Growth of Solar Energy in India – Present Status and Future Possibilities

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Abstract – The sun can be one of the most possible powerful renewable energy sources. Solar energy is finite energy resources to meet up long term global energy crisis. The recent energy crisis and environmental burden are becoming increasingly urgent and drawing enormous attention to solar-energy utilization. The present study is intended to review on recent advances in developing the STE and SPV technologies for solar power generation. Capturing and using just the sunlight which hits the earth in one day could provide enough energy for the entire world all year. Solar power has the immense capacity to bring in stability to the fluctuating electricity tariffs in India as it is cheaper than thermal and domestic coal. We have realized that solar radiation in the worst part of India is better than the best part of Europe. In India, the electricity demand is drastically increasing. Solar Thermal (STE) and Photovoltaic Electricity (SPV) technology can be implemented in India as solar resources and large wasteland areas are widely available in the country. Solar thermal energy is finite energy resources to meet up long term global energy crisis. The recent energy crisis and environmental hazards are drawing enormous attention to solar-energy utilization. The utilization of solar energy in India has got prime importance in the present scenario of energy crisis in the country.

Keywords - renewable energy, solar thermal & solar photovoltaic technologies, growth of solar energy in India, global energy crisis.

I. INTRODUCTION

India is facing an acute energy scarcity which is hampering its industrial growth and economic progress of the country. In India there has been a continuous effort in the direction of the use of lesser amount of fossil fuels and increased supply of energy which can only be met by a planned harnessing of more renewable energy sources and the government is serious in the planned development of these sources.

The National Action Plan on Climate Change (NAPCC) also points out: "India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as future energy source. It also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level".

Often the economic growth of a country like India is measured in terms of GDP. But on the concept of "GREEN ECONOMY" economists are saying that to measure economic growth only in terms of GDP is not appreciably appropriate. The proper way is to take the cumulative effect of GDP and human development index (HDI). If we take cumulative effect then we cannot see a satisfactory economic growth.

In India, till 2012, no commercial solar thermal power plant generating bulk electricity has been installed. There is ample scope in India to meet the energy problems through solar thermal technologies which will help to protect the global climate by reducing GHG and CO_2 emissions for sustainable economic and social development of the country.

The main features of the radiation climatology of India are as follows:

- About 3300 to 3700 hours of bright sunshine are available in a year in the northwest and West Central regions of the sub-continent and 2900 hours over Central peninsula except Assam, Kerala and Kashmir where it is appreciably lower.
- About 7.5 Kwh/m^2/day of solar energy is received over the country as a whole, for the major portion of the year, of which the maximum about 210 Kwh/m^2/month is received during cloud free winter months and pre-monsoon months and the minimum 140 Kwh/m^2/month is received during monsoon seasons.
- During winter, the lowest radiation is received in North India and the highest in the South India. During summer, a reversal occurs with high values in North and low in South.
- Diffused solar radiation is a minimum 740 KWh/m^2 over Rajasthan increasing eastwards to 840 KWh/m^2 in Assam and to 920 KWh/m^2 in extreme South of the peninsula.
- The total solar energy received by this subcontinent is over 60 x 10^{13} MWh. There are between 250 to 300 days of usual sunshine per year in most parts of the country.

Solar energy thus emerges as a positive alternative energy sources with certain unique advantages for the Indian condition. The industrialized nations are requesting India to take the leadership in the development of solar energy in the Third World.

II. HISTORICAL GROWTH OF SOLAR ENERGY IN INDIA

Solar energy development programmes have been undertaken by the advanced countries immediately after the Second World War the progress however, slowed down with the coming of the nuclear era in sixties. The experience with nuclear energy and the hike of oil price in the seventies once again focused attention on solar energy. The Department of Nonconventional Energy Sources, Govt. of India, formed in 1982, undertook a number of developmental programmes and demonstration projects.

Solar power generating capacity grew by 73% in 2010, picking up the pace again after a brief slowdown in 2009.

In 2006, the Rural Electrification Program was the first step by the Government of India in recognizing the importance of solar power. It gave guidelines for the implementation of off-grid solar applications. However, at this early stage, only 33.8MW of capacity was installed through this policy in 2012.

According to International Energy Agency (IEA), solar energy (solar photovoltaic and solar thermal) could meet most of the global demand of electrical energy by 2060. Carbon dioxide emissions from the energy sector would fall to about 3 gigatons per year compared to 30 gigatons at current levels.

