NEW TECHNOLOGIES TO ACCELERATE COST EFFECTIVE GRID MODERNIZATION

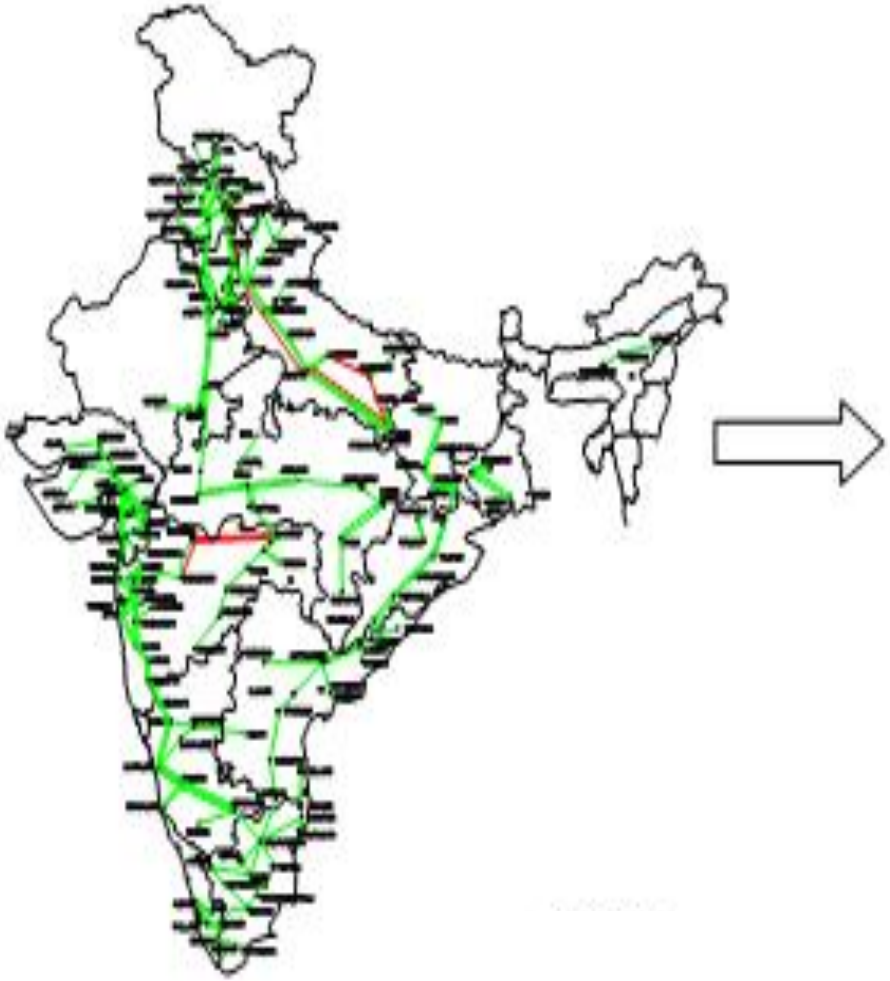
DUM NOVEMBER 1, 2018

GLOBAL CHALLENGE- CONGESTED CITIES

- Occupy less than 4% of land
- House 54% of World's population
- Use 75% of available resources
- Account for 70% of green house gas emission
- Accounts for 80% of Global GDP

In India also, Urban Population would almost double to 814 million by 2050

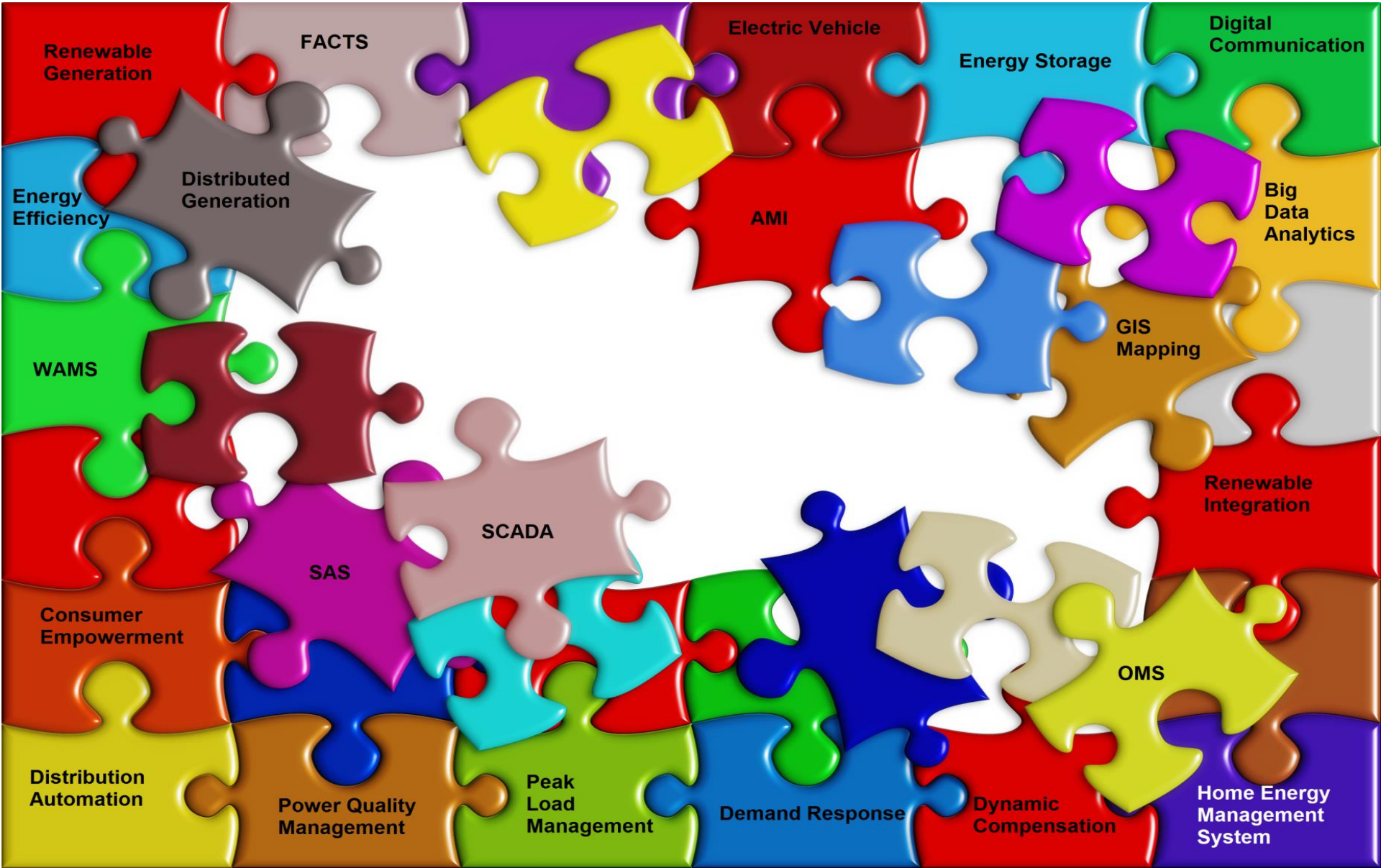
Rapid Expansion of Indian Grid



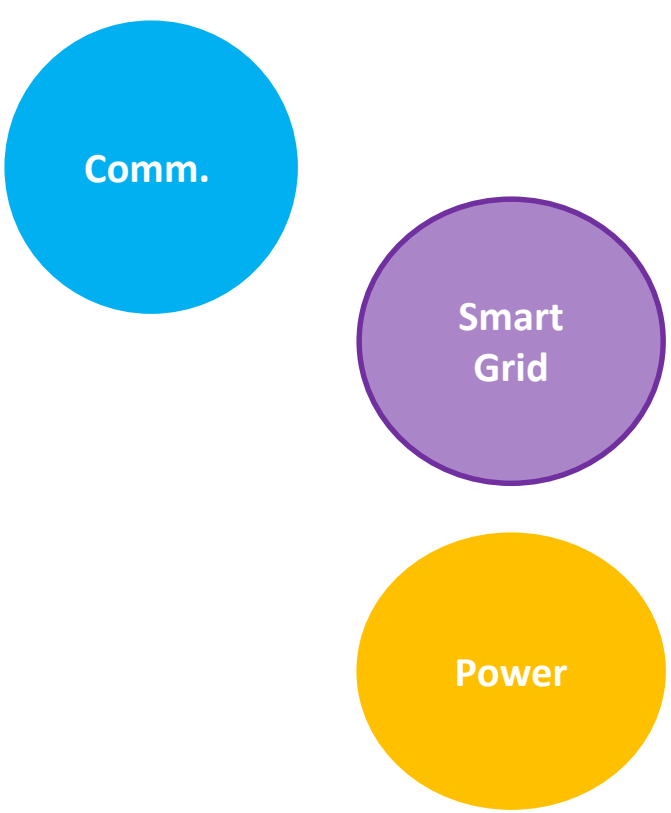
Grid in 1980s

Grid in 21st Century

What is Smart Grid ?



Smart Grid

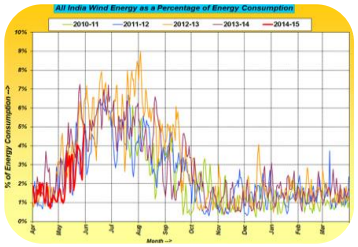


"Smart Grid is integration of Information and Communication technologies with power infrastructure to induce intelligence aiming at enhanced efficiency, reliability, asset utilization and consumer experience"

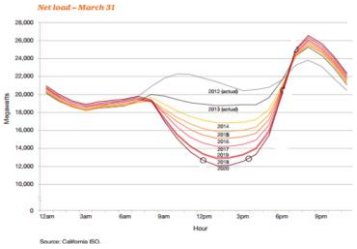
Need for Smart Grids !!

Depletion of Fossil Fuel

Climate Change



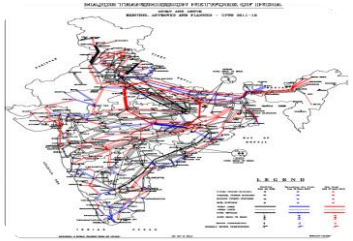
Erratic nature of Renewable



Huge load variations

High AT&C Losses

Increased stress on reliability



Large interconnected networks

Commercial value of interruptions

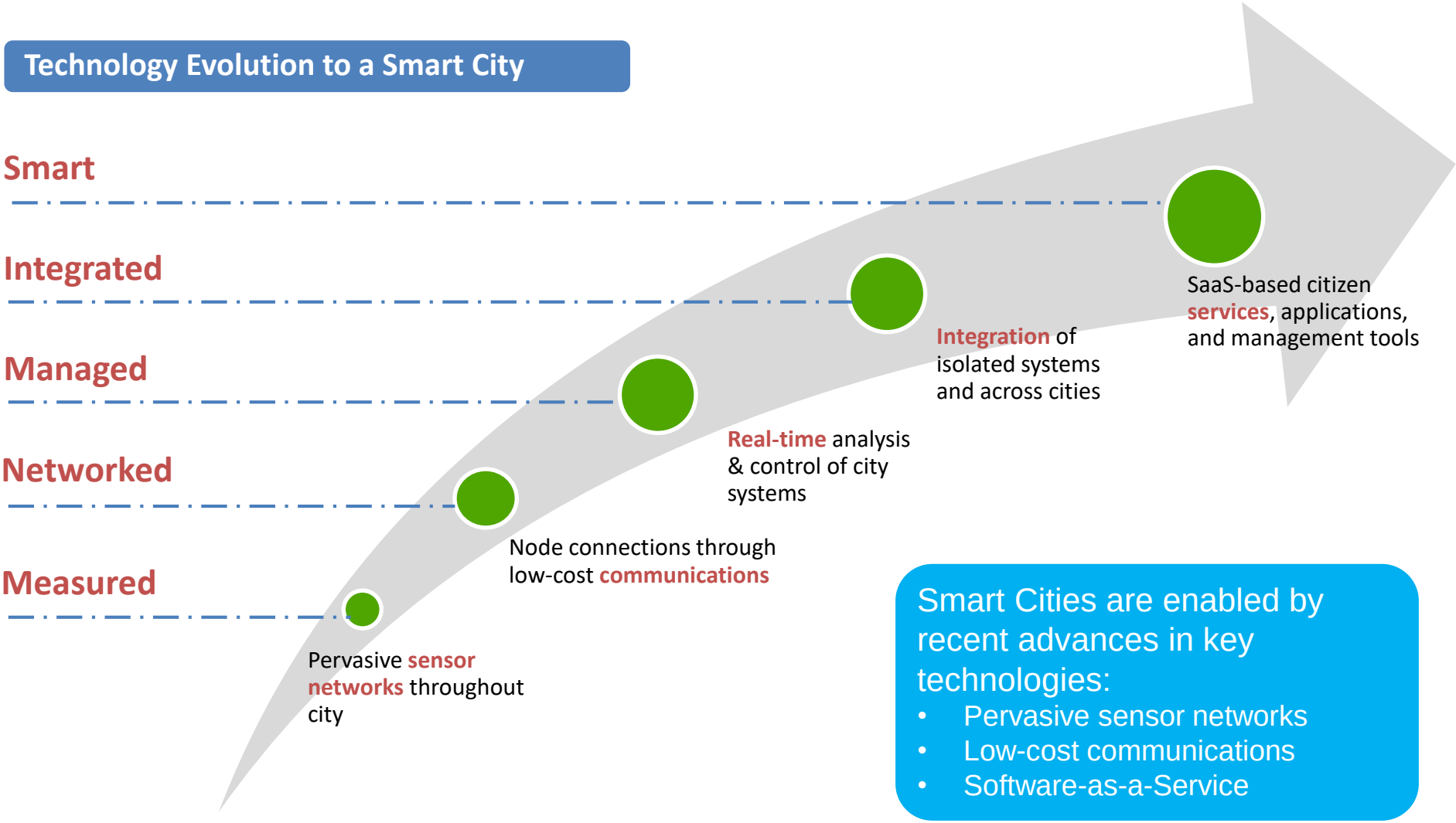
Stringent Regulations

Consumer Aspirations

In the background of such challenges and tremendous development in communication and computation technologies in last two decades have brought in huge space for

