SMART GRID : ROADMAP AND CHALLENGES IN INDIAN SCENARIO

Contents

- What is Smart Grid
- Key Drivers of Smart Grid
- Key Components of Smart Grid
- A Case Study
- India's Road Map
- Potential Challenges

What is a Smart Grid?

What is Smart Grid → Key Drivers of Smart Grid → Key Components of Smart Grid → A Case Study → India's Road Map → Potential Challenges

Origin of the term 'Smart Grid'

The term Smart Grid was coined in year 2005, when it appeared in the IEEE P&E Magazine in an article "Towards A Smart Grid" by Amin and Wollenberg*.

Somehow there is a common belief that the smart grid will revolutionize the electricity business and change the business model that has been in place for the past 75 years and more.

* S. Massoud Amin and Bruce F. Wollenberg, 2005. Toward a Smart Grid, *IEEE P&E Magazine* **3**(5) pp34–41

Smart Grid

- Smart Grids are also known as self healing or self adaptive grids.
- Automated objective analysis and the correlation of various type of events enable the utilities to **proactively responds to feeder events** rather than merely being able to react to them.

5

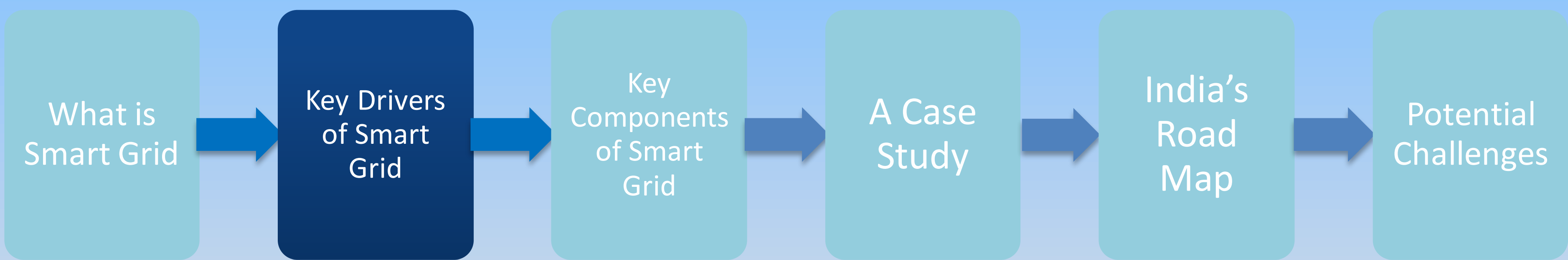
SMART GRID: Definition

Although there is no standard definition of Smart Grid and the same is still evolving but broadly the term stands for:

'A Power System' that uses some ICT (information and communications technology) tools to improve the efficiency, reliability, economics, and sustainability of the generation, transmission or/and distribution of electricity.

In fact most of the work that has been going on in power system modernization, especially substation and distribution automation, is now being termed as smart grid, of course there are few additional capabilities being evolved as well.

What are the key drivers of Smart Grid



KEY DRIVERS OF SMART GRID

1. Challenges in achieving a balance of supply-and-demand in real time.
2. In some areas, supply of electricity, especially at peak times, could not keep up with this demand, resulting in poor power quality including blackouts and power cuts.
3. During peak load hours the demand is met by an array of 'peaking Power generators' that would only be turned in for short periods each the day. The relatively low utilization of these peaking generators resulted in high costs to the electricity companies, which were passed on in the form of increased tariffs.

SMART GRID IS ……

- **Intelligent – capable of sensing system overloads and** rerouting power to prevent or minimize a potential outage; of working autonomously when conditions require resolution faster than humans can respond…and cooperatively in aligning the goals of utilities, consumers and regulators.
- **Efficient –** capable of meeting increased consumer demand without adding infrastructure.
- **Accommodating – accepting energy from virtually any fuel source including** solar and wind as easily and transparently as coal and natural gas; capable of integrating any and all better ideas and technologies – energy storage technologies, for example – as they are market-proven and ready to come online.

