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# Transforming India Into a Green Nation: Bottom Up Approach through Solar Energy Education, Training and Innovations

Engineering

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## ABSTRACT

*India has tremendous energy needs and is finding it difficult to meet those needs through traditional means of power generation. Electricity consumption in India has been increasing at one of the fastest rates in the world due to population growth and economic development. India's economic growth has been some what stalled because the amount of energy generated is inapt to keep the growth motor of India running at the desired speed and there are energy shortages almost everywhere in the country. Renewable energy also has the advantage of allowing decentralized distribution of energy — particularly for meeting rural energy needs, and thereby empowering people at the grass roots level.*

### 1.Introduction:

Majority of India's population lives in villages. The population in these communities has grown substantially in past fifty years. This growth has put tremendous pressure on resources needed to support this sector. In addition, it has resulted in enormous pollution of air, water and land. There is also substantial growth of population in India's cities resulting in similar problems that are encountered by village and rural folks. Clearly, sustainable developments innovations and clean energy technologies are needed to accommodate the growing population in India for healthier environment. The presence of solar energy at any location in a village makes its uses attractive for such an environment. Most prominent of these are the drying of foods, vegetables and fruits for preservation and assured availability during off season periods of the year. The examples of technologies that are in use in rural India include mobile phones, home appliances, farm implements, vehicles for human, animal, and crop transport. The burning of wood and other materials for multiple uses continues. The cost and reliability for the supply of these energy sources has been a source of concern throughout India. The environmental impact from their use has also surfaced as a major concern. For this reason, solar technologies for rural applications have to be rugged, reliable and easy to use and repair. The ease of maintenance is essential for successful technology intervention. Furthermore, costs associated with repair and maintenance should be minimal.

### 2. Solar Energy Potential & Technologies

Solar is the prime free source of inexhaustible energy available to all. And, India is one of the sun's most favoured nations, blessed with about 5,000 TWh of solar insulation every year. Even if a tenth of this potential is utilized, it could mark the end of India's power problems — by using the country's deserts and farm land to construct solar plants. Renewable energy has the potential to re-energize India's economy by creating millions of new jobs, allowing the country to achieve energy independence, reduce its trade deficits and propel it forward as a "Green Nation". In short, renewable energy offers too many benefits for India to ignore, or delay its development [1].India should take full advantage of this golden opportunity because renewable energy has particular relevance in remote and rural areas, where there are around 289 million people who don't have access to reliable sources of energy. Solar energy is the most cost-effective option for India to reduce energy poverty without having to extend national grid services to provide power for individual homes and buildings.

India's present generation capacity is about 226,000 MW. The country could potentially increase grid-connected solar power generation capacity to over 226,000 MW and wind energy to over 100,000 MW by 2030 if the right resources (and more importantly, energy policies) were developed. India can develop massive commercial wind farms to harness the strong onshore costal area and offshore wind to boost the country's supply of clean renewable energy [2-3]. But, to tap this vast resource, India must develop and implement smart business models and favourable policies as quickly as possible.

### 2.1 Solar Powered Battery Well

The concept of Solar Powered Battery Well is similar to the village Community water well. In this case, the solar energy is harvested and stored and inhabitants can charge devices or energy storage systems from energy stored in batteries for a fee. The installation and maintenance of this system can be done through a village cooperative arrangement so that it can be made accessible to inhabitants at a lower cost per watt.

### 2.2 Solar Powered Vehicles

For fast transportation of materials, crops and humans, rural areas now depend on vehicles that run on gas/patrol. These vehicles could be designed to run on solar power.

### 2.3 Solar Powered Food Preservation Facility

Farm products degrade in normal climatic conditions. Low temperatures and humidity allows these products to extend their usable life. Storages with compartmental design can be built in rural areas and their environment can be regulated with solar energy technology. These storages can be built through village cooperatives and then rented to farmers for their use. Food preservation will greatly help to satisfy India's growing demands.

### 2.4 Solar Powered Water Wells

In a typical village in rural India, the villagers have community water wells drawing water from underground. They also have water wells for irrigating fields. Most of these are operated manually and those that operate on electric power are limited by the availability of such power. The power availability in rural India for use by farmers is extremely limited. Solar powered water wells will undoubtedly increase crop yield and better the quality of life of the inhabitants.