Smart Grids

Becoming smarter is a long-term process and a step-by-step approach



Smart Cities are enabled by recent advances in key technologies:

- Pervasive sensor networks
- Low-cost communications
- Software-as-a-Service

Span of Smart Grids

Generation

- Generation from renewables
- Flexibility
- Balancing Reserves
- REMCs

Transmission

- Renewable Integration
- Energy Storage
- WAMS
- Dynamic Compensation
- FACTS
- Digital Substations

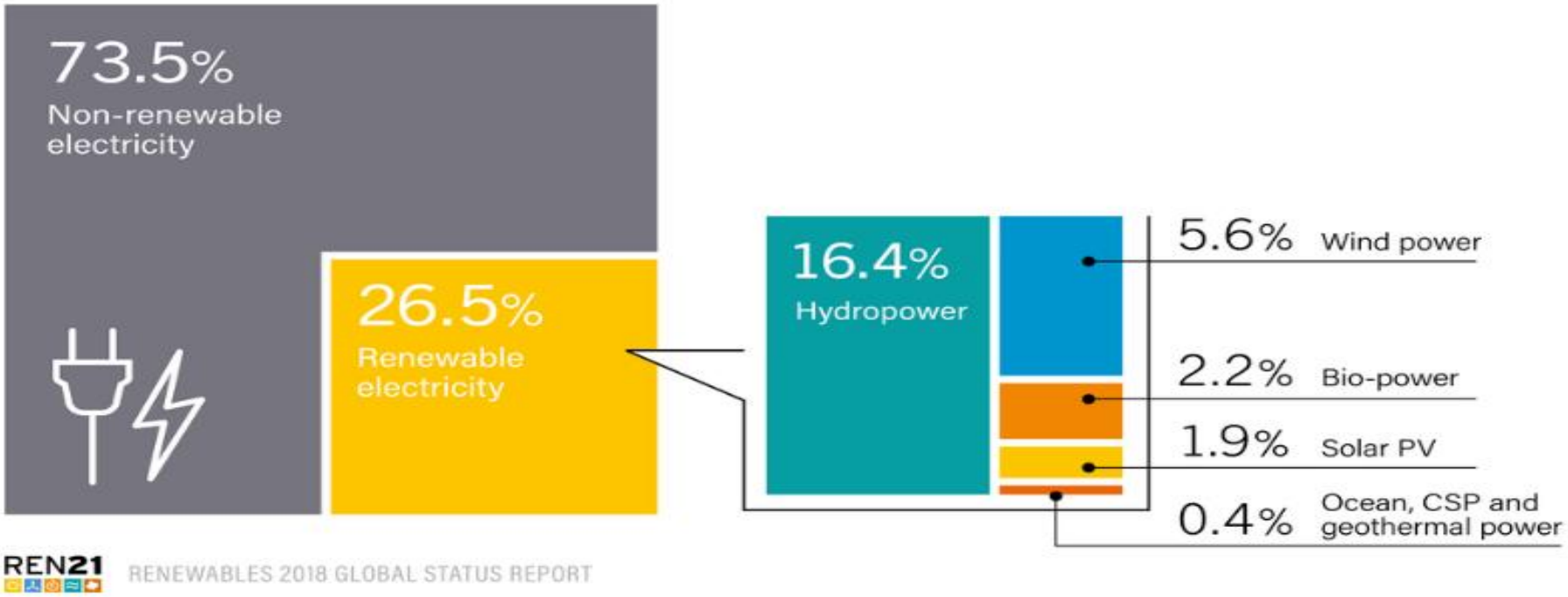
Distribution

- AMI
- OMS
- PLM
- SCADA & Automation
- Distributed Generation
- Microgrids

Renewable Forecasting, Automation, Remote Monitoring & Control

Global Renewable Scenario

Total RE	Hydro	Wind	Solar	Other (Bio Energy, Geo Thermal, Marine
2195 GW	1114 GW	539 GW	402 GW	140 GW



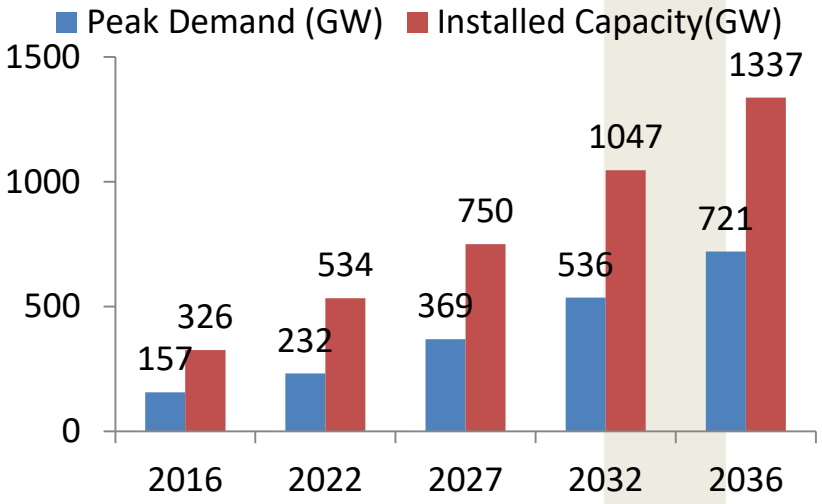
9%	**The highest** ever **growth rate** in RE capacity additions during 2017
70%	**Renewable Energy** as part of Net additions to global power generating capacity
178 GW	**Total increase** in global RE capacity in 2017
55%	Share of **Solar PV** in newly installed renewable power capacity in 2017

Glimpse of Indian Power System

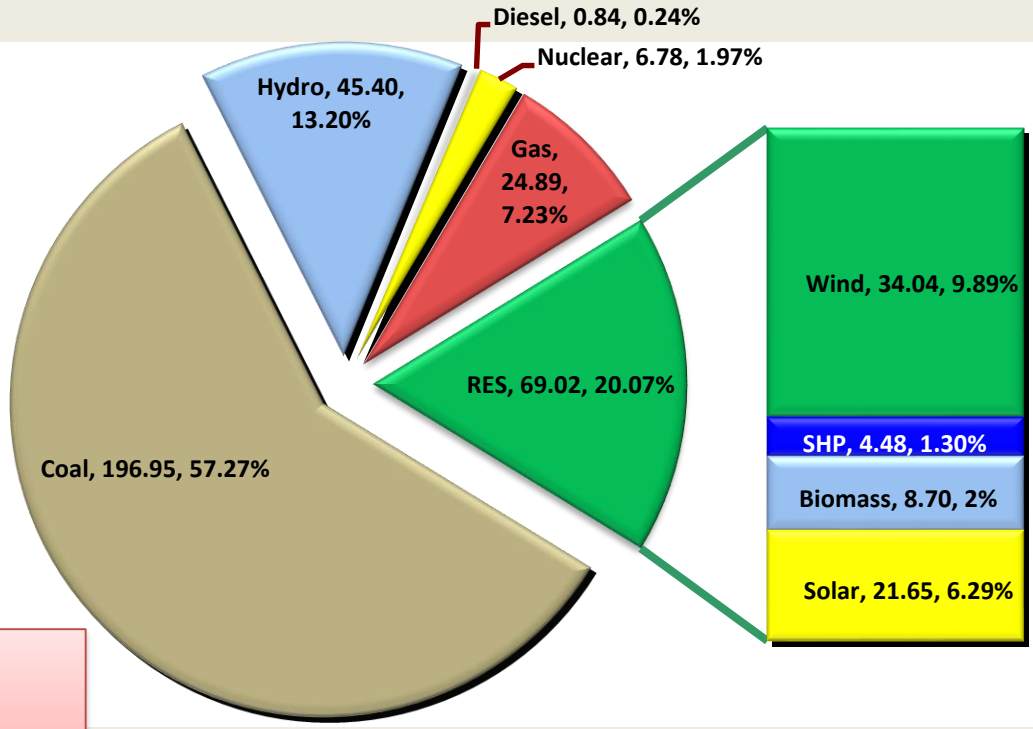
Total Installed Capacity
~ 344 GW

Peak Demand Met
~173 GW

Renewable
69 GW



Type Wise Capacity



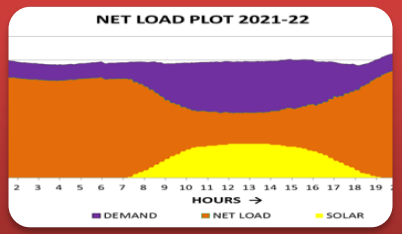
Electricity Share in Total Energy Consumption
- Present 17% (World Average : 23%)
- By 2040: 26%

Power Market
~7 %

Annual Consumption
> 1200 BU

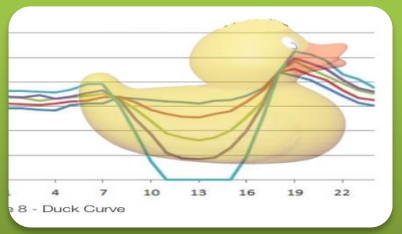
As on May 2018

Issues in Handling Large Volume of RE



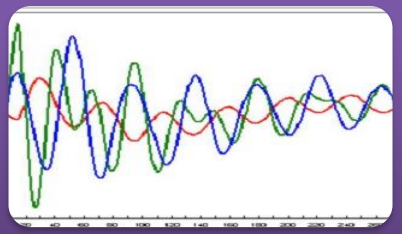
Balancing

- Peak doesn't match with load
- Huge uncertainties
- Limited flexibilities in conventional generators



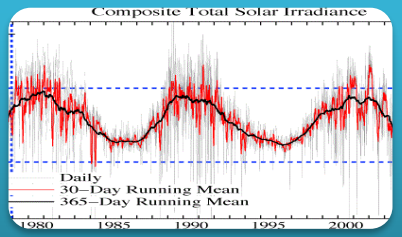
Ramping

- Present ramp rate: 200 MW/ Min (Evening), 140 MW/Min (Morning)
- With heavier belly and longer neck, large ramp rates would be required
- Lack of mechanisms for grid ramping services



