Welcome to - *The Smart Grid Experience: Applying Results, Reaching Beyond*

October 27-29, 2014

Opening Session:

Patricia A. Hoffman

Assistant Secretary DOE Office of Electricity Delivery and Energy Reliability

Mark McGranaghan

Vice President of Power Delivery and Utilization, EPRI

Becky Harrison

CEO, GridWise Alliance

Antitrust Guidelines

Antitrust laws apply to EPRI, its members, funders, advisors, licensees, contractors, and vendors. Violations can lead to civil and criminal liability.

DO NOT DISCUSS…

- Pricing, production capacity, or cost information which is not publicly available;
- Sales territories, market shares, future product offerings;
- Confidential market strategies or business plans;
- Other competitively sensitive information;
- Complaints concerning customers/suppliers/competitors.

DO NOT AGREE…

- To discriminate against or refuse to deal with a supplier (boycott);
- To only do business on certain terms and conditions;
- To set (or fix) prices;
- To divide markets or technologies;
- To allocate customers/suppliers/territories;
- To suppress a technology.

"The Smart Grid Experience: Applying Results, Reaching Beyond"
October 27 – 29, 2014

Office of Electricity Delivery & Energy Reliability

Realization of the Smarter Grid

Patricia Hoffman
Assistant Secretary, Office of Electricity Delivery and Energy Reliability

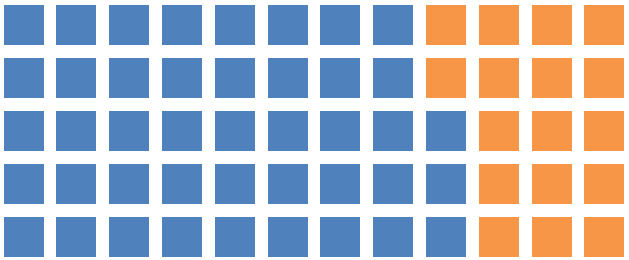
October 27, 2014

Grid Modernization Investments

SGIG projects *accelerate* industry investment to achieve a modern grid

ARRA Spending **$7.9 billion with cost share to be spent through 2015**

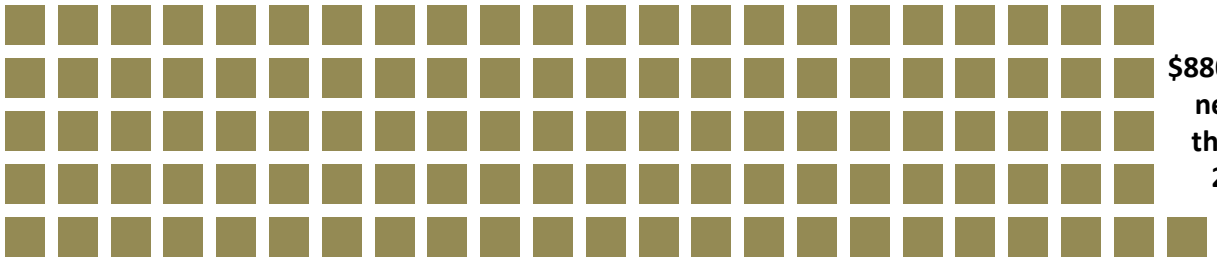
EPRI Estimate



$338 - $476 billion needed through 2030

EPRI. Estimating the costs and benefits of the smart grid: A preliminary estimate of the investment requirements and the resultant benefits of a fully functioning smart grid. EPRI, Palo Alto, CA; 2011.

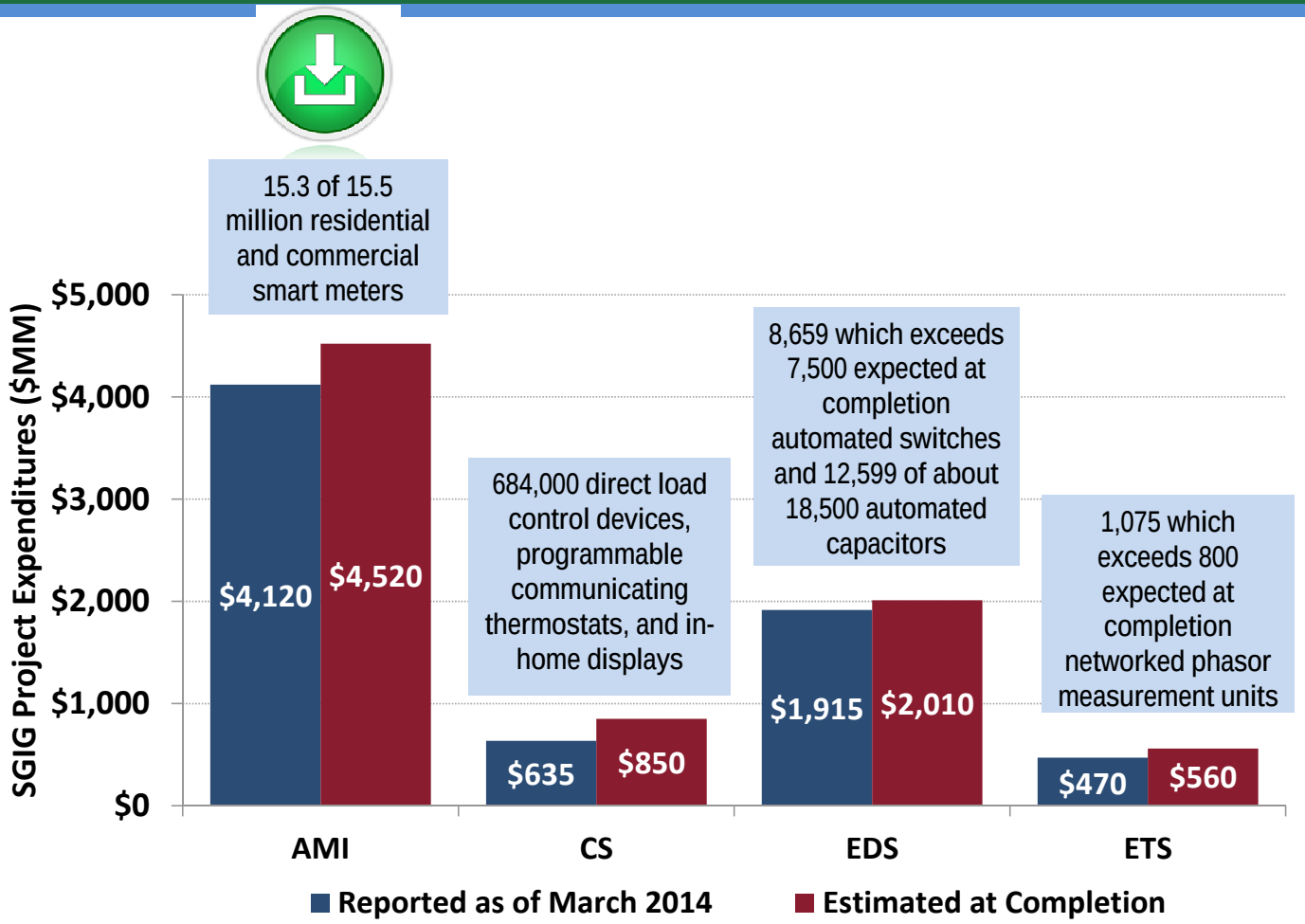
Brattle Group Estimate



$880 billion needed through 2030

Chupka, M.W. Earle, R., Fox-Penner, P., Hledik, R. Transforming America's power industry: The investment challenge 2010 – 2030. Edison Electric Institute, Washington D.C.,: 2008.

SGIG Deployment Status



PMU Technology: Enhancing Transmission Reliability

2003

2003 Blackout investigation calls for wide-area visibility into grid

2009

9 SGIG projects focus on deploying PMUs on grid, <200 PMUs deployed

2013

PMU applications developed and tested:

- Wide area visibility
- Disturbance detection
- Islanding detection
- Oscillation and frequency monitoring

2014

DOE investment helps make PMUs standard equipment and helps reduce costs by a factor of 10, total deployed PMUs tops 1,800

2015

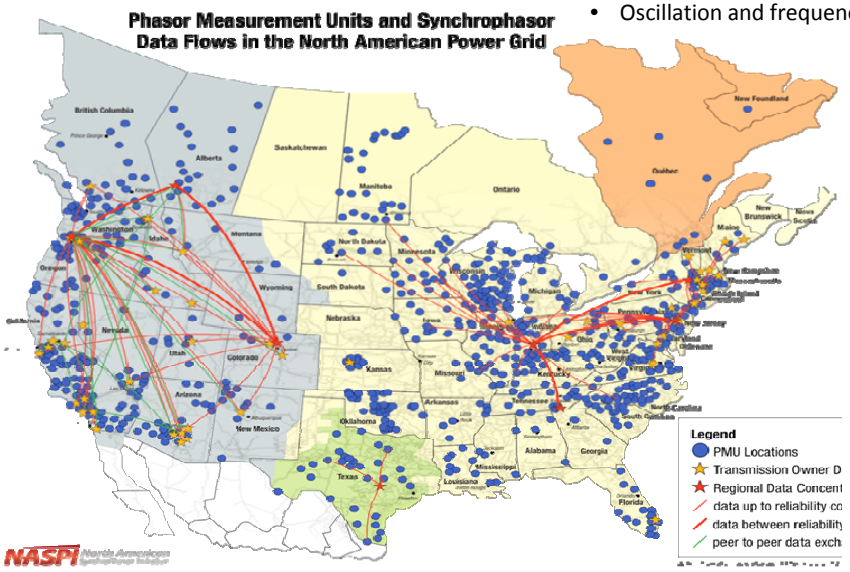
2016

Develop applications using PMU data for:

