Integrating rooftop solar with grid

March 2018

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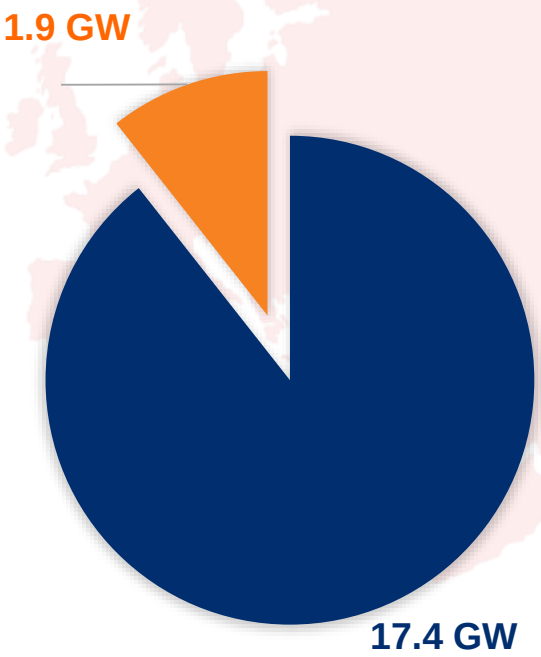
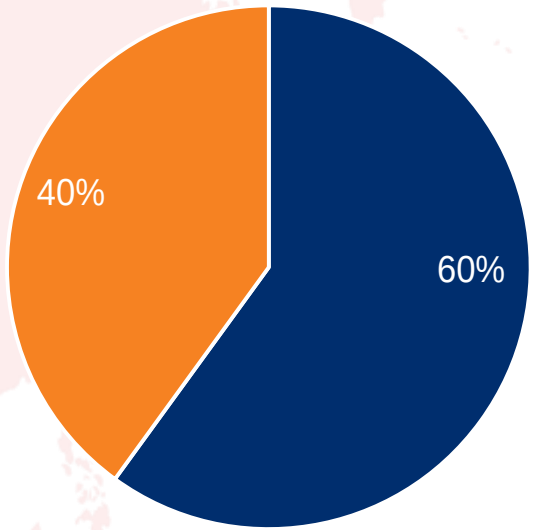
Indian rooftop solar market is in nascent stage, but government has an ambitious target

Installed capacity



MNRE target (100 GW)



