Smart Grid Technology Landscape
Use of digital technology to improve reliability, security, and efficiency of the electric system with applications for dynamic optimization of system operations, maintenance, and planning
**Smart Grid Challenges**

Smart Grid System Report (July 2009)* identifies challenges to smart grid deployments in 4 broad categories:

- Costs and their recovery
- Interoperability standards
- Technical barriers
- Changing technologies and policies


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**American Recovery and Reinvestment Act ($4.5 B) Jumpstarts Smart Grid**

<table>
<thead>
<tr>
<th>Office of Electricity Delivery and Energy Reliability</th>
<th>$ Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Grid Investment Grant Program; ±3 years</td>
<td>$3,400</td>
</tr>
<tr>
<td>Smart Grid Demonstrations; 3-5 years</td>
<td>$615</td>
</tr>
<tr>
<td>Interoperability Framework Development by NIST</td>
<td>$10</td>
</tr>
<tr>
<td>Resource Assessment and Interconnection-Level</td>
<td>$80</td>
</tr>
<tr>
<td>Transmission Analysis and Planning</td>
<td></td>
</tr>
<tr>
<td>State Electricity Regulators Assistance</td>
<td>$50</td>
</tr>
<tr>
<td>Enhancing State Government Energy Assurance</td>
<td>$55</td>
</tr>
<tr>
<td>Capabilities and Planning for Smart Grid Resiliency</td>
<td></td>
</tr>
<tr>
<td>Workforce Development</td>
<td>$100</td>
</tr>
</tbody>
</table>

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**Recovery Act: Smart Grid Investment Grants**

(100 projects: $3.4B Federal; $4.7B non-Federal)

<table>
<thead>
<tr>
<th>Smart Grid Infrastructure and Equipment</th>
<th>Numbers of Items</th>
<th>Improvements</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational Phase: Measurement Links</td>
<td>872</td>
<td>- Non-nationwide coverage</td>
<td>Enhanced educational awareness and electric system resiliency</td>
</tr>
<tr>
<td>Smart Transformers</td>
<td>203,083</td>
<td>- Enable preventative maintenance</td>
<td>1440 MWh of peak demand reduction per year (self-reported savings)</td>
</tr>
<tr>
<td>Automated Substations</td>
<td>671</td>
<td>- 5% of close transmission and distribution substations in the U.S.</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
<tr>
<td>Load Control Devices</td>
<td>170,014</td>
<td>- Enable peak demand reductions</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
<tr>
<td>Smart Thermoregs</td>
<td>170,210</td>
<td>- Enable peak demand reductions</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
<tr>
<td>Smart Meters</td>
<td>18,679,602</td>
<td>- 12% of the 142 million consumers in the U.S.</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
<tr>
<td>In-Home Displays</td>
<td>1,185,265</td>
<td>- Enable customer empowerment</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
<tr>
<td>PHENs / Charging Stations</td>
<td>12 / 109</td>
<td>- Accelerated market entry</td>
<td>Transformational changes in consumer behavior and energy consumption</td>
</tr>
</tbody>
</table>

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**Smart Grid Value in Power Disturbance Savings**

Smart Grid technologies would reduce power disturbance costs to the U.S. economy by $49 billion per year, according to the EAC report titled “Smart Grid, Enabler of the New Energy Economy,” December 2008.

43 significant disturbances and outages occurred in 2008, as compared with 30 such events in 2007. A rise in misoperations of protection systems and controls and other factors (equipment failure, vegetation contacts, and human error) drove the increase in 2008.

North American Electric Reliability Corporation, Reliability Performance Gap Index

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**DOE’s Smart Grid Development Engages Public/Private Partnerships to Leverage All Available Resources**

<table>
<thead>
<tr>
<th>Partnerships</th>
<th>Transformation</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Recovery Act; commercial applications and demonstrations of near-term technology</td>
<td>Dynamic Optimization of Grid Operations &amp; Resources</td>
<td>Reduced Peak Load and Consumption</td>
</tr>
<tr>
<td>• Base Programs; R&amp;D on longer-term technology</td>
<td>Demand Response and Consumer Participation</td>
<td>Operational Efficiency</td>
</tr>
<tr>
<td>International Coordination</td>
<td></td>
<td>Grid Reliability and Resilience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More Distributed and Renewable Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Carbon Dioxide Emissions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enhanced Economic Productivity</td>
</tr>
</tbody>
</table>

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**Smart Grid Value in Energy Efficiency**

Assuming 100% penetration of smart grid in 2030:

- 12% direct reductions from smart charging of PHEVs at very high penetrations (> 100%)
- 5% indirect reductions from reinvestment of $50 billion from avoiding the additions of extra capacity for regulation and reserves to support a 25% renewable portfolio standard
- $55 billion uncertainty under each mechanism investigated

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**Smart Grid Task Force: Federal Coordination**

Established under authorization of EISA 2007 to ensure awareness, coordination, and integration of the diverse smart grid activities in the Federal Government.

