# Smart Grid - Way Ahead for Utilities and Regulators

Pankaj Batra
Member (Planning),
Central Electricity Authority

# The need for a smart grid

- In order to **reduce carbon emissions to limit temperature rise**, the Governments have decided to **improve energy efficiency and energy conservation** and rapidly ramp up energy produced from **renewable sources of energy**, notably solar and wind power.
- Smart grid technologies can **improve the reliability and resilience of the grid**, **enable the large-scale integration of variable renewable power** and the **dynamic management of electricity demand**, and potentially contribute to **reductions in carbon dioxide emissions from electricity generation and use**.

# ABB Definition

- A smart grid is an evolved grid system that manages electricity demand in a sustainable, reliable and economic manner, built on advanced infrastructure and tuned to facilitate the integration of all involved.

FORUM OF REGULATORS

# MODEL SMART GRID REGULATIONS

2015

# LIST OF INDICATIVE COMPONENTS OF SMART GRID PROJECTS

- Automated Metering Infrastructure (AMI)
- Demand Response
- Micro-Grids
- Distribution SCADA/Distribution Management
- Distributed Generation
- Peak Load Management
- Outage Management

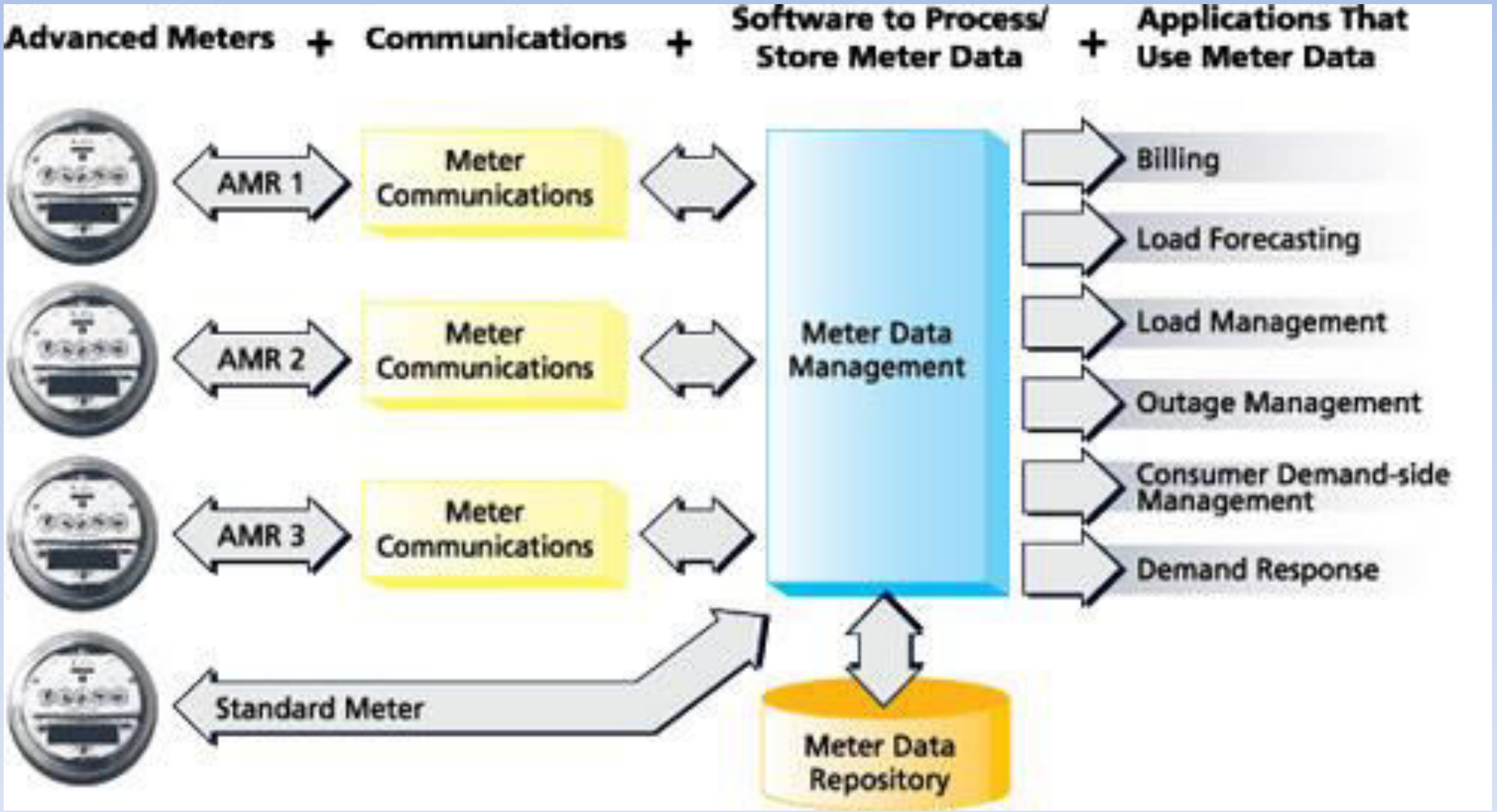
# LIST OF INDICATIVE COMPONENTS OF SMART GRID PROJECTS

- Asset Management
- Wide Area Measurement Systems
- Energy Storage Projects
- Grid Integration of Renewables
- Electric Vehicle including Grid to Vehicle (G2V) and Vehicle to Grid (V2G) Interactions
- Smart Grid Data collection and analysis
- Tariff Mechanism including reliable and interruptible supply tariffs, dynamic tariffs, time of use, critical peak pricing, real time pricing etc

# Distribution SCADA

# Smart Meter

# AMI



Advanced Meters
+
Communications
+
Software to Process/ Store Meter Data
+
Applications That Use Meter Data
AMR 1
AMR 2
AMR 3
Meter Communications
Meter Communications
Meter Communications
Standard Meter
Meter Data Management
Meter Data Repository
Billing
Load Forecasting
Load Management
Outage Management
Consumer Demand-side Management
Demand Response

# Remote Transformer Monitoring Unit


- Measures Voltage, Energy, Current and Temperature.
