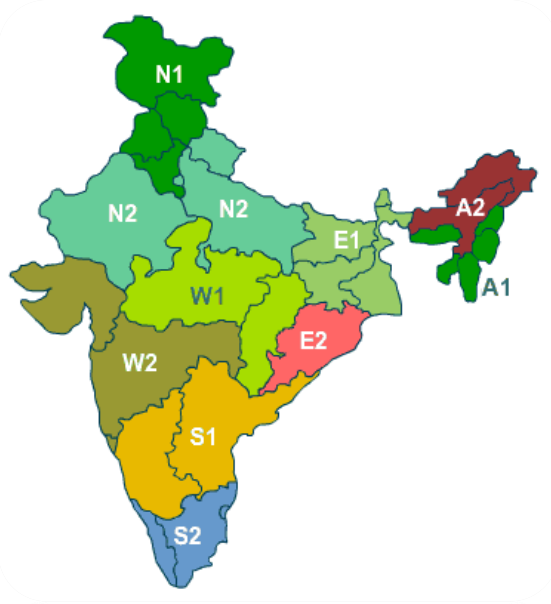
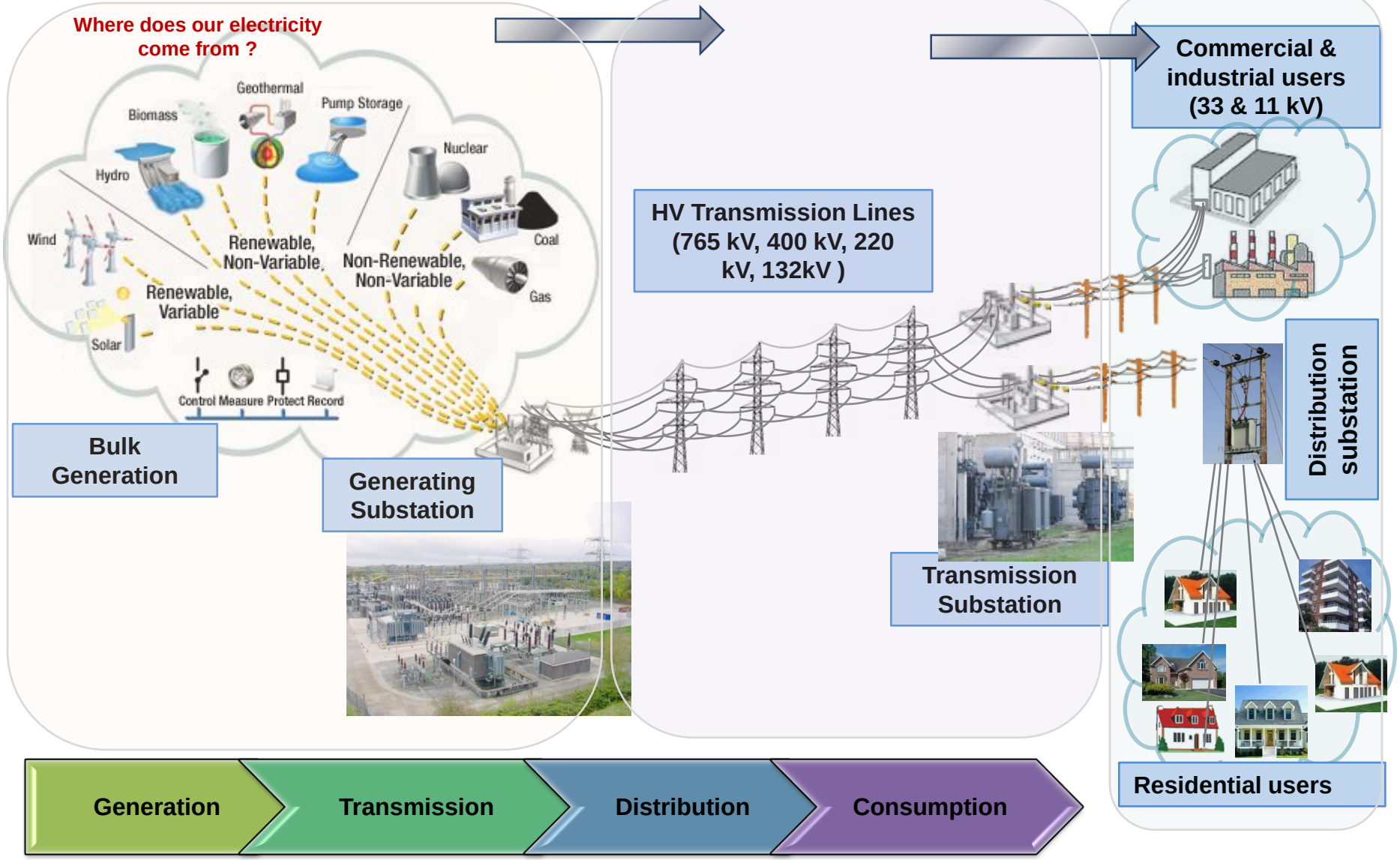
Indian Power Sector – Initiatives to Smart Grid



Dr. N M Pindoriya
Assistant Professor | Electrical Engineering
IIT Gandhinagar, Gujarat, India
Email: naran@iitgn.ac.in

Electric Power Supply System



Energy Resources for Electricity Generation

Nonrenewable Energy Resources

- **Fossil Fuels**: Coal, oil (petroleum), and natural gas

- **Nuclear Fuels**: Elements with unstable nuclei, such as uranium

Renewable Energy Resources

- **Hydropower:** The force of moving water from streams, rivers or storage reservoirs

- **Wind**: The force of moving air

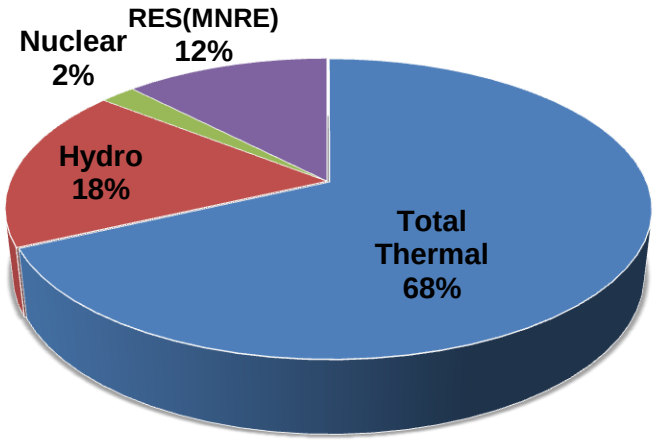
- **Solar**: The radiant energy from the sun

- **Biomass**: Plant material (including wood) or organic waste

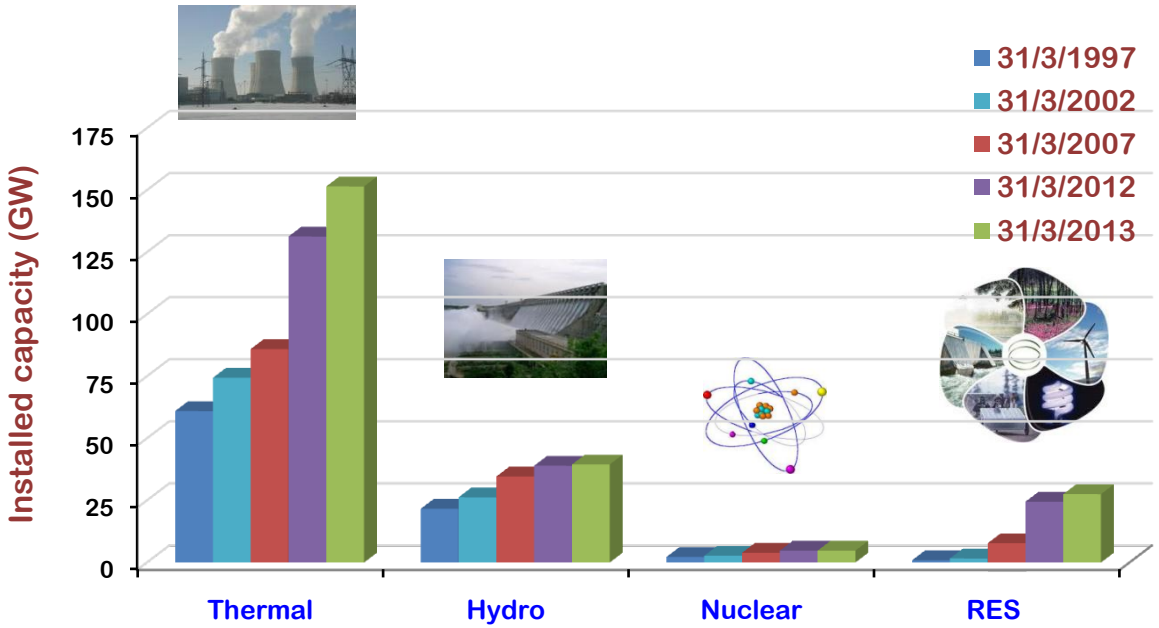
- **Ocean**: The mechanical energy of ocean tides, currents, and waves, and the sun's heat energy stored in the ocean

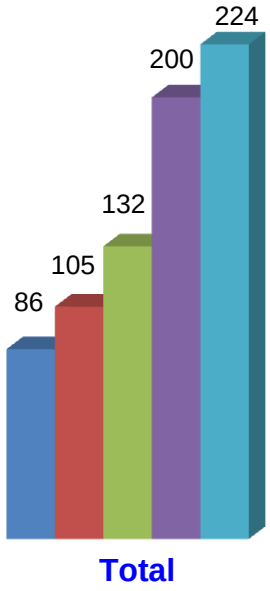
- **Geothermal**: The natural heat in the earth

Electricity Generation Mix: Present Status



Fuel	GW (as on 31/5/2013)
Thermal	153.19
Hydro	39.62
Nuclear	4.78
RES(MNRE)	27.54
Total	225

