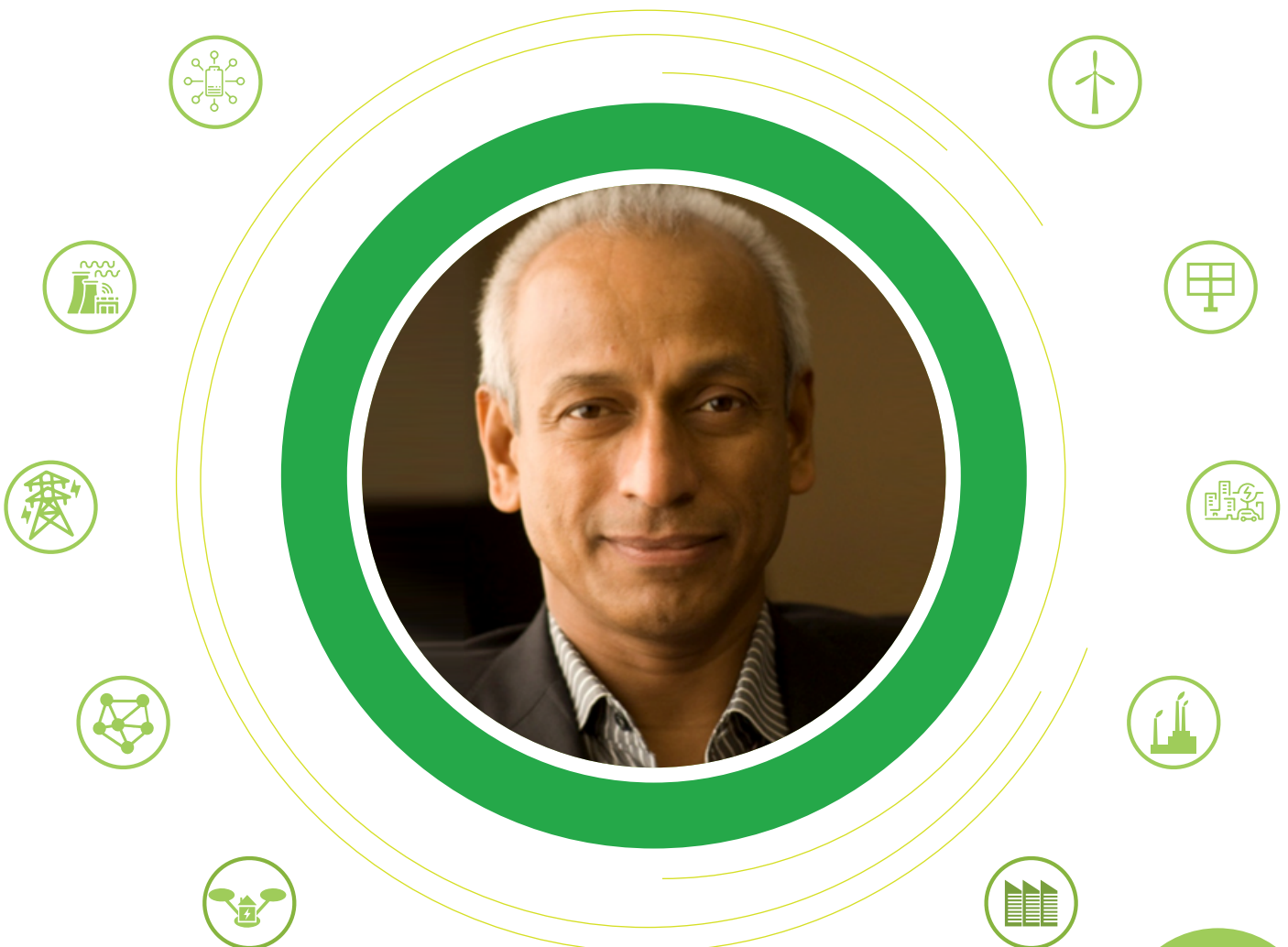


UNLEASHING A SOLAR ROOFTOP REVOLUTION IN INDIA

Reji Kumar Pillai
President, ISGF and Chairman, GSGF

India is pursuing an ambitious program for development of 175,000 MW of renewable energy by 2022. This comprises of 40,000 MW from rooftop solar panels installed on 20 million buildings across the country; and year-wise targets were allotted to all the states. While the about 50% of the overall target of 175,000 MW is achieved by December 2019, the performance of the rooftop segment is less than 10%. All the states and union territories in India had issued net-metering policies between 2013 and 2016. Theoretically every electricity consumer can be a “prosumer” – producer and consumer of electricity by installing solar panels at their premises. Initially, electricity distribution companies (DISCOMs) were not enthusiastic about promoting solar rooftops in their service areas owing to the fear of revenue losses. That is fast changing. Now, with the prices of the kilo-watt (kW) scale solar photo-voltaic (PV) systems in the range of INR 50,000/kW (or US\$ 700/kW) including installation charges, and many DISCOMs actively promoting solar rooftops, the time has come to unleash a solar rooftop revolution in the country.



Cost of Solar PV Systems

Cost of installing 1kW and 5 kW systems are presented in the Table-1 below:

S. No	Item/Component	Cost/Watt	Cost (in INR)		Remarks
			1 kW System	5 kW System	
1.	Solar PV Panels	₹20	₹20,000	₹1,00,000	
2.	Inverter	₹12	₹12,000	₹50,000	1kW system with a single-phase inverter and the 5kW system with a 3-phase inverter; cost of inverter reduces as size increases
3.	Support Structures	₹4	₹4,000	₹20,000	
4.	Balance of System	₹6	₹6,000	₹30,000	
5.	Installation and Commissioning Charges	₹10	₹10,000	₹40,000	For bigger systems installation cost reduces
Total cost		₹52	₹52,000	₹2,40,000	

In most part of India 1kW panel could generate average 1200-1500 kWh or more of electricity in a year. Commercial customers in the country pay average INR 9 per kWh; and residential customers who consume 500 kWh or more per month pay INR 7 per kWh for the power from the grid, which are likely to increase every year. At the above price levels, the payback period for rooftop solar is about 4-5 years for commercial customers and 6-7 years for residential customers while the life of a PV system is 20-25 years with minimum annual maintenance and performance deterioration.



Net Metering Policies in Various States

