Smart Grid – Issues and Prospects for India

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WHAT IS SMART GRID

- Smart Grid has got many meanings;
- However, to put it simply it means a grid which increases the robustness, efficiency and flexibility of the power system.
- It is also sometimes called a “self healing grid”.

What does the smart grid achieve ?

- Solves grid problems by itself.
- Informs the System Operator in advance of an impending grid instability/disturbance.
- Optimum utilization of power system assets so as to minimize the cost to consumers.
- Takes care of unpredictable nature of wind and solar energy resources.

SMART GRID

A **smart grid** is a digitally enabled **electrical grid** that gathers, distributes, and acts on information about the behaviour of all participants (suppliers and consumers) in order to improve the efficiency, reliability, economics, and sustainability of electricity services

The Need

- Perennial shortages dogging the country.
- Promoting the smart grid in India for efficient utilization of the generation, transmission and distribution resources of the country.
- Promoting use of renewable sources of energy, to reduce dependability on fossil fuels.
- Reduction of technical losses.
- Prevention of theft of electricity.

ENABLING PROVISIONS IN THE EA 2003

- Section 61 under **Tariff Regulations** : "The Appropriate Commission shall, subject to the provisions of this Act, specify the **terms and conditions for the determination of tariff**, and in doing so, shall be guided by the following, namely:-
- …..
- **the factors which would encourage competition, efficiency, economical use of the resources, good performance and optimum investments**;"
- ……..
- Section 79 under **Functions of the CERC** : "**to specify and enforce the standards with respect to quality, continuity and reliability of service by licensees**"

Policy Level Initiatives

INDIA SMART GRID FORUM AND INDIA SMART GRID TASK FORCE

- India Smart Grid Forum and India Smart Grid Task Force launched by the Hon'ble Minister of Power in May, 2010.

- To accelerate implementation of Smart Grids in India in alignment with the Ministry of Power's overarching policy objectives of **"Access, Availability and Affordability of power for all"**

INDIA SMART GRID FORUM AND INDIA SMART GRID TASK FORCE

- ***India Smart Grid Forum*** is a non-profit voluntary consortium of public and private stakeholders with the prime objective of accelerating development of Smart Grid technologies in the Indian Power Sector

- ***India Smart Grid Task Force*** is an inter-ministerial group and will serve as Government's focal point for activities related to "Smart Grid"

INDIA SMART GRID TASK FORCE

- **Chairman** - **Sh. Sam Pitroda (Advisor to the PM on Public Information Infrastructure and Innovation)**
- **Convener -** **Sh. B. N. Sharma, JS, MOP**
- The Main functions of ISGTF pertaining to Smart Grid are:
  - To ensure awareness, coordination and integration of diverse activities related to Smart Grid Technologies.
  - Practices & services for research & development of SMART GRID.
  - Coordination and integrate other relevant inter governmental activities.
  - Collaborate on interoperability framework.
  - Review & validate recommendations from India Smart Grid Forum etc.

INDIA SMART GRID TASK FORCE

- Five Working groups have been constituted to take up the different task related to SMART GRID activities i.e.

  - WG1 – Trials/Pilot on new technologies.
  - WG2 – Loss reduction and theft, data gathering and analysis.
  - WG3 – Power to rural areas and reliability & quality of power to urban areas.
  - WG4 – Dist Generation & renewable.
  - WG5 – Physical cyber security, Standards and Spectrum.

INDIA SMART GRID FORUM

- The goal of the Forum is to **help the Indian power sector to deploy Smart Grid technologies in an efficient, cost-effective, innovative and scalable manner** by bringing together all the key stakeholders and enabling technologies
- The India Smart Grid Forum will **coordinate and cooperate with relevant global and Indian bodies** to leverage global experience and standards where available or helpful, and will highlight any gaps in the same from an Indian perspective
- The Forum will operate in a hierarchical or layered structure with **different working groups focusing on different aspects of Smart Grid**

INDIA SMART GRID FORUM

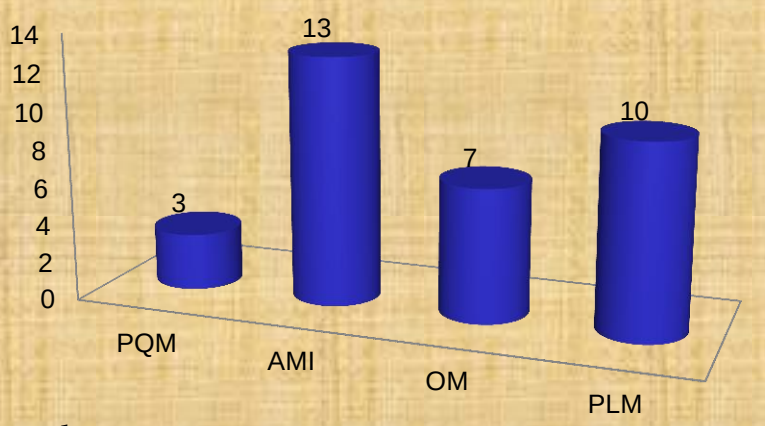
- Ten Working Groups dealing with the following were constituted:
  1. Advanced transmission
  2. Advanced distribution
  3. Communications for Smart Grid
  4. Metering including Interoperability standards
  5. Consumption & load control
  6. Policy and regulations
  7. Architecture & design incl. interoperability
  8. Pilots and business models
  9. Renewables and Microgrids
  10. Cyber Security