SMART GRID IS ……

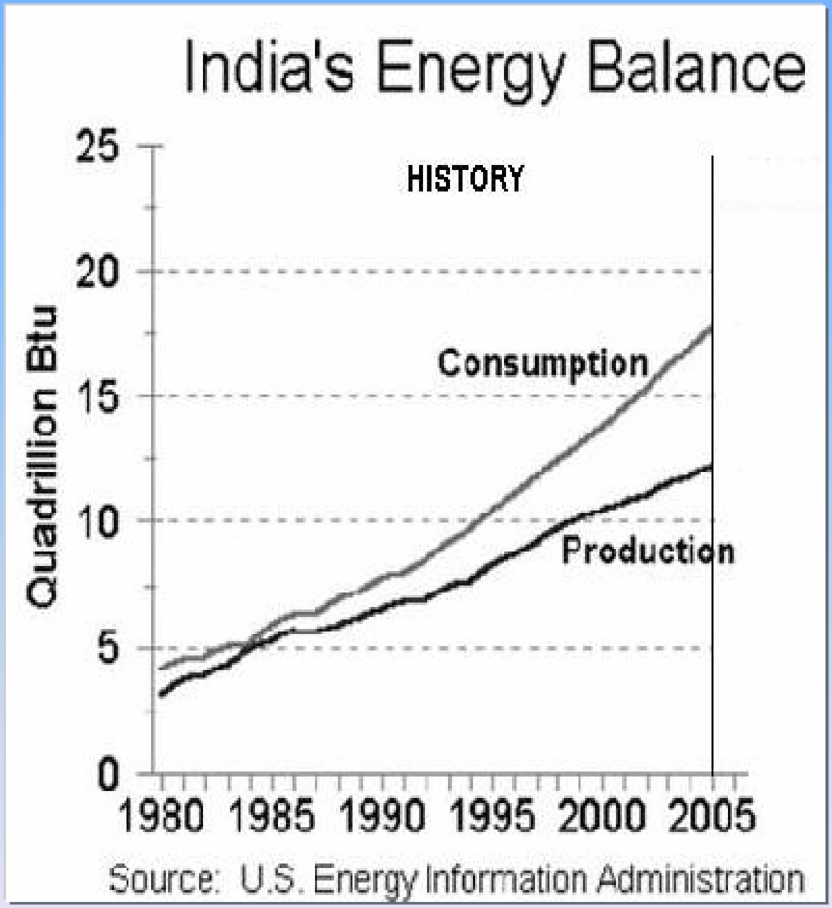
- **Motivating – enabling real-time communication between the consumer and utility so** consumers can tailor their energy consumption based on individual preferences, like price and/or environmental concerns.
- **Opportunistic – creating new opportunities and markets by means of its ability to capitalize on** plug-and-play innovation wherever and whenever appropriate.

SMART GRID IS ……

- **Quality-focused – capable of delivering the power quality necessary – free of sags, spikes, disturbances** and interruptions – to power our increasingly digital economy and the data centers, computers and electronics necessary to make it run.
- **Resilient – increasingly resistant to attack and natural disasters as it becomes more decentralized and reinforced** with Smart Grid security protocols
- **"Green" – slowing the advance of global climate change and offering a genuine path toward significant** environmental improvement

Key Drivers in India

- Supply shortfalls.
- High AT&C losses.
- India's robust economic growth with limited reserves of oil, gas or high-quality coal.
- Substantial fraction of the consumption still not metered.
- Challenges in achieving a balance of supply-and-demand in real time.
- Managing the "human element" in system operations.