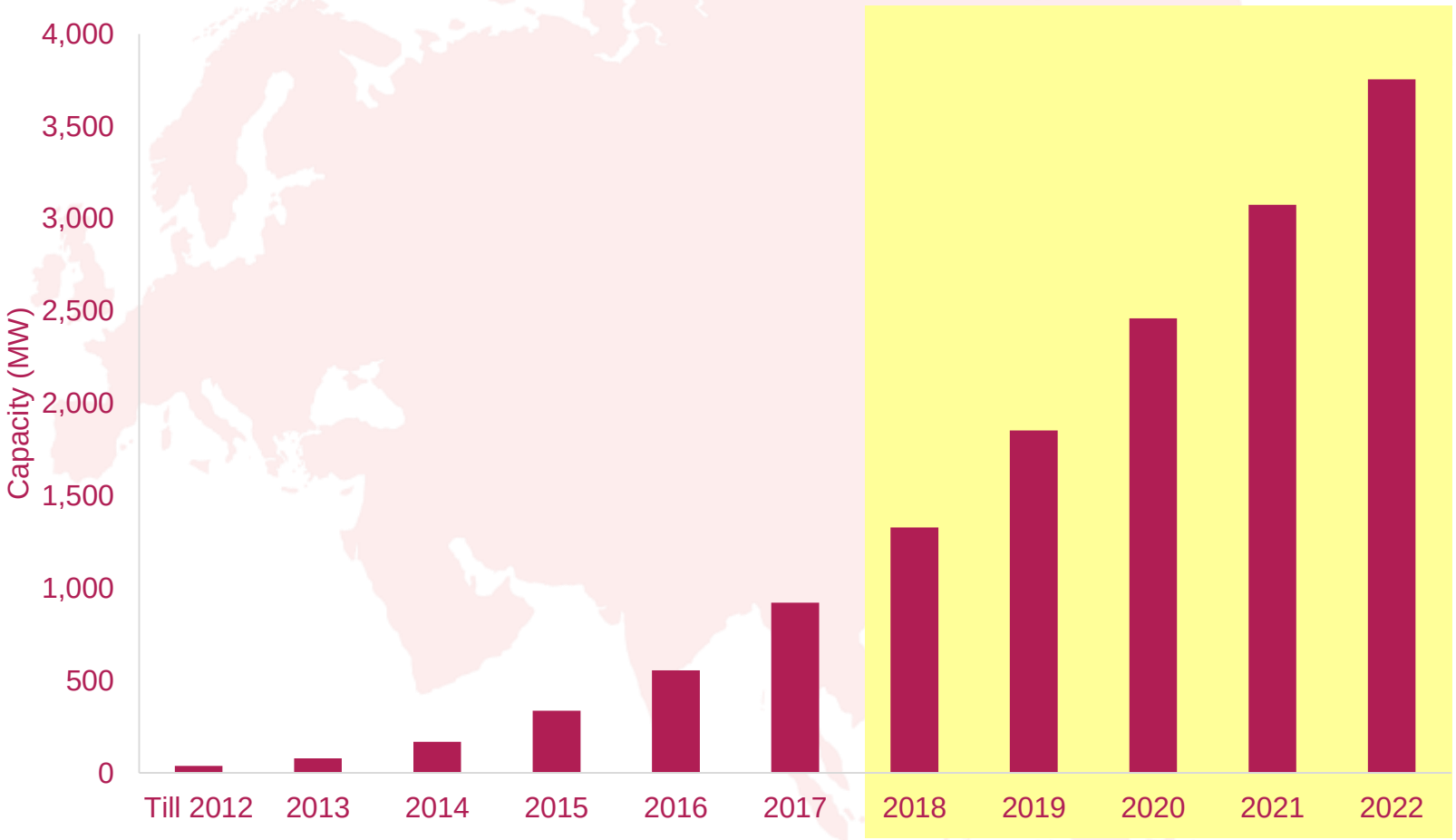
Utility scale

Rooftop solar

Note: The data is updated until September 2017

Source: BRIDGE TO INDIA database

We expect the rooftop market to reach 15 GW by 2022



Source: BRIDGE TO INDIA analysis

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There is no specific central regulation for solar PV power quality in India until date

- The guidelines by CEA pertaining to both utility scale and rooftop solar projects in India are currently in the draft stages
- In absence of a generalized guidelines, requirements differ from one state to another for validating the power quality of solar PV plants
- The situation is till in control in utility scale plants as the ticket size is large and there are only a few players. However, in fragmented rooftop segment, it is a massive exercise for DISCOMs to keep power quality in check
- DISCOM's representatives try their best to check the islanding feature, frequency, harmonics and voltage profile, but usually have limited means to check the flicker and DC injection into AC grid

Usually IEC standards are followed in India for integrating solar PV plants

- All key regulatory requirements for integrating solar plants with grid are met by inverters
- Usually, authorities adopt IEC standards while approving utility scale solar plants

Requirements	IEC codes
Efficiency measurement	IEC-61683
Environmental testing	IEC 60068-2/ IEC 62093
Electromagnetic capability	IEC 61000-6-2, IEC 61000-6-4
Harmonic Control in Electrical Power Systems	IEEE 519
Utility - interconnected photovoltaic inverters - Test procedure of islanding prevention measures and other electrical safety	IEEE1547/ IEC 62116/ UL 1741 or equivalent EN/BIS standards
Safety of power converters for use in photovoltaic power systems	IEC 62109
Technical Guidelines for Generating plant connected to Medium voltage network	BDEW 2008

Harmonics control is one of the most important requirement for grid safety

Harmonics

- Harmonics are measured as Total Harmonic Distortions (THD)
- India adopts IEEE 519 and caps THD at 5%. In USA, this is restricted this to 3%
- Most recent utility scale tenders restrict this to either 3% or 4%, but the control is not applicable for rooftop solar plants
- Draft changes suggested by CEA propose to cap THD at 2%
- Increasing topologies can help in reducing THD - an inverter working on 2 level topologies could generate THD of around 4% whereas an inverter working on 5 level topologies could effectively reduce THD to less than 1%
- Improvement in AC harmonic filter can also play an important role in reducing THD