Var Management

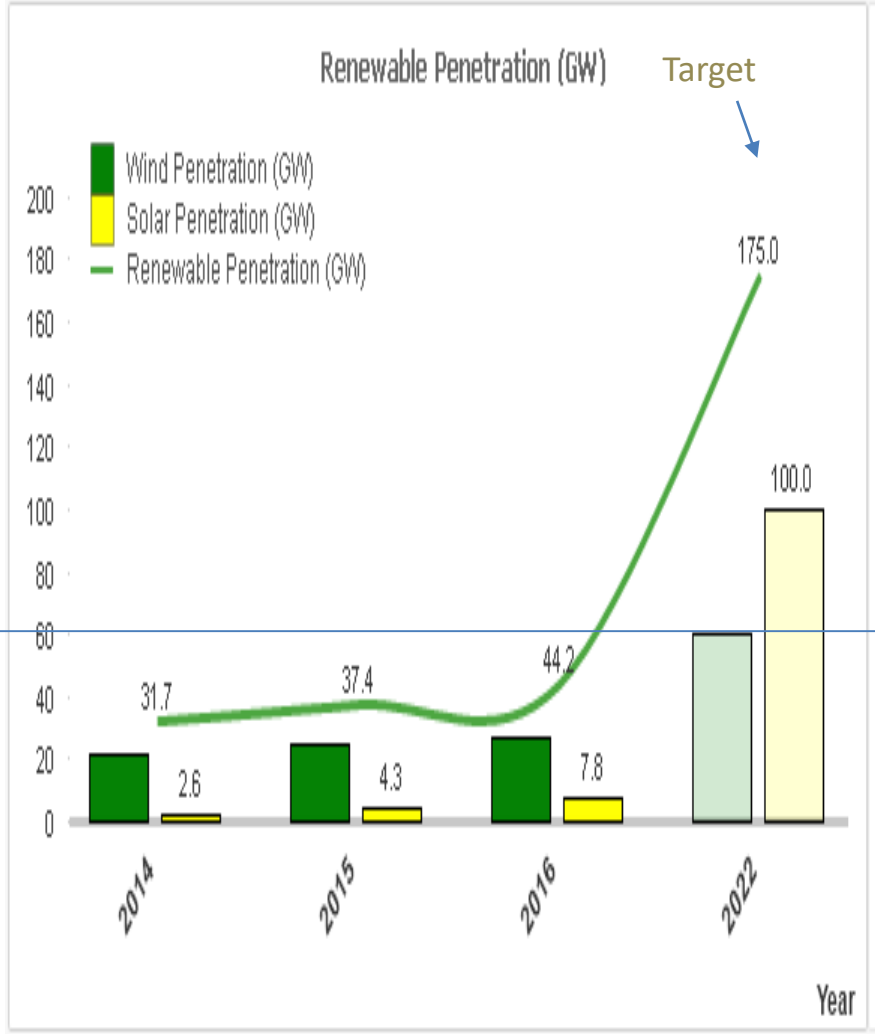
- Long lines for evacuation
- Large variation in line loading
- Inverters sensitive to voltage variation

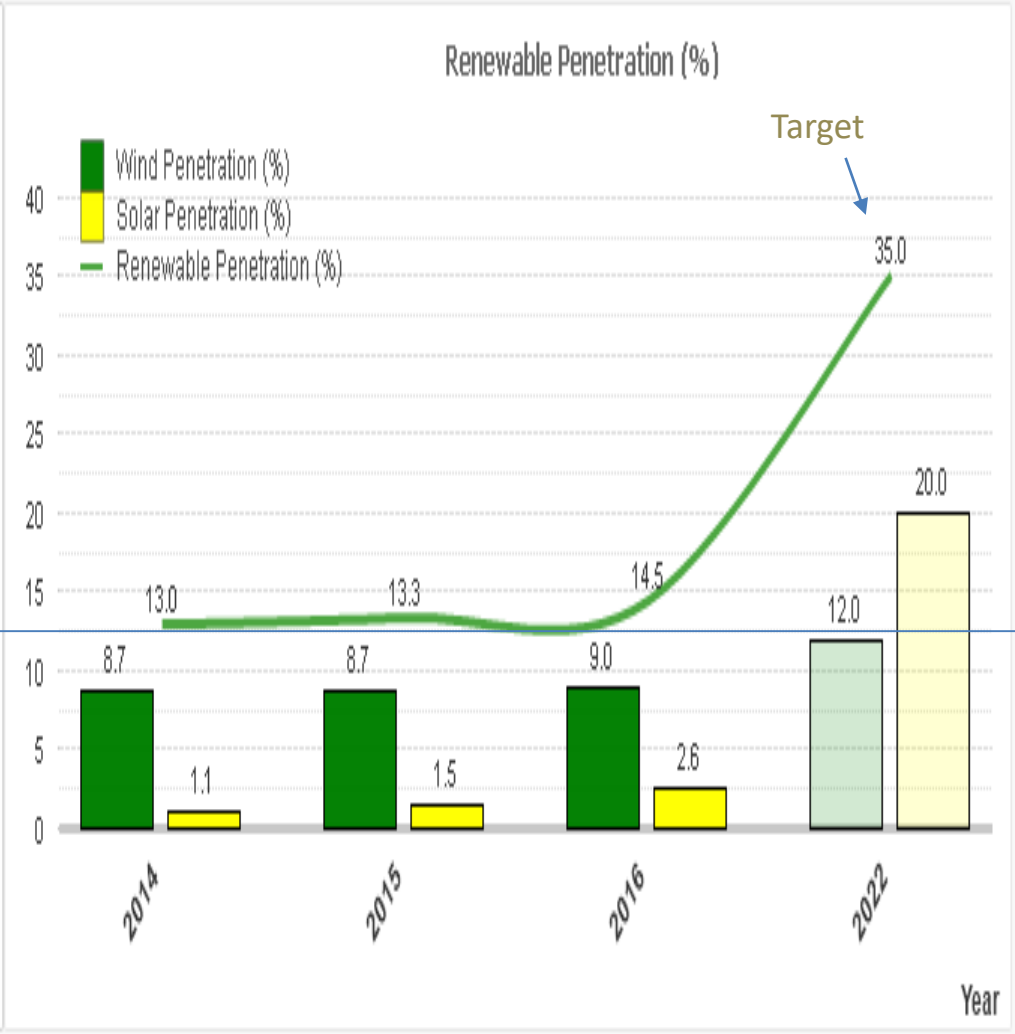


Scheduling & Forecasting

- Quick variations in small time windows
- Large forecasting error during rainy season
- Practically non-dispatchable