### 2.5 Solar lighted Streets/Corners/Farm ways

Solar lights are very commonly used in many cities to provide safety and needed light to enable an individual to accomplish jobs. Now they need to be used in rural areas.

### 2.6 Solar Powered Rural Homes/Huts

The technologies to be used in home include lights, phones, refrigerators, food cookers, heaters, television and other electronic devices, air/water coolers, water well and fans.

**2.7 Solar Powered (Mobile) Tools/Implements**
Tools are essential for farmers. From digging to harvesting the crops, several implements /tools are needed. Many of these are manually operated presently to save energy use. Solar powered farming will realize great leap forward in productivity and quality of life of farmers.

**2.8 Solar Powered Waste Management:**
Farms and farm homes produce waste which largely pollutes land, water, and air thereby becoming a health hazard, in addition to being an eye sore. Solar powered compressors or waste conversion to useful products would benefit immensely the rural communities.

**3. Renewable Energy Policies in India**
India is one of the world leaders for installed renewable generation with a total capacity of almost 26 GW as of June 2013 [3]. The key drivers for renewable energy in India include:

- Good levels of resource availability.
- The forecast growth in energy demand.
- Energy security concerns in light of increasing imports of fossil energy.
- Economic and quality of life costs associated with the environmental impacts of fossil fuel combustion.

The Government of India has long recognised the potential business opportunities offered by growing demand for renewable energy in local and overseas markets. It established the world's first ministry focusing on renewable energy, the Ministry for New and Renewable Energy, (MNRE). The Indian Renewable Energy Development Agency (IREDA) is administered by MNRE and was established in 1987 to operate a revolving fund for development and deployment of new and renewable sources of energy. MNRE also administers national institutions such as the NISE [4].India's existing capability and potential for innovation is supported by a well-educated, professional and skilled workforce. There is a thriving renewable energy sector with strong growth in biomass generation, wind turbine and photovoltaic manufacturing that offers opportunities for synergy with the CSP sector [5].

**4. Major Steps to Harness Renewable Energy**
Aggressively expand large-scale deployment of both centralized and distributed renewable energy including solar, wind, hydro, biomass, and geothermal to ease the strain on the present transmission and distribution system – and allow more off-grid populations to be reached. Facilitate growth in large scale deployment by installing 100 million solar roofs and large utility-scale solar generation, through both centralized and distributed energy within the next 20 years. Enact a National Renewable Energy Standard/Policy of 20 % by 2020 — to create demand, new industries and innovation, and a new wave of green jobs. Develop favourable Government policies to ease the project permitting process, and to provide start-up capital to promote the exponential growth of renewable energy. Create and fund a national smart infrastructure bank for renewable energy. Accelerate local demand for renewable energy by providing preferential Feed-in-Tariffs (FIT) and other incentives such as accelerated depreciation; tax holidays; renewable energy funds; initiatives for international partnerships/collaboration incentives for new technologies; human resources development; zero import duty on capital equipment and raw materials; excise duty exemption; and low interest rate loans.

Establish R&D facilities within academia, research institutions, industry, Government and civil society to guide technology development.Accelerate the development and implementation of Solar and Wind farms; utility-scale solar and wind generation nationwide.Initiate a move to electrify automotive transportation or develop electric vehicles and/or plug-in hybrids — such as the Nissan Leaf or Chevy Volt, etc.

Aggressively invest in a smart, two-way grid (and micro-grid). Invest in smart meters, as well as reliable networks that can accommodate the two-way flow of electrons. Such networks need to be resilient enough to avoid blackouts and accommodate the advanced power generation technologies of the future. Develop large scale solar manufacturing in India (transforming India into a global solar manufacturing hub).Work towards a Hydrogen Economy development plan. Hydrogen can be fed into fuel cells for generating heat and electricity — as well as for powering fuel cell vehicles. Produce hydrogen using renewable energy with solar and wind power. If done successfully, hydrogen and electricity will eventually become society's primary energy carriers of the twenty-first century.

