Proposed Policy Roadmap for Solar Energy Development in India

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Organized By: -

World Institute of Sustainable Energy
Pune, India

Prepared By: -

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FOREWORD

Solar India 2007 is the first such event in India focused on solar energy development in the country. WISE is privileged to have taken the initiative to organize the same. The last three years have been high points in global solar energy development, with growth rates averaging 35%. If predictions are to be believed, this upward trend is only the beginning of a new cycle of growth. So, *Solar India 2007* has been scheduled at a very appropriate time.

One of the distinctive planned outcomes of the conference is to bring out a theme paper outlining a draft policy road map for development of solar energy in India. This is the first draft to be presented in the exclusive session on policy, to be chaired by Mr V Subramanian, Secretary to the Ministry of New and Renewable Energy, in the conference. Preparatory documentation of thousands of pages of global best practices and latest trends in technology, investments, financing, and policy has been done to facilitate the creation of this draft. ABPS Infrastructure Advisory, the Knowledge Partner of the conference, was ably supported by the team at WISE in this effort. This draft has been circulated in advance to about 30 selected distinguished stakeholder delegates.

Climate change and energy security have become twin critical concerns of our time. The main option for mitigation of climate change is to transition to a low-carbon energy economy. Solar energy offers enormous potential for a much-needed quick transition. As of now, although grid-grade solar power may seem expensive, vast possibilities of demand-side management using viable solar energy devices exist even today. Emerging technologies like 'concentrating solar power' (CSP) offer avenues for competitive production of electricity by as early as 2015. Alongwith other renewables like wind, biomass etc, solar energy can play a vital role in solving or ameliorating the two most critical problems of our time. What is required is an imaginative, forward-looking, and bold policy initiative. This document could just be the beginning of such a new path.

It is proposed that a Working Group consisting of stakeholders from various areas like government, industry, academia and civil society may be constituted during *Solar India 2007*. Post-conference, this group could carry forward the work of continuously refining the initiative, working out finer details of sub-sector policies and then pursuing their advocacy with the government. WISE will offer a platform and continuing secretarial assistance for this initiative to see it fructify in the near future. We believe in working with the government for policy development in the sustainable energy sector. We are thankful to ABPS Infrastructure Advisory, and especially its managing partner Mr. Balawant Joshi, for all the hard work in generating this draft. I am happy to present this document for discussion and further action.

(G. M. Pillai)
Director General

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1. INTRODUCTION

India is the seventh largest and the second most populous country, and the most populous liberal democracy, in the world. India has made rapid economic progress in the last decade and has become the third largest economy in terms of purchasing power. India's GDP is US $1103 billion, which makes it the twelfth largest economy in the world. With 9.4% growth in GDP in 2006/07, Indian economy is among the fastest growing economies in the world.

1.1 Energy Scenario in the Country

India has achieved tremendous success in developing its electricity systems. Commencing with a meagre installed capacity of about 1360 MW in 1947, the year the country attained independence, India's power sector grew substantially over the last six decades, and the installed capacity at the end of the Tenth Five-Year Plan increased to about 1,32,330 MW.

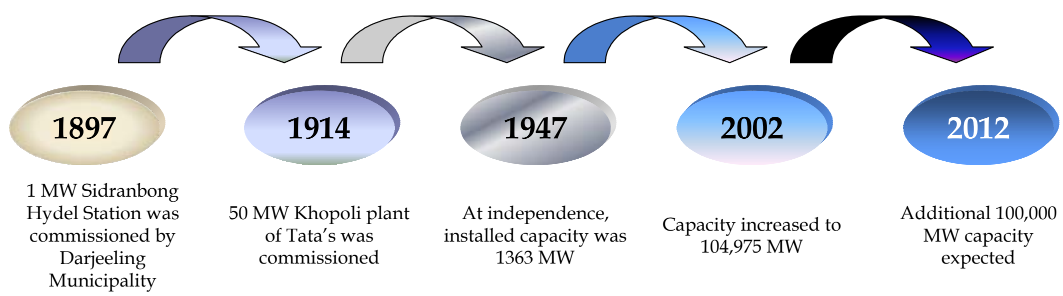
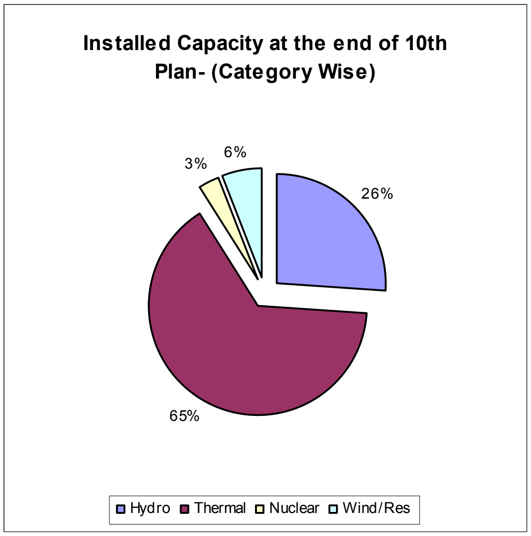


Fig 1.1: Growth of Electricity Generation Capacity in India

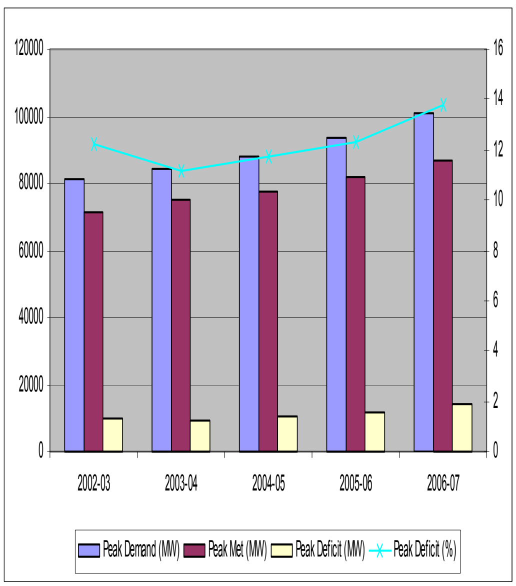
However, if India has to ensure a sustained GDP growth rate in excess of 8%, it has to ensure sufficient energy for industrial and commercial activity in the country, as energy is an essential input in the economy. Further, India has set itself an ambitious target of electrifying every village by 2008 and every household by 2009. Further, the Government of India desires that the annual per capita consumption increases to 1000 units from the current level of 660 units. The government would also like to ensure a minimum 'lifeline' consumption of 1 unit per household per day as a merit good by 2012.

In order to achieve this scale of supply and ensure sufficient electricity to all at reasonable rates, it is necessary not only to have an efficient and competitive power sector but also to explore all possible options of generating and supplying electricity.

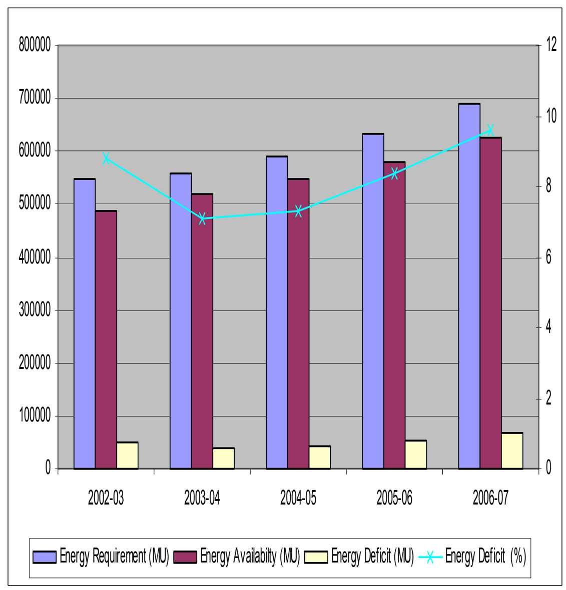


The current installed capacity (as on 31 March 2007) is about 1,32,330 MW. As shown in the adjacent graph, out of the total installed generation capacity, 65% is thermal, 26% hydro, 3% nuclear, and 6% renewable (including wind).

Despite impressive growth in the generation capacity since independence, India has always experienced shortage in terms of peaking capacity requirement as well as energy. In the recent past, capacity and energy shortages have increased to the level of 13.8% and 9.6% respectively, in the country as a whole.



Peaking Capacity Shortage in India



Energy Shortage in India

Figure 1.3: Energy and Peaking shortages in India

Considering that roughly 57% of rural households are yet to get access to electricity and that the government aims to provide electricity to all households by 2009, shortages of peaking capacity and energy willl only going to increase. Needless to say, all efforts need to be made to explore all energy supply options.

1.2 Need to develop Renewable Sources of Energy

As seen earlier, India has been dependent on fossil fuels such as coal, oil, and gas for its energy requirements. Today, more than 65% of its capacity is fossil-fuel dependent. In terms of energy, the share of fossil fuels is even higher. With recent discoveries of gas as well as initiatives to develop coal reserves, it is likely that our dependence on fossil fuels will continue in the near future. However, in the last couple of years, the price of fossil fuels has shown a consistent upward trend. The price of crude oil has touched USD 72/bbl and is expected to increase further.

India currently imports about 72% of its total oil consumption and this share of imported oil is expected to reach 90% by 2031/32; the story of coal imports is not expected to be significantly different. It is envisaged that India will import 50–60 MT of coal every year by the end of the 11th Five-Year Plan. According to scenarios developed as a part of the Integrated Energy Policy Report (IEPR) by the Planning Commission, imports could increase to as high as 45% of the total coal requirement.

The growing dependence on imported fuels raises several concerns. India's requirements of fossil fuels for the year 2030 based on the scenarios developed under IEPR are projected to be 337 to 462 MT of oil, 99 to 184 Mtoe of gas, and 602 to 954 Mtoe of coal. If the global fossil fuel supply increases by only 1.7%, as projected by IEA, India's share in 2030 would range from 5.8% to 8.0% for oil, 2.4% to 4.5% for natural gas, and 16.7% to 26.5% for coal. This will make the country vulnerable to price shocks as well as increase the risk of political arm-twisting by the supplying countries.

Given this scenario, it is of paramount importance that the country develops all possible domestic energy sources. India cannot afford to ignore any source of energy just because it is currently expensive, because the economic loss due to non-supply of electricity will be greater than the cost of selected sources of energy. Minimizing the dependence on import of conventional fuel and providing energy to all at affordable prices should be the main concerns of India's energy policy. Therefore, India must make every effort to harness indigenous renewable resources.

1.3 Role of Solar Power in Energy Security

While wind has been a success story in India and still has great potential, wind is extremely site-specific and therefore unsuitable for large-scale distributed generation. Further, the total wind potential (about 50 GW) in the country is much less than the total solar potential (about 600 GW). Further, this estimated potential is at current levels of technology efficiency; if the technology is improved, the potential could increase significantly.

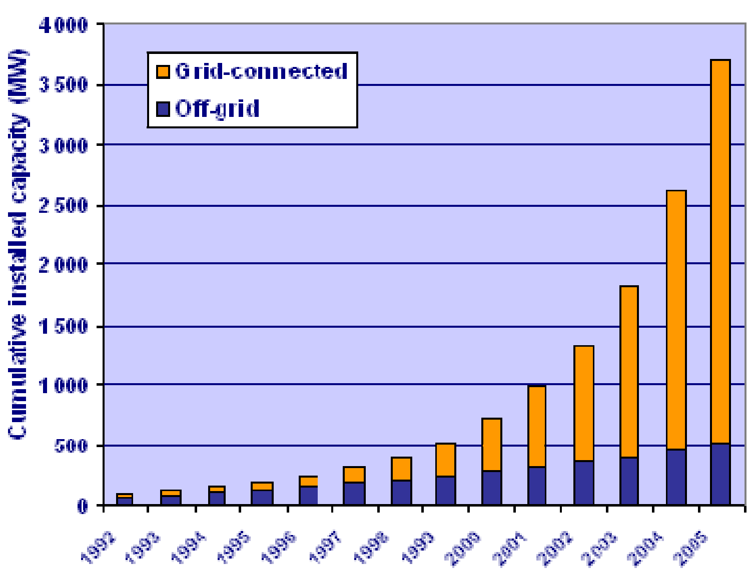
Moreover, solar energy systems do not require any fuel and, therefore, the running costs are lower. As a result, the cost of some of the solar energy systems such as solar water heaters, solar cookers, and solar lanterns can be lower than that of conventional energy products when calculated over the life of the systems. The other advantages of solar energy systems are that the systems are modular, long-lasting, and reliable and require low maintenance.

Therefore, the Government of India must make conscious efforts to develop this infinite source of power and develop appropriate strategies to promote accelerated use of the universally and freely available solar energy.

1.4 International Development of Solar Energy

It is useful to take a look at international developments in the field of solar energy. According to the IEA's factsheet *Renewables in Global Energy Supply*, the solar energy sector has been growing annually by 32% since 1971.

While we take a closer look at the various technologies and their applications in the next section, solar applications can be broadly divided into grid-connected and off-grid. Worldwide, grid-connected solar PV continues to be the fastest-growing power generation technology. The graph alongside depicts the growth in cumulative installed capacity using grid and off-grid PV technologies in IEA – PVPS countries between 1992 and 2005. It can be seen from the graph that worldwide, solar energy is being primarily used for grid connected generation and not merely for off-grid or rural energy applications.