- Intelligent alarming
- Direct state estimation
- Operator decision support
- Stability monitoring
- Renewable integration
- Threats detection

2017

Control room applications of PMUs deployed



Source: Map from North American Synchrophasor Initiative, 2009

Transmission Planning Has Become Regional Electricity Delivery System Planning

1990s	2000–2012	2012–future
• Transmission planning done at utility level, with regional coordination under NERC to ensure reliability • Voluntary compliance with reliability standards	• Rise of regional planning led by RTOs • EPAct 2005 makes compliance with FERC-approved reliability standards mandatory • Interconnection-level planning w/ ARRA funding • FERC Order 1000 requires regional-scale planning	• New technologies blur boundary between transmission and distribution • Penetration of diverse distributed energy technologies • Loads becoming more controllable, price-responsive • Need to extend utility control systems and economic dispatch into distribution sector • Planners face increased variability and uncertainty

Technology and Policy:

- Reconductoring
- Evaluation of ROW for future needs
- Visualization of system performance
- Predictive analysis
- Power flow control
- Critical components
- Stress test for energy security

Distribution is Critical to Grid Modernization

1990s

- Restructuring for competition
- Utility business models evolving

2000–2014

- **Peak demand reductions exceeding 30% depending on the rate design**
- **Automated feeder switches and supporting sensors, communications equipment, and control systems is showing reliability improvements that include shorter (up to 56%) and less frequent (11%–49%) outages, and fewer affected customers**
- **Voltage regulators, automated capacitor banks, and other advanced voltage and volt-ampere reactive (VAR) technologies are showing conservation voltage reductions that range from 1 to 2.5 percent during peak periods**

2014–future

- Penetration of diverse distributed energy technologies
- Loads becoming more controllable, price-responsive
- Need to extend utility control systems and economic dispatch into distribution sector
- Business model – uncertain

Technology and Policy:

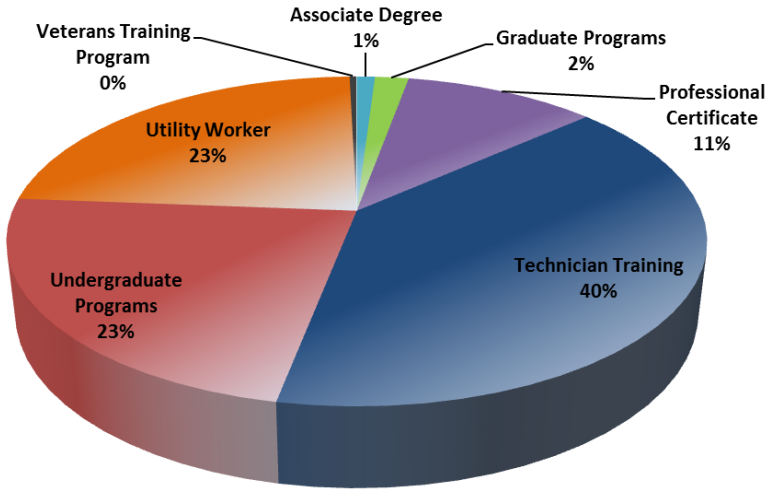
- Visualization of system performance
- Transactive or market-based control signals
- Set reliability expectations, Microgrids
- Next Generation Energy Management Systems

Workforce Development

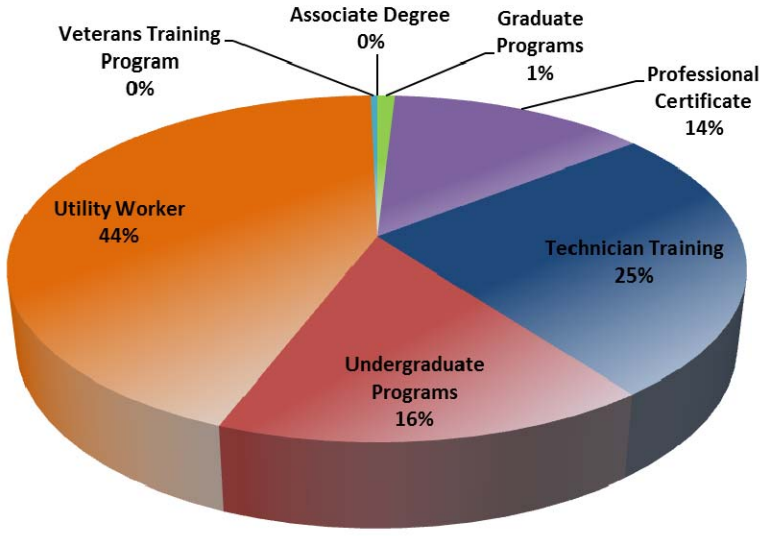
Table 1: Summary of Awards

Program Area	Number of Awards	Total Award Value ($)
Developing and Enhancing Work-force Training Programs (Topic A)	21	$13,756,289
Strategic Training and Education in Power Systems (STEPS)	11	$27,346,317
Smart Grid Workforce Training Projects (Topic B)	17	$52,552,741
Totals	**49**	**$93,655,347**

Projected Distribution of Graduates

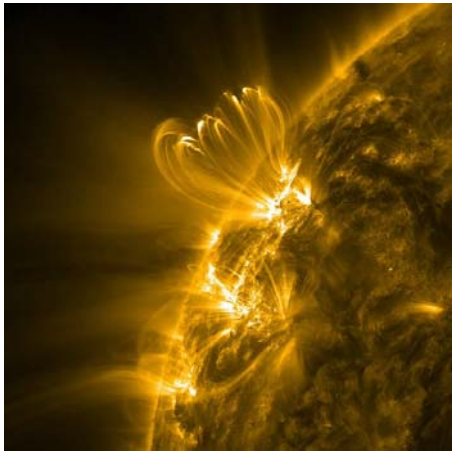


Distribution of Graduates to Date



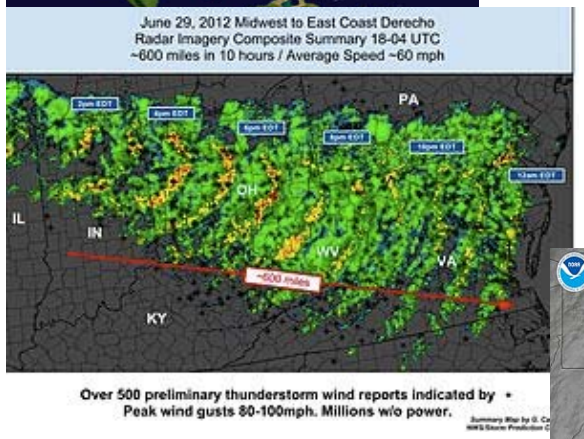
Understanding Risks

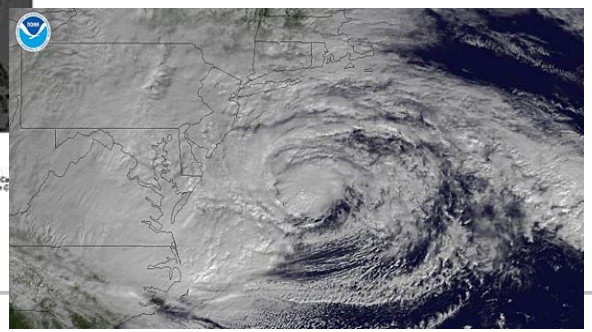
- Operational issues
- Climate/Weather
- Cyber Security
- Physical Security
- Infrastructure interdependencies
- Pandemic



Resilience combined with modernization defines success

Hurricanes/Extreme Weather





Hurricane Sandy
October 22, 2012; 115 mph winds, 148 direct deaths; $68 B economic damage;8.6 million customers (at peak)

Derecho
2012; 4.3 million customers (at peak)

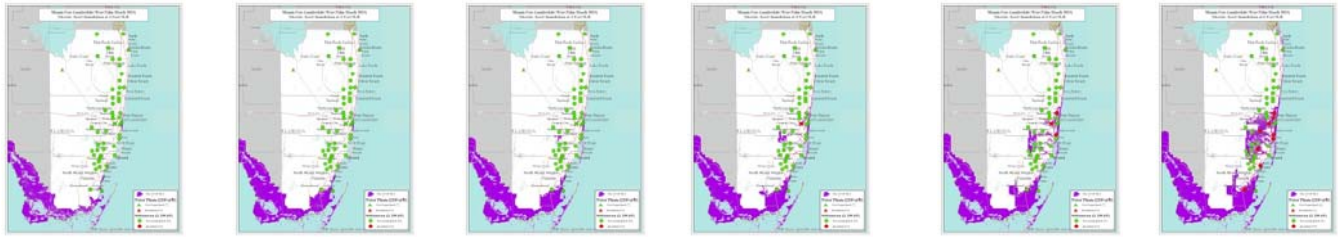
Hurricane Irene
2011; 6.7 million customers (at peak)

DOE Sea Level Rise Study

The DOE sea level report is a pilot study of four cities to help establish a baseline understanding of the threat Sea Level Rise poses to coastal energy infrastructure.