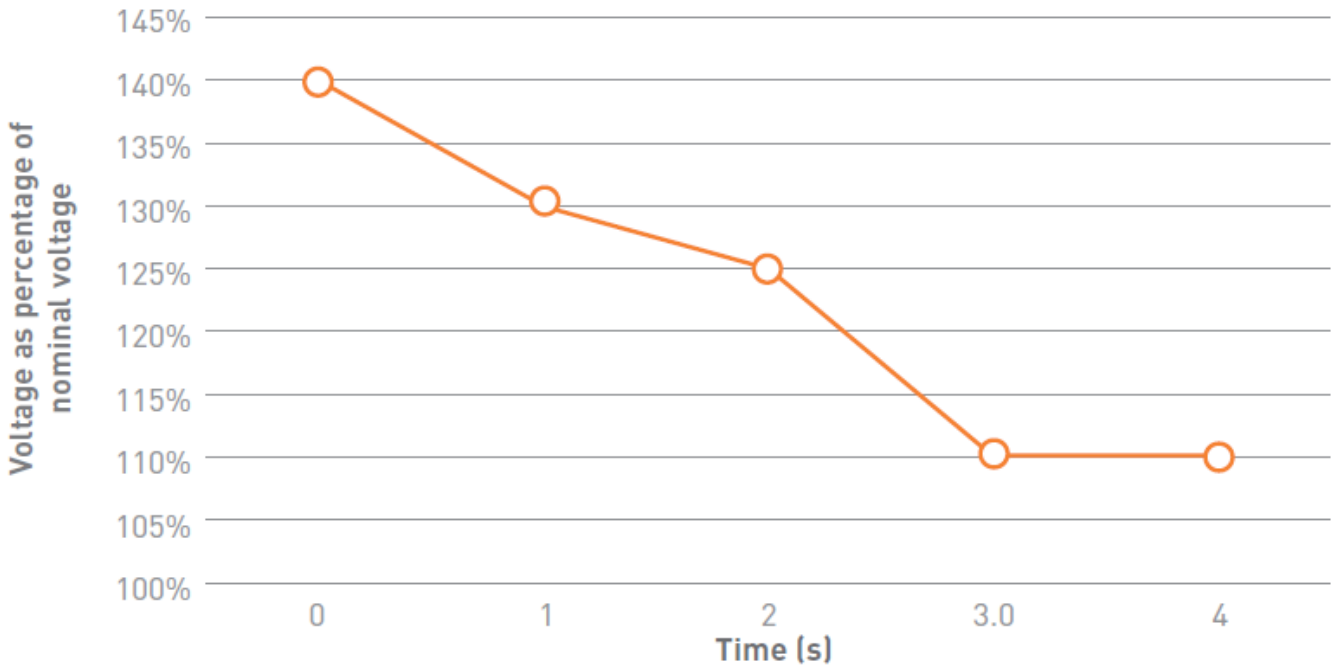
Current regulation in India has put voltage protection for solar plants in line with conventional plant, but more is required

Voltage

- In solar plants, the voltage fluctuation usually results from sudden change in power generation because of moving cloud cover or any other fault
- CEA mandates that inverters should be disconnected from the grid when grid voltage exceeds 110% of nominal voltage or falls below 80% of nominal voltage
- However, in case of short circuit in the grid, when there is momentary flow of a high current, current regulations require inverter to be tripped. But this could cause the line voltage to decrease further leading to a cascading effect

CEA has proposed voltage ride through provision for solar projects for grid safety purposes

HVRT functionality of inverter proposed by CEA



Source: CEA guideline of technical standards for connectivity to the grid

Fluctuation in frequency can damage electrical and power generating equipment

Frequency

- Traditionally, power flowed only in one direction – from power station to consumers – and grid managers were responsible for managing grid frequency by controlling power generation to effectively meet power demand
- However, with increasing penetration of rooftop solar plants, managing the grid is becoming more complex
- Germany has identified a problem famously known as “50.2 Hz” for overcoming voltage and frequency shocks because of abrupt changes in power supply-demand. The country has since then has mandated frequency response or “droop functionality” and retrofitted existing system
- In India, conventional power plants are required to have frequency response. However, there is no such regulation for solar PV plants. (CEA has proposed to mandate solar projects of over 10 MW capacity to provide immediate frequency response)

