National Solar Mission & Solar Technology Deployment in India

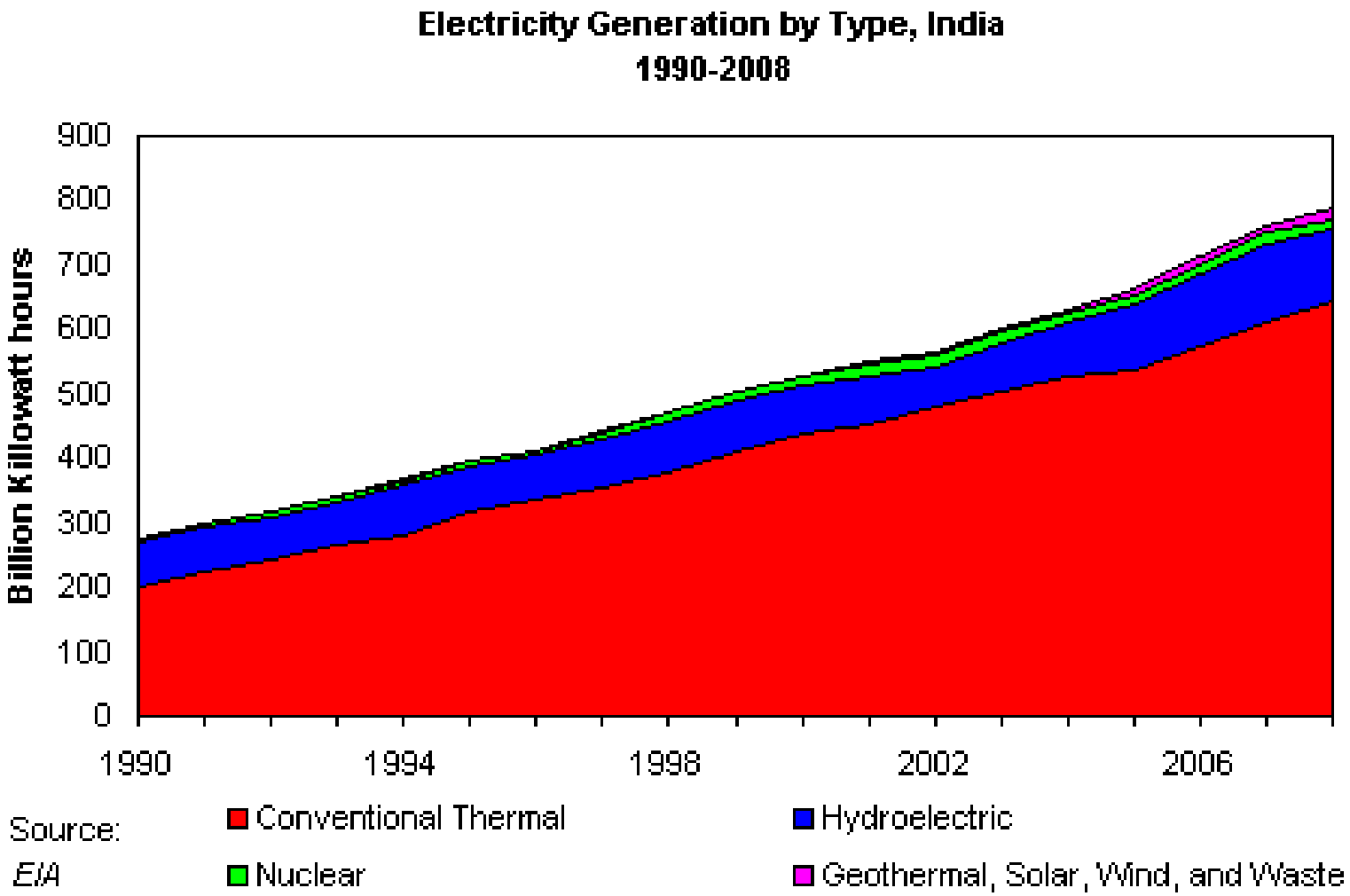
S. Rao Peddada,

Surya Power Inc, October 2010

India’s Energy Generation Overview

- India is world's 6th largest energy consumer, accounting for 3.4% of global energy consumption
- In June 2010, the installed power generation capacity of India stood at 162 GW
- Total Power Generation Breakdown:
  - Thermal: 104 GW (64%)
  - Hydroelectric: 37 GW (22%)
  - Nuclear: 4.5 GW (4%)
  - Renewables (bio mass, wind, solar, geothermal, etc.): 16.5 GW (10%)
- Electricity losses in India during transmission and distribution are extremely high and vary between 30 to 45%.
- Theft of electricity, common in most parts of urban India, amounts to 1.5% of India's GDP (~$1.4 Trillion)
- The average electricity deficit is >10% and in some states as high as 20%!
- As India’s economic activity increases so does the energy demand
  - Expect annual increase of >4%
- Today, India’s largest consumer of electricity is the farming industry which depends on the monsoons for water and needs electricity for water pumping