Generation: Renewable Penetration in India

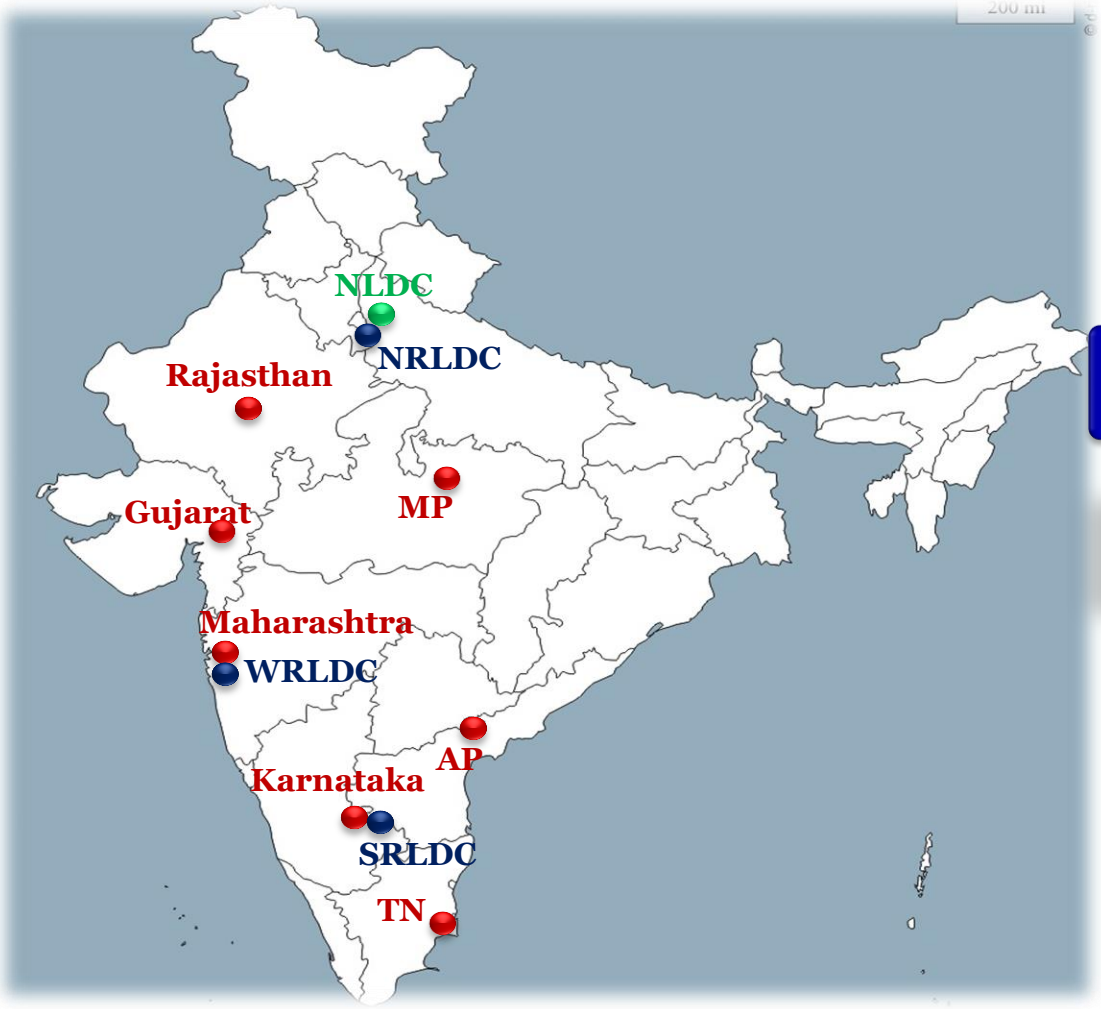


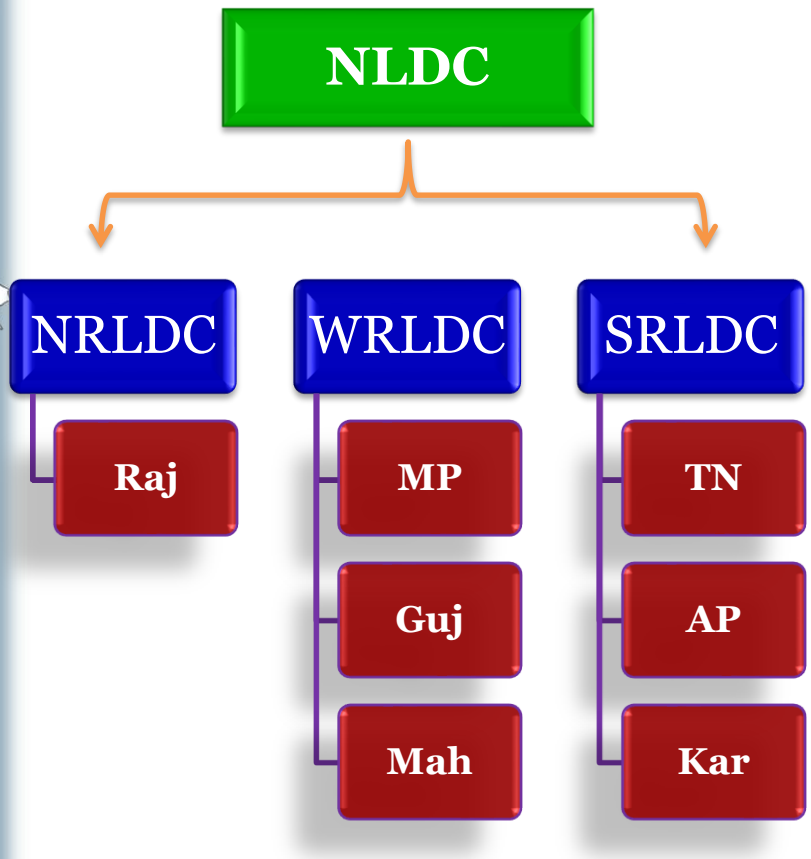


....Catalyst for change

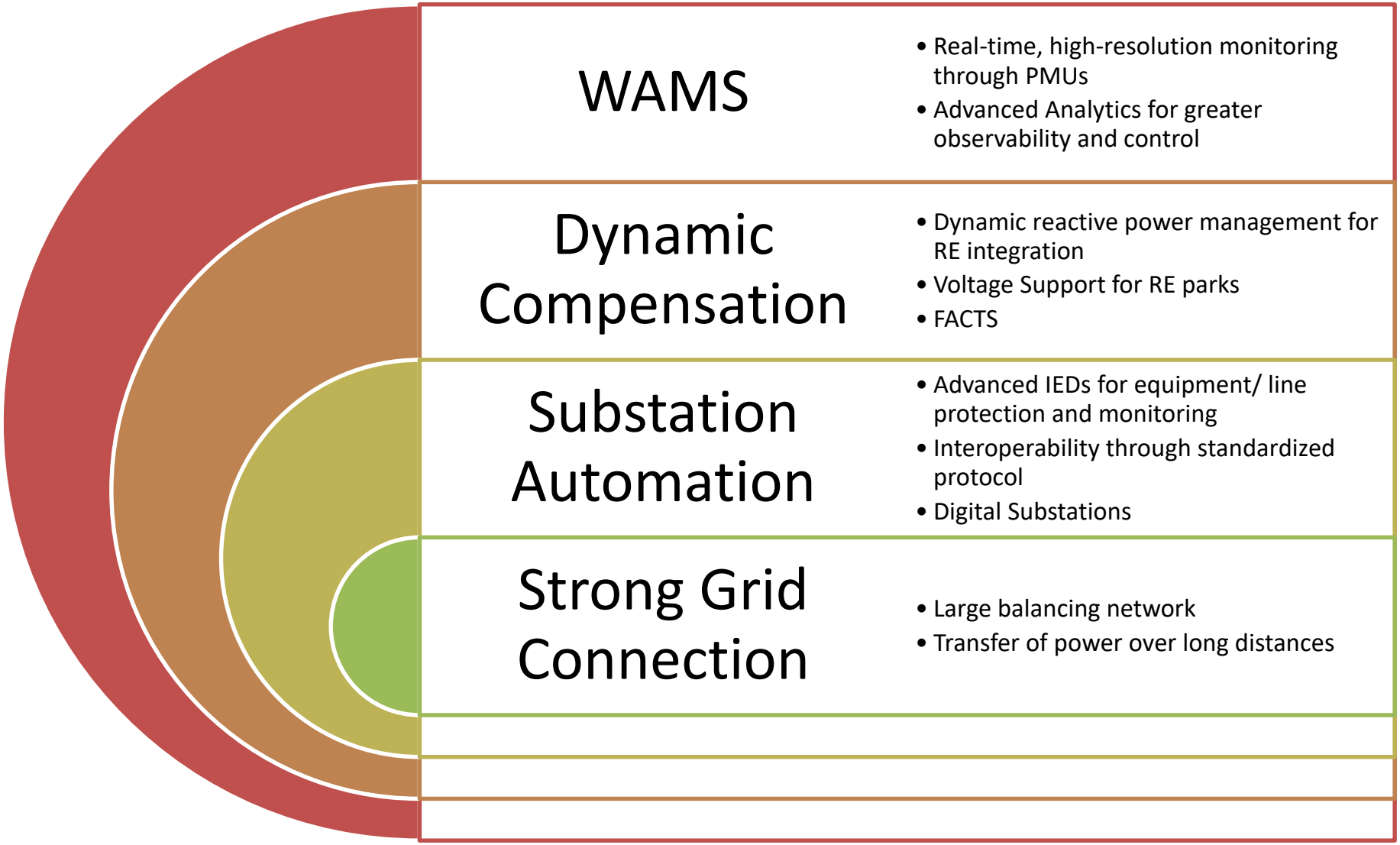
Establishment of REMCs

- 11 nos. REMCs to be established at State, Regional & National level co-located with respective Load dispatch centers
  - States LDCs (7), Regional LDCs (3) & NLDC (1)





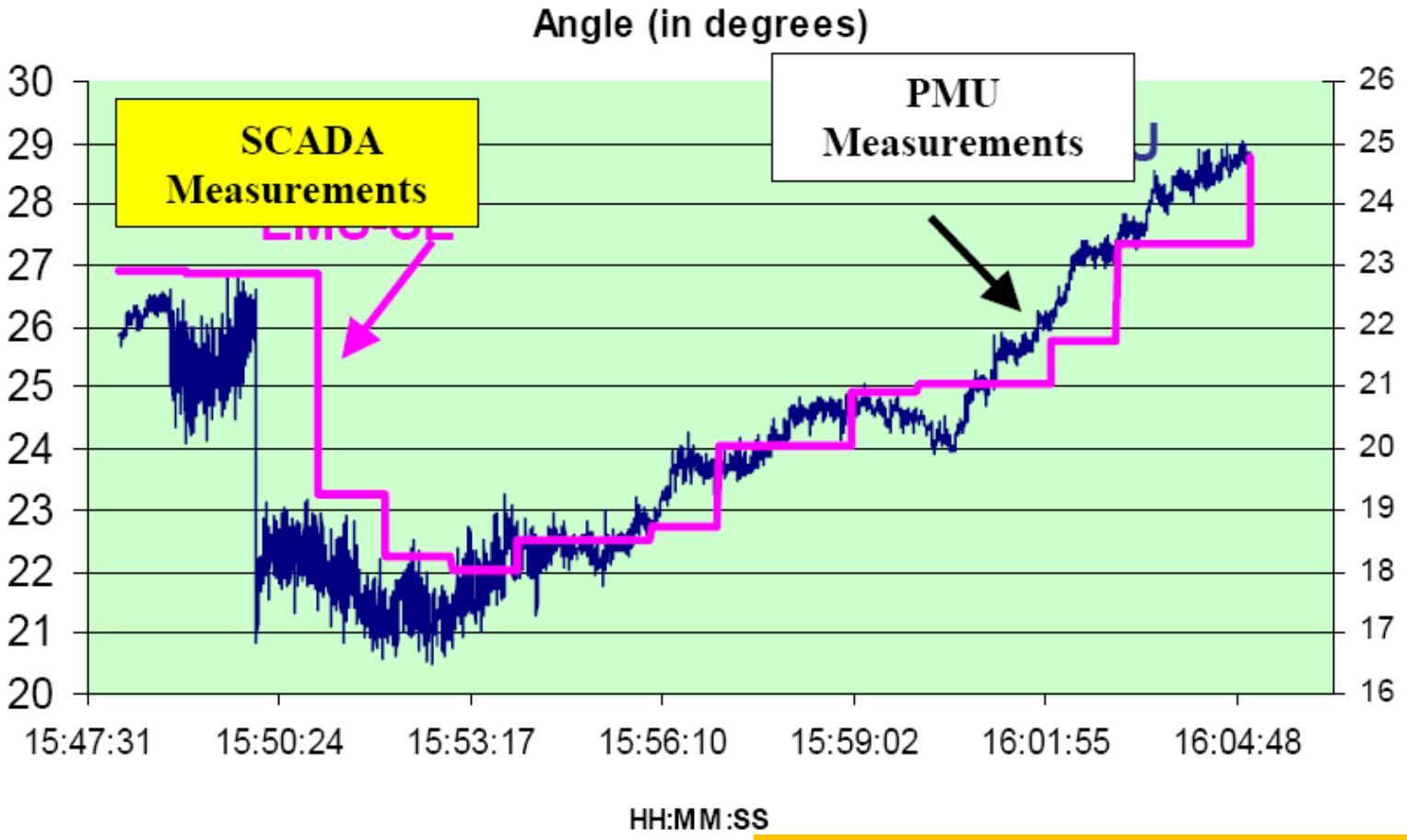
Transmission



PMU Placement

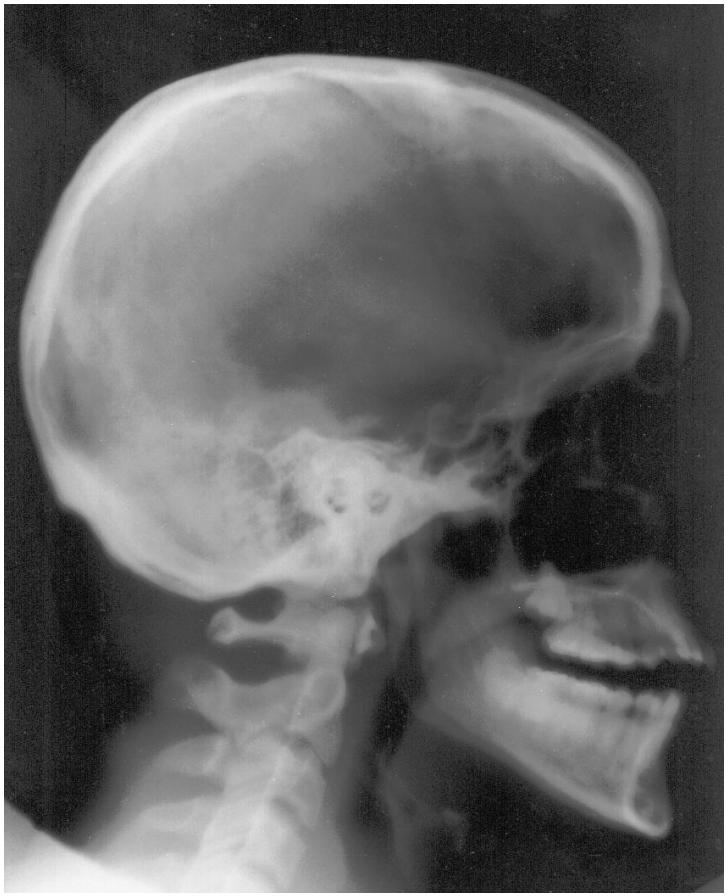
- All 400kV and above substation in State and Central grids & IPPs
- Generating stations at 220 kV level and above
- HVDC terminals and important Inter-Regional and Inter-National tie lines
- Both ends of all 400kV and above Transmission lines of State, ISTS grids and IPPs

Higher Resolution for Greater Observability

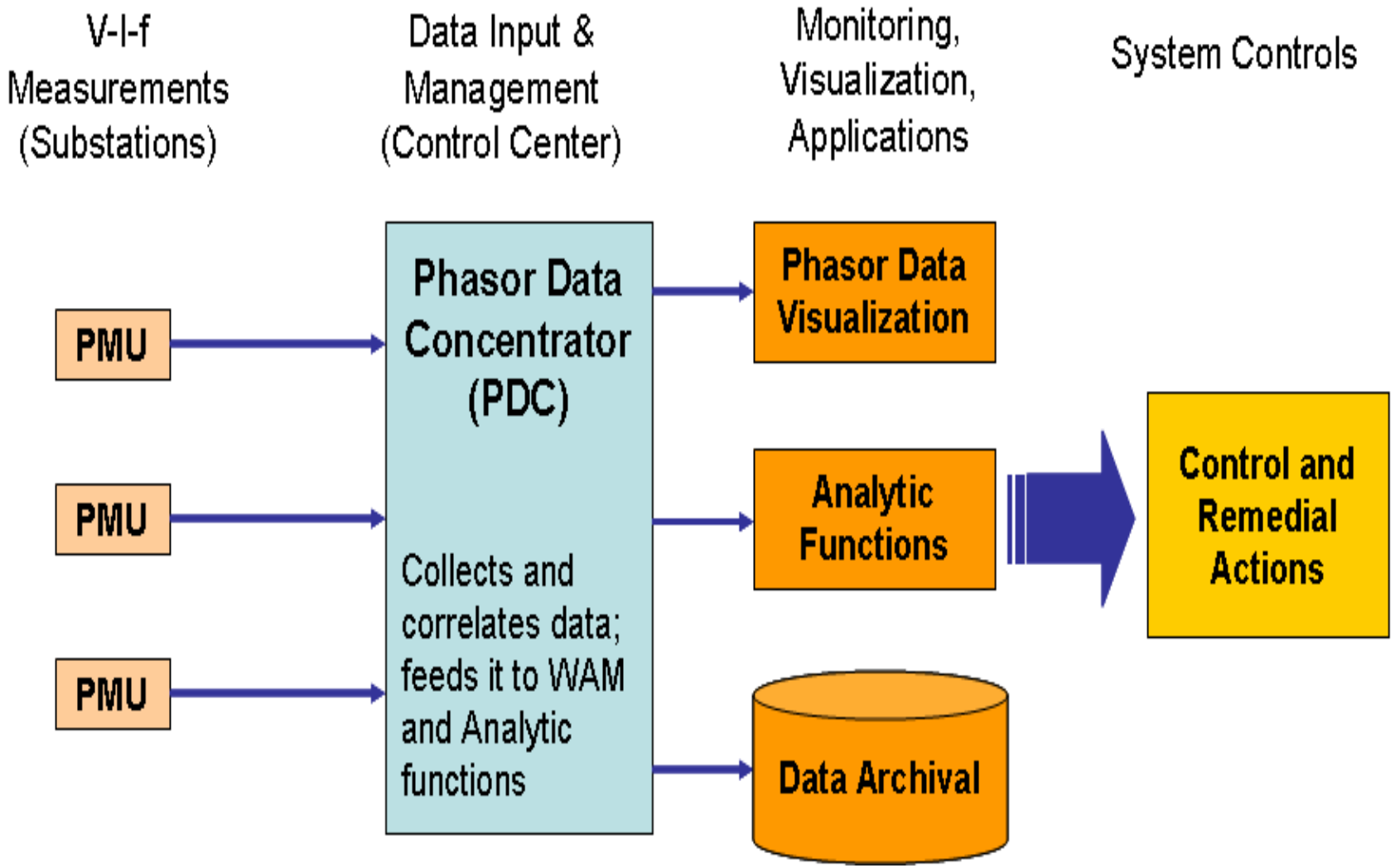


Much Higher Resolution (typically 25-50 samples/second)
Compared to 4 to 10 seconds /sample of SCADA