Over the years most state electricity regulatory commissions (SERC) have been fine-tuning the net metering policies periodically. Salient features of the latest net metering policies in various states are presented in Table-2 and Table-3 at the Appendix.



Fear of DISCOMs

The DISCOMs have been apprehensive of their revenue loss from rooftop solar as those installing such systems are high volume customers who pay INR 7 or more per kWh whereas the average power purchase cost of the DISCOM is below INR 5/kWh. The profit they make from these categories of customers is what DISCOMs leverage to subsidize the poor customers to whom they supply electricity at INR 2-3/kWh. If large number of high volume customers start producing and consuming electricity from rooftop solar systems, DISCOMs tend to lose revenue; and for buying the electricity from them, DISCOMs have to pay higher than the average power purchase cost. Hence DISCOMs have been viewing rooftop solar as a double-edged sword and this has been the main hurdle in scaling up of rooftop solar. It is time to have a relook at the new market dynamics to see how rooftop solar can help DISCOMs.

Advantages to DISCOMs from Solar Rooftop Systems

In most urban areas the feeders are mixed use with commercial and residential customers and during the day there is reasonable load on the feeder. So, the electricity generated during the day by rooftop systems gets consumed in the same locality in the low voltage network itself. On many such feeders the maximum load is during the afternoon hours when solar generation is maximum. This is owing to the air-conditioning load in the afternoon hours. Evening time although shops are still open, offices and other business establishments closes. Residential air-conditioning load increases post 9-10pm and by then shops are closed. On such feeders with mixed category of loads, the peak demand is usually during the day while solar rooftop systems generate power. As the load increases in each locality, DISCOMs need to upgrade the distribution system – higher capacity distribution transformers and cables/wires. This is an exercise that DISCOMs do periodically. In certain cases, they need to build bigger substation and the transmission companies have to build high voltage lines to supply to the new substation. In urban India, space for locating new transformers and substations is not easily available. If the peak load is partially met by local generation from solar rooftops, the distribution system upgrade can be delayed by few years.