SOME OF THE STEPS TAKEN BY GoI

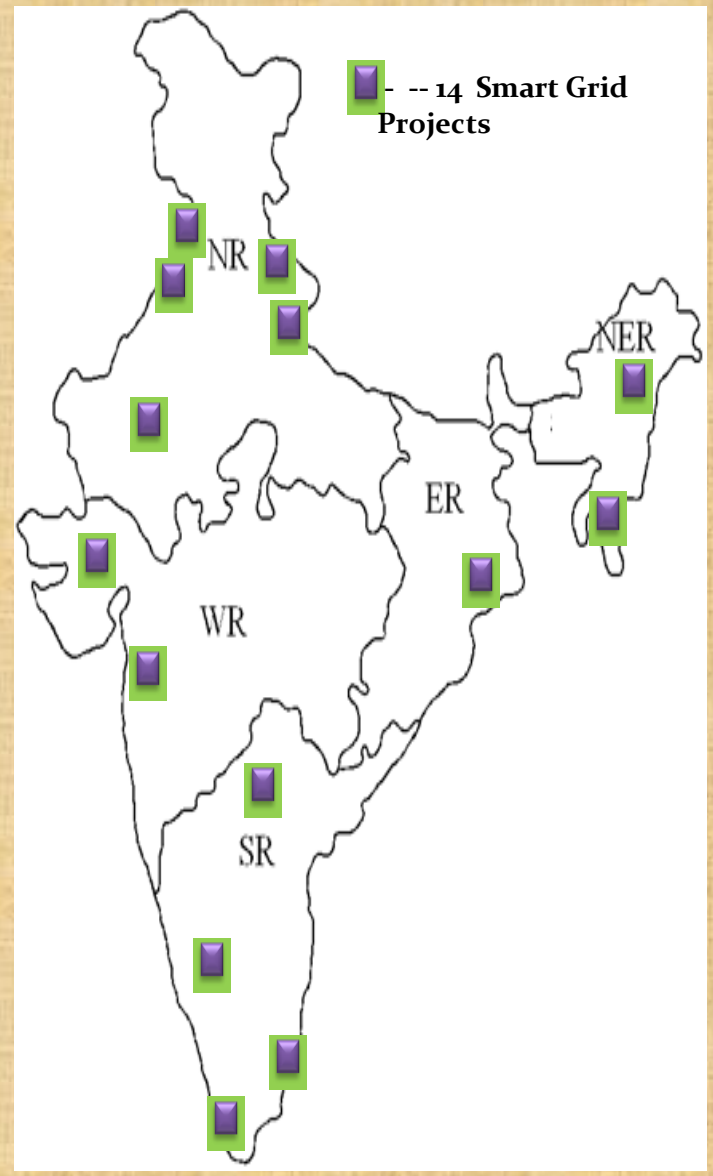
- Launch of the India Smart Grid Knowledge Portal in Jan 2013
- Sh. Kapil Sibal released the IPv6 Roadmap version 2 on 26th March 2013. Power and Banking are the two chosen sectors for implementing IPv6 on fastrack
- Approval of 14 smart grid pilot projects by the India Smart Grid Task Force in 14 States in June 2013 (CESC, Mysore and UGVCL, Gujarat have recently released Smart Grid Pilot Project RfP)
- A committee was constituted by Ministry of Power, under Chairperson, CEA to review Functional Specifications of Low Cost Single Phase Smart Meters and its report was released on 12th June 2013
- Power Minister, Sh. Jyotiraditya Scindia released Smart Grid Vision and Roadmap for the country at the Power Ministers Conclave on Sep 10th 2013

SMART GRID PILOT PROJECT PROGRAM IN INDIA

- GoI had kept Rs. 200 crores for 20 Smart Grid Pilot Projects in India, for ***public*** distribution utilities, with matching contribution from the State utility
- Most of the 14 Projects selected involve installation of Smart meters for the purpose of reduction in distribution losses.
- Functionalities covered under these projects are:



PQM- Power quality management
AMI- Advanced metering infrastructure
OMS- Outage Management System
PLM- Peak load management



SMART GRID ROADMAP: DISTRIBUTION

Objectives: ***In order to achieve the Smart Grid vision, stakeholders will undertake (across all sectors):***

1. Appropriate policies and programs to provide access for electricity for all
   - Uninterrupted life line supply (8 hours/day minimum) by 2015
   - Electrification of 100% households by 2017
   - 24x7 quality supply on demand to all citizens by 2027

