Introduction to India's Energy and Proposed Rural Solar-PV Electrification

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Abstract: - India's energy outlook from fossil fuels sources, in particular in the sector of oil and gas, point out to a very high import dependence in the next twenty years. On the other hand, the prospect of obtaining energy from renewable energy sources has a positive outlook due to abundant availability of such resources in various parts of the country. Out of all these sustainable resources, solar, wind and biomass energy are some of the fields where past and present development have already witnessed major achievement. The above development has benefited certain areas of the country, while at the same time; it has helped, to a certain level, to develop the local economy. Solar energy in particular, from a recent governmental policy, has gained the momentum as one of the most important sources of energy for the country.

Key-Words: India, Energy, Electrification, Fossil Fuels, Development, Solar Energy

1 Introduction

In order to move further in the development of the electrification process in the countryside and establishing a base for the renewable sources - as the main energy source for rural electrification programme - there should be always adequate financial support and relevant institutional governmental policy. At the same time, all kinds of political interference should be left aside. That means electrification programmes should be based purely on economical and transparent agenda directed toward an actual benefit for the rural community. Technical issues, whether in the form of design and/or standards requirements should be developed and adopted to fit with the local and national needs. Also, minimising electricity losses during distribution in the form of load and load mix are another way of reducing cost and ensuring power supply. Subsidies and tariff structure, whenever this is applicable, are also other essential criteria which will help in the development of the rural electrification programme.

Rural electrification is one of the main issues where additional momentum is needed to accelerate the process, as Kerosene is still being used for lighting as a result related to lack of electricity supply in many parts of rural India. While wood and animal dung burning are the norms as a method for cooking food. Obtaining energy for domestic use in this way can be the cause of health and environmental problems, i.e. there is the potential of indoor pollution which put the health of the family, in particular women and children, at risk. It has been reported that chronic lung illnesses are wide spread among women with no history of smoking, as well as various level of respiratory infections among children [1]. Health experts point out that this kind of daily exposure to toxic fumes can lead to premature death.

2 India's Energy

As domestic energy resources are not sufficient for the country's needs, India imports large part of its growing energy requirement from other parts of the world, despite the government's heavy investment in oil and gas exploration to help in reducing the dependency on foreign energy sources [7]. However, if current comparison can be made between China and India in regard to energy requirement, for China, the primary energy needs is expanding on annual average rate of 3.2%, however, in India, on the other hand, the expansion in this sector is 3.6%, which is higher than China [6]. In simple terms, the need for energy in both countries counted to be faster than the rest of the global

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energy expansion, i.e. the demand for energy through to 2030 for India and China count up to 45% of energy world demand [6]. As an example, India's annual GDP growth rate of more than 8% during 2005 – 2006 is a good indicator of the level of development taking place [2]. The potential in development and higher energy demand, therefore, may continue to rise for the foreseeable future, depending on India's economic stability and international politics. This kind of ascending demand for energy is natural occurrence, as in order to fulfill the increasing scale of development and, consequently, for the provision of a higher standard of living, energy supply in various forms will be always needed. However, this is only part of the overall picture, in that India's fast development and the lacking behind of the rural electrification aspects, makes the urgency to balance the general growth and needed distribution of energy, i.e. electrification, more urgent and vital than ever before.

2.1 Coal, Oil, Natural Gas and Nuclear

According to MNES, 2010 [8], the government of India encouraged and supported the private participation within the energy sector by introducing new policies for the purpose of promoting private investment in this field. The participation of the private sector in coal mining, oil and gas exploration as well as within the power sector is an indication of the progress which is taking place within India's fuel economy. Reportedly, India's Ministry of Coal and Mines has estimated that there are around 246 billion tones of hard coal reserve, where 92 billion tones of this reserve are already proven (2010). On the other hand, India's Ministry of Petroleum & Natural Gas has estimated that there are approximately 700 million metric tons (MMT) of oil and gas which have been discovered in recent years.

India has one of the largest reserves in the world of nuclear fuel, i.e. Thorium. However, the nuclear energy sector needs further development, mainly in the form of fuel cycling process [9]. On the other hand, the report by EIA, 2009 [10] concerning world proved reserves of oil and natural gas, in their most recent estimated figures for India (according to Oil & Gas Journal) has been illustrated in the following figures: Oil (billion Barrels) for the year 2009 = 5,625 and Natural Gas (Trillion Cubic Feet) for the year 2009 = 37,969.

2.2 Renewable Energy Sources

Apart from hydropower, which has been estimated with a potential of 150,000 MW^3, India's other renewable energy sources have even higher potential, in particular within the solar, biomass and wind energy sources (Table 2) (MNES, 2010).

According to India's Ministry of New and Renewable Energy, 2007, the present capacity of renewable energy is 9220 MW, i.e. around 7.3% of the overall generation capacity.