India's Energy Sources



Source:
EIA

India’s Energy Plans

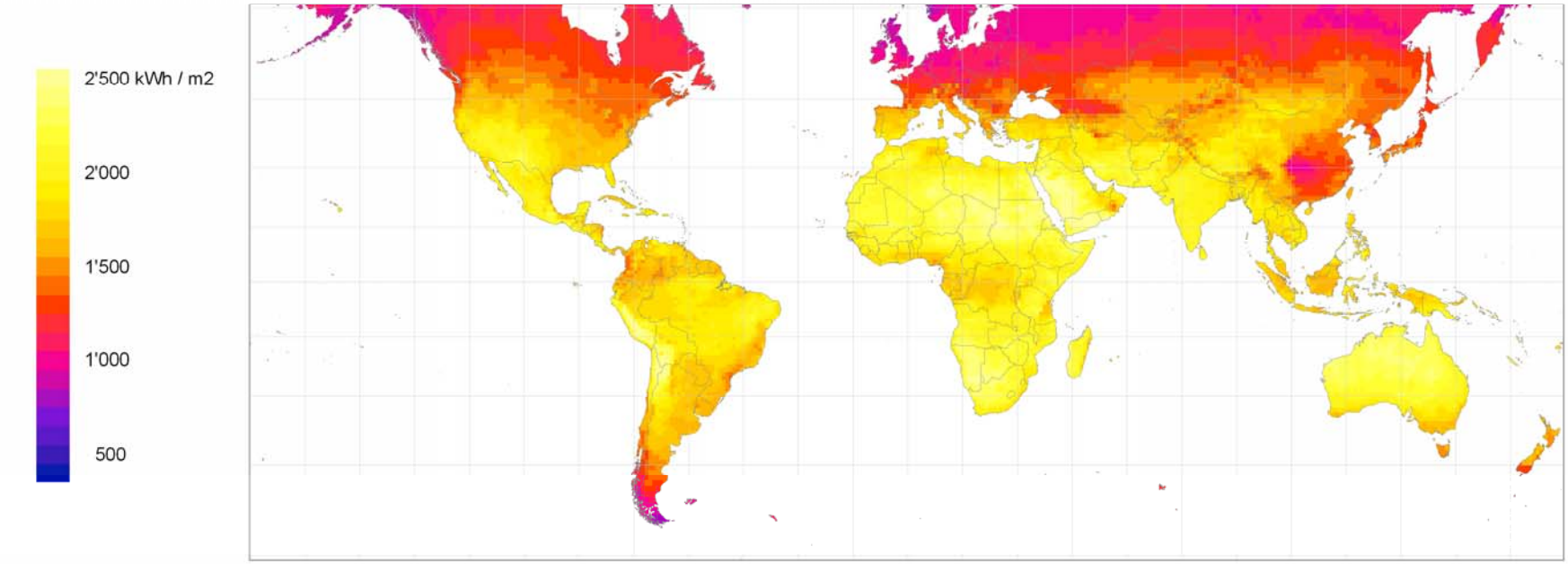
- The Indian government has set an ambitious target to add approximately 78 GW by 2012.
- The total demand for electricity in India is expected to cross 950 GW by 2030.
- Plan to increase the Renewable Energy and decrease the dependence on oil & coal.
- As of 2009, India's installed wind power generation capacity stood at ~11.6 GW which is 5th largest in the world.
  - Plans to increase wind power generation by additional 6 GW by 2012
- While Hydro-electricity plays a major role today, they depend on Dams for power generation which have displaced people and raised the specter of ecological problems.
- India has plans to construct various nuclear reactors which would generate at ~30 GW (over a decade).
- In July 2009, India unveiled a $19 billion plan to produce 20 GW solar power by 2022 under the Jawaharlal Nehru National Solar Mission (JNNSM)