1 – 6 Ft SLR in Miami, Florida

	NCA Low Scenario						NCA Intermediate-Low Scenario						NCA Intermediate-High Scenario						NCA High Scenario					
County	1 Ft	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	1 Ft	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	1 Ft	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	1 Ft	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft
Miami-Dade, Florida	2146	2282	2418	2554	2690	2826	2073	2113	2145	2172	2197	2219	2046	2068	2086	2102	2115	2127	2035	2052	2065	2077	2087	2096

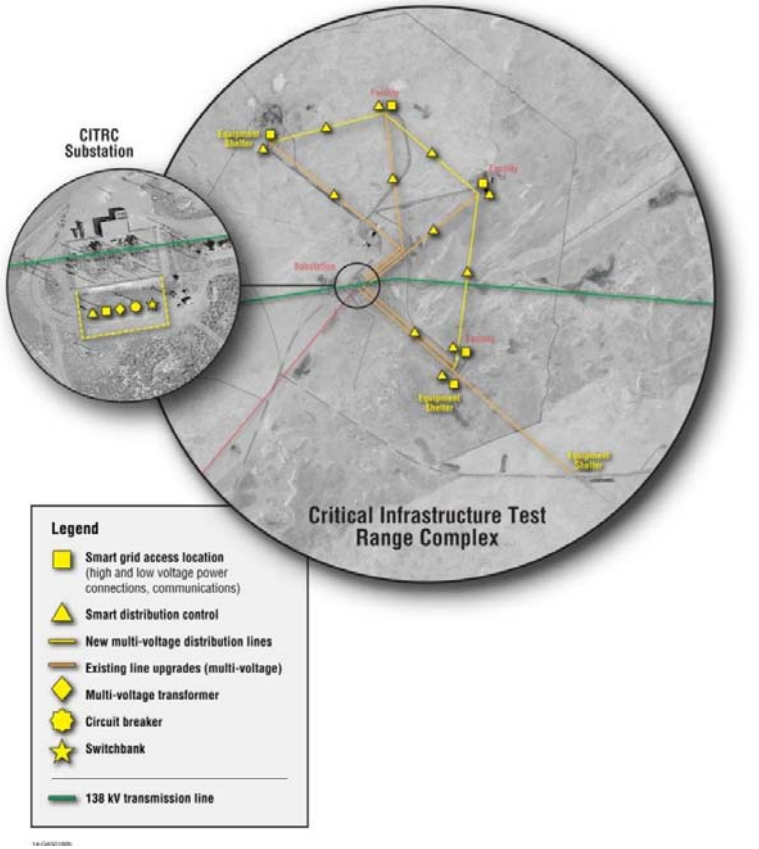


1 Ft SLR Year 2046 | **2 Ft SLR Year 2068** | **3 Ft SLR Year 2086** | **4 Ft SLR Year 2102** | **5 Ft SLR Year 2115** | **6 Ft SLR Year 2127**

Download Study on Energy.gov/OE

Idaho National Lab Grid Testing and Communications

- Increasing capability to test communications and distribution system.
- Expanding distribution test bed to model up to 62% of all US feeder configurations.
- Full fiber optic coverage plus Wireless Test Bed overlay for any communications technology.
- Smart Grid communications analysis tool development underway suitable for industry use.



Sharing Results

SGIG/SGDP Output
(DOE and Awardee Generated)

- SGIG Progress Reports
- Metrics and Benefits Reports
- Case Studies
- Presentations/Briefings & Articles
- Best Practices/Lessons-Learned
- Consumer Behavior Reports
- Technology Performance Reports

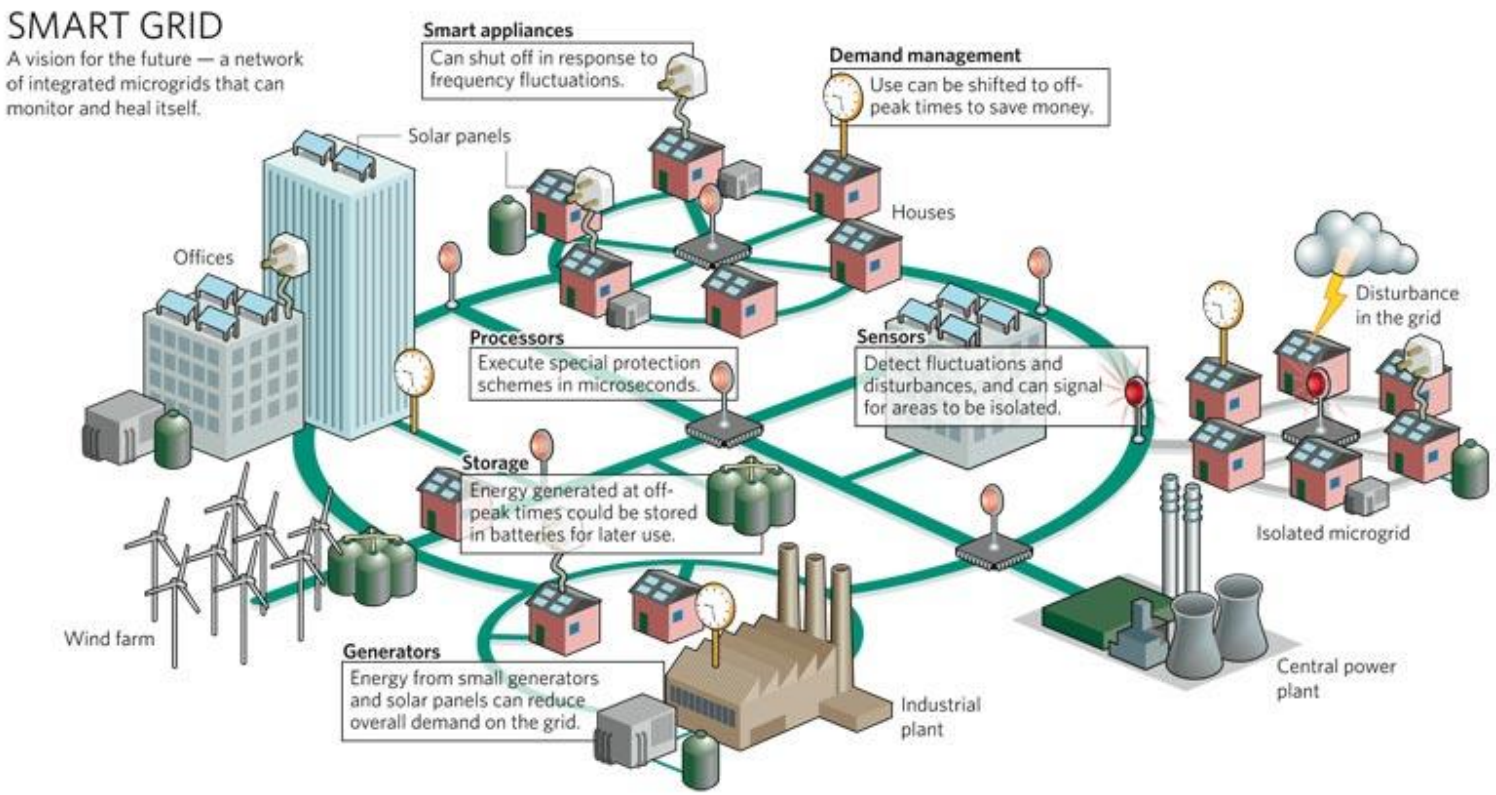
Communication Mechanisms

- www.smartgrid.gov
- Conferences
- User/focus groups
- Partner/stakeholder outreach

To Advance

- The business case for smartgrid technology
- Knowhow in systems integration an communications
- Cybersecurity practices
- Architecture and interoperability standards
- Grid integration with renewable and distributed energy resources
- Effective customer interactions

Creating the Grid of the Future



Picture courtesy of: Smart Grid 2030

For More Information

ALL DOE SMART GRID PROGRAM AND ANALYSIS REPORTS CAN BE DOWNLOADED FROM

www.smartgrid.gov

AND

www.oe.energy.gov

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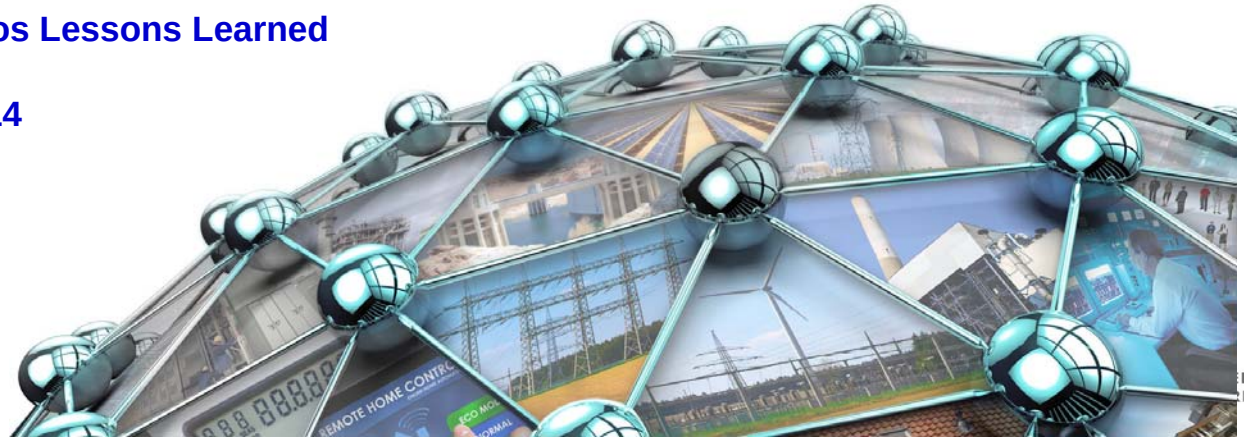
THE INTEGRATED GRID