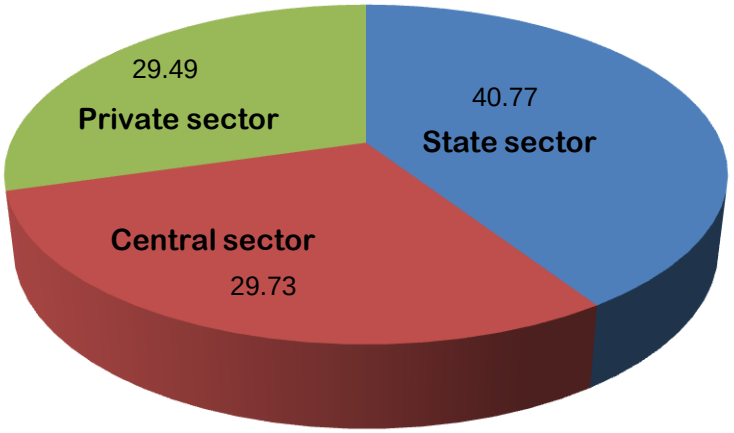


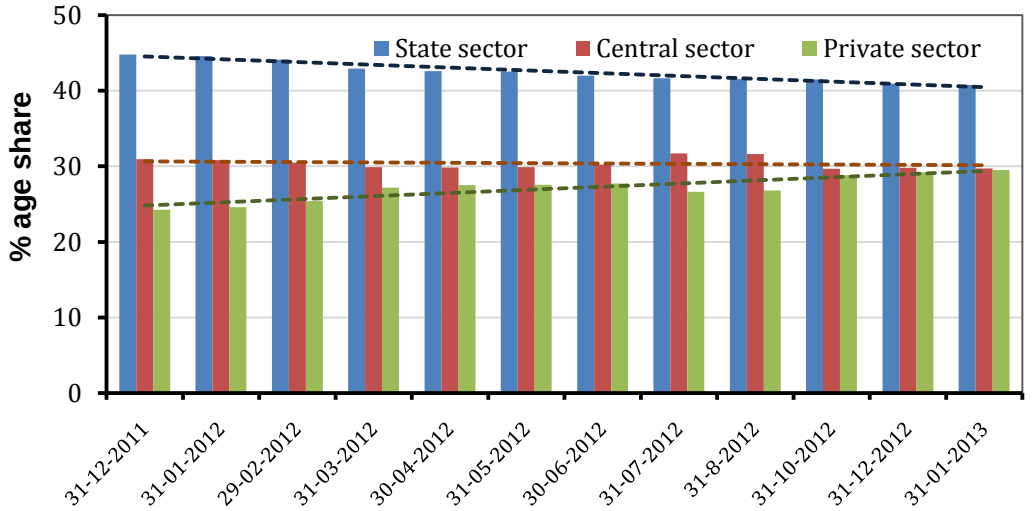


Growth of RE: major share by the private sector

Source: http://www.cea.nic.in

Electricity Market Players





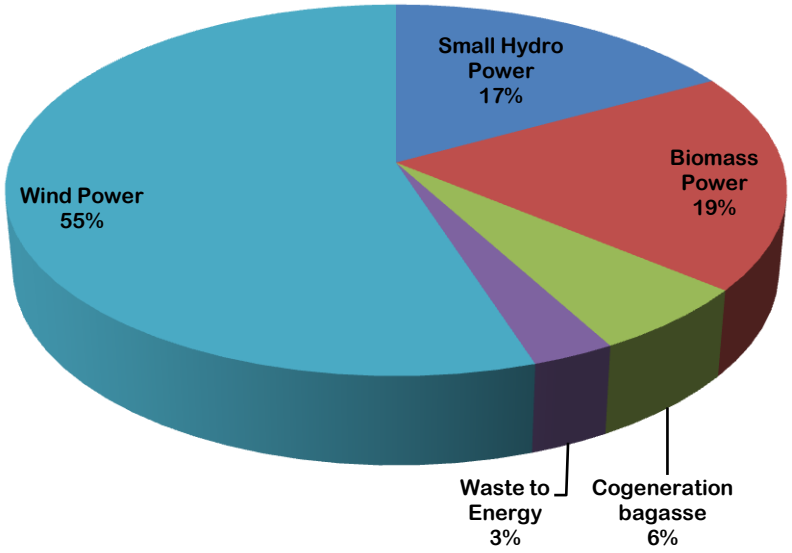
Top Players in the Power Sector

एनटीपीसी NTPC A Maharatna Company; एन एच पी सी NHPC; एनपीसीआईएल NPCIL NUCLEAR POWER CORPORATION OF INDIA LIMITED A Government of India Enterprise; State level corporations	PSU (Central and State)
पावरग्रिड POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise)	
TATA POWER Lighting up Lives! Adani Power Limited RELIANCE	Private Sector

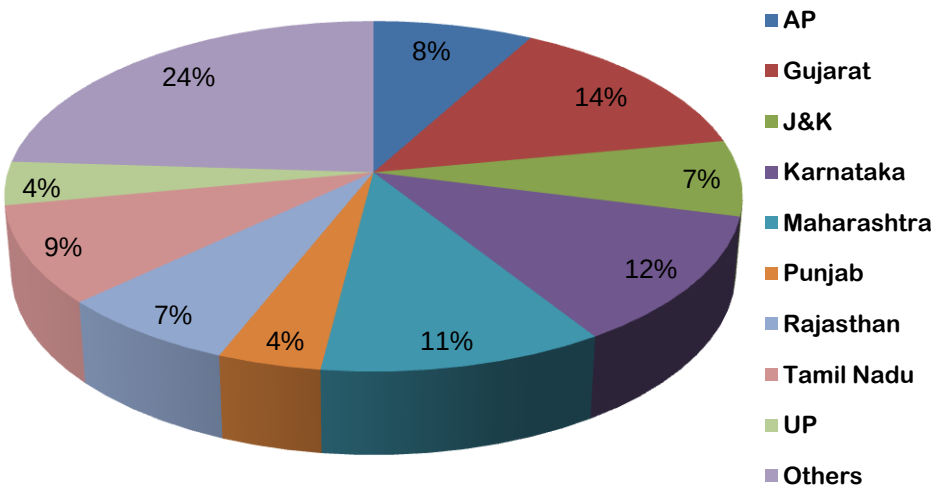
Potential of Renewable Power in India

Resources	Potential (MW)
Wind Power	49,130
Small Hydro Power	15,000
Biomass and Waste	30,000
Solar power	20-30 MW/ sq. km (50000 Approx.)