Solar Energy Deployment in India

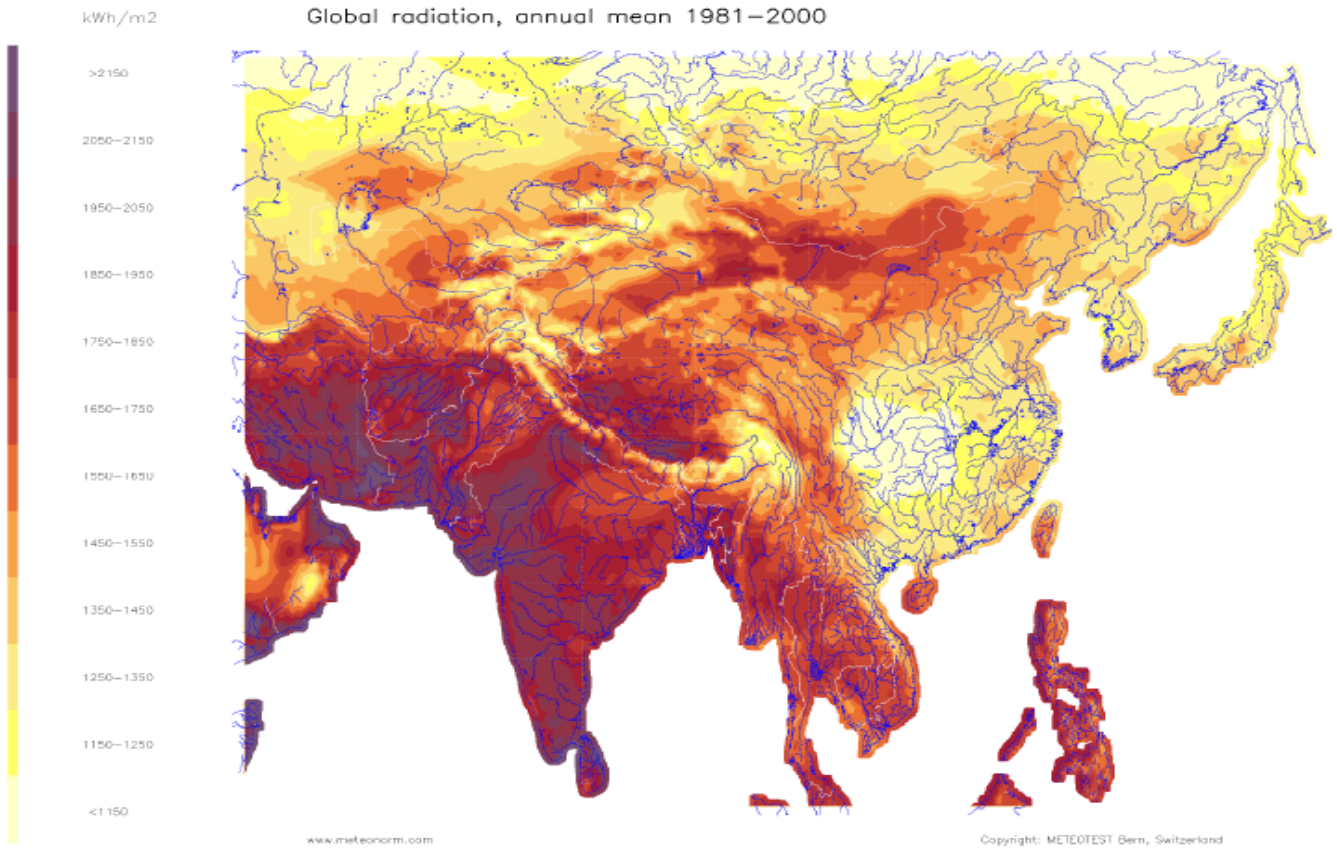
- The amount of solar energy produced in India is merely 0.4% compared to other energy resources.
- The Grid-interactive solar power as of 2010 is <5 MW.
- India is ranked very high in terms of installed Solar Power generation capacity
  - Number of solar street lighting systems: 55,795
  - Number of home lighting systems: 342,607
  - Solar lanterns: 560,295
  - Solar photovoltaic power plants: 1566 kW
  - Solar water heating systems: 140 km2 of collector area
  - Box-type solar cookers: 575,000
  - Solar photovoltaic pumps: 6,818