2. Integrated technology trials through a set of smart grid pilot projects by 2015
   - Based on outcome of the pilots, full rollout of smart grids in pilot project areas by 2017; in major urban areas by 2022 and nationwide by 2027

3. Completion of existing complementary or building block projects such as R-APDRP
   - Planning for integration of such systems into future smart grid deployments

4. Availability of an indigenous low cost smart meter by 2014

   AMI *roll out* for all customers in a phased manner based on size of connection (and geography and utility business case)

   - Starting with consumers with load >20 KW by 2017, 3-phase connections by 2022 and all consumers by 2027
   - Development of innovative and sustainable financing/business models for smart meter roll outs

5. Working with other stakeholders, building of National Optical Fibre Network by connecting all the 2,50,000 Gram Panchayats in the country by Optical Fibre Cable and including the telecom link at the nearest 33/11 kV substation to support smart grid in distribution by 2017

6. Enabling programs and projects in distribution utilities to reduce AT&C losses
   - Below 15% by 2017, below 12% by 2022, and below 10% by 2027

7. Conversion of existing EHV sub stations in all urban areas and sub transmission and medium voltage substations in metro cities to advanced (such as) Gas Insulated Substations (GIS) in a phased manner through innovative financing models

SMART GRID ROADMAP: DISTRIBUTION (CONT.)

8. 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, optimally use installed capacity and eliminate load shedding and black-outs

9. Push for mandated roof top solar power generation for large establishments with connected load >20kW

10. EV charging facilities should be created in all parking lots, institutional buildings, apartment blocks etc; and quick/fast charging facilities to be built in fuel stations and at strategic locations on highways

11. Microgrids in 1,000 villages/industrial parks/commercial hubs by 2017 and 10,000 villages/industrial parks/commercial hubs by 2022
    - Can island from main grids during peak hours

12. Optimally balancing different sources of generation through efficient scheduling and dispatch of distributed energy resources (including captive plants in the near term) with the goal of long term energy sustainability

13. Improvement in power quality and quantum across the board

SMART GRID ROADMAP: TRANSMISSION

1. Development of a reliable, secure and resilient grid supported by a strong communication infrastructure that enables greater visibility and control of efficient power flow between all sources of production and consumption by 2027
2. Implementation of Wide Area Monitoring System (WAMS, using Phasor Measurement Units, or PMUs) for the entire transmission system
   - Installation of a larger number of PMUs on the transmission network by 2017 or sooner, as guided by the results of initial deployments
   - Indigenization of WAMS technology and PMU development and development of custom made analytics for synchrophasor data by 2017
3. Setting up of Renewable Energy Monitoring Centres (REMCs) and Energy Storage Systems to facilitate grid integration of renewable generation
4. Installation of 50,000 km of optical fibre ground wire (OPGW) over transmission lines by the year 2017 to support implementation of smart grid technologies
5. Enabling programs and projects in transmission utilities to reduce transmission losses to below 3.5% by 2017 and below 2.5% by 2022
6. Implement power system enhancements to facilitate evacuation and integration of 30 GW renewable capacity by 2017, 80 GW by 2022, and 130 GW by 2027, or as mutually agreed between MoP and MNRE

SMART GRID ROADMAP: POLICY, STANDARDS AND REGULATIONS

1. Formulation of effective customer outreach and communication programs

2. Development of state/utility specific strategic roadmap(s) by 2014 for Smart Grid deployments
3. Required business process reengineering, change management and capacity building programs to be initiated by 2014

4. Policies for grid-interconnection of consumer generation facilities (including renewable) where feasible
5. Policies for roof-top solar, net-metering/feed-in tariff as well as peaking power by 2014

6. Policies supporting improved tariffs such as dynamic tariffs, variable tariffs, etc., including demand response programs
7. Bulk consumers by 2014; extending to all 3-phase (or otherwise defined) consumers by 2017

8. Policies created by 2014 for implementing energy efficiency in public infrastructure and EV charging facilities starting by 2015 and Demand Response ready appliances by 2017

9. Finalization of frameworks for cyber security assessment, audit and certification of utilities by 2013

10. Development of business models to create alternate revenue streams by leveraging the Smart Grid infrastructure to offer other services (security solutions, water metering, traffic solutions etc) to municipalities, state governments and other agencies

11. Build upon the results of smart grid pilot projects and recommend appropriate changes conducive to smart grid development in Acts/Plans/etc. by end of 2015

12. Development of 1st set of Indian Smart Grid Standards by 2014

13. Active involvement of Indian experts in international SG development bodies

SMART GRID ROADMAP: OTHER INITIATIVES

1. Tariff mechanisms, new energy products, energy options and programs to encourage participation of customers in the energy markets that make them "***prosumers***" – producers and consumers – by 2017

