Krishna, Kaveri etc. There is an unique character of these rivers. For example, major river in northern India, the Ganga and it's tributaries, are flowing from near west towards the east. At central Indian region, we have two major rivers the river Narmada & Tapi, flowing from the East towards the West. As we go further down, in south Indian peninsular region all the remaining rivers – Mahanadi, Godavari, Krishna, Kaveri etc..are flowing again from the West towards the East. This is an unique feature of a natural water resource in India. No other country in the world has such a phenomena. Linking of these rivers could have solved our country's water problem and our farmer's problem for ever. But we are yet to take up this major task in a concerted way.

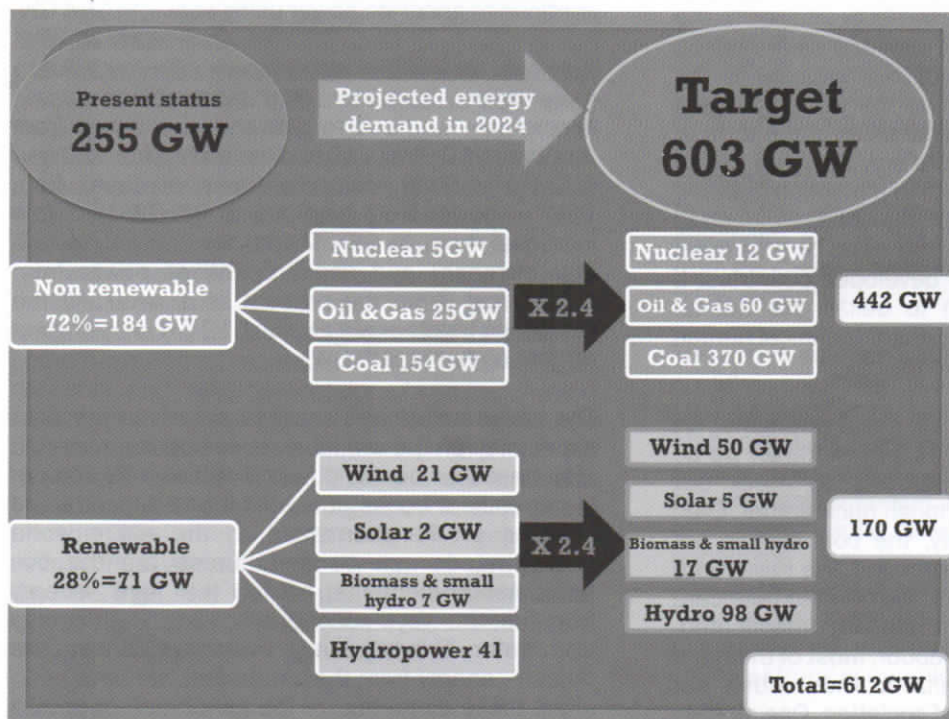


Figure 3 : Different types of renewable and non-renewable fuels being used for power generation in India during 2014 and the target energy demand for the year 2024 is reached with a simple multiplication factor of 2.4 with the existing fuel source.

Other unique feature of our country is the distribution of hot water as natural springs with temperature of the water varying from 40-80 C. There are nearly 300 such locations in India distributed in different parts. For example all along the Himalayan region, all along the central Indian region following the mega lineament, namely, the Narmada-Sone lineament zone, along the Mahanadi, Krishna-Godavari, Cambay rift valleys, along the Konkan coast etc. The surface temperature of 40-80 C of the hot water at these locations increases to as much

- ◉ We have plenty of Sunlight
- ◉ We have plenty of Wind during all seasons
- ◉ We have many Rivers, Himalayan mountains
- ◉ We have more than 300 hot springs (40-80°C)
- ◉ We have vast landmass = 32,87,263 km²
- ◉ We have large technical manpower

