



## Promotion and Developments of Renewable Energy in Power System Technology and Energy Markets in India

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**Abstract**— *In this paper, The renewable energy sources are regarded as related to present atmospheric movements. The Solar Electric systems, which are also called photovoltaic or PV systems are reliable and pollution-free. Solar Radiation, along with secondary solar-powered resources and other such as wind and wave power, hydroelectricity and biomass, account for most of the available renewable energy on earth. India is gradually shifting focus toward its renewable energy resource, Driven by an increasing demand for electricity and widening gap between demand and suppl. India has plans to generate 1,000 MW of power by 2013 and the toward target to the solar generation electricity 20 GW in 2020. All types of energy, types of solar cell technology, renewable or non-renewable, can be traced back to either atmospheric activities in the past or to the present and future activities within the atmosphere and also describe the benefits and application of renewable energy. Renewable energy policy, electricity act 2003, national rural electrification policies (NREP), and 2006: Electricity market liberalization has also progressed integration in power systems operating in a competitive environment.*

**Keywords**—*Theoretical consideration, Benchmark Capital Cost , Future trends, solar power project map in India, Types of solar technologies, photovoltaic application, scenario and renewable energy policy*

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### I. INTRODUCTION

This document is a template. An electronic copy can be downloaded from the Journal website. For questions on paper guidelines, please contact the journal publications committee as indicated on the journal website. Information about final paper submission is available from the conference website. Solar electric systems, which are also called photovoltaic or PV systems, are reliable and pollution-free. They make use of a renewable source of energy the sun and PV systems for homes and businesses are becoming more affordable all the time. Radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation, along with secondary solar-powered resources such as wind and wave power, hydro electricity and biomass, account for most of the available renewable energy on earth. Only a minuscule fraction of the available solar energy is used [1]. India is both densely populated and has high solar insolation, providing an ideal combination for solar power in India. In solar energy sector, some large projects have been proposed, and a 35,000 km<sup>2</sup> area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 gigawatts. India is endowed with rich solar energy resource. The average intensity of solar radiation received on India is 200 MW/km square (megawatt per kilometer square). With a geographical area of 3.287 million km square, this amounts to 657.4 million MW. However, 87.5% of the land is used for agriculture, forests, fallow lands, etc., 6.7% for housing, industry, etc., and 5.8% is either barren, snow bound, or generally inhabitable. Thus, only 12.5% of the land area amounting to 0.413 million km square can, in theory, be used for solar energy installations. Even if 10% of this area can be used, the available solar energy would be 8 million MW, which is equivalent to 5,909 mtoe (million tons of oil equivalents) per year.

In July 2009, India unveiled a \$19 billion plan, to produce 20 GW of solar power by 2020. Under the plan, solar-powered equipment and applications would be mandatory in all government buildings including hospitals and hotels. On November 18, 2009, it was reported that India was ready to launch its National Solar Mission under the National Action Plan on Climate Change, with plans to generate 1,000 MW of power by 2013[2]. Technological breakthroughs for cost-effective photovoltaic technology could generate a quantum leap in the renewable energy sector since India is well endowed with solar insolation (average of 6 kWh/ sq.mt./day). India plans to announce increased subsidies for solar-power generation, as the country looks to scale up production of renewable energy and show it is committed to mitigating climate change.

The Karnataka Power Corporation Limited (KPCL) has installed India's largest solar photovoltaic power plant at Yalesandra village in Kolar district of Karnataka. Built at the cost of about \$13 million, the plant makes use of modular crystalline technology to generate solar energy (Fig.1).



Fig1. India's largest Solar Photovoltaic Power Plant.

Numbers of solar appliances used in India are mentioned in table 1 below:

TABLE 1: TOTAL SOLAR POWER CONSUMPTION IN INDIA

Number of Solar road(Street) lights System	55,795
Number of Home Light( illumination) systems	342,607
Number of Solar lamp(Lanterns)	560,295
Solar photovoltaic Power( energy) plants	Less Than< 10 MW
Solar water heaters System	140 km <sup>2</sup> of collector area
Box-shaped(type) solar cookers	575,000
Solar photovoltaic pumps	6,818