Within 2035, the world's renewable energy sources could grow by at least 60 percent and could even double. And by 2060, renewable energy could supply up to four times more energy than today. Solar energy could be the world's largest primary energy source by 2060. The industrialized nations are requesting India to take the leadership in the development of solar energy in the Third World.

The Ministry of New and Renewable Energy has set up Solar Energy Centre (SEC), established in 1982, is a dedicated unit of the Ministry of New and Renewable Energy, Government of India for development of solar energy technologies and to promote its applications through product development .

A projection in the 12th Plan document of the Planning Commission indicates that total domestic energy production of 669.6 million tons of oil equivalent (MTOE) will be reached by 2016-17 and 844 MTOE by 2021-22. This will meet around 71 per cent and 69 per cent of expected energy consumption respectively with the balance to be met from imports, projected to be about 267.8 MTOE by 2016-17 and 375.6 MTOE by 2021-22.

The Jawaharlal Nehru National Solar Mission (JNNSM) was launched on the 11th January, 2010 by the Prime Minister. The Mission has set the targets which includes (i) deployment of 20,000 MW of grid connected solar power by 2022, (ii) 2000 MW of off-grid solar applications including 20 million solar lights by 2022, (iii) 20 million sq. solar thermal collector area (iv) to create favourable conditions for developing solar manufacturing capability in the country (v) aggressive R&D to achieve this objective and make India a global leader in solar energy.

Mission will create an enabling policy framework to achieve this objective and make India a global leader in solar energy.

III. SOLAR PHOTOVOLTAIC IN INDIA – PRESENT STATUS AND FUTURE POSSIBILITIES

India lies in a sunny tropical belt (High isolation).Its total theoretical available potential is annually over 5000 trillion kWh. Exploited potential (production/installed capacity) is very little including total installed capacity (grid & off grid) of approximate 110MW and that only about 17.82MW (as of Dec 2010) is grid connected (as of Jan 2011).

Phase 1	2010-2013	500 MW
Phase 2	2014-2017	2000 MW
Phase 3	2018-2022	7500 MW

Table 1. Solar PV module demand in India

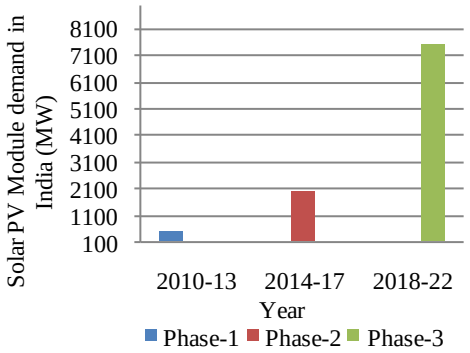

Fig. 1: Solar PV module demand in India phase wise.

2010	2011	2012	2013	2014	2017	2020
13.6GW	20.2 GW	23.8 GW	33 GW	45.3 GW	85 GW	200 GW

Table 2. Solar PV module demand worldwide year wise in GW

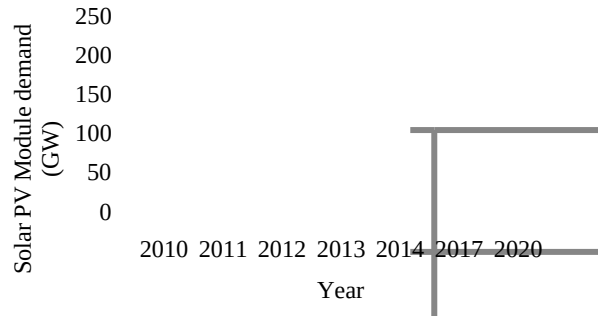

Fig. 2: Solar PV module demand worldwide year wise in GW

The significant demand projections indicate excellent potential for solar PV module industry(Figure 1).In the year 2009 annual global solar PV capacity had increased by 55% rising from 14 GW by end of 2008 to over 21GW.By 2011 the opportunities in the global sector module segment had 130% growth over the previous year. A 25MW plant of solar PV module can be set up in a space of less than half an acre.

IV. GLOBAL ENERGY CRISIS

By curtailing our anthropogenic emissions of greenhouse gases one can reduce global warming. Overpopulation leads to high energy demand & hence use of fossil fuel cannot be stopped. Earth's natural reserves are in limited supply & its high demand has brought the world an urgent need to prevent ecological degradation on a large scale.85% of the world's energy supply comes from 37% oil,25% coal & 23% gas. It is achieved by utilization of alternative sources in near future. The issue of depletion of fossil reserves is growing worse day by day despite of many efforts. The world is not immune to it. Wrong usage of fossil fuel is the cause behind the energy crisis. Energy has to be conserved. Governments are working on the alternative energy sources especially solar energy to lessen the use of natural energy resources to generate power.