India's theoretical solar potential is about 1000 trillion KW·h per year (i.e. 600 TW), far more than its current total consumption!

World Solar Radiation (source: Meteonorm)

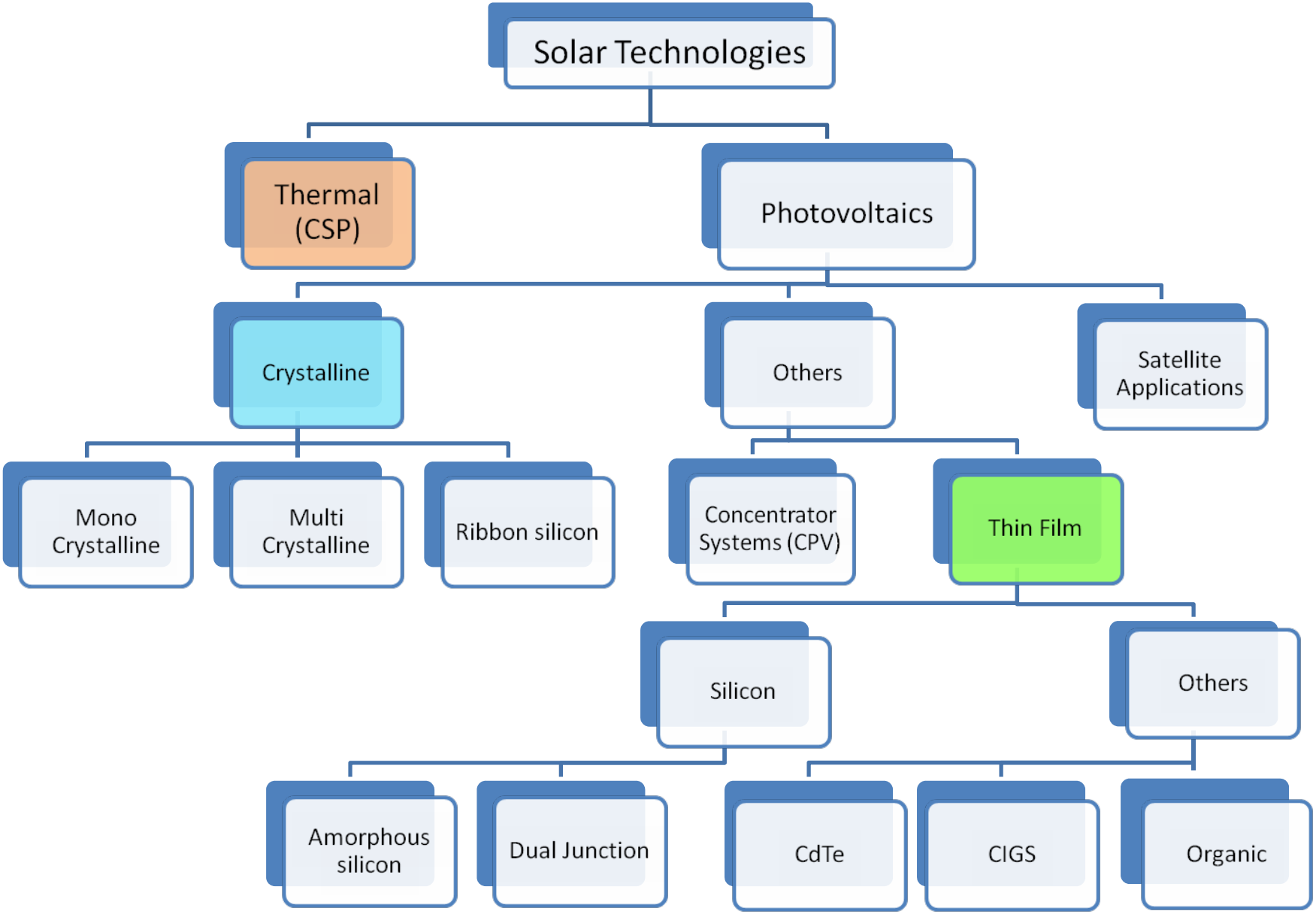


India Solar Radiation (source: Meteonorm)



- India's annual solar energy yield is ~1,500 to 2,000 kilowatt