2. Create an effective information exchange platform that can be shared by all market participants, including prosumers, in real time which will lead to the development of new and enhanced energy markets

3. Investment in research and development, training and capacity building programs for creation of adequate resource pools for developing and implementing smart grid technologies in India
   - Can also become a global leader and exporter of smart grid know-how, products and services

SMART GRIDS – NEED FOR A ROADMAP

- A transparent roadmap on future policies and programs will help capacity building by all stakeholders - utilities and the industry - so that projects can be implemented without time or cost overruns
- Smart Grids span multiple functionalities and options – each utility could be different based on legacy, priorities, business case, etc
  - There isn't (*and cannot be*) a Systems Requirement Specification (SRS) Template like that of R-APDRP for Smart Grids
  - Need flexibility and dedicated specialized manpower to handle the diverse, complex, and evolving needs of technology, standards, policy, regulations, innovation, etc
- Smart Grids are more a process than a product – cannot buy a standard package off-the-shelf

The suggested Roadmap will be an evolving policy document that will give a clear direction to state governments, regulators, utilities and industry

SMART GRID ROADMAP – NEXT STEPS

Phase I: Strengthen the existing institutional mechanisms for Smart Grid **(immediate)**

- ISGTF presently has a small secretariat with 3 people on deputation from PowerGrid, functioning from PowerGrid's Gurgaon offices; their costs are reimbursed from R-APDRP
- Urgent need to strengthen ISGTF Secretariat with 8-10 smart grid experts inducted from different streams
- Secretariat may be moved to Central Board of Irrigation and Power (CBIP) in Chanakyapuri which will facilitate better coordination with MoP and ISGF

Phase II: Begin a Ministry of Power level Smart Grid Mission **(within 3 months)**

- The strengthened ISGTF Secretariat could prepare a blueprint for taking MoP's Smart Grid Mission to a National Smart Grid Mission
  - The blueprint would cover details relating to specific programs and projects in different utilities in each state and estimate the capital outlays for such programs and projects and its timelines
  - All stakeholders may be consulted in preparing the same. They would also lead to smart grids standards development and build technically feasible and economically sustainable business models relevant to the Indian context
  - Such an initiative at MoP level will accord higher institutional authority and budgetary support for ISGTF as well as demonstrate MoP's commitment for a national mission which will help harnessing support from other stakeholders

P*hase III: National Smart Grid Mission* **(early 2014)**

- Launch an independent national mission with its own resources and funding mechanism that will bring national level support from other Ministries, Departments, and the States after drawing wider consensus on needs, targets, and delivery mechanisms