The International Energy Agency's(IEA) own analysis in its World Energy Outlook on present oil supply(i.e.70% from 1600 fields),show an observed decline rate of 6.2%,double the IEA's stated estimated of future decline rate of about 3% by 2035.Organization of Petroleum Exporting countries(OPEC) populations since 2000 have increased twice the rate of the world as whole that has driven them to increase their oil consumption four times curtailing global exports by a corresponding increase in domestic subsidies.

A. Causes of Energy crisis

- Land scarcity
- Overpopulation
- Overconsumption
- Poor Infrastructure & Distribution system
- Unexplored Renewable Energy Options
- Delay in Commissioning of Power Plants
- Wastage of energy
- Major accidents & Natural calamities
- Wars & attacks etc.

V. CHALLENGES AND CONSTRAINTS OF SOLAR POWER DEVELOPMENT IN INDIA

A major portion of our rural area is still starved of electricity for agricultural purposes and house appliances. Solar energy can play major role to solve this problem. Swedish scientist Svante August Arrhenius in 1896 warned about the gradual warming of the earth due to 'Green House' effect. In 1789, the famous British economist Thomas Robert Malthus clearly indicated that earth would face a serious problem in the near future unless steps to be taken to control rate of increase of population. A large scale solar power plant typically requires approximately one square kilometre for every 20-60 MW generated. The capital cost of solar power system is higher than that of conventional system of power generation. India's inadequate financing capabilities for funding of solar projects is a major constraint for development of solar power in India. However, the Jawaharlal Nehru National Solar Mission and National Solar Mission have taken major initiative to make provisions to address the situation.

The JNNSM is encouraging the production of both PV & CSP technology with equal weight age. This Governmental mission has deployed 20 GW of solar power by 2022 which is shown below in Table 3.The recent policy guidelines initiated by Government includes development of solar power, address of power shortages, stakeholder concessions etc. Their policy has gained momentum in 21 st century providing significant interest for the development of solar energy.

Application Segments	Target for phase 1 2012-2013	Cumulative target for phase 2 2013-2017	Cumulative target for phase 3 2018-2022
Grid solar power includes roof top & small solar project	1100MW	4000MW	20000MW
Off grid solar applications includes rural solar lights	200MW	1000MW	2000MW
Solar collector	7 million sq. metre	15 million sq. metre	20 million sq. metre

Table 3. Target of installed solar systems in the year 2012-2022[Figure 3.(a) & (b)]

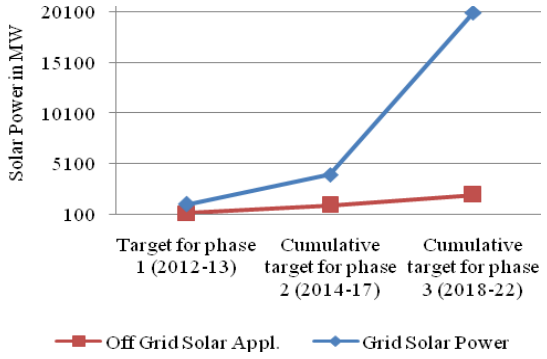

Fig. 3(a) : Grid solar power & Off grid solar power phase wise.

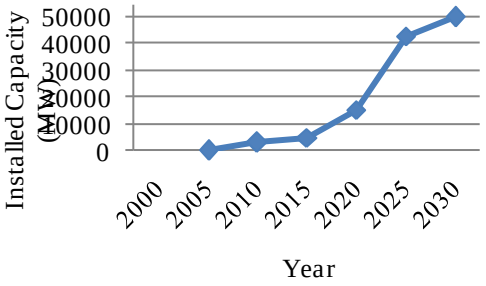

Fig. 3(b). Solar collector (million sq. metre) phase wise.

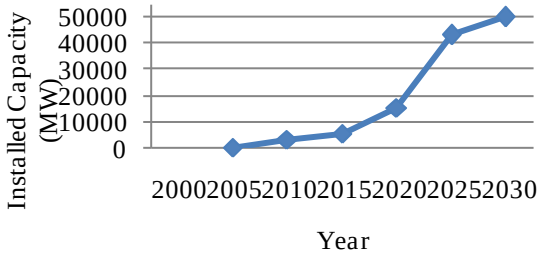

Fig. 4: Projected Global Growth in CSP

This year's budget has encouraged private solar companies by reducing customs duty on solar panels by 5% & excise duties on solar photovoltaic panels are exempted. The cost of rooftop solar panel installations are also reduced by 15-20%.The falling prices of PV panels from china & US has increased the cost of grid power in India. Adequate solar resources have also helped to increase the development of this industry.