hours per kilowatt peak (kWh/KWp) of the installed capacity
- India's theoretical solar potential is ~1000 trillion KW·h per year (i.e. 600 TW), far more than its current total consumption!

Solar Technologies



Solar Technologies

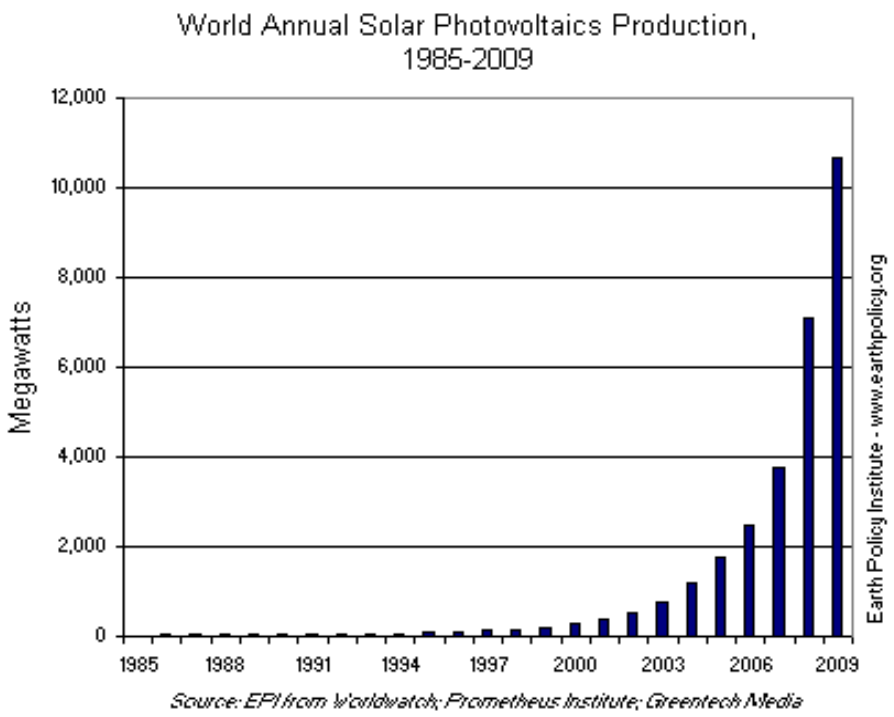
CSP: Tube of fluid heated by focused sunlight