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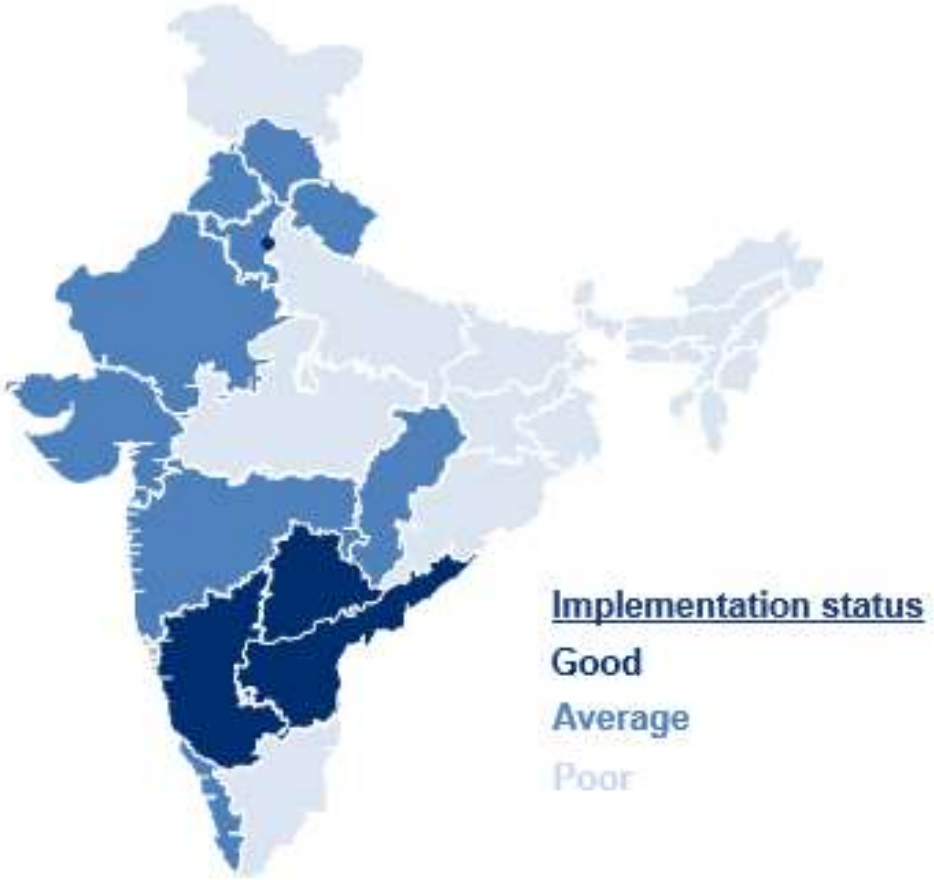
The government has offered several tax and financial incentives to support the market…

Capital subsidies	Up to 30% subsidy for residential, institutional and public sector consumers
Accelerated depreciation	40% depreciation for business consumers
GST	Concessional rate of 5% on equipment
Concessional credit	Lines of credit from WB and ADB

But net-metering execution remains a challenge

DISCOM's are losing their high paying industrial and commercial customers to rooftop solar



DISCOMs must be brought on board through a technical and financial support package

Make DISCOMs active stakeholders

- Technical assistance for DISCOMs
- Business model
  - Inspection and connectivity services
  - Power banking
  - Billing, documentation and operational services
- Financial assistance for infrastructure and distribution network upgrades