KEY DRIVERS OF SMART GRID

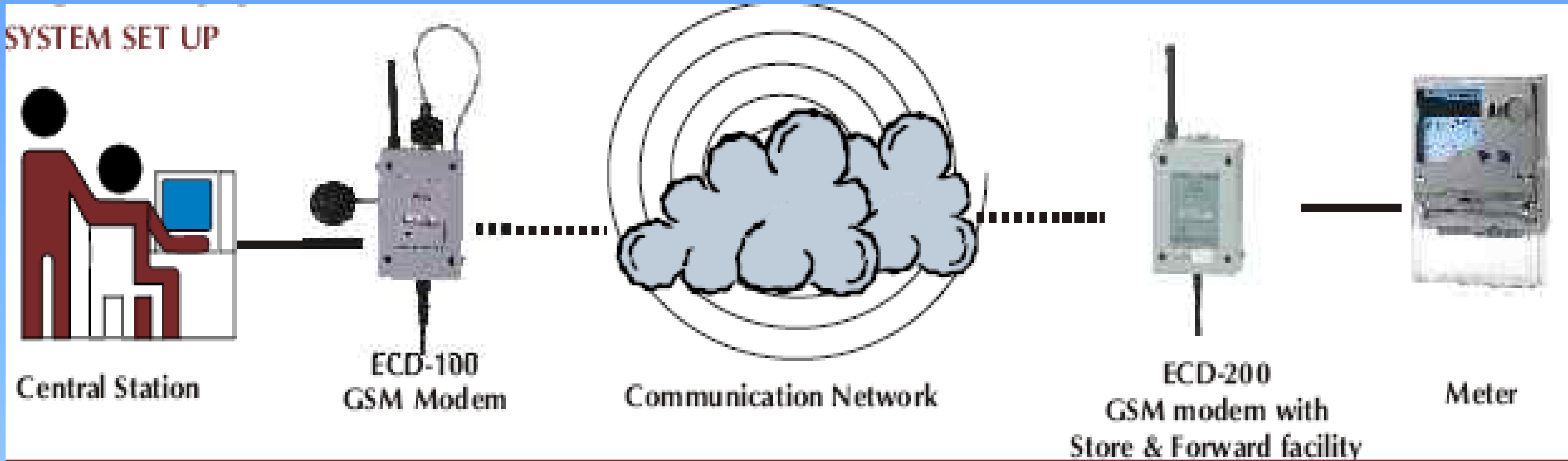
1. Enabling Improved balance of supply-and-demand in real time
2. Renewal-Energy-friendly.
3. Distributed Generation friendly.
4. Bidirectional Energy Flow.
5. Utility to communicate directly with consumer home appliances.
6. Reliability