- **Applications**
- Asset Management and Condition Monitoring Preventive Maintenance Recognition
- Demand Response Assistance
- Distributed Generation Monitoring (i.e., bi-directional energy monitoring)
- Transformer Under/Over-sizing Recognition (e.g., Electric Vehicle charging station impacts,etc…)

# Cable Fault Locator


- A high voltage impulse is transmitted down the cable to cause the fault to arc. The arcing fault is then pinpointed using an appropriate impulse detector.

# Rooftop solar PV

# Microgrid in an Indian village

# Benefits to the Distribution Utility

- Savings in Aggregate Technical & Commercial (AT&C) losses
- No necessity to take the grid to far flung areas
- Handling of variability of intermittent type of Renewable Energy Sources.
- Reduction of downtime due to outages in distribution system.
- Reduced burning of distribution transformers.
- Optimum utilization of transmission and distribution assets.
- Savings in sub-transmission and distribution system upgrades.
- Reduction in electricity bills of consumers.

# Benefits to the customer in the Indian context

- Access to electricity for all consumers
- Reduction in electricity bills of consumers.
- Improved reliability of service.
- Improved quality of supply.

# Objective of the Business model for the State Distribution Utility

- Mutual benefit for the Distribution Utility and the consumer.
- Private entities can set up microgrids in far flung areas – no need of large investment by the State DISCOM
- For upfront money, technology company can provide the same.
- Useful to have the technology company to also do the billing and collection along with the maintenance of the Distribution SCADA and AMI.

# Business model for the Distribution Utility for Distribution SCADA and AMI

- **Costs** :
- Installation of Distribution SCADA (includes Outage Management function/Energy Audit function)
- Installation of Advanced Metering Infrastructure (AMI) (i.e Smart Meters, Communication, Hardware and Software).
- **Benefits** :
- Savings in AT&C losses
- Reduction of downtime due to outages in distribution system, therefore more revenue.
- Optimum utilization of transmission and distribution assets.