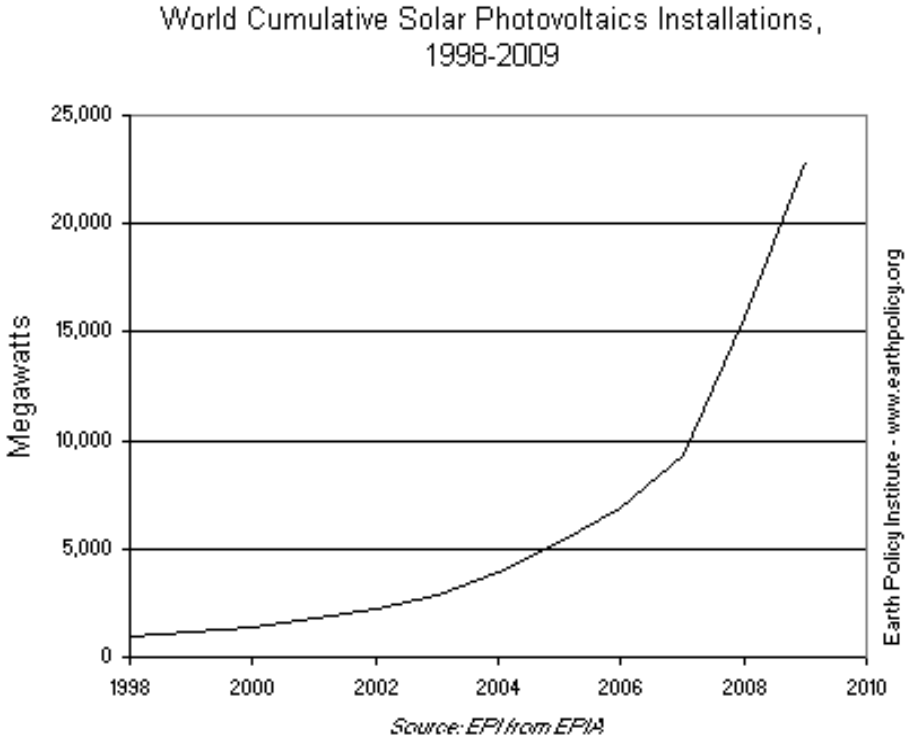
CPV: Lens array to focus sunlight on cells

TF PV: Glass-on-glass laminates with Thin PV Coating

Crystalline PV: Si PV cells bonded on glass

Solar Technologies – Deployment World Wide





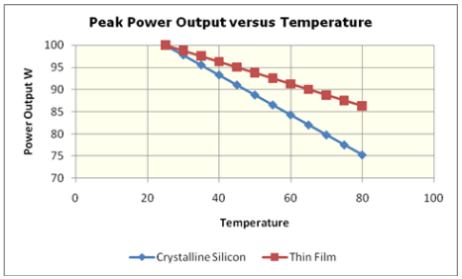
World Wide Installations:
PV: 22,000+ MW (c-Si: 80-85% and TF: 20-15%)
CSP: < 1000 MW
CPV: <100 MW

PV System Losses

Example: 17% c-Si module deployed in a 35 ^{o}C ambient climate.

1. Module efficiency	17.0%
2. Module T, ^{o}C (Ambient T + 20 ^{o}C)	55
3. Temp. Coefficient (c-Si modules)	-0.0048

Loss Item	Relative Loss	Net output	Net Efficiency
Initial value	-	100.00%	17.00%
Temperature	0.88	88.00%	14.96%
Inverter losses	0.97	85.36%	14.51%
Wiring losses	0.98	83.65%	14.22%
Panel Tolerance	0.97	81.14%	13.79%
Incident angle	0.96	77.90%	13.24%
Dirt and dust	0.98	76.34%	12.98%
Shadowing	0.97	74.05%	12.59%
Other losses	0.99	73.31%	12.46%



There is ~27% reduction in energy output of a solar panel from it's rated capacity – need to factor this in plant sizing. Simulations required as part of solar farm design.