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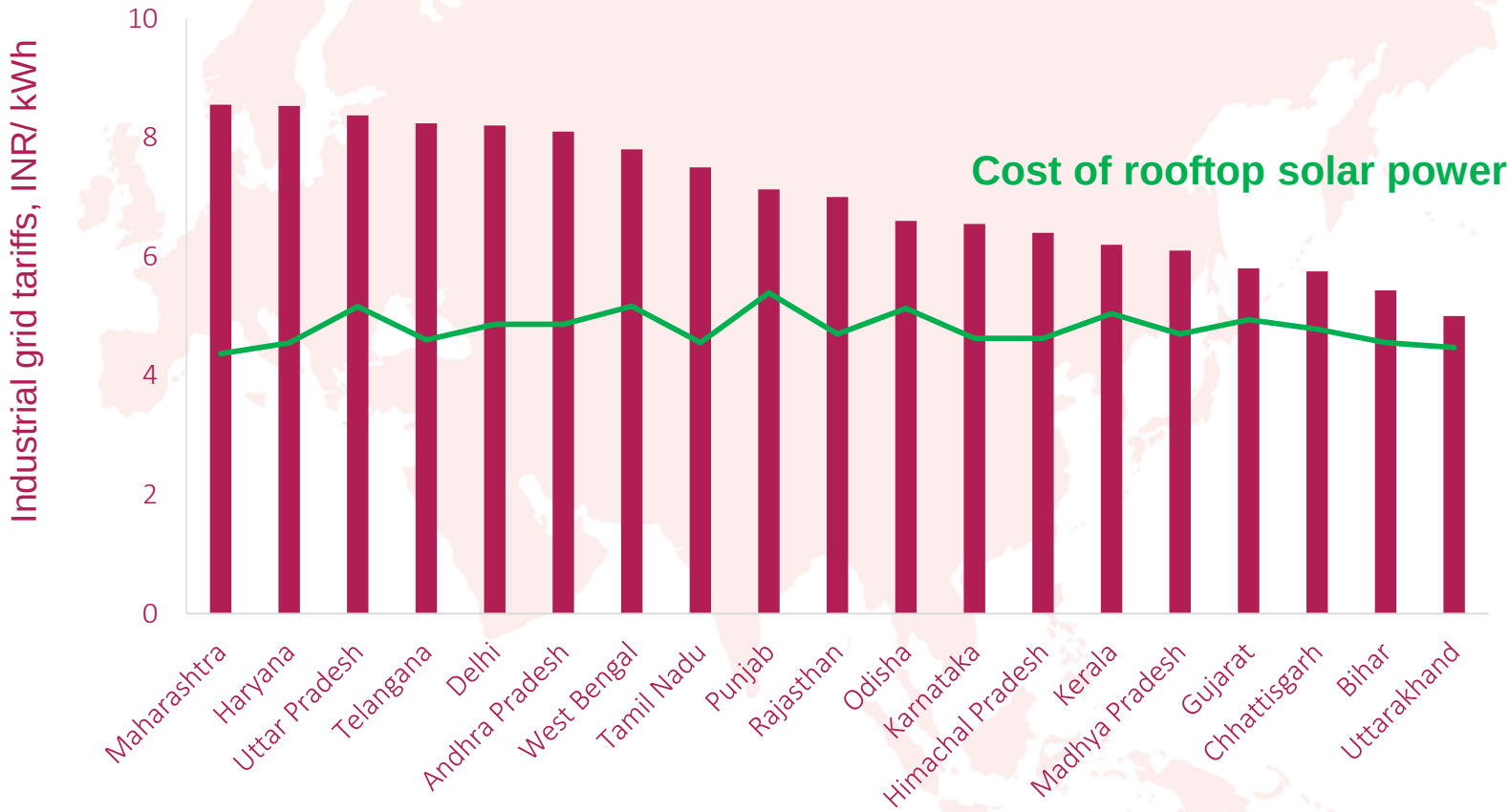
Rooftop solar price competitiveness has become a no-brainer



Solar system can in fact help in improving grid stability by providing reactive power support

- Reactive power arises due to phase differences between voltage and current. This phase difference is created by electric and magnetic fields in inductive and capacitive loads such as motors or capacitor banks

- An inverter is capable of running on non-unity factor on demand. It can help in managing reactive power in two ways:

  - It can adjust power factor very quickly (not usually possible for conventional AC power rotating generators)

  - PV inverters can provide reactive power even when not generating real power

- Germany was the first country to mandate reactive power support from inverters. Karnataka is the only state in India to mandate utility scale solar plants to supply around 20% of capacity as reactive power support

- Even at full load, the impact of 20% reactive power support could be only around 2% loss of active power

Steps are already being taken for grid integration, but its implementation is key

175 GW of renewable capacity in 2022 would meet more than 70% of national power demand at peak capacity – high potential of grid destabilizationTaking que from EU, India needs to manage grid more effectively at such proportion of peak load