Figure 4 : Six major strengths of our country

as 100-200 C at varying depths of 500-2000m. (Ref. 4) With new technology, one can generate power from as low as 51 C. India is yet to enter the geothermal power scenario. Although, MNRE with the help of the national institutes like Geological Survey of India (GSI) and National Geophysical Research Institute (CSIR-NGRI) have investigated many geothermal locations, exploitation of this resource is yet to be initiated. Additionally, another advantage of our country is that we have a large land mass totalling to about 33 lakhs of sq.km. Other small countries are generating large power from solar energy alone. For example, small country like Germany which has a land mass of 1/9th of our country is generating about 33 GW from solar energy alone, where as we are yet to reach 2 GW from solar as on 2014. Our vast land mass has large uncultivated land and plenty of buildings that contains large roof area are yet to be utilized to the fullest use, for example to install the solar panels. Other important strength of our country is the technical manpower. We have the world's largest human resource with technical skills in the form of engineers, doctors, scientists etc. We need to use them for our country's growth in a planned manner. We need to provide them suitable jobs. We need to make them entrepreneurs. We need to give them comforts on par with other developed countries. If we make a strategic plan to utilize this human resource, we may become a major technical human resource hub to the whole world.

While, we can boast of our six major strengths, we do have our own weaknesses. For example, we do not have enough hydrocarbons to meet our demand. We do not have enough nuclear fuel. Even our large resource, namely, the coal fuel is not enough to meet our power demand. We have more than 1 billion people with us. We need to take care of their welfare. Most of them are uneducated. Most of them are unskilled labour. Most of them are not well cultured and civilized. Thus within our country we have two types of societies. One side we have civilized, cultured, educated, wealthy citizens. They are on par with any developed country citizens but they are in minority in number. Other side we have uncivilized, uneducated, uncultured, poor

citizens and they are in majority in number. As a country we need to take care of all our citizens equally. This is our social responsibility.

Another issue which has surfaced recently is the global warming. (Ref. 5) Due to excess release of CO₂ into the atmosphere by many countries, especially the developed countries for the last several decades, it is now noticed that temperature of the Earth is rapidly increasing beyond the expectation. (Ref. 6) This may lead to catastrophe for all the countries. For example, sea level rise of 1 to 5m may be a disastrous to low altitude countries like Bangladesh. The country may lose its land resource and leads to calamity for all its citizens. This is one of the problem. There may be many other problems related to atmosphere, seasons, environment, health etc. for many countries.

Fig.5 Different types of fuels being used for power generation during the year 2014. The non-renewable energy fuels is multiplied with a number close to 1 and renewable energy sources are multiplied with different numbers depends on the growth and resources available in our country.

Keeping our country's strengths and weaknesses and also realizing the importance of the global issues like climate change problem, a smart solution is suggested here. In this suggested solution, the non-renewable energy fuels presently being used for power generation need to be continued almost at the same level. This means, we continue to generate power using coal with 154 GW, nuclear with 5 GW, Oil and Gas with 25 GW. However, we need to aggressively plan to generate more power from our own renewable sources. Accordingly, we need to plan the wind power from 21 GW to 210 GW, (a 10 fold increase), from 2GW to 100 GW of Solar power (50 times increase), from 7GW of power from biomass to 21 GW (a 3 fold increase), from 41 GW of hydro power to 82 GW (a 2 fold increase) and about 5 GW of power from geothermal (from the present zero level). All the resources together will give us 612 GW crossing our target number of 603 GW.

The above solution is reached based on our past experience on the available renewable sources and also based on our Hindu ancient books (Puranas). In our ancient books, it is said if one depends and believes on Panchamahabhut, the entire world energy needs can be met. These are the five fundamental elements, namely the 'Agni', energy from fire, the 'Vayu', energy from wind, 'Jal', energy from water, 'Pritvhi', energy from the Earth and the 'Akash', energy from the sky. In fact, we have been using these elements for the generation of power. For example, 'Agni' being used by burning the coal and biomass etc., 'Vayu' being used to generate power using wind mills, 'Jal' being used to generate hydro power, 'Pritvhi' being used to generate