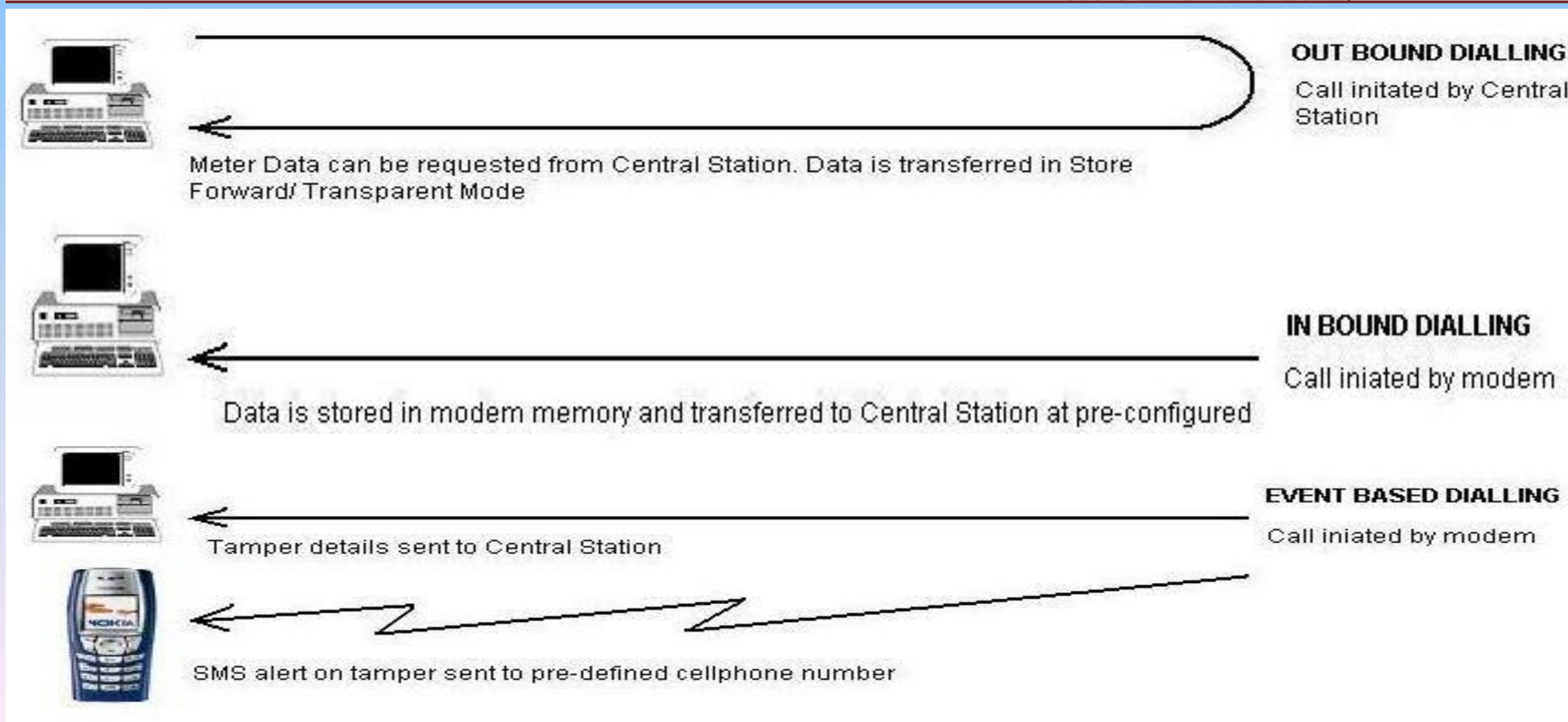
(A) FEATURES OF SMART GRID: RELIABILITY

The smart grid will make use of technologies that improve **fault detection** and result into **self-healing** of the network without the intervention of technicians.

This will ensure more reliable supply of electricity, and reduced vulnerability to natural disasters or attack.

PRESENT AMR SYSTEM: UNIDIRECTIONAL COMMUNICATION





FEATURES OF SMART GRID:
(A) BI-DIRECTIONAL ENERGY FLOW

- Conventional grids were designed for one-way flow of electricity, but if a local sub-network generates more power than it is consuming, **the reverse flow can raise safety and reliability issues.** A smart grid aims to manage these situations.

- Next-generation transmission and distribution infrastructure will be better able to handle possible **bidirection energy flows**, allowing for **distributed generation** such as from photovoltaic panels on building roofs, batteries of electric cars, wind turbines, captive plants of industries and other sources.

FEATURES OF SMART GRID:

(B)CONTROL OF CONSUMER HOME APPLIANCES BY UTILITY

- Smart grid technology would facilitate utility's control over the consumer appliances.
- For example turning off air conditioners during short-term spikes in electricity price.
- The overall effect would be less redundancy requirement in transmission and distribution lines, and greater utilisation of generators, leading to lower power prices.
- A smart grid may warn all individual television sets, or another larger customer, to reduce the load temporarily (to allow time to start up a larger generator) or continuously (in the case of limited resources).
- Using mathematical prediction algorithms it is possible to predict how many standby generators need to be used, to reach a certain failure rate. In the traditional grid, the failure rate can only be reduced at the cost of more standby generators. In a smart grid, the load reduction by even a small portion of the clients may eliminate the problem.

FEATURES OF SMART GRID:
(C) **PEAK CURTAILMENT AND TIME OF USE PRICING**

To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used.

It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overloads. An example would be a utility reducing the usage of a group of electric vehicle charging stations.

To motivate them to cut back use and perform what is called **peak curtailment** or **peak leveling**, prices of electricity are increased during high demand periods, and decreased during low demand periods.