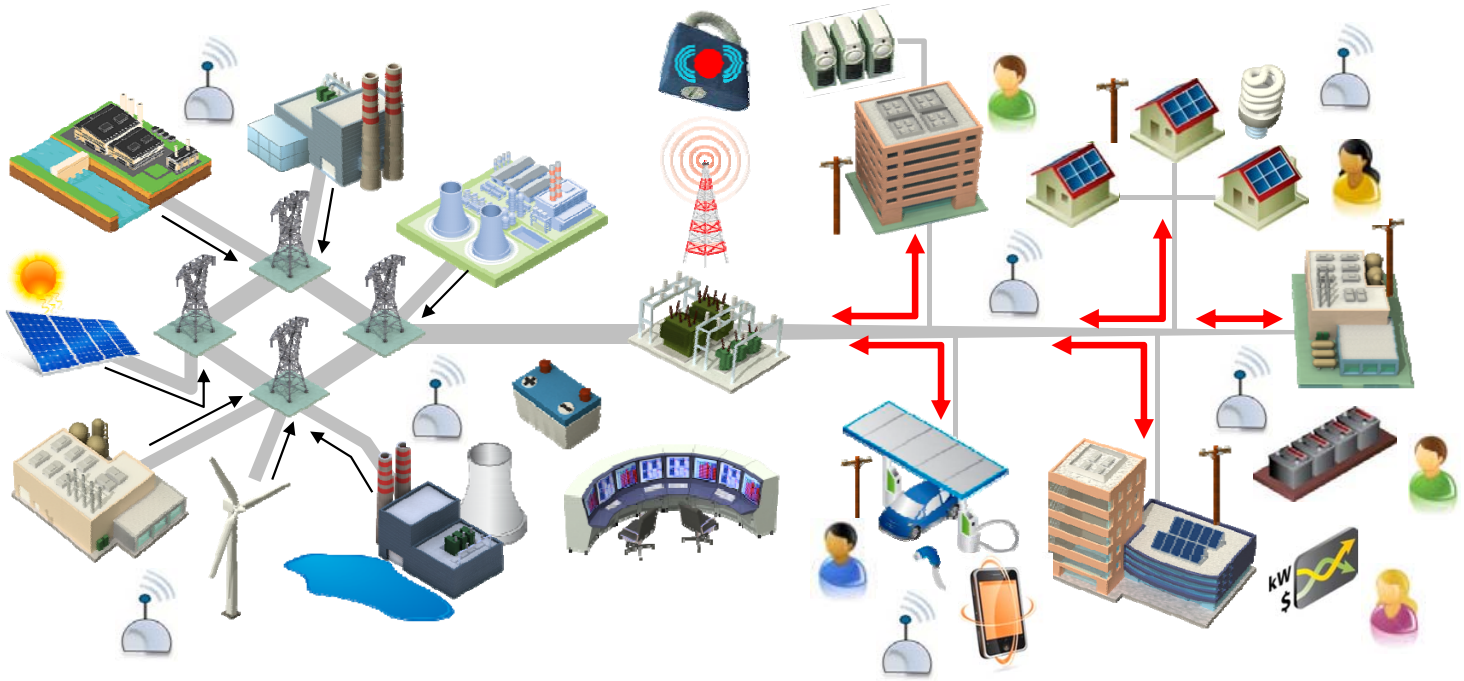
REALIZING THE FULL VALUE OF CENTRAL AND DISTRIBUTED ENERGY RESOURCES

Mark McGranaghan
Vice President, Power Delivery and Utilization

Smart Grid Demos Lessons Learned
Charlotte
October 27, 20114



Integrated Grid Vision

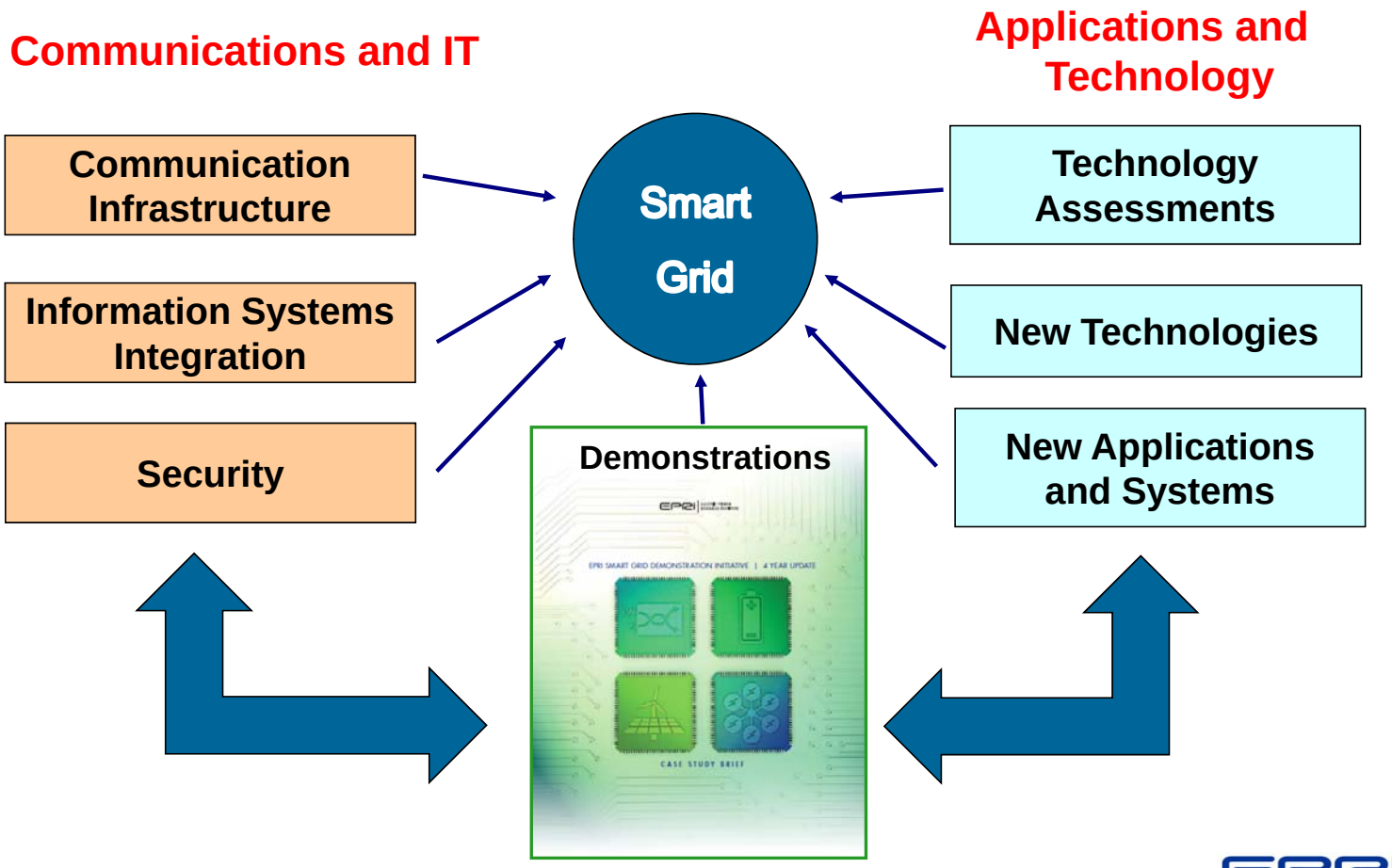


Power System that is Highly Flexible, Resilient and Connected and Optimizes Energy Resources

The Integrated Grid is about Enabling the Customer

The integrated grid allows **Local Energy Optimization** to become part of **Global Energy Optimization.**

