

World Renewable Energy Forum

May 13-17, 2012

Denver, Colorado (USA)



Meeting the Dual Goal of Energy Access and Sustainability – CSP Deployment in Developing Countries

Present Status of India

Presented by:

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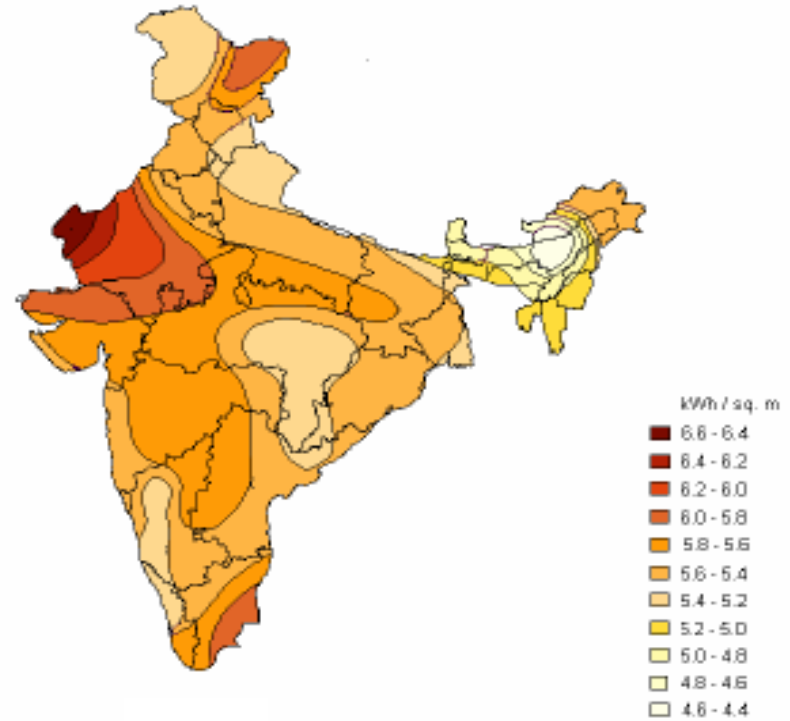
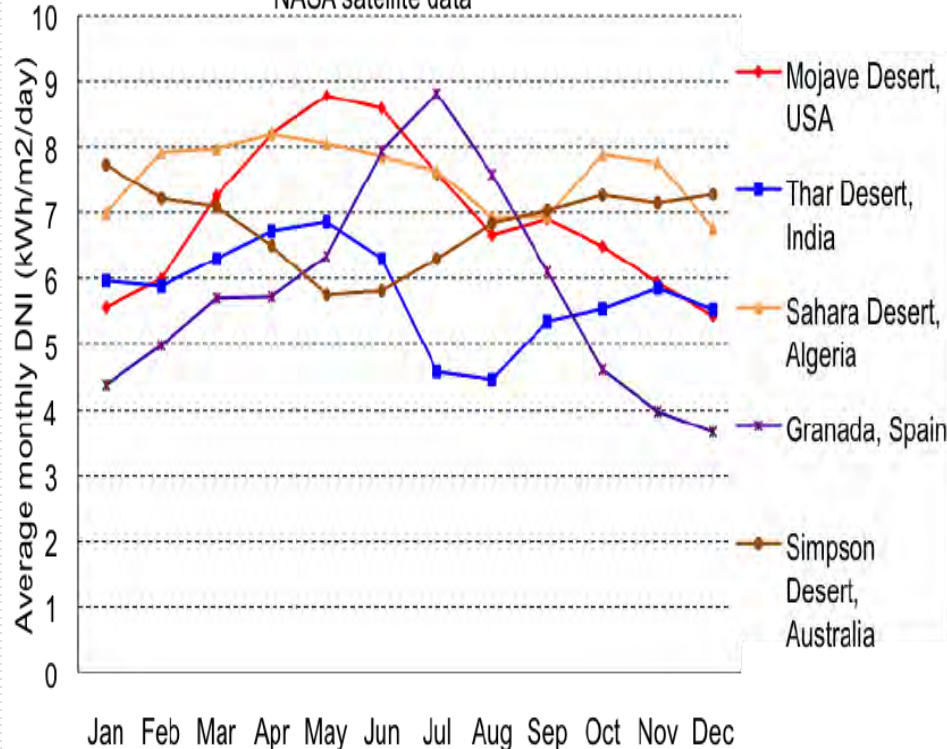
SECRETARY

