Smart Grid Overview

Ryan Egidi
Integrated Electric Power Systems
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Topics

• The "Case for Action"
• What is the Smart Grid?
• The Systems View
• Performance Modes
• Principal Characteristics
• Key Technology Areas
• Metrics
Case for Action

- Today’s grid is aging and outmoded
- Unreliability is costing consumers billions of dollars
- Today’s grid is vulnerable to attack and natural disaster
- An extended loss of today’s grid could be catastrophic to our security, economy and quality of life
- Today’s grid does not address the 21st century power supply challenges
- Missed opportunity to enjoy the benefits of a Smart Grid
- Disturbing trends in prices, reliability, peak loads, transmission congestion, & asset utilization

But is it worth it?
Smart Grid Supports 21st-Century Demand

The grid of the last century: large, centralized plants ship power in one direction — to the customer

The modern grid incorporates new centralized plants with renewables, distributed generation, “aggregated” backup generators, energy storage, and demand-response programs — seamlessly and safely
The “Market” will create new stresses

- **Generation**: 47% • 17,342 units
  - 500 wind parks
  - 50 solar parks

- **Transmission**: 43% • 164,000 miles
  - 5,000 distributed wind
  - 5,000 utility solar

- **Distribution**: 34% • 3 million miles

- **Consumer Systems**
  - <1%
  - 12.3 M DG
  - 25 M residential solar
  - 1 M PHEV/PEV
  - 10 M PHEV/PEV
  - 50 M PHEV/PEV

- **Demand Response Conservation**
- **2 M architectural wind**
- **5 M building solar**

- **100,000 Buildings as PP**
Electric Power System

- Markets, System Operators and Communications

- Generation and Storage
- Transmission
- Substations
- Distribution & DER
- Consumers & DER
The Systems View

Key Success Factors

- Performance
- Metrics
- Principal Characteristics
- Key Technology Areas
The Smart Grid is MORE:

- Reliable
- Secure
- Economic
- Efficient
- Environmentally friendly
- Safe
Some of the performance modes include:

- Emergency Response
- Restoration
- Routine Operations
- Optimization
- System Planning
Smart Grid Characteristics

**Principal Characteristics of a Modern Grid:**

- *Enable* active participation by consumers
- *Accommodate* all generation and storage options
- *Enable* new products, services, and markets
- *Provide* power quality for the digital economy
- *Optimize* asset utilization and operate efficiently
- *Anticipate & respond* to system disturbances (self-heal)
- *Operate* resiliently against attack and natural disaster

...the enabler
It will “Enable active participation by consumers”

- **Consumers have access to new information, control and options to engage in electricity markets**
  - Reduce consumption and energy bill
  - Enable new technologies (PHEV, HAN, EMS, smart appliances, etc.)
  - Sell resources for revenue or environmental stewardship
  - Incentives to participate (i.e. smart rates)

- **Grid operators have new resource options**
  - Reduce peak load and prices through demand response
  - Improve grid reliability
  - Ancillary services

<table>
<thead>
<tr>
<th>Today</th>
<th>Tomorrow</th>
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<tbody>
<tr>
<td>Little or no info, limited use of smart pricing, few choices</td>
<td>Full price info, choose from many plans, prices and options, buy and sell, “E-Bay”</td>
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</table>
It will “Accommodate all generation and storage options”

- Seamlessly integrates all types and sizes of electrical generation and storage systems
- “Plug-and-play” convenience
  - Simplified interconnection processes
  - Universal interoperability standards
- “Moves the needle”– shifts to a more decentralized model
- Large central power plants will continue to play a major role.

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<td>Dominated by central generation. Little DG, DR, storage, or renewables</td>
<td>Many “plug and play” distributed energy resources complement central generation</td>
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It will “Enable new products, services and markets”

• Links buyers and sellers – consumer to RTO
• Supports the creation of new electricity markets
  – Demand Response
  – Energy, Capacity, Ancillary Services
  – Brokers, integrators, aggregators, etc.
  – In-home devices and applications
• Provides for consistent market operation across regions

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<td>Near-zero market interaction at distribution level</td>
<td>Distribution assets and consumers act as resources for transmission, growth of new secondary markets</td>
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It will “Provide power quality for the digital economy”

- Monitors, diagnoses and responds to PQ issues
- Supplies various grades of power quality at different pricing levels
- Greatly reduces consumer losses due to PQ (~$25B/year)
- Quality Control for the grid