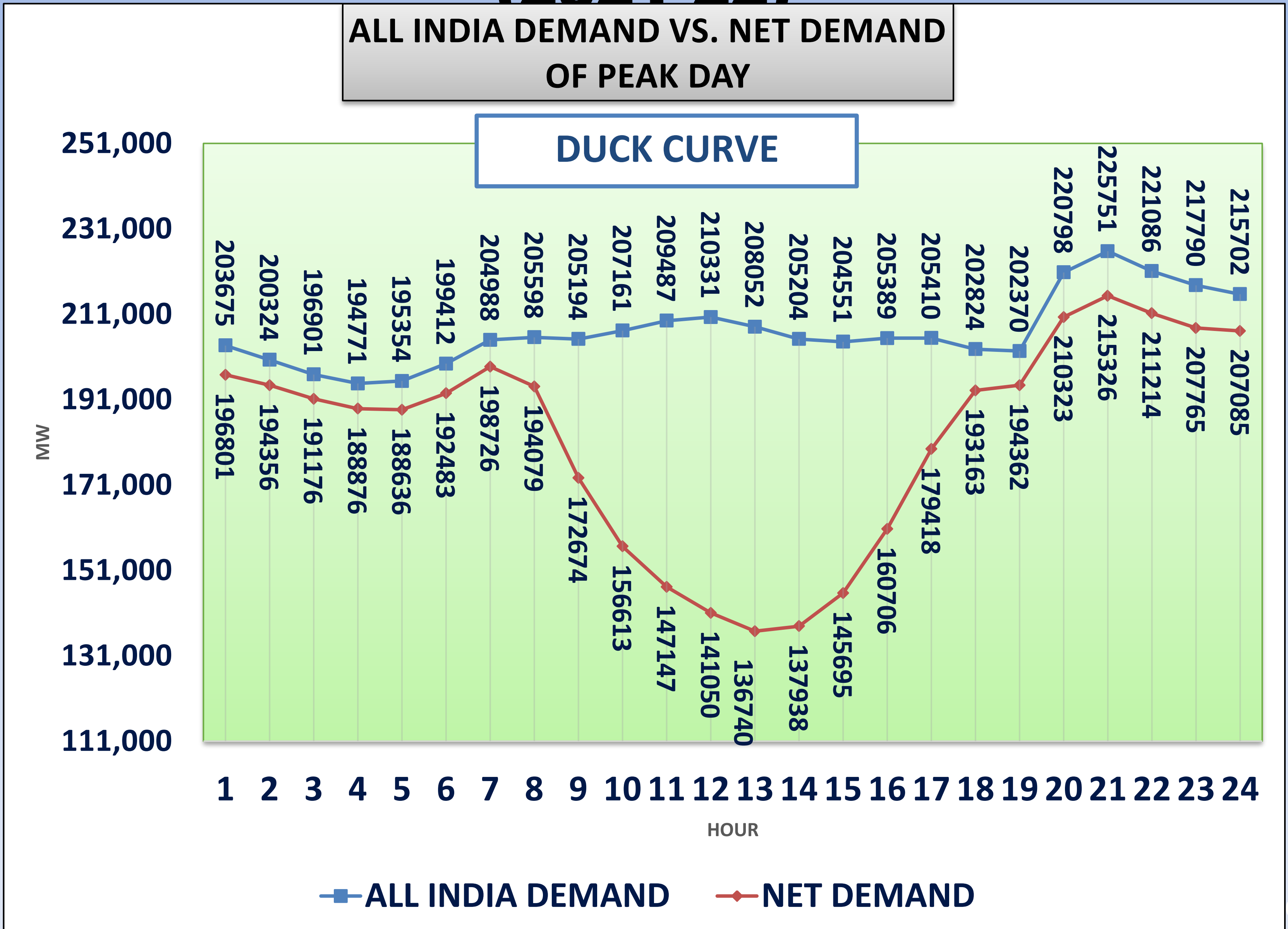
# Savings in AT&C losses – **Test case Uttar Pradesh (UP)** – a State in India

- 93,052 million units consumption for 2015-16.
- AT&C losses – 27%
- Saving of 1% losses means saving of 930 million units in a year.
- Average cost of purchase – About Rs. 4 per unit.
- Savings in Rupees – Rs. 372 crores.
- Cost of one Distribution SCADA – Rs. 5 crores
- Cost of Distribution SCADA for 4 Distribution Utilities – RS. 20 crores

