Smart Grid Demonstrations
Integrating Large Scale Distributed Energy Resources

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### Smart Grid

**Sensors….Two Way Communications….Intelligence**

<table>
<thead>
<tr>
<th>Markets</th>
<th>Transmission</th>
<th>Substation</th>
<th>Distribution</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
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</tbody>
</table>

### Information & Communication Enabled Power Infrastructure

#### Acting on this Information Will:

<table>
<thead>
<tr>
<th>Enable active participation by consumers</th>
<th>Anticipate &amp; respond to system disturbances (self-heal)</th>
<th>Accommodate all generation and storage options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate resiliently against attack and natural disaster</td>
<td>Enable new products, services and markets</td>
<td>Provide power quality for the digital economy</td>
</tr>
<tr>
<td>Optimize asset utilization and operate efficiently</td>
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Smart Grid Demonstrations will Manage Expectations to enable Realistic Business Evaluation and take us Quickly to the Plateau of Productivity
Smart Grid – CO₂ Impact from Integrating DER

1. Smart Grids and Communication Infrastructure
2. Transmission Grids and Associated Energy Storage Infrastructures
3. Advanced Light Water Reactors
4. Coal-Based Generation Units with CO₂ Capture and Storage

Avoided CO₂ Emissions from Smart Grid, 2030 (Tg CO₂)*

<table>
<thead>
<tr>
<th>Technology Challenges</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Feedback</td>
<td>60</td>
<td>211</td>
</tr>
<tr>
<td>PHEV Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE &amp; Demand Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Load Mgmt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Line Losses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cont. Comm. Large Commercial Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total U.S. CO₂ Emissions</td>
<td>~3%</td>
<td>~10%</td>
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</tbody>
</table>

~80% of Avoided CO₂ Emissions from Smart Grid are from Integration of DER

* Source: EPRI Publication 1016905, The Green Grid Savings and GHG reduction Enabled by a Smart Grid
EPRI Smart Grid Demonstrations

• Integration of Distributed Energy Resources (DER)

• Deploying the Virtual Power Plant

• Several regional demonstrations
  – Multiple Levels of Integration
  – Multiple Types of Distributed Energy Resources & Storage

• Leverages Information & Communication Technologies
EPRI Smart Grid Demonstration Goals

• 5 Year Initiative

• Leverage Utility Investments
  – Application of Technologies & Standards Available Today
  – Research Beyond Scope of Typical Utility Deployment
    • Advance/Further Technology, Standards, Interoperability

• Leverage the Collaboration Benefits
  – The Whole is Greater than the Sum of its Parts

• Understand the “State of the Smart Grid”
  – Cost Benefit Analysis (CBA)
  – Gaps in Technology, Standards, CBA
Smart Grid Demonstration Approach

- Integration of DER with Utility Operations

- Ensure Interoperability of DER
  - Demonstrating use of common language to exchange information with distributed resources from various manufacturers
  - Multiple use of communication and metering infrastructure for control, measurement & verification of the dispatchable resource

Shared Learning from Multiple Demonstrations and Use of EPRI’s IntelliGrid Architecture will Lend to Expandability, Scalability, and Repeatability
Diverse Characteristics Lead to Multiple Demonstration Sites

- Regional characteristics
  - Weather
  - Regulatory / Market
  - Availability of Renewable Generation & Storage

- Customer / Load characteristics
  - Residential, Commercial, Industrial

- Distribution system characteristics
  - Rural, suburban, urban overhead and underground systems

- Communication Infrastructure available
  - Public (internet, cellular)
  - Private (AMI, licensed)
Objectives of the Demonstration Initiative

- Define information models and communications interfaces
  - All Levels of distributed resource integration (home, enterprise, market)

- Develop application guidelines, integration requirements and standards for distributed resource integration.

- Field Assessments to:
  - Understand required systems and technologies for distributed resource integration

- Verify Smart Grid business case assumptions
  - Describe costs and benefits associated DER Integration
Using IntelliGrid Methodology to Develop the Smart Grid Architecture

- **Business Case/Cost Benefit Analysis**

- **Define** Requirements of Each Smart Grid Application using the **Use Case Process**

- **Design** an Architecture for Security, Data Management and Network Management

- **Select** Technologies, Finalize Cost Benefit Assessment

EPRI’s IntelliGrid Methodology is Accepted as an International Recommended Specification and an Industry Best Practice to Architect a Smart Grid
Collaboration with DOE Distribution Integration Awards

- Allegheny Power, WVU, NC State, Research & Development Solutions, Augusta Systems, Tollgrade – **West Virginia Super Circuit**


- Chevron Energy Solutions, Alameda County, PG&E, VRN Power Systems, SatCon, Univ of Wisc., NREL, LBNL, E3 – **Solar, fuel cell and storage microgrid**.

- City of Fort Collins, Colorado State Univ, InteGrid Lab, Comm Found of Northern Col, Governor’s Energy Office, Advanced Energy, Woodward Spirae, Eaton – **3.5 MW mixed distributed resources for peak load reduction**.

- IIT, Exelon/ComEd, Galvin Electricity, S&C – “perfect Power” demonstration

- Con Edison, Verizon, Innovative power, Infotility, Enernex – **Interoperability between utility and end use customers for DG aggregation**.

- SDG&E, Horizon Energy Group, Advanced Control Systems, PNNL, Univ of San Diego, Motorola, Lockheed Martin – **Integrating multiple distributed resources with advanced controls**.

- Univ of Hawaii, GE, HECO, MECO, Columbus Electric Coop, NM Inst of Mining and Tech, Sentech, UPC Wind – **Mgt of distributed resources for improved quality and reliability, grid support, and transmission relief**.