Source wise breakup

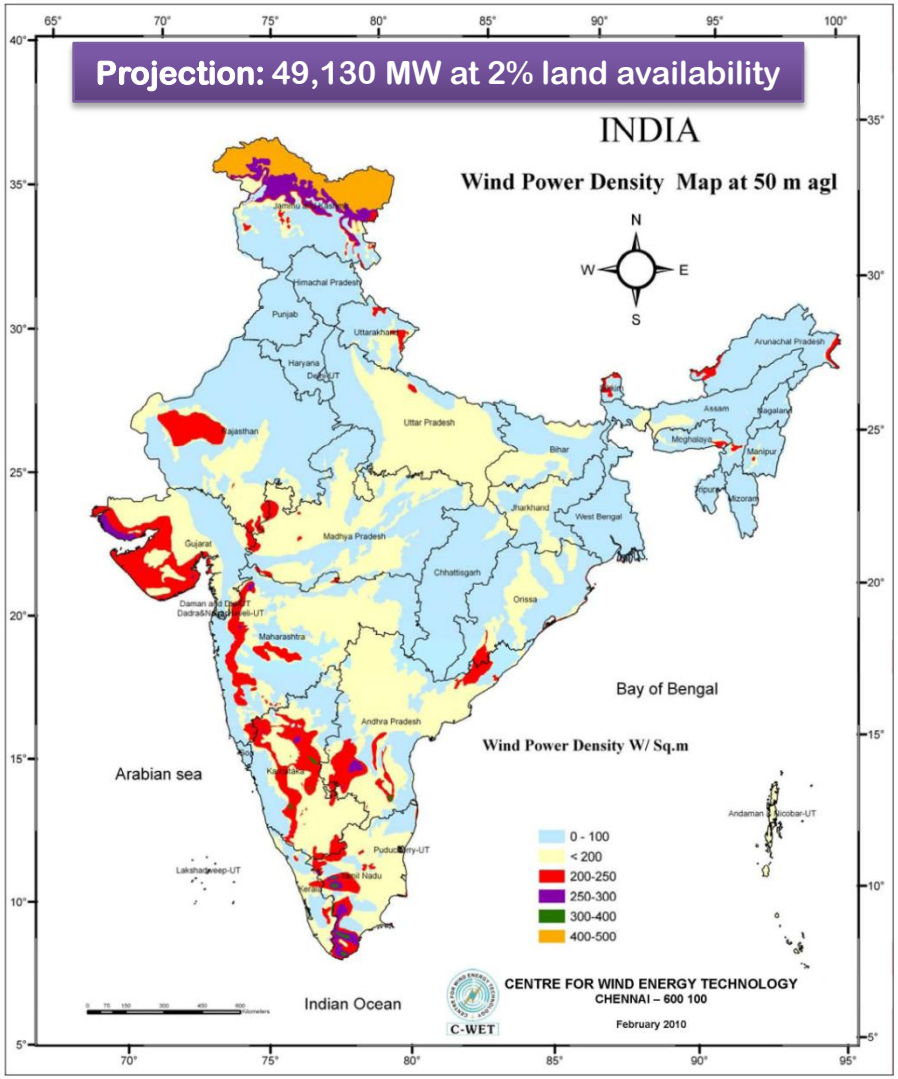


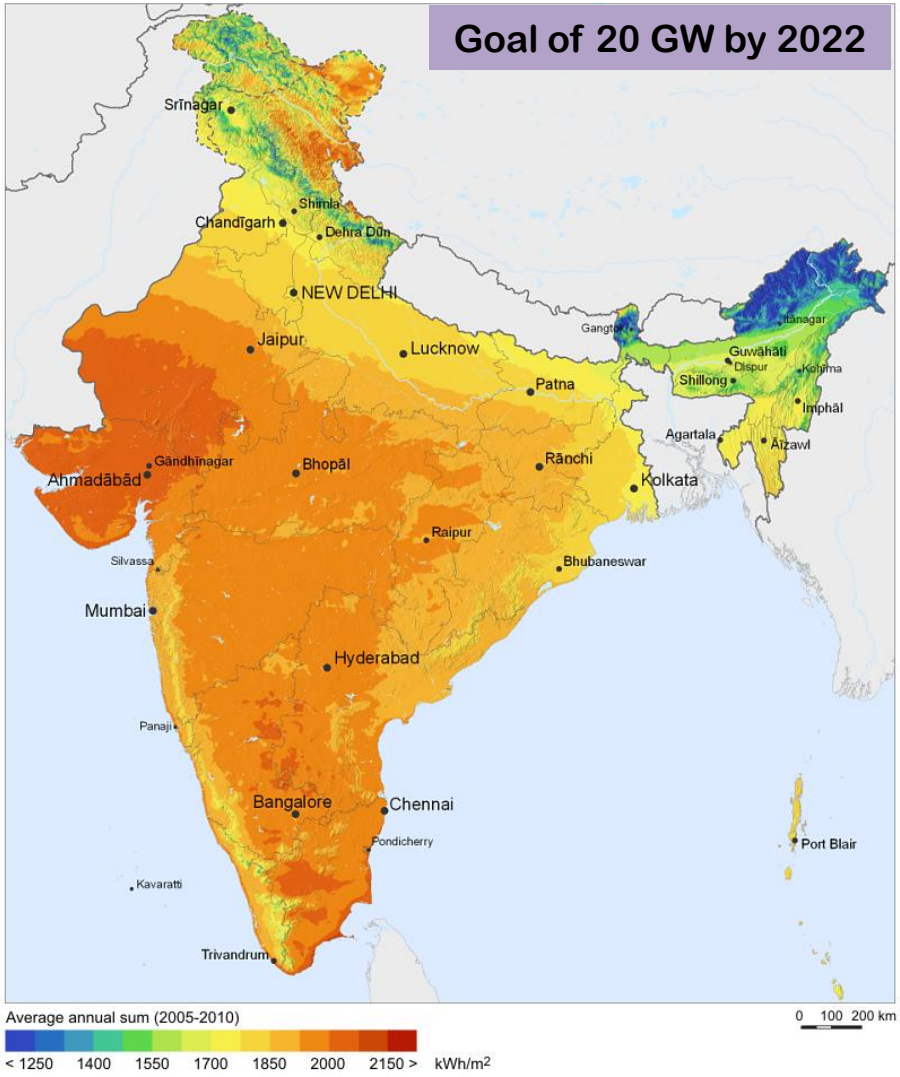
State wise breakup



Source : MNRE, India

Potential of Wind and Solar Power in India

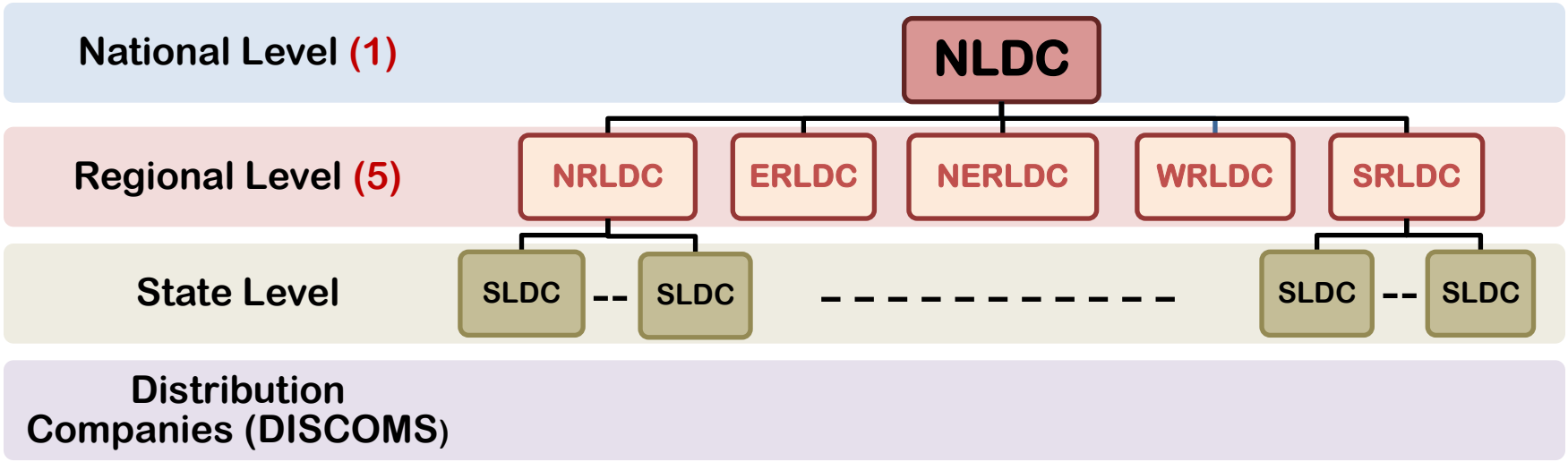




Source: www.cwet.tn.nic.in/

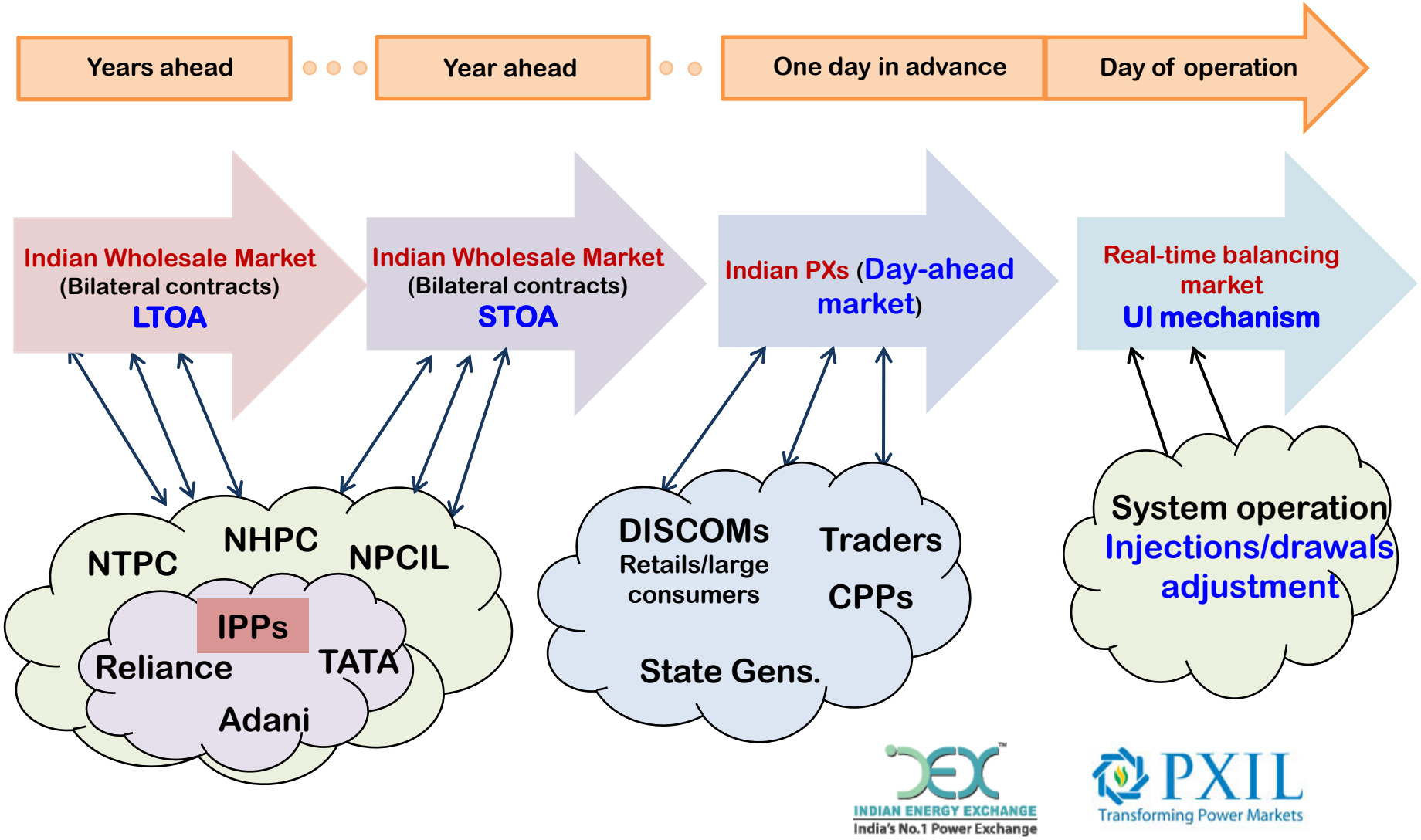
Power Grid Operation in India

- 3 levels of grid management systems (national, regional and state), using SCADA
- Grid Management is being looked after by POSOCO



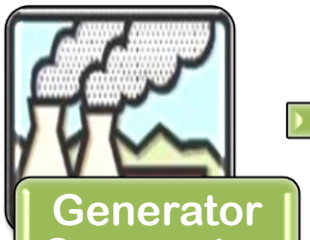
For example: in Gujarat (MGVCL, PGVCL, DGVCL, UGVCL four DISCOMS and one controlling body GUVNL, and one generation company GSEC) and private DISCOMS : Torrent power

Electricity Market Operation: Segments

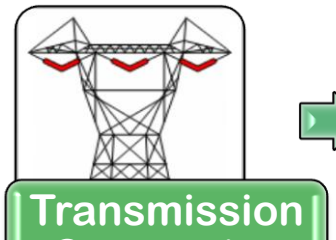


Different Entities in Electricity Market

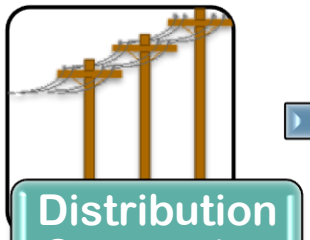
Independent System Operator (ISO)



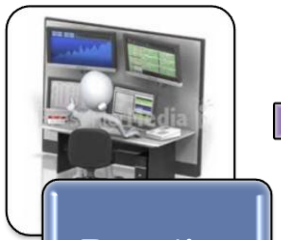
Generator Companies (GenCos)



Transmission Companies (TransCos)



Distribution Companies (DisCos)

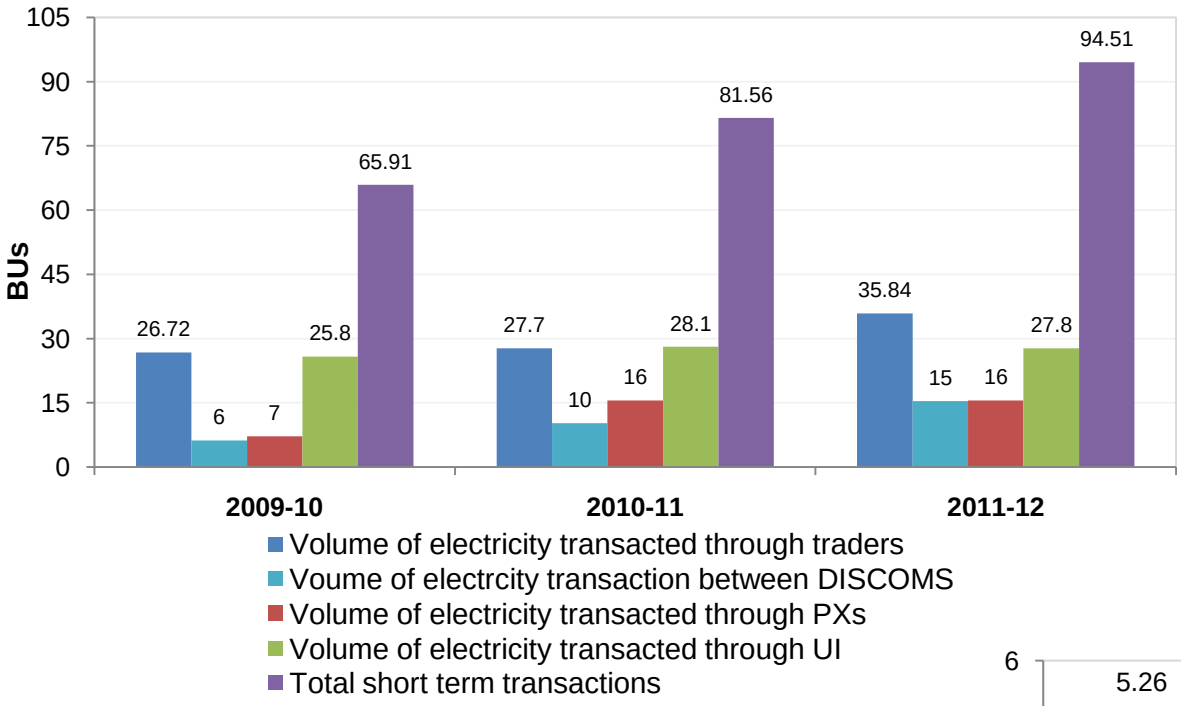


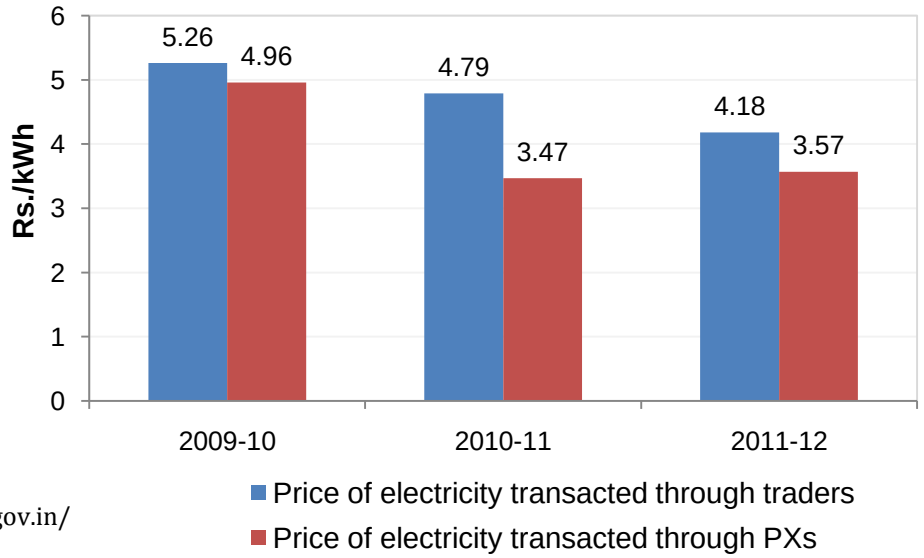
Retailer

Customer

Electricity Regulatory

Short Term Transactions





Source: http://www.cercind.gov.in/

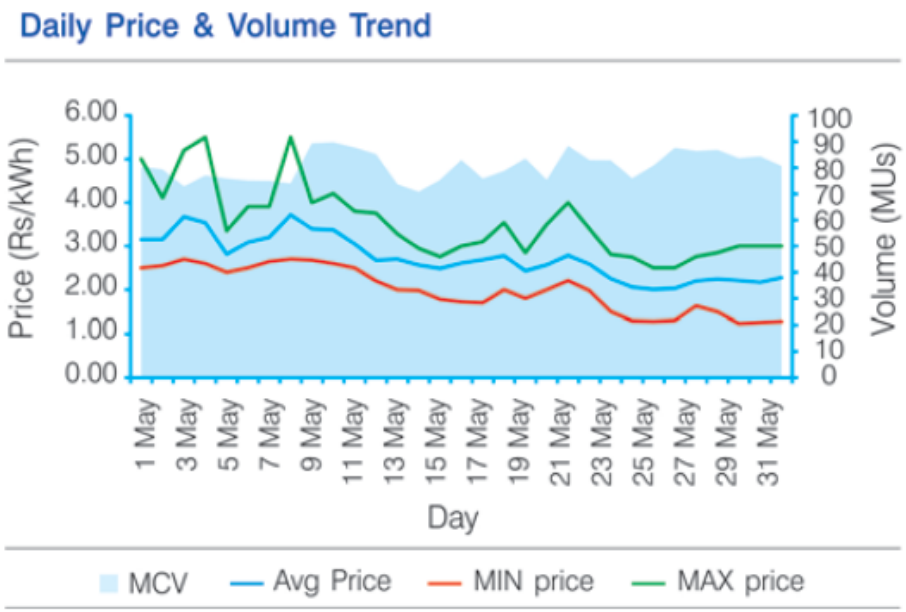
IEX Transactions

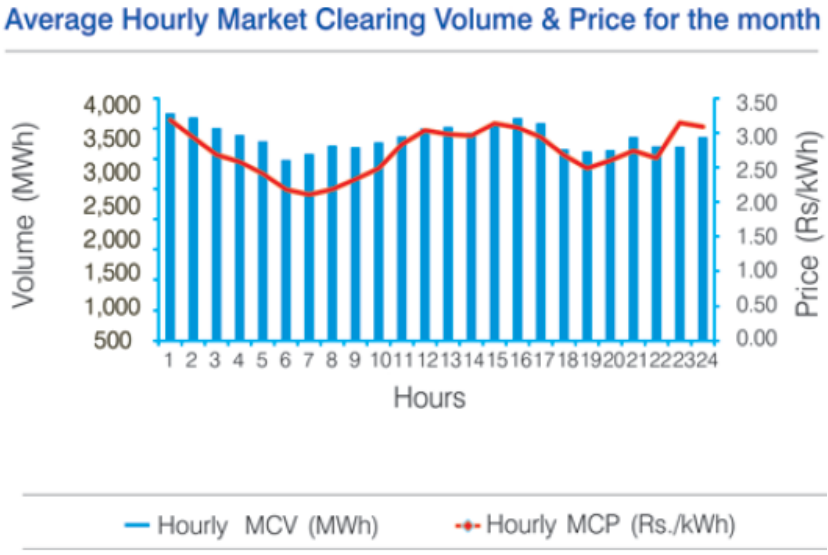
Falling electricity prices at the exchange