(D)FEATURES OF SMART GRID: SUSTAINABILITY

- The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage.
- Current network infrastructure is not built to allow for many distributed feed-in points, and typically even if some feed-in is allowed at the local (distribution) level, the transmission-level infrastructure cannot accommodate it.
- Rapid fluctuations in distributed generation, such as due to cloudy or gusty weather, present significant challenges to power engineers who need to ensure stable power levels through varying the output of the more controllable generators such as gas turbines and hydroelectric generators. Smart grid technology is a necessary condition for very large amounts of renewable electricity on the grid for this reason.

(E) FEATURES OF SMART GRID: **MARKET ENABLING**

- The smart grid allows for systematic communication between suppliers (their energy price) and consumers (their willingness-to-pay), and permits both the suppliers and the consumers to be more flexible and sophisticated in their operational strategies.
- Only the critical loads will need to pay the peak energy prices, and consumers will be able to be more strategic in when they use energy. Generators with greater flexibility will be able to sell energy strategically for maximum profit, whereas inflexible generators such as base-load steam turbines and wind turbines will receive a varying tariff based on the level of demand and the status of the other generators currently operating. The overall effect is a signal that awards energy efficiency, and energy consumption that is sensitive the time-varying limitations of the supply.
- At the domestic level, appliances with a degree of energy storage or thermal mass (such as refrigerators, heat banks, and heat pumps) will be well placed to 'play' the market at seek to minimize energy cost by adapting demand to the lower-cost energy support periods.

(G) FEATURES OF SMART GRID: DEMAND RESPONSE SUPPORT

- Demand response support allows generators and loads to interact in an automated fashion in real time, coordinating demand to flatten spikes. Eliminating the fraction of demand that occurs in these spikes eliminates the cost of adding reserve generators, cuts wear and tear and extends the life of equipment, and allows users to cut their energy bills by telling low priority devices to use energy only when it is cheapest.
- Currently, power grid systems have varying degrees of communication within control systems for their high value assets, such as in generating plants, transmission lines, substations and major energy users. In general information flows one way, from the users and the loads they control back to the utilities. The utilities attempt to meet the demand and succeed or fail to varying degrees (brownout, rolling blackout, uncontrolled blackout). The total amount of power demand by the users can have a very wide probability distribution which requires spare generating plants in standby mode to respond to the rapidly changing power usage. This one-way flow of information is expensive; the last 10% of generating capacity may be required as little as 1% of the time, and brownouts and outages can be costly to consumers

(H) FEATURES OF SMART GRID:

Smart Home Appliances

It is aimed to encourage consumers to save energy by using real-time information and producing smart home appliances that operate in response to electric utility rates.

(I) FEATURES OF SMART GRID:

Smart Transportation

It is intended to build a nationwide charging infrastructure that will allow electric vehicles to be charged anywhere. It also establishes a V2G (Vehicle to Grid) system where the batteries of electric vehicles are charged during off-peak times while the resale of surplus electricity takes place during peak times.

FEATURES OF SMART GRID:
REDUCTION IN CARBON EMISSION

- Smart Grid shall help in reducing carbon emissions by increasing system load and delivery efficiencies & use of RE
- India is currently the world's 7th largest emitter of global warming pollution and 5th largest for emissions from fossil fuel combustion.
- India has to reduce the Carbon Emission per unit of GDP 20 to 25 percent below 2005 levels by 2020.

Existing Grid Vs Smart Grid

Centralized Generation	Distributed Generation
One-way communication	Two-way communication
Hierarchical	Networked
Manual Restoration	Self Healing
Failures and blackouts	Adaptive and islanding
Blind	Self Monitoring
Manual Check/Test	Remote Check/Test

Key Components of SMART GRID

What is Smart Grid → Key Drivers of Smart Grid → **Key Components of Smart Grid** → A Case Study → India's Road Map → Potential Challenges

Key Components for Smart Grid

- Meters
- Storage devices
- Distributed generation
- Renewable energy
- Energy efficiency
- Home area networks
- Demand response
- IT and back office computing
- Security
- Integrated communications systems
- Superconductive transmission lines.
- Distributed Generation and Storage
- Energy Efficiency
- System Operation

Potential Benefits of the Smart Grid

- Optimizing the value of existing production and transmission capacity
- Incorporating more renewable energy
- Enabling step-function improvements in energy efficiency
- Enabling broader penetration and use of energy storage options
- Reducing carbon emissions by increasing system, load and delivery efficiencies
- Improving power quality
- Improving a utility's power reliability, operational performance, asset management and overall productivity
- Enabling informed participation by consumers by empowering them to manage their energy usage
- Promoting energy independence.