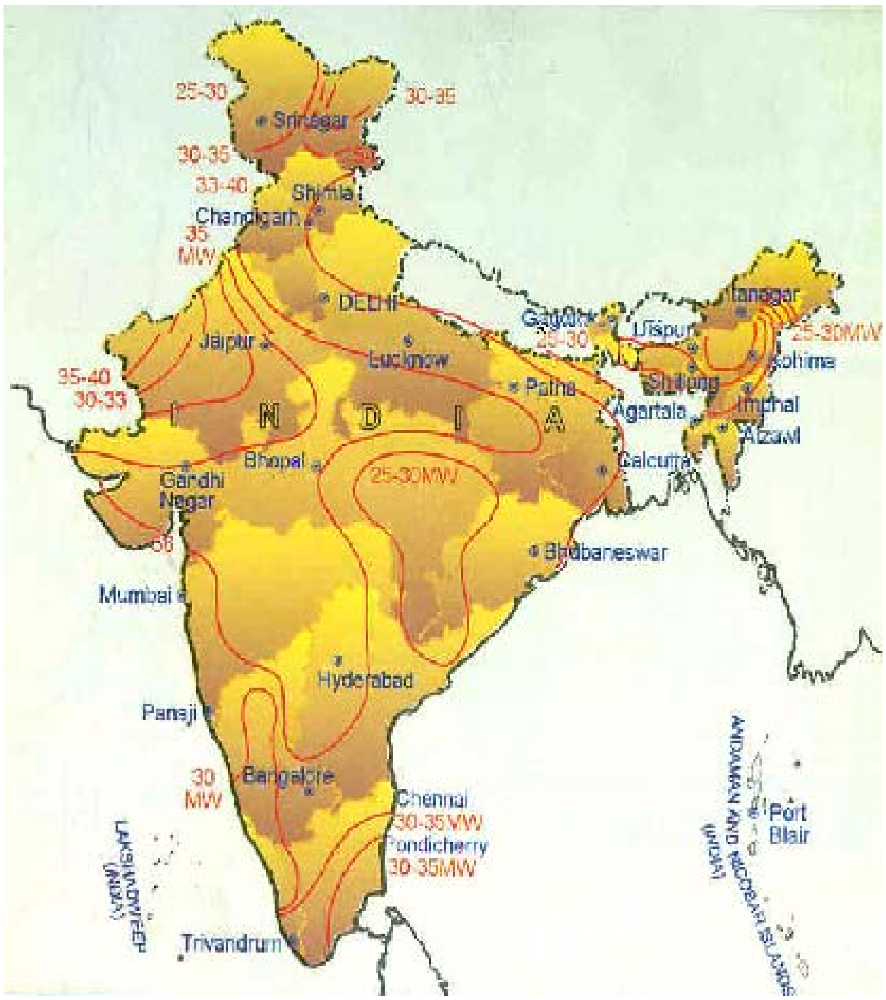
(Source: www.iea-pvps.org)

1.5 Potential for Solar Power in India

India receives solar energy equivalent to nearly 5,000 trillion kWh/year which is equivalent to 600 GW—far more than the country's total energy consumption today. But

India produces solar energy in negligible amounts, a mere 0.2% of that from other energy resources. Further, the entire electricity generation uses solar photovoltaic (SPV) technology: power generation using solar thermal technology is still in the experimental stage. Currently, India has only 2.74 MW of grid-connected solar PV capacity.

The following graph depicts solar energy potential in the country. While India receives solar radiation of 5 to 7 kWh/m² 300 to 330 days in a year, power generation potential using SPV is about 20 MW/km² and that using solar thermal generation about 35 MW/km².



1.6 *Achievements till date*

The Government of India and the state governments have attempted to promote the use of solar energy technologies in India, which has resulted in deployment of these technologies across India. The following table provides cumulative achievements under different renewable energy programmes as on 31 March 2007:

Grid-interactive renewable power	Installed capacity
Solar power	2.93 MW
Solar photovoltaic systems	
i. SPV street lighting systems	61,321 nos.
ii. SPV home lighting systems	313,859 nos.
iii SPV lanterns	565,658 nos.
iv. SPV power plants	1867.80 kWp
v. SPV pumps	7068 nos.
Solar thermal systems	
i. Solar water heating systems	1.90 million m^2 collector area
ii. Solar cookers	0.603 million

Source: Planning Commission

The solar PV programme began in the mid 1970s in India. While the world has progressed substantially in production of basic silicon mono-crystalline photovoltaic cells, India has failed to achieve the same momentum.

2. SOLAR ENERGY TECHNOLOGIES AND INTERNATIONAL DEVELOPMENTS

Solar energy technologies can be divided into two primary categories based on the mechanism used to covert solar energy into other useful forms of energy. The technology that converts solar radiation directly into electricity is popularly known as solar photovoltaic whereas technologies that convert solar radiation into thermal energy are called solar thermal technologies. Several applications have been developed using both the technologies. In this section, we discuss the technologies and in the next, the applications developed using these technologies.

1.7 Solar Photovoltaic

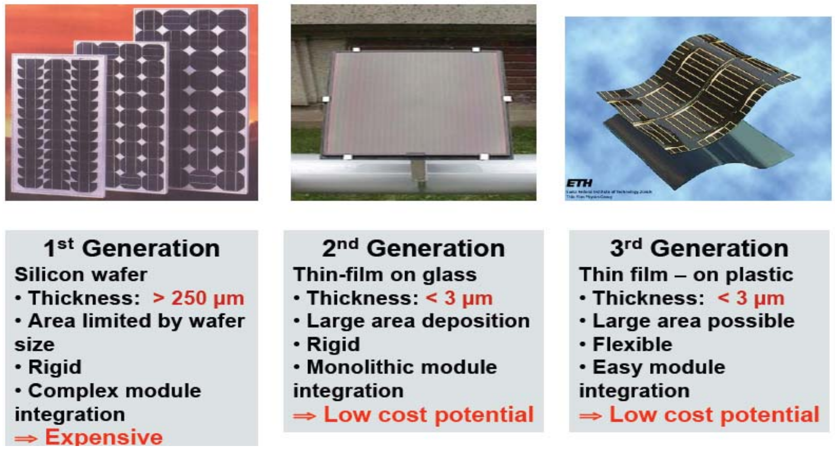
Photovoltaic, or PV for short, is a solar power technology that uses solar cells or solar photovoltaic arrays to convert light from the sun directly into electricity.

Solar cells produce direct current electricity from light, which can be used to power equipment or to charge batteries. Cells require protection from the environment and are packaged usually behind a glass sheet. When power that can be delivered by a single cell is insufficient, cells are electrically connected together to form photovoltaic modules, or solar panels. A single module is enough to power an emergency telephone, but for a house or a power plant, the modules must be arranged in arrays.

The first practical application of photovoltaics was to power orbiting satellites and other spacecraft and pocket calculators, but today around the world the majority of photovoltaic modules are used for grid-connected power generation. In this case, an inverter is required to convert the DC to AC.

The installation of photovoltaic cells has increased dramatically in recent years. Worldwide, total nominal 'peak power' of installed solar PV arrays was about 3700 MW at the end of 2005, a 42% increase over the 2004 levels, and most of this consisted of grid-connected applications. Although the selling price of modules is still too high to compete with grid electricity in most places, significant financial incentives in many countries have triggered a huge growth in demand.

Large numbers of solar technologies have been developed over the last few decades. The following chart lists the various technologies and shows how they are classified.



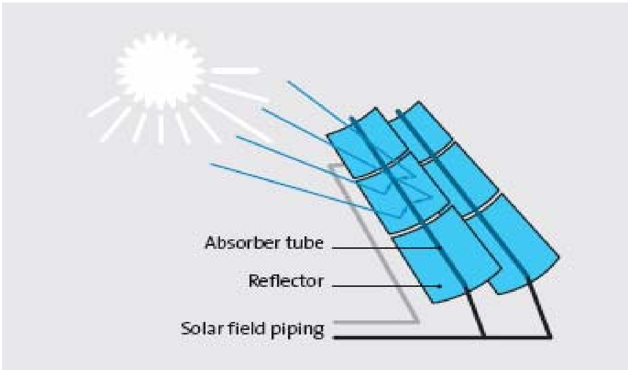
The limited market expansion of first- and second-generation silicon-based solar cell manufacturing is attributable to the hurdles in cutting production costs and material costs, silicon availability, and conversion efficiencies of modules. In contrast, however, the way forward has been brightened by many researchers through sustained efforts over more than two decades to create low-cost solar cells using nanotechnology. The world market is heading towards CIGS (copper-indium-gallenium-selenide) semiconductor technology for electricity generation. CIGS are multi-layered thin film composites. Unlike the basic silicon solar cells, which can be modelled as a simple p-n junction, these cells are best described by more complex hetero-junction models. The best efficiency of thin film solar cells as on December 2005 was 19.5% with CIGS. Theoretically, maximum efficiency of CIGS could reach 33%, while realistically achievable efficiency is 22%.

1.8 Solar Thermal or Concentrated Solar Power

Solar thermal power systems convert short-wave direct sunlight radiation into long-wave heat radiation or use the heat radiating from the earth's surface. The heat is used to produce a gas flow, which is fed to a turbine. The turbines that produce the power in a solar thermal power plant are of the same kind as those used in fossil-fuel-fired power plants, hydro plants, or wind generators. The gas flow produced by a specific technology, like steam, hot dry air, or cooled wet air, determines which kind of turbine is used. Because solar thermal power uses direct sunlight, the number of hours with a clear sky determines the suitability of an area for solar thermal power applications. Therefore, the hours of power production coincide theoretically with the hours of sunshine. However, with some adaptations, such as energy storage, it is possible to control the hours of power production. The application of the produced heat distinguishes a concentrating solar thermal power system from a solar thermal hot water system for residential buildings. A solar thermal system for a residential building uses the produced heat for low- to medium-temperature warm water or air for space and water heating. Solar thermal power technologies can roughly be divided into three main categories.

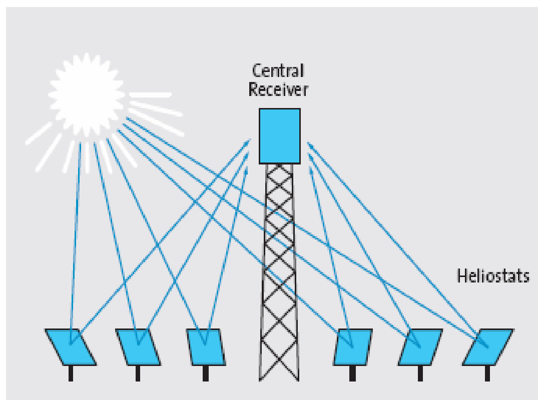
1.8.1 Parabolic trough system

Parabolic trough-shaped mirror reflectors are used to concentrate sunlight on thermally efficient receiver tubes placed in the trough's focal line. A thermal transfer fluid, such as synthetic thermal oil, is circulated in these tubes. Heated to approximately 400 °C by concentrated rays of the sun, this oil is then pumped through a series of heat exchangers to produce superheated steam. The steam is converted to electrical energy in a conventional steam turbine generator, which can either be part of a conventional steam cycle or integrated into a combined steam and gas turbine cycle.



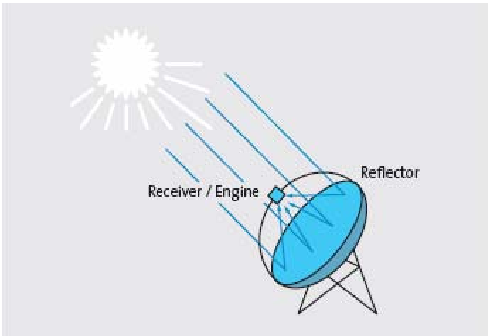
1.8.2 Power tower system

A circular array of heliostats (large individually-tracking mirrors) is used to concentrate sunlight on a central receiver mounted at the top of a tower. A heat-transfer medium in this central receiver absorbs the highly concentrated radiation reflected by the heliostats and converts it into thermal energy to be used for the subsequent generation of superheated steam for turbine operation. To date, the heat transfer media demonstrated include water/steam, molten salts, liquid sodium and, air. If pressurized gas or air at very high temperatures of about 1000 °C or more is used as the heat transfer medium, it can even be used to directly replace natural gas in a gas turbine, thus making use of the excellent cycle efficiency (60% and more) of modern gas and steam combined cycles.



1.8.3 Parabolic dish systems

A parabolic dish-shaped reflector is used for concentrating sunlight on a receiver located at the focal point of the dish. The concentrated beam radiation is absorbed by the receiver to heat a liquid or gas (air) to approximately 750 °C. This liquid or gas is then used to generate electricity in a small piston or Stirling engine or a micro turbine attached to the receiver.



Each technology has its own characteristics, advantages, and disadvantages, some of which are detailed in the following table.

1.8.4 Comparison of solar thermal power technologies

	Parabolic trough	**Central receiver**	**Parabolic dish**
Applications	Grid-connected plants, mid- to high process heat (highest single-unit solar capacity to date: 80 MWe). Total capacity built: 354 MW	Grid-connected plants, high temperature process heat (highest single-unit solar capacity to date: 10 MWe). Total capacity built: about 11 MW	Stand-alone, small, off-grid power systems or clustered to larger grid-connected dish parks (highest single unit solar capacity to date: 25 kWe). In recent designs, the uni size is about 10 kW.
Advantages	▪ Commercially available; over 12 billion kWh of operational experience; operating temperature potential up to 500 °C (400 °C commercially proven) ▪ Commercially proven annual net plant	▪ Good mid-term prospects for high conversion efficiencies, operating temperature potential beyond 1000 °C (565 °C proven at 10 MW scale)	▪ Very high conversion efficiencies: peak solar to net electric conversion over 30% ▪ Modularity ▪ Hybrid operation possible ▪ Operational

	efficiency of 14% (solar radiation to net electric output) ▪ Commercially proven investment and operating costs ▪ Modularity ▪ Best land-use factor among all solar technologies ▪ Lowest requirement of materials ▪ Hybrid concept proven ▪ Storage capability	▪ Storage at high temperatures ▪ Hybrid operation possible	experience of first demonstration projects
Disadvantages	▪ The use of oil-based heat transfer media restricts operating temperatures today to 400 °C, resulting in steam of only moderate quality	▪ Projected annual performance values, investment and operating costs still need to be proven in commercial operations	▪ Reliability needs to be improved ▪ Projected cost goals of mass production still need to be achieved

1.9 Status of Indian Industry

Although India has negligible quantum of installations as compared to potential, India ranks 5th in solar PV installations and 9th in solar thermal application installations in the world. Currently, India has 10–12 manufacturers producing about 100 MW of solar PV cells and about 20 manufacturers with total installed capacity of 120 MW in module manufacturing. India also has a large number of integrators-cum-service providers (about 80) with total capacity of about 245 MW. India exports 160 MW of solar PV products to other developed and developing countries.