Demonstrations Provide a Critical Foundation



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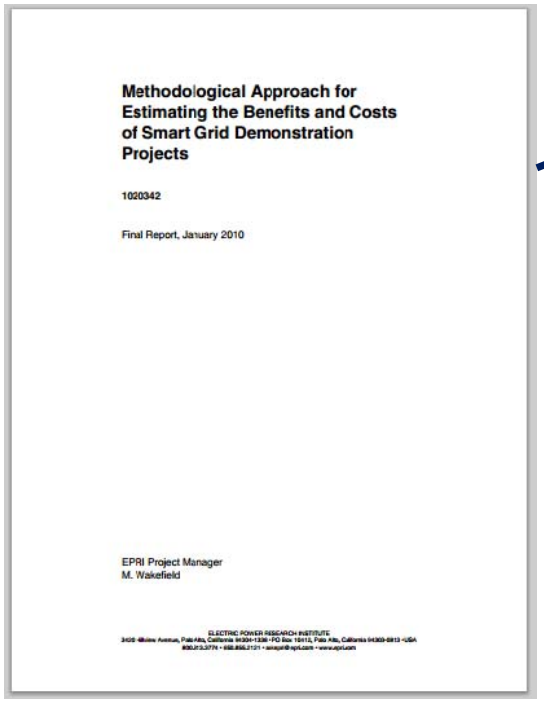
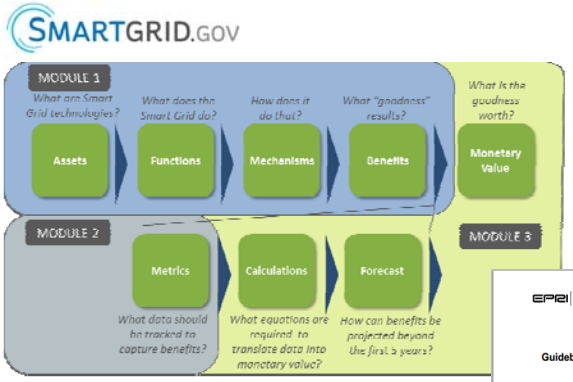
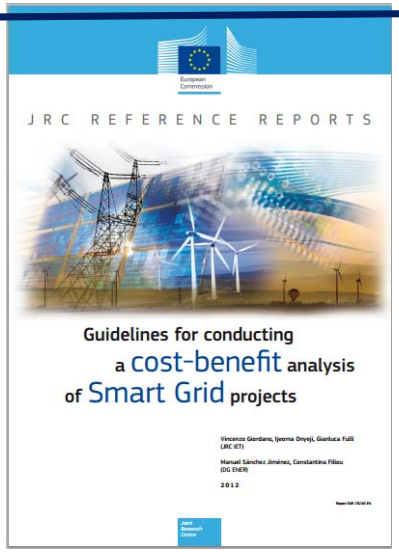
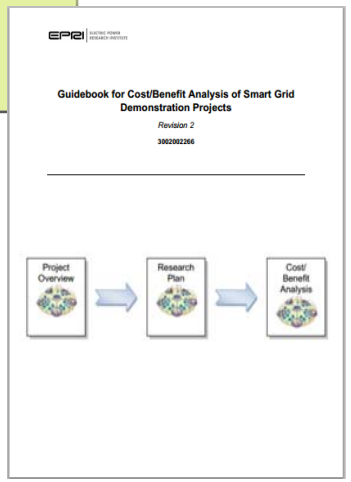
Understanding the Value









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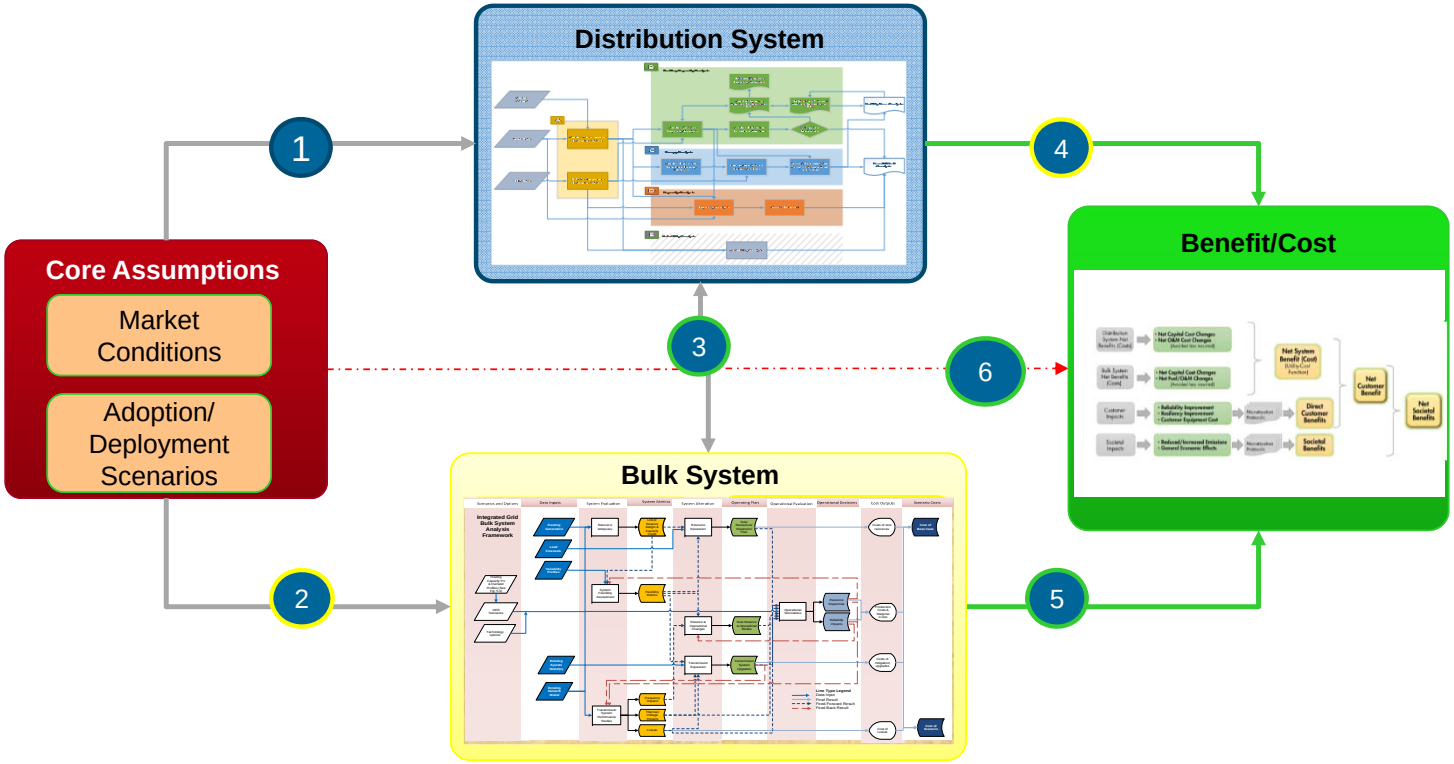
Economics of System-Wide Deployment



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Technology Examples

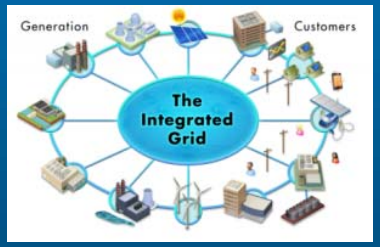
- Renewable Technologies
- Voltage Control
- Energy Storage
- Electric Vehicle Charging
- Demand Response
- Microgrids

Research Gaps

Architecture for the Integrated Grid

Integrating the Customer/ Customer Model

Integrated T&D Planning and Operations



Resiliency and Asset Management

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Working together!

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THE
INTEGRATED GRID

REALIZING THE FULL VALUE OF CENTRAL
AND DISTRIBUTED ENERGY RESOURCES

GridWise Alliance & DOE/OE

Future of the Grid Initiative Outcomes

EPRI/DOE

The Smart Grid Experience:

Applying Results, Reaching Beyond

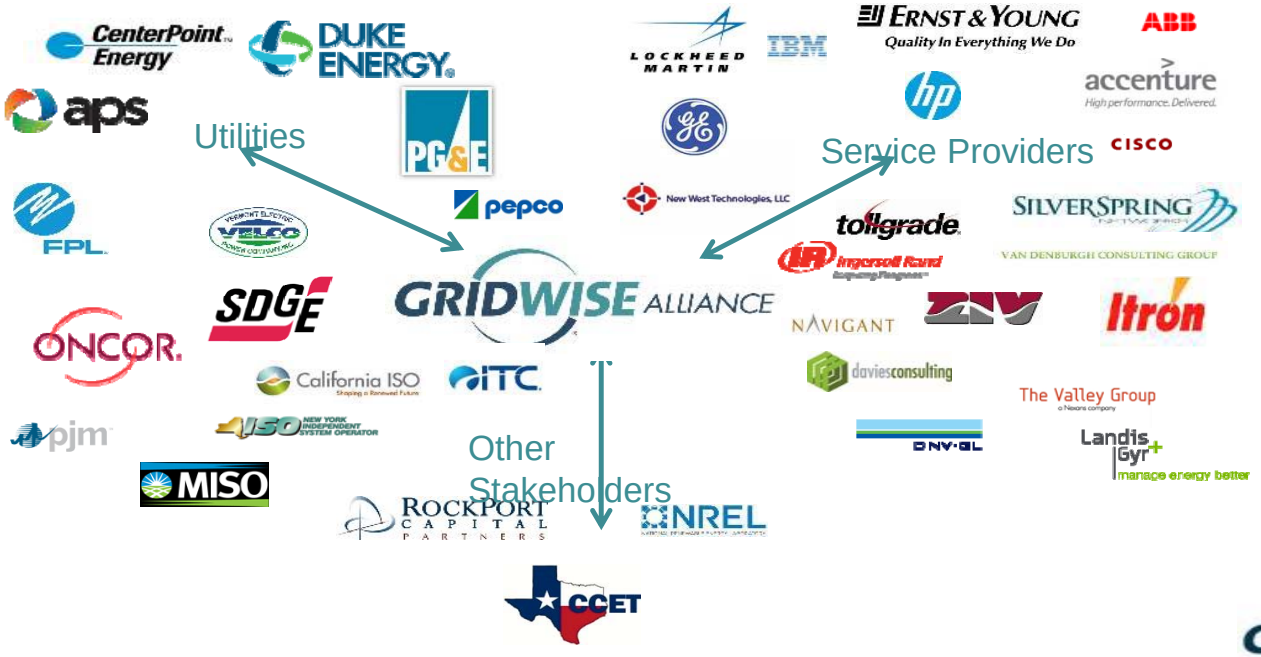
Monday, October 27, 2014

Charlotte, NC

- Who we are
- Review the process
- Frame our discussion
- Highlights of what we learned
  - Evolving of Grid Operations
  - Evolving of Business Models
  - Evolving of Regulator Models
  - Planning the Transition

GridWise Alliance

A consortium of passionate stakeholders focused on modernizing our electric grid. The Alliance collaborates to transform the nation's electric power grid to achieve a sustainable energy future.