Jawaharlal Nehru National Solar Mission (JNNSM) VISION

"Our vision is to make India's economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on no renewable and depleting sources of energy to renewable source of energy. In this strategy, the sun occupies centre-stage, as it should, being literally the original source of all energy. ***We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people.*** *Our Success in this endeavour will change the face of India. It would also enable India to help change the destinies of people around the world."*

Dr. Manmohan Singh, Prime Minister of India

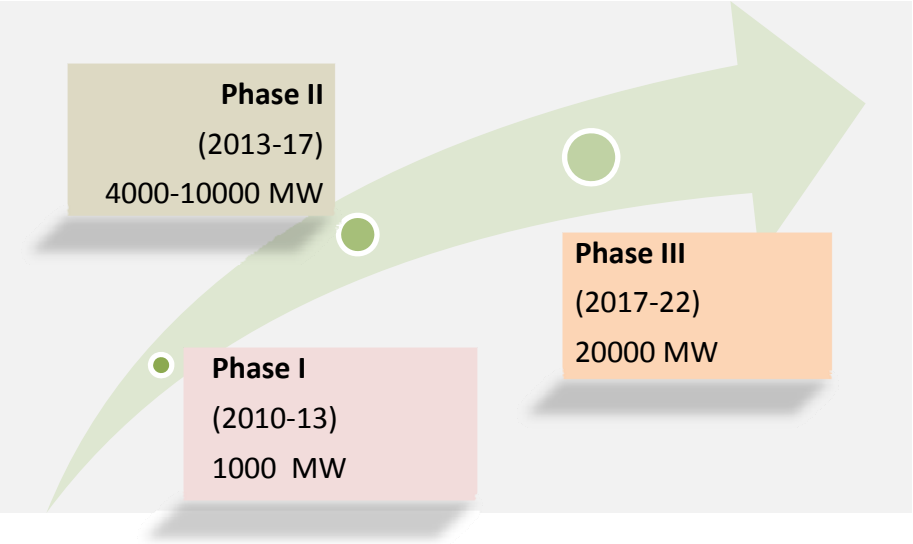
Launching India's National Action Plan on Climate Change on June 30,2008

The JNNSM Plan Overview

- Install 20GW of grid connected capacity by 2022 in Three Phases.
- Install 2 GW of off-grid solar applications by 2022
- Solar lighting for 20 million households by 2022.

Key Objective:

Establish India as a global leader in solar energy by creating policy for its diffusion across the country as quickly as possible: focus on setting up an environment for solar technology penetration in the country both at centralized and decentralized levels.



Indian PV market is poised to grow from <5 MW in 2009 to 500MW by 2013.

Guidelines for Implementation of Phase I

Key Objectives:

1. To facilitate a quick start of the JNNSM
2. To ensure serious participation of projects selected
3. To facilitate speedier implementation of the projects
4. To enhance confidence of the Project Developers
5. To promote manufacturing in the solar sector in India

Capacity of Projects:

- Total Installed Grid Connected Capacity in Phase 1: 1000 MW
- Solar PV Technology Projects: 500 MW
  - Batch 1: 150 MW (Selection of Projects in FY 2010-11)
  - Batch 2: 250 MW (Selection of Projects in FY 2011-12)
- Solar Thermal Technology Projects: 500 MW (Selection of Projects in FY 2011-12)

Key Guidelines for Selection of Projects for Phase I

1. Each Project to be 5 MW ±5% and connect to the Grid at 33kv or above
2. Only one application per Company including its Parent, Affiliate or Ultimate Parent-or any Group Company - to ensure wider participation
3. **Technical:** Only commercially established and operational technologies to minimize the technology risk and to achieve the commissioning of the Projects .
   - Require ≥90% of rated energy production after 1st 10 yrs and ≥ 80% after 25 yrs
   - "Bankability" requirements are stringent – banks require demonstrated technology
4. **Domestic Content:** Developers are expected to procure their project components from domestic manufacturers, as far as possible
   - In the case of Solar PV Projects in 1st batch during FY 2010-11, it will be mandatory for Projects based on crystalline silicon technology to use the modules manufactured in India.
   - For Solar PV Projects to be selected in 2nd batch during FY 2011-12, it will be mandatory for all the Projects to use cells and modules manufactured in India.