With regard to solar thermal application, India has more than 200 manufacturers of solar water heaters and 40 of solar cookers. Also, 5–6 manufacturers are involved in producing solar drying, cooking, process heat, and air-conditioning applications. It is expected that several players will enter solar thermal application development in the coming months.

Recently, several companies such as Tata BP Solar, Signet Solar, and Moser Baer have announced multi-million-dollar plans for investment in solar cell manufacturing capacities in the country. With announcement of the semiconductor policy in March 2007, it is envisaged that several multinational companies will enter silicon manufacturing as well as solar cell manufacturing.

1.10 Solar Technology Applications

Both solar photovoltaic as well as solar thermal technologies have several applications. As depicted in the following paragraph, these applications could be divided into two primary categories, namely grid-connected and off-grid.

	PV	Thermal
GRID connected	BIPV	Solar Trough, Solar Power Tower, Parabolic Dish,Fresnel reflectors
OFF-GRID	**Agriculture** • water pumping, irrigation • electric fencing for livestock and range management	Solar Cooker Room heating Industrial process Heat Food Processing Solar Air conditioning Solar Crop drying Solar Water Heating Chemical Production Metal production
	Community • water pumping, desalination and purification systems lighting for schools and other community buildings	
	Domestic • lighting, enabling studying, reading, income-producing activities and general increase in living standards • TV, radio, and other small appliances • water pumping	
	Healthcare • lighting for wards, operating theatre and staff quarters • medical equipment • refrigeration for vaccines • communications (telephone, radio communications systems) • water pumping • security lighting	
	Small enterprises • lighting systems, to extend business hours and increase productivity • power for small equipment, such as sewing machines, freezers, grain grinders, battery charging • lighting and radio in restaurants, stores and other facilities	

3. CONTEXT OF PROPOSED POLICY ROADMAP

Over the last several years, the Indian economy has been growing annually at more than 8%. To sustain this growth, it is necessary to provide energy in sufficient quantity and at affordable rates. Further, integration of domestic markets with the global markets for fuel has led the volatility of fuel prices in international markets being reflected in Indian energy prices. This is raising concerns of energy security among policy-makers.

India has made several efforts to develop domestic energy resources. Through various rounds of the New Exploration and Licensing Policy (NELP), the government has involved the private sector in exploration of various off-shore and on-shore exploration blocks. Further, the government has also invited private-sector participation in another important energy sector, namely coal and coal bed methane. At the same time, the government has initiated dialogue with other countries for expanding its nuclear energy generation capability.

While these efforts are certainly required, it is also necessary that adequate efforts are made to improve the utilization of indigenous renewable resources. In the 1990s, the government adopted a liberal policy for the development of wind sector in India. As a result, India achieved remarkable success in developing wind power. Today, India has the fourth largest wind power capacity in the world. Now, it is necessary to turn our attention towards another important renewable resource, namely solar energy.

In this section, we give an overview of the various policy and legislative initiatives undertaken by the Government of India towards development of energy resources.

a. Enactment of Electricity Act 2003

Enactments prior to the Electricity Act, 2003 (EA 2003), had no specific provisions to promote renewable or non-conventional sources of energy. As a consequence, the policies for renewable sources of energy were left to the whims and fancies of state governments and electricity boards although the Ministry of Non-conventional Energy Sources (MNES; now MNRE, the Ministry of New and Renewable Energy) attempted to give impetus to the sector by way of policy guidelines in 1994/95. These efforts had mixed results. However, EA 2003 has radically changed the legal and regulatory framework for the renewable energy sector by providing for policy formulation by the Government of India and making it mandatory for state electricity regulatory commissions (SERCs) to take steps to promote renewable and non-conventional sources of energy within their area of jurisdiction. In fact, Section 3 of EA 2003 clearly mandates that the formulation of the National Electricity Policy, Tariff Policy and Plan thereof for development of power systems shall be based on optimal utilization of all resources including renewable sources of energy. Further, EA 2003 has specific provisions for determination of feed-in tariffs for renewable energy sources as well as for creation of renewable portfolio standards for states.

Section 61 of EA 2003 (reproduced below) prescribes the philosophy to be followed by SERCs while determining tariffs.

> *"61. The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely …*
>
> *(h) the promotion of co-generation and generation of electricity from renewable sources of energy;"*

For the first time, promotion of cogeneration and generation of electricity from renewable sources of energy has been made the explicit responsibility of SERCs, which are bound to take these considerations into account while drafting their 'Terms and Conditions of Tariff' regulations. Several SERCs have issued their tariff regulations incorporating suitable clauses, which will enable SERCs to offer preferential treatment to renewable energy sources during the tariff determination process.

While Section 61 (h) of EA 2003 is important from the perspective of the determination of preferential tariffs, probably the most important section in EA 2003 from the perspective of renewable energy is Section 86 (1)(e), which reads as follows:

> *"86. The State Commission shall discharge following functions, namely*
>
> *…*
>
> *(e) promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee"*.

Under this section, many SERCs have specified the percentage for purchase of renewable energy out of total energy input into the distribution system of licensee. There is a significant variation in the target percentage specified by various SERCs, which reflects the difference in the potential of renewable sources of energy in different states. The Tamil Nadu Electricity Regulatory Commission has specified a target as high as 10%, whereas the Madhya Pradesh Electricity Regulatory Commission has specified a target of only 0.5% for distribution utilities in its jurisdiction. This is a direct consequence of the fact that Tamil Nadu has huge wind potential whereas Madhya Pradesh is not endowed with any significant renewable resources.

b. *Integrated Energy Policy Report (IEPR)*

The Government of India, realizing that energy is a vital input to the economy, because it is necessary to ensure reliable availability of energy to sustain higher growth rates, directed the Planning Commission to constitute an expert committee to undertake a comprehensive review and to make policy recommendations on this subject. The expert committee was constituted with Dr Kirit Parikh, Member, Planning Commission, as the chair. The expert committee submitted its final report, titled the *Integrated Energy Policy Report*. The specific recommendations made in this report are valuable inputs for policy-making and development of the 11th Five-Year Plan. In the following paragraphs, we give excerpts related to solar power development in India.

Renewable Energy Resources [Chapter 3 Para 12 of IEPR]

Given the limited amount of domestic resources of conventional energy sources, renewable energy resources become important. It may be noted that many renewables require land. The potential indicated for each option is assessed independently. If all such options are developed together, the combined potential may be less than the sum as we would run out of available land for energy generation as other competing land uses may dominate.

Renewable Energy Resources [Table 3.5 of IEPR, excerpt related to Solar]

Resources	Unit	Present	Potential	Basis of Accessing Potential
Photovoltaic	Mtoe/year	-	1200	Expected by utilising 5 million Ha wasteland at an efficiency level of 15 percent of solar Photovoltaic Cells
Thermal	Mtoe/year	-	1200	MWe scale power plants using 5 million Ha

Source: Respective Line Ministries

Solar Energy [Chapter 3 Para 21 & 22 of IEPR]

Solar energy has a large potential in the country. The average solar insolation in the country is 6 kWh/m^2/day. The present conversion efficiency of commercially available photovoltaic cells is less than 15%. With this efficiency, the potential of covering just 5 million hectares of land with photovoltaic cells is 1200 mtoe/year. The photovoltaic technology is proven but expensive and the cost of electricity exceeds Rs 20/kWh at present. Potential to reduce costs and increase efficiency exists and a technology mission for this is highly desirable.

Solar thermal is economical for water heating. Much of its potential has yet to be exploited. Appropriate policies need to be designed to accelerate the exploitation of this potential. Solar thermal generation has not found acceptance globally, though the potential to use it in hybrid systems may be there.

Developing solar power [Chapter 3 Para 37 of IEPR]

As suggested by President Kalam, if efficiency of solar photovoltaic can be increased from the present 15% to 50% without increasing the cost, we can have all the power we need at competitive costs by covering a small fraction of our land (the land required can be further reduced by putting photovoltaic cells on all rooftops).The surplus solar power during daytime can be used to split water to produce hydrogen that can provide electricity at night and can also be used to run motor vehicles using fuel cells as engines.

Energy Security [Chapter 4 Para 16 (g) of IEPR]

New domestic sources: The domestic resource base can also be expanded through developing hitherto poorly developed or new sources of energy. Some of these resources may require R&D to make them economical. Among these are …

Solar: Solar energy, if it can be economically exploited, constitutes a major energy resource of the country. Solar electricity generated through thermal route or through photovoltaic cells provides comparable amount of electricity per unit of collector area. Both currently provide about 15% conversion efficiency. While it is clear that the ratio of capital cost to efficiency of energy conversion needs to be brought down significantly, solar thermal and solar photovoltaic route to electricity offers major scope for enhancing India's energy security. Nanotechnology holds a hope for making a major breakthrough in solar photovoltaic technology. It is stressed here that solar water heating is cost-effective for India today and can reduce India's demand for oil, gas, and coal if pursued to meet the demand for hot water in industry and households.

Policy for Renewable and Non-Conventional Energy Sources [Chapter 7 Para 3 of IEPR]

Respective power regulators should mandate feed-in laws for renewable energy, where appropriate, as provided under the Electricity Act and as mandated in many countries.

The following specific policies to promote various renewables are recommended.

Solar thermal water heaters (*SWH*): Solar water heaters are economical and the main barrier is the expense of retrofitting in households and industries. To encourage all new buildings and factories to have SWHs, the heaters may be made mandatory. Alternatively incentives may be given in the form of rebates, rebates in transfer fees or in electricity connection charges. The last two are preferable as they are one-time rebates. Government property including defence and public sector account for a significant amount of new construction, and installation of SWH should be made compulsory in government buildings.

Solar thermal power plants: The economic viability of solar thermal plants has not yet been fully established. To encourage entrepreneurs to invest in the technology, a higher premium on feed-in tariff may be given. The higher premium can be justified on grounds of the higher risk and may be made available only to the first 5000 MW of solar thermal plants.

Solar photovoltaic: Although the present cost is very high, since the ultimate potential is very large, incentive to commercialize and lower the cost may be provided through a higher feed-in tariff, again for the first 5000 MW of installed capacity.

Capital costs and the typical cost of generated electricity from the renewable options [Table 7.1 of IEPR]

Source	**Capital Cost (Rs. Crore/MW)**	**Estimated Cost of Generation (Rs./kWh)**	**Total Installed Capacity (MW)**
Solar Photovoltaic	26.5	15.00-20.00	2.54

Source: Ministry of Non-Conventional Energy Sources (MNES)

Energy R&D [Chapter 9 Para 5 (a) of IEPR]

The following technology missions are suggested.

Solar technology mission: Solar technology is often seen as relevant to niche applications. Given that solar energy is one of our major energy sources and the only renewable energy source with sufficient potential to meet almost all our energy needs, we should give a high priority to development of solar technology for large-scale deployment. A technology mission should be mounted to bring down the cost of solar photovoltaics or solar thermal by a factor of five as soon as possible.

c. *Eleventh Plan Proposal of Ministry of New and Renewable Energy (MNRE)*

A working group under the chairmanship of Secretary, MNRE, was constituted by the Planning Commission to formulate proposals for the 11th Five-Year Plan (2007–2012) of the Ministry of New and Renewable Energy. The working group created four task forces to develop proposals for the following four areas:

i. renewable power
ii. renewables for urban, industrial, and commercial applications
iii. renewables for rural areas
iv. R&D in renewable energy

In this section, we discuss the proposals for the 11th Five-Year Plan with regard to solar energy development in the country.

i. Grid Interactive and Distributed Renewable Power

A physical target of 15,000 MW with an outlay of Rs 3925 crore is proposed for grid interactive/distributed renewable power generation for the 11th Plan, which includes solar programme, the details of which are given below.

Programme	Physical target (MW)	Proposed outlay
Solar power (Grid-interactive/DRPS)	50	Rs 200 crore Subsidy limited to Rs 50,000 per household

To achieve this target, a provision of Rs 200 crore has been made for subsidy. However, while subsidy has been proposed, a caveat has been inserted, which states that subsidy will be provided when technology improves, costs come down, and the unit cost of generation is at par with small hydro power. This is impractical, and may effectively mean that the subsidy is not going to be disbursed.

Further, subsidies are proposed to be disbursed in the following manner.

Special-category states (NE region, Sikkim, J&K, HP, Uttaranchal)	General-category states
Rs 30,000/kW_p	Rs 30,000/kW_p** for residential/commercial purposes (**subsidy per household limited to Rs 50,000)

Rs 50,000/kW_p	Rs 50,000/kW For community/institutional purposes

ii. Renewable Energy for Rural Applications

Under the area of renewable energy for rural applications, the Ministry is primarily promoting two programmes, namely Remote Village Renewable Energy and Grid-Connected Village Renewable Energy. Different types of approaches and subsidies have been suggested for these two programmes. As stated earlier, in this section we look at areas relevant to solar energy development.

