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The Smart Grid

Smart Grid – What's so Smart About It?
An Educational Forum on Smart Grids
Joe Miller – Modern Grid Strategy Team
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Agenda

- **What is the Smart Grid?**
- **EISA 2007 Highlights**
- **DOE Activities**
- **Questions**

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What is the Smart Grid?

What is the role of the MGS?

- Develop a vision for the Smart Grid
- Reach out to stakeholders to get input
- Assist in the identification and resolution of barriers & issues
- Act as an “independent broker” consistent with the vision
- Promote testing of integrated suites of technologies
- Communicate concepts to assist interested stakeholders

Our role is Strategic rather than Tactical!

MGS Activities

- Concept development (early 2005)
- Regional summits (7) to get stakeholder input
- Version 2.0 documents published on website
- Regulatory technical support
- Communication of concepts in various forums
- Smart Grid Implementation Workshop
- Developmental Field Tests with Allegheny and AEP

Why Modernize the Grid?

- 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 21^{st} century power supply challenges
- The benefits of a modernized grid are substantial

Running today's digital society through yesterday's grid is like running the Internet through an old telephone switchboard.

Reid Detchon, Energy Future Coalition

Smart Grid Values

The Smart Grid is MORE:

- **Reliable**
- **Secure**
- **Economic**
- **Efficient**
- **Environmentally friendly**
- **Safe**

These values define the goals for grid modernization and suggest where metrics are needed to monitor progress.

Value Proposition

Cost to Modernize

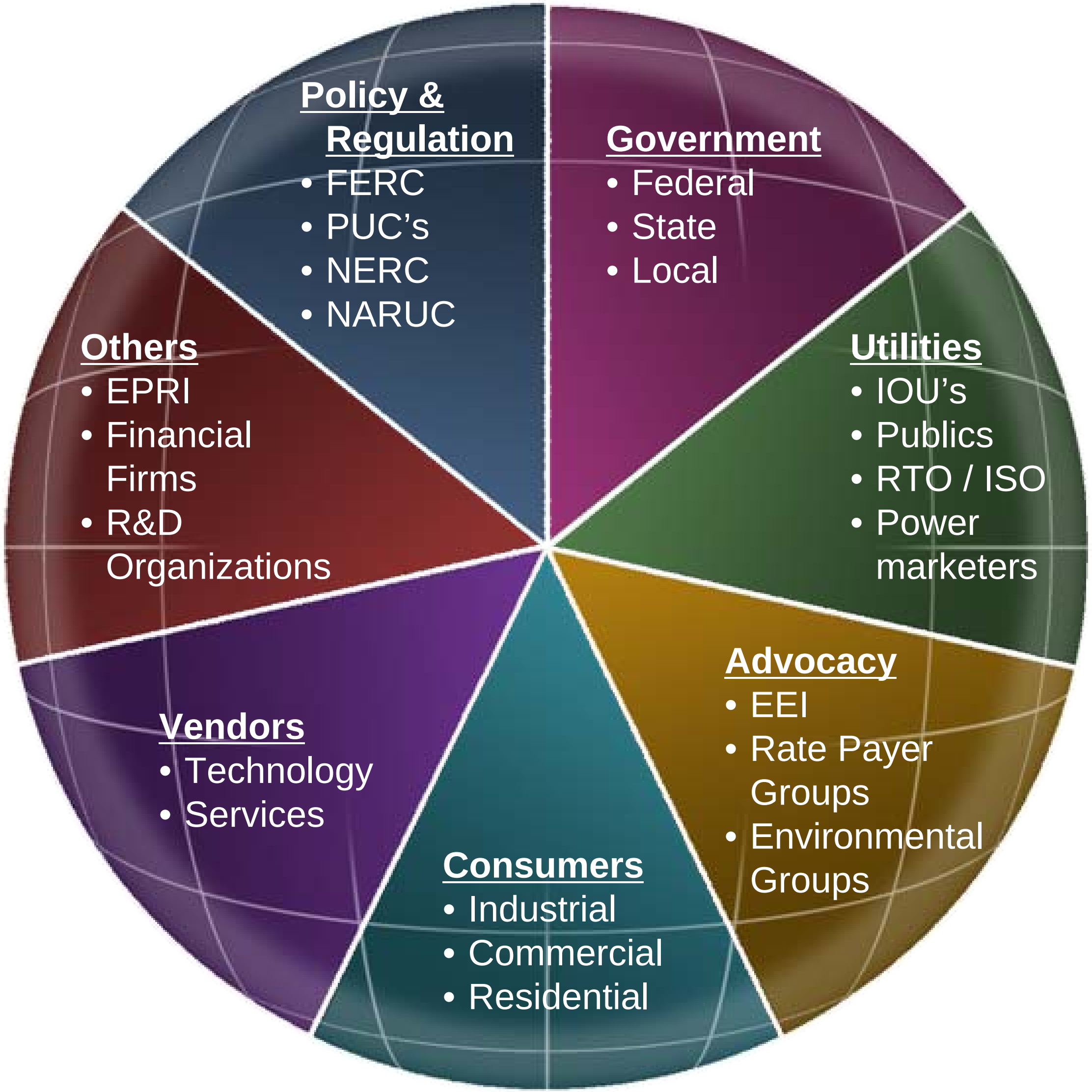
- **$165B over 20 years**
  - $127B for Distribution
  - $38B for Transmission
- **~$8.3B per year (incremental to business-as-usual)**
- **Current annual investment - $18B**