A recent study by Council on Energy, Environment and Water (CEEW) and BSES Rajadhani Power Ltd (BRPL) in Delhi have calculated a net benefit of INR 0.22 per kWh generated from rooftop solar . They considered following benefits:

- ⚠️ Avoided power purchase cost which is the fixed cost paid to generators for the power contracted through long term power purchase agreements
- ⚠️ Avoided transmission charges which are fixed transmission charges paid to transmission companies based on the quantity of power contracted
- ⚠️ Avoided distribution capacity cost which is capex avoided in enhancing the distribution network capacity to meet the additional load. The rooftop solar power is generated and consumed in the low voltage network itself without any additional enhancements in the medium voltage or low voltage networks to bring that much additional power from elsewhere
- ⚠️ Avoided cost of renewable energy certificates. Presently, the renewable energy purchase obligation (RPO) to DISCOMs set by the government is 17.5% of which 7.25% must be from solar energy. Generation from grid-connected rooftop solar systems within the DISCOM service area contributes towards the fulfilment of their RPO targets. DISCOMs are buying renewable energy certificates (REC) at market prices to meet their RPO obligations which is about INR 0.48 per kWh.
- ⚠️ Avoided working capital cost for the 4 items listed above

On the cost side, the study considered revenue loss, program administration cost and added distribution services cost to the DISCOMs. This study took actual data from ten distribution transformers (DT) connected to residential, commercial, industrial and institutional customers with rooftop solar capacity varying from 10 kW to 220 kW. BRPL is actively promoting rooftop solar in their service and have installed 59 MW so far. This study should be an eye opener for other DISCOMs discouraging rooftop solar.



Peer to Peer Trading of Solar Rooftop Power

Peer-to-peer (P2) trading of electricity is gaining momentum globally. This is achieved through smart contracts executed on blockchain. Several successful pilot projects have come up in different countries that have established the technology. The participants in this market place could sell electricity from their rooftop solar to other participants at the best prices they can get almost in real-time. Some participants having no rooftop solar who are buyers of electricity from the blockchain platform could look for the availability of cheapest electricity and schedule their consumption or even meet their RPO targets. In the revised solar policies issued by Uttar Pradesh Electricity Regulatory Commission (UPERC) in December 2018, the Commission advised DISCOMs in Uttar Pradesh to promote P2P trading of solar rooftop through smart contracts on blockchain technology . This P2P trading system will protect the DISCOMs from revenue loss and also open up new revenue streams from wheeling charges (fee for using the DISCOM's distribution network for transporting the electricity from the rooftop solar to the buyer) and fee for billing and settlement.

Steps to Scale Up of Solar Rooftop Systems

In our view, the primary obstacle in offtake of rooftop systems is the lack of awareness amongst the customers. They do not know what systems to buy, how to get it installed and how to get the net metering connections. The resistance from DISCOMs in giving connections is also often alleged for the slow progress of the solar rooftops. Lack of tested and certified installers is another big issue. Our recommendations are:

- 1** Commoditized solar rooftop systems: Like other household appliances such as air-conditioners and washing machines, we do not see advertisement of solar rooftop systems in local papers and social media. We guess the market is ripe for entrepreneurs to launch commoditized full systems that can be bought from local appliances stores. Ministry of New and Renewable Energy (MNRE) and state renewable energy development agencies should work towards this goal. DISCOMs could empanel tested systems that may be made available in local appliance stores.
- 2** Testing and Certifications for Installers: DISCOMs and other designated agencies may conduct training programs and certify skilled installers. This could generate millions of new jobs across the country. With smart metering rollouts, thousands of meter readers who will become redundant could be trained and redeployed for solar rooftop installation by DISCOMs themselves for standard fees competitive with market rates.

3 Government subsidies to DISCOMs: As indicated in the beginning, solar rooftop systems are already economically attractive to customers and they do not require any grant or subsidies. Government's support should go to DISCOMs who need to upgrade the distribution systems to accommodate increasing share of distributed renewable resources that are intermittent. ISGF modelling studies in 2019 estimated about 10 GWh of battery energy storage systems to integrate the targeted 40 GW solar power with medium voltage and low voltage grid.

4 Promote P2P Trading: Frame appropriate regulations to promote P2P trading of rooftop solar energy amongst customers across the DISCOM service area. Such energy produced and traded may be counted in the RPO target of the DISCOMs. RPO regulations are silent on this presently which may be amended.