Bid Area	May '13	May '12	% change	April '13	% change
North-East (A1,A2)	2.32	4	-42%	2.75	-16%
East (E1,E2)	2.31	3.21	-28%	2.6	-11%
North (N1,N2)	2.36	3.21	-26%	2.67	-12%
North (N3)	2.36	3.21	-26%	2.67	-12%
South (S1)	6.47	8.13	-20%	7.83	-17%
South (S2)	6.47	8.13	-20%	8.41	-23%
West (W1,W2)	2.36	3.21	-26%	2.67	-12%
West (W3)	2.36	3.21	-26%	2.67	-12%
UN_MCP*	2.73	3.42	**-20%**	3.16	**-14%**

	May '13	May '12 (Same month last year)	April '13
Avg. daily cleared volume (MUs)	80.62	44.78	83.85

Source: www.iexindia.com

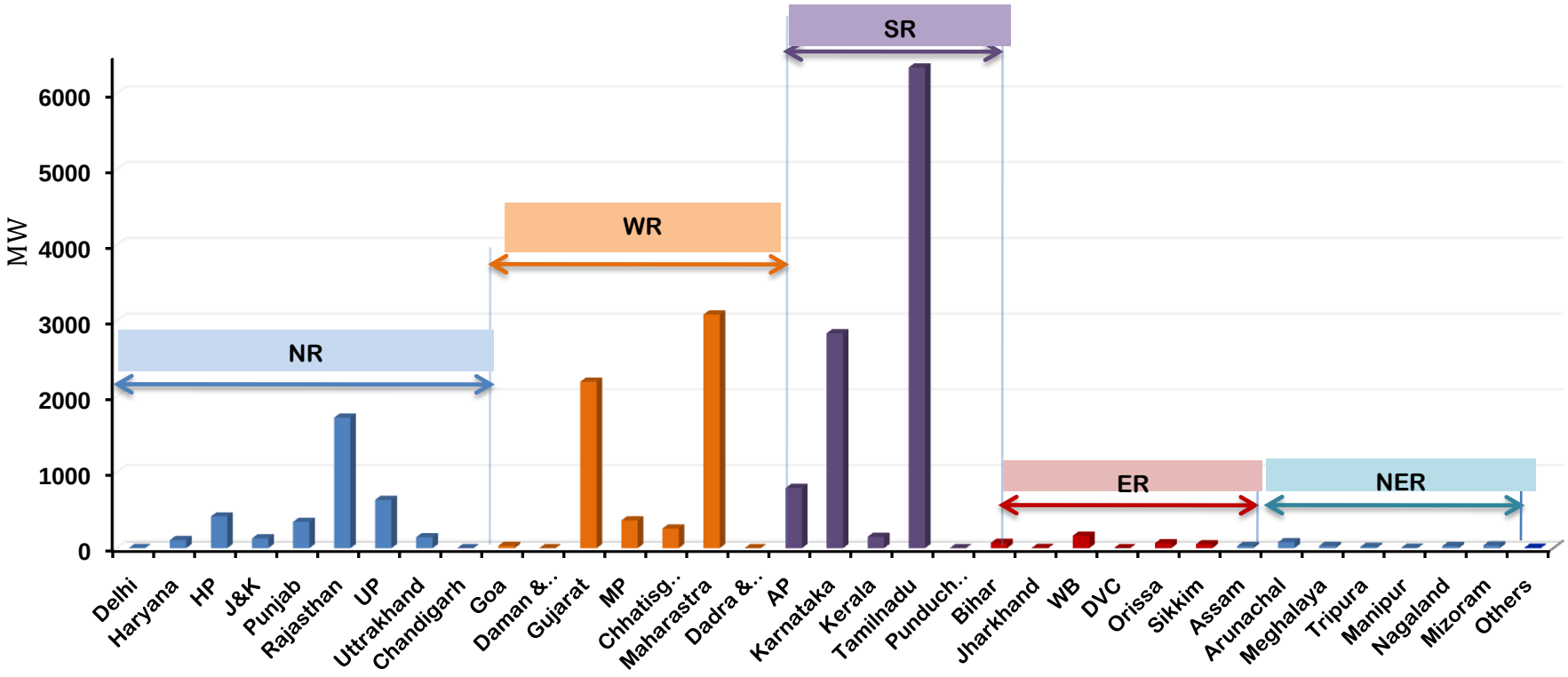




RPO and REC Mechanism : Promote RE Generators

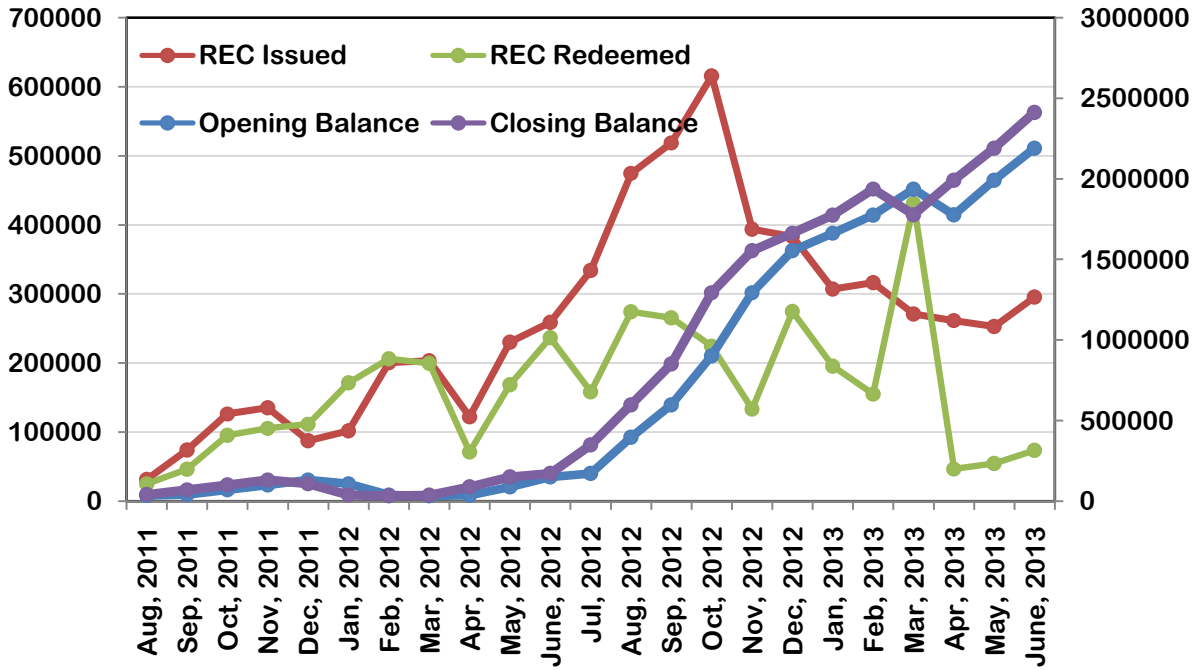
Renewable Purchase Obligation (RPO): EA 2003 empowers the SERCs to set targets for DISCOMs to purchase certain % age (between 1% and 15%) of their total power requirement from RES

Under NAPCC, one of the missions is targeted at increasing the contribution of RE to the grid to **15% by 2020**.



RPO and REC Mechanism : Promote RE Generators

- **Renewable Energy Certificate (REC):** Market based instrument
  - Provides evidence that a generator has produced a certain quantum of power from a RE resource which has been consumed
  - Effects the environmental attributes of the source of generation
- REC mechanism is expected to overcome geographical constraints and provide flexibility to achieve RPO compliance.
- Create competition among different RE technologies



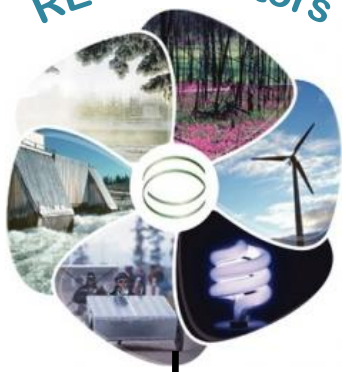
Renewable Energy Trading

Cost of electricity through RE generation

Cost equivalent to conventional resources

Cost for "GREEN" Attributes

RE Generators



Solar PV	• 12-15 Rs/kWh for first 12 years • 3-5 Rs/kWh for next 13 years
Solar Thermal	• 9-11 Rs/kWh for first 12 years • 3 -4 Rs/kWh for next 13 years
Wind	3-5 Rs/kWh

Unbundling of REC from electrical energy

REC Option

Feed-in-Tariff (FiT)

Electricity

Green attributes

Electricity sale at market price

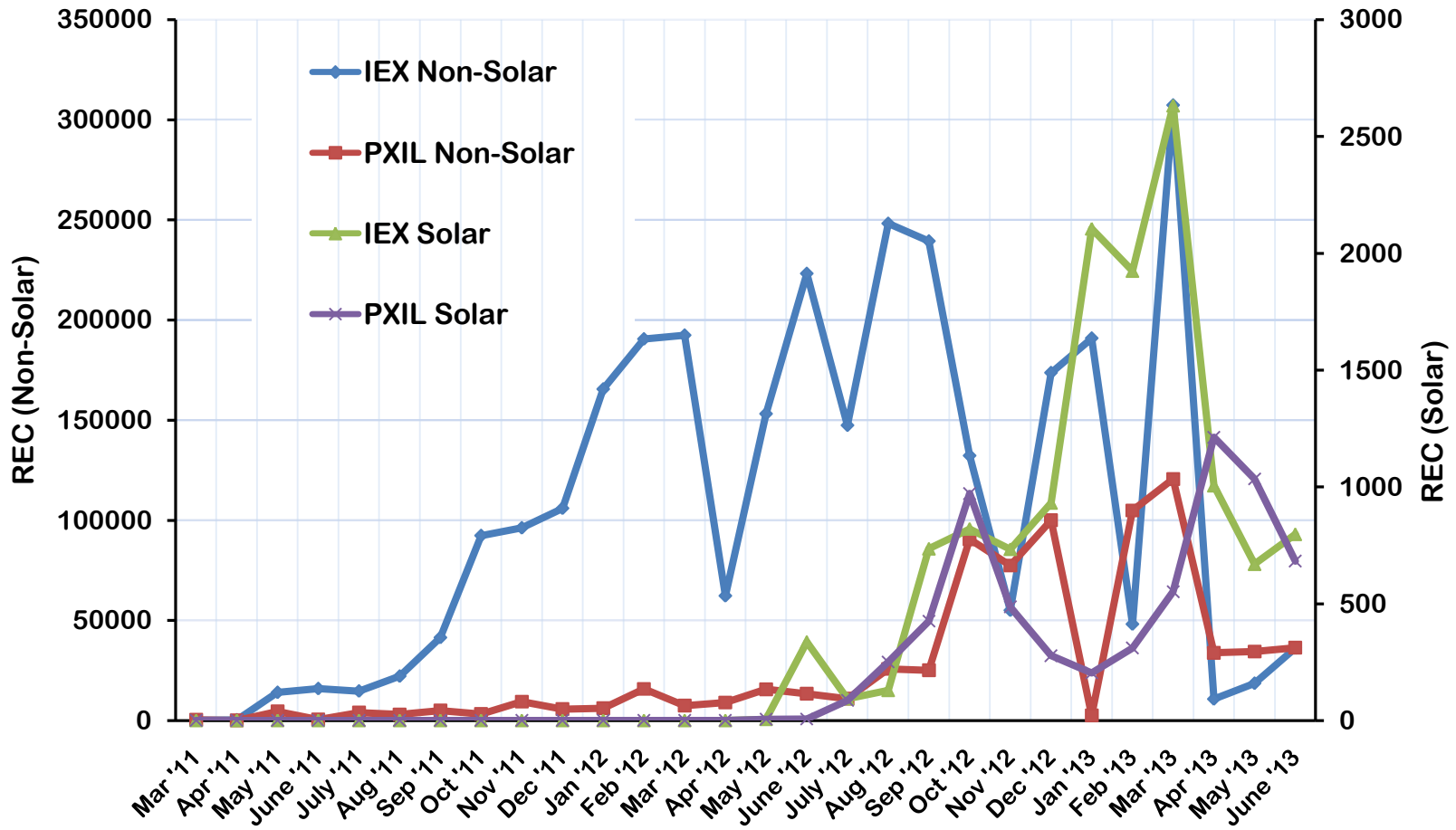
Sale of electricity to obligated entities at price ≤ average price