## II. BENCHMARK CAPITAL COST NORM FOR SOLAR PV POWER PROJECTS FOR 2011-12

### A. Solar PV Power Projects

In Solar PV power project, the two major sub-systems are Solar PV modules and balance of Systems (BOS). Solar PV modules constitute 65-70 % of the cost while BOS comprises the rest. The Solar PV modules are predominantly crystalline Silicon based. Within the modules the intermediate products at different stages of the manufacturing process are Poly-silicon, Silicon Wafer, Solar Cell, and Solar PV Module. There is presently negligible domestic manufacturing capacity for Poly-silicon and Silicon Wafer in our country. The manufacturing capacity including projects under execution for Solar Cells and Modules are about 600 MW and 1000 MW respectively. The PV modules manufactured in the country meet the international standards

### B. Future trends expected in global solar PV industry

In 2010, increase in global PV manufacturing capacity and reduction in demand due to global recession has resulted solar PV module price decline. According to the Clean Energy Trends- 2010, the price drop, along with other internal financial and policy drivers, is causing some countries to reduce national incentive programs. Germany plans to reduce feed- in tariffs at the beginning of July 2010 by 11 to 16 percent, depending on the application. This move will further intensify the demand for less expensive PV in the solar market. Further, according to the Navigant Consulting report, as quoted in the Indian Semiconductor Association report on Solar PV Industry 2010(shows in fig 2). Contemporary scenario and emerging trends: May 2010, the global capacity of solar PV modules is expected to reach 54 GW by end of year 2012 as indicated [3] in the graph below

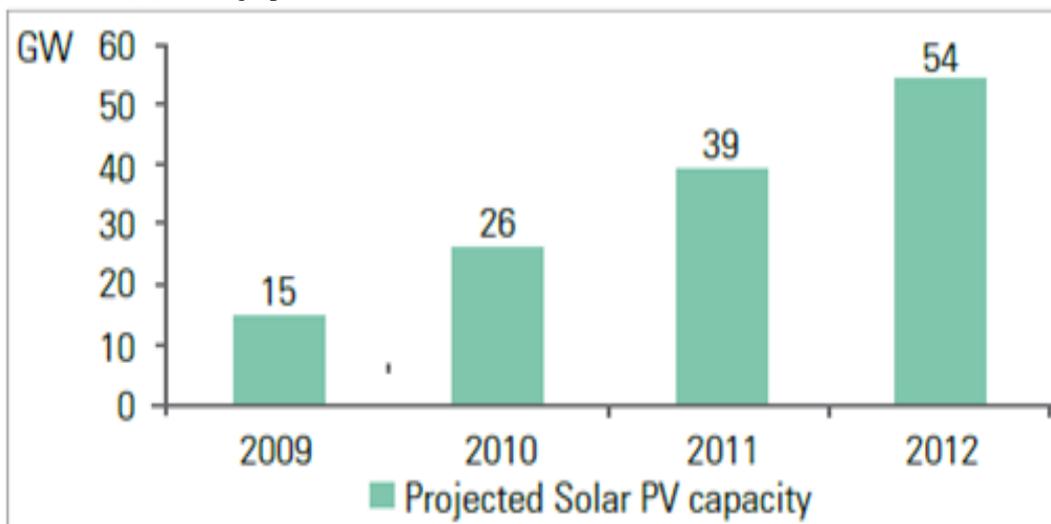


Fig.2. Cumulative capacity additions planned in solar PV until 2012

### III. RENEWABLE ENERGY AND ELECTRICITY

#### A. Renewable Energy overview

- There is unprecedented interest in renewable energy, particularly solar and wind energy, which provide electricity without giving rise to any carbon dioxide emission.
- Harnessing these for electricity depends on the cost and efficiency of the technology, which is constantly improving, thus reducing costs per peak kilowatt.
- Utilizing electricity from solar and wind in a grid requires some back-up generating capacity due to their intermittent nature. Policy settings to support Renewable are also generally required, and some 50 countries have these.
- Utilizing solar and wind-generated electricity in a stand-alone system requires corresponding battery or other storage capacity.
- The possibility of large-scale use of hydrogen in the future as a transport fuel increases the potential for both Renewables and base-load electricity supply.

#### B. Condition for investing in large grid connected power plant

The attractiveness of investing in large PV-grid connects power plants depends on the risk portfolio. The essential questions for investors in contradiction to home owners are: How secure is the law? What if the government changes? How safe is the legal situation of the power purchase agreement with the utility? How fast can a project be planned? How many authorizations are involved in the process for getting the permissions? In comparisons to a home owner investors are very radical with these uncertainties. As a matter of fact in most of the countries the bureaucracy and uncertainty to these questions are the lynchpins and often impedes the progression in the development of large PV-power plants. If only one of these mentioned factors is unclear, a large power plant will not be installed. There is only a YES or a NO for investors and this depends heavily on the return of investment and the risk level rather than on the nature of a particular investment [4].