5 In 2016, Government of Haryana issued an order mandating all new buildings in the state on a plot size of 500 Sq Yard or above to have solar rooftop of minimum 1 kW or 5% of the connected load. However, this order has not been strictly implemented. We propose to make this mandatory all over the country and the cost of rooftop solar system may be included in the total cost of the house for home loans by financial institutions.

6 Both rooftop solar and electric vehicles (EV) are typically connected to the low voltage grid. The AC charging points for EVs in new buildings may be equipped with vehicle-to-grid (V2G) functionalities. This would help store the solar generation in the EV batteries when local consumption is less than solar generation avoiding curtailment. The EV batteries could also help smoothen the intermittency of solar generation from the rooftop systems thereby improving the power quality in the low voltage. Various incentives schemes could be framed for the EV owners who participate in the V2G program. Many of them could buy electricity from the grid when price is low and sell back to the grid when price on the grid price for electricity is higher.



APPENDIX

Table-2: Solar Rooftop PV limits according to net metering policies

State or Union Territory	Limits for Individual Customers	Installed Capacity Limit as % of DT Capacity
Andaman and Nicobar Islands (UT)	<500 kWp	50% of DT capacity
Andhra Pradesh	Not Specified	60% of DT capacity
Arunachal Pradesh	<1000 kWp	15% of DT capacity
Assam	40% of contracted load, 2016, 80% of contracted load of Individual, 2017 draftBihar	Specified by commission from time to time, 2015, 20% of DT capacity
Bihar	<Sanctioned load	15% of DT capacity
Chandigarh (UT)	<500 kWp: 80% of the sanctioned load	50% of DT capacity
Chhattisgarh	Not Specified	
Dadra and Nagar Haveli (UT)	<500 kWp	50% of DT capacity
Daman and Diu (UT)	<500 kWp	50% of DT capacity
Delhi	No limit specified (depends on feasibility)	Not less than 20% of DT capacity
Goa (UT)	<500 kWp	50% of DT capacity
Gujarat	<50% of the sanctioned load	65% of DT capacity
Haryana	<Connected load	30% of DT capacity in case of interconnection is at LT and 15% of the peak capacity of the PT in case of interconnection is at HT
Himachal Pradesh	<80% of the sanctioned contract demand for consumers under two-part tariff <30% of the sanctioned connected load for consumers under single part tariff	30% of DT capacity
Jammu and Kashmir	<50% of the sanctioned load of the consumer	20% of DT capacity
Jharkhand	<100% contracted load	15% of DT capacity
Karnataka	<100% contracted load	80% of DT capacity

Kerala	<100% contracted load	For generation at LT: 15% of DT capacity. For generation at HT: Cumulative capacity connected to the distribution feeder under a particular power transformer is less than 80% of the average load as in the previous one year
Lakshadweep (UT)	<500 kWp	30% of DT capacity
Madhya Pradesh	<1MWp at HT	30% of DT capacity
Maharashtra	<100% contracted load	40% of DT capacity, allowed to exceed upon detailed load study
Manipur	<100% contracted load	40% of DT capacity
Meghalaya	<100% contracted load	15% of DT capacity
Mizoram	<100% contracted load	40% of DT capacity
Nagaland	<80% of the sanctioned load	15% of DT capacity
Odisha	Not Specified	75% of DT capacity
Puducherry (UT)	<500 kWp	50% of DT capacity
Punjab	80% of the sanctioned load	30% of DT capacity
Rajasthan	80% of the sanctioned load	30% of DT capacity
Sikkim	<100% contracted load	For generation at LT: 15% of DT capacity. For generation at HT: Cumulative capacity connected to the distribution feeder under a particular power transformer is less than 80% of the average load as in the previous one year
Tamil Nadu	<100% contracted load	30% of DT capacity
Telangana	For Residential and Government consumers: up to a maximum of 100% of the consumer's sanctioned load; For Industrial, Commercial and Other Consumers: up to a maximum of 80% of the sanctioned load / contracted demand of the consumer	For LT consumers, 50% of DT capacity. For HT consumers, 50% of the maximum load permitted on the feeder, allowed to exceed upon detailed load study
Tripura	<100% contracted load	15% of DT capacity, allowed to exceed upon detailed load study
Uttar Pradesh	<100% contracted load	75% of DT capacity
Uttarakhand	<500	15% of DT capacity, issue raised to increase this value
West Bengal	>5 kW, injection shall not be more than 90% of the consumption from the licensee's supply in a year	Not Specified