1. Remote Village Renewable Energy Programme

The Remote Village Renewable Energy Programme (RVREP) will include Remote Village Solar Lighting Programme (RVSLP), which will provide only lighting service through SPV home-lighting devices in remote villages where DRPS under VESP or DGS under RGGVY is not feasible and cost-effective. It is proposed to provide single-light SPV systems for 9000 remote villages/hamlets (each with about a hundred households) @ 90% of actual system cost or Rs 7200/system/household, whichever is less.

2. Grid-Connected Village Renewable Energy Programme

The Grid-Connected Village Renewable Energy Programme (GVREP) will provide support to only off-grid applications such as solar thermal cooking, hot water, and drying applications. The following subsidy levels are proposed for renewable energy systems/devices envisaged to be set up under GVREP.

Solar thermal systems:

Application	**Subsidy (Rs/m²)**
Hhot water	1500
Cooking and drying	1250
Concentrating cooker	2500

SPV Systems:

As per the general principle of not encouraging solar SPV systems where grid has reached, subsidy is not proposed for SPV systems/devices under GVREP. Instead, it is suggested that such systems/devices should be promoted through fiscal concessions only in electrified or to-be-electrified areas.

3. Proposed Physical Targets and Financial Outlays

The proposed physical targets and financial outlays for various components of the rural energy programme for the 11th Plan are summarized below.

Programme Component	**Physical Target (in Nos. of remote Villages/ hamlets)**	**Proposed outlay (Rs. crore)**
RVSLP:	9000	650
GVREP: **Subsidy @ upto 25% of normative system / device cost; and @ upto 33% in Special Category States.**		
Solar thermal systems	Collector area	
Flat plate collectors for hot water: @ Rs.1500/m² [*]	**1 million m²**	**150**
Cooking & drying applications @ Rs.1250/ m² [**] (box type cookers & flat plate solar collectors)	**0.5 million m²**	**50**
Concentrating cooker applications @ Rs.2500/m² [***]	0.1 million m²	**25**
	TOTAL	**875**

* @ Rs. 1250/m² for general category states and Rs.1650/m² for special category states

** @ Rs. 1125/m² for general category states and Rs.1500/m² for special category states

*** @ Rs. 2250/m² for general category states and Rs.3000/m² for special category states

iii. RE for Urban, Industrial and Commercial Applications

The MNRE has proposed several activities to promote the use of solar energy in urban areas. One of the major activities proposed is to use solar energy as a demand-side management measure, thereby reducing the load on electricity grids. Major activities proposed are as follows.

1. Solar Passive Architecture

Energy efficient buildings can be designed through solar passive architecture concepts so that energy requirements of heating and cooling could be reduced. Solar buildings that cost an additional 5%–10% have the potential of saving up to 30%–40% energy. Subsidy for preparation of DPR and construction of such buildings is proposed for continuation during the 11th Plan @ Rs 100/m² of covered area for which a provision of Rs 50 crore is proposed. In addition, Rs 25/m² is proposed for training and another Rs 25/ m² for information and publicity, for which there exists a subsidy provision of Rs 12.5 crore.

2. Akshay Urja Shops

The Ministry has been providing subsidy for the establishment of Aditya solar shops, renamed Akshay Urja shops, with a view to facilitating availability of solar energy products. The target for the 11th Plan is 2000 Akshay Urja shops for which a subsidy of Rs 48 crore is proposed @ Rs 2.40 lakh per shop besides another Rs 7 crore towards interest subsidy on loans to be taken by the entrepreneurs for setting up these shops. A total subsidy provision of Rs 55 crore is accordingly proposed,which will be linked with actual VAT payments by these outlets to facilitate monitoring.

3. Physical Targets & Financial Requirements for XIth Plan

The following table provides details of physical targets and financial outlays for activities proposed under this programme.

Programme component	**Physical target**	**Subsidy level**	**Financial requirements (Rs. crore)**
Solar thermal systems/ devices - water heating - drying -other (steam generation) - instl./prog. support - mun. Corpns. – incentive	10 million. m^2 collector area 9.50 million m^2 0.25 million m^2 0.25 million m^2 - 100 nos.	 1550/m^2* 1250/ m^2 2500/ m^2 - @ Rs. 10 lakh each	521.55 Say 522.00 375.00 31.25 62.50 50.00** 10.00
Energy-efficient buildings	5 million m^2 floor area	Rs.100/ m^2	50
Akshay Urja Shops	2000 nos.	Incentive + recurring grant : Upto Rs.2.40 lakh/ shop + interest subsidy	55
Solar Cities	100 nos.	Rs. 50 lakh / city	50
			684.20 ~ 685

* Subsidy for only 2.5 million m^2 targeted during first 2 years of the Plan.

** @ 200/ m^2 to motivators and banks for 2.5 million m^2 water heating systems targeted with subsidy during first 2 years of the Plan.

iv. Research, Design & Development in RE

The Plan proposals prepared by MNRE have suggested an amount of Rs 1500 crore to support research, design, and development (RD&D) of new and renewable energy technologies. The proposals have indicated several areas for RD&D in solar energy.

Solar Photovoltaic Energy

- Silicon and other materials
- Crystallize silicon solar cells
- Thin-film solar cell modules
- New-materials-based solar cells
- Concentrating solar cells & modules
- PV systems; storage, balance of system, modules, designs

Solar Thermal Energy

- Solar thermal power generation
- Solar heat (up to 250 °C) for industrial processes
- Low-temperature applications

In order to take up the above mentioned activities, financial outlay of Rs 400 Crore has been proposed in the 11th Plan proposal. A breakdown of the proposed outlay by activity is given in the following table.

Sl.	Area	Amount (Rs. in crore)
	Solar Energy Centre:	**400**
1	Centre	40
2	Solar Thermal	140
3	Solar Photovoltaic	220

v. Supporting Programmes

A total budget provision of Rs 525 crore is proposed for information, publicity, and extension activities in the 11th Plan period of which Rs 262.50 crore is proposed for solar energy programme in the following manner.

Sl.	Programme	Rs. crore
1	SPV/ Hybrid/ SPV devices/ other RE devices	250.00
2	Solar Passive Architecture - Training & Publicity	12.50
	Total	**262.50**

vi. Summary of Plan Proposals

The budget provision proposed in 11th Plan proposals for various solar energy programmes/activities proposed is summarized below.

Sl.	Plan	Rs. Crore
1	Grid-interactive & Distributed Renewable Power	200.00
2	RE for Rural Applications	875.00
3	RE for Urban, industrial and commercial applications	685.00
4	Research Design& Development	400.00
5	Supporting Programmes	262.50
	Total for Solar Energy Development	**2422.5**

vii. Perspective Plan for Solar Energy for Urban, Industrial and Commercial Applications

Programmes	2012	2022	2032
Solar thermal systems/ devices	10 million m^2 collector area	30 million m^2	50 million m^2
Energy-efficient Buildings	5 million m^2 floor area (1000 buildings)	20 million m^2	40 million m^2
Akshay Urja Shops	2000 nos.	-	-

(**Source**: Planning Commission Report of Working Group for XIth Five Year Plan)

4. EXISTING POLICIES & PROGRAMMES

The Ministry of New and Renewable Energy (earlier known as the Ministry of Non-conventional Energy Sources) has initiated innovative schemes to accelerate utilization and exploitation of solar energy. A number of incentives such as a subsidy, soft loan, 80% accelerated depreciation, concessional duty on import of raw materials and certain products, and excise duty exemption on certain devices/systems are being provided for the production and use of solar energy systems. The Indian Renewable Energy Development Agency (IREDA), a public limited company established in 1987, provides a revolving fund to financing and leasing companies offering affordable credit for the purchase of PV systems. In this section, we give an overview of the existing policies and programmes of the Government of India for development of solar energy.

a. Capital Subsidy

The MNRE has been running several capital subsidy programmes, the details of which are given in Annexes 1 to 4 of this document. These subsidies are provided on installation of the equipment; they are not linked to the use or performance of the equipment. The MNRE is currently running the subsidy scheme for following items of equipment in solar energy segment:

a. solar water heating systems
b. cookers, lanterns
c. drying applications
d. other steam generation applications
e. pumping systems
f. solar wind hybrid systems.

In one such scheme, the MNRE has been providing assistance towards installation of solar PV water pumping systems for irrigation and drinking water applications through subsidy since 1993/94. Typically, a 1800 Wp PV array capacity solar PV water pumping system, which costs about Rs 3.65 lakh, is being used for irrigation purposes. The Ministry provides a subsidy of Rs 30 per watt of PV array capacity used, subject to a maximum of Rs 50,000 per system. The majority of the pumps fitted with a 200 watt to 3000 watt motor are powered with a 1800 Wp PV array, which can deliver about 1,40,000 litres of water/day from a total head of 10 metres.

It has been the intention of the government to reduce the capital subsidies and develop schemes that encourage performance of the installed equipment. The government is in the process of phasing out capital subsidies. One of the first casualties of the decision of the government has been the solar energy sector, as the Government of India has stopped providing capital subsidy to grid-connected solar photovoltaic systems.

b. *Interest Subsidy*

The government has been providing subsidies in the form of reduction in the interest rate for financing installation of equipment. Currently, interest subsidy is available to end-users of solar thermal programme, for both domestic and commercial applications. The interest subsidy is available only for term loans funded by IREDA. Interest subsidy of 2% is given under such programmes, i.e. if the prevailing interest of IREDA is, say, 12%, the loans for solar thermal programmes will be given at 10%, i.e. a reduction of 2%.

Box: Interest Rate Subsidy for Solar PV Systems

A four-year US $7.6-million effort was launched in April 2003 to help accelerate the market for financing solar home systems in southern India. The project is a partnership between UNEP's Energy branch, UNEP Risoe Centre (URC), and two of India's major banking groups – Canara Bank and Syndicate Bank – and Grameen banks sponsored by them. As per the existing policy, foreign direct investment (FDI) up to 100% is permitted in non-conventional-energy sector through the automatic route. The FDI received in non-conventional-energy sector from January 2003 to September 2006 is estimated at about Rs 35 crore.

c. *Sales Tax Benefit*

The development of wind energy generation in some states, including Maharashtra, was linked significantly to the fiscal incentive given to the developers in the form of sales tax incentive. The salient features of the sales tax benefit for wind energy generation are given below.

- Wind power projects were entitled to a sales tax incentive of Rs 5 crore per megawatt, which could be availed of either as a deferment or a waiver for 6 consecutive years. For every year, the benefit was limited to 1/6th of the qualifying investment. Investments in plant and machinery, new building, land development, and technical development and design in a wind power project were considered as qualifying investment.
- The developer was allowed to change from sales tax deferment to sales tax exemption or vice versa only once in 6 years.
- The sales tax incentive was transferable to a different party every year.
- sales tax benefit could be availed of on the finished product as well as on the raw materials used.

- The promoter was not eligible for sales tax benefit for use of second-hand machinery and old wind electric generator.
- The sites approved by MNES were eligible for sales tax benefit.

Sales tax benefits have been offered to other sectors also, with the aim of encouraging investment in the sector and ensuring long-term benefits. However, many states have opted for implementation of value-added tax (VAT) in place of sales tax. VAT, in simple terms, is a multi-point levy on each of the entities in the supply chain with the facility of set-off of input tax, which is the tax paid at the stage of purchase of goods by a trader and on purchase of raw materials by a manufacturer. Only the value added by each of the entities is subject to tax. As a consequence of the switch to a VAT regime, sales tax benefits have also been phased out.

d. Use of SWHS in buildings

Currently, solar thermal applications in use are all off-grid applications and require different methodologies for promotion. Typically, rebates are given in utility bills or property taxes for installation of these systems. One widely used thermal application is the solar water heating system (SWHS). However, implementation of the scheme is tedious as several authorities are involved in implementation of any scheme involving SWHS. First, the states have to issue orders to the municipalities within the state on making the SWHS compulsory. As of date, thirteen states and two union territories have issued orders making installation of the SWHS mandatory in certain categories of new buildings. The states are Andhra Pradesh, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Madhya Pradesh, Maharashtra, Nagaland, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and Uttarakhand, the union territories being Chandigarh and Dadra and Nagar Haveli.

However, for these orders to take effect, it is essential that the municipal corporations amend their building bye-laws. Movement has been very slow on this part, as so far, only 13 municipal corporations spread across the above states and union territories have amended their building bye-laws. Three, namely Thane, Amravati, and Durgapur provide 6%–10 % rebate in property tax on installation of solar water heaters.

Other states have provided rebates or incentives in the form of rebate by the local distribution licensees. Some examples of the rebate are as given below.

States	Rebate
Assam	Rs.40/month
Rajasthan	15 paise/unit
Haryana	Rs.100 / 100 LPD upto 300 LPD
Karnataka	50 Paise/unit
Uttaranchal	Rs.75 /sq.m.
West Bengal	40 paise to max of Rs.80

e. Research & Development (R&D)

There are a number of R&D projects on solar PV in India. The Solar Energy Centre was established by the Government of India as a part of the MNRE to undertake activities related to design, development, testing, standardization, consultancy, training, and information dissemination in the field of solar energy. Recently, development of polycrystalline silicon, thin-film solar cells, and small-area solar cells has been initiated at the Indian Association for the Cultivation of Science (IACS) at Jadavpur University. The National Physical Laboratory, New Delhi, is working on development of materials and processes to make dye-sensitized nanocrystalline TiO_2 thin films. The Centre for Materials for Electronics, Pune, has been working on the development of phosphorous paste for diffusion of impurities in solar cells. Under a joint R&D project of MNRE and the Department of Science & Technology (DST), the IACS continues to work on optimization of process for fabrication of large-area double junction amorphous silicon modules.