Smart Grid Implementation: A Case Study

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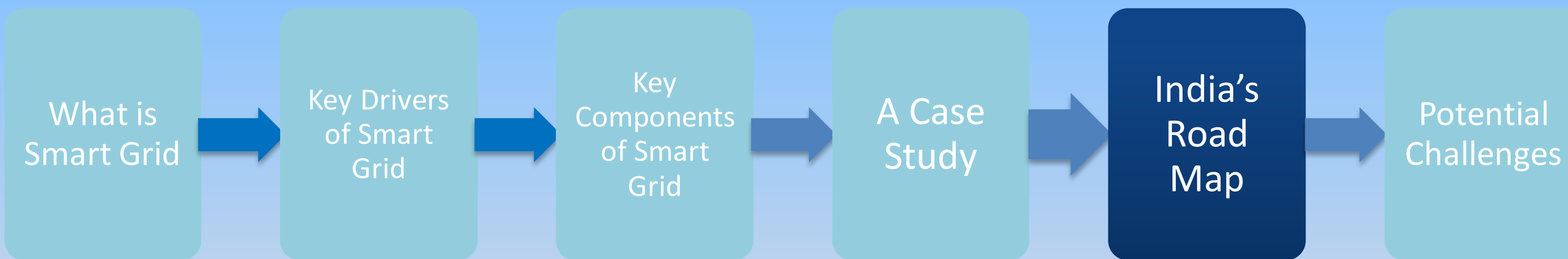
Road Map in India



How Should India Respond to the Smart Grid Vision?

- Commercially viable and self-sufficient discoms.
- Public awareness and acceptance of the smart grid.
- A national smart grid vision and a flexible plan.
- Appropriate smart grid standards.

Smart grid initiative in India

- Formation of Smart Grid forum under MoP, Discoms are member of the forum
- Pilots projects under RAPDRP Part-A
- Appointment of PGCIL as nodal agency

Challenges to quantifying smart grid benefits.

- Environmental benefits will be difficult to quantify due to the complex dimensions of the smart grid and the fact that benefits are often dispersed and therefore not readily identifiable or easily quantifiable. Some other reasons for this concern include:
- Environmental benefits tend to occur due to avoided emissions or offset impacts, which are often difficult to quantify
- The benefits cannot always (or easily) be traced to a single organization
- Benefits will occur outside the boundary of the firm implementing the program
- Environmental benefits accrue over very long time periods.

PILOT PROJECTS IN INDIA

- A few months earlier Power Ministry (MoP) has received a number of proposals from various state utilities for smart grid projects.
- The proposals were evaluated by a committee, of which 14 were finally selected. Selection was based on a number of criteria, including technical capacity, geographical spread, scale-up capability, and operating conditions that India possesses.
- The total outlays of the smart grid pilots are set at Rs 400 crore. Government of India (GoI) plans to provide funds up to 200 crore from the Re-structured Accelerated Power Development and Reform Programme (R-APDRP's) innovation budget line, and the rest will be complemented by matching funds from the states.

Smart Grid Vision and Roadmap for India

National Smart Grid Mission (NSGM)

"Quality Power on Demand for All by 2027"

- **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*

National Smart Grid Mission (NSGM)

Objectives:

In order to achieve this vision, stakeholders will undertake:

- **Smart Customer:**
  1. Appropriate policies and programmes to provide access for electricity for all with life line supply (to be defined) by 2015, electrification of 100% households by 2020 and 24x7 quality supply on demand to all citizens by 2027.
  2. Smart meter roll out for all customers by 2022
  3. Tariff mechanisms, new energy products, energy options and programmes to encourage participation of customers in the energy markets that make them “prosumers”
  4. Formulation of effective customer outreach and communication programmes for active involvement of consumers in the smart grid implementation.