States and UTs	Latest Solar Rooftop Policy (web link)	Salient Features
Andhra Pradesh	https://bit.ly/3aLaLzT	<ul style="list-style-type: none"> ● To target a minimum total solar power capacity addition of 5,000 MW in the next five years in the State with a view to meet the growing demand for power in an environmentally sustainable manner ● To develop solar park(s) with the necessary utility infrastructure facilities to encourage developers to set up solar power projects in the State ● To promote distributed generation that can help in avoiding upstream network cost and contribute towards loss reduction
Assam	https://bit.ly/2Grxd2Z	<ul style="list-style-type: none"> ● To create an enabling environment for businesses and developers to participate and invest in the process of targeted solar power capacity expansion of 590 MW by 2019-20 in the state of Assam by means of multiple models of solar power generation ● To encourage residential, commercial, industrial and Government consumers for adoption of modern solar power technology with on-grid and off-grid installations
Chhattisgarh	https://bit.ly/2O3RxeW	<ul style="list-style-type: none"> ● To encourage, develop and promote solar power generation in the State with a view to meet the growing demand for power in an environmentally and economically sustainable manner ● To create a favourable environment for development of solar manufacturing capabilities within the State
Delhi	https://bit.ly/2U1CW7E	<ul style="list-style-type: none"> ● Reduce Delhi's reliance on conventional energy while increasing its energy security and lowering average energy prices in the long term ● Ensure fairness for all stakeholders in the solar ecosystem, including roof top owners, DISCOMS, investors, consumers of non-solar power, technology and services providers ● Promote net metering / gross metering and grid connectivity for all solar plants by simplifying and streamlining processes and methods
Goa	https://bit.ly/38IXS7D	<ul style="list-style-type: none"> ● The Small Prosumer will be billed on NET Metering up to Sanction load/Contract demand up to 90KW such that anticipated generation in the year is not more than 100% of the electricity consumption in the previous (12) months ● The Small Prosumer opting for Gross metering will get benefit of 50 paise in addition to Joint Electricity Regulatory Commission (JERC)
Gujarat	https://bit.ly/2t5JWFG	<ul style="list-style-type: none"> ● To promote green and clean power and to reduce the State's carbon emission ● To reduce dependency on fossil fuels for energy security and sustainability
Haryana	https://bit.ly/2O4bXVf	<ul style="list-style-type: none"> ● To promote generation of green and clean power in the State using solar energy ● To create conditions conducive to the participation of private and public sector as well as PPP in the promotion and setting up of up Solar Energy based power projects in the State

Himachal Pradesh	https://bit.ly/36woW8B	<ul style="list-style-type: none"> ● Strengthen and sustain the Policy of 100% clean electricity consumption in the State, by providing a suitable alternative to coal and gas-based power and to provide firm base load power during the sunshine time of the day, so that water in the hydro projects are impounded during day time for peaking power ● Contribute to macro policies and strategies on climate change, environment protection and sustainable development
Jammu & Kashmir	https://bit.ly/3oXo48G	<ul style="list-style-type: none"> ● To contribute to solar capacity addition and fulfilment of Solar targets set by the Ministry ● To optimally utilize the available solar energy resource in the State ● To encourage development and promotion of environment friendly solar energy generation contributing to sustainable development
Jharkhand	https://bit.ly/37uN7pp	<ul style="list-style-type: none"> ● To encourage participation of Private Sector to set up Solar Power based projects in the State & increase solar power generation to 2650 MW by the year 2020 in a phased manner. ● To build a favourable atmosphere for setting up Solar Power projects
Karnataka	https://bit.ly/3aLexZU	<ul style="list-style-type: none"> ● To add solar generation of minimum 6000 MW by 2021 in a phased manner by creating a favourable industrial atmosphere. ● To translate Karnataka in to an investor friendly state. ● To promote Solar Roof Top Generation and Technologies.
Kerala	https://bit.ly/2TYEoJu	<ul style="list-style-type: none"> ● Increase the installed capacity of the solar sector in the State to 500MW by 2017 and 2500 MW by 2030 ● Contribute to long term energy security of the State of Kerala as well as ecological security by reduction in carbon emission ● Define end users who can adopt solar in a big way and target them
Madhya Pradesh	https://bit.ly/2Grp1Qm	<ul style="list-style-type: none"> ● To encourage participation of Private Sector to set up Solar Power based projects in the State ● To define the incentives and benefits to be provided to the participants of the Private Sector in clear terms ● To build a favourable atmosphere for setting up Solar Power projects
Manipur	https://bit.ly/38J5LKO	<ul style="list-style-type: none"> ● This policy aims to lay a framework for harnessing the ubiquitous Solar energy in the State by utilizing the empty rooftops of the buildings in the State ● The policy aims to utilize the existing roof space of buildings for the roof-top SPV systems to replace DG gensets installed for minimum load requirement for operation during load shedding