SCADA to PMU: X-RAY to MRI



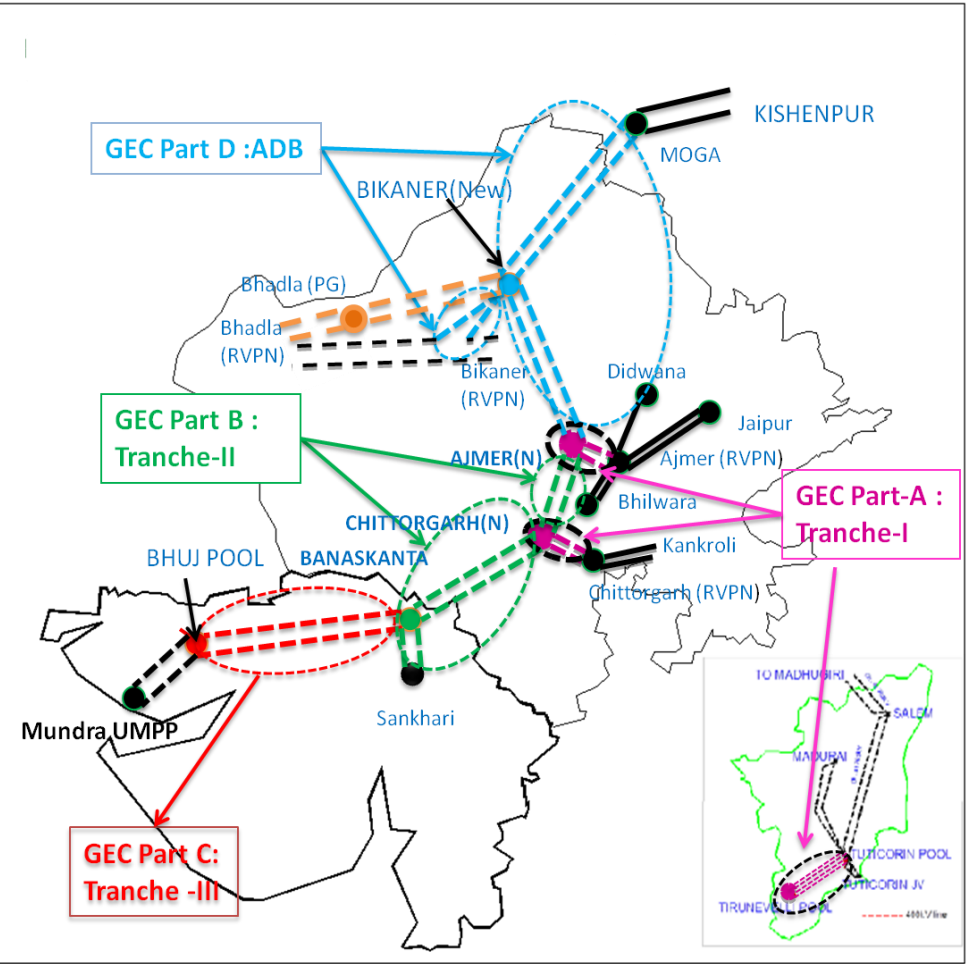
Integration of PMU data



Analytics using PMU data

- **Line Parameter Estimation**
- **Online vulnerability analysis of distance relays**
- **Linear State Estimator**
- **Supervised Zone-3 distance protection scheme to prevent unwanted tripping**
- **CT/CVT Calibration**
- **Control Schemes for improving system security (Based on angular, voltage & frequency stability)**

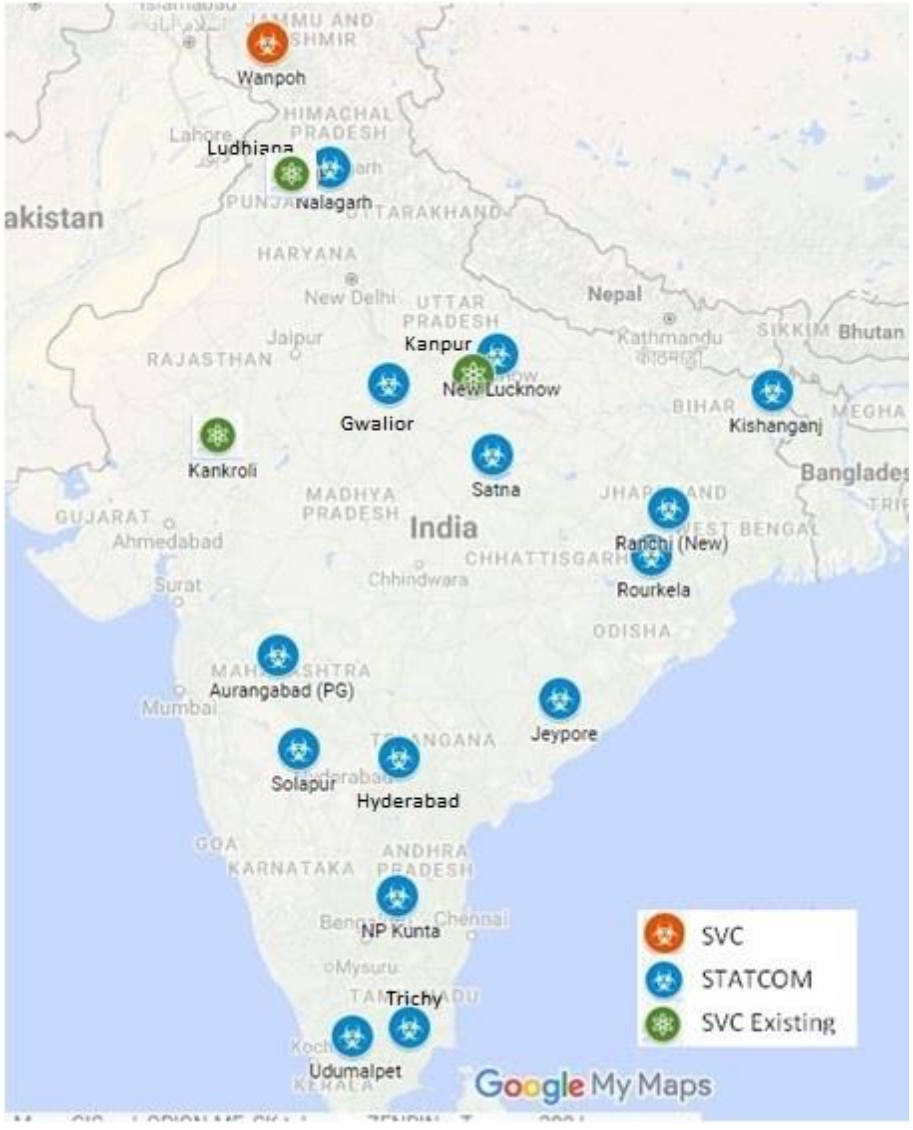
Green Energy Corridors : Components



- Intra & Inter State Transmission strengthening : For integration of Renewable energy sources with the grid
- Dynamic compensation (SVC & STATCOM): To maintain grid parameters
- Renewable Energy Management Centres (REMC) : For RE forecasting, Scheduling & real time monitoring

GEC Status- Under Implementation

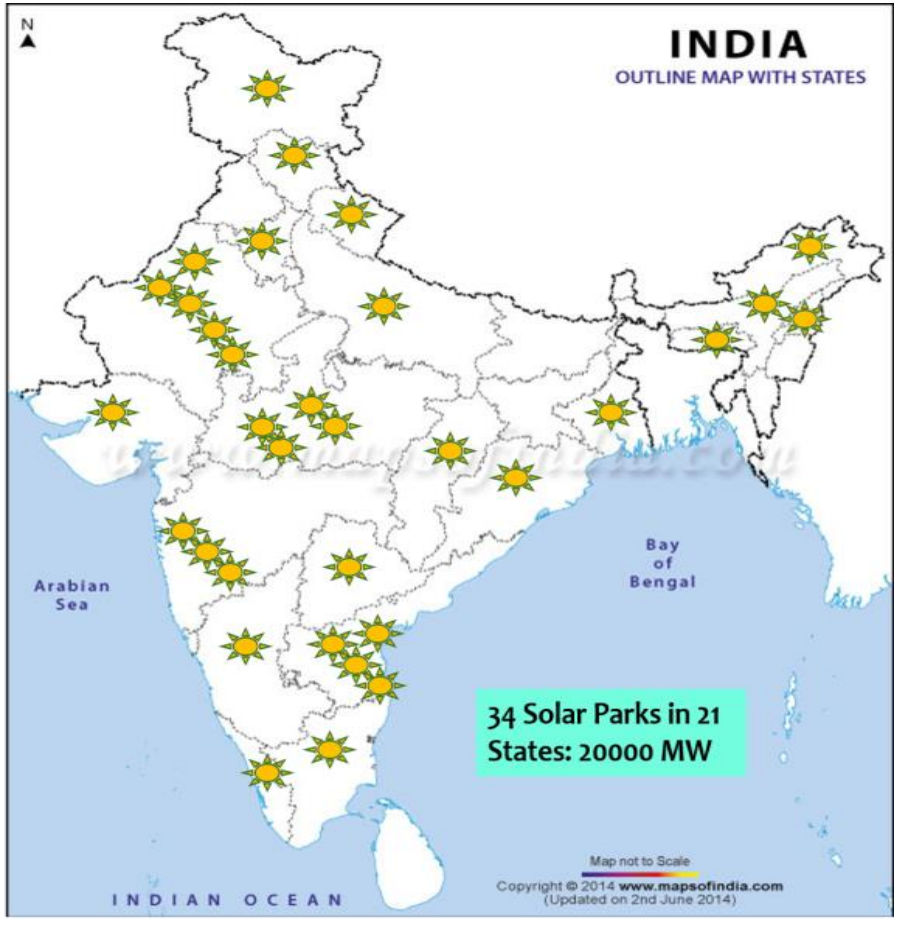
Dynamic Compensation



- **Facilitating Renewable Integration**
- **Maintaining Grid Parameters**
- **14 No. of Hybrid STATCOMs**
- **(Typical size ±300 MVAR+ 1x125 MVAR MSC + 125 MCR)**
  - 1 no. existing at NP Kunta
- **4 No. of SVCs (Typical size +600/-400 MVAR) – 3 nos. existing**

Green Energy Corridors-II (Solar Parks)

Locations of Ultra Mega Solar parks



*** 5 States**

- Andhra Pradesh
- Madhya Pradesh
- Rajasthan
- Karnataka
- Gujarat

Evacuation System for Solar Parks

✓34 Solar Parks in 21 states (20 GW)