The major constraints that hinder the development of solar energy system in India are as follows:

- Dependency on imported wafers for cell preparation
- High cost of financing
- Low demand in India
- Lack of technical knowledge especially in the upstream segment.

VI. PER CAPITA ENERGY CONSUMPTION

In per capita energy consumption India ranks amongst the lowest of the countries in the world. Looking at the Indian Economy, we find that around 47% of India's population is engaged in agriculture according to the World Bank Report 2012 and the share of agriculture and allied sectors in India's GDP is likely to decline to 13.7% in 2012-13. The poverty, unemployment and low rate of growth keep the majority of the population below the poverty line. As the country's energy scenario being strongly interlinked with the economy and per capita energy consumption is very low as seen from the following table.

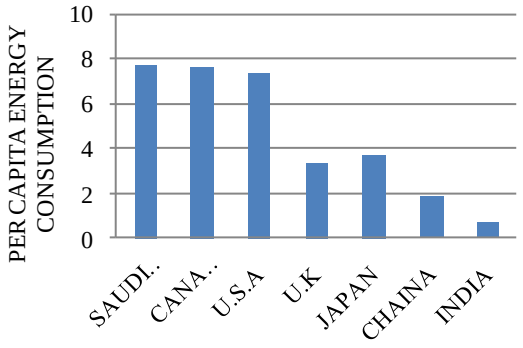

Fig.5 : Per Capita Energy Consumption (2013) in metric tons of oil equivalent (Source: Economist Intelligence Unit. 2011. Derived from International Energy Agency)

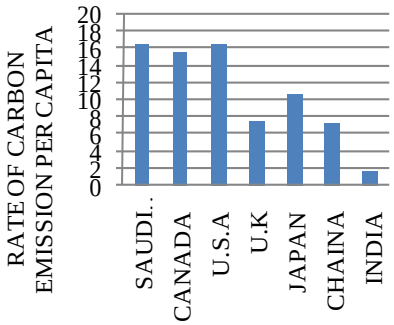

Fig. 6. Rate of Carbon Emissions Per Capita (2013) in metric tons

Date & Year	Total Installed Generating Capacity (MW)	Total Installed RES Generating Capacity (MW)	% 0f Total capacity
As on 31.03.1990	63636	18	0.03
As on 31.03.1992	69065	32	0.05
As on 31.03.1997	85795	902	1.05
As on 31.03.2002	105046	1658	1.58

As on 31.03.2007	132329	7761	5.86
As on 31.03.2008	143061	11125	7.78
As on 31.03.2009	147965	13242	8.95
As on 31.03.2010	159398	15521	9.74
As on 31.03.2011	173626	18455	10.63
As on 31.03.2012	199877	24503	12.26
As on 31.03.2017*	318414*	54503**	17.12

Table 4. Growth of Installed Capacity & Percentage share of RES in the total installed generating capacity in India
(Source : General Review 2011, DMLF division, CEA** Tentative projection for 12th. Plan)

Decade	Total capacity (GW)	Capacity Factor (%)	Operation Time (hrs./yr)	Output (TWh)	% of Global Electricity Production
By 2020	148	32	2800	414	1.3
By 2030	337	39	3400	1140	3.8
By 2040	715	45	3900	2790	8.3
By 2050	1089	50	4380	4770	11.3

Table 5. Growth Forecast for Solar Power

State	MW	%
Andhra Pradesh	23.5	1.6
Chhattisgarh	4.0	0.2
Delhi	2.53	0.1
Gujarat	824	57
Haryana	7.8	0.54
Jharkhand	16	1.11
Karnataka	14	0.97
Madhya Pradesh	11.75	0.81
Maharashtra	34	2.35
West Bengal	2	0.13
Orissa	13.0	0.90
Punjab	9.33	0.6
Rajasthan	442.25	30
Tamil Nadu	17.06	1.17
Uttar Pradesh	12.38	0.86
Uttarakhand	5.05	0.35

Table 6. State wise solar energy capacity in India in 2013

VII. PRESENT STATUS OF SOLAR ENERGY IN INDIA

Presently the grid connected capacity (all PV) in India is 481.48MW as in 31st Jan, 2012. However the market of solar energy is set to grow significantly in the next ten years. Encouraging the spread of solar mode of power generation(both CSP & PV) & aiming current status of grid parity at around Rs 5 / kWh by 2022 & coal power generation currently at around Rs4/kWh by 2030 forms the key element in India's comprehensive long term policy. In India solar power generation particularly for PV & solar thermal are Rs8 &Rs15 respectively per kWh.