In the very near future, breakthroughs in nanotechnologies promise significant increase in solar cell efficiencies from the current 15% to over 50%. However, this research is insignificant compared to RD&D requirements of the sector. Further, most of the efforts mentioned above are efforts of individual institutions and it is necessary to develop a co-ordinated programme for RD&D, which will develop materials and technologies suitable for Indian context.

f. Semiconductor Policy

The Department of Information Technology of the Ministry of Communication and Information Technology, vide its notification dated 21 March 2007, announced a special incentive package scheme to encourage investments for setting up semiconductor fabrication and other micro- and nanotechnology manufacturing industries in India. This incentive package would also be available for manufacturing solar cells in India. The special incentive package is as follows.

a. The investment has to be for the manufacture of all semiconductors and eco-system units, namely displays including liquid crystal displays (LCD), organic light-emitting diodes (OLED), plasma display panels (PDP), any other emerging displays, storage devices, solar cells, photovoltaic, other advanced micro and nanotechnology products, as well as assembly and testing of all the above products.

b. The special incentive package shall be for state-of-the-art technology.
c. In the case of semiconductor manufacturing (Fab units) products, the threshold net present value (NPV) of investment will be Rs 2500 crore and above. The threshold NPV of investment in manufacture of other eco-system products will be Rs 1000 crore and above. This threshold value shall be taken as the NPV of investments made during the first 10 years of the project's life and the discount rate will be 9%.
d. The central government or any of its agencies shall provide incentive of 20% of the capital expenditure during the first 10 years for units in SEZ and 25% of the capital expenditure for non-SEZ units. Non-SEZ units shall be exempt from Ccountervailing duty (CVD).
e. The incentives, if any, offered by the state government or any of its agencies or local bodies shall be over and above this amount.
f. The period of 10 years shall be the first 10 years of the project's life from the start of the project and not with regard to the start of any subsequent phase of the project.
g. Any unit may claim incentives in the form of capital subsidy or equity participation in any combination of the following:
    i. equity in the project, not exceeding 26%
    ii. capital subsidy in the form of investment grant and interest subsidy.
h. The entire equity contribution will be taken towards the value of incentive package. There shall be an exit option, to be exercised by the government, at a suitable point of time in the future, after the project goes on stream.
i. Those investors who choose equity as part of their incentive package shall be given such equity after the financial closure for the project and the equity shall be released on a proportionate basis as equity is brought in by the promoters.
j. All other incentives shall be released after the end of the financial year in which the NPV of the total investment exceeds the threshold value.
k. Thereafter, the incentives shall be provided on an annual basis on the value of investments made during the year and be restricted to the first 10 years of the project life.

5. BARRIERS TO DEVELOPMENT OF SOLAR ENERGY

Poor development of solar energy in the country so far is proof of the fact that solar energy development faces several barriers. While high cost of solar systems is certainly the primary barrier for the development of solar energy, it is also necessary to change the general mindset about solar power technologies. In this regard, the perception of the Government of India, as reflected in the 11th Five-Year Plan, is illustrative. While clarifying the major reasons for lower actual expenditure against GBS (gross budgetary support) during the 10th Plan, the Working Group on New and Renewable Energy stated:

> "*Provision for the 140 MW integrated solar combined cycle plant at Mathania, Rajasthan, could also not be utilized on the basis of a review that recommended a more cautious approach towards deployment of grid-interactive solar projects, in view of the very high unit cost of generation of solar electricity apart from technological and commercial reasons.*"

It is necessary to accept the fact that any technology during the initial period is bound to be expensive due to the technology development cost and the inability to achieve desired efficiencies in the absence of adequate operating experience, as well as non-availability of economies of scale. Efficiencies will not increase without adequate experimentation. If we do not develop pilot plants, we will not get the experience necessary to reduce the costs. It is a vicious cycle and must be consciously broken to ensure the development of technologies suitable for Indian context. Therefore, the Government of India must invest in new technologies such as solar.

Some of the other barriers are as follows.

a. *Estimation of potential for various RE technologies*

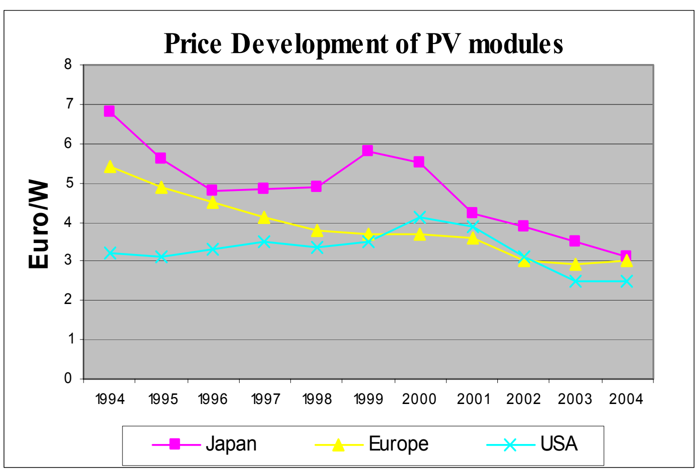
The Expert Committee on Integrated Energy Policy (Section 3 of this report), has commented that the potential for each renewable energy technology be assessed independently. However, if all such options are developed together, the combined potential may be less than the sum as we would run out of available land for energy generation as other competing land uses may dominate.

While this observation may be true to a certain extent, land is not the requirement of renewable energy technologies alone: all sources of energy generation require huge tracts of land. For example, while actual plant and machinery in case of coal-based power plants may not require a great deal of land, requirement of land for coal mines, coal handling systems, ash handling, and water systems is huge, and would be comparable to the land requirement of renewable energy projects. Similarly, land requirement of conventional, dam-based hydro-electric projects is also huge. Therefore, competing uses of land is going to be an issue for all types of projects and not only for renewable energy projects.

It is also a fact that resource assessment has not been comprehensive and does not account for all potential options. Further, for solar power, scientific assessment of resource is not available. Without such assessment, it would be difficult to optimize our investments in solar energy technologies.

b. Cost of Solar Power

At present the initial cost of both types of solar energy systems is higher than the cost of conventional energy systems and also that of some other renewable energy systems. However, it should be noted that solar PVs now cost one-tenth of what they did in the early 1980s. Despite the fact that the price of solar photovoltaic technology has been coming down over the years, it still remains economically unviable for power generation purposes. The estimated unit cost of generation of electricity from solar photovoltaic and solar thermal technologies in India would be in the range of Rs 12–20 per kWh and Rs 10–15 per kWh respectively, which is 4–5 times costlier than that for electricity obtained from conventional fossil fuels. However, as stated earlier, unless economies of scale are achieved, the costs are unlikely to come down.



The adjacent graph is illustrative in this regard. It depicts reduction in cost of PV modules over the period 1994 to 2004 in three major markets for PV systems, namely Japan, USA. and Europe.

c. Manufacturing Capability & Availability of Materials

The manufacturing process for production of silicon, wafers, cells, etc., is technologically very advanced. Currently, there is no capacity for production of silicon in India. As a result, manufacturers of cells are totally dependent on import. In 2004, about ten Indian companies were in the business of manufacturing solar cells. The total installed manufacturing capacity is approximately 100 MWp per year. The major players in solar PV are Tata BP Solar, Bharat Heavy Electricals Ltd (BHEL), Central Electronics Ltd, Rajasthan Electricals & Instruments Ltd, etc. Recently, several companies such as Tata BP Solar, Signet Solar, and Moser Baer have announced multi-million-dollar plans for investment in solar cell manufacturing capacities in the country.

It is necessary to develop indigenous capability to manufacture materials for solar cells if India wants to be self sufficient. Further, silicon reserves in India are limited. It may not be possible to develop significant solar capacity using silicon. Therefore, India needs to identify technology that uses material available in India and then develop the same so as to be commercially and economically viable.

d. Grid Integration Issues

In India, solar energy is usually considered for rural or off-grid applications. However, international experience shows that while solar energy has very good applications for rural and off-grid requirements, technology development and commercialization is best achieved by way of large-scale deployment of solar PV in grid-integrated mode. In 2004, Germany had total installed capacity of 920 MW, of which 91% was grid-connected and only 9% was off-grid.

Installed PV Power as of the end of 2005					
Country	PV Capacity				
	Cumulative			Installed in 2005	
	Off Grid PV [kW]	On Grid [kW]	Total [kW]	Total [kW]	Grid-tied [kW]
Japan	87,057	1,334,851	1,421,908	289,917	287,105
Germany	29,000	1,400,000	1,429,000	635,000	632,000
United States	233,000	246,000	479,000	103,000	70,000
Australia	41,841	8,740	60,581	8,280	1,980
Spain	15,800	41,600	57,400	20,400	18,600
Netherlands	4,919	45,857	50,776	1,697	1,547
Italy	12,300	15,200	37,500*	6,800	6,500
France	20,076	12,967	33,043	7,020	5,900
Switzerland	3,250	23,800	27,050	3,950	3,800
Austria	2,895	21,126	24,021	2,961	2,711
Mexico	18,654	40	18,694	513	30
Canada	15,622	1,124	16,746	2,862	612
Korea	5,663	9,358	15,021	6,487	6,183
United Kingdom	924	9,953	10,877	2,732	2,567
Norway	7,177	75	7,252	362	0
Sweden	3,983	254	4,237	371	0
Denmark	295	2,355	2,650	360	320
Israel	1,019	25	1,044	158	2
Total	503,475	3,173,325	3,659,300	1,092,870	1,039,857

(**Source**: http://www.iea-pvps.org/isr/01.htm)

The above table shows cumulative capacity at the end of 2005. It clearly demonstrates that all over the world, PV technology is being used more for grid-connected power generation application than for off-grid applications. However, India faces unique challenges in development of grid-connected systems. Indian grids are not as stable as European or other Western grids, which operate within a very narrow band of frequencies. Indian grid officially operates within the frequency range of 49–50.5 Hz, which is a very wide-band operation for power electronics. However, with creation of the national grid, it is expected that grid operation will be more stable. Further, India needs to develop suitable power electronics that will work under the current grid conditions.

6. PROPOSED POLICY INITIATIVES

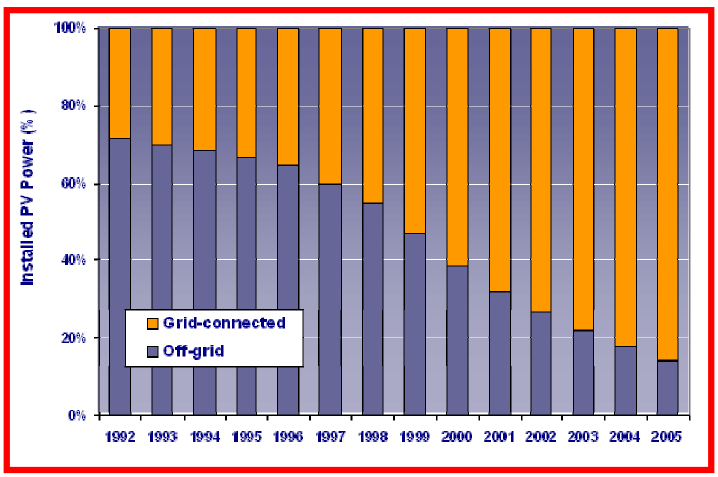
India has vast solar energy potential. Initial estimates suggest that the total potential is as high as 600 GW, which is far more than total electricity consumption today. While this technical potential may not be exploitable commercially, it is necessary to make all-out efforts to tap this potential to ensure energy security for the country. In this section, we discuss several potential approaches to promoting solar energy in India.

a. *Approach towards Solar Energy*

Before attempting to develop a policy road map for solar power development in India, we need to have a hard re-look at our approach towards solar energy. In Section 3, we discuss the 11th Plan proposals of the MNRE as well as the recommendations of the Expert Committee on Integrated Energy Policy.

i. Grid interactive vs off-grid applications

The MNRE's proposal for the 11th Plan clearly favours solar off-grid applications over grid-connected SPV or concentrated solar power technologies. While MNRE has not cited any particular reason for this approach, high initial cost of the solar systems appears to be one of the reasons for this approach. In this regard, it would be interesting to look at the international trends in this regard. The adjacent graph plots the share of grid-connected and off-grid PV installed capacities in member countries of the IEA PVPS programme. These countries represent more than 80% of solar PV installations in the world. From the adjacent graph, it can be clearly seen that the share of off-grid applications has reduced from more than 80% in 1992 to less than 20% in 2005. Further, it should be noted that the graph represents total cumulative installed capacities in the member countries; if one looks at the capacities installed during 2005, the share of grid-connected applications is more than 95%. (Source: www.iea-pvps.orgwww.iea-pvps.org)



India has set itself an ambitious target of electrifying every village by 2008 and every household by 2009. We need to design our strategies for solar energy against the backdrop of these targets. If we have all households electrified by 2009, will there be large number of takers for off-grid solar applications such as solar lights and lanterns? Further, it has been seen that once access to commercial forms of electricity is available, the tendency is to overlook other conventional forms of energy. Therefore, the strategy to rely only on off-grid solar applications needs to be reviewed.

ii. Comparison with cost of generation of small hydro plant

Currently, the approach of the MNRE towards grid-connected systems is negative, as is demonstrated in its suggestion that while subsidy of Rs 200 crore has been proposed for grid-interactive solar systems, the subsidy will be provided when technology improves, costs come down, and the unit cost of generation is at par with small hydro power.

The proposal of the Ministry is inexplicable as it is unlikely that the cost of generation of solar power will come down to that of small hydro power plants. It is necessary to note that any technology is bound to be expensive during the initial period due to technology development cost, the inability to achieve desired efficiencies in the absence of adequate operating experience, and lack of economies of scale. Mobile telephony is a case in point. When the mobile communication technology was introduced in India in the mid-1990s, talk time rate was as high as Rs 16 per unit, for incoming calls as well as outgoing calls, which has come down to as low as 10 paise per unit for outgoing calls, while incoming calls are free under the 'calling party pays' (CPP) principle. Another reason for higher cost during the initial period is very high level of risks associated with the new technology.