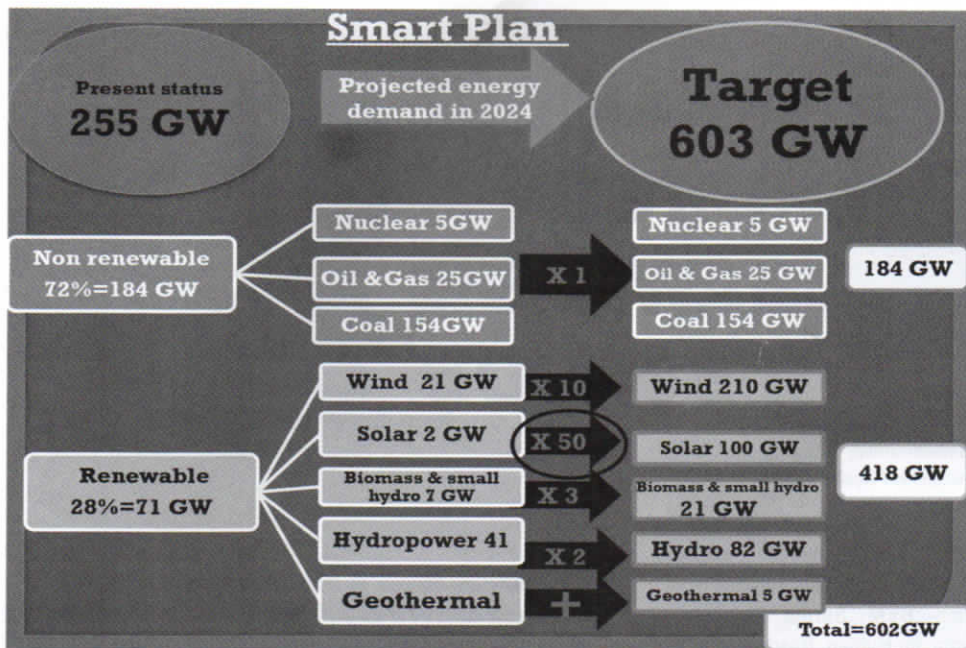


Figure 5

sources and 28% from renewable sources. Assuming that we aggressively increase our economy with 9% annual growth, the expected power generation is 603 GW by the year 2024. In such a situation, we have two options to reach this goal. One option is to multiply the power presently being generated with 2.4 to reach the target. For example, 184 GW of electricity will become 442 GW electricity from non-renewable sources and 71 GW electricity will become 170 GW electricity, totalling to 612 GW electricity.

geothermal power by many countries and finally the 'Akash', being used to generate power from the sunlight coming from the sky. However, the quantity of power being generated from these resources is far below as compared to other resources. The time has come to depend and concentrate more on the renewable source as compared to non-renewable resource.

However, in the present study this type of solution is not recommended as this solution will make India depends on other countries, all the time. Accordingly, an innovative solution based on the following is suggested. The non renewable sources of power (presently at 184 GW) will be maintained more or less at the same level. However the present generation of 71 of GW electricity from renewable sources need to be enhanced to reach 418 GW of electricity. In this model, the present generation of 21 GW of wind needs to be increased to 210, generation of about 2 GW electricity from solar need to be enhanced to 100 GW, generation of 7 GW of power from biomass and small hydro need to be increased to 21 GW, generation of 41 GW electricity from hydro power need to be increased to 82 GW electricity. Finally, the near zero power generation from geothermal resource need to be increased to 5 GW electricity.

For more than a century our technology has developed more towards non-renewable resource, namely the Coal, Oil, Gas and Nuclear. Technology to generate power using renewable source has started late and more seriously only for the last few decades or so. Thus the technology is still growing with more and more innovations. The cost economics point of view the energy generation from renewable sources is higher as compared to non-renewable source. As the technology grow more, and matured, the cost of generation is likely to come down. Thus more focus need to be paid on research and development for power generation using renewable sources. All new innovations need to be encouraged and experimented with pilot scale models. At more and more locations and more and more countries started using renewable sources, all the equipment costs and the prices of accessories will automatically comes down. One day the cost may be on par with non-renewable energy fuels and the citizens will have a choice to choose the way they want use power.

The above solution will make India less dependent on other countries. Even in our old ancient books (PURANAS), it is clearly stated that Mahapanchabhutam are the solution to our energy needs. They are-Jal (hydro power), Vayu (wind power), Agni (biomass), Prithvi (coal thermal power) and Akash (solar power). However, instead of depending on all these sources, we concentrated only on the fuels available inside the earth (Prithvi). This is the main problem of our earlier power planning. Thus, the suggested solution make our country strong economically.

Summary

In the present study, the power scenario of our country has been critically examined. It is observed that 72% of power comes from non renewable

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