GRIDWISE ALLIANCE

Future of the Grid Initiative
The Process

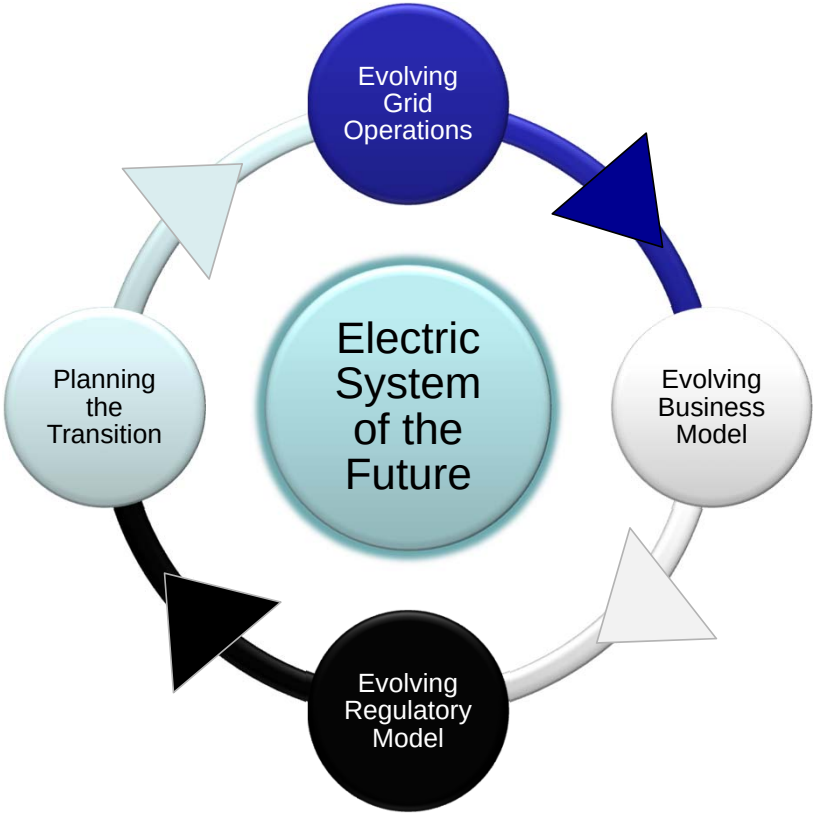
- Partnership - GridWise Alliance and the Office of Electricity Delivery and Energy Reliability
- Four Regional Workshops
  - Challenge of Balancing Supply and Demand as Grid Complexity Grows
  - Challenge of Involving Customers and Their Electrical Loads in Grid Operations and Planning for Empowered Customers
  - Challenge of Higher Local Reliability through Multi-customer Microgrids
  - Challenge of Transitioning Central Generation to Clean Energy Sources - Large-Scale Wind, Solar, and Gas
- National Summit in Washington, DC
- Pre-reads and summary reports from each workshop
- Final report – to be issued the end of October

GRIDWISE ALLIANCE

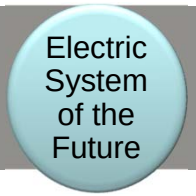
Background

- Across the four regions – common themes emerged
- Business models, regulatory models will vary
  - Deregulated/unbundled markets
  - Full integrated markets
  - State by state approach
- Sense of urgency varies
  - Penetration of distributed energy resources
  - Renewable portfolio standards and penetration
  - Resiliency concerns

Our Approach



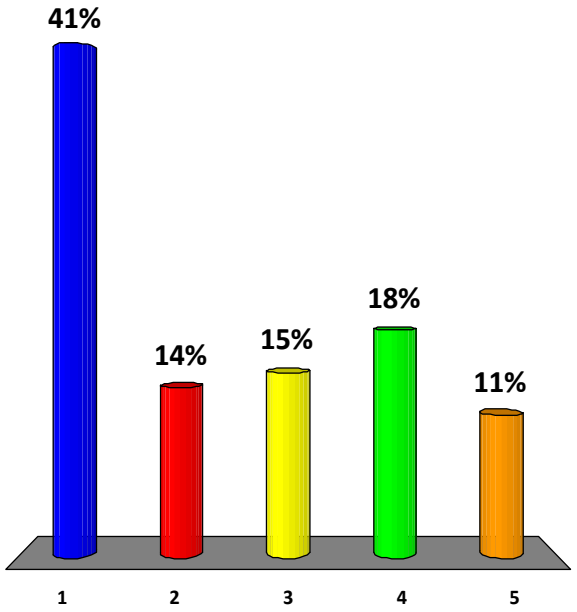
Characteristics
Electric System of the Future



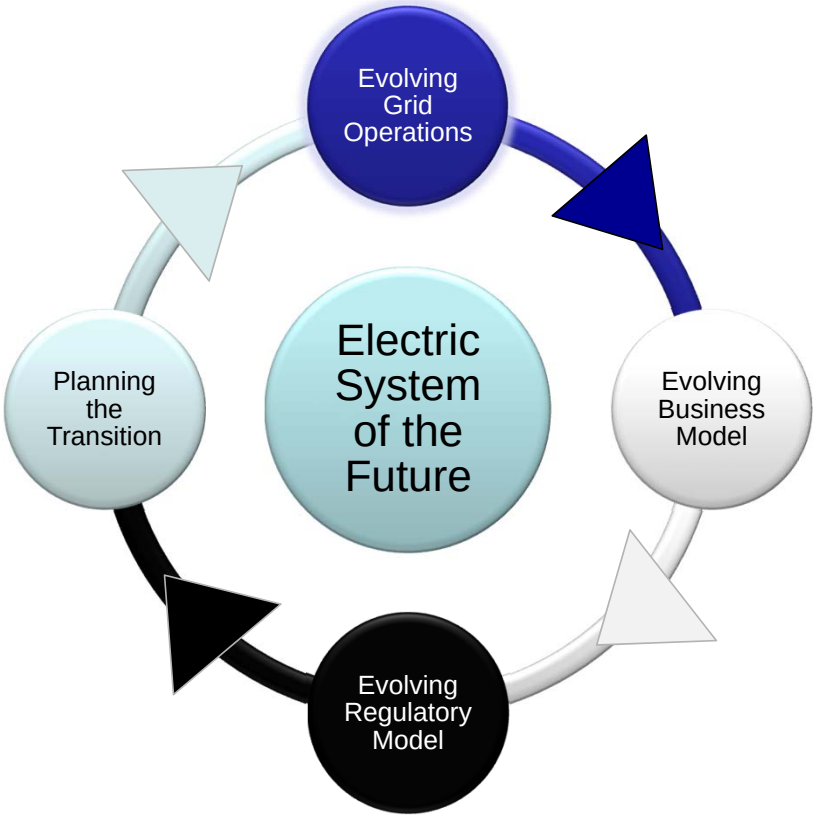
- Generation
  - Centralized and distributed
  - Dispatchable and non-dispatchable
  - Microgrids – complementary not replacement
- Energy storage – won't replace the need for "dispatchable" options
- Balancing supply and demand increasing complex and important
- Consumers
  - Different expectations and options
  - Prosumers
- Markets
  - Wholesale and retail
  - Third party non-regulated competitive players

The first step in the transition should be:

1. Aligning on a vision for the future electric system
2. Defining what will be regulated and what will be market driven
3. Defining the new utility business model
4. Developing a coordinated approach to overseeing this transition
5. None of the above



Frame of Reference

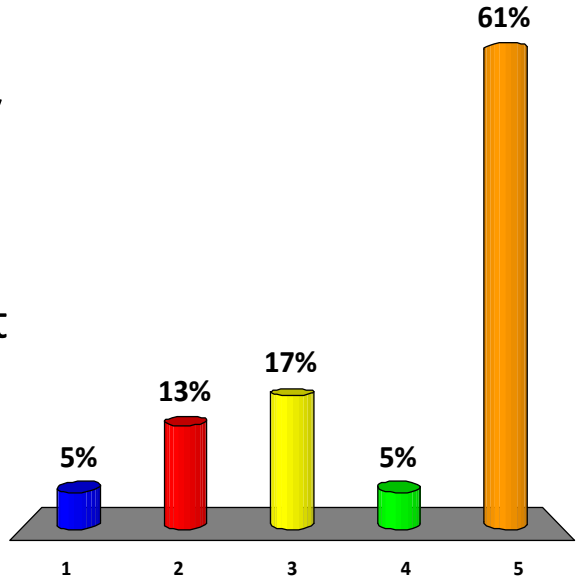


Evolving Grid Operations
Key Themes

- Will still want and need a grid – but very different role
- Enabling platform
- Must be agile and “fractal” - flexible, adaptable, responsive
- Enables robust markets – wholesale and retail