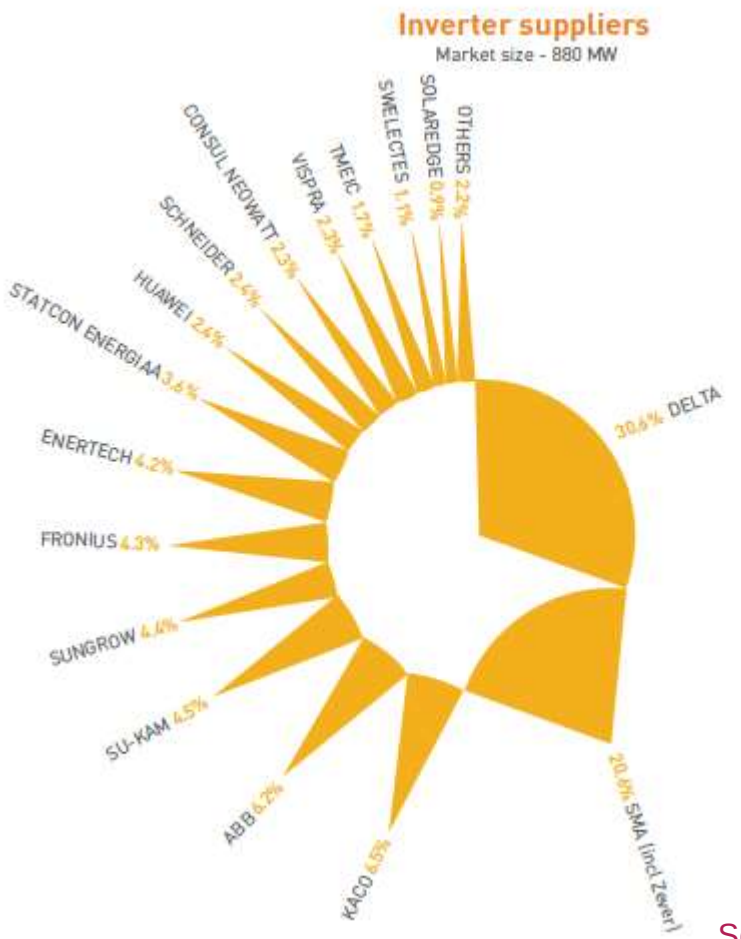
- "Must-run" status granted to solar although NO evacuation guarantees
- Grid curtailment as high as 30-40% in select locations
- Insufficient peaking and balancing reserves
  - Lack of sufficient hydel or gas based generation capacity
  - Storage still too expensive

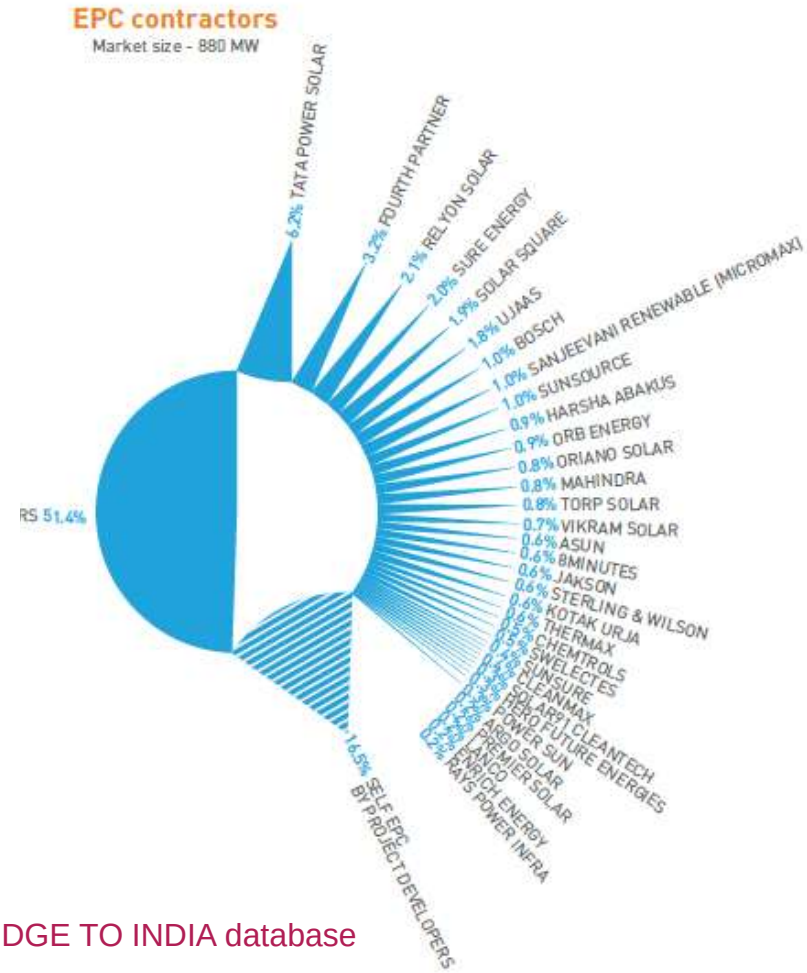
Green Corridors under development

National Smart Grid Mission approved

National Storage Mission in planning stages

BIS Standards are introduced, but implementation is challenging with fragmented market





Source: BRIDGE TO INDIA database

For more details, you can refer to following reports:

Inverter Design and Selection	http://www.bridgetoindia.com/reports/inverter-design-selection-march-2018/
Grid Integration of Distributed Solar Photovoltaics (PV) in India	http://www.ncpre.iitb.ac.in/research/pdf/PEG_grid_integration_dist%20PV_summary_2014.pdf

Thank you

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