- Univ of Nevada, Pulte Homes, Nevada Power, GE Ecomagination – **Integrated PV, battery storage, and consumer products with advanced metering**.
# Project Participants and Collaboration

<table>
<thead>
<tr>
<th>EPRI BoD Initiative &amp; IntelliGrid Program</th>
<th>EPRI/Utility Team</th>
<th>Standard Development Organizations (SDO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Energy Commission</td>
<td>OPEN HAN</td>
<td>IEEE</td>
</tr>
<tr>
<td>NYSERDA</td>
<td>OPEN SEC</td>
<td>AHAM</td>
</tr>
<tr>
<td>Others</td>
<td>OPEN AMI</td>
<td>NIST</td>
</tr>
<tr>
<td></td>
<td>OPEN Enterprise</td>
<td>NEMA</td>
</tr>
<tr>
<td></td>
<td>Utility AMI</td>
<td>SAE</td>
</tr>
<tr>
<td></td>
<td>GridWise Alliance</td>
<td>J2836 (Communication between utility and Plug-in-vehicles)</td>
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<td></td>
<td>European Smart Grid Initiatives</td>
<td>ANSI</td>
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<td></td>
<td>Manufacturers</td>
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Smart Grid Demonstration Critical Elements

1. Integration of Multiple Distributed Resource Types
   - Demand Response, Distributed Generation, Storage, Renewable Generation

2. Connect retail customers to wholesale conditions
   - Dynamic Rates, Ancillary Services

3. Integration with System Planning & Operations
   - Level of integration, Tools & Techniques, Visibility
4. Critical Integration Technologies and Standards
   – Use of standards, common object models, Comm interfaces

5. Compatibility with EPRI’s Initiative and Approach
   – Use cases, business case development, enables wide spread integration

6. Funding requirements and leverage of other funding resources
   – Government, Research Orgs, Vendors, Universities
   – Capitol costs born by utility
Host Sites Overview  (3 sites selected, expecting 8-10 total over 5 years)

<table>
<thead>
<tr>
<th>Resources</th>
<th>Consolidated Edison</th>
<th>FirstEnergy</th>
<th>PNM Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Distributed Generation</td>
<td>HVAC (Res., C&amp;I) DR Electric Storage Thermal Storage</td>
<td>Solar PV (residential &amp; System) Storage &amp; DR</td>
</tr>
<tr>
<td>Integration</td>
<td>End-to-end (Customer owned DG, DR provider, Con Edison, NYISO)</td>
<td>Real Time T&amp;D Ops &amp; Planning PJM</td>
<td>HAN, SCADA, System Ops &amp; Planning</td>
</tr>
<tr>
<td>Diversity</td>
<td>Dense Urban Environment Customer Owned Resources</td>
<td>Smart Grid w/Out use of AMI system Master Controller Concept</td>
<td>Large deployment of Residential PV. Optimization Incl. Volt &amp; Freq control</td>
</tr>
<tr>
<td>Business Case</td>
<td>Increase Reliability Reduce Peak Demand</td>
<td>Grid efficiency and reliability at local level</td>
<td>15% peak load reduction at feeder</td>
</tr>
<tr>
<td>Furthers Industry</td>
<td>Interoperability of Distributed Energy Resources (DER)</td>
<td>Local delivery system Integration of DER</td>
<td>Technologies &amp; Standards for Renewable Integration</td>
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Sample of Deliverables

- Smart Grid Resource Center & Use Case Repository
  - www.smartgrid.epri.com
- Smart Grid Economic Assessment / Cost Benefit Analysis
  - Co-Developing with DOE & Oak Ridge National Labs
- Smart Grid Architecture Framework
  - How to Minimize Risk of Technology Obsolescence
- Analytical Tools
  - Modeling, CO2 Impact, Regulatory Impact
- Lab & Field Trials of Technology
Smart Grid Resource Center

This site serves as a home for information about EPRI Smart Grid research, demonstration projects, and the Smart Grid Use Case Repository.

Smart Grid
A Smart Grid is one that incorporates information and communications technology into every aspect of electricity generation, delivery and consumption in order to:
- minimize environmental impact;
- enhance markets;
- improve reliability and service;
- reduce costs and improve efficiency.

Smart Grid Use Case Repository
The Use Case Repository is a public resource for the electric power industry to house Smart Grid related use cases as well as provide a forum for the industry to contribute to this effort by submitting their own use cases.
- Use Case Repository

Smart Grid Advisory Update Newsletter
- December
- November
- September

EPRI Smart Grid Resource Center launched: www.smartgrid.epri.com
Smart Grid Use Case Repository

Use Case Categories

- General (18)
- Customer Services (22)
- Distributed Energy Resources (3)
- Distribution Operations (3)
- Market Operations (6)
- Transmission Operations (8)

View all Smart Grid Use Cases (61)

The Use Case Repository is a collection of Smart Grid use cases and requirements developed within the industry as well as through EPRI's smart grid demonstration initiative. All Use Cases are delivered as PDFs. All Use Cases are under the Creative Commons license. You may use the NIST Use Case Template to create your own use cases and submit them to mwakefield@epri.com for posting.

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Category: Customer Services

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Summary

• Maximize the benefits of existing and planned investments
  – Communications and advanced metering infrastructures
  – Identify and further the foundation for demand side resource integration.

• Integration of distributed resources with utility system operations and planning

• Integration of distributed power generation, storage, demand response technology, and renewables into a demand-side virtual power plant.

• Demonstrations should further the industry in regards to integration of distributed resources

• Expect 8-10 EPRI Demonstrations
Questions?