CENTRAL ELECTRICITY REGULATORY COMMISSION

Indian Solar Resource

Comparison of desert sites across the world

NASA satellite data



Solar radiation on India

Source: TERI

□ The best sites in India are in the north west of the country

Policy and Regulatory Framework:

Solar Promotion in India: Technology agnostic

- ❑ The Electricity Act, 2003: RPO
- ❑ Tariff Policy :Separate RPOs for solar
- ❑ Jawaharlal Nehru National Solar Mission
- ❑ REC Mechanism: Separate Solar REC
- ❑ Announcement of solar policy by some States
- ❑ State-wise RPO Orders by Regulators
- ❑ Exemption from environmental clearance for solar power projects

Solar RPO

- ❑ Amendment to National Tariff Policy has mandated solar specific renewable purchase obligation of 0.25% by March, 2013, gradually increasing to 3% by 2022.
- ❑ At the National level total electricity generation in 2011-12 was ~ 879 billion units
 - ❑ 0.25% solar RPO means 2.20 million units : 1250 MW solar power generation capacity
- ❑ Most of the States have announced solar specific RPOs
- ❑ Many States (Gujarat – 968.5 MW, Maharashtra – 125 MW + 80 MW, Karnataka-80 MW, Rajasthan-100 MW) have announced specific plans.

State wise Solar RPOs – Status

State	2012-13	2013-14	2014-15	2015-16
AP	0.25%	0.25%	0.25%	0.25%
Assam	0.15%	0.20%	0.25%	
Bihar	0.75%	1.00%	1.25%	
Chhattisgarh	0.5%			
Delhi	0.20%	0.25%	0.30%	0.35%
Gujarat	1.00%			
Haryana	0.75%	1%	1.25%	
Himachal Pradesh	0.25%	0.25%	0.25%	0.25%
J & K	0.25%			
Jharkhand	1%			
Karnataka	0.25%	0.25%	0.25%	0.25%
Kerala	0.25%	0.25%	0.25%	0.25%
MP	0.6%	0.8%	1.0%	
Maharashtra	0.25%	0.50%	0.50%	0.50%
Rajasthan	0.50%	0.75%		

State wise Solar RPOs – Status

State	2012-13	2013-14	2014-15	2015-16
Manipur	0.25%			
Meghalaya	0.4%			
Mizoram	0.25%			
Nagaland	0.25%			
Orissa	0.15%	0.20%	0.25%	0.30%
Punjab	0.13%	0.19%		
Tripura	0.10%			
Tamil Nadu	0.05%			
UP	1%			
Uttarakhand	0.05%			
UTs & Goa	0.40%			

State wise Solar Power requirement

State	Solar RPO	Installed Capacity (MW)	Solar Power Required (MW)										
	2011-12	as on 31.05.2011	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Andhra Pradesh	0.25%	14268	143	294	454	622	799	984	1179	1381	1592	1812	2226
Arunachal Pradesh	0.25%	135	1	3	4	6	8	9	11	13	15	17	21
Assam	0.25%	951	10	20	30	41	53	66	79	92	106	121	148
Bihar	0.25%	1854	19	38	59	81	104	128	153	179	207	235	289
Chhattisgarh	0.25%	4632	46	95	147	202	259	320	383	448	517	588	723
Delhi	0.25%	5800	58	119	184	253	325	400	479	561	647	737	905
Goa & UT	0.25%	822	8	17	26	36	46	57	68	80	92	104	128
Gujarat	0.25%	13722	137	283	436	598	768	947	1133	1328	1531	1743	2141
Haryana	0.25%	5880	59	121	187	256	329	406	486	569	656	747	917
Himachal Pradesh	0.25%	2201	22	45	70	96	123	152	182	213	246	280	343
Jammu & Kashmir	0.25%	2167	22	45	69	94	121	150	179	210	242	275	338
Jharkhand	0.25%	1979	20	41	63	86	111	137	163	192	221	251	309
Karnataka	0.25%	9530	95	196	303	416	534	658	787	923	1064	1210	1487
Kerala	0.25%	3573	36	74	114	156	200	247	295	346	399	454	557
Madhya Pradesh	0.25%	8114	81	167	258	354	454	560	670	785	906	1030	1266
Maharashtra	0.25%	20271	203	418	645	884	1135	1399	1674	1962	2262	2574	3162
Manipur	0.25%	152	2	3	5	7	9	10	13	15	17	19	24
Meghalaya	0.25%	258	3	5	8	11	14	18	21	25	29	33	40
Mizoram	0.25%	102	1	2	3	4	6	7	8	10	11	13	16
Nagaland	0.25%	75	1	2	2	3	4	5	6	7	8	10	12
Orissa	0.25%	5299	53	109	169	231	297	366	438	513	591	673	827
Punjab	0.25%	6690	67	138	213	292	375	462	553	648	747	850	1044
Rajasthan	0.25%	7508	75	155	239	327	420	518	620	727	838	954	1171
Sikkim	0.25%	154	2	3	5	7	9	11	13	15	17	20	24
Tamil Nadu	0.25%	9803	98	202	312	427	549	676	810	949	1094	1245	1529
Tripura	0.25%	249	2	5	8	11	14	17	21	24	28	32	39
Uttar Pradesh	0.25%	9848	98	203	313	429	551	680	813	953	1099	1251	1536
Uttarakhand	0.25%	2309	23	48	73	101	129	159	191	224	258	293	360
West Bengal	0.25%	8155	82	168	259	356	457	563	674	789	910	1036	1272
Total		146501	1465	3018	4659	6387	8204	10109	12101	14181	16350	18606	22854