#### C. Solar Power Projects Map in India

The map show the solar power project installation in India in which place the insolation is well in compare to other places (shows in fig 3.).

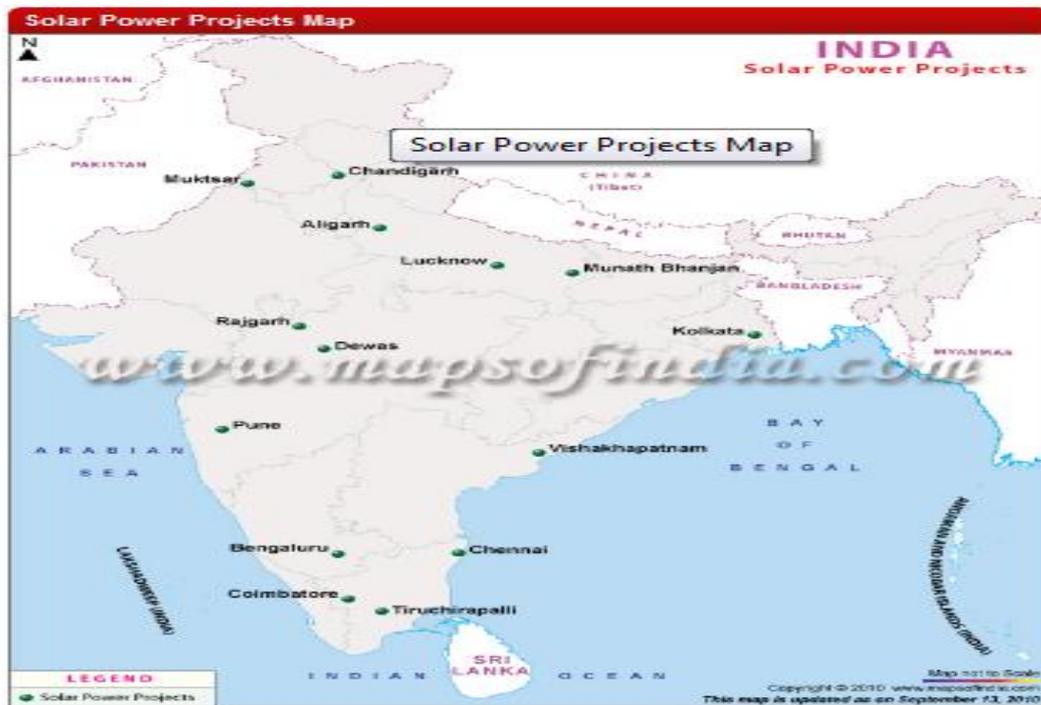


Fig 3. Solar Power Projects installed Map in India.

### IV. TYPES OF SOLAR TECHNOLOGIES

#### A. Photovoltaic Cells (PV)

PV technologies make use of silicon solar cells to convert sunlight directly to electricity. PV cells can provide electric power to meet different needs - from small devices such as watches or calculators, to local electric utilities.

#### B. Concentrating Solar Power (CSP)

CSP technologies use reflectors to focus sunlight onto receivers that collect sun's heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine. Previously, Floyd Associates published a research report

on CSP and the major players within the sector [5]. PV Technologies: Photovoltaic modules that produce up to 100W or more of power are constructed by bringing together and connecting an array of solar cells. The properties of the module depend on the type of solar cell used. The following list represents the three main technologies currently used to create solar cells:

#### *C. Crystalline solar cells:*

The foundation for crystalline solar cell production lies with a block of silicon ingot, which is sawn into thin silicon wafers [6]. The sawn wafers of 1mm thickness are then placed between two plates, plane and parallel to each other, which rotate in opposite directions and adjust the thickness of the wafer to 1/1000mm. From there, the wafers are cleaned, diffused at a temperature of 800 degrees Celsius, and covered with oxygen plasma. Finally, the cells are sintered at a high temperature, completing the cell production process.

#### *D. Amorphous Solar Cells:*

Amorphous solar cell, otherwise known as thin-film solar cell, is another type of technology utilized to create PV modules. First in the solar cell production process the glass substrate is cleaned. Afterwards, a lower contact layer is applied. From there, the surface is divided into bands and covered with a silicon layer. Lastly, the surface is re-banded and metal electrodes are applied.