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<td>Focus on outages not power quality</td>
<td>PQ a priority with variety of price/quality options based on needs</td>
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It will “Optimize asset utilization and operate efficiently”

- **Operational improvements**
  - Improved load factors and lower system losses
  - Integrated outage management
  - Risk assessment

- **Asset Management improvements**
  - The knowledge to build only what we need
  - Improved maintenance processes
  - Improved resource management processes
  - More power through existing assets

- **Reduction in utility costs (O&M and Capital)**

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<td>Limited grid information &amp; minimal integration with asset management</td>
<td>Deep integration of grid intelligence enabling reduction in O&amp;M and CapEx</td>
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It will “Anticipate & respond to system disturbances”

• Performs continuous self-assessments
• Detects, analyzes, responds to, and restores grid components or network sections
• Handles problems too large or too fast-moving for human intervention
• Self heals - acts as the grid’s “immune system”
• Supports grid reliability, security, and power quality

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<td>Protects assets following disruption (e.g., trip relay)</td>
<td>Prevents disruptions, minimizes impact, restores rapidly</td>
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It will “Operate resiliently against attack and natural disaster”

- System-wide solution to physical and cyber security
- Reduces threat, vulnerability, consequences
- Deters, detects, mitigates, responds, and restores
- “Fort Knox” image
- Decentralization and self-healing enabled

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<td>Vulnerable to terrorists and natural disasters</td>
<td>Deters, detects, mitigates, and restores rapidly and efficiently—“cyber proof”</td>
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Key Technology Areas

- Performance
- Key Success Factors
- Principal Characteristics
- Metrics
- Key Technology Areas

The Smart Grid is a System.

- Advanced Control Methods
- Integrated Communications
- Advanced Components
- Decision Support & Improved Interfaces
- Sensors and Measurement
Sensors and Measurement

Smart meters
Smart sensors
- Operating parameters
- Asset Condition

Wide area monitoring systems (WAMS)
Dynamic rating of transmission lines
Advanced Control Methods

Applications that:
- Monitor and collect data from sensors
- Analyze data to diagnose and provide solutions
- Real time and predictive
- Determine and take action autonomously or via operators
- Provide information and solutions to operators
- Integrate with enterprise-wide processes and technologies
Decision Support & Improved Interfaces

- Advanced Control Methods
- Integrated Communications
- Sensors and Measurement
- Advanced Components

- Decision Support & Improved Interfaces

- Data reduction
- Data to information to action
- Visualization
- Speed of comprehension
- System operator training
Advanced Components

- Advanced Control Methods
- Integrated Communications
- Decision Support & Improved Interfaces
- Sensors and Measurement

**Next generation FACTS/PQ devices**
- Advanced distributed generation and energy storage
- PHEV - V2G mode
- Fault current limiters
- Superconducting transmission cable & rotating machines
- Micro-grids
- Advanced switches and conductors
Integrated Communications

Consider all needs:
- Smart meters
- Smart sensors
- Demand Response
- DG dispatch
- Distribution automation
- Micro-grids
- Markets
- Work force management
- Mobile premises (PHEV’s)
Smart Grid Metrics

• Metrics are needed to measure progress in achieving the vision.
  – Build metrics are leading indicators and measure progress in the implementation of the Smart Grid.
  – Impact metrics measure how the Smart Grid influences the Key Success Factors.

If we do this right – we can all be winners
  – Suppliers
  – Consumers
  – Society
Value Proposition

• Utilities (What’s in it for my shareholders?)
  – Rate of return, outage restoration, billing, reduce T&D losses, optimize asset utilization, maintenance, planning and improved customer satisfaction

• Consumers (What’s in it for me?)
  – More reliable service, reduce business loss, energy bill savings, transportation cost savings, options, sell resources into the market

• Society (What’s in it for us?)
  – Rate Downward pressure on prices, improved reliability, grid robustness, new jobs and growth in GDP, revolutionize the transportation sector and reduce import of foreign oil.

• Overall benefit to cost ratio is 4:1 to 5:1
For More Information

For additional Information:
www.netl.doe.gov/smartgrid

Federal Smart Grid Website
www.smartgrid.gov

Smart Grid Information Clearinghouse
www.sgiclearinghouse.org

Ryan Egidi
National Energy Technology Lab
304-285-0945
Ryan.Egidi@netl.doe.gov