**5.CSP R & D Progress in India**
CSP technologies rely on direct beam radiation and ambient temperature for operation and also dependent on climatic condition. That is radiation direct from the sun that has not been diffused or deflected by clouds or other atmospheric factors and so can be focussed by the mirrors. Ideally the data needed to assess potential sites is short interval, Direct Normal Irradiation (DNI) measurements collected over several years. In designing a CSP plant, knowledge of the seasonal variation in DNI resource is needed to make an optimal economic assessment of the degree to which the solar field is oversized relative to the power block in the high season and undersized in the low season.

Details of the major R&D Projects recently undertaken at National Institute of Solar Energy (formerly Solar Energy Centre), MNRE

**5.1 National Solar Thermal Power Testing, Research and Simulation Facility**
The facility envisages a grid connected Solar Thermal Power Plant of 1 MW capacity. This will also include a test set up that enables companies and research institutions to test the performance of different solar concentrators, coatings and materials, components and system for a Solar Thermal Power Plant. The project is being implemented by IIT Mumbai and a consortium partners consisting of Tata Power, Tata Consulting Engineers, Larsen & Toubro, Clique, KIE Solatherm.

**5.2 Concentrated Solar Thermal Energy Technology based on Parabolic Dish collectors**
The project is a cooperative effort between Megawatt Solutions Pvt. Ltd. and NISE under MNRE's initiative to promote research, development and demonstration of indigenously developed renewable energy systems and technologies under a cost-sharing basis. It involves demonstration and evaluation of 4 interconnected dish concentrators each of $90m^2$ aperture area providing heated thermic fluids up to $400^0$C.

**5.3 Solar Stirling Engine**
The project has been taken up in collaboration with ONGC Energy Centre (OEC). Three units of engines of 3 kW capacities each have been installed and commissioned in the campus. The objective of the project is to carryout long term performance evaluation under Indian conditions. The engines have been connected to the local grid and the electricity produced during the sunshine hours is being utilized in the Technical Block. The rated output of the facility is 9 kW (peak power) at solar insulation of 850 W/m2 at 200C ambient temperature.

**5.4 Development of a Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation**
Sun Borne Energy with support from MNRE will be setting up a 1 $MW_{Th}$ CSP Central Tower pilot facility in partnership with NISE. The main objective is to develop the optimized designs of the heliostat field, volumetric air receiver and thermal storage, the three major components of a Concentrated Solar Power (CSP) Central Receiver plant and also to develop the local sources for all the key components of the plant with a focus on lowering costs.

**5.5 High Efficiency Solar Thermal Air-conditioning Systems – a collaborative project of Thermax Limited and NISE**
The project (100 kW cooling capacity) is being implemented

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by M/s Thermax Limited at NISE with an objective to integrate parabolic trough collectors, vapour absorption machine (VAM) and appropriate thermal storage system to achieve consistence performance of the system with Coefficient of Performance (COP 1.75) [6].

**5.6 Cold Storage with Solar – Biomass Hybrid System:-**
It is an APP project in partnership with TERI, Thermax Limited, NISE and CSIRO Australia with an objective to develop cold storage particularly in rural areas utilizing exhaust heat of biomass gasifier engine/solar scheffler dish.

**6. Education and Training on Renewable Energy**
**6.1 Objectives Of The Centre of Excellence**
Each technical university must establish a centre of excellence on renewable energy technology with following objectives:

- o To provide education on Renewable Energy Technology;
- o To engage in Research & Development in Solar Photovoltaic and Concentrated Thermal Energy Technologies and their various applications for power generation, air conditioning, process heat industries;
- o To promote Renewable Energy Innovation Park for general public, RWA, Women, children, NGOs etc;
- o To carry out training programme(s) in the field of Renewable Energy Technology for students of other Engineering/ Polytechnic/ ITIs/Arts, Science and Commerce colleges;
- o To Collaborate with Industries and national and international agencies related to promotion of education and research;

**6.2 Major Activities of the Proposed Centre in India**
**6.2.1 Higher Education:**
- B. Tech. (Energy Technology)
- M. Tech. (Renewable Energy Technology
- PhD Programme with specialization in Solar Thermal and Photovoltaic energy technology.
- PGDM in relevant area of Renewable Energy