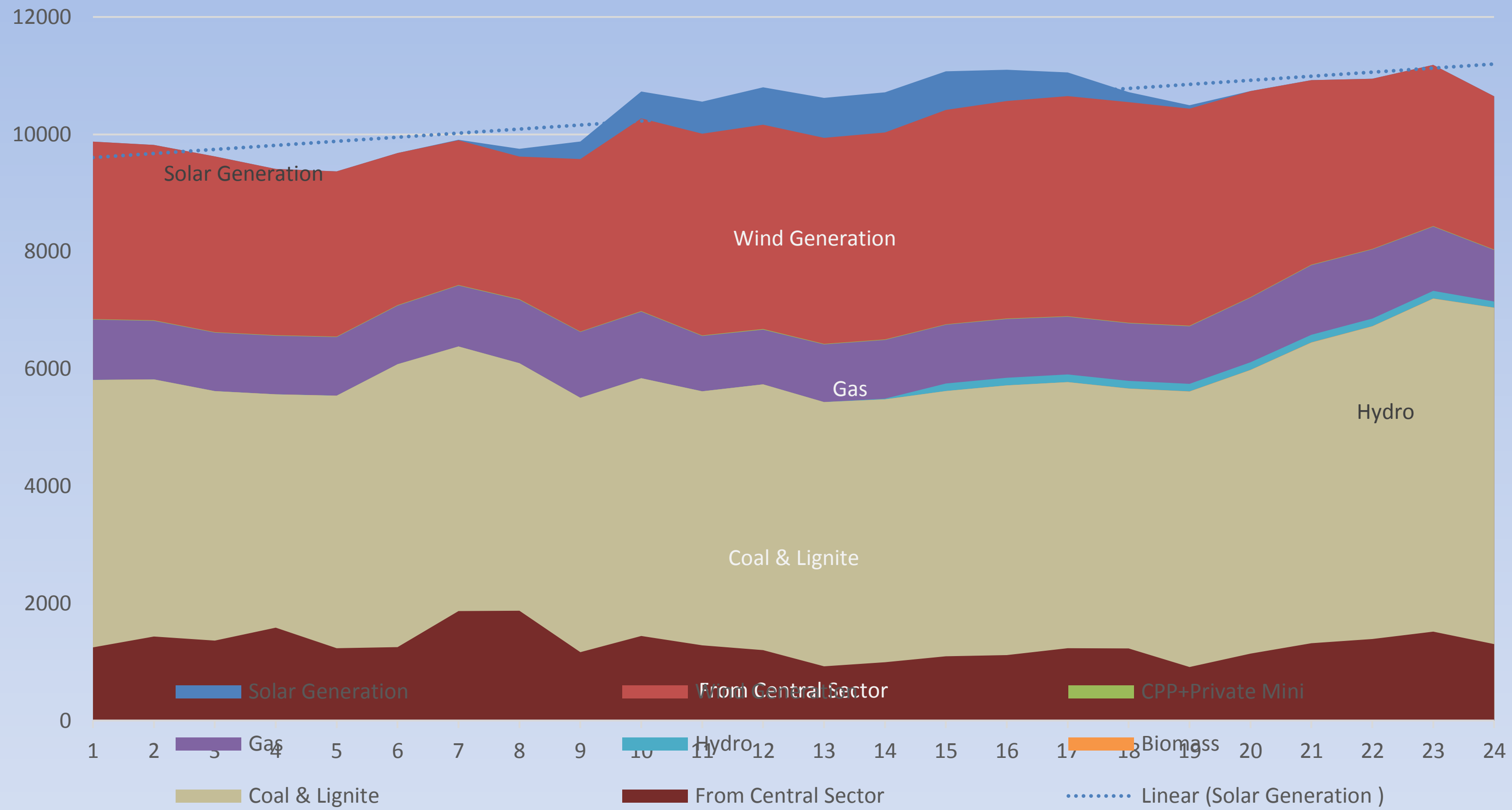
# Savings in AT&C losses – Test case UP

- Number of consumers registered – About 1 crore
- Cost of AMI – Say about Rs. 3000 per unit
- Total cost of AMI meters – Rs. 3000 crores
- Cost recovery for 1% savings in AT&C losses for 9 years - Rs. 3300 crores.
- If 2% savings, cost recovery in 4 ½ years, if 3% savings cost recovery in 3 years, if 6 % savings, cost recovery in 1 ½ years.
- **One Business Model** : Technology company bears this initial cost, and recovers this through demonstrated savings on a monthly basis; then continued savings for the Distribution company.