National Smart Grid Mission (NSGM)

- **<u>Smart Utilities:</u>**
  1. Enabling programmes and projects in distribution utilities to reduce AT&C losses to below 15% by 2017, below 12% by 2022, and below 10% by 2027; and in transmission utilities to reduce transmission losses to below 3% by 2017 and below 2% by 2022.
  2. Development of 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.
  3. Development of utility specific strategic roadmap for implementation of smart grid technologies across the utility by 2013. Required business process reengineering, change management and capacity building programmes to be initiated by 2014.
  4. Integrated technology trials through a set of smart grid pilot projects by 2015; and rollout of smart grids in all urban areas (to be defined) by 2020 and nationwide by 2027.
  5. 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 energy markets.

National Smart Grid Mission (NSGM)

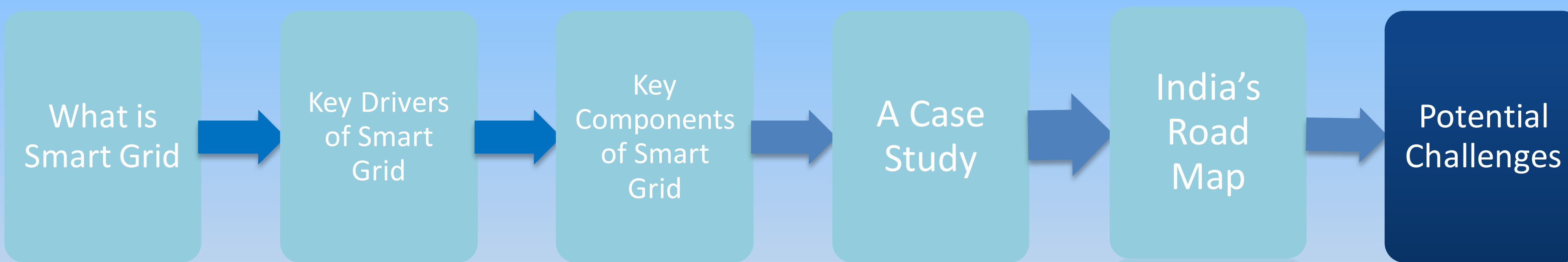
- **Smart Generation & Transmission:**
  1. Optimally balancing different sources of generation through efficient scheduling and dispatch of distributed energy resources (including captive plants in the near term) with the goal of long term energy sustainability
  2. Implement power system enhancements to facilitate integration of 30 GW renewable capacity by 2017, 70 GW by 2022, and 120 GW by 2027. *< to be reviewed in consultation with MNRE and MoP>*
  3. 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

National Smart Grid Mission (NSGM)

- **Smart Policies:**
  1. Formulation of policies and programmes by 2013, for mandatory demand response (DR) infrastructure for all customers with load above 1 MW by 2013, above 500 kW by 2015, above 100 kW by 2017 and above 20 kW by 2020.
  2. Policies and systems for grid-interconnection of captive generation facilities above 1MW; and peaking power stations.
  3. Policies for DR ready appliances and public infrastructure including EV charging facilities by 2014.
  4. Investment in research and development, training and capacity building programmes for creation of adequate resource pools for developing and implementing smart grid technologies in India as well as export of smart grid know-how, products and services.
  5. Development of appropriate standards for smart grid development in India; and active involvement of Indian experts in international bodies engaged in smart grid standards development.

