MANAGEMENT REVIEW

Solar Farming: India's Energy Solution for the Future

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Abstract

India has been a power deficient country with an increasing demand – supply gap in energy. Renewable energy sources and technologies have the potential to provide solutions to the longstanding energy shortage problems of our country. Solar energy is the largest exploitable renewal energy resource as more energy can be generated from sunlight that strikes the Earth in one hour than all of the energy consumed by humans in an entire year. Besides being abundant, solar energy offers a solution to fossil fuel emissions and global climate change. Solar thermal electricity (STE) also known as concentrating solar power (CSP) and Solar Photovoltaic (SPV) are emerging renewable energy technologies that can be developed as future potential option for electricity generation in India. In this paper, efforts have been made to summarize the availability of power, current status of power sector and future potential of solar energy and the strategies needed to transform the country to a solar powered economy.

Keywords

Renewable energy, solar farms, concentrated solar power, photovoltaic

Introduction

The newest crop in India could be electricity from the sun. "Solar Farming" can help change India's energy economy to clean and efficient renewable energy during the day, when it is needed the most. It can create millions of jobs and could help India achieve energy independence and better national security. It is an energy source that can provide many times more energy than we could ever expect to need or use. An hour of sunlight bathing the planet holds far more energy than human population worldwide consumes in a year. Solar energy is an enormous resource that is readily available to all countries throughout the world, and all the space above the earth. It may sound incredible, even funny, but solar energy is a crop that can be harvested daily, on the most barren desert and arid land, requires no fertilizer or tillage, and that produces no harmful emissions. It is clean, no waste comes from it, and it's "free."

This "free" source of electricity can be used to supply the energy needs of homes, farms and businesses. Through the use of Photovoltaic (PV), Concentrated Photovoltaic (CPV) or Concentrated Solar Power (CSP), sunlight is converted into electricity that can provide power to businesses, homes, and drive motors.

Rationale & Objective of the study:

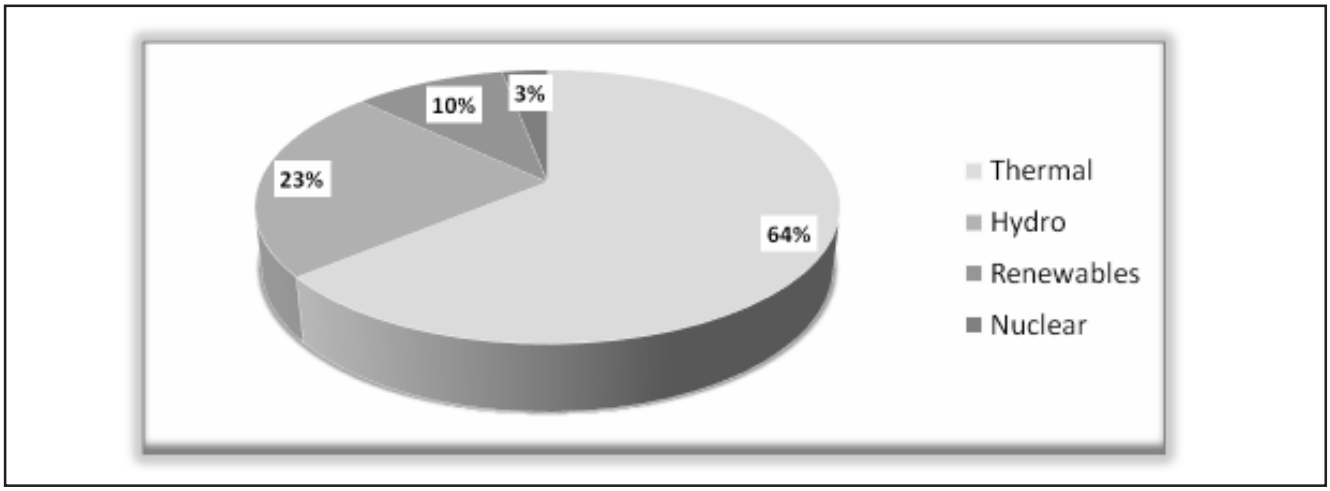
Solar energy is the largest exploitable renewal energy resource as more energy can be generated from sunlight that strikes the Earth in one hour than all of the energy consumed by humans in an entire year. Besides being abundant, solar energy offers a solution to fossil fuel emissions and global climate change. Energy sector is one of the major contributors to the carbon dioxide emissions that induce climate change. Hence, there is need for the development of

renewable sources that do not emit carbon dioxide to the atmosphere. Driven by perpetually rising demand for energy and the imperative need for clean energy, more than 100 countries including India have enacted policies and programmes for harnessing solar energy. This paper discusses the potential that solar energy sources and technologies have to provide solutions to the long-standing energy problems being faced by India and policy interventions of government to incentivise renewables for the future. Specifically, it discusses the current status of power in India, the urgent need for development of renewable energy sources, the potential offered by solar energy and the strategies to transform the country into a solar powered economy through use of solar farming.