Regulatory Initiatives

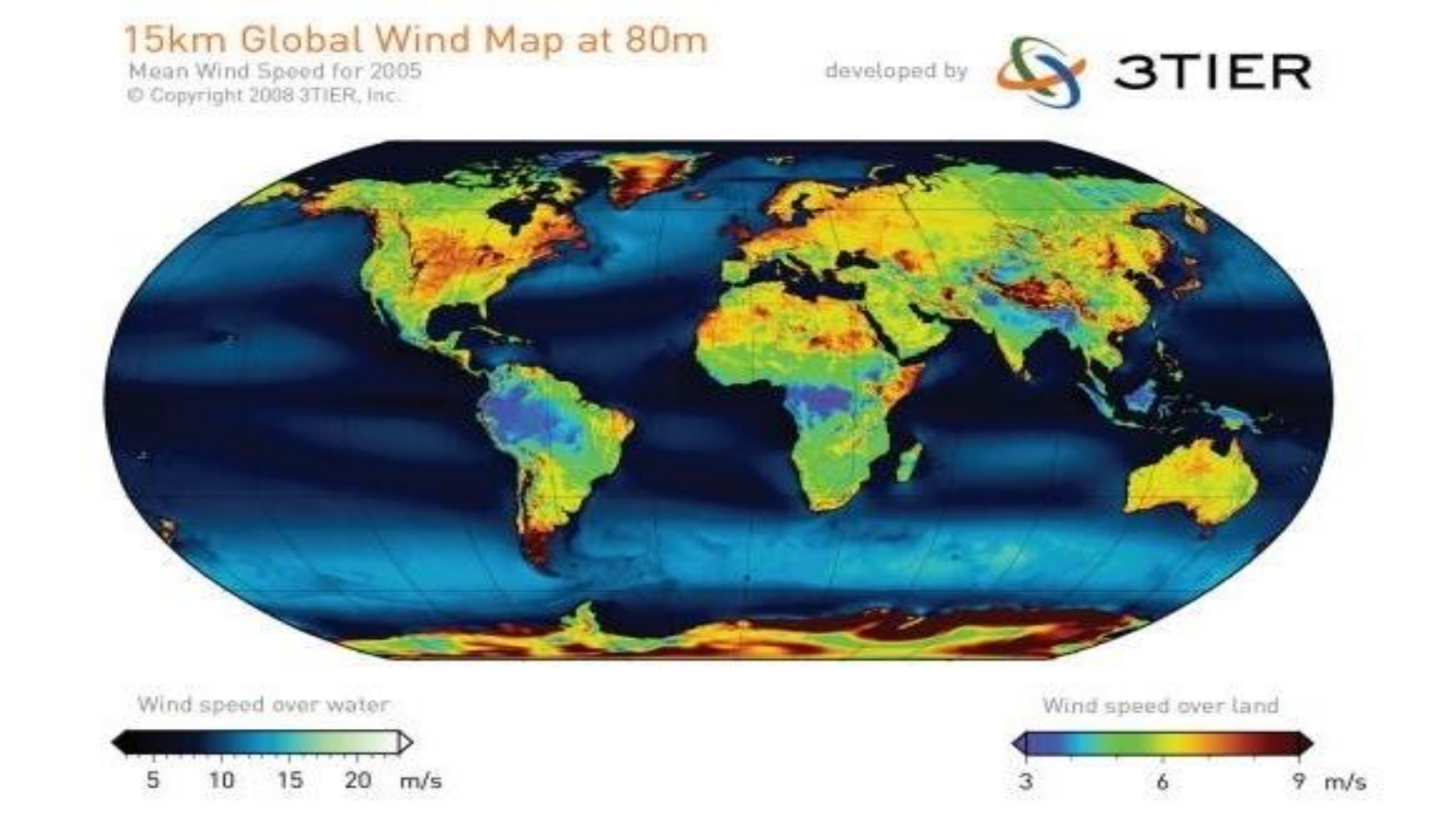
SOME STEPS TAKEN BY THE CERC

- Restricted Free Governor Mode of Operation
- **Integration of renewable energy sources into the grid**
- Automatic demand management
- Wide area measurement systems (WAMS)
- Special protection schemes
- Taking up a pilot project in Mumbai(through Forum of Regulators)

SOME BRIEF FACTS ON WIND GENERATION GROWTH

- Wind generation capacity grew worldwide @ 19% in the year 2012
- Several countries have achieved relatively high levels of wind power penetration, such as 21% of electricity production in Denmark, 18% in Portugal, 16% in Spain, 14% in Ireland and 9% in Germany in 2010