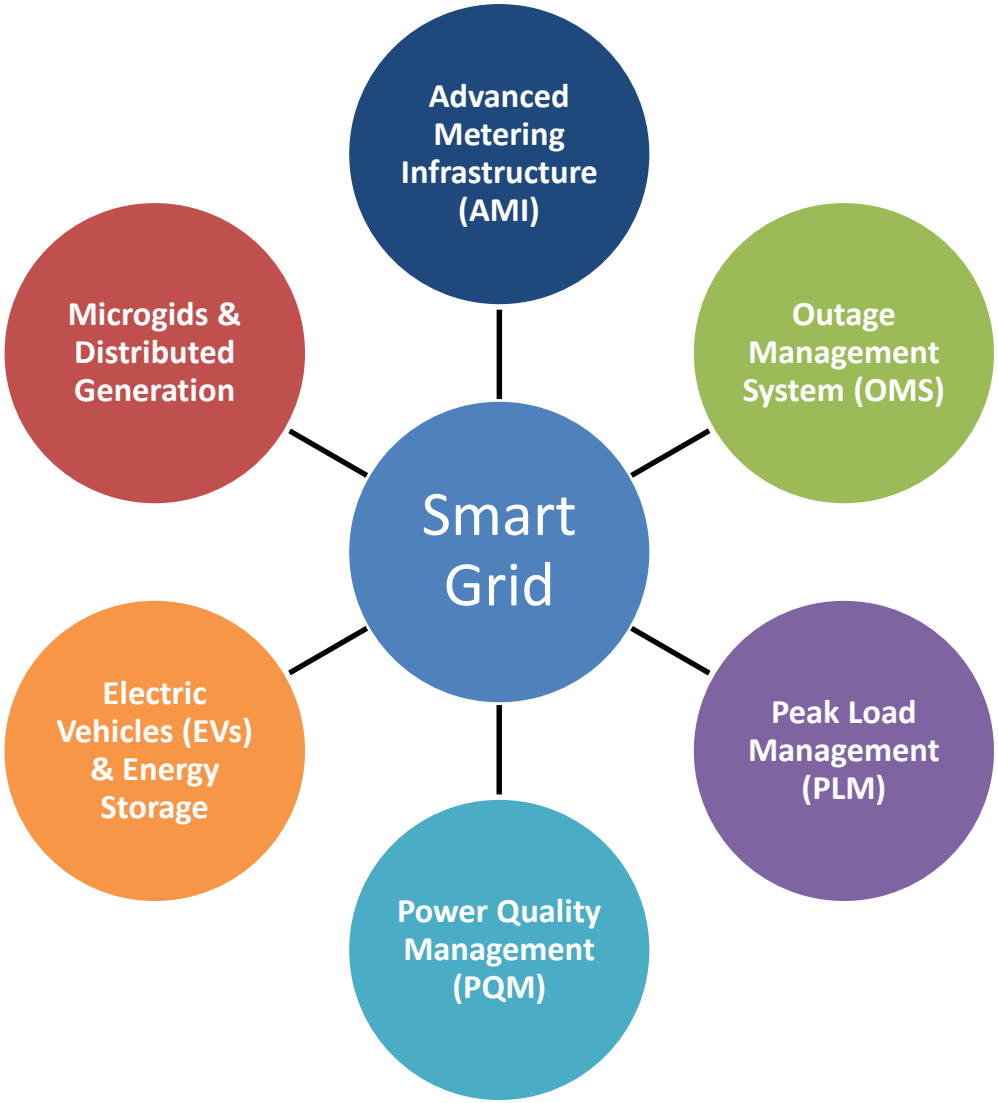
✓Evacuation System for Solar Parks of over 20,000 MW under Implementation

✓POWERGRID assigned to implement evacuation system for 8 Solar Parks in 5 States (*) (Estimated cost Rs 4300 Cr)

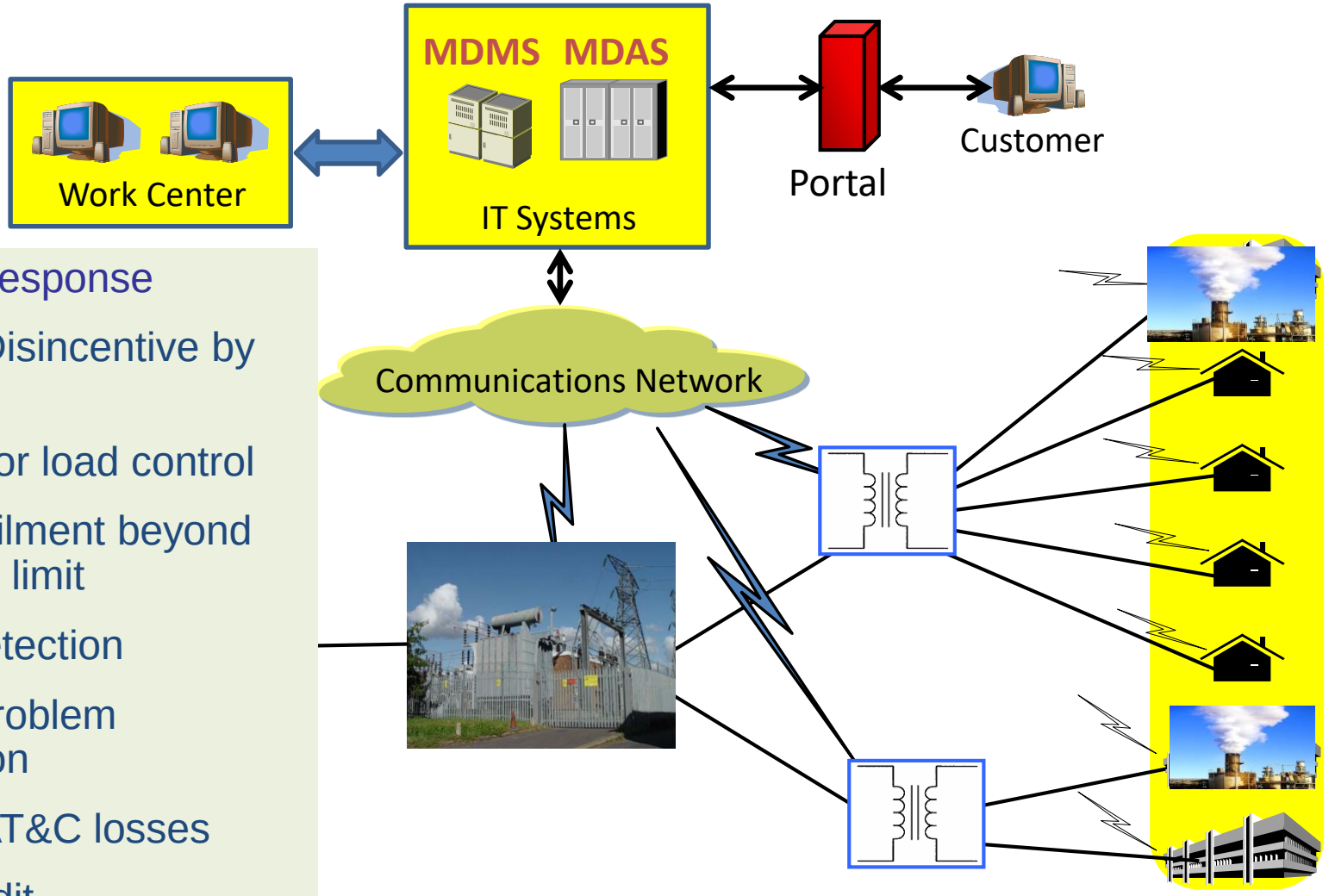
✓N.P Kunta (1500MW) Solar Park in District Anantpur, Andhra Pradesh, Ph-I commissioned

✓Transmission system for other solar parks being implemented

Distribution: Smart Grid



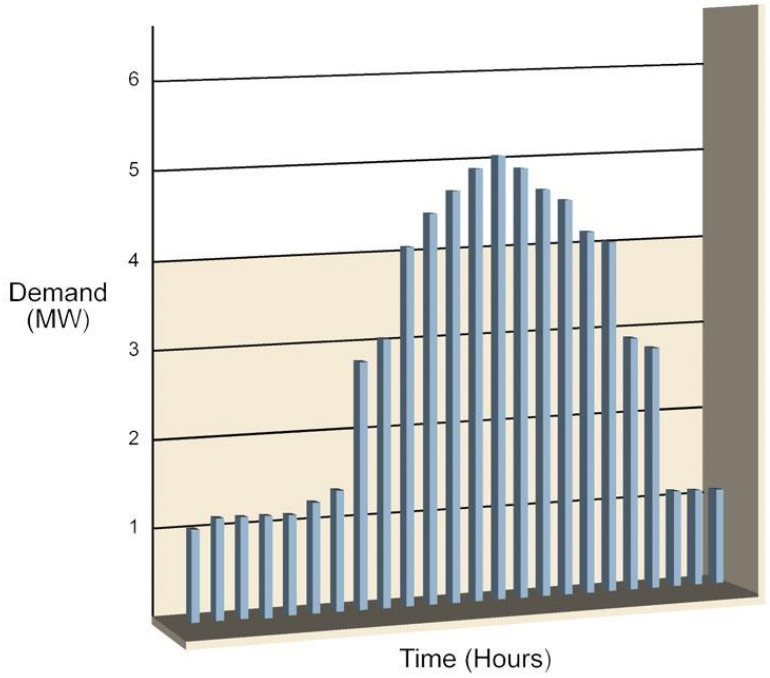
Advanced Metering Infrastructure

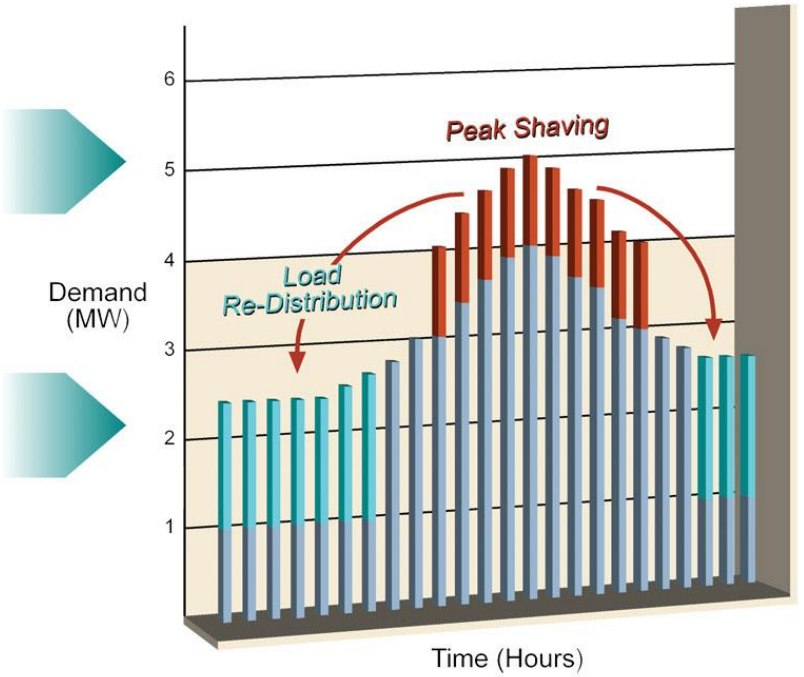


- Demand Response
- Incentive/Disincentive by TOU tariff
- Signaling for load control
- Load curtailment beyond sanctioned limit
- Tamper Detection
- Network Problem identification
- Reduced AT&C losses
- Energy Audit
- Billing Efficiency