In 2030, your vision for distribution operations is:

1. Performs the same function as today
2. Builds, manages and maintains the physical infrastructure only
3. Becomes the balancing authority for distribution grid
4. Operates a robust retail market exchange
5. Both 4 & 5



Evolving Grid Operations
Distribution Grid

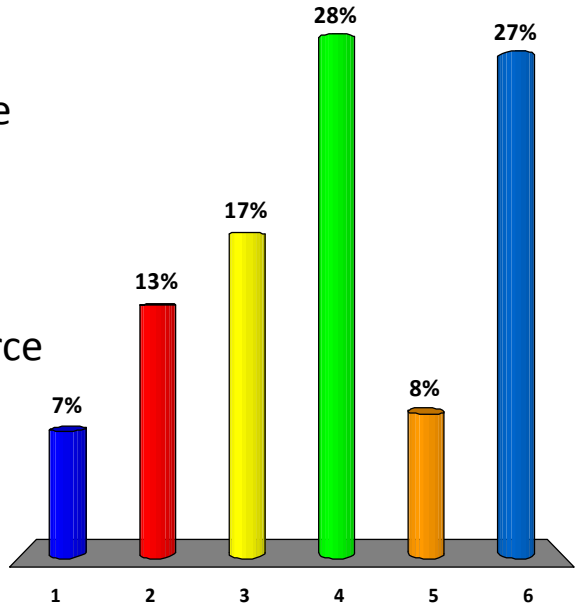
- Will look and act more like transmission grid
- Increasing interdependencies between T&D
- Greater visibility across the entire grid
- Balancing supply and demand from retail consumers to centralized generation producers
- Requires new investments in ITC infrastructure
- Big data => analysis and action
- Significant business process change and changing workforce needs

Evolving Grid Operations Transmission and ISO/RTOs

- Distribution no longer “just load”
- Connecting wholesale and retail markets
- More complex resources
  - Intermittent generation
  - Distributed generation
  - Energy storage
  - Responsive loads
  - New/increasing interdependencies (i.e. water, gas)
- Need new tools and models
  - More complex electric flow models
  - Incorporate external factors such as weather
  - Situational awareness down into distribution grid/end points

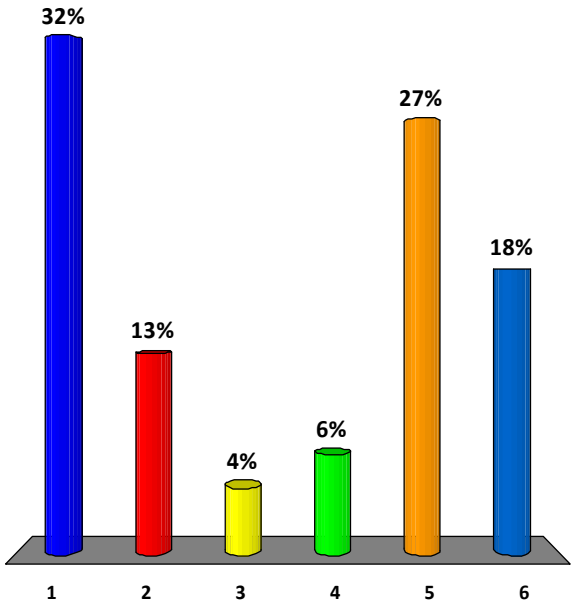
What is the most critical technology challenge that needs to be addressed in the next 15 years?

1. Improving situational awareness down to end device
2. Implementing high bandwidth, low latency, cost effective and interoperable communications systems
3. Leveraging "big data" analytics and integrating into real-time operations
4. Incorporating distributed energy resource management
5. Integrating multi-customer microgrids
6. Achieving cost effective energy storage



What is the most urgent technological challenge today?

1. Dealing with intermittency of renewable generation
2. Dealing with extreme weather events
3. Incorporating advanced weather modeling into operations
4. Reducing peak demand
5. Dealing with “big data”
6. Meeting environmental mandates



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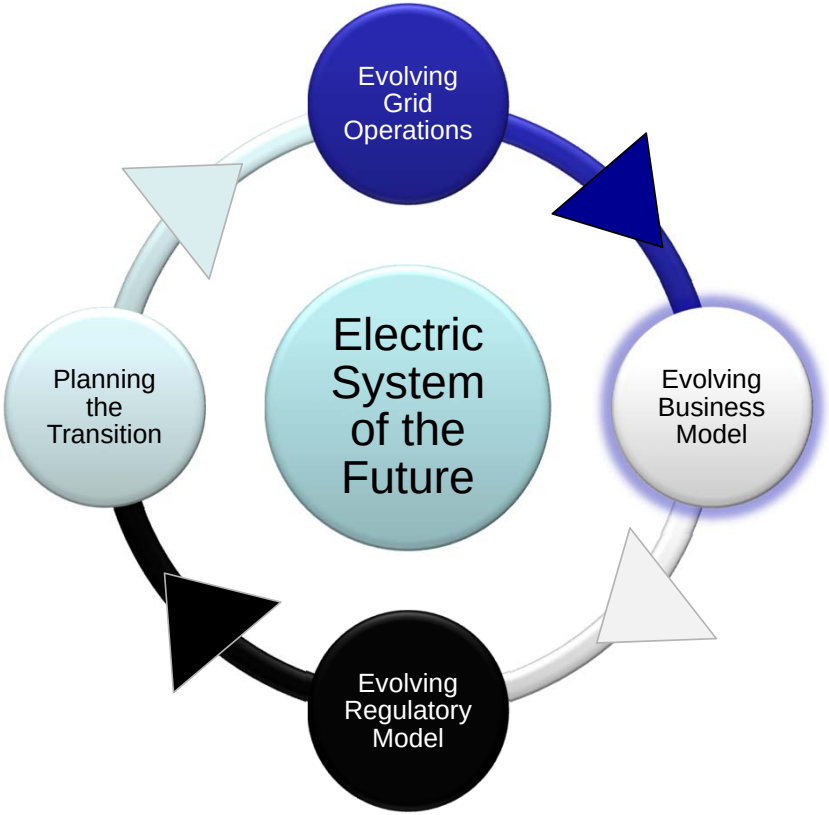

Evolving Grid Operations
Evolving Business Model
Evolving Regulatory Model
Planning the Transition
Electric System of the Future

Evolving the Business Models Adapting for the Future Grid

Evolving Business Models

- Grid owners and operators must be equitably compensated for the value they deliver
  - Integrating all types of generations
  - Being agnostic as to where supply comes from
  - Increasing grid efficiency
  - Enabling customers to provide services back to grid
  - Facilitating a retail market for consumers to buy and sell services
  - Optimizing assets utilization
  - Supporting/implementing public policies
  - Maintaining a safe and reliable grid
  - Enabling highly reliable and resilient energy services to end consumers
  - Identifying most cost-effective way to achieve outcomes

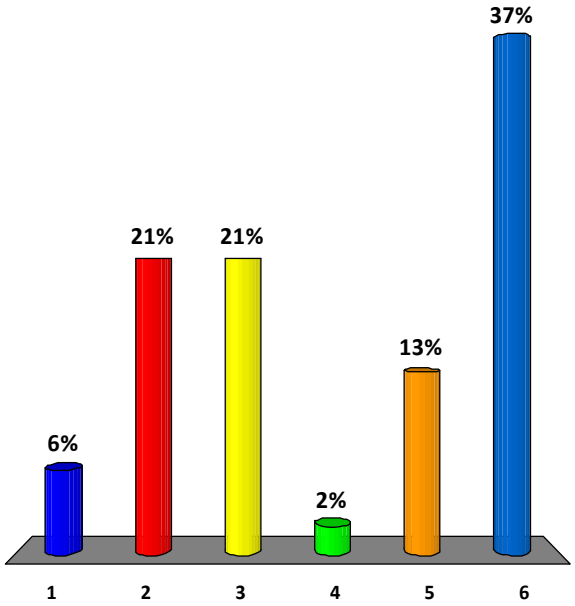
Evolving the Business Models Portfolio of "Selectable Services"

Evolving Business Models

- Basic service
- Enhanced service
- High-reliability services
- Microgrid services
- Financing services
- Buying/selling ancillary services, such as:
  - VAR Support
  - Voltage Support
  - Frequency Response
  - Spinning Reserve
  - Backup Power Support