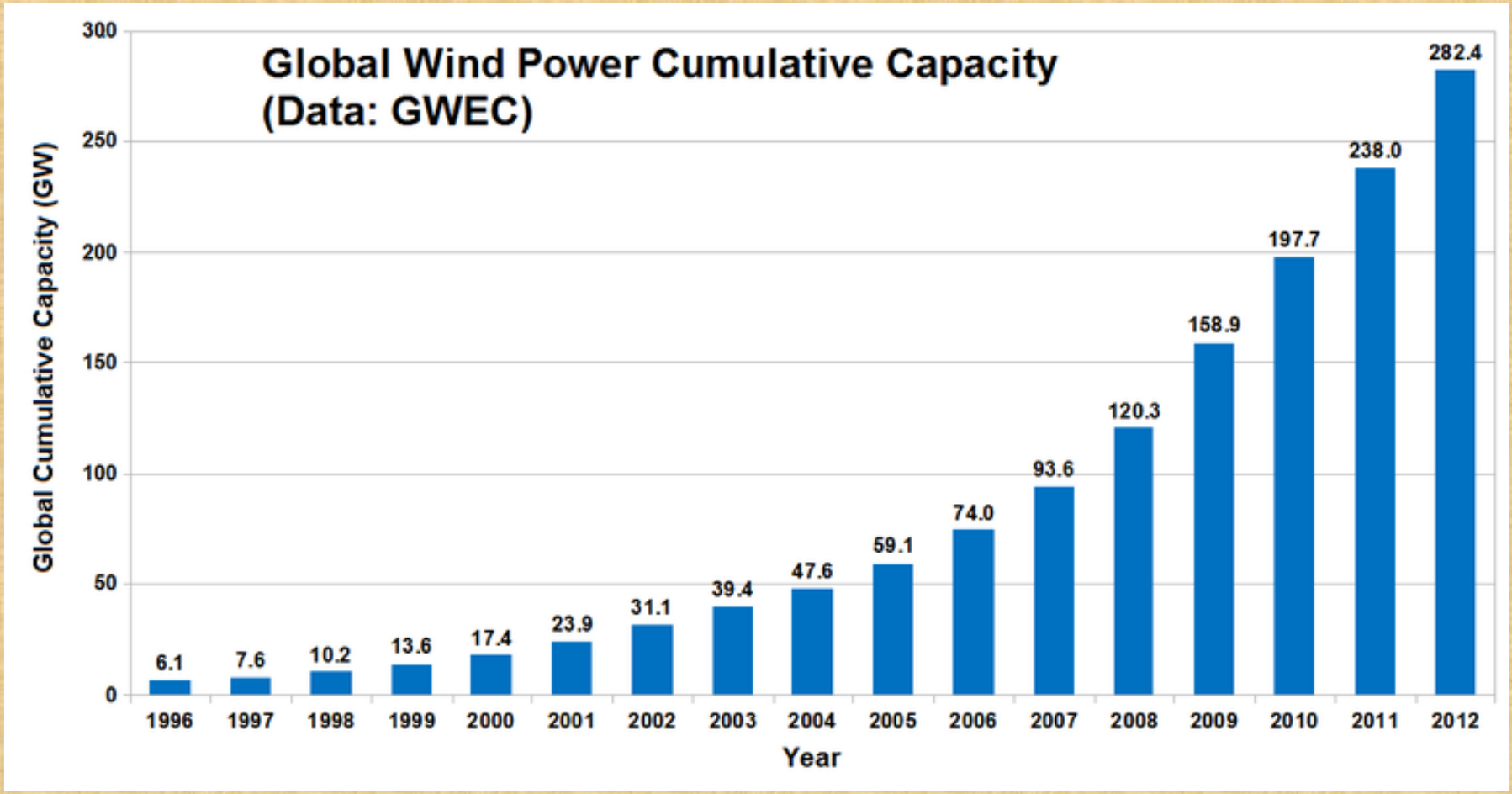
GLOBAL WIND MAP



TOP 10 WIND POWER COUNTRIES AT THE END OF 2012 (MW)

China	75,564
United States	60,007
Germany	31,332
Spain	22,796
India	19,051
United Kingdom	8,445
Italy	8,144
France	7,196
Canada	6,200
Portugal	4,525
Total	**282,482**