**6.2.2 Research & Development in Proposed Centre:**
**6.2.2.1 Solar Photovoltaic**
- Use of solar photovoltaic in the development of solar rickshaw, passenger car
- Fundamental research in PV-related materials and cost reduction;
- Development of PV cells from several material systems;
- Development of standardized tests and performance models for PV devices;
- Developing advanced concentrating photovoltaic technologies

**6.2.2.2 Solar Thermal Energy system**
- Cross Linear Concentrated Solar Power technology for solar process heat, refrigeration and electrical power generation.
- Solar process heat and space cooling.
- Concentrating solar systems for steam generation for cooking.
- Development of new designs and manufacturing processes for solar components and systems with an emphasis on improved performance, reliability and service life.
- Prototype development of systems through modeling and optimization.
- Characterization of the system's performance, and accelerated materials durability testing.
- Cost and performance of solar air heating thermal systems.
- Research on lowering the cost of solar water heating systems.

**6.2.2.4 Bio Energy Technologies:**
- Carbon capture and sequestration.
- Biomass densified briquettes and pallets
- Gasifier and related Technologies
- $CH_4$ Production from Sanitary Land fill
- Biogas Generation from Kitchen, vegetables and Animal waste

**6.2.3 Renewable Energy Innovation Park**
- This will be the front face of the proposed Centre and showcase the latest trends & technologies in Renewable energy area of relevance to the world.
- Solar Water Heating Applications
- Solar Air Heating Systems Applications.
- Large Scale grain Dryers.
- Residential and Office Space Heating.
- Fruit and Vegetable Drying for off seasons Applications.
- Solar Steam Cooking in Hostels.
- Solar Cooling and Refrigeration for Library Buildings
- Photovoltaic Power Generation
- LED street lighting systems
- Information and Communications Technologies powered by SPV plant.
- Solar operated cars and vehicles and solar energy charged battery Operated vehicles including solar rickshaw

**6.2.4 Knowledge Partners of the proposed Centre of Excellence**
Collaborative program shall be focus on development of new and efficient research on Solar Technologies & new horizons of Renewable Energy. The Institutions/universities/centres should collaborate with MNRE, National Institute of Solar Energy (formerly Solar Energy Center) and other world class Universities/ Institutions in India & abroad. They also collaborate among major IIT's, NIT's and other universities of higher learning's and generate funds from AICTE, and other bodies such as Department of Environment & Forest of GNCT Delhi, Ministry of Environment & Forest ( MoEF), GOI & Ministry of New and Renewable Energy (MNRE), GOI , UGC,DST, and International organizations such as UNESCO, UNDP, IDRC, SDA, DANIDA, GTZ, IDRC, SIDBI etc.

**6.2.4.1 Indian Knowledge Partner**
- R & D Institutions of MNRE
- Bergen Group
- Sunborne Systems
- Thermax Pvt. Ltd.
- Rajiv Gandhi Technological University, Bhopal
- National Thermal Power Corporation

**6.2.4.2 International Knowledge Partners**
- Tokyo Institute of Technology, Japan
- Asia Pacific Sunbelt Development Association, Japan
- Toyo Engineering, Tokyo, Japan,
- Richo, Japan
- University of South Florida

**Concluding Remarks:**
India has emerged as a global power in the past decade. With an animal GDP growth rate of 8.6%, it is the world's fourth largest country in terms of purchasing power, the second most populous country in the world and a leading player in IT, telecom and business outsourcing. The government of India recognizes that in order to sustain this growth rate and strengthen its national competitiveness, solar energy innovation has a critical role to play in India. The Government of India's Solar Mission is a visionary and inspiring policy measure that has the potential to be a leading example for the world.Harnessing the potential of solar energy for the benefit of rural areas of India will enlighten the hearts and minds of the rural population. Research on all aspects of solar energy including science, technology, engineering, economics, and management will engage diverse body of faculty and students in a team environment. This can energize the entire University for a worthy cause. India's population lives in rural areas and the quality of life will positively be affected by innovative use of solar energy.

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