Table 2 India's Renewable Energy Sources estimated potential (source: MNES, 2010 [8])

Source	**Approx. Potential** (MWs)
Biomass Energy	19,500
Solar Energy	20,000
Wind Energy	47,000

Within the wind energy production sector, India presently is reported to be the fourth largest in the world [3]. Present generation of electricity from wind power was around 5 billion units of KWh per annum which has been fed to the national grid. This is mainly due to India's present wind power installed capacity, which is around 1167 MW [8]. Reportedly, the same source also claims that a net potential of around 45,000 MW from thirteen Indian states can be obtained from wind power alone. Generating energy from wind power has a high potential for India's future renewable energy prospect, however, the capacity for solar energy could have a similar potential, i.e. India has an average insolation of around 6 kwh/m^2/day [3]. According to MNES, capacity of more than 44 MW, of around 700,000 PV systems for a variety of applications has been already installed.

In regard to biomass, there is already a capacity of more than 22 MW. India 2000 established biomass gasifiers in various villages, an indication that biomass utilisation is a growing field, in particular where rural areas are concerned [8]. However, the overall renewable energy achievement for the countryside the government of India has managed to meet is only 1% of the actual energy need for the rural areas, obtained by the end of the tenth five year plan [11]. The above percentage target achieved could go higher as within the following eleventh five year plan, the government of India launched two new additional schemes related to the field of renewable energy [12]. These two schemes are:

1. Remote Village Renewable Energy Programme (RVREP); 2. Grid- Connected Village Renewable Energy Programme (GVREP)

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The RVREP is divided into the following two sections: a. Village Energy Security Programme (VESP); b. Remote Village Solar Lighting Programme (RVSLP)

The GVREP is divided into the following two sections: a. Solar Thermal Systems;
b. Biogas Plants.

The Indian government has introduced a number of incentives, mainly for the purpose of attracting investment in the field of renewable energy. These incentives range from grants, subsidies, policies support, framework for regulatory and legislative aspects, consultations and sources of finances, research and development, planning and resource assessments and help in upgrading existing energy generating technologies.

2.3 Electricity

India's electricity generation during 2008 was estimated to be around 830 TWh, which is only 4.1% of the world total electricity production during that year. However, during the same year, India imported 9 TWh of electricity, which make the overall total of 839 TWh, consumed in one year by the whole country [13]. The above data provide a clear view that electricity's high demand and shortages are major challenges, not just in the rural areas, but in other parts of the urban centres in India. Even when there is a power connection for rural and urban parts, the access to electricity is poor, the generation capacity does not usually meet peak demand and the unpredictability of supply, i.e. outages and quality of service causes additional problems faced by the end users [14]. Up to recent years, the main electricity payers were the urban centers and industries, which the main utilities turn to recover their cost, excluding their other customers which are spread in the countryside and already receive electricity supply. However, reforming the electricity sector was an important step taken by the Indian government in that two important initiatives such as the Electricity Regulatory Commission Act of 1998 and the Electricity Act of 2003 were introduced as part of the electricity market liberalisation. According to Srivastava and Rehman, 2006 [16], the majority of India's villages presently have access to electricity, i.e. around 85%. However, it has been reported that the consumption of electricity by households is less than 60%, while at the same time, 81.5% of urban have access to electricity. On the other hand, within the rural areas the percentage is around 46.2% [15]. The eastern and north eastern part of India is the areas of the country where lack of electricity supply is more prominent in the countryside than elsewhere.

When it comes to the conversion factor, i.e. converting final electricity output consumption to what has been termed as 'primary energy', is relatively high in India with a value of 4.2 for the year 2005 [17]. According to the above source, this means that four units of energy at the source, out of these four units, only one unit of energy will be possible to consume effectively. There are a number of reasons why this is the case, such as electricity losses during distribution, which are very high. According to CEA, 2006 [18], the overall electricity losses during distribution for the year 2004 were around 31% of the total electricity production for that year. The other reason for the above losses is the low efficiency related to the method of the electricity generation, i.e. the low efficiency of the fuel combustion method used at various power stations. According to de la Rue Can, et. al., 2009 [17], 82% of the power stations in India uses this method to generate electricity. Other losses have been counted as part of direct and indirect theft, i.e. illegal access to power cables and the absence of electricity meter reading, in particular in some rural areas of the country.

2.4 Electricity Supply and Applications

The latest report of IAE, 2010[2] [19] reported that 404 million people in India do not have access to electricity supply, while at the same time; around 855 million people still rely on the traditional use of biomass materials, as a way for cooking their food.
According to de la Rue Can, et. al., 2009, [17], the percentage of electricity supply being used in India is 16% for intensive industry (including small portion related to transport, such as railways usage), 23% for industry (not including intensive energy usage), 18% agricultural pumping, 18% for residential usage, 13% for household lighting and around 12% is related to services. Knowing the above percentage of electricity usage pattern, the most important question which should be asked is 'what are the main sources of energy that are being used for the generation of electricity?' According to the data obtained during 2005, the highest source is coal, followed by gas, hydro, oil and, the last in the list is nuclear [17]. The top three are providing electricity as in the following figures: Coal 78.5 GW, large hydropower 36.9 GW, and gas 16.4 GW, while production of electricity from renewable sources is approximately 13.2 GW [20]. A comparison concerning various figures from various

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dates, originated from the Indian's government - past and present data related to future energy output and growth - has been looked at briefly (Table 2). This is mainly to show how the authority presents and see future energy needs for the country. A prediction of around 8.5% by India's Ministry of Power related to future electricity growth and output will be possible. A comparison has been also made by India Planning Commission in regard to present usage of energy sources compared to those predicted for the year 2031 – 32 (Table 3).