Current status of Indian Power Sector:

India has always been a power-deficient country. The demand for power is huge in India. India has the world's 5th largest electricity generation capacity and it is the 6th largest energy consumer accounting for 3.4% of global energy consumption. Due to the fast-paced growth of the Indian economy, the country's energy demand has grown at an average of 3.6% p.a. over the past 30 years. As per the latest Report of CEA (Central Electricity Authority) i.e. as on 31-03-2011, the Total Installed Capacity of Power in India is 173626.40 MW (See figure 1).

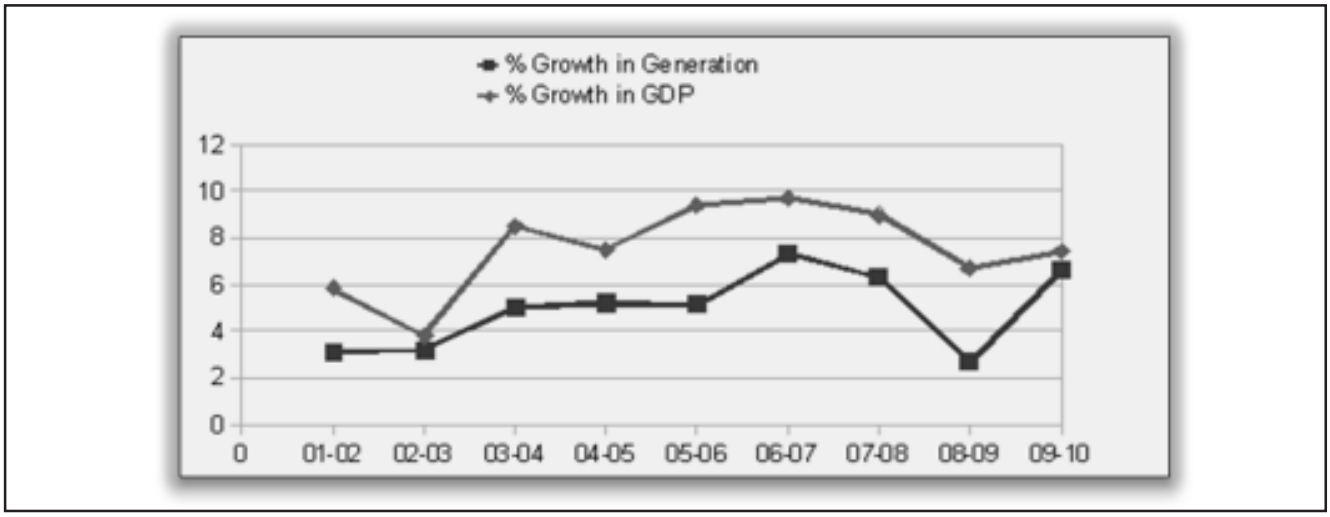
Figure 1: Indian Power Sector (Total Installed Capacity-173626.40 MW March 2011)



Data source: Ministry of New and Renewable Energy

Rapid economic development & increasing population will impose a growing demand for energy. Growth in the power sector is related to India's GDP growth rate (See Figure 2) and a sustained 8% GDP growth of India requires an annual increase of commercial energy supply from 3.6% to 6.1%.