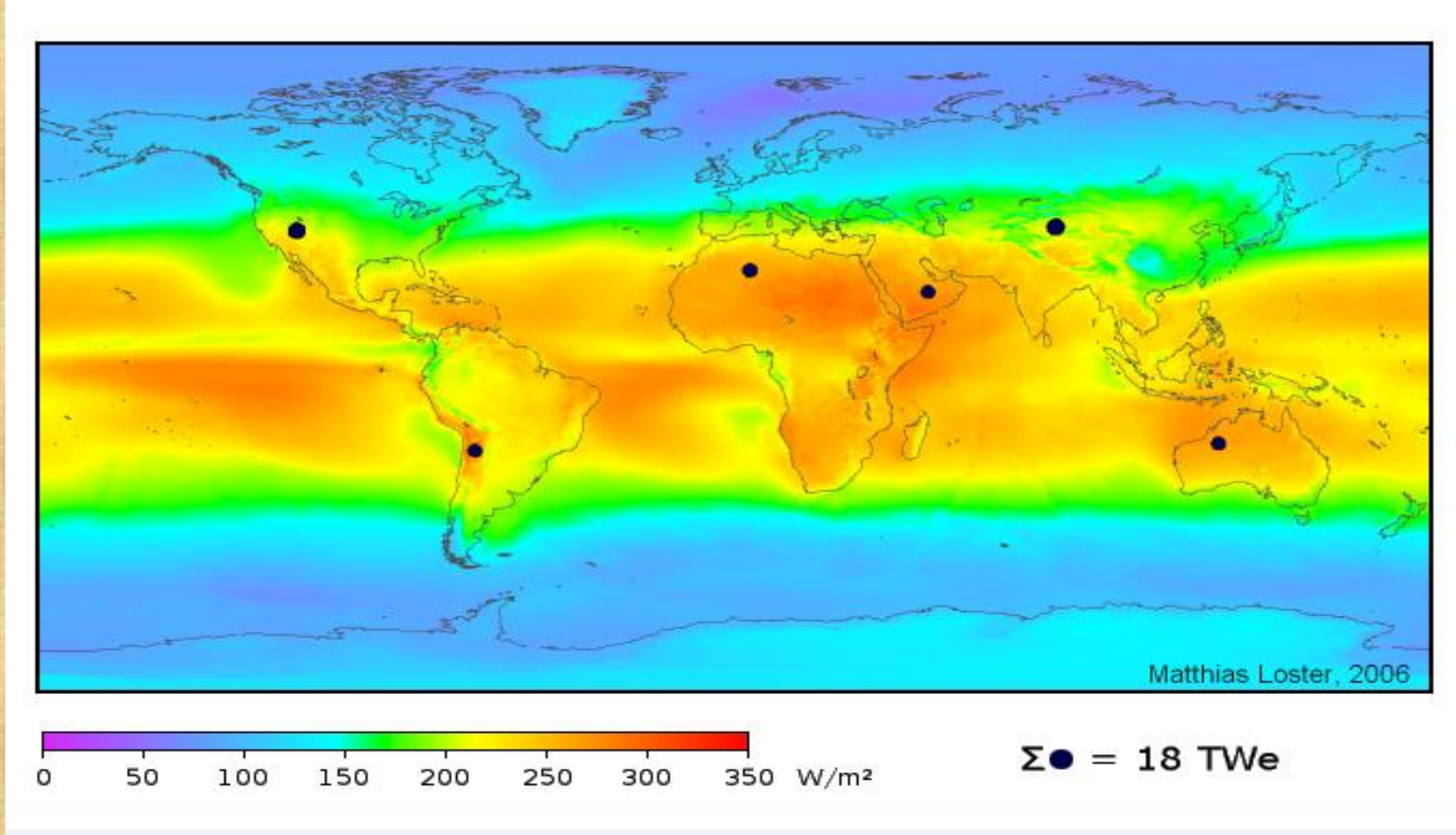
GLOBAL WIND POWER CUMULATIVE CAPACITY



HIGHEST SOLAR PV PEAK POWER CAPACITY (MW) (DEC. 2012)

Germany	32,509
Italy	16,987
China	8,043
United States	7,665
Japan	6,704
Spain	4,214
France	3,843
Belgium	2,018
Australia	2,291
Czech Republic	1,960
United Kingdom	1,831
India	1,686
Total	**1,02,024**

AVERAGE SOLAR INSOLATION SPREAD ON EARTH



AVERAGE SOLAR INSOLATION SPREAD ON EARTH

- Figure shows average insolation, showing land area (small black dots) required to replace the world primary energy supply with solar electricity. 18 Tera Watts(1E12 watts) is 568 Exajoule (EJ)(1E18 joules) per year. Insolation for most people is from 150 to 300 W/m^2 or 3.5 to 7.0 $kWh/m^2/day$.

INTEGRATION OF RENEWABLE ENERGY SOURCES INTO THE GRID FOR L-G BALANCE (WIND)

- The wind generators shall be responsible for forecasting their generation upto an accuracy of 70%. Therefore, if the actual generation is beyond +/- 30% of the schedule, wind generator would have to bear the UI charges
- For actual generation within +/- 30% of the schedule, no UI would be payable/receivable by Generator, The host state , shall bear the UI charges for this variation, i.e within +/- 30%. However, the UI charges borne by the host State due to the wind generation, shall be shared among all the States of the country in the ratio of their peak demands in the previous month, in the form of a regulatory charge known as the Renewable Regulatory Charge

INTEGRATION OF RENEWABLE ENERGY SOURCES INTO THE GRID FOR L-G BALANCE.(SOLAR)

- In case of solar generation no UI shall be payable/ receivable by Generator. The host state , shall bear the UI charges for any deviation in actual generation from the schedule. However, the net UI charges borne by the host State due to the solar generation, shall be shared among all the States of the country in the ratio of their peak demands in the previous month based on the data published by CEA , in the form of regulatory charge known as the Renewable Regulatory Charge

RENEWABLE REGULATORY FUND (RRF) MECHANISM

- First envisaged in the IEGC to be operational from 1.1.2011
- Later postponed twice due to request from Indian Wind Energy Association
- Came into effect from 15.7.2013
- The provision for commercial implication has been put on hold up till the date of notification by the Commission, in its latest amendment dated 6.1.2014.

USA - FERC NEW RULEMAKING PROCESS TO ENCOURAGE INTEGRATION OF RENEWABLE ENERGY SOURCES FOR L-G BALANCE

- Issued on 1.12.2010
- Comments were due on 31.1.2011
- Three reforms proposed :
  - Scheduling on 15 minute basis
  - Forecasting
  - Ancillary service to be compulsorily purchased or self-supplied by the variable generation to balance generation output variability

WIDE AREA MEASUREMENT SYSTEMS (WAMS) (SMART GRID IN TRANSMISSION)

- Two schemes in the Northern and Western Regions of India
- The scheme in Northern Region is a pilot scheme for installation of four Phasor Measurement Units (PMUs) at certain identified locations. Commissioned in the end of April 2010 and data has been flowing since then to the system operator of Northern Region
- The scheme in Western Region is a pilot scheme for installation of 28 PMUs at various locations in the Western Region. Optimum location through software program
- Full-fledged Scheme petitioned by PGCIL approved by CERC in its Order in September 2013 for Phase-I for 1186 PMUs, where existing fibre optic cable existing or awarded.

AREAS IN SMART GRID WHICH NEED TO BE TAKEN BY THE GOVERNMENT/REGULATORS

- To introduce Demand Response by giving incentives for the same to consumers willing to subscribe to interruptible demand – Policy level by the Government and Regulatory level by the Regulators. **This is a must for enabling integration of intermittent sources of renewable energy**
- Smart meter is the basic component required for Demand Response
- CEA has issued specifications for a low cost single-phase Smart Meter
- Specifications for three-phase meters in progress

STEPS IMPLEMENTED/IN PROCESS

- Technical Standards for **Connectivity of Renewable Sources of Energy** to the high voltage grid and Distributed Generation Sources, including Roof-top solar, to the low voltage grid notified by CEA in Oct 2013.
- Task Force headed by Chairperson, CEA, formed by the Ministry of Power for dealing with issues w.r.t. integration of Renewable Sources of Energy to the Grid. Report under finalization
- One of the issues is for making technical standards for the same
- Regulations for Technical Standards for Connectivity already in place. Regulations pertaining to the operational standards to be formulated by CEA. Expected to be formulated within a year