VIII. THE US-CHINA WORKING GROUP ENERGY EFFICIENCY REPORT 2014

This report is submitted for the strategic & Economic dialogue to the Special Representatives of the Leaders of United States & China. By large scale cooperative taken by the United States & China to reduce greenhouse gas emission is more remarkable than ever.

In July 2013,enhanced policy dialogue & five action initiatives such as Emissions Reduction from Heavy-duty & other vehicles; Smart Grids, Carbon capture, Utilization & Storage; Energy efficiency in buildings & industry& collecting & managing greenhouse gas emission data has been launched by the working group. These provide cleaner air & energy savings. The framework of this report highlights the developments on the enhanced policy dialogue & five initiatives along with collaboration with hydrocarbons.

IX. DEVELOPMENT IN THE FIELD OF FIVE ACTION INITIATIVES

Special attention must be given in the following fields for the progress in this area.

- Enhanced heavy duty & other vehicles fuel efficiency standards to reduce climate impact & improve quality of air. The US intends to develop fuel economy standards for 2018 model medium & heavy duty vehicles whereas China for 2020 model heavy & light duty vehicles which is yet to be finalized by 2016.
- Clean fuels(i.e. ultra low sulfur fuels of 10ppm) for improving air quality by the end of 2016 & vehicle emissions control technologies and
- Promotion of efficient, green freight initiatives.

Several events held in 2014 to establish institutional links & co-ordination mechanism with other ECPA energy efficiency activities are as follows-

- Seminar for promotion of energy efficiency in Haiti was held on June 17-20,2014
- Technical exchange on experiences in the implementation & development in the field of energy efficiency programs at Santiago, Chile on June 16-18, 2014
- Technical exchange mission to encourage the energy efficiency of the residential sector at Monterideo, Uruguay on May 22, 2014
- Seminar was organized on innovation Science& Technology for the Energy efficiency Development

program including Green-Sustainable Buildings at Tuxtla-Gutierrez, Mexico on May 8-9, 2014.

The Energy Efficiency Working group support the Government's efforts to promote energy efficiency & works on its conservation by policy & regulatory norms, equipment certification, program design and implementation, standards & labeling, public awareness campaigns.

X. FUTURE GROWTH OF SOLAR IN INDIA

For solar CSP & PV together, National Solar Mission attempts to reach an installed capacity of 1-2GW by 2013,4-10GW by 2017 and 20GW by 2020.Thar Desert has been set for solar power projects sufficient to generate 700 -2100GW.National Solar Mission & other Generation Based Government Incentives(GBI) are available through Ministry of New & Renewable Energy. Government is expected to spend $ 19 billion until 2022 on this project. Key bottlenecks and barriers of this project are the cost of solar PV, high population density (land scarcity) and technology obsolescence. It is expected that by 2016 the solar power could be 15% lower than the most expensive grid-connected conventional energy resources. Indian market will see the significant change.8GW obtained from conventional sources will correspond to 25 to 30 GW from solar generation in near future. The rapid demand of electricity & fossil fuel availability could increase the solar power potential to more than 50 GW within 2022.Initiatives taken in lowering the solar costs in combination with rising price in grid power will convince the distribution companies, private firms using open access & firms putting up their own captive capacity to initiate its growth phase & make solar power cost-efficient alternative to conventional power source.

XI. CONCLUSION

The increased collaboration between USA & India, on energy efficiency can drive economic activity & productivity, strengthen energy security & improve environmental impacts. Development of solar sector in India has been visible ever since independence. Solar industry has uplifted the Indian society to an immense socio-economic growth opportunity. But solar industry requires supportive polices for its continuous growth. Investors are keen enough toward this sector in our country thereby contributing to the development of economy via three fold return(i.e. economically, socially & environmentally).The institutional framework & co-operation in New &Renewable energy between U.S.A.& India encourages & enhances the communication between two countries at working level. The routine meetings on action causing events by Joint Working Group of USA-India on Renewable energy can often spur further initiatives & promotes measures of sustainability. Within the frameworks of this paper, the authors have tried to discuss the journey of solar energy in India since 1950 till date. Moreover, the potential barriers & challenges are highlighted that impacts the ambitious mission taken up by Central & State Governments.

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