REC (Solar and non-solar)

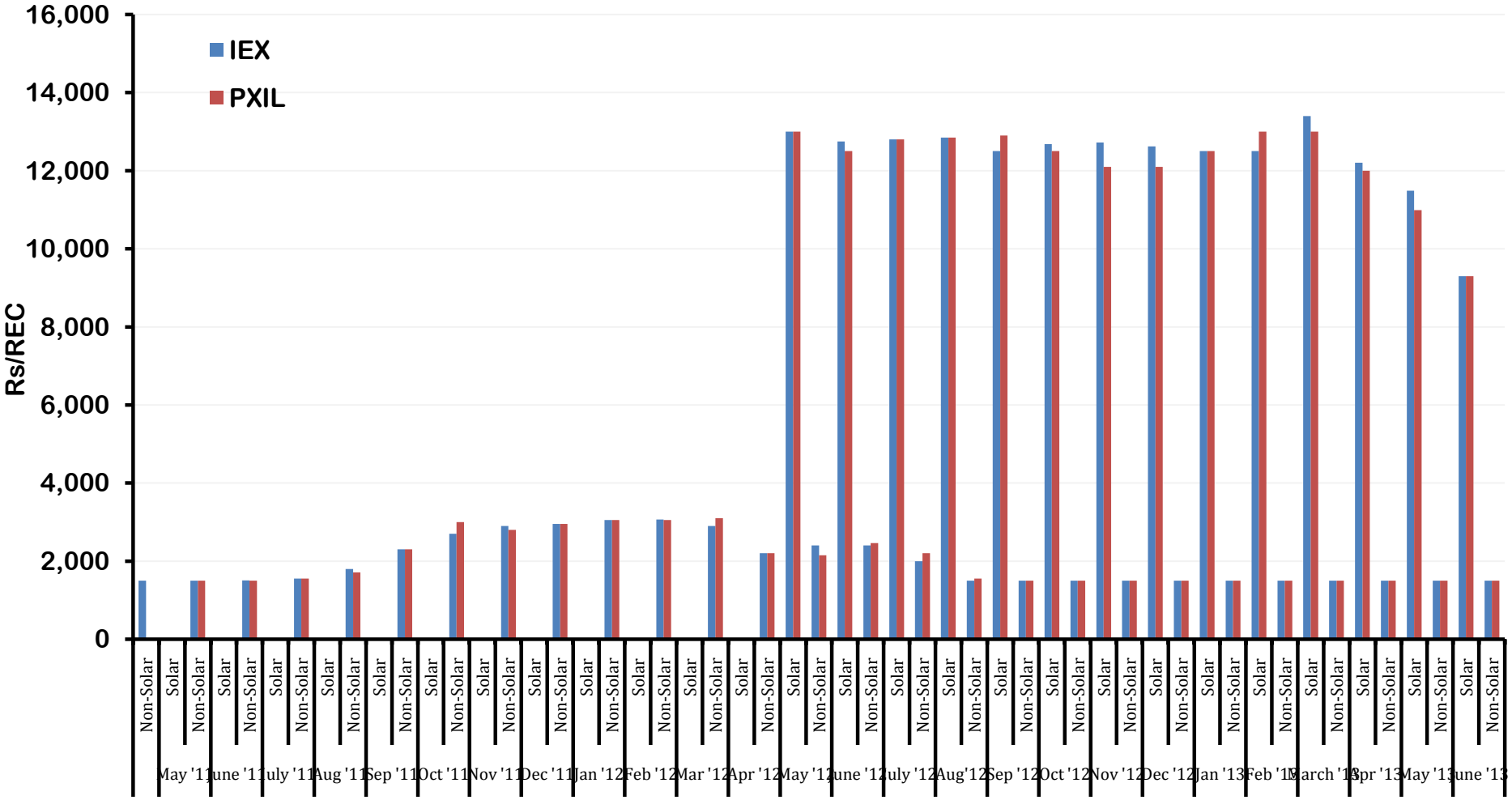
Sale of REC at PXs

Sale of electricity to *obligated entities* (DISCOMs, CPPs, OA consumers) at preferential tariff

REC Trading: Experience so far



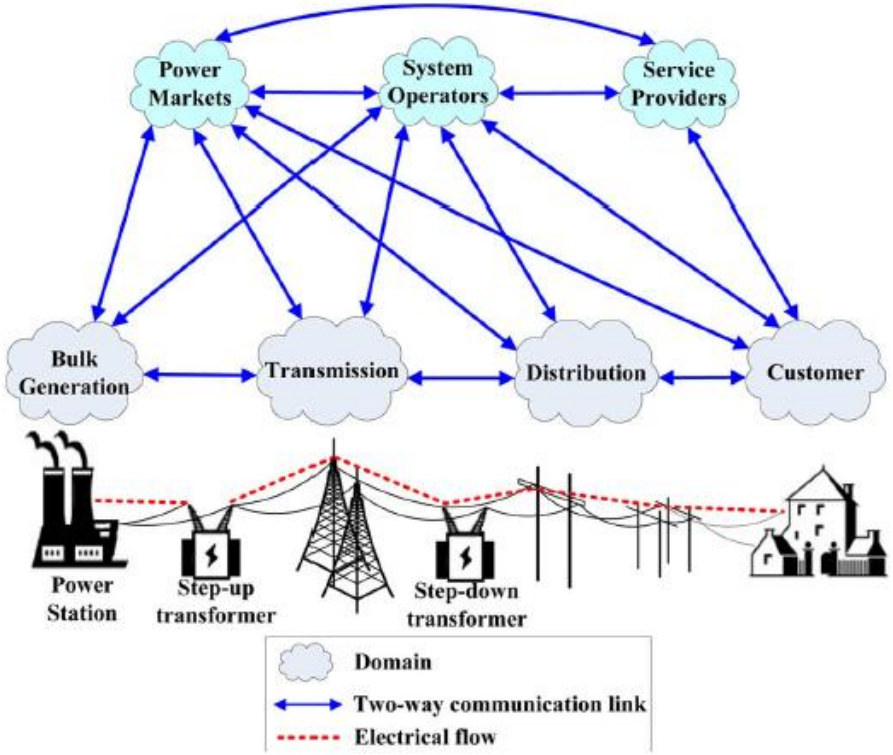
REC Trading: Experience so far



Smart Grid Initiative in India

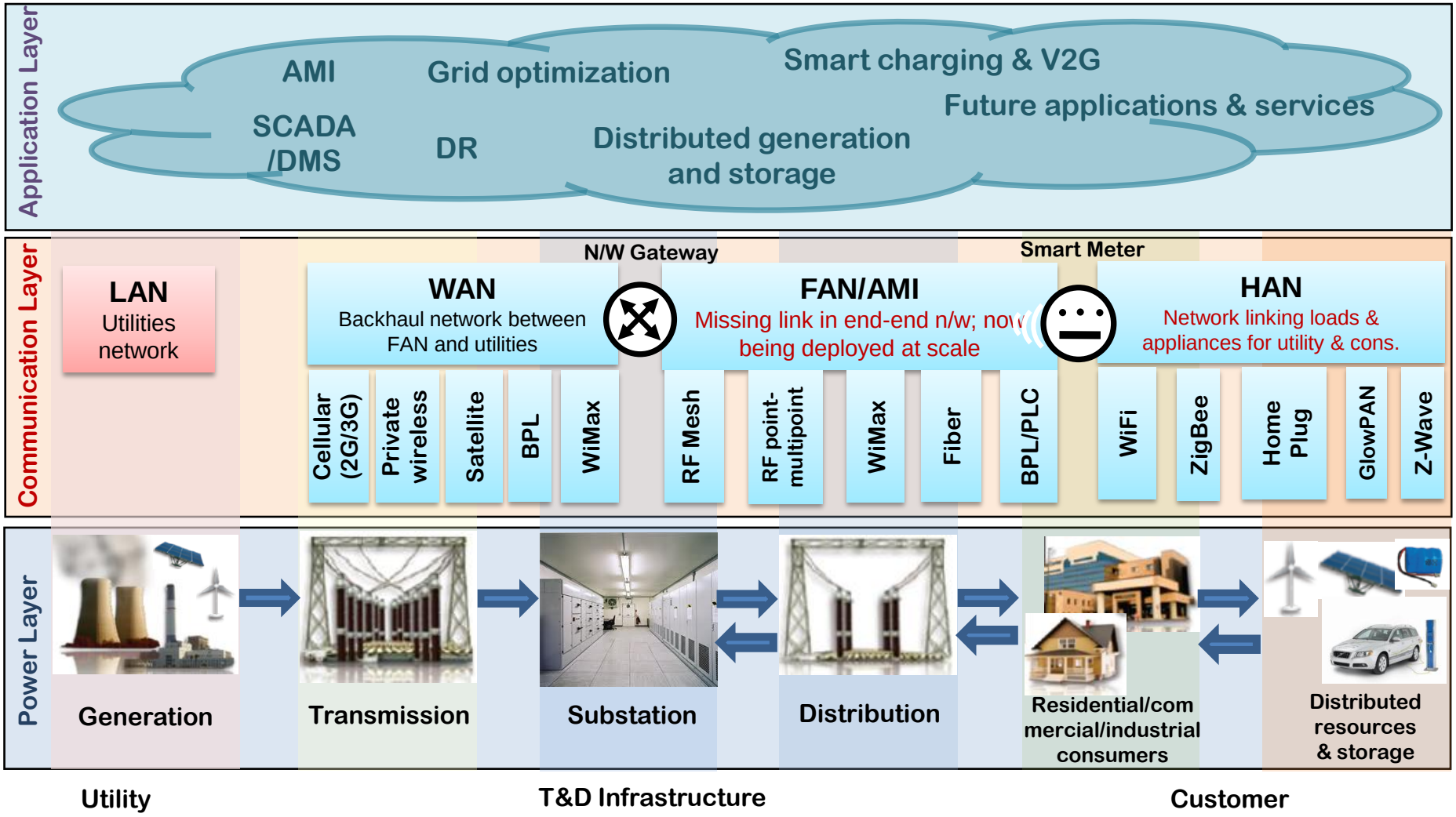
- *Smart grid* is the integration of Information & Communication Technology (ICT), through which dynamic two-way digital communication is possible, into at all levels of power grid.
- It encompasses a broad set of applications, including software, hardware and technologies that enable utilities to integrate, interface with, and intelligently control innovations.

two-way information and communication network between the energy suppliers and their customers



Source of this image: Smart Grid Communication: Its Challenges and Opportunities, IEEE TRANSACTIONS ON SMART GRID, VOL. 4, NO. 1, MARCH 2013

Smart Grid Framework



Smart Grid Framework

Building additional layers of automation, communication and IT systems to transform it to a smarter grid