#### *E. Other Solar Cells:*

Other solar cell technologies less frequently used are the EFG (Edge Defined Film fed Growth) method and Apex solar cells from silicon, cadmium telluride solar cells and copper-indium selenide (CIS). EFG mono-crystalline solar cells are produced directly from silicon melt, eliminating sawing to wafers, which results in lower production costs and material savings due to reduced waste.

### **V. PHOTOVOLTAIC IS EMERGING**

As a major power source due to its numerous environmental and economic benefits and proven reliability.

- 1) The fuel is free. The sun is the only resource needed to power solar panels and the sun will keep shining until the world's end. Also, most photovoltaic cells are made from silicon, and silicon is an abundant and nontoxic element
- 2) It produces no noise, harmful emissions or polluting gases. The burning of natural resources for energy can create smoke, cause acid rain, pollute water and pollute the air. Carbon dioxide CO<sub>2</sub>, a leading greenhouse gas, is also produced. Solar power uses only the power of the sun as its fuel. It creates no harmful byproduct and contributes actively to reduce the global warming.
- 3) PV systems are very safe and highly reliable. The estimated lifetime of a PV module is 30 years. Furthermore, the modules' performance is very high providing over 80% of the initial power after 25 years which makes Photovoltaic a very reliable technology in the long term. In addition, very high quality standards are set at a European level which guarantees that consumers buy reliable products.
- 4) 4 PV Modules can be recycled and therefore the materials used in the production process can be reused. Recycling is not only beneficial for the environment but also for helping to reduce the energy needed to produce those materials and therefore the cost of fabrication [7].
- 5) It requires low maintenance. Solar modules are almost maintenance-free and offer an easy installation.
- 6) It brings electricity to remote rural areas. Solar systems give an added value to rural areas House lighting, hospital refrigeration systems and water pumping are some of the many applications for off-grid systems. Telecommunication systems in remote areas are also well-known users of PV systems.
- 7) It can be aesthetically integrated in buildings (BIPV). Systems can cover roofs and facades contributing to reduce the energy buildings consume. They don't produce noise and can be integrated in very aesthetic ways. European building legislations have been and are being reviewed to make renewable energies as a required energy source in public and residential buildings. This fact is accelerating the development of eco-buildings and positive energy buildings which opens up many opportunities for a better integration of PV systems in the built environment [8].
- 8) The energy pay-back time of a module is constantly decreasing. This means that the time required for a PV module to produce as much energy as it needs to be manufactured is very short, it varies between 1,5 years to 3 years. A module therefore produces 6 to 18 times more energy than is needed to manufacture it.
- 9) It creates thousands of jobs. The PV sector, with an average annual growth of 40% during the past years is increasingly contributing to the creation of thousands of jobs in Europe and worldwide.
- 10) It contributes to improving the security of Europe's energy supply. In order to cover 100% of the electricity demand in Europe, only the 0.7% of the total land of Europe would be needed to be converted by PV modules. Therefore Photovoltaic can play an important role in improving the security of Europe's energy supply.

### **VI. PHOTOVOLTAIC APPLICATIONS**

The Photovoltaic technology can be used in several types of applications:

#### *A. Grid-connected domestic systems*

This is the most popular type of solar PV system for homes and businesses in developed areas. Connection to the local electricity network allows any excess power produced to feed the electricity grid and to sell it to the utility. Electricity is

then imported from the network when there is no sun. An inverter is used to convert the direct current power produced by the system to alternative current (AC) power for running normal electrical equipments (shows in fig 4).