Time Line for PV Projects

Sl.	Event	Date
01	Notice for Request for Selection	Zero date ←Aug 18, '10
02	Submission of Applications with documents for Registration	Zero date+30 days
03	Short-listing of Projects based on RfS received and decision on tariff discounting	Zero date+75 days
04	Tariff discounting process and submission of proposals by short-listed developers	Zero date+90 days
05	Evaluation of Tariff discounting proposals	Within 30 days from submission of tariff discounting proposals (zero date+120 days)
06	Issue of letter of intent	Within 15 days from evaluation of tariff discounting proposals (zero date +135 days) ←Jan 1, '11
07	PPA Signing	Within 30 days from the date of issue of letter of intent (LOI date +30 days)
08	Financial Closure of the project	180 days from the date of signing of PPA
09	Commissioning of the Project	12 months from the date of signing of PPA

Zero date is 18th August 2010

Solar Farm Cost Components

1. Module Price : function of technology & efficiency
2.Total Balance Of System (BOS) Cost: function of module technology & efficiency
a) Electrical - Cables + Combiner boxes, etc.
b) Mechanical - Ground mount structures, supports, etc.
c) Inverter
d) Others: Plant Monitoring Equipment, Transformer, UPS, control room, etc.
3. Services: Design + Installation + Permits + Commissioning + Program Management
4. Insurance/Taxes: insurance for performance guarantee, import/sales taxes/VAT,
5. Finance Costs: function of interest rates, debt:equity ratio

Key Parameter to compare technologies for power generation:
Levelized Cost of Energy (LCOE): ¢/kWh/kWp

Conventional Thermal Power Vs PV Power Generation

No.	Category	Thermal Generation	Solar Power
1	Capital Cost per MW	$1M	$3M
2	Generation per MW per annum	7.5 MU (85% PLF)	1.7 MU (~20% PLF)
3	Land Requirement	~1 acre per MW	~5 acres per MW
4	Cost of Generation	Rs. 2.0 per Unit (kWh)	Rs. 15 per Unit (kWh)
5	Plant Operations & Maintenance	Fuel Required throughout life time of project. Maintenance of equipment required.	No fuel required. 100% Investment on plant operation and maintenance made upfront.
6	Environmental Impact	Huge CO_2 implications;	"Greenest" form of Energy generation
7	Suitability for Continious Power supply	Provides 24x7	Only during the day - without expensive back-up. Grid can assimilate about 5% load with solar power.

Note:

Rs 1 = ~2.1 ¢

Summary

- Solar energy is well suited for Indian conditions – climate, economic, etc.
  - Since India has among the highest solar insolation in the world
  - Off-grid systems will help alleviate some of the T&D losses
  - Best option for large seasonal demands (during summer/drought for farmers)
- National Solar mission is expected to accelerate solar technology development and deployment in India
  - Provide the necessary incentives to invest in solar technology
  - Test beds for solar thermal – enough data will be collected in the next few years to evaluate the merits of CSP
  - Already large manufacturing capacities have been installed in anticipation
    - Panel manufacturing capacity: >1.5 GW
    - Cell manufacturing capacity: > 1GW
    - Future expansion plans: >1 GW
- Next couple of years will set the trend for entire supply chain development for solar industry (PV and CSP) in India and showcase solar technology at the global level

Services offered by Surya Power

Consulting
- Provide guidance on different solar power technologies
- Solar energy harvest and guidance on suitable technology

Planning
- Provide detailed financial model
- Prepare detailed project report (DPR)

Engineering
- Provide detailed layout and structural design
- Provide detailed electrical design

Procurement
- Identify Bill of Materials for the entire solar power plant
- Procure reliable and low cost materials and equipment

Construction
- Site selection and site development
- Equipment installation and commissioning

Management
- Project monitoring
- Help with site permits and clearances

Operation & Maintenance
- Plant operation & billing
- Plant Maintenance

Contact Information:

Dr. S. Rao Peddada
Founder, Surya Power Inc.
rpeddada@suryapowerinc.com