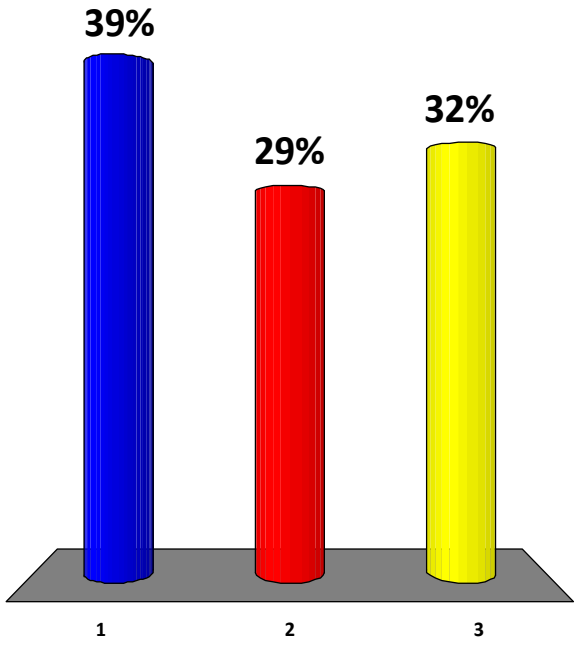
Which do you believe will be the "forcing function" for utility business model change:

1. Financial markets
2. Utility management reacting to future revenue projections
3. Third-party products and services providers
4. Policy makers
5. Regulators
6. Customer's expectation/choices



Which is the highest risk scenario in transitioning utility pricing to a products and services model:

1. Debating change but continuing with status quo
2. Transitioning to a services pricing model and eliminating all policy related cross subsidies built into today's rates
3. Transitioning to services pricing model while continuing current policy related cross subsidies



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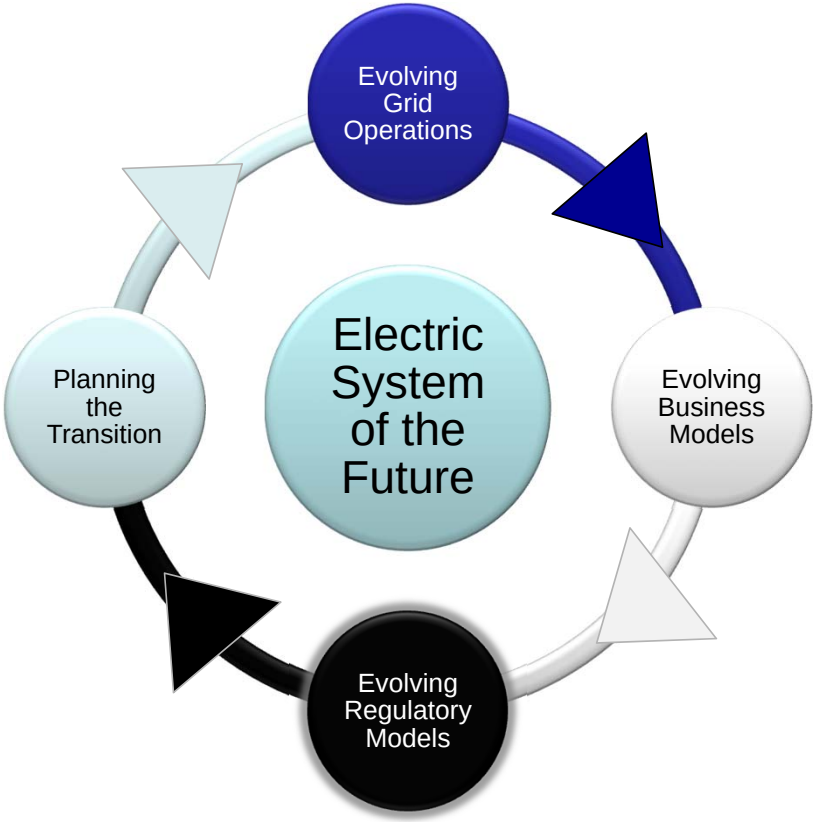
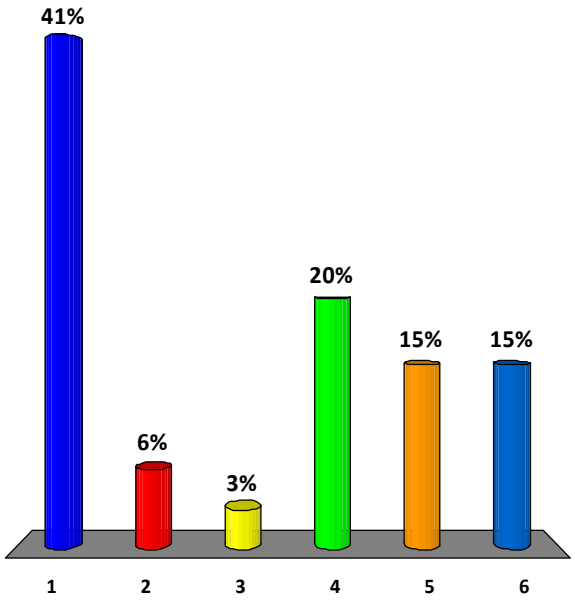


Evolving the Regulatory Models
New Challenges for Regulators

- Providing regulatory clarity in time of significant change
- Matching regulatory process with the speed of change and technology innovation
- Balancing pubic good with the needs and desires of individual consumers
- Addressing consumers' obligations to the grid as well as utilities' obligations to consumers in the future

What will be the most challenging element of evolving regulation at the state level:

1. Establishing new pricing structures and addressing societal policy issues (i.e. cross subsidies, obligation to serve)
2. Establishing retail market rules
3. Establishing DER interconnect rules
4. Emerging unregulated market for DER and “behind the meter” products and services
5. Stranded assets created in transition
6. Educating and engaging customers in the change



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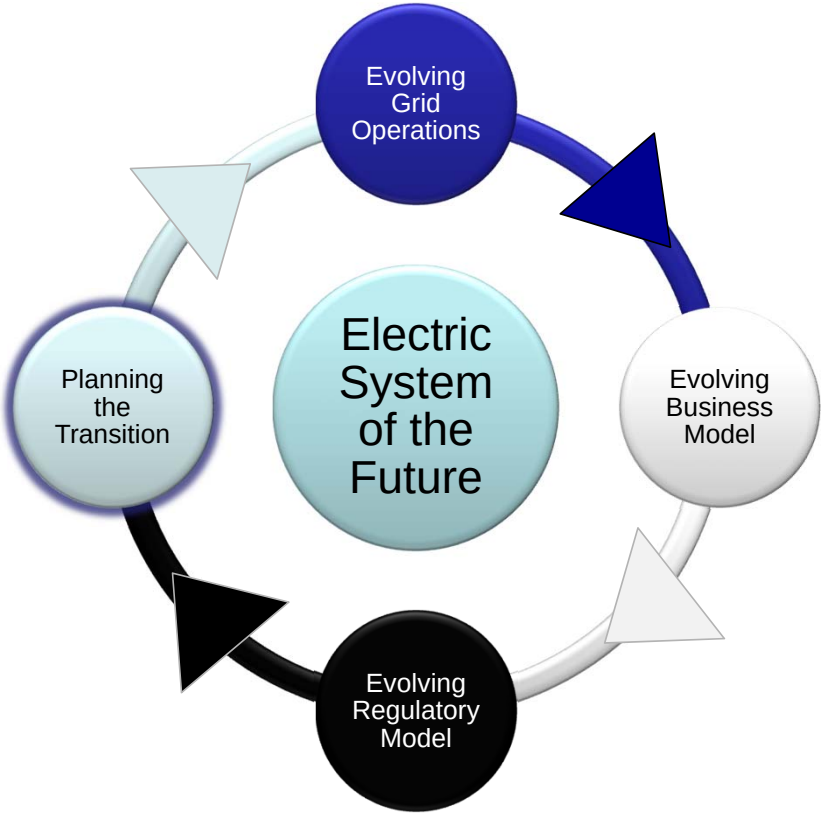
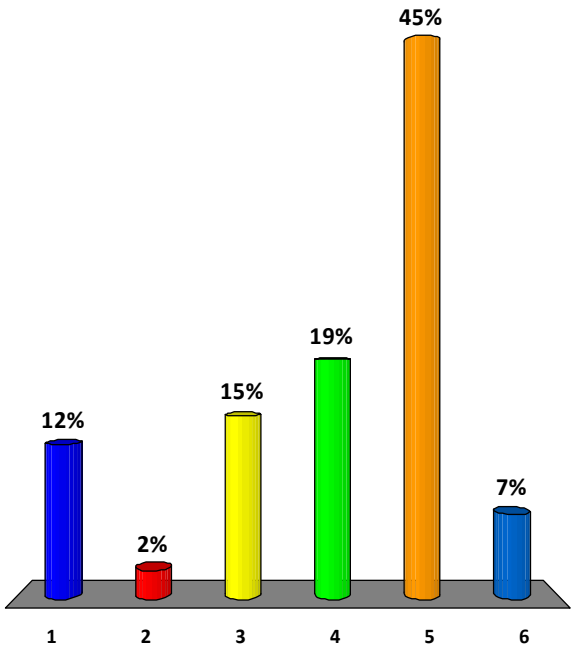


What do you see as the biggest barrier to evolving grid operations?

1. Lack of a clear vision for the future electric system
2. Lack of national policy to achieve the vision
3. Lack of a business model to support the transition
4. Lack of a regulatory model to support the transition
5. All of the above
6. None of the above



Planning the Transition

- Need collaborative approach that engages the ecosystem of stakeholders
- Establish guiding principles
- Establish a unifying architecture for the future electric system
- Develop standardized industry metrics
- Develop transition framework to assist with the development of regional/state roadmaps
- Establish foundational investments
- Leverage opportunities to advance the transition

Q&A

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