# TYPICAL ALL INDIA DEMAND & NET LOAD CURVE (2021-22)



# Gujarat Load Curve



# Financial Implications – Case Study of Gujarat

| | | |
|---|---|---|
| 1 | total balancing charge for coal based station (fixed +fuel charge)(Rs/Kwh)-Spread over renewable generation | 0.15 |
| 2 | Imapct of DSM per unit- Spread over renewable generation | 0.30 |
| 3 | impact on tarrif PER UNIT for gujrat discom for backing down coal generation assuming solar and wind at Rs. 4/kwh and coal fuel charge at Rs. 2.0/KWH- , considering 25% substitution - Spread over renewable generation | 0.50 |
| 4 | Stand by charge (Rs/Kwh)- Spread over renewable generation | 0.20 |
| 5 | Extra transmission charge (Rs/Kwh)- Spread over renewable generation | 0.26 |
| | | |
| | **Total Impact- Spread over renewable generation (Rs/Kwh)** | **1.41** |
| | **Total Impact- Spread over Total Energy Met (Rs/Kwh)** | **0.51** |

**Table 2: Summary of ancillary services (Response times, duration and cycle time) (Source: B. Kirby)**

| Service | Service Description | | |
|---|---|---|---|
| | *Response Speed* | *Duration* | *Cycle Time* |
| Regulation | Power sources online, on automatic generation control, that can respond rapidly to system-operator requests for up and down movements; used to track the minute-to-minute fluctuations in system load and to correct for unintended fluctuations in generator output to comply with Control Performance Standards (CPSs) 1 and 2 of the North American Reliability Council (NERC 2002) | | |
| | *~1 min* | *Minutes* | *Minutes* |
| Spinning reserve | Power sources online, synchronized to the grid, that can increase output immediately in response to a major generator or transmission outage and can reach full output within 10 min to comply with NERC's Disturbance Control Standard (DCS) | | |
| | *Seconds to <10 min* | *10 to 120 min* | *Days* |
| Supplemental reserve | Same as spinning reserve, but need not respond immediately; units can be offline but still must be capable of reaching full output within the required 10 min | | |
| | *<10 min* | *10 to 120 min* | *Days* |
| Replacement reserve | Same as supplemental reserve, but with a 30-min response time; used to restore spinning and supplemental reserves to their pre-contingency status | | |
| | *<30 min* | *2 hours* | *Days* |
| Voltage control | The injection or absorption of reactive power to maintain transmission-system voltages within required ranges | | |
| | *Seconds* | *Seconds* | *Continuous* |

## Table 1: Types of ancillary services in US energy markets (Source: Sandia)

| ISO/RTO | Primary Frequency Control Reserve | Secondary Frequency Control Reserve | Tertiary Frequency Control Reserve | | | |
|---|---|---|---|---|---|---|
| CAISO | no market | *Regulation Reserve*<br>Regulation Up<br>Regulation Down | Spinning reserve | Non-spinning Reserve | | |
| ERCOT | no market | *Regulation Services*<br>Reg Service - Up<br>Reg Service - Down | Responsive Reserve Service | Non-Spinning Reserve Service | Replacement Reserve Service | |
| ISO-NE | no market | Regulation | Ten-Minute Spinning | Ten-Minute Non-Spinning | Thirty-Minute Operating | |
| MISO | no market | Regulating Reserve | *Contingency Reserve*<br>Spinning Reserve | Supplemental Reserve | | |
| NYISO | no market | Regulation | 10-Minute Spinning Reserve | 10-Minute Non-Synchronized Reserve | 30-Minute Spinning Reserve | 30-Minute Non-Synchronized Reserve |
| PJM | no market | Regulation | *Contingency Reserve*<br>Synchronous Reserve | Quick Start Reserve | Supplemental Reserve | |
| SPP* | no market | *Regulation*<br>Regulation Up<br>Regulation Down | *Contingency Reserve*<br>Spinning Reserve | Supplemental Reserve | | |

# Demand Response

- One of the biggest sources of balancing the intermittency, which is being increasingly used in developed countries, is ***demand response***.
- Immediately available
- Rules and Smart Meters need to be put into place
- Essential and non-essential loads accompanied with 24x7 and Interruptible tariff

# Social risks - Boulder Smart Grid City Pilot Project in Colorado, USA

- One of the customers didn’t know if the contraption on the back of his house was a smart meter. He said that he can log in to his account and see how much electricity he uses each day, but he never actually does.
- One resident said that when her smart meter was installed in 2008, the technician refused to explain what he was doing and gave her an 800 phone number to call instead.
- Fiber optic communication technology, turned out to be less ideal than hoped.