Applications or building blocks of a smart grid

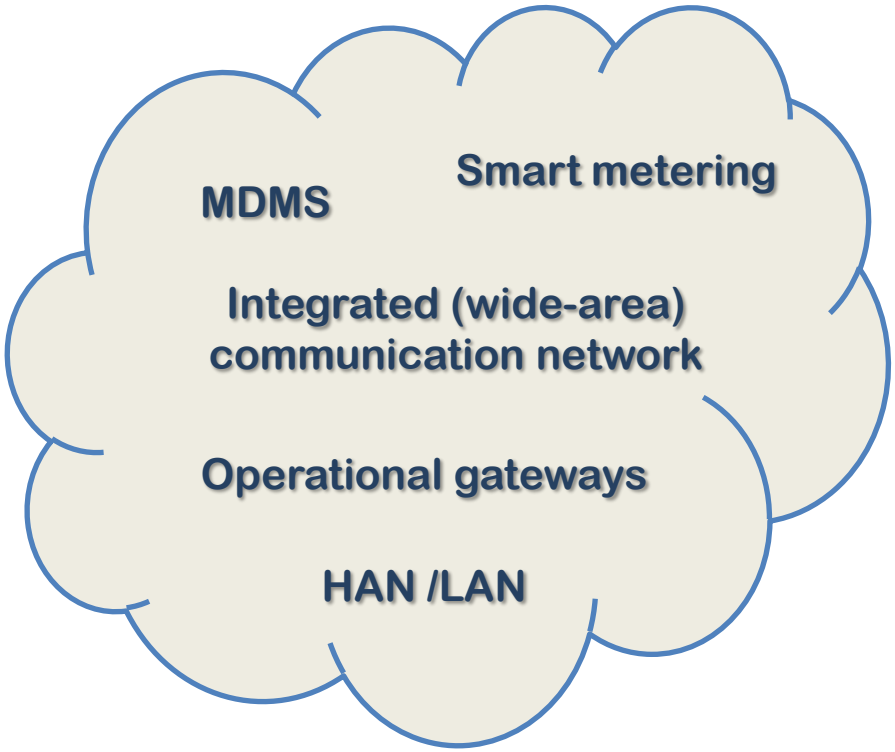
- SCADA with Energy Management Systems (EMS) and Distribution Management Systems (DMS)
- Enterprise IT network covering all substations and field offices with reliable communication systems
- Geographical Information Systems (GIS) – mapping of electrical network assets and consumers on geospatial maps,
- modernization of the substations with modern switchgear and numerical relays,
- Advanced Metering Infrastructure (AMI) with two way communication and MDMS
- Electronic billing systems and customer care systems,
- Distribution Automation and Substation Automation Systems
- Outage Management Systems (OMS),
- Wide Area Measurement and Control Systems,
- Enterprise Resource Planning (ERP)/Asset Management Systems,

Smart Grid: Enabling Technologies

- **Advanced Metering Infrastructure (AMI) & Smart Meters**

AMI/AMR Technology

- integration of many technologies that provides an intelligent connection between the grid, consumers and their loads, and generation and storage resources

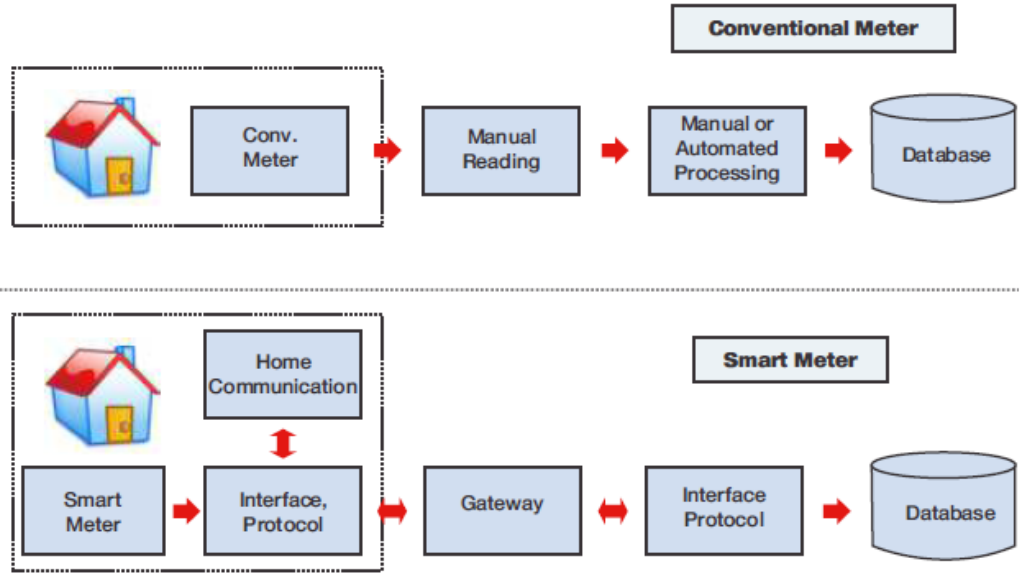


Smart Grid: Enabling Technologies

- **Smart Meters**

✓ enable consumers to monitor and manage their power use practically in real time and thus conserve energy.

✓ utilities benefit from better grid load planning and lower cost and gain detailed insight into network dynamics.



Ref: white paper on smart Metering

Electromechanical Meter

Electronic Meter

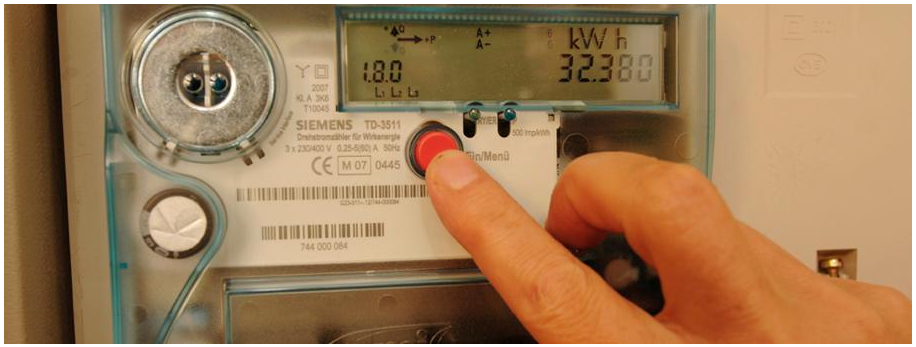


Photo: Siemens

Smart Grid: Indian Context

- ***Smart grid*** is defined by the complexities of managing
  - synchronized national grid
  - power exchanges
  - open access transactions
  - diverse generation resources
  - AT&C loss reduction
  - demand-side management
- System operators: seeking to minimize human interface to limit the margin for error
- National objective: to progressively increase renewable energy share in the grid, which necessitates real-time monitoring, forecasting and efficient grid dispatch

Smart Grid: Institutional framework

- **India Smart Grid Forum (ISGF)**
  - A non-profit voluntary consortium of public and private partnership body constituted in Sept. 2010
  - **Objective**: to accelerate the development and implementation of Smart Grid technologies in the Indian Power Sector

An Initiative of

सत्यमेव जयते

Ministry of Power
(Govt. of India)

- **India Smart Grid Task Force**
  - An inter ministerial group was constituted to help frame Govt. policies for creating conductive policy framework for accelerated implementation of Smart Grid
  - Designed to work with various Govt. agencies to convert the recommendations made by the ISGF in to policies.

Drivers for smart grids in India

Utilities:

- Reduction of T&D losses in all utilities to 15% or below
- Peak load management – multiple options
- Reduction in power purchase cost
- Better asset management
- Increased grid visibility
- Self-healing grid
- Renewable integration

Customers:

- Improve reliability of supply to all customers – no power cuts, no more DG sets and inverters
- Improve quality of supply – no more voltage stabilizers
- User friendly and transparent interface with utilities
- Increased choices for consumers, including green power

Source: Draft on Smart Grid Roadmap for India, ISGF

Drivers for smart grids in India

Government & Regulators:

- Satisfied customers
- Financially sound utilities
- Tariff neutral system upgrade and modernization
- Reduction in carbon and other pollutant emissions and emission intensity

Source: Draft on Smart Grid Roadmap for India, ISGF

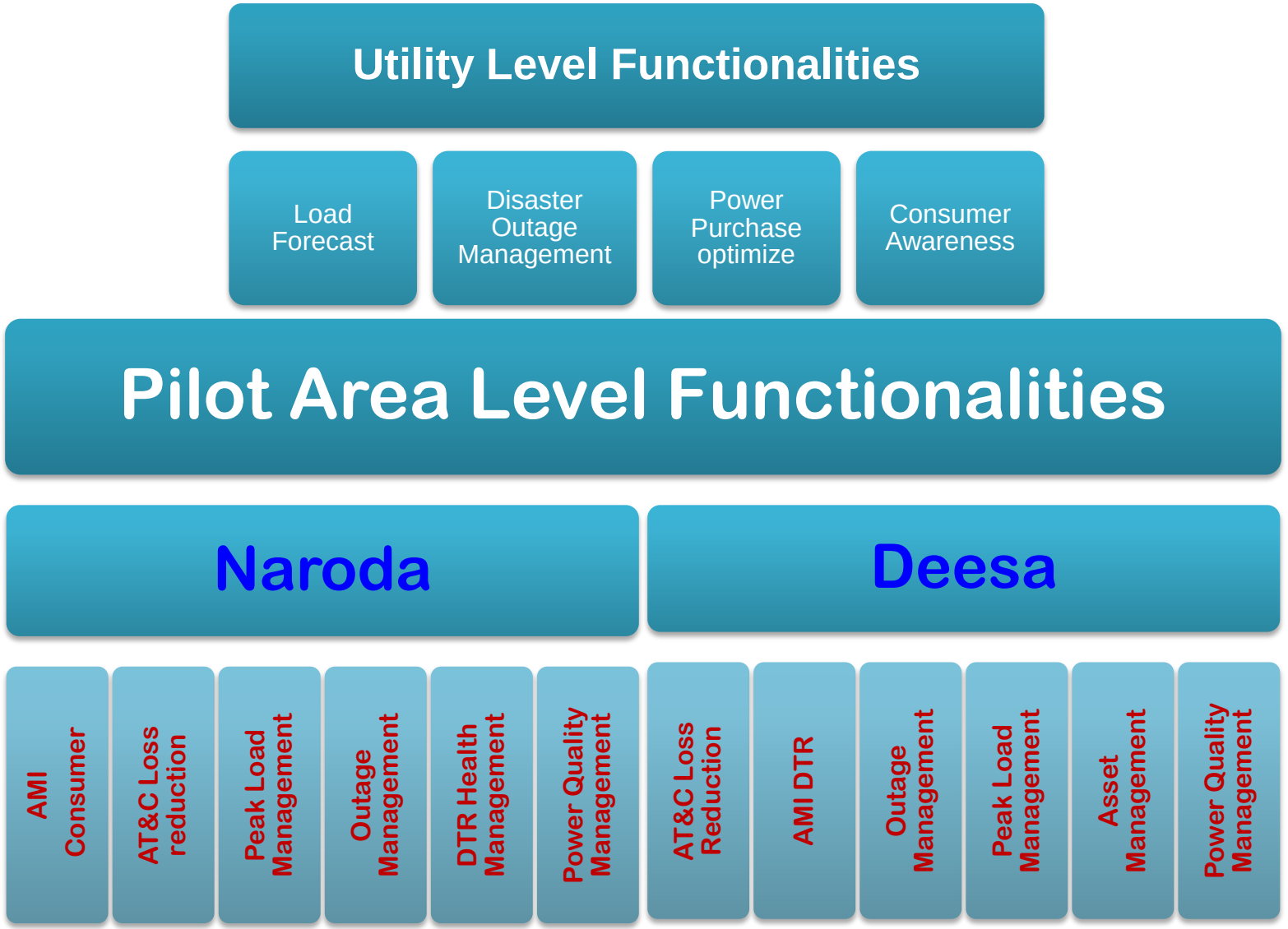
Smart Grid Vision for India

"Transform the Indian power sector into a secure, adaptive, sustainable and digitally enabled ecosystem by 2027 that provides reliable and quality energy for all with active participation of stakeholders "