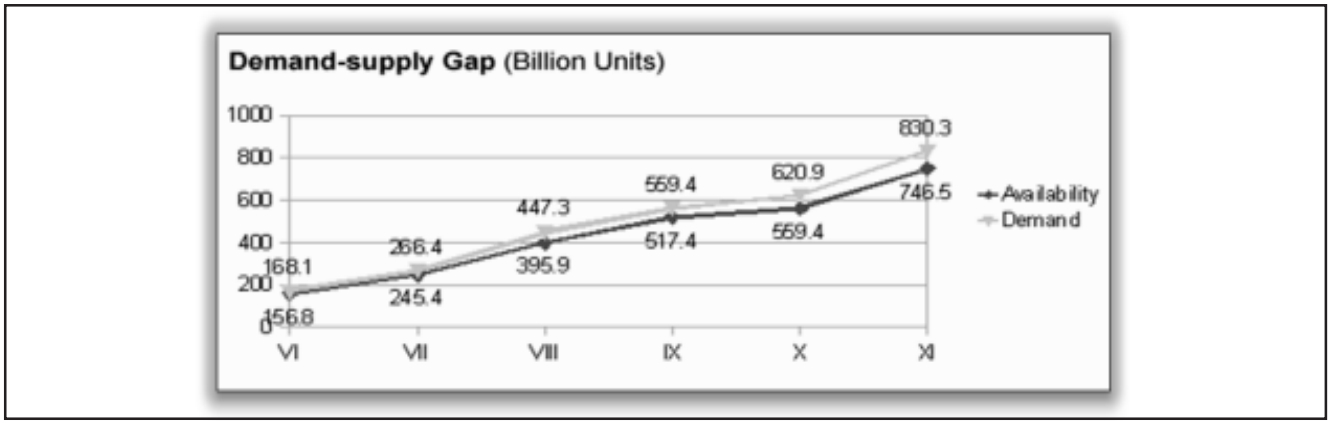
Figure 2: Relation between growth in GDP and generation



Source: *Source: Ministry of non-conventional energy sources*

Under the Government's "Power for all by 2012" plan, it has targeted per capita consumption of 1000 kWh by the end of the 11th FiveYear Plan (2007-2012) as compared to levels of 734 kWh in 2008-09. In order to provide per capita availability of over 1000 kWh of electricity by year 2012, it is estimated that capacity addition of more than 1,00,000 MW would be required. According to International Energy Agency Report 2007 (IEA 2007), India's energy consumption is set to triple (to 1936 MTOe) by 2030. Although, the Indian power sector is one of the fastest growing sectors in the world and energy availability has increased by around 36% in the past 5 years, the demand for power outstrips its supply (See figure 3). The energy and peaking deficits have been hovering around double digits for the past two years and the condition might worsen in the coming years considering the huge demand of power from India's rising population and rapid industrialization and urbanization.

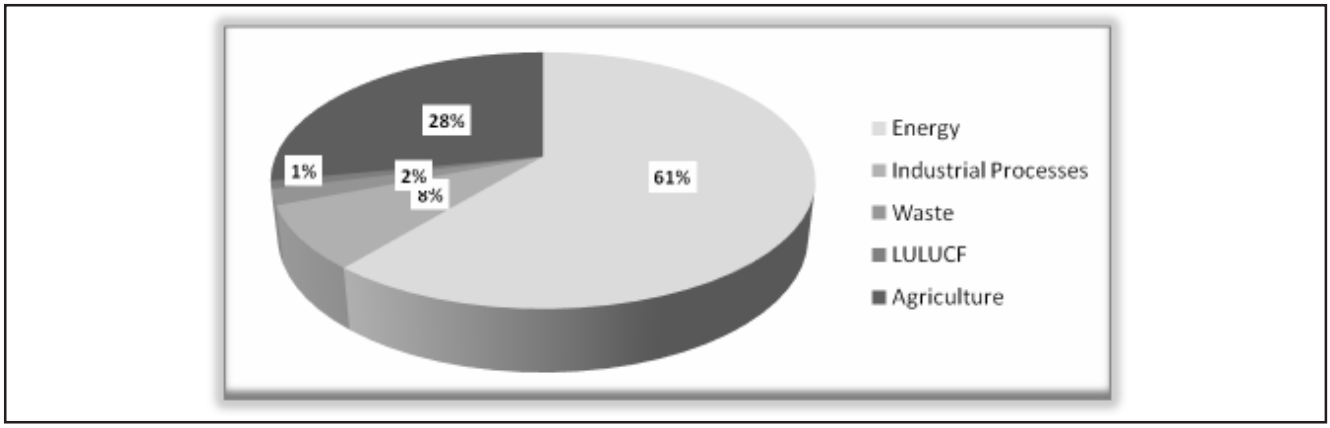
Figure 3: Demand – supply gap (2006 – 2011)



Source: Ministry of non-conventional energy sources

The above data & graph reveals that India is facing an acute energy scarcity which is hampering its industrial growth and economic progress. Setting up of new power plants is imperative & is inevitably dependent on import of highly volatile fossil fuels. Most of the power generation in India is carried out by coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission (See figure 4). Our power plants emit 0.94 kg CO_2 per kWh (*50% higher than world average),* which will make India the 3rd largest emitter of CO_2 by 2015 (IEA 2007).