# Lessons of smart grid test in Boulder

- US based Xcel Energy Inc. launched a SmartGridCity project in Boulder, Colorado, USA in 2009.

- The utility received criticisms relating to a lack of communication with customers, and cost overruns that were being paid for by Xcel's 1.4 million Colorado ratepayers.

- Initially, utility sold the idea of having fully electronic houses and solar generation with the installation of this technology but there was no roadmap to bring the promise out of paper into reality.

- One of the Xcel employee admitted that there should have been a better job setting expectations on the cost estimate and the objectives for the customer.

- Utility misread the market for programmable, in-home smart devices which could allow customers to remotely control appliances but in practice, customers reportedly found the devices too simplistic, and demand was not as great as Xcel anticipated. Additionally, many homes didn't meet Xcel's installation criteria. So utility ended up installing only 101 out of planned 1850 of these devices.

# Additional lessons learned from Smart Grid City

- **Communication:** While "robust and reliable," Xcel found that broadband over power line technology with fiber optics as a backhaul too expensive.
- **Metering capabilities:** Advanced meters, or so-called "smart meters" are not always necessary for realizing customer value, "given that automated meters with similar capabilities have already been widely deployed by many utilities, including Xcel Energy,".
- **Technical requirements:** "There are distinct and meaningful differences in technical requirements when one considers grid control capabilities versus meter reading capabilities," .
- **How SmartGridCity works**
- A fiber-optic backbone allows near real-time communication between customers, substations and the utility's central control.
- The two-way flow of information is enabled by electric smart meters installed on the outside of 23,000 homes, about half the residential base of Boulder. Another 700 businesses were also provided the outdoor meters, which send signals every 15 minutes through a broadband over power line technology.
- On the customer side, Xcel installed programmable energy management systems inside homes to allow the customer greater control over his electricity usage.

# Social Risks - **Smart meter roadmap for UK**

- The UK Government set a target of having 53 million units installed in the country by 2020.
- The plan to begin mass rollout in the first quarter of 2016 was unsuccessful, with the exception of a few rollout.
- As on October 2016, the launch of the The Data Communications Company (DCC), which is the primary entity responsible for smart meter data acquisition and telemetry to energy suppliers, was yet to take place.
- Recently, the House of Commons Science and Technology Committee report found that the Government is not being clear on the benefits of smart meters.
- After over a year of delays to its technology, DCC's system went live in November but was found to be unable to support pre-payment meters, which supply around six million homes across the country. The complete version is expected in the spring, almost two years later than expected.

# Smart metering in UK

- The UK government planned to install smart meters in every home by 2020 to reduce national household energy consumption by 5-15%, and thereby help meet the UK's climate change targets.
- Lack of consumer engagement, insufficient information, and inadequate attention to vulnerability has slowed down the UK roll-out of energy smart meters.
- In a year, energy providers had only managed to install the meters in 7% of homes. To hit the target by 2020, suppliers would need to install 40,000 smart meters per day for the duration of the programme.
- The new technology is not only supposed to increase awareness around household energy needs, but also make households more energy efficient and reduce energy bills. However, rather than engaging consumers about the potential benefits, the technology has only generated 'confusion and resistance' in many households.
- Some of the 2 million households already fitted with the smart meters experience problems with their accuracy, meaning they can receive demands from their energy provider to make extra payments to cover their actual usage.
- One woman received a bill of £1,900, more than a year after having a smart meter installed, because it had not been configured correctly.
- Some people reported that smart meters had been installed but had failed to send readings back to their supplier.

# Key takeaway from the UK smart meter roll-out Program

- Smart meters should signal the end of inaccurate bills and it's not right that people with this technology should suffer because of suppliers' mistakes. Setting a limit on the time period for which suppliers can send catchup bills for smart meters will give people greater protection when things go wrong.

- Smart meters should be installed at locations from where they can conveniently send data to the power utility or else some signal augmentation device should be coupled with them if they are installed in the basements or other areas with poor signal reception.

- Need to improve consumer engagement and the provision of information about the benefits of the technology. This is especially true when it comes to vulnerable classes of people, such as the elderly and those less educated.

# Thank you