Further, small hydro technology has matured over the last one century. The first small hydro plant (a large hydro power plant then) of 1 MW capacity was installed by Darjeeling Municipality in Sidrambong in India way back in 1897. While details regarding subsidies made available to the first megawatt-size hydro power plants are not available, one can easily guess that the entire funding was from public sector. Moreover, 1 MW represented nearly 10% of the total installed capacity in India at that time. Over the last 110 years, hydro technology has matured significantly, thereby enabling reduction in costs. Despite this, the MNRE is providing subsidy as high as Rs 1 crore per megawatt in special-category states and Rs 0.67 crore per megawatt in general-category states.

The intention of the above discussion is not to debate the necessity of subsidies for small hydro electric plants; rather, the objective is to demonstrate that the logic used by the

MNRE for not providing subsidies for solar grid interactive systems is not based on rational grounds. While the MNRE must ensure efficacy of subsidy mechanisms and therefore needs to maintain a balance between capacity-based subsidies and output-based subsidies, subsidies cannot be entirely ruled out. In subsequent paragraphs, we discuss the modalities for provision of the subsidies.

iii. Economies of Scale

While the 1-MW hydro power plant of Darjeeling Municipality in 1897 represented nearly 10% of total installed capacity in the country, grid-interactive solar capacity in the country is less than 3 MW, when the total installed capacity has increased to more than 130 GW. This shows that solar installed capacity contributes less than 0.05% of the total installed capacity in the country.

Further, efficiencies will not increase without adequate operational experience and if we do not develop pilot plants, we will not get the operational experience necessary to reduce costs. It is a vicious cycle and must be consciously broken to ensure the development of technologies suitable for Indian context. This is applicable to solar technologies as well. We, as a country, have very little experience of solar energy technologies. Therefore, the Government of India must invest in new technologies such as solar.

Further, reduction of costs is possible only with economies of scale. We need to have a large-scale manufacturing capacity, which will help us reduce manufacturing costs. Such capacity cannot be created for the miniscule rural off-grid applications alone. It has been the experience of several countries that costs drop with increase in installed capacity. The graph in Section 1.8.1 clearly proves this logic.

One can argue that operational experience could also be gained from operation of off-grid applications. However, it should be noted that off-grid systems are primarily used in rural applications where grids cannot reach. These areas are usually economically backward and therefore the potential for installation of large systems is practically zero. Further, it is difficult to collate information on operational performance from systems installed at remote locations, thereby making it difficult to identify lessons for operational improvements and reduction in costs.

Therefore, it is necessary that we change our approach towards solar energy. We must develop a policy road map that will encourage grid-connected systems. If India has to launch programmes on the lines of the Million Rooftop Programme in California at any time in future, it must first gather the experience of running large (multi-megawatt) solar PV plants. Without adequate experience of grid integration issues, it will not be possible to launch a large-scale photovoltaic programme. Therefore, we strongly recommend installation of at least ten 1-MW solar PV plants in the country during the 11th Five-Year Plan. Similarly, a few grid-connected power plants using the concentrated solar power technology should also be implemented during the 11th Five-Year Plan.

b. *Programmatic Approach*

Unlike conventional power technologies such as steam or gas turbine and nuclear, most renewable energy technologies including solar energy systems are essentially modular in nature. While concentrated-solar-power plants of 30 MW or larger have been conceptualized and commissioned in some parts of the world, these are rare: most systems/applications in the world are small. This is particularly true for off-grid applications. In order to ensure large-scale implementation of these small systems, involvement of a large number of people is critical. It is necessary to develop policies that will encourage people to participate in the programme in large numbers.

It is necessary adopt a programmatic approach to ensure the involvement of large numbers of people in the development of solar programme. The Million Solar Roofs Program in California and the 100,000 roof programme in Germany are classic examples of such programmatic approach.

Box: California Solar Initiative (CSI) Program

The California Solar Initiative is an ambitious incentive programme launched jointly by California Energy Commission (CEC) and California Public Utilities Commission (CPUC) with the goal of adding 3000 MW of new solar facilities in homes and businesses in California by 2017. To be eligible for incentives under this scheme, the solar project's site must be within the service territory of and receive retail-level electric service from Pacific Gas and Electric (PG&E), Southern California Edison (SCE), or San Diego Gas & Electric (SDG&E). Municipal electric utility customers are not eligible to receive incentives from the designated Program Administrators. Responsibility for administration of the initiative is shared by the following three Program Administrators:

1. PG&E—PG&E customers
2. SCE—SCE customers
3. San Diego Regional Energy Office (SDREO)—as a contractor to SDG&E for its customers.

Other notable CSI programme features include:
1. A state-wide on-line application process and database
2. An open process to draft initial and future CSI programme handbooks
3. A CSI Programme Forum to provide a process for stakeholder involvement in the on-going implementation of the CSI.

India also needs to adopt the programmatic approach for the development of solar power. Such programmes may be undertaken through state nodal agencies. However, if such large-scale implementation is to be undertaken through state nodal agencies, it would be necessary to strengthen the capabilities of these nodal agencies.

c. Solar Technology Mission

The IEPR has recommended a technology mission for solar energy and argued that as solar energy is one of our major energy sources and the only renewable energy source with sufficient potential to meet almost all our energy needs, we should give a high priority to the development of solar technology for large-scale deployment. A technology mission should be mounted to bring down the cost of solar photovoltaics or solar thermal by a factor of five as soon as possible.

i. Objective of the Solar Mission

We also recommend 'Technology Mission for Solar Energy' with the specific mission of increasing contribution of solar energy to India's commercial energy needs to 2% by the end of 11th Five-Year Plan. The Solar Mission should take up following functions.

a. Reduction in cost of solar PV systems by a factor of five
b. Assessment of solar resources by region
c. Development of solar thermal technology suitable for India
d. Development of manufacturing facilities for solar cells using those materials that are abundant in India
e. Development of policy and regulatory initiatives for widespread use of solar energy
f. Collection and disseminatation of information pertaining to solar energy
g. Acting as an interface with the international solar community

ii. Institutional Mechanism for Solar Mission

In order to design sub-missions and activities under each of those sub-missions as well as subsequent monitoring of activities, an institutional set-up would be required by the Mission. For this purpose, the existing Solar Energy Centre should be brought under the control of the Technology Mission for Solar Energy. This would also reduce the possibility of duplication of efforts by the Solar Energy Centre. In the 11th Plan proposals, a budget of approximately Rs 400 crore has been allocated to the Solar Energy Centre. That should be be made available to the Mission immediately on being set up.

iii. Way Forward

An expert committee chaired by an eminent person should be set up to develop the mission objective, sub-missions, activities, budgets, organizational structure, etc., for the Technology Mission for Solar Energy. The Committee may be directed to submit its report within six months of being set up. A time-bound programme should be developed for implementation of the mission. It is suggested that the mission may be set up by April 2008.

d. Participation in Global Market Initiative (GMI)

Recent activities indicate that CSP technologies are poised at the threshold of extensive commercial deployment. Currently, approximately 13 CSP project locations are under development around the world, totalling about 1000 MWe of new concentrating solar power capacity. One of the market barriers to further deployment is lack of knowledge about the current technology and the near-term potential of CSP on part of energy policy makers, regulators, general contractors, and would-be owners and users. With increased awareness of the numerous benefits of using solar thermal energy resources around the world and the necessary policy framework in place, it is anticipated that more CSP projects will come on line. And these projects would start faster and be more profitable if there is a forum for collaboration among interested countries and states. To create such a forum, an international public–private CSP partnership (recognized as a UNEP Market Facilitation WSSD Type-II Partnership for Concentrating Solar Power Technologies) was established at the World Environmental Summit in Johannesburg, South Africa, in September 2002.

The goal of this coordinated action, called the CSP Global Market Initiative (GMI), is to facilitate and expedite the building of 5000 MWe of CSP power worldwide by 2015 (see the chart). Participation is open to all governments in countries or states with adequate solar thermal resources, to countries that have an industrial capability in CSP technologies but lack the appropriate solar resources, and to others who contribute to establishing the framework proposed below. If the benefits of CSP are to be spread globally, it is essential that the participating industrial countries outside the sun belt either support investments in sun-belt countries and/or allow import of solar power at cost-covering rates, thereby stimulating investment in CSP plants.

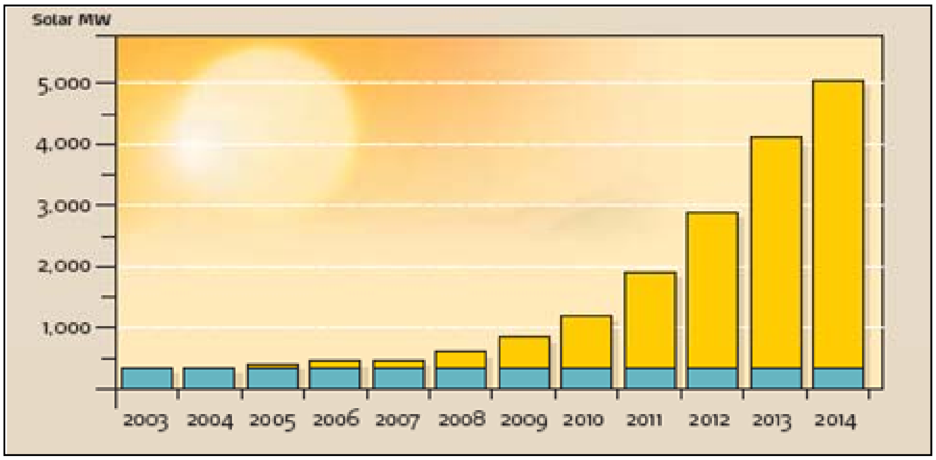


Figure 1.4: Anticipated Market for CSP

A visible, reliable, and growing market for solar thermal power with normal risk levels must be established for project developers and CSP equipment suppliers to make the needed long-term investments to achieve acceptable investment costs, and hence competitive rates. The following policy areas will have the greatest impact on the use of concentrating solar power. Each country or state participating in the CSP GMI will contribute with the following policy measures.

Targets: As the overall goal of the CSP GMI is 5000 MWe to reach cost competitiveness by 2015, national and/or regional targets will be set for CSP capacity. These targets may be a specific number of megawatts over a certain period, or may be a percentage of CSP within the new capacity to be built over a certain period, as in renewable portfolio standards.

Tariffs: The level of revenue from CSP projects needs to be adequate to encourage private-sector investment and provide a stable investment climate. This can be achieved by feed-in tariffs, production tax credits, or public benefit charges specific to CSP. These supports will be designed to reduce over time as the CSP technology becomes competitive in the power market after 5000 MWe of CSP has been built by 2015. The use of long-term power purchase agreements or similar long-term contracts with creditworthy offtakers or equity ownership by public organizations will build confidence in investors and financial institutions.

Financing: Cooperating bilateral and/or multilateral financial institutions will ensure that project-related flexible Kyoto instruments the such as Clean Development Mechanism and Joint Implementation Actions become applicable to CSP and that the mechanisms are bankable. The establishment of national or regional loan guarantee programmes via existing windows at multilateral banks, national lending programmes, and global environmental programmes such as GEF, UNEP, and UNDP will further reduce the inherent risk in introducing new technology for private-sector banking institutions. Investment tax credits, which stimulated the first 354 MWe of CSP plants in the United States, should be maintained and production tax credits similar to those that have stimulated the growth of wind power in the United States should be made available to CSP plants.

Regulation: Limitations on CSP plant capacity or operating strategies that make the technology introduction costlier need to be avoided. Legal restrictions on and barriers to more cost-effective connections of CSP plants to the electric grid at the end-user (customer), distribution and/or transmission points need to be identified and eliminated.

India has large amount solar resources which could be effectively utilised by the CSP technology. We strongly recommend that India should join the Global Market Initiative for CSP. This would enable India not only in technology transfer but also will help in developing overarching framework for development of solar technologies.

e. Material Manufacturing

The Department of Information Technology of the Ministry of Communication and Information Technology vide its notification dated 21 March 2007 announced a special incentive package scheme to encourage investments for setting up semiconductor fabrication and other micro- and nanotechnology manufacturing industries in India. This incentive package would also be available for manufacturing of solar cells in India. We discuss this policy in the section on existing policies and programmes.

It is necessary that the Ministry of New and Renewable Energy now takes the initiative to set up manufacturing facilities specifically for materials used in solar cells. The Ministry may undertake the activity under the public–private partnership model, which will help get the best technology and at the same time reduce the risks for the private-sector investor.

f. Energy Services Performance Contracts

India has recently signed an agreement with the International Energy Agency (IEA) and become party to the 'Implementing Agreement for Co-operation on Technologies and Programmes for Demand-Side Management'. Off-grid solar applications such as solar heaters and passive solar architecture could be effectively used for demand-side management and energy conservation. India is actively participating in Task XVI of the IEA-DSM programme, which deals with development of market for competitive energy services.

Currently, a limited number of energy services companies (ESCOs) are in operation in India. One of the reasons for the same is the lack of institutional framework that will enable energy services companies to be a one-stop-shop for all energy-related needs. This makes the business model of energy services companies unviable. It should be possible for energy services companies to enter into contracts and be able to provide all energy services such as lighting, heating, air-conditioning, and pumping. It should be left to the ESCO to provide these services in the most economical manner. In this regard, the business model of SunEdison LLC is interesting (See adjacent box). The firm provides solar energy services to its clients in the government, commercial, and utility segments without any upfront capital investment on part of the client.