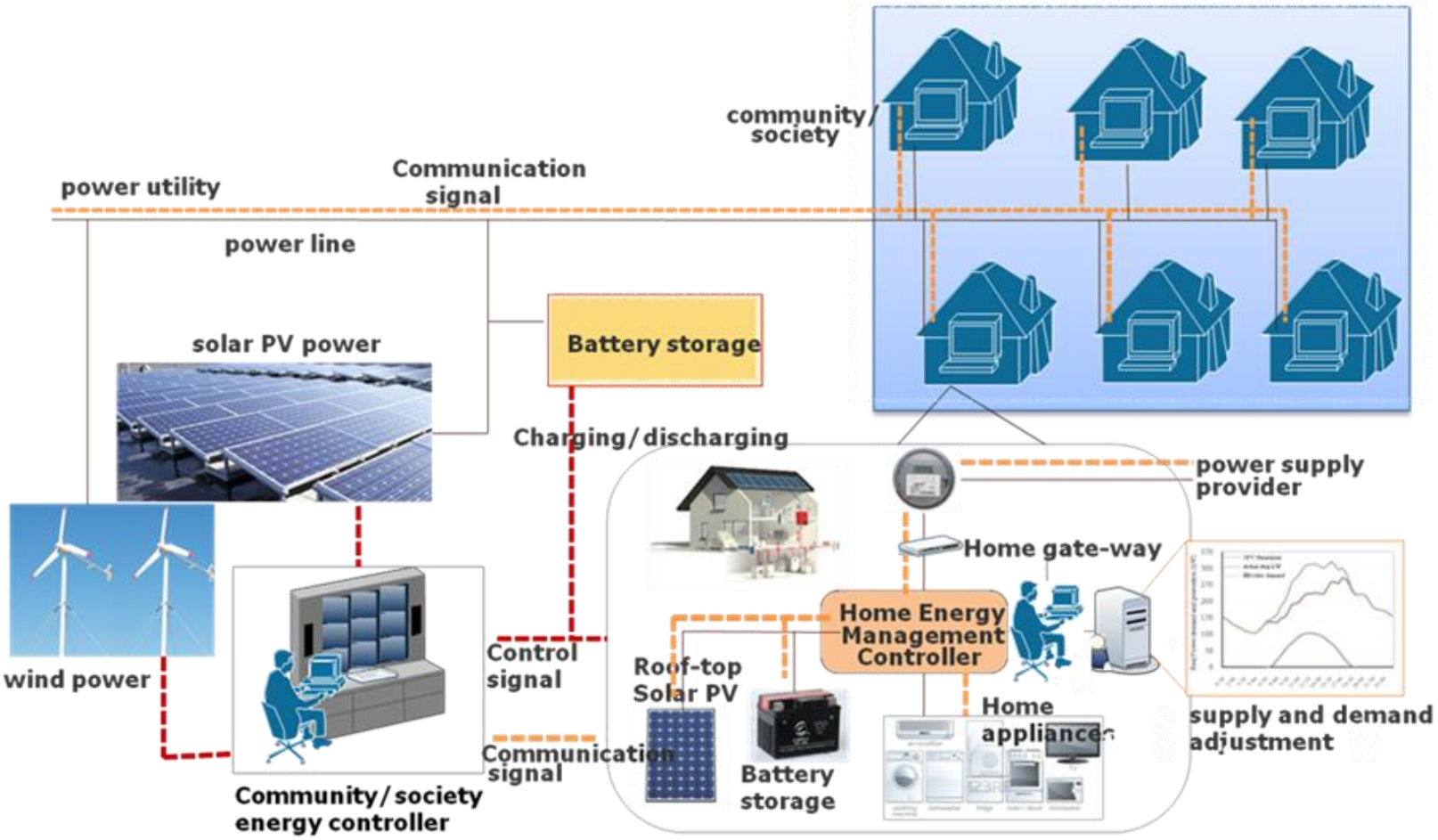
- Integrated technology trials through a set of smart grid pilot projects (14 across India) by 2015
- Integration of R-APDRP building blocks into future smart grid development
- Availability of an indigenous smart meter by 2014
- National Optical Fibre Networking for better communication for most of S/S 33/11 kV
- Enabling programs and projects in distribution utilities to reduce AT&C losses to below 15% by 2017, below 12% by 2022, and below 10% by 2027
- Conversion of existing distribution sub-stations to GIS based substations
- Formulation of effective customer outreach and communication programs for active involvement of consumers (Knowledge portal)
- development of Microgrids, storage options, virtual power plants (VPP), vehicle to grid (V2G), solar to grid (PV2G), and building to grid (B2G) technologies in order to manage peak demand, optimal use of installed capacity and reduce load shedding and black-outs.

Source: Draft on Smart Grid Roadmap for India, ISGF

SG Pilot Project - UGVCL

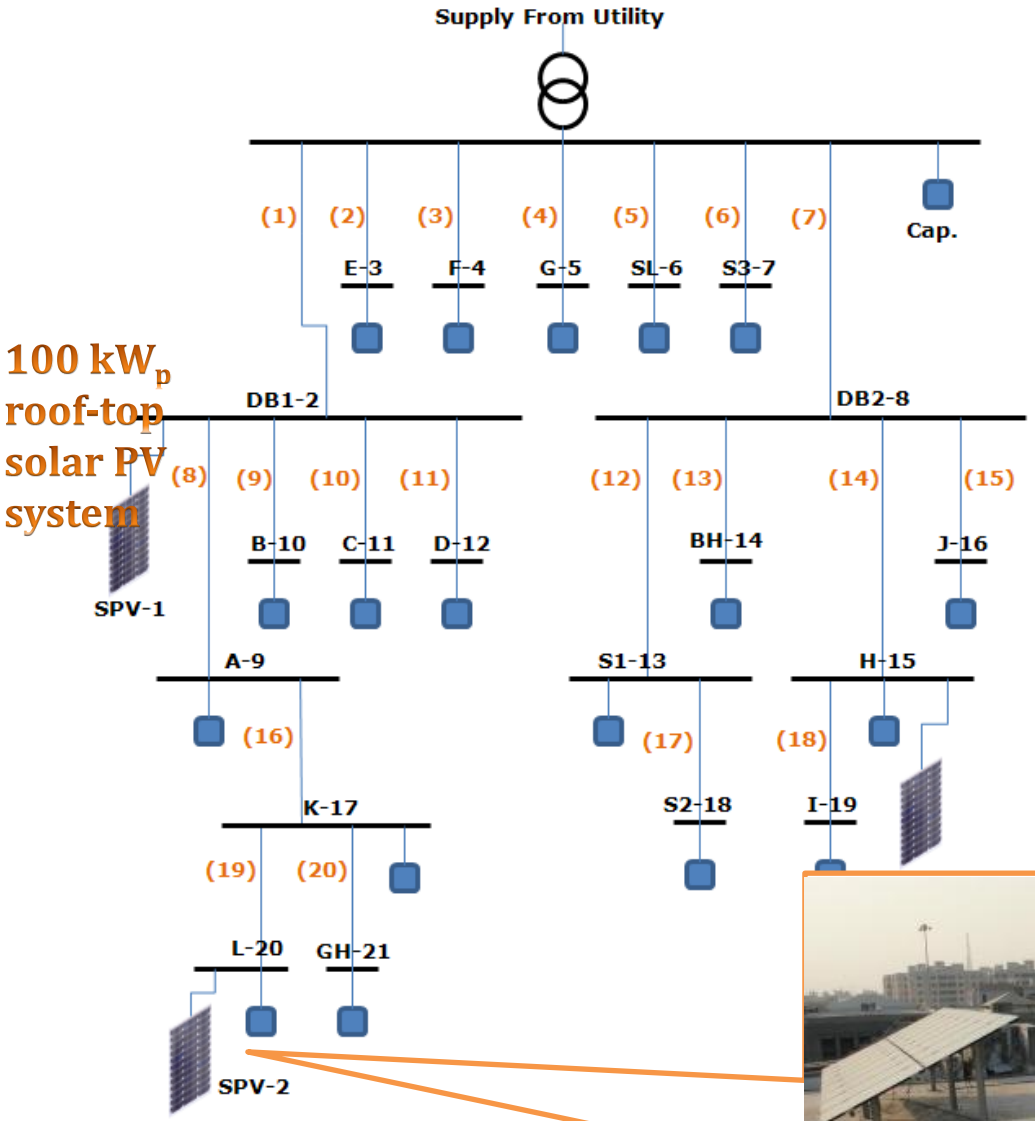


Intelligent Energy Management System



Illustrative smart home energy management system

VGEC-IIT GN Power Distribution Network

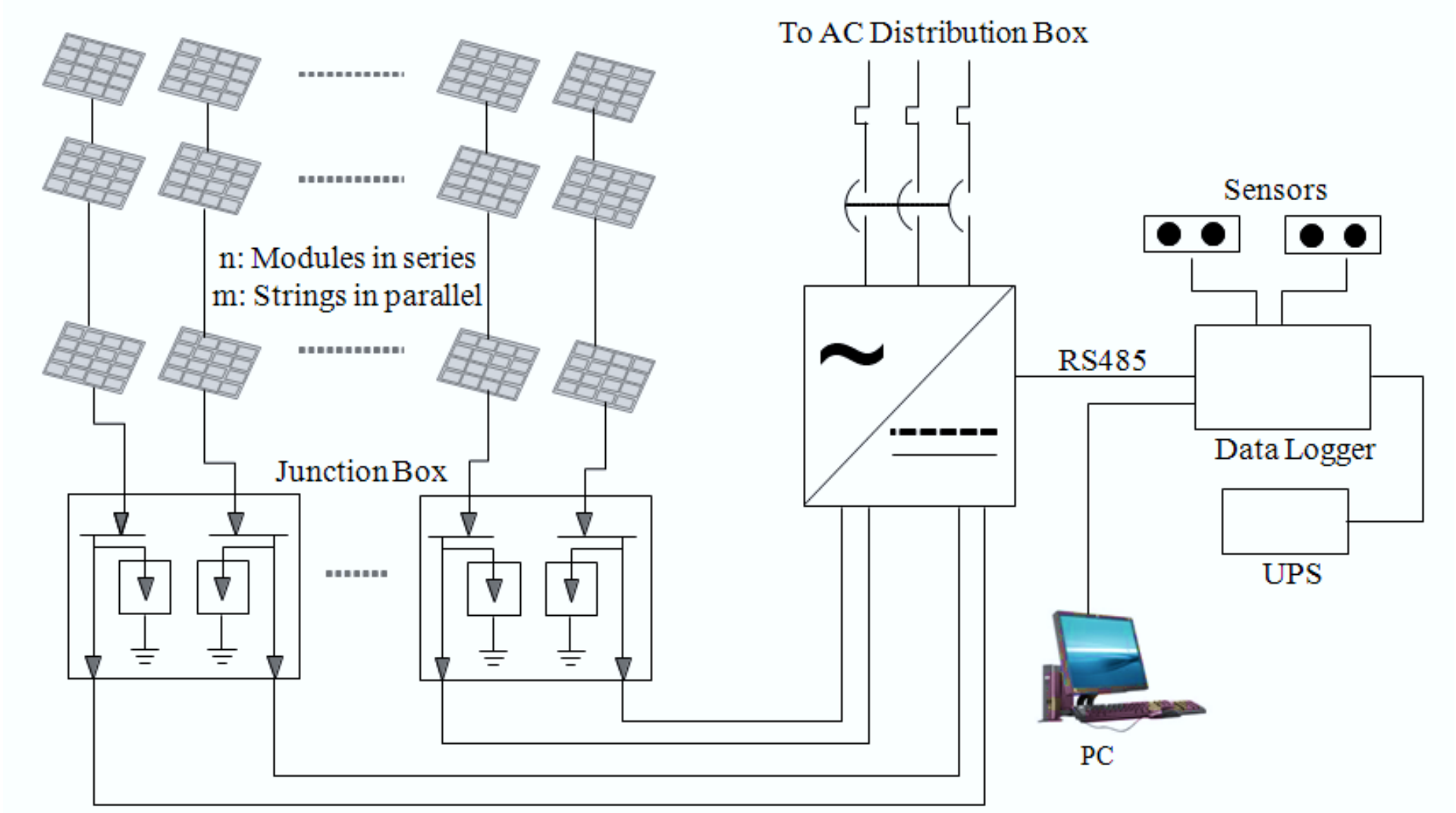


100 kW_p roof-top solar PV system

10 kW_p roof-top solar PV system –Multi-crystalline

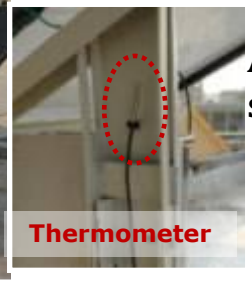
10 kW_p roof-top solar PV system –Thin-film