Figure 4: Sectoral Distributions of GHG Emissions



Data source: Technology and Action for Rural Advancement (www.tara.in/)

Also, limited supply of coal, coupled with its poor quality; low level of technological advancements; high environmental hazards; limited domestic reserves and uncertain foreign supply of hydrocarbons make the conventional thermal power a less preferred source of energy.

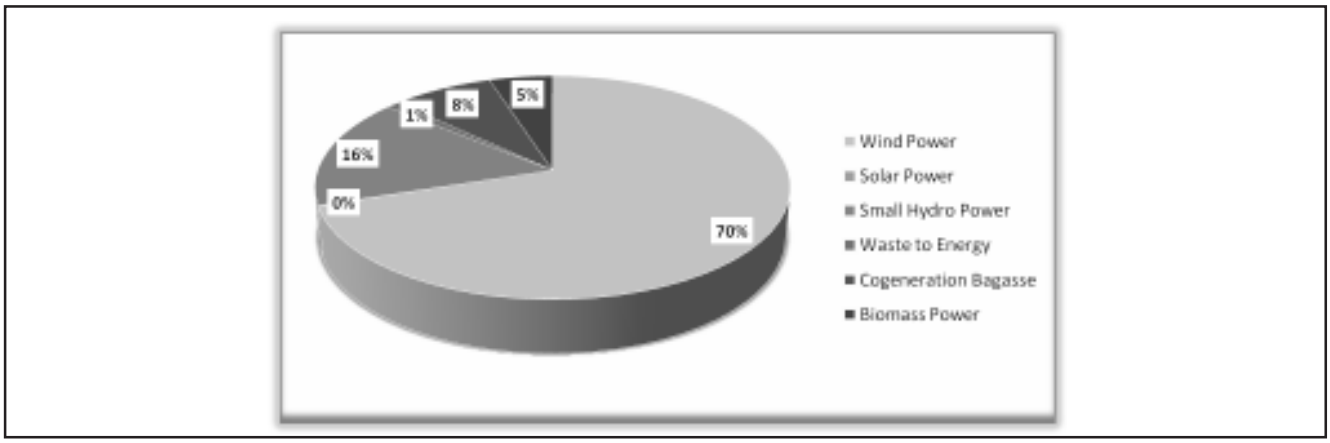
Thus, it is essential to tackle the energy crisis through judicious utilization of abundant renewable energy resources. Apart from augmenting the energy supply, renewable resources will help India in mitigating climate change. India has a large potential for energy generation by utilization of renewable energy sources. (See table 1 & figure 5).

Table 1: Grid-connected renewable power generation capacity in MW (As 30 June 2011).

Renewable energy program	Target for 2011–2012	Total achievement during 2011–2012	Cumulative achievement up to 30.06.2011
Wind energy	2400	394.68	14,550.68
Small hydro power	350	63.00	3105.63
Biomass power	460	48.00	1045.10
Bagasse cogeneration		75.00	1742.53
Waste to power (Urban & Industrial)	25	-	19
		-	53.46
Solar power	200	2.00	39.66
Total	3435	300.03	20,556.05

Source: Ministry of New and Renewable Energy Source India

Figure 5: Installed capacity from renewable energy as on March 2010



Data source: Ministry of New and Renewable Energy

MNRE (Ministry of Non Renewable Energy Sources) had planned a target capacity addition of 10,000 MW during the 11th five year plan. It has also planned to achieve 10% of annual power capacity additions from Renewables in the period 2003-2012. This has led to India becoming the world's next clean energy 'hotspot' as it plans to meet its substantial future energy from renewable sources.

Potential of Solar Energy in India:

India has been endowed with a vast pool of renewable energy sources such as hydro, solar, wind, bio-mass etc. India's solar energy holds great promise. Solar farming is an opportunity for those in the agricultural sector to view solar energy as a "replacement harvest" and create cleaner forms of energy by transforming vacant or even underused land into farms that produce electrical energy. It can produce about 12 to 15% or more assured return on investment for 30 years without any up-front money. Having a solar energy system allows production of electricity not only for own use but also for sale of some of the electricity to neighbours, local businesses, or even the local utility company. Solar energy farms, especially larger ones, can be interconnected into the electricity grid and produce significant levels of electricity offsetting traditional sources of generation. Moreover, large-scale solar-power generation has the potential to help meet India's enormous energy needs and help assure achievement of economic development goals. Solar farms will also play a vital role in reducing greenhouse gas emissions that contribute to global warming as solar farming is truly environmentally friendly. Solar electricity could also shift about 90 percent of daily trip mileage from gasoline to electricity by encouraging increased use of plug-in hybrid cars. For drivers in India this means that the cost per mile could be reduced by one-fourth (in today's prices).