12th Plan (2012 – 2017)	13th Plan (2017 – 2022)	14th Plan (2022 – 2027)
1. Access to "Electricity for All" 2. Reduction of transmission losses (>66 kV) to below 3% 3. Reduction of AT&C losses in all Distribution Utilities to below 15% 4. Reduction in Power Cuts; Life line supply to all by 2015; grid connection of captive plants >1 MW 5. Renewable integration of 30 GW; and EV trials 6. Improvement in Power Quality and Reliability 7. ToU (Time of Use) Tariff 8. Energy Efficiency improvements 9. Standards Development for Smart Grids including EVs 10. Strengthening of EHV System 11. Efficient Power Exchanges 12. Training & Capacity Building 13. Customer Outreach & Participation 14. Research & Development 15. Sustainability Initiatives 16. SG Pilots 17. Cost-Benefit Analysis	1. Reduction of transmission losses (>66 kV) to below 2% 2. Reduction of AT&C losses to below 12% in all Utilities 3. Improvement in Power Quality 4. End of Power Cuts; Peaking power plants; Electrification of all households by 2020 5. Nationwide Smart Meter roll out 6. Renewable integration of 70 GW; 5% EV penetration 7. Standards Development for Smart Infrastructure (SEZ, Buildings, Roads/Bridges, Parking lots, Malls) and Smart Cities 8. UHV and EHV Strengthening 9. Research & Developments; Training & Capacity Building 10. Export of SG products, solutions and services to overseas 11. Customer Outreach & Participation 12. Sustainability Initiatives & Public Safety	1. Reduction of AT&C losses to below 10% in all Utilities 2. Financially viable utilities 3. Stable 24x7 power supply to all categories of consumers all across the country 4. Renewable integration of 120 GW; 10% EV penetration 5. Smart Cities and Smarter Infrastructures 6. Export of SG products, solutions and services to overseas 7. Research & Development ; Training & Capacity Building 8. Active Participation of "Prosumers" 9. Sustainability Initiatives & Public Safety

Barriers & Challenges in Smart Grid Implementations in India



What are the Barriers to Smart Grid Implementation in India?

- No proven commercial viability for large-scale smart grid roll outs
- Poor financial health of most state-owned T&D companies
  - Low awareness of technological developments in the utility sector
- Impact on tariff
- Requirement of Legislation

Legislation

- In line with USA Energy security Act 1980 Section 13 , Smart Grid is mandatory for transmission and Distribution utility
- Amendment in Electricity Act 2003 is required in similar line

Impact on Tariff : Example

Capitaliation	400	Rs Cr

	Debt (Loan)			Equity (Own Funds)
%age	70%		% age	30%
Rs Cr	280		Rs Cr	120

Annual Fixed Costs Computation

Interest on Loan (@ 10%)	28	Rs Cr
Return on Equity (@16%)	19	Rs Cr
O&M Exp(Salaries/R&M/A&G)	10	Rs Cr
Interest on Working Capital	10	Rs Cr
Depreciation(@ 5%)	20	Rs Cr
Total burden on 1st year tariff	**87**	**Rs Cr**

(Consider a utility with ABR=Rs 4 PU & 10000 MU sale Rs 87 Cr additional ARR means PU tariff rise 8.7 Ps)

Other challenges in Smart Grid Implementation in India?

- The technical challenges of new systems, new devices, new communications technologies, and a deluge of new data can be overwhelming .
- The impact on existing business processes needs to be identified, with new business processes defined.
- The organization has to make itself ready for the significant and perhaps radical changes that will take place.
- Customers, regulators and investors need to understand the change and be convinced that it is beneficial.
- A successful migration to a smart grid environment will require that all of them embrace the vision, not merely accept it.

Communication Issues

- The Last Mile Connectivity” for smart grid applications – particularly for smart metering – continues to be the major hurdle in smart grids rollout in India.
- GPRS/CDMA connectivity presently used for AMR applications is too expensive when millions of meters are involved and coverage in of GPRS/CDMA in non-urban areas is still poor.
- Moreover whether this medium can be reliable for demand response applications – given the network congestion and call drops – is debatable.
- With the level of public interference on the low voltage electrical network the viability of PLC and BPL solutions are also doubtful – we need large field trials in different regions.·
- On the wireless side while results of large scale deployment of Zigbee is awaited, sub-GHz wireless is still under trials. The free band of 865-867 MHz spectrum is available in India is considered to be too small a slice for effective results and also has poor penetration capabilities across concrete and double-brick walls.

CYBER SECURITY ISSUE

THANK YOU