Solar PV Systems – Schematic Arrangement

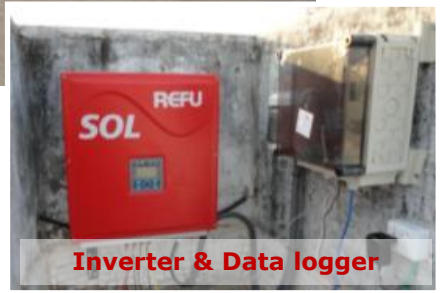


10 kW_p Solar PV (Thin-film, CIS) System

Pyranometer and Irradiance sensors with module temperature sensor



Ambient temperature sensor



PV Inverter (REFU*sol* 010K)

Data logger (Solar-Log 200)

PV module

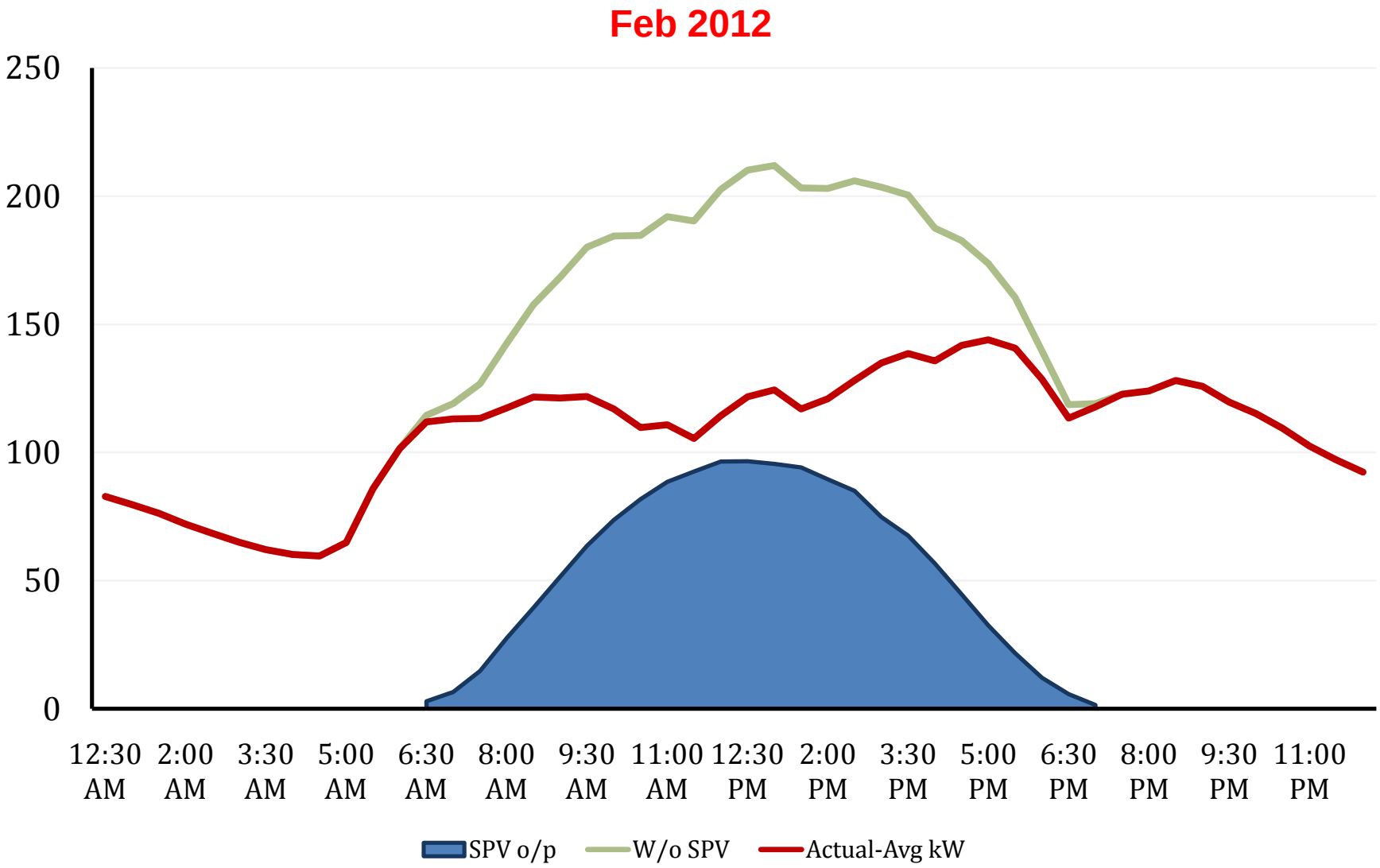
Manufacturer	: Solar Frontier, Japan
Type	: CIS (SF150-L)
Nominal value	: 150 W_p

(http://www.solar-frontier.com)

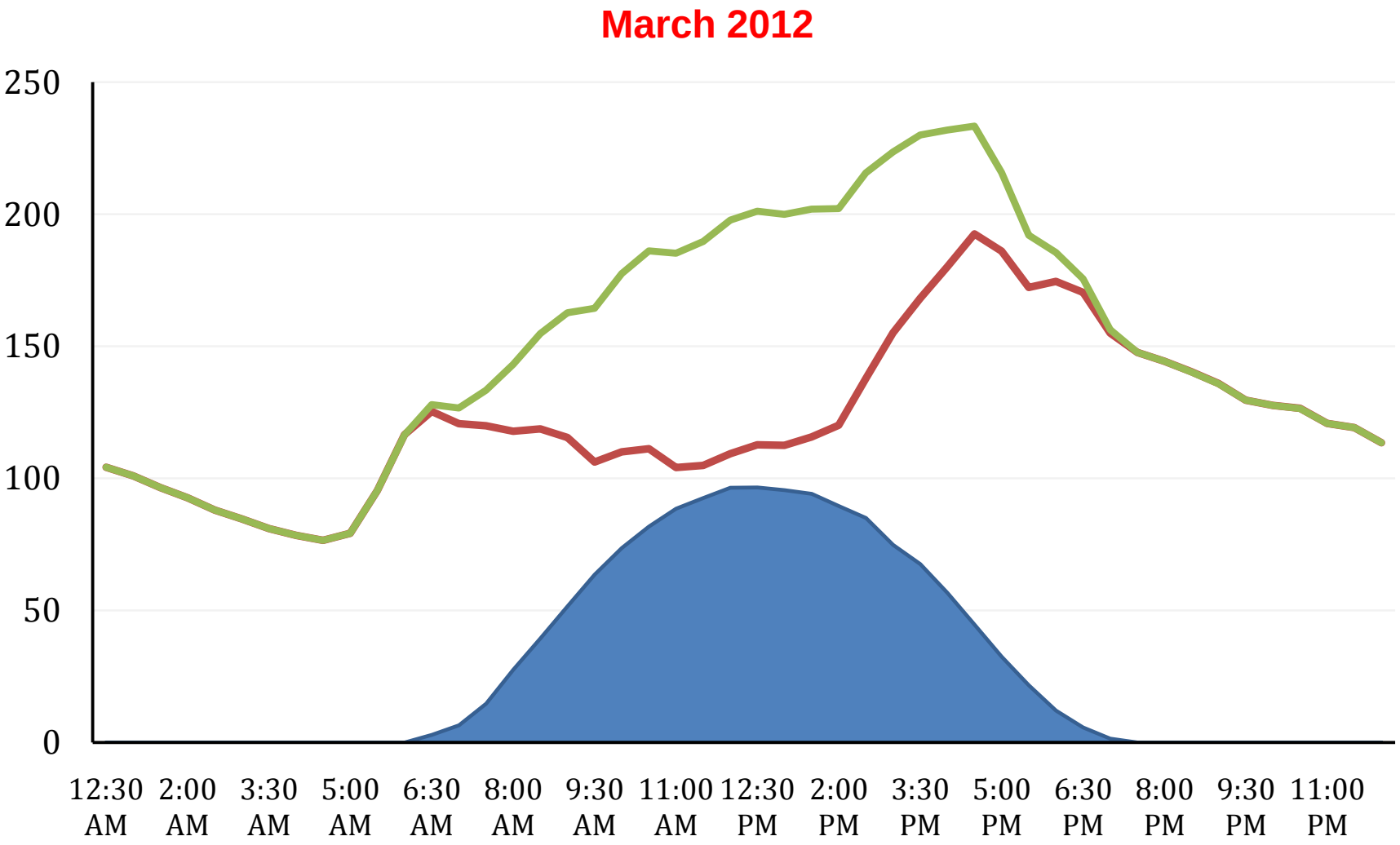
Installation conditions

Inclined angle	: 25°
Orientation	: South

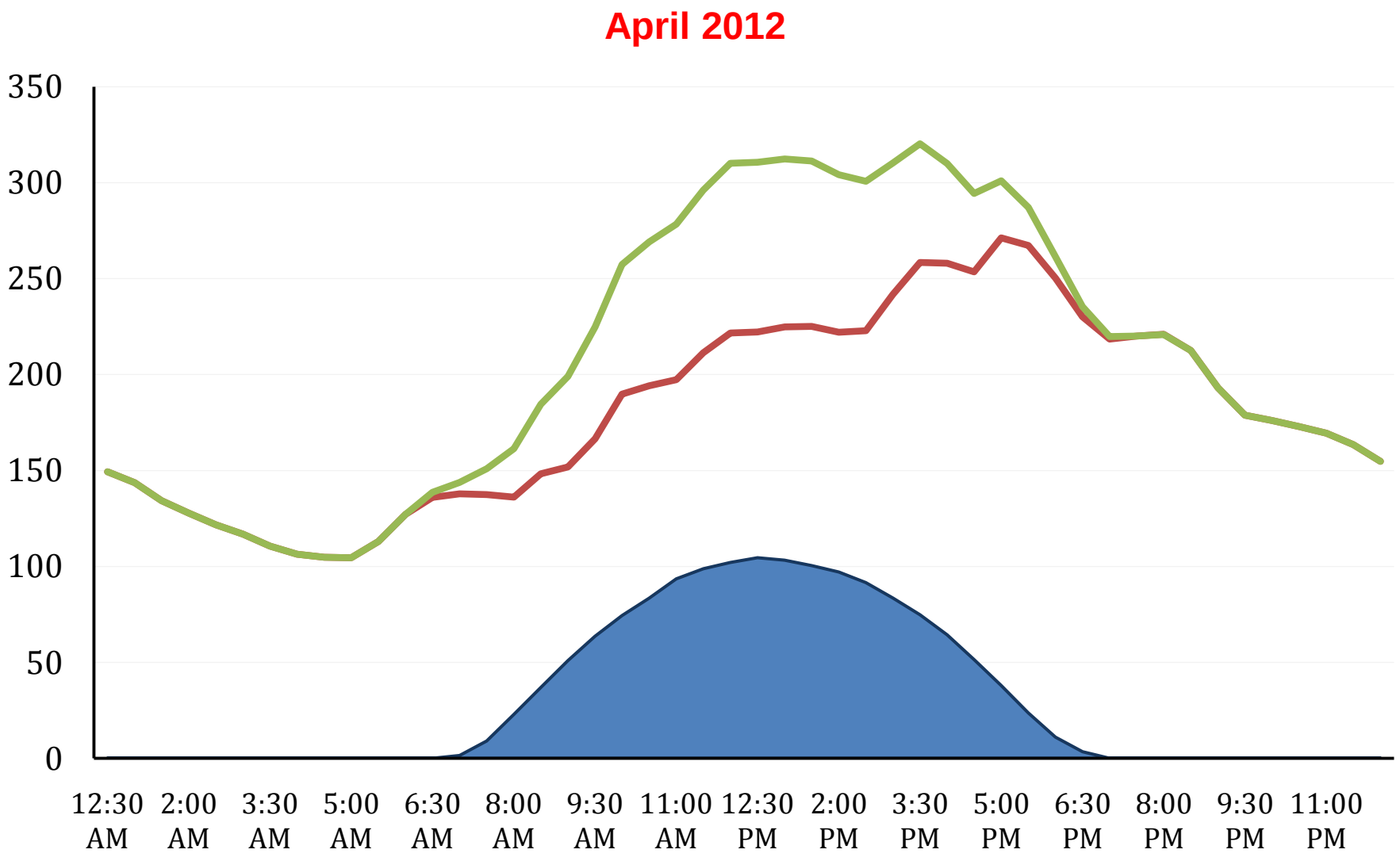
Load Profile & PV Generation



Load Profile & PV Generation



Load Profile & PV Generation



Thanks for your kind attention !!!

… Any questions ???