Box: SunEdison LLC

SunEdison, LLC, headquartered in Baltimore, Maryland, provides financial and installation solutions for solar projects to the public, private, and municipal sectors. Using available incentive programmes, straightforward structured financing, and socially responsible investors, SunEdison packages solar to 'host' customers in a way that provides competitively priced solar energy with none of the hassles or risks associated with system ownership. SunEdison helps customer achieve predictable energy pricing for the long-term, without the upfront costs required by traditional solar product vendors.

SunEdison is a private corporation whose primary business is to finance photovoltaic installations on commercial roofs. The power generated is sold to the roof owner at a fixed price while SunEdison retains ownership of the renewable energy credits (RECs) produced. Since the revenue from selling power is insufficient to recover the costs of the installation, SunEdison relies on selling the RECs for profitability.

It is not possible to implement the business model adopted by SunEdison in India as supply of electricity to consumers would be construed as supply business and therefore would require a licence from the state regulator. Further, the Electricity Act 2003 has only one type of license for supply business. This would make company adopting SunEdison model liable for stringent regulatory requirements including universal service obligations. It is necessary to develop overarching regulatory framework that will allow different business models such as that of SunEdison.

Further, any institutional mechanism at the federal level creates more complexities in development and implementation of suitable policies. While promotion of renewable energy and its applications such as solar heaters, passive solar architecture, and solar air-conditioning is in the domain of MNRE, the broader issue of development of viable framework for energy services companies is the responsibility of the Bureau of Enery Efficiency (BEE). Therefore, it is necessary that MNRE works in close cooperation with BEE to develop a viable business model for ESCOs.

g. *Financial Support Schemes*

Financial Support schemes could be primarily divided into two, those supporting reduction in capital costs by provision of capital grants and subsidies and those involves supporting reduction of interest costs by improving the viability of the schemes.

i. **Capital Subsidy**

Capital subsidy schemes are widely used across the world to promote new technologies. Currently, the Government of India provides subsidies/capital grants for projects using several technologies such as small hydro, wind, biomass, and solar–wind hybrid. Right now, no direct subsidy is available for grid-connected solar photovoltaic systems.

The Government of India has been consciously avoiding capital subsidies in the past, the rationale being that capital subsidies help in creation of capacity although it is not necessary that those capacities will in fact deliver benefits that the systems were intended to deliver. The MNRE has stopped subsidy to grid-connected solar PV systems. However, it needs to be realized that capital subsidies are required during the initial period for any technology. Further, it is not rational to stop subsidies to an emerging technology such as grid-connected solar PV when the MNRE continues to provide capital subsidies to several established technologies such as small hydro, baggasse cogeneration, and biomass.

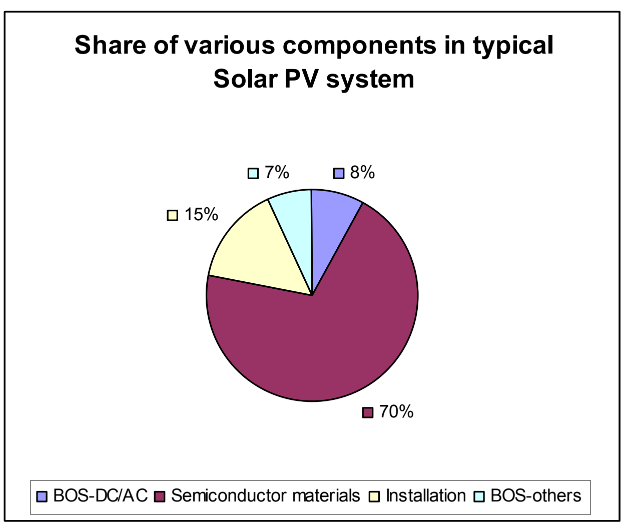
The MNRE should develop a programme for provision of subsidies with specific sunset dates, during which defined subsidies would be provided to grid-connected solar PV projects. These subsidies will be factored in by the state regulators while determining tariffs for grid-connected solar PV projects. Since the viability of any grid-connected project will depend on the electricity generation from the project, subsidies will be used in an effective manner and will serve the intended purpose.

ii. Interest Rate Subsidy

To ensure effective utilization of subsidies, the MNRE may consider giving the subsidies in the form of interest rate subsidies, which will help reduce the cost of the project by reducing the burden of interest payment on the developer. Usually, these subsidies are available only if the projects deliver the intended benefits. Currently, IREDA provides interest rate subsidy to developers of nearly all renewable energy technologies.

It is suggested that Government of India develops a scheme under which debt would be made available to developers of solar energy systems at discounted rate of interest. Currently, interest rate subsidies are primarily given by IREDA although a few other banks are also providing the same. The reach of IREDA and these other banks is limited. For interest rate subsidies to be effective, it would be necessary to involve a large number of financial intermediaries such as banks, financial institutions, and mutual funds. A mechanism for processing of applications, disbursement, validation, etc., would be required for these financial intermediaries. Further, these financial intermediaries may not have the necessary know-how to understand the risks involved in the projects and therefore, for processing of loan applications. It would be necessary to build capacity within these intermediaries. This would significantly increase the reach of solar energy technologies. In this regard, efforts taken under United Nations Energy Program (UNEP) are illustrative.

iii. Reduction in duties on balance of system (BOS)



While focus is on reducing the cost of solar cells, which constitutes approximately 70% of the costs of the solar systems, attention needs to also be given to reduce other costs such as the cost of balance-of-system items such as power electronics and batteries. While batteries used in solar applications are special 'deep discharge' batteries, these are usually clubbed with other general-purpose items and, as a result, attract very high level of customs duty. If the duties are reduced on items specifically used for solar systems, it is possible to bring down the cost of solar systems in India. The MNRE should persuade the Ministry of Finance to reduce taxes on the items used for solar systems.

iv. Tax benefit for individual investors

Unlike conventional power plants, solar systems are modular in nature and could be installed by individuals on their rooftops or space available with them. This is a unique characteristic of solar power, which is not possessed by any other form of energy. Further, using existing structures will not only reduce costs but also save the precious land available with the country. Every effort must be made to benefit from this property of solar energy.

However, given significant costs and lack of incentives, individuals are not keen to install solar applications. Penetration of such equipment such as solar water heating systems or solar cookers is very poor in urban areas where access to grid exists. It is necessary to incentivise individuals to invest in solar energy, whether grid connected or off-grid.

Currently, no tax benefit is available to individual investors for investments in solar energy products. While capital subsidies or interest rate subsidies improve the viability of solar applications for individuals, the subsidies do not improve the cash availability to the investor. However, if tax benefit is given to individual investors for investment in solar panels, it would provide the investor with additional cash in the form of reduction in tax payable. Similar mechanism was available to companies investing in wind sector, wherein the companies could claim up to 80% depreciation in the first year of operation. Since solar projects are small and involve individuals, it is necessary to make this mechanism available to individual investors. This will give a major boost to investment in solar power sector.

h. Measures to incentivise solar/ renewable energy

With restructuring of electricity industry across the world and introduction of competition in the supply and delivery of electricity, it has become necessary to ensure continuation of public benefit programmes traditionally administered or funded by electric utilities. Many countries have built-in methods of supporting renewable energy sources into their restructuring plans. One of the most popular policy mechanisms for ensuring such continued support has been the system-benefits charge (SBC). However, different instruments such as carbon tax, green cess, and clean energy tax have been levied on the 'brown' or polluting generation to collect funds for promoting renewable energy or 'green' energy. Typically, these funds are operated at the state level. Such funds have been operation in several countries in the world. In India, such a fund has been in operation only in the state of Maharashtra.

The Government of Maharashtra is authorized to levy tax on sale of electricity (TOSE) under provisions of the Maharashtra Tax on Sale of Electricity Act, 1963. The government had been levying tax under Section 3 of the said Act on sale of electricity by the licensees in the city of Mumbai at specified rates. The Government decided to enhance the rates by four paise for licensees in the city of Mumbai and also decided to bring the sales to industrial and commercial consumers in remaining parts of Maharashtra within the ambit of the Act. The government issued a notification to give effect to this decision with effect from 6 April 2004. It is proposed that the funds collected (Rs 500 crore over 5–6 years) by way of additional TOSE would be used specifically for promotion and development of renewable and non-conventional sources of energy. Recently, the Government of Maharashtra has invited private-sector participation in the fund to enhance the quantum of the fund as well as to bring in professional management.

i. Regulatory Interventions for Grid Connected Solar Energy

i. Tariff for Grid Connected Solar Power plants

Section 61 of the Electricity Act, 2003, prescribes the philosophy to be followed by SERCs while determining tariffs. Sub-section (h) of the said Section 61 prescribes 'promotion of cogeneration and generation of electricity from renewable sources of energy' as one of the criteria for determination of tariff. The state regulator is bound to take this provision into account while drafting the 'Terms and Conditions of Tariff' regulations. Nearly all SERCs have issued their tariff regulations incorporating clauses that will enable them to offer preferential treatment to renewable sources during the tariff determination process.

Further, many SERCs have issued tariff orders for various technologies such as those based on wind, small hydro, biomass, and municipal solid waste. However, no SERC has issued any order specifying tariff for solar energy technology. The reasons for not specifying such tariffs are not difficult to fathom. The high cost of solar energy makes its large-scale deployment unviable. Further, unlike small hydro and biomass, subsidies are not available for grid-connected solar projects. At the same time, due to significant export potential, manufacturers are not keen on supplying material in the domestic market. As a result, there has not been any move to get tariffs approved for solar energy technologies.

Feed-in tariffs for renewable sources of energy are not a new concept; it was successfully used for the first time in Germany as part of the widely popular Renewable Energy Law

(See Box below). Apart from Germany, it has been used in several other countries including Spain, Denmark, Italy, Unites States, China, and India.

Box: Feed – In Tariffs in Germany

Feed-in tariffs have been successfully used as a key instrument of promoting solar power in the country. While feed-in tariffs could be used for both solar PV and solar thermal, these have been used primarily for solar PV applications. Germany launched the Renewable Energy Law in 2000 and amended it in 2004. The law guarantees sufficiently attractive and secure feed-in tariffs for PV investors. This has resulted in Germany becoming the leading PV market worldwide. Following are the salient features of the German feed-in tariff law.

Beneficiaries: any PV producer

• Feed-in-tariffs:

Size of the scheme	Feed-in tariff (€ct/kWh)
Less than 30 kWp, rooftop	54.53
30 –200 kWp, rooftop	51.87
More than 100 kWp, rooftop	51.30
BIPV bonus	+ 5
Ground-based installations	43.42

• Decrease mechanism: 5% per annum

• Guarantee period: 20 years

• Cap: none.

Germany also provided financial support with possibility of financing nearly 100% of the initial cost, which enabled many investors to invest in PV installations. However, the support was gradually withdrawn over time and, with the amended Renewable Energy Law, it was completely withdrawn.

In India, the Electricity Act, 2003, prescribed a mechanism using which SERCs can prescribe tariffs for purchase of renewable energy by the distribution companies. Accordingly, several SERCs have specified tariffs for various technologies. The following table lists the states that have determined specific tariffs for renewable energy technologies in India.

State	Wind	Small Hydro	Biomass	Co-generation	Municipal solid waste	Solar
Maharashtra	√	√	√	√	√	
Andhra Pradesh	√	√	√	√		
Madhya Pradesh	√	√	√	√		
Tamil Nadu	√	√	√	√		
Karnataka	√	√	√	√		
Kerala	√	√	√			
Gujarat	√		√	√		
Rajasthan	√		√			
West Bengal	√					
Haryana	√		√	√		
Uttar Pradesh		√	√	√		
Uttarakhand		√				
Chhattisgarh			√			
Punjab			√			

Ironically, although no SERC has determined the tariff for purchase of energy by the distribution licensees from any of the solar technologies, the Government of Punjab vide its notification dated 24 November 2006 has announced a policy for renewable energy technologies. This policy has prescribed the tariff for solar energy technologies. [See Box] It is necessary that SERCs take initiative in this regard and determine tariffs for various solar energy technologies which are grid interactive.

Box: Government of Punjab Policy for New & Renewable Sources of Energy

The Government of Punjab announced the 'New and Renewable Sources of Energy (NRSE) Policy – 2006' on 24 November 2006. The policy aims at development of a sustainable economy based on conventional and renewable energy and wishes to develop and promote technologies based on new and renewable sources of energy and energy conservation measures, thereby addressing the problems arising from depletion of conventional sources of energy and environment pollution.

The state of Punjab is endowed with solar energy estimated at 4–7 kWh/m^2 of solar insolation levels. The policy prescribes the tariff for power generation from solar energy to be Rs 7.00 per unit (Base Year 2006/07) with five annual escalations @ 5% up to 2011/12. The policy also intends to provide import–export metering facility to developers of solar energy.

It is necessary that attractive tariffs are provided for grid connected solar energy plants. MNRE should take the initiative in approaching State Electricity Regulatory Commissions for determination of tariffs for solar energy plants.

ii. RPS Segmentation

While Section 61 (h) is important from the perspective of improving viability of the projects, Section 86 (1)(e) helps develop market for renewable energy projects by requiring the SERC to prescribe the percentage for purchase of energy from renewable sources by distribution companies and others.

As of date, several SERCs have put significant emphasis on specifying the percentage of electricity to be procured by the distribution licensees from renewable sources of energy. Regulators in Maharashtra, Madhya Pradesh, Karnataka, Kerala, Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu etc. have issued orders or regulations and specified percentages ranging from 0.5% to 10% for renewable energy procurement.

Grid-interactive renewable power installed capacity as on 31 October 2006 aggregated 9013 MW corresponding to about 7% of the total power installed capacity, which equates to over 2% of total electricity.