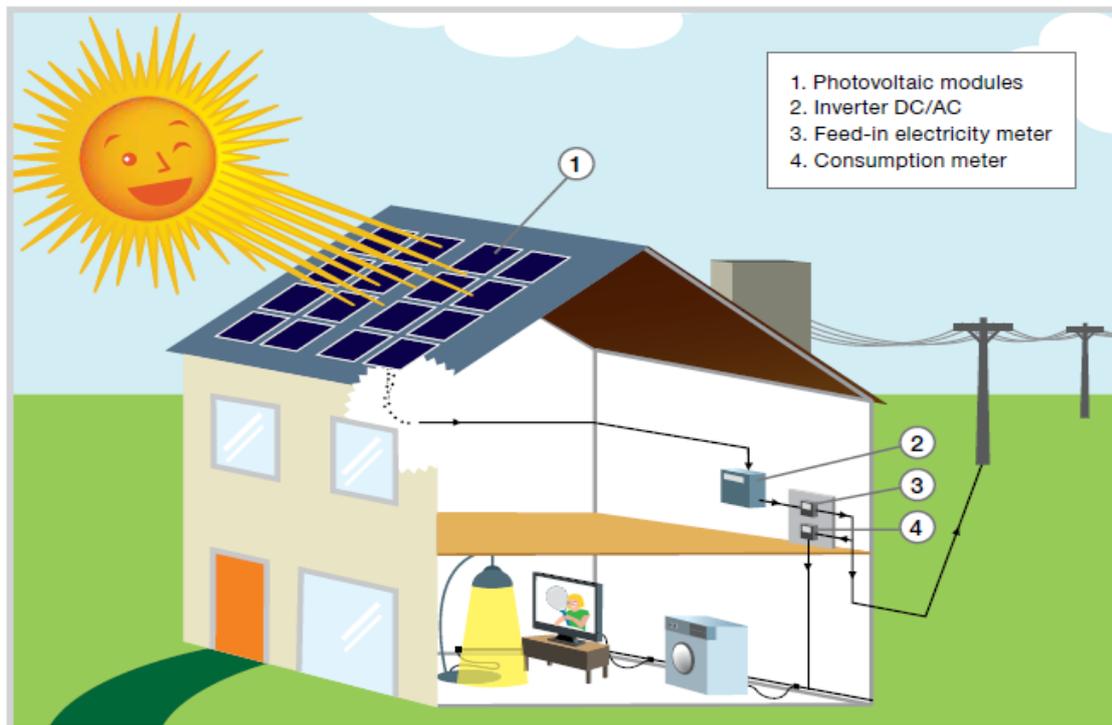


Fig4. Grid-connected domestic systems

#### *B. Grid-connected power plants*

These systems, also grid-connected, produce a large quantity of photovoltaic electricity in a single point. The size of these plants range from several hundred kilowatts to several megawatts. Some of these applications are located on large industrial buildings such as airport terminals or railway stations. This type of large application makes use of already available space and compensates a part of the electricity produced by these energy-intensive consumers.

#### *C. Off-grid systems for rural electrification*

Where no mains electricity is available, the system is connected to a battery via a charge controller. An inverter can be used to provide AC power, enabling the use of normal electrical appliances. Typical off-grid applications are used to bring access to electricity to remote areas (mountain huts, developing countries). Rural electrification means either small solar home system covering basic electricity needs in a single household, or larger solar mini-grids, which provide enough power for several homes.

#### *D. Hybrid systems*

A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator - to ensure a consistent supply of electricity. A hybrid system can be grid-connected, stand-alone or Grid-support [9].

#### *E. Consumer goods*

Photovoltaic cells are used in many daily electrical appliances, including watches, calculators, toys, battery chargers, professional sun roofs for automobiles. Other applications include power for services such as water sprinklers, road signs, lighting and phone boxes.

#### *F. Off-grid industrial applications*

Uses for solar electricity for remote applications are very frequent in the telecommunications field, especially to link remote rural areas to the rest of the country. Repeater stations for mobile telephones powered by PV or hybrid systems also have a large potential. Other applications include traffic signals, marine navigation aids, security phones, remote lighting, highway signs and waste water treatment plants. These applications are cost competitive today as they enable to bring power in areas far away from electric mains, avoiding the high cost of installing cabled networks.

### **VII. LONG TERM POTENTIAL OF SOLAR POWER**

In the long term it is estimated that solar power could contribute to an increasing part of the total energy consumption. With appropriate policies both in developed and developing countries, EPIA and Greenpeace have devised in a joint scenario, that in 2030 (shows in fig 5.), photovoltaic could produce enough energy to supply electricity to 3, 7 million people globally. The majority of them will be located in remote areas where there is no access to the electricity grid [10].