Looking at the advantages offered by this alternative energy resource, it is being used world over to move away from the polluting fossil- fuel based energy. In US, states like California & Arizona have become home to the world's largest solar plant, harnessing their most abundant renewable energy resource – the sun. Worldwide, Germany and Spain are leaders in solar power generation with 4,000 megawatts and 600 megawatts of installed capacity, respectively.

Solar power can satisfy most of India's energy demand from a renewable, safe and clean source. But India produces a very negligible amount of solar energy i.e. a merely 0.2 percent compared to other energy resources, despite the fact that India is blessed with a vast Solar

Energy potential. About 5,000 trillion kWh of solar energy is incident over India every year, which is far more than the total energy consumption of the country today.The average intensity of solar radiation received over India is 200 MW/km square (megawatt per kilometer square) with 250–325 sunny days in a year. India's deserts and farm lands are the sunniest in the world, and thus suitable for large-scale power production. Recent research has shown that India has a vast potential for solar power generation since about 58 percent of the total land area (1.89 million km^2) receives annual average Global insolation above

5Wh/m^2/day. Indeed, at present efficiency levels, 1% of land area is sufficient to meet electricity needs of India till 2031.

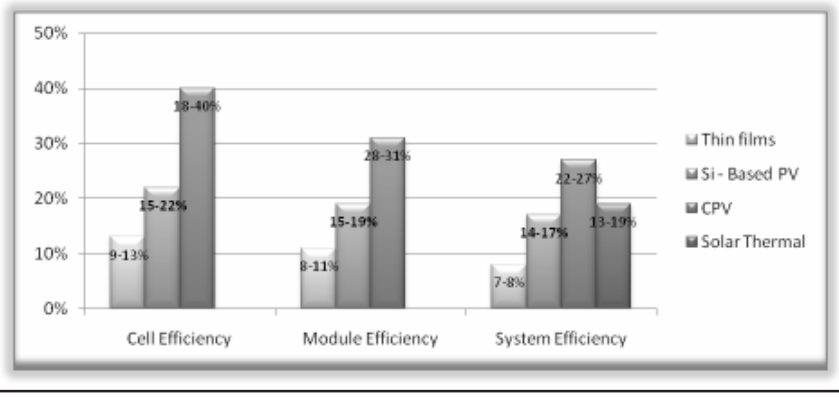
Rajasthan, the largest state of India constitutes about 10.4 percent of geographical area of India. Rajasthan has about 2,08,110 km^2 of desert land, which is 60% of the total area of the state. Interestingly, Rajasthan receives solar radiation of 6.0-7.0 kWh/ m^2. As the area has low rainfall, about 325 days have good sunshine in a year and in western areas in Thar Desert it may extend up to 345-355 days as rains occur only for 10.4-20.5 days in a year. The vast Rajasthan Desert has the potential to become the largest solar farm in India. On a solar farm, large amounts of power are generated from sunlight. Since solar energy is collected from a wide area, the process is viewed as 'farming' to 'harvest' renewable energy from the sun.

Due to high levels of available sunlight, CSP plants in Rajasthan could begin satisfying most of India's energy needs in just a few years. Solar energy could be India's energy for the future and solar farming could help India transform into a solar energy economy. CSP plants generate electricity from sunlight by focusing solar energy, collected by an array(s) of sun-tracking mirrors called heliostats, onto a central receiver. Liquid salt (a mixture of sodium nitrate and potassium nitrate) is circulated through tubes in the receiver, absorbing the heat energy gathered from the sun. The heated salt is then routed to an insulated tank where it can be stored with minimal energy losses. To generate electricity, the hot molten salt is routed through heat exchangers and a steam generation system. The steam is then used to produce electricity in a conventional steam turbine. After exiting the steam generation system, the now cool salt mixture is circulated back to the "cold" thermal storage tank, and the cycle is repeated.