Further, while most SERCs have specified single targets for procurement of renewable energy technologies, some SERCs have specified separate technology-specific targets. For example, Madhya Pradesh Electricity Regulatory Commission has specified a target of 0.5% for purchase from wind energy sources. Similarly, the Andhra Pradesh Electricity Regulatory Commission has reserved 0.5% for procurement from wind energy sources out of minimum purchase requirement of 5% from renewable energy sources. These targets have given a significant push to development of renewable energy technologies that are close to commercialization. However, it is unlikely that any distribution licensee will procure any energy from solar energy sources as solar energy is more expensive than other renewable energy technologies. Currently, none of the SERCs has specified any target for purchase of energy from solar energy technologies. It is necessary that these powers are used by the Commission to specify a percentage for purchase of solar energy by the distribution licensees. Currently, solar energy projects, whether photovoltaic (PV) or solar thermal, are viewed and implemented as off-grid application projects and not for grid connected energy generation. As of date, less than 3 MW grid-connected solar PV projects have been implemented in the country. However, in view of its excellent distributed generation characteristics, there is a need to give impetus to development of solar energy projects. It is necessary that these powers are used by the Commission to specify a percentage for purchase of solar energy by the distribution licensees. It is suggested that all regulatory commissions should mandate utilities to purchase at least 0.2% energy from grid-connected solar energy projects in the final year of the 11th Five-Year Plan, i.e., 2011/12.

iii. Connectivity Standards & Net Metering

With careful reading, Section 86 (10(e) could be easily divided into three parts:

- suitable measures for connectivity to the grid
- sale of electricity to any person
- specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee.

As of date, most SERCs have put significant emphasis on the last part of this important sub-section, i.e. specify percentage of electricity to be procured by the distribution licensees from the renewable sources of energy while virtually ignoring the first two parts.

Most renewable generation technologies require interconnection with the grid at medium voltage or high voltage level. However, solar energy plants especially solar PV plants require interconnection with the grid at distribution or LT level. This could pose significant security hazard for the plant operator if the system is not able to isolate itself in case of fault. In developed countries, standards exists for interconnection for solar plants with the grid. It is essential that Central Electricity Authority (CEA) develops inter-connection standards for small generators connected to LT grid.

Further, protocols exist for metering and billing for generators connected to the low tension grid. These arrangements which are popular in some developed countries are commonly referred to as 'net metering' (See Adjacent Box).

Box – Net Metering

Net – metering is a simplified method of metering the energy consumed and produced at a home or business that has its own renewable energy generator, such as a wind turbine or solar PV panels. Under net metering, excess electricity produced by any renewable resource will spin the existing home or business electricity meter backwards, effectively banking the electricity until the customer needs it. This provides the customer with full retail value for all the electricity produced. Providers or utility operators may also benefit from net metering because when customers are producing electricity during peak periods, the system load factor improves.

In India, it may not be possible to use 'net metering' in its classical form as used in the developed countries due to the inverted tariff structure. In India, tariffs to LT consumers are usually lower than the tariffs applicable to HT or industrial consumers. This makes the difference between applicable tariff and cost of generation from solar energy generation very high. Instead, the Regulator may consider mandating installation of generator meter or import-export meter for the purpose of determination of compensation payable to investor.

j. Solar resource assessment using GIS and Software

On 30 March 2007 the European Commission published a map of the solar power potential of Europe. The map was produced by the Photovoltaic Geographical Information System of the Joint Research Centre, which also includes an interactive service allowing users to calculate the solar power potential of any location in Europe. The information in the map shows that an identical solar system will generate twice as much energy in sunny areas of Europe, such as Malta and Southern Spain, than in areas such as Scotland or northern Scandinavia. The interactive information service map allows very specific calculation of the amount of energy that can be generated in any given location in Europe and its neighboring regions. This calculation is based on knowledge of the Sun's energy, geographic distribution, the different terrain across Europe and detailed technological analysis of the available photovoltaic technologies. The map shows that considerable potential exists in Europe for greater use of solar energy. The EU is seeking to increase the share of renewable energies in its consumption to 20% in 2020.

A similar effort was completed in the United States also. Direct normal solar radiation values can be derived from satellite data. Geostationary weather satellites, such as GOES, continuously monitor the Earth's cloud cover on a time and location basis. This information can be used to generate solar irradiance data that are time- and site-specific, leading to the generation of high-resolution maps of solar radiation. Not all the land area with solar radiation is suitable for large-scale CSP plants, because such plants require relatively large tracks of nearly-level open land with economically attractive solar resources. To address this issue, Geographical Information System (GIS) data can be applied on land type (e.g. urban, agriculture), ownership (e.g., private, state, federal), and topography. The study showed that even if only the high-value resources are considered, nearly 7000 GW of solar generation[*] capacity exists in the U.S. South-west. According to the Energy Information Agency in 2003, about 1000 GW of generation capacity exists in the entire United States.

India has the technological capabilities to undertake such an assessment. It needs to be done on a war footing with cooperation of all agencies like MNRE, ISRO, and IMD. Many parts of India would emerge as potential sites for power generation through the CSP route.

k. Research, Design & Development

Solar energy technologies are at the early stage of commercialization. Current costs and efficiencies do not allow these technologies to compete with conventional energy technologies. Further, challenges exist in terms of availability of materials as well as manufacturing capabilities. While some of these challenges are faced by solar technology across the world, some, e.g. manufacturing capability, are acute in India. Therefore, it is necessary to undertake coordinated research, design, and development in solar energy technologies. The Ministry of New and Renewable Energy has already allocated a budget of Rs 400 crore for this purpose. This is a significant sum. The Ministry must make every effort to spend this amount on proper RD&D effort in the country. Priority should be given to those projects that seek to identify domestic resources for solar cells and customization of CSP technologies for Indian environment.

l. Human Resources Issues

As any sector or industry grows, requirement of human resources starts increasing. Usually human resources in sufficient quantity are not available during that period. Scarcity of resources in the BPO industry and IT industry are classic examples of this phenomenon. Several educational institutions and universities then start courses to train personnel for different functions and, in a short period, a large number of people are available in the industry. In power industry as well, this phenomenon has been experienced by the wind sector, which experienced sudden explosive growth. While it is not possible to entirely avert this phenomenon, it is possible to reduce its intensity by careful planning. It is recommended that short- and long-term courses on solar technology may be started at university level.

Further, as solar systems are mainly being used in off-grid and rural applications, requirement of technicians exists in rural areas. It is necessary to start courses on maintenance of power electronics as well as batteries as vocational courses in polytechnics and industrial training institutes.

As the number of projects increases, it would be necessary to train bankers and analysts on issues such as risk analysis and project evaluation of the solar projects. The proposed Solar Technology Mission may develop a sub-mission for the development of human resources for solar energy development in India.

7. PROPOSED POLICY ROADMAP FOR SOLAR ENERGY DEVELOPMENT IN INDIA

In this Section, we summarize our recommendations in the earlier sections and develop a 'Proposed Policy Road Map for Solar Power Development in India'.

1. India must change its approach towards solar energy. It should be accepted that solar energy is not meant only for off-grid and rural applications. We must pursue grid-connected strategy for the development of solar energy. Accordingly, we strongly recommend installation of at least ten 1-MW solar PV plants in the country during the 11th Five-Year Plan. Similarly, a few grid-connected power plants using CSP technology should be implemented during the 11th Five-Year Plan.
2. All state electricity regulatory commissions should mandate utilities to purchase at least 0.2% of their energy requirement from grid-connected solar energy projects by 2011/12.
3. India should adopt a programmatic approach to the development of solar energy projects. State nodal agencies should be strengthened to undertake such solar energy programmes.
4. India should set up a Solar Technology Mission with the specific objective of increasing contribution of solar energy to 2% of total commercial electricity production in the country. The Mission may establish specific sub-missions for specific activities.
5. India should join the Global Market Initiative for Concentrated Solar Power technologies to facilitate quicker technology transfer.
6. Solar energy technology is still nascent and is far from being commercially viable. Therefore, subsidies need to be provided to ensure that the sector develops. Every effort should be made to provide production-oriented subsidies such as interest rate subsidies. However, it may not be possible to eliminate capital subsides.
7. Taxes and duties on balance of supply items such as inverters and deep discharge batteries should be reduced so that cost of the overall system could be reduced.
8. State electricity regulatory commissions should determine feed-in tariffs for solar energy projects on a case-to-case basis to begin with. The commissions should take into account all benefits given to the developer while determining the tariffs.
9. State electricity regulatory commissions should make necessary regulations to provide connectivity to solar energy plants at LT voltages. Necessary net-metering schemes should be developed for metering and billing of these plants.
10. An institutional framework for performance-based energy services contract should be developed as soon as possible. This will give a major fillip to solar sector.

11. A large number of financial intermediaries should be involved in provision of interest rate subsidies. The necessary institutional framework for appraisal and risk assessment of the projects and timely disbursement of loans should be put in place.
12. Solar energy technologies are modular in nature and therefore investors are required in large numbers for large-scale implementation of solar projects. To encourage a large number of individuals to invest in solar projects, tax benefits may be provided to individuals. This will help individuals by increasing the available disposable cash. In short, the phenomenon observed in wind sector should be replicated in solar sector.
13. Research, design, and development should be undertaken to identify indigenously available materials suitable for solar cells. Efforts should be also be made to customize CSP technologies for Indian environment.
14. India should immediately undertake solar resource assessment using state-of-the-art technologies. This will help the Solar Technology Mission to chart out a plan for solar energy development in India.

ANNEXURE 1

Policy for Implementation of Solar Photovoltaic (SPV) Programme(s) during 2006/07 Pattern of Central Financial Assistance (CFA) for SPV Systems

SPV System	**CFA for GENERAL AREAS** 50% of the cost subject to a maximum of	**CFA for NE & SPECIAL AREAS** 90% of the cost subject to a maximum of	**Service Charge**
Solar Home System Model 1 (18 W Module, 1 light)	Rs 2500	Rs 4500	Rs 200
Solar Home System Model 2 (37 W Module, 2 lights)	Rs 4800	Rs 8660	Rs 200
Solar Home System Model 3 (37 W Module, 1 light, 1 fan)	Rs 4800	Rs 8660	Rs 200
Solar Home System Model 4 (74 W Module, 2 lights, 1 fan)	Rs 4800	Rs 8660	Rs 200
Solar Home System Model 5 (74 W Module, 4 lights)	Rs 4800	Rs 8660	Rs 200
Street Lighting System (74 W Module, 1-2 lamps)	Rs 9600	Rs 17300	-
Stand Alone Power Plant of capacity more than 1 kWp	Rs 1,25,000 / kWp	Rs 2.25,000 / kWp	Rs 10,000
Stand Alone Power Plants of capacity more than 10 kWp with Distribution Line	Rs 1,50,000 /kW	Rs 2,70,000 / kW	Rs 10,000
Solar Pumps	Rs 30/Wp, subject to a maximum of Rs. 50,000/- per system	Rs 30/Wp, subject to a maximum of Rs 50,000/- per system	

ANNEXE 2

Scheme for Interest Subsidy for users of SPV Systems

S.No.	**Feature**	**Implementation through**	
		IREDA	**Banks**
1.	Rate of interest	7% (commercial borrowers, who can claim depreciation benefits) 5% (individuals and other organizations that undertake not to claim depreciation benefits) Financial intermediaries who borrow funds from IREDA for on-lending at 5% or 7% rate of interest will be charged an interest rate of 2.5% or 4.5% respectively by IREDA. Such intermediaries will not be able to claim depreciation benefit and the on-lending arrangement will not be treated as a lease arrangement.	5%.
2.	Loan period	5 years	5 years
3.	Moratorium	1 year	No moratorium
5.	Upper limits for a loan	No limit	Rs 5 lakhs.
6.	Service Charge	1% of the loan disbursed	Rs 300 per loan disbursed

ANNEXE 3

MNES Solar Lantern Programme

1. The Ministry will provide a CFA of Rs 2400 per solar lantern to the eligible beneficiaries through the state nodal agencies (SNAs) and Akshaya Urja shops.

2. Ministry will provide Rs 100 per lantern as service charges to the SNAs and the Akshaya Urja shops. MNES will also provide Rs 100 per lantern to SNAs towards inspection charges of solar lanterns sold by the Akshaya Urja shops, maintained by NGOs. No separate service charges will be paid for the shops maintained by the SNAs.

3. 50% of the MNES CFA will be released to the SNAs, as an advance.

4. The remaining 50% of MNES CFA and service charges will be released after completion of the project. The agency will furnish a project completion report along with the inspection report of at least 20% of the lanterns distributed and also submit the audited statement of expenditure and UC as per formats

ANNEXE 4

Capital subsidy for installation of Solar Water Heating Systems

1. Capital subsidy equivalent to upfront interest subsidy @ Rs 1100/- per m^2 of collector area will be available to registered institutions and @ Rs. 825/- per m^2 of collector area to registered commercial establishments that do not avail soft loans from banks/FIs under the above mentioned interest subsidy scheme of the Ministry.

2. SNAs will be provided service charges @ Rs100/ m^2 of installed collector area. The municipal corporations, central/state government departments will also be eligible to receive similar service charges for the claims processed and forwarded by them to the Ministry.

3. The scheme is open only for installation of systems during financial year 2006/07. Capital subsidy will be available to systems installed after 31 March 2006 provided interest subsidy has not already been applied for or availed for the system. Claims for reimbursement for systems installed up to 31 March 2007 should be received in the Ministry latest by 30 April 2007.

Annexe 5

Solar Photovoltaic Water Pumping Programme during 2006/07

Solar Pumps	**Allocated budget (Rs crore)**
Grant in aid	1.00
Subsidies	4.00