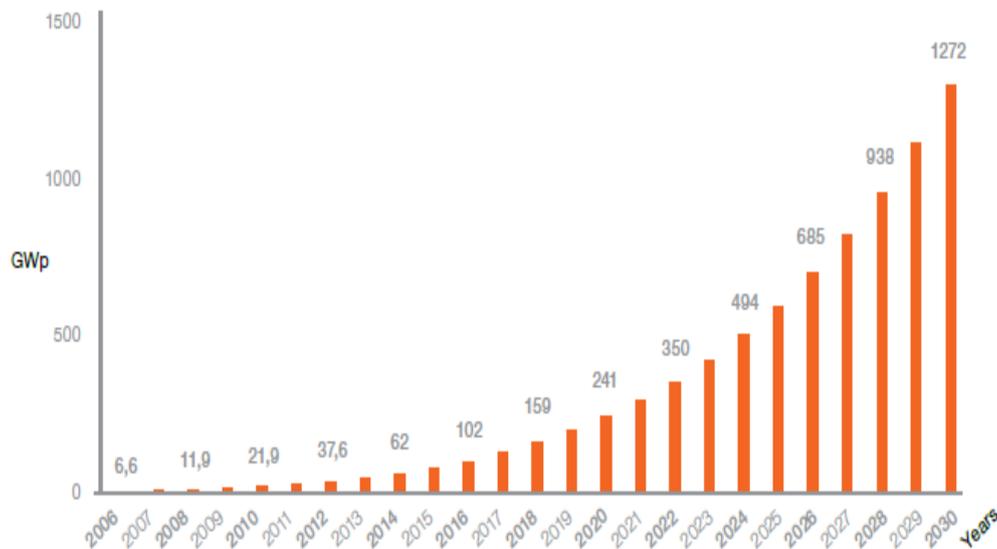


Fig5. Global Cumulative Capacity up to 2030 - Advanced scenario.

The following table demonstrates the current capacity utilization of alternative sources of energy and their potential given in the table 2.

TABLE 2: RENEWABLE ENERGY CURRENT CAPACITY AND POTENTIAL THE END OF MARCH, 2009

S. No	Alternative Energy	Current capacity(MW)	Potential(MW)
1	Wind power	10242.5	45195
2	Bio Power	703.3	16881
3	Bagasse co-generation	1048.73	5000
4	Small Hydropower(up to 25)	2429.67	15000
5	Energy Recovery From waste	92.97	2700
6	Solar photovoltaic power	2.12	-
7	Biomass / cogeneration	170.78	-
8	Biomass gasifies	105.46	-
	Total	14795.53	-

#### A. Optimistic Scenario

The optimistic scenario for the penetration of RES in 2010 is presented in Table 3. This predicts that the 2010 target will be realized by 80.4%, i.e. 9.86 TWh, as compared to 12.26 TWh [11]. The implementation of 50% of the investments for which installation permits have already been granted will continue without any obstacles. This assumption is realistic considering that these projects are at a mature stage, no appeals have been filed against them with the Council of State, access thereof to the grid has been guaranteed, and consequently it is possible to secure funds for these projects. The extensive works for enhancing local grids in the areas of Eastern Macedonia - Thrace will be completed, and thus it will be possible to implement 50% of the projects for which production authorizations have already been granted on condition that they will be implemented following the extension/enhancement of the System, of a capacity of 115MW.

TABLE 3: OPTIMISTIC SCENARIO- ESTIMATED POSSIBLE RES OUTPUT IN 2010.

Source	Installed capacity in (Sep 2009) [MW]	Installed permit (Sep 2010) [MW]	Additional wind farm due to already planned activity [MW]	Additional RES (50-80% of installation permit) [MW]	Estimated total capacity in 2010 [MW]	Estimated output in 2010 [TWh]
Wind	1140	1048	58	524	1722	3.92
Small-scale hydros	180	93		47	227	0.7
Large-scale hydros	3018		344	0	3362	4.57

Boimass	41	47		23	64	0.49
Geothermal				0	0	0
solar	37	83		66+30	133	0.18
total	3316	1271	402	690	5058	9.86

### B. Conservative scenario

The three conditions of the optimistic scenario described in this work that could prevent the realization of the target. That is why a more conservative scenario [11] has also been formulated, taking into account the following:

1. That 20% of the projects for which installation permits have already been granted (50% of PV systems and an additional 20MW from small-scale plants) will be implemented from the last months of 2009 up to the end of 2010.
2. That there will be a delay in the completion of the works for enhancing local grids in the areas of Eastern Macedonia – Thrace and the completion of the licensing process for relevant additional RES projects, and thus it will be possible to implement only 20% of the projects for which production authorizations have already been granted on condition that they will be implemented following the extension/enhancement of the System.
3. That the planned large-scale hydroelectric projects will not be implemented.