While CSP technology is not new, it offers one of the most promising utility-scale, and sustainable technology options for meeting India's energy needs from renewable energy resources. But a large scale initiative is needed to make it more cost effective. The Rajasthan desert has the potential to produce solar power at a cost low enough to be competitive with fossil and nuclear power. Concentrating solar collectors are very efficient and can completely replace the electricity traditionally produced by fossil fuel power plants.Today's CSP plants supply the heat needed to generate electricity at a cost equivalent to $50 – $60 per barrel of oil. This cost is expected to be slashed by 50 percent to below $25 – $30 per barrel in the next ten years.

Another new technology that also holds promise is Concentrated Photovoltaic (CPV). First brought to commercial operation in 2008, CPV uses a concentrating optical system that focuses a large area of sunlight onto the individual photovoltaic cells. This feature makes CPV panels two to three times more efficient (approximately 40 percent) at converting sunlight to electricity as compared to silicon-based PV (15 percent to 20 percent) and thin films (9 percent to 13 percent). (See figure 6)

Figure 6: Efficiency Comparison of Solar Technologies as on 23.06.2011



Data source: www.cmic.org/

Even in CPV technology, major cost reductions will be realized through mass manufacturing. The steep increase in system efficiency, combined with decreases in manufacturing costs could levelize the cost of energy for CPV at around $0.10/kWh by 2015. Various incentives by Central and State governments, including tax credits and feed-in tariffs, can further reduce the cost. Cost reductions on mass production are so dramatic that Bloomberg recently reported solar energy could soon rival coal. The cost has become so competitive during peak times in Japan and California that the U.S. Department of Energy's SunShot goal of $1 per watt for large projects by 2017 may happen a lot sooner. The same cost competitiveness can be realised in India too.

All new energy production in India could be from renewable sources by 2030 and all existing generation could be converted to renewable energy by 2050, if deployment is backed by the right enabling public policies.

Future Growth Drivers:

India is the most developed renewable energy market in South Asia, with annual revenue of about $185 billion and is the third most attractive country to invest in renewable energy, according to Ernst & Young. The Indian Government expects the renewable energy sector to grow to $19 billion till 2012, with renewables making up 20% of the 70,000 MW of total additional energy planned from 2008-2012. One of the key drivers of renewable energy is the demand-supply gap in power which is currently at 10.3 percent and is set to expand due to the increase in the population's standard of living. The utilization of renewable energy sources is still relatively low in India, thus presenting excellent business potential.

- *Existing Policy Initiatives*: The MNRE has issued guidelines to all state governments to create an attractive environment for the export, purchase, wheeling and banking of electricity generated by renewable power projects. In March 2007 the Indian Government announced a semiconductor policy under its Special Incentive Package Scheme (SIPS). According to this policy, the government or its agencies will provide 20 percent of the capital expenditure during the first ten years for semiconductor industries, including manufacturing activities related to solar PV technology located in Special Economic Zones (SEZ), and 25 percent for industries not located in an SEZ. The government also allows 100% foreign direct investment (FDI) in the renewable energy sector and has put in place conducive policies to attract foreign companies in the sector. Some of the other key incentives provided by the government of India for the renewable energy industry are:
  - Feed-in-tariffs
  - Up to 80 percent accelerated depreciation for renewable energy investments
  - Relief in customs duty, excise duty and sales tax
  - Exemption from Central Sales Tax, and customs duty concessions on the import of material, components and equipment used in renewable energy projects
  - Soft loans
  - Generation-based incentives for solar and wind power projects
- *Creating Enabling Environment* : India should begin creating a mainstream solar energy market with the goal of making solar power cost-competitive with fossil fuel-generated electricity. One step toward achieving this goal would be to start a nationwide solar initiative of building 10 million solar roofs within ten years. It has often been said that it is not a question of if, but when solar power becomes cost-competitive with traditional electricity sources. With the right programs and policies today, India can have a great deal of control over how rapidly solar power becomes cost-competitive. The technology is well established and available. All that is needed to make this concept a reality is political commitment and appropriate investments and funding to harness this renewable solar energy resource. Envisioning the future course of action for this promising source of energy can lead to India's sunny, barren lands prove valuable for other regions as well. This can lay the foundation for an energy independent future – one in which the Government of India takes advantage of the vast amounts of energy available from the sun to power its future energy needs.

Conclusion

For centuries, the Indian tradition has worshipped the sun as the source of life, energy and creation. It is somewhat ironic that after over a millennium of amnesia and destruction, mankind is returning to the same elements it once revered and worshipped. But it is still not too late to avail of the opportunity to transform the promise of boundless and clean energy to reality. The time is apt to rise to the challenge and translate to reality the vision of a better future where every citizen has access to clean energy, reliably and affordably.

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