Jawaharlal Nehru National Solar Mission (JNNSM)

- JNNSM was launched by the Government of India in January 2010.
- JNNSM is one of the major global initiatives in promotion of solar energy technologies.
- Mission aims to achieve grid tariff parity by 2022 through
 - Large scale utilization, rapid diffusion and deployment at a scale which leads to cost reduction
 - R&D and technology demonstration
 - Local manufacturing and support infrastructure

JNNSM Road Map

Application Segment	Target for Phase I (2010-13)	Cumulative Target for Phase 2 (2013-17)	Cumulative Target for Phase 3 (2017-22)
Grid solar power incl. roof top & distribution grid connected plants	1,100 MW	4,000 - 10,000 MW	20,000 MW
Off-grid solar applications	200 MW	1,000 MW	2,000 MW
Solar collectors	7 million sq meters	15 million sq meters	20 million sq meters

Grid Solar Power - Large Plants

- **1,000 MW Capacity solar power (connected to 33 KV or higher grid) through bundling**
 - **500 MW Solar thermal**
 - **500 MW Solar PV**

- **500 MW Solar Thermal**
 - **To be completed in 28 months after signing PPA**
 - ❖ **Permitted plant capacity for a new project: 20 MW to 100 MW for solar thermal**

Grid Solar Thermal Power-New projects

Solar Thermal :

- 7 projects for 470 MW selected in December, 2010 through competitive bidding
- Average Tariff Rs. 11.48/kWh (0.23 C/kWh)
 - CSP Projects scheduled to be synchronized in early 2013
- 2.5 MW capacity of a 10 MW CSP project (under FiT) synchronized to the grid in May, 2011

**10 MW capacity
project at
Bikaner by
ACME: 2.5 MW
Commissioned**



Solar REC

- ❑ 1 MWh = 1 REC
- ❑ Solar REC will be traded between floor rate effective April 2012 as Rs. 9300/MWh (\$186/MWh)
- ❑ Forbearance price is Rs. 13400/MWh (\$268/MWh)
 - ❑ Valid up to control period 2016-17
 - ❑ 3 Solar PV projects registered under REC framework of 8.055 MW

R&D Strategy

- ❑ **Research at Academic/Research Institutions on materials & devices with long term perspective**
- ❑ **Applied Research on existing processes and developing new technologies**
- ❑ **Technology Validation aimed at field evaluation of materials, components and systems**
- ❑ **Development of Centers of Excellence in thematic areas of research in the area of Solar Energy.**
- ❑ **Support for Incubation and Innovation**
- ❑ **International collaborations with institutional/industrial**

R&D Activities

- 36 R&D projects under implementation
- Centers of Excellence in research and education - *5 Centers sanctioned*
- Technology Validation - *1 MW solar thermal power with storage; field trials of thermal systems for industrial process heat*
- Testing & Training - *6 test labs for PV & 6 for solar thermal systems*
- International collaborations - *Joint projects with USA, Japan, Germany, Spain*
- 51 new centers set up for Solar Radiation Data collection

National Solar Thermal Power Testing, Simulation and Research Facility

- **1MWe Solar Thermal Power Plant**
 - Research and Demonstration plant
 - Combination of different collector fields
(Direct and Indirect Steam Generation)

Parabolic Trough Field
- 8700 sq. m
- 3.3 MWth (Design)