Table 2 India Ministry of power (MOP) projection for Electricity Requirement up to 2032 (Cited at: Planning Commission of India, 2006 [3])

Year	Billion kWh		Installed Required Capacity (GW)	
	8% Growth Rate	9% Growth Rate	8% Growth Rate	9% Growth Rate
2006-07	700	700	140	140
2011-12	1029	1077	206	215
2016-17	1511	1657	303	331
2021-22	2221	2550	445	510
2026-27	3263	3923	655	785
2031-32	4793	6036	962	1207

Table 3 Comparison of energy utilization in 2031-32 with present (source: Planning Commission of India [3])

Resource	**Current utilisation (Mtoe)**	**Resource Utilisation in 2031-32 (Mtoe)**
Oil	119	350-486
Natural Gas (including CBM)	29	04-150
Coal	167	632-1022
Hydro	7	13-35
Nuclear	5	76-98
Solar	<1	1200
Wind	<1	10
Fuel wood	140	620
Ethanol	<1	10
Bio diesel	<1	20

3 India's Solar Energy Policy and Resources

As a country located within the earth tropical region, India has immense solar energy potential for generating electricity, as well as for thermal heating purposes. Reportedly, there are about 250-300 of sunny days per year, i.e. approximately between 4-7kwh/m^2 [21].

As has been mentioned previously, this kind of energy is mainly due to the average insolation in India of 6 kWh/m^2/day. Solar energy can be used directly or indirectly for a variety of daily applications. However, the present PV technology in India is mostly used for domestic applications, such as for lighting and for cooking/heating purposes.

India's PV hardware manufacturing process itself is developing and progressing steadily. This development is considered to be as a result of the local commodity market energy needs. The above development received further support in that the government of India has presented to their citizens what they have termed as 'National Solar Mission'. The aim of the initiative is to develop the solar energy further on a national scale, while at the same time, it can be seen as another step by the government concerning the climate change approach, i.e. for the next decade, the National Solar Mission should be able to provide additional 1,000 MW of solar power to the already existing energy system [22]. Prior to the above announcement, the government introduced in March 2007 the semiconductor policy under its Special Incentive Package Scheme (SIPS), which during the first ten years of the semiconductors industries, should provide 20% of the capital expenditure for those manufacturers which are located in the Special Economic Zones (SEZ), and 25% for those who are located outside the above zone, according to US–India Energy Partnership Summit, 2009. The same source also reported that the government will provide support of up to 50 MW for projects related to grid interactive solar power generation. The above are examples of the Indian government policy approach in supporting the development and applications of solar energy. Policy and regulations are good incentives for the industries, however, the fact on the ground for the solar energy remains to be seen, i.e. whether this kind of support is sufficient to speed up the development in this field within the time scale provided by the government. Also, there are other aspects of these policies where economical and social aspects may not have been examined and supported thoroughly.

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3.1 Challenges

There are still a number of challenges facing the field of solar energy in India, in particular where the average family concerned is in the rural parts of the country. Some of these challenges have been summarised in the following points [23].

1. Prices are still not within the reach of the low income families; 2. From national prospective, there is still low demand for solar systems; 3. Not enough awareness, knowledge and, consequently interests about solar systems and their benefits by the general public; 4. Lack of subsidy about the scheme in certain parts of the country; 5. Lack of knowledge by the general public about the climate changes and greenhouse effects; 6. As part of the feed-in tariff systems, grid integration of rooftop energy systems issues still remain to be addressed; 7. Other technical issues such as measurement of power and the frequency of supply are also in need for technical and regulatory solutions; 8. The present solar technologies being used in India have poor efficiency in regard to their solar cells; 9. The estimation capacity of solar-PV in India is approximately 112 MW while grid connection from this output, reportedly, is only 2 MW

4 Conclusion

Understanding India's present energy needs and its future development (from both local and national prospective) should provide the mechanism for new ideas and solutions to some of the issues related to electricity shortages, in particular where rural electrification is concerned.

India's abundant sources of renewable energy is one way of bridging the electricity shortage gap and, at the same time, reducing the dependency on energy import.

Electricity generation from solar energy is one of the main aims for the Indian government in the frame of a solution for the power shortages in the countryside. Governmental policy in this field should provide a better access to domestic and commercial sectors in making it possible to obtain power at a lower cost from sustainable energy sources. However, despite the positive outlook, there are a number of challenges still facing Solar-PV applications and their manufacturers in this field. Some of these challenges can be overcome with the introduction of a national and local awareness programme related to the benefits of using solar energy resources.

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