TABLE 4: CONSERVATIVE SCENARIO ESTIMATED POSSIBLE RES IN 2010.

Source	Installed capacity in (eally 2009) [2009]	Additional wind farms due to already planned activities[MW]	Additional RES in the rest of Greece[MW]	Conservative estimate of total capacity in 2010	Estimated output in 2010 [TWh]
Wind	1140	-35	-314	1373	3.13
Small-scale hydros	180	-	-28	199	0.61
Large- sacle hydros	3018	-344	0	3018	4.2
Boimass	41	-	-14	50	0.38
Geothermal	-	-		0	0
solar	37	-	-34	99	0.13
Total	4416	-397	-390	4739	8.45

According to the above scenario, the share of renewable energy in the gross electricity consumption will reach 69% of the target, as shown in Table 4, i.e. 13.85%. In view of the above, it is clear that additional measures and policies are required to realize the 20.1% target [11].

## VIII. RENEWABLE ENERGY POLICY

Several electricity policies in the last few years have talked about the need and priority to promote RE. Foremost Amongst them is the Electricity Act (2003) which de-licensed standalone generation and distribution systems in rural areas [12]. The National Electricity Policy (2005) also stresses the need for urgent electrification [13]. The New Tariff Policy (2006) stated that a minimum percentage of energy, as specified by the Regulatory Commission, is to be purchased from such sources [14]. The details of directive released by Indian government to promote renewable energy are discussed in later sections

### A. Electricity Act 2003

The Electricity Act 2003 provides that co-generation and generation of electricity from renewable sources would be promoted by the SERCs by providing suitable measures for connectivity with grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee. Such percentage for purchase of power from these sources should be made applicable for the promotional tariffs to be determined by the SERCs at the earliest. Progressively the share of electricity from renewable energy sources would need to be increased as prescribed by State Electricity Regulatory Commissions. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before renewable technologies compete, in terms of cost, with conventional sources, the Commission may determine an appropriate differential in prices to promote these technologies [12].

### B. National Rural Electrification Policies (NREP), 2006

The goals of NREP-2006, include provision of access to electricity to all households by the year 2009, quality and Reliable power supply at reasonable rates, and minimum lifeline consumption of one unit/ household/day as a merit Good by year 2012[15]. For villages/habitations where grid connectivity would not be feasible or not cost effective, off grid solutions based on stand-alone renewable based systems may be taken up for supply of electricity. Where these also are not feasible and if only alternative is to use isolated lighting technologies like solar photovoltaic, these may be adopted. However, such remote villages may not be designated as electrified. State governments have to be prepared and

notify a rural electrification plan in their respective states, which should map and detail the electrification delivery mechanism. The plan may be linked to an integrated with district development plans. The plan should also be intimated to the appropriate commission. Moreover, Gramapanchayat involve in it and shall issue the first certificate at the time of the village becoming eligible for declaration as electrified. Subsequently, the Gram Panchayat shall certify and confirm the electrified status of the village as on 31st March each year [15, 16]. Central Electricity Regulatory Commission (CERC) has a key role in rationalizing tariff of generating companies owned or controlled by the Central Government in consultation with State Electricity Regulatory Commission (SERC) [17]. At present India is sixth largest country in the world in electricity.

### *C. Integration In Power Systems Operating In A Competitive Environment*

Electricity market liberalization has also progressed, requiring huge changes in economic and financial issues and implying technical changes. Power systems have been evolving, with new methods and techniques but the overall philosophy of power system operation remains the same, with punctual changes. Addressing the new challenges, in a flexible and secure way, requires much deeper technological and methodological changes [18].

## **IX. CONCLUSION**

This paper presents the Renewable Energy capacity in India and installation of Renewable Energy Generation. Cumulative capacity additions planned in solar PV until 2012, Future trends expected in global solar PV industry. In this paper describe the area in which the more insolation of sun light is available in India, the solar power plant is installed in that place, types of solar cell technology, the conservative scenario and the optimistic scenario for the penetration of RES in 2010 is presented scenario presented and the 2010 target will be realized by 80.4%, i.e. 9.86 TWh, as compared to 12.26 TWh and also provide the Long term potential of solar power the grid connected photovoltaic power plant and its application. Renewable energy policy, electricity act 2003, national rural electrification policies (NREP), and 2006: Electricity market liberalization has also progressed integration in power systems operating in a competitive environment

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