Meter Data Management System

Peak Load Management



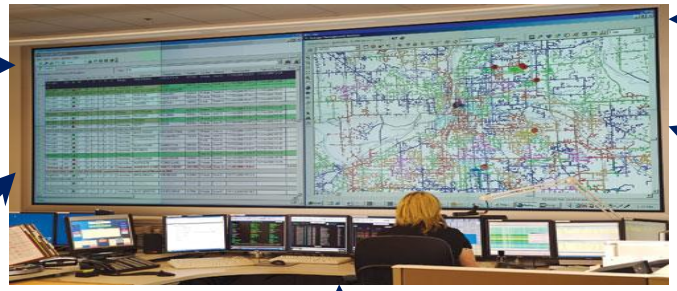


Demand Response

Demand Side Management

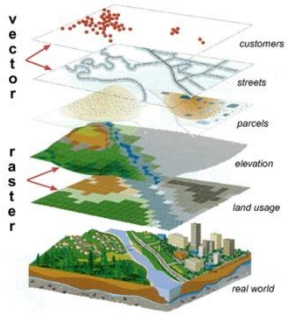
Outage Management System

AMI

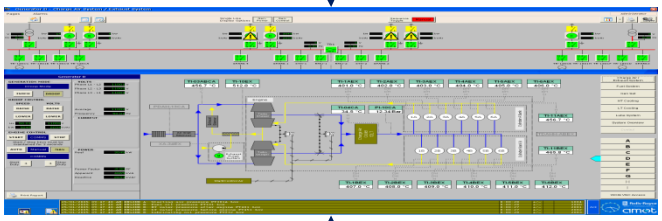


Maintenance Crew

IVR



GIS



SCADA

CIS

RTU

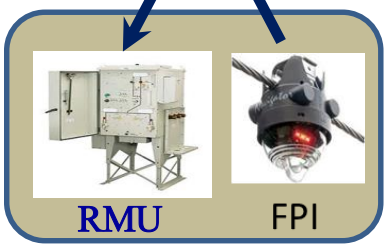
Communication System

DTMU

Communication Gateway

FRTU

O/H FPI

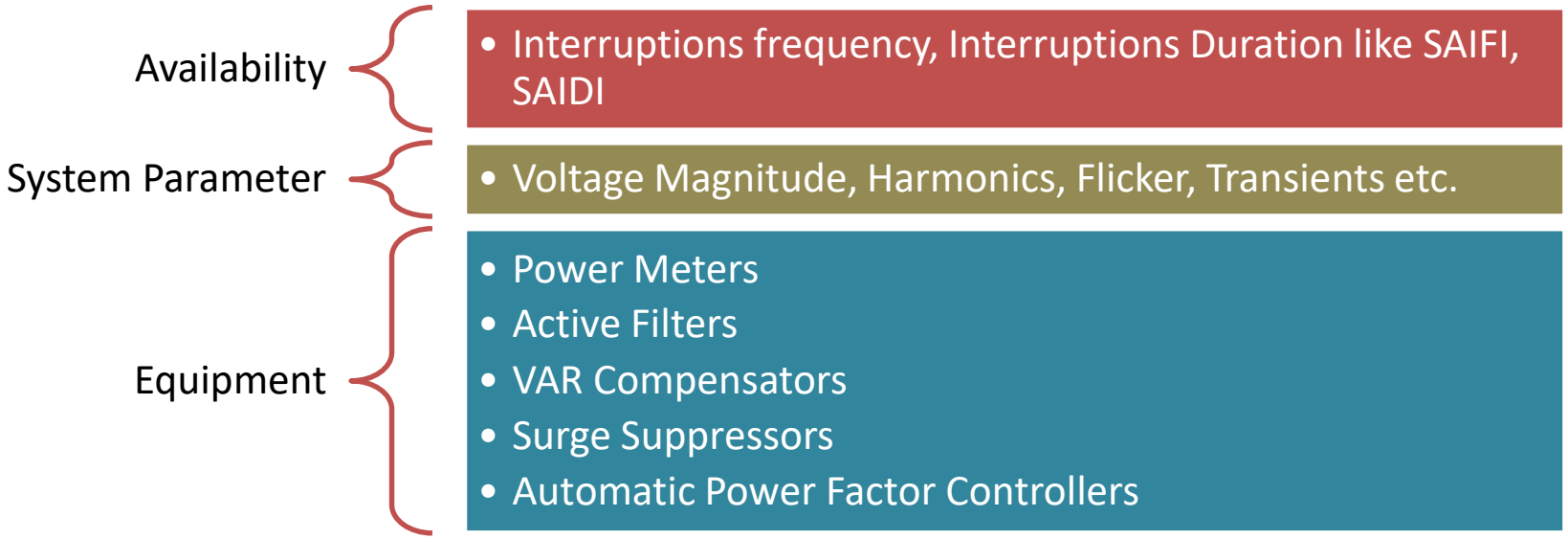


Load breaking switches

Distribution Transformer

CT

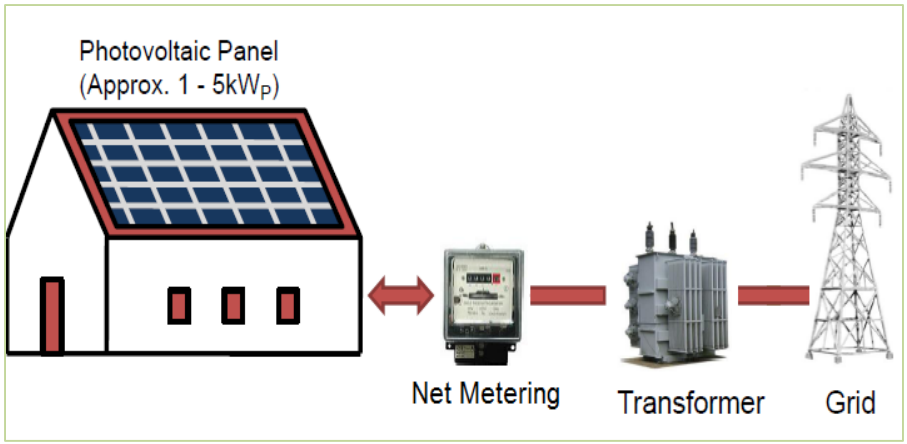
Power Quality Management



Key benefits of PQM are:

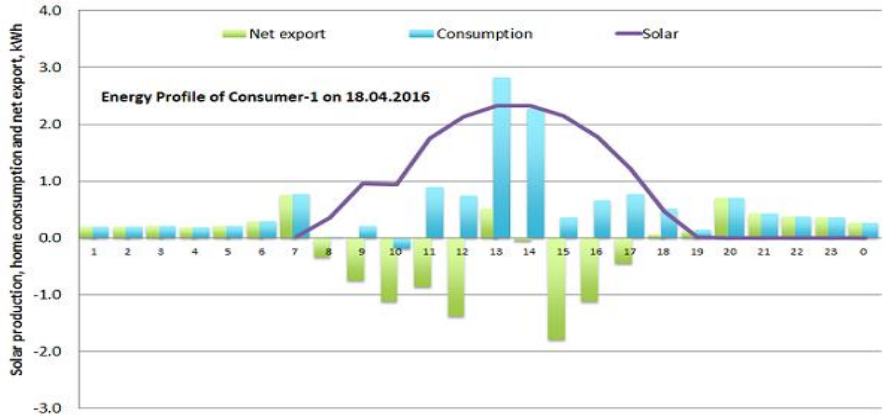
- Reduction in Technical Losses
- Increase in Life of the equipment
- Optimal utilization of the infrastructure
- Improvement in Power Quality

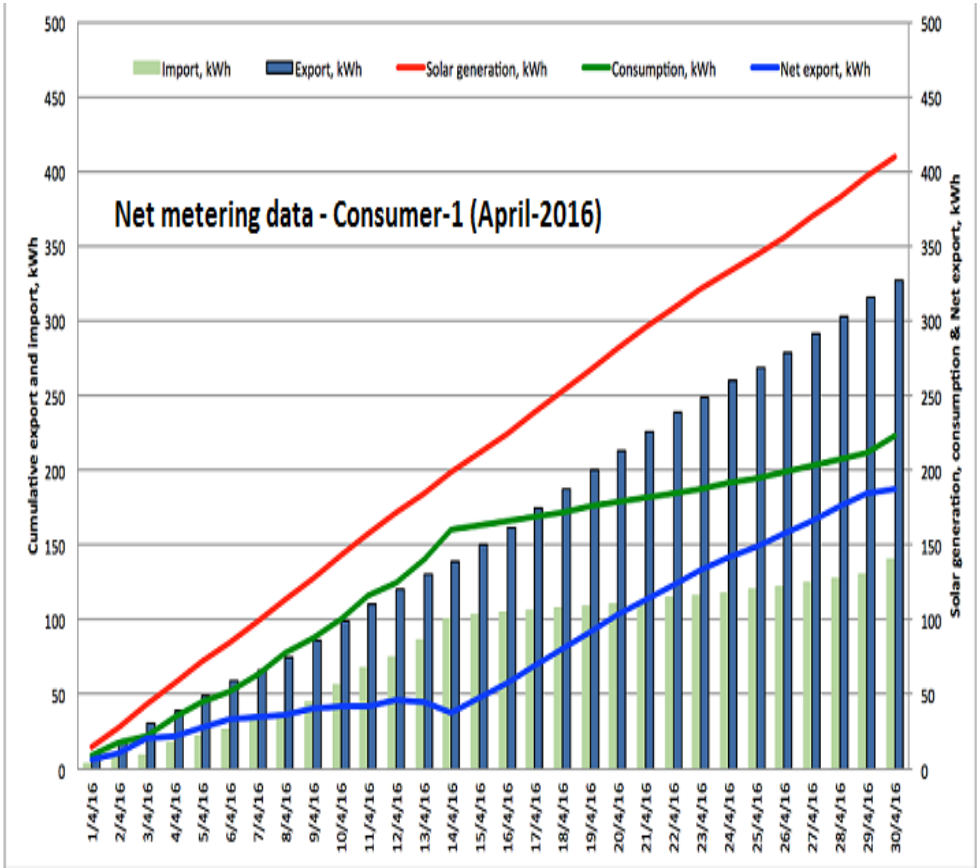
Distributed Generation: Net-Metering



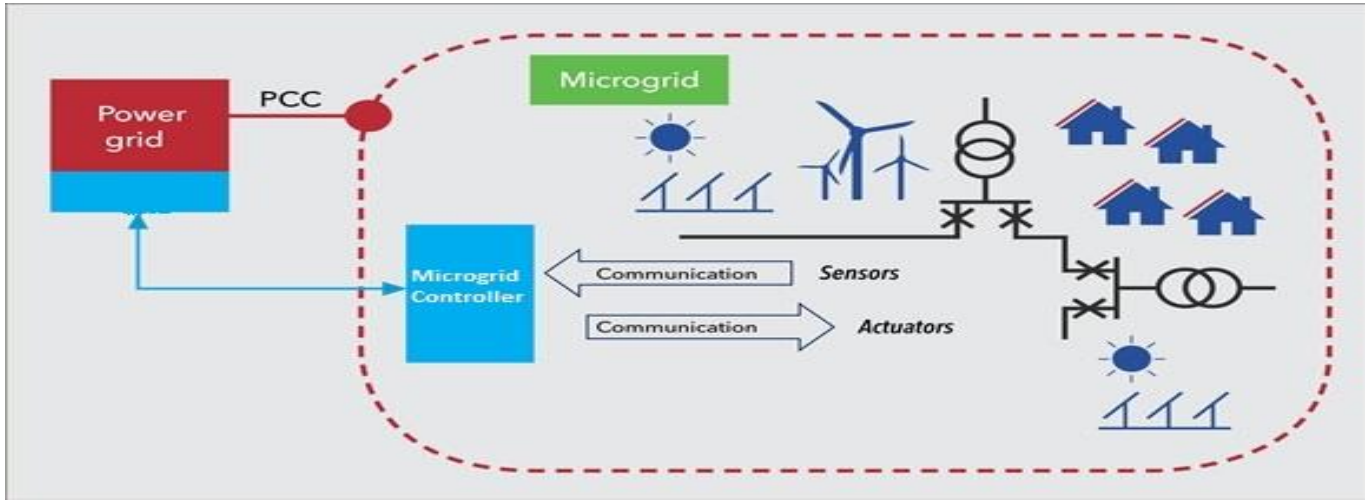
"Net Metering: Records the net consumption over a billing cycle (Import Energy – Export Energy)"

Energy Exchange for typical year (kWh)	Consumer-1 3 kWp	Consumer-2 2.4 kWp
Total Import from Grid	6419	16063
Total Export to Grid	8651	4808
Net Energy Exchange with Grid	-2232	11255





Micro Grid



Remote area electrification through renewables

Deferment of investments in bulk transmission and distribution network

Improves energy efficiency

Reduction of energy losses in the network

Supports the central grid like a controllable load

Improves reliability

Saves from the mass outage or black out

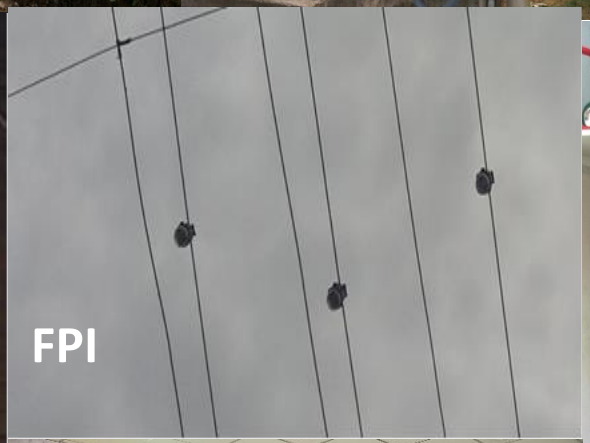
Puducherry Smart Grid Pilot Project

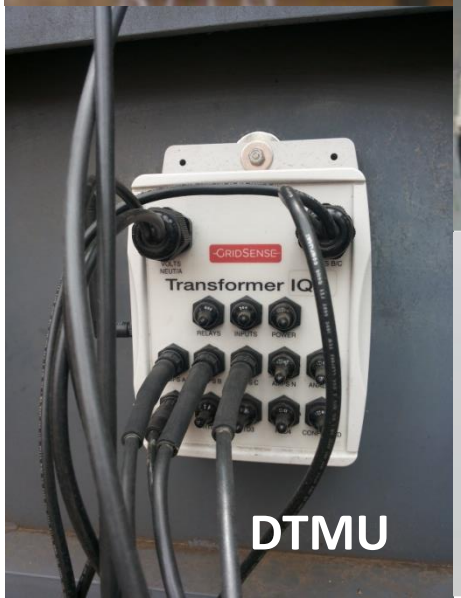
Smart Grid Pilot Project implemented by POWERGRID jointly with PED and in collaboration with other organizations

