PPT slides will be available at

www.srahman.org
What is the Smart Grid?
This is the Electric Power Grid

Source: www.sxc.hu
Desire to make the grid smarter, safer, reliable and more cost-effective using advanced sensors, communication technologies and distributed computing.
Difference Between a Normal Grid And a Smart Grid

Normal Phone

Smart Phone

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Beginning and End of Smart Grid

From Generator to Refrigerator

- Power Plant
- Transmission
- Distribution
- Home Business
- End-use Appliances
Building Blocks of a Smart Grid

- Technology
- Standards
- Rates & Regulations
- Consumer Awareness & Education
What Makes it Smart?

Intelligence
Two-way communication
Real-time monitoring & control
Merging Power Flow with Information Flow

Integrated Communications
Electric Power & Communication Infrastructures

1. Power Infrastructure

- Central Generating Station
- Step-Up Transformer
- Distribution Substation
- Receiving Station
- Distribution Substation

2. Information Infrastructure

- Control Center
- Micro-turbine
- Residential Data Concentrator
- Photovoltaics
- Batteries

Residential

Data network Users

Source: EPRI
Interconnected Intelligent Microgrids

Intelligent Load
Demand or price-driven control of appliances

Sensors
Detect outages, fluctuations, and disturbances

Distribution Network
Interconnected micro grids

Distributed Arch.
Local monitoring and control

Bulk Power Plant

Wind Power Park

Smart Inverters and Storage
Minimize voltage and power fluctuations

Control Room Functions
Balance electricity supply/demand across the grid

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Beginning of the Smart Grid

- Smart meter is just the beginning of a smart grid

- Two-way communication allows customer participation
Remote detection – sensors everywhere
Central and distributed analysis
Correction of disturbances on the grid
Optimizes grid assets
Distribution Automation
Leverage data to understand system performance better
“Self Healing”
Enable use of renewable resources
Enable electrification of transportation

Source: EnerNex
Issues in Smart Grid Deployment

• Regulatory
• Business
• Technical
• Security and Privacy
Regulatory Issues

- Time varying rates
- Who pays the upfront costs
- Customer desire for information
Business Issues

- Return on investment
- Customer acceptance
- Trained manpower
Technical Issues

- Service monitoring and recovery
- Remote meter reading & billing
- Transformer/Switchgear loading
- Peak load reduction
- Renewables integration
- Demand response applications
Faster Recovery from Outages

Smart meters allow automated outage information notification.

Distribution automation and advanced switching capability allow sectionalizing and faster distribution circuit reconfiguration to restore healthy sections to service.
Peak Load Management

- Peak load of 19,140 MW
- Peak loads exceed 16,000 MW only 5% of the time
- 3,140 MW or 16.5% of peak load
Peak Load Management Opportunities

- In the **US** 15% of the load happens 5% of the time
- In **Australia** 15% of the load happens less than 1% of the time
- In **Egypt** 15% of the load happens 1% of the time
- In **Saudi Arabia** 5% of the load happens 0.5% of the time
The presence of smart meters allow conservation voltage reduction (CVR). Smart meters can be equipped with WiFi capability to address thermostats, water heater controllers, etc.
Secure the communication between the customer meter and utility data center

Points of vulnerability
- Smart meter, communication between the meter and data collection point, utility data storage

Who owns the data?

What can the utility do with the data?
Changing Landscape of the Electric Utility & the Smart Grid
Issues with Distributed Generation

- Wind and solar are intermittent
- Hydro is space limited
- Resource is free but not always usable
Wind Energy
Wind Output & Load Mismatch (PJM)
(A peak day in June)

1-minute wind power variation at a 150-MW Farm in Texas, USA

Wind output can drop 43.7 MW in 1 minute for a single 150-MW wind farm

Source: NREL
Hourly wind power variation (MW) in Texas, USA

01 Jan

02 Jan

Installed Capacity 4,541 MW
Hourly wind power variation (MW) in Texas, USA

Installed Capacity 4,541 MW
Roof-top Solar Photovoltaics in Virginia
7-Day Solar PV Output in Virginia
Smart grid can provide a balance between the variable supply, demand and storage.

Short term load control for a large number of end-use devices through demand response makes it possible to get quick load relief to partially match fluctuations in generation.
Demand Response is a customer action to control load in response to signals that could be price driven or triggered by system reliability concerns. Here the customer can choose what load to control and for how long.

This is different from Demand Side Management (DSM) where the load is controlled by the electric utility, but the customer has no control beyond the initial consent. Water heater control, A/C control, etc.
A Customer-facing Approach:

• A demand reduction request (kW) is sent to individual residential/commercial/industrial customer through a customer interface device.

• The customer now has a choice and can decide which appliances to control based on their preference and load priority.
Customer Load Control

1) HEM unit and 2) load controller box
Thank you

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