Mizoram	https://bit.ly/3oWYDqP	<ul style="list-style-type: none"> ● To encourage, develop and promote solar power generation. ● To develop Mizoram into an investor friendly State ● To encourage public as well as private investment in solar power generation ● To promote decentralized and distributed generation
Odisha	https://bit.ly/2U1Jwef	<ul style="list-style-type: none"> ● Contributing to long term energy security of the State as well as ecological security by reduction in carbon emissions ● Providing a long-term sustainable solution for meeting energy needs and reducing dependence on depleting fossil fuel resources like coal ● Productive use of wastelands, thereby utilizing the non-industrialized areas that receive abundant sunshine for creation of solar power hubs
Puducherry	https://bit.ly/2uAoM2G	<ul style="list-style-type: none"> ● Define clear and transparent policy governance ● Encourage public-private partnerships and joint ventures to mobilize investments in solar energy projects, manufacturing facilities, research and technology development ● Facilitate open access to the public electricity grid of the Puducherry Union Territory and thereby create opportunities for grid-connected distributed generation of solar power and smart grid solutions, such as the propagation of electric transport, in order to reduce the dependence on fossil fuels and urban air pollution
Punjab	https://bit.ly/37wl9bs	<ul style="list-style-type: none"> ● This Policy shall apply to the distribution licensee and consumers of distribution licensee of the State of Punjab ● The eligible consumer may install the rooftop solar system under net metering arrangement which; a) shall be within the permissible rated capacity as defined under this Policy. b) shall be located in the consumer premises. c) shall interconnect and operate safely in parallel with the distribution licensee network
Rajasthan	https://bit.ly/2Gnj72L	<ul style="list-style-type: none"> ● Developing a global hub of solar power of 25,000 MW capacity to meet energy requirements of Rajasthan and India ● Contributing to long term energy security of Rajasthan as well as ecological security by reduction in carbon emissions ● Providing a long-term sustainable solution for meeting energy needs and considerably reducing dependence on depleting fossil fuel resources like coal, oil and gas
Tamil Nadu	https://bit.ly/2RurCiL	<ul style="list-style-type: none"> ● Define clear and transparent policy governance ● Establish an eco-system that translates the solar energy vision into enabling policy systems and processes ● Use regulatory mechanisms to ensure that Tamil Nadu will achieve, or exceed, the solar energy portfolio obligations as may be determined by the Tamil Nadu Electricity Regulatory Commission (TNERC) from time to time
Telangana	https://bit.ly/3aNW9jo	<ul style="list-style-type: none"> ● Realize and harness the vast solar power potential of the State. ● Contribute to long-term energy security of the state and promote a sustainable fuel mix in generation through higher contribution of solar energy ● To promote solar parks

Uttar Pradesh

<https://bit.ly/38IfOB>

- To contribute to solar capacity addition and energy security
- To optimally utilize the available solar energy resource in the State
- To encourage development and promotion of environment benign solar energy generation contributing to sustainable development

Uttarakhand

<https://bit.ly/2NYomtO>

- Promoting green and clean power using solar energy to reduce the dependence on conventional source of energy like coal, gas and oil
- Aims to target to set up 500 MW of solar power plants by the year 2017