Attributes Implemented:

- ✓ Advanced Metering Infrastructure (AMI)
- ✓ Peak Load Management (PLM) including Demand Side Management, Demand Response
- ✓ Outage Management System (OMS)
- ✓ Renewable Energy integration with net metering
- ✓ Power Quality Management (PQM)
- ✓ Micro grid
- ✓ Energy Storage & Electric Vehicle with solar charging station
- ✓ Street Light Automation

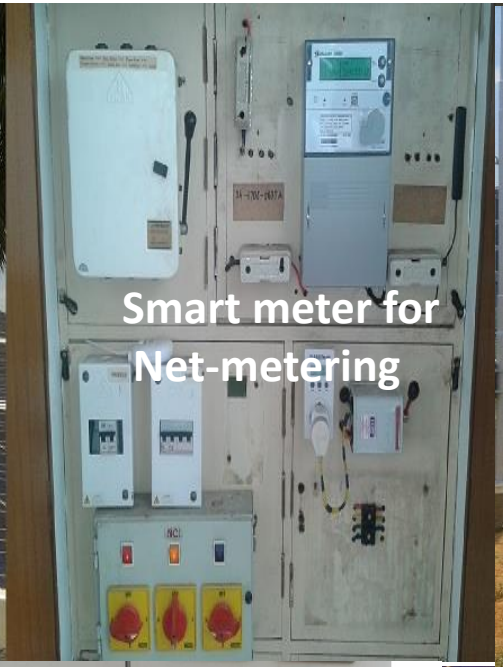
Snapshot of Installations-AMI, OMS, SGCC

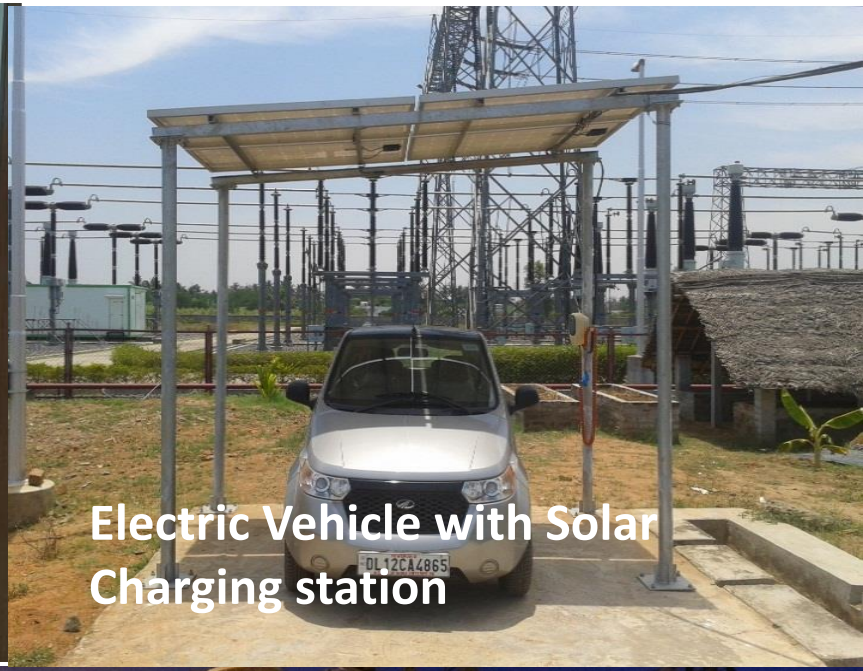




Snapshot of Installations-PQM, Integration of RE, Electric Vehicle


Roof top Solar


Smart meter for Net-metering

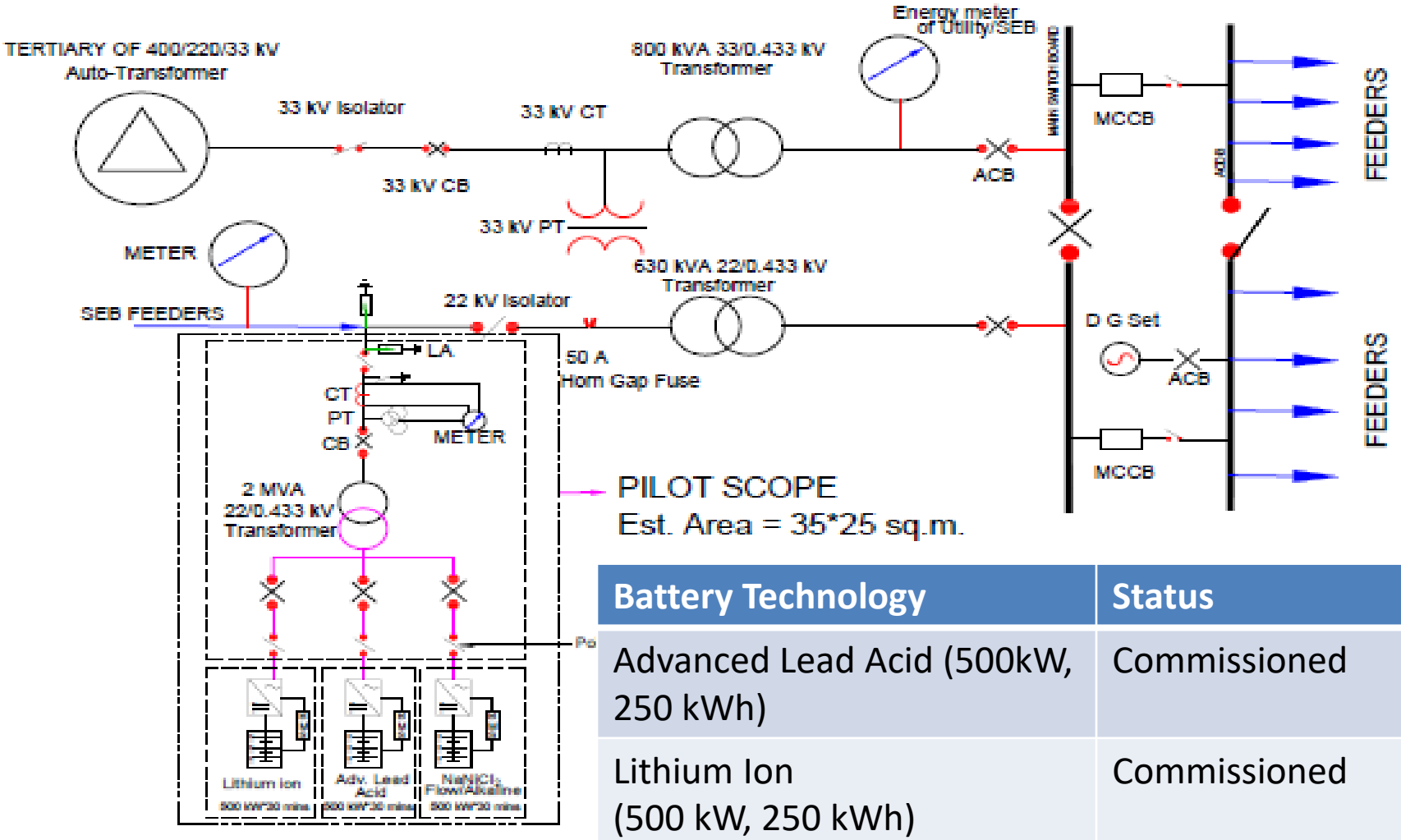

Electric Vehicle with Solar Charging station


APFC

Active Filter

Transformer online monitoring

POWERGRID's Pilot Project for Battery Energy Storage System



Battery Technology	Status
Advanced Lead Acid (500kW, 250 kWh)	Commissioned
Lithium Ion (500 kW, 250 kWh)	Commissioned
Flow (250 kW, 1000 kWh)	Under Implementation

Controllers for Battery Energy Storage

- Energy Time Shifting
- Frequency Regulation
- RE Firming
- Load Following
- Voltage Support
- Peak Shaving


पावर ग्रिड कारपोरेशन ऑफ़ इंडिया लिमिटेड
पुदुच्चेरी
Power Grid Corporation Of India Ltd
Puducherry
प्रायोगिक परियोजना
Pilot Project
बैटरी ऊर्जा भंडारण प्रणाली
Battery Energy Storage System

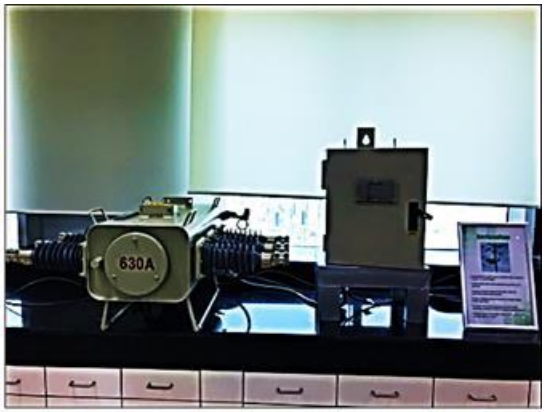

Narada
Exicom
litlium-ion battery Energy Storage System
पावरग्रिड


Narada
Exicom
Advanced lead Acid Battery Energy Storage System


Narada
Exicom
Storage Capacity: 250kWh
Rated Power: 500KW


Narada
Narada
Narada

Smart Grid Knowledge Centre



Smart Grid Consultancy being provided by POWERGRID

S. No.	Area	Utility	Attributes
1	Kala Amb, Himachal Pradesh	HPSEBL	AMI, PLM, OMS (RF & GPRS)
2	Agartala, Tripura	TSECL	AMI, PLM (PLC)
3	Siliguri, West Bengal	WBSEDCL	AMI, PLM (RF)
4	Mysore, Karnataka	CESC	AMI, PLM, SCADA, OMS, Agri DSM (RF)
5	Panipat, Haryana	UHBVN	Communication System for AMI (RF, GPRS, PLC)
6	Gurgaon, Haryana	DHBVN	Distribution Infra
7	Naroda, Gujarat	UGVCL	AMI, PLM (RF)
8	Puducherry	PED	AMI, PLM (RF)


Thank you!

Synchro-phasor Technology

- **With Phasor technology and Phasor Measurements Units (PMU), we have:**
  - –Power System measured states (VIf & Angle) and not estimates
  - –Dynamic system conditions via High Resolution Data (25 – 50 samples/sec)
  - –Ability to compare regions due to Time Synchronized data

- **Technology provides high resolution, time synchronized data, useful for calculation and monitoring, e.g.:**
  - –% damping (inter-area and local area oscillations)
  - –Measured sensitivities, such as $\Delta V/\Delta P$, $\Delta\delta/\Delta P$
  - –Angle Difference
  - –Transmission capability

Other Smart Grid Functionalities

- **Hybrid Network Development**
  - Comprehensive EHVAC & HVDC System for flexible operation & grid stability
- **Dynamic Compensation**
  - Installation of SVC, STATCOM
- **Digital Substation & Substation Automation**
  - Improved Reliability, Reduction in O&M Cost & Fast Restoration
  - Substation Automation
- **Remote Operation & Monitoring**
  - Leading to virtual manning of substations
  - Better Coordinated Operation

Other Smart Grid Functionalities …

- **Intelligent Asset Management- Reduced outages**
  - Thermal Image Sensing (Thermo-vision scanning)
  - Hot-line maintenance
  - On-line monitoring
  - Predictive Maintenance
- **Grid Connected Battery Energy Storage System for Frequency Regulation and Energy Time shift**