- **Functions**
  - Serves as Federal focal point on all things “smart grid”
  - Coordinates and integrates inter-governmental activities
  - Oversees report production for submission to Congress
  - Collaborates with and supports the Electricity Advisory Committee

- **Member Organizations**
  - DOE (OE / EERE / NETL)
  - FERC
  - EPRI
  - NREL
  - NIST (INL, ITA)
  - DOD
  - USDA
  - DHS

- **Website**
  - [www.oe.energy.gov/smartgrid_taskforce.htm](http://www.oe.energy.gov/smartgrid_taskforce.htm)
  - Charter
  - Presentations
  - Publications
  - Events

**High Penetration Solar Energy Challenges**

- For high distributed PV penetration
  - Significant fluctuations in electricity output requires other grid assets to compensate for it
  - Ramping issues (morning and evening) require other generators to ramp up or down
  - Potential issues when feeding electricity back into the grid (circuit breaker protection schemes are designed for unidirectional power flow)

- For solar thermal power plants
  - Operate on the principal of a steam turbine plant
  - No ramping issues because of large thermal storage
  - BUT: significant water requirements for cooling the water/steam medium of steam turbine plant

**Smart Grid Maturity Model (SGMM)**

A management tool to help utilities benchmark smart grid development and share best practices; 60+ utilities have completed SGMM surveys.

- **Regional demonstrations**
  - Demonstration of technical/operational/business-model feasibility on a regional scale
    - 8 NERC regions
    - 27 eGrid sub-regions
    - co-ops or publicly owned utilities in the (sub)regions

- **Grid-scale energy storage demonstrations**
  - Battery storage for utility load shifting or for wind farm operations
  - Frequency regulation ancillary services
  - Distributed energy storage for grid support
  - Compressed air energy storage (CAES)
  - Demonstration of promising energy storage technologies

**Recovery Act: Smart Grid Standards Development**

NIST having primary responsibility to coordinate development of protocols and model standards for interoperability of Smart Grid devices and systems.

- **Phase 1**: Identified an initial set of existing consensus standards and develop a roadmap to fill gaps
  - Draft report, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, published in September for public comment
  - Identified ~80 existing standards that can be used now for smart grid development
  - Identified 14 high priority gaps plus cyber security in need for new or revised standards

- **Phase 2**: Established public/private Standards Panel in December 2009 to provide ongoing recommendations for new/revised standards

- **Phase 3**: Initiate implementation of the testing and certification framework in 2010

**Recovery Act: Smart Grid Demonstration Program**

(32 projects: $620M Federal; $1,028M non-Federal)

- **60+ utilities have completed SGMM surveys**
- smart grid development and share best practices;
- A management tool to help utilities benchmark smart grid activities in the Federal Government
- aware, coordination, and integration of the diverse smart grid activities
- Established under authorization of EISA 2007 to ensure awareness, coordination, and integration of the diverse smart grid activities in the Federal Government

**Longer-term Smart Grid R&D**

- **Multi-Year Program Plan (FY10-14)**

- **Development**
  - MYPP to guide Smart Grid R&D investments with staged development process
    - Meeting in October involving national labs
    - Stakeholder Roundtable Meeting in December
    - Public comment in March-April 2010
  - Estimated budget: $30M in Federal funds over 5 years

- **Implementation**
  - Industry solicitation in April, with awards in September 2010
  - Estimated budget: $33M in Federal funds over 5 years
DOE Programs Addressing High Penetration PV Challenges (1)

Smart Grid R&D
- Enable the effective use of distributed energy resources to allow for increased consumer engagement, the integration of high levels of renewable generation, and the electrification of transportation
- Five R&D focus areas, plus foundation/infrastructure building

DOE Programs Addressing High Penetration PV Challenges (2)

Systems Integration
- Solar Energy Grid Integration systems (SEGIS) to develop inverters/converters with EMS interfaces for integrating solar energy with smart grid applications
- Solar system modeling & benchmarking
- Resource & Safety R&D

International Smart Grid Action Network (ISGAN)
Proposed to be announced at the Clean Energy Ministerial this summer to promote international cooperation in smart grid development and deployment targeted at maximizing GHG reductions
- Expanding bi-lateral collaborations to a global framework
- Supporting Implementation of the Major Economic Forum (MEF) Technology Action Plan on Smart Grids
- Open to all interested countries, with support through financial or in-kind contributions
- Six key areas identified for cooperation and coordination
- Governance structure determined by consensus, with the IPEEC structure being considered as a model
- Complementary to existing and proposed international institutions, such as ENARD and Global Smart Grid Federation

Upcoming International Smart Grid Events in the U.S.
- GridWise® Global Forum
  - Washington, DC, September 21-23, 2010
  - http://www.gridwiseglobalforum.org/
- GridWeek 2010
  - Washington, DC, October 18-21, 2010
- 4th International Conference on Integration of Renewable and Distributed Energy Resources
  - Albuquerque, New Mexico, December 6-10, 2010
  - http://4thintegrationconference.com/

Smart Grid Information Clearinghouse
To “make data from smart grid demonstration projects and other sources available to the public”
- Competitive award to Virginia Tech (Lead)/EnerNex/IEEE Team to establish Web-based public info clearinghouse
  - Serving as a central repository for smart grid information, including at Recovery Act smart grid projects
  - Sharing and dissemination of information on knowledge gained, lessons learned, and best practices
  - Supporting decision making by both State/Federal Regulators
- Responded to high priority identified by NARUC/FERC Smart Grid Collaborative & Electricity Advisory Committee
- Clearinghouse User Group comprising key stakeholder groups assembled to guide collaborative development

Smart Grid Resources
- Smart Grid System Report (2009)
- Smart Grid Metrics for Measuring Progress
- Smart Grid – Introduction and Stakeholder books
- Smart Grid Maturity Model
- Smart Grid Information Clearinghouse
- SmartGrid.gov
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OE: www.oe.energy.gov
Smart Grid: smartgrid.gov