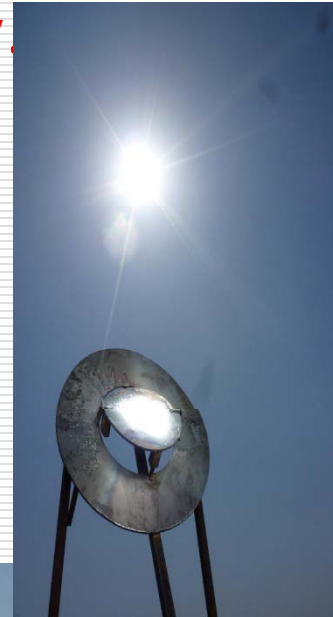


Linear Fresnel Field
- 7200 sq. m
- 2.2 MWth (Design)



**Turbine operating conditions:
saturated steam at 350 deg. C and 40 bar**

1 MW with 16 hour thermal storage Project at Mount Abu By WRST with co-funding from German Ministry and Indian industry.



Ground Measurements of Solar Radiation

Andhra Pradesh	6
Gujarat	11
Haryana	1
Madhya Pradesh	3
Karnataka	5
Rajasthan	12
Chhattisgarh	1
Ladakh	1
Maharashtra	3
Pudducherry	1
Tamil Nadu	6



- C-WET is implementing the project for setting up 51 ground monitoring stations
- Centralized data collection, analysis and calibration of measuring sensors

Solar Energy Centre

- **Solar Energy Centre (SEC) near New Delhi under the Ministry is the lead Centre for testing and training in solar energy in the country**
- **SEC has NABL accredited testing facilities for PV module qualification as per Indian and International standards**
- **SEC is imparting training in solar energy at various levels**
- **SEC is regularly conducting international training programmes in solar energy with MEA**
- **Demonstration of several solar PV and thermal applications including setting up of 1 MW capacity solar thermal simulation and validation facility at SEC is under progress**



Solar PV outdoor test bed at SEC



Other Initiatives

- **30% domestic content in the cost of solar thermal power projects has been made mandatory for the Phase 1 projects**
- **Strengthening of transmission network for evacuation of solar power in Rajasthan, Gujarat and some other States**
- **Pilot projects on solar thermal power to address issues related to air cooling, hybridization, large thermal storage, new technologies etc.**
- **Proposal to set up National Institute for Solar Energy (NISE) which will include Solar Energy Centre.**
- **Consultation process for launching Phase-II to be started now to maintain continuity in implementation of grid solar power projects**

Institutional Arrangements

- ❑ **Solar Energy Corporation of India (SECI) set up as a Company Not for Profit under Section 25 of Company Act for implementation of activities under the Mission**
- ❑ **Mission Steering Group**
- ❑ **Solar Energy Research Advisory Council,**

CERC Initiatives

- ❑ Capital cost Rs. 13 Crore/MW (2600 \$/kW), With out storage
 - Higher capital cost for projects with storage but with higher CUF levelized tariff much not different
- ❑ Capacity Utilization Factor: 23%
- ❑ Levelized Tariff : Rs. 12.46/kWh (0.25 C/kWh)
- ❑ Project specific tariff provision for CSP project with thermal storage and Hybrid projects

Solar Thermal	09-10	10-11	11-12	12-13
Capital Cost :Rs. Crore/MW (\$/kW)	13 (2600)	15.30 (3060)	15 (3000)	13 (2600)
Tariff :Rs. /kWh (Cent/kWh)	13.45 (0.27)	15.31 (0.306)	15.04 (0.30)	12.46 (0.25)

Barriers to CSP Deployment

- **Cost: current high capital cost**
 - **Drastic cost reduction in PV**
- **Financing: A significant barrier**
 - **Financier are unfamiliar with CSP investment**
- **Manufacturing scale-up**
 - **Currently lack of Domestic manufacturing facility**
- **Solar Data**
 - **Reliable long term DNI and weather data**

Way Forward For developing countries

- ❑ **CSP with storage facility to meet peak demand**
 - **Thermal storage to provide more cost-effective approaches to achieving renewable energy dispatchability**
- ❑ **Solar Hybrid system for existing plants (Steam and gas turbines)**
- ❑ **Solar Parks for large-scale CSP projects**
- ❑ **Establish one or more Demonstration Solar Parks“ for small-scale, commercial demonstration systems for different technology**
- ❑ **Establish projects to improve on DNI data availability, by both adding ground based data gathering and also to reverse analyse, correlate and re-calibrate all existing forms of historical data**
- ❑ **Make all such data freely available and easily accessible**
- ❑ **Innovative financing scheme for CSP projects**

Thank You !