ENABLING ACTIONS REQUIRED

- Bringing about awareness of the benefits of Smart Grid to the State Utilities and State Regulators
- Bringing about awareness of the Methods of **Cost-benefit Analysis** for implementation of Smart Grid

LIST OF BENEFITS AS PER EPRI COST BENEFIT ANALYSIS (2010)

- Optimized Generator Operation
- Reduced generation and transmission and distribution capacity investment
- Reduced Ancillary cost
- Reduced Congestion Cost
- Reduced equipment failure
- Reduced meter reading cost

LIST OF BENEFITS AS PER EPRI COST BENEFIT ANALYSIS (2010)

- Reduced electricity theft
- Reduced losses
- Reduced outages
- Reduced fossil fuel usage
- Reduced CO2, SOx, NOx emissions
- Reduced Sags and Swells

Smart meters or AMI

- **Advanced metering infrastructure** (AMI) involves enabling two-way flow of information, providing customers and utilities with data on electricity price and consumption, including the time and amount of electricity consumed.

SMART METERS

- informs consumers as well as the distribution utility on the manner of consumption of the consumer.
- Load reduction of individual appliances in the house in order to reduce the cost to the consumer.
- Enables integration of generation at the consumer level from roof top solar units, small domestic wind mills and even battery - powered vehicles, which can sell power back to the grid.

Smart Meter Functionalities

- Obtain 15 minute interval data
- Status indicators and event logs
- Customer connect/disconnect both from remote and local
- Time clock synchronization
- Settings for normal supply limit and emergency supply limit
- Anti-tamperproof
- Automatic meter reading
- Data encription
- Power Quality Recording

EMERGING AREAS IN SMART GRID

- Using FACTS devices for flexible transmission capacity
- Using phase shifters to divert power to lightly loaded paths
- Storage Devices
- Inter-operability Standards

EMERGING SMART GRID TECHNOLOGIES

Transmission enhancement applications

- **Flexible AC transmission systems (FACTS)** are used to enhance the controllability of transmission networks and maximise power transfer capability. Can improve efficiency and defer the need of additional investment
- **High voltage DC (HVDC)** technologies are used to connect offshore wind and solar farms to large power areas, with decreased system losses and enhanced system controllability
- **Dynamic line rating (DLR)**, which uses sensors to identify the current carrying capability of a section of network in real time, can optimise utilisation of existing transmission assets, without the risk of causing overloads
- **High-temperature superconductors (HTS)** can significantly reduce transmission losses and enable economical fault-current limiting with higher performance, though there is a debate over the market readiness of the technology

- Using **phase shifting transformers, variable frequency transformers (VFT),** etc. for controlling power flow, so as to avoid congestion and redirecting flows to under-loaded lines.
- The variable frequency transformer behaves as a continuously adjustable phase-shifting transformer. It allows control of the power flow between two networks. Unlike power electronics solutions such as back-to-back HVDC, the variable frequency transformer does not demand harmonic filters and reactive power compensation. Limitations of the concept are the current-carrying capacity of the slip rings for the rotor winding. Research on the VFT is in progress.

EMERGING SMART GRID TECHNOLOGIES

Distribution grid management

- Distribution and sub-station sensing and automation can reduce outage and repair time, maintain voltage level and improve asset management
- Fault location
- Automatic reconfiguration of feeders
- Voltage and reactive power optimisation
- Control distributed generation
- Sensor technologies can enable condition- and performance-based maintenance of network components

Smart grid technologies

- **Energy Storage**
- In order to meet the fluctuation of generation from renewable energy sources like wind and solar generation, some fast acting generation is required, which could be gas or liquid generation or ***energy storage mechanisms like storage hydro generation, batteries, flywheel, etc.*** A lot of research is going on in the field of efficient, ***fast charging and mass storage batteries of the capacity of MWs***.

Smart grid technologies

- **Future battery charging for vehicles**
- Vattenfall, a public power company in Sweden, is doing R&D work with solutions for ***fast charging*** and automatic charging.
- Also looking at ***inductive automatic charging*** system – without the need for a cord. The electric car is placed over a plate in the ground and electricity is transferred wirelessly to the car battery, without the components having direct physical contact.

PROSPECTS FOR INDIA

- Reduction of theft.
- Reduction of technical losses.
- Improvement of distribution system reliability.
- Integration of Renewable Sources of Energy to the Grid is in a State of progress, with new issues cropping up as we go along. Therefore would require to add new standards for Connectivity and Operation
- For example, storage technology is expected to play a big role in the future. This is in a state of development. Standards would need to be developed for new technologies, new issues.

THANK YOU