Benefit of Modernization

- **$638B - $802B over 20 years**
- **Overall benefit to cost ratio is 4:1 to 5:1**

Thus, based on the underlying assumptions, this comparison shows that the benefits of the envisioned Future Power Delivery System significantly outweigh the costs. *(EPRI, 2004)*

There are many stakeholders



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Our future will change

Imagine a World with 200 million electric vehicles that:

- **Connect anywhere**
- **Provide transportation and act as storage and generators for the grid**

And are powered by:

- **Clean nuclear and coal with carbon capture**
- **Renewables and other distributed generation**

A shift from gasoline to PHEVs could reduce U.S. petroleum imports by 52% *(PNNL – Impact assessment of PHEV's)*

Resulting in:

- Dramatic reduction in tailpipe emissions
- Reduction in petroleum imports of >50%
- Reduction in peak loads – lowering prices for consumers
- Improved grid reliability – decreasing today's consumer losses of >$125 Billion annually
- Increased grid security – the "Fort Knox" model

But we need a Smart Grid to enable such "worlds"

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Smart Grid Characteristics

It will "Enable active participation by consumers"

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- **Consumers have access to new information, control and options to engage in electricity markets**
  - Energy management
  - Investment in DER and PHEV
  - Offer resources to market
- **Grid operators have new resource options**
  - Reduce peak load and prices
  - Improve grid reliability
- **E-bay level of activity**

Involving the consumer is win – win!

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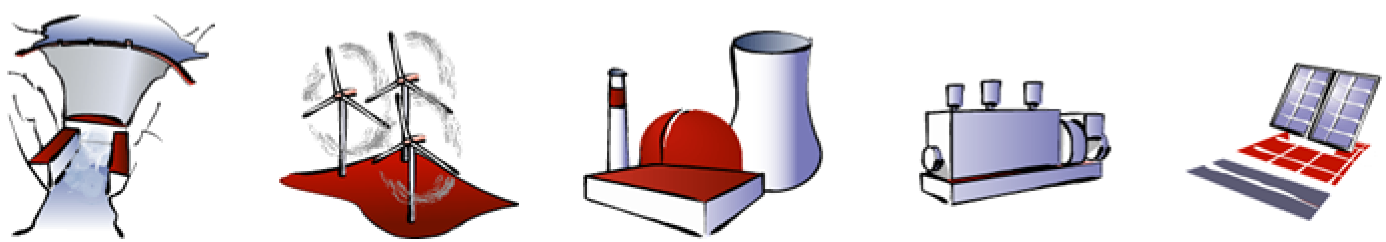
It will "Accommodate all generation and storage options"

- **Seamlessly integrates all types and sizes of electrical generation and storage systems**
- **"Plug-and-play" convenience**
  - Simplified interconnection processes
  - Universal interoperability standards
- **Number of smaller, distributed sources will increase – shift to a more decentralized model**
- **Large central power plants will continue to play a major role.**



It will "Enable new products, services and markets"

- **Links buyers and sellers**
- **Consumer to RTO**
- **Supports the creation of new electricity markets**
  - PHEV and vehicle to grid
  - Brokers, integrators, aggregators, etc.
  - New commercial goods and services
- **Provides for consistent market operation across regions**

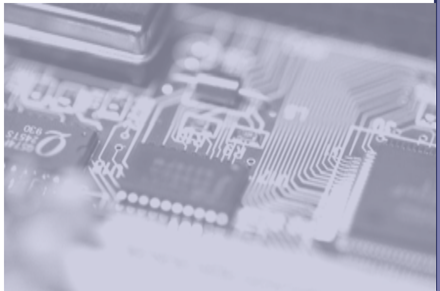
Markets motivate behavior and get results!

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**

Voltage dips that last less than 100 milliseconds can have the same effect on an industrial process as an outage that lasts several minutes or more

Primen, 2002



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)**

Convergence of operating information with asset management processes will dramatically improve grid efficiency

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**

The blackout of August 2003 took hours to build up. Once it breached the original service territory, it took 9 seconds to blackout 50M people.

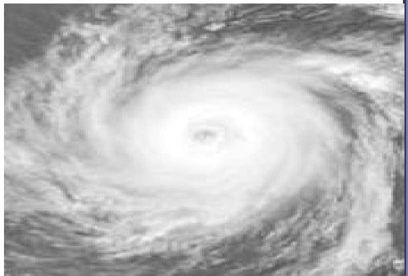
PNNL, June 2006

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**

The lack of a concerted, deliberate technical approach risks serious consequences from security threats to the power delivery system infrastructure.

Erich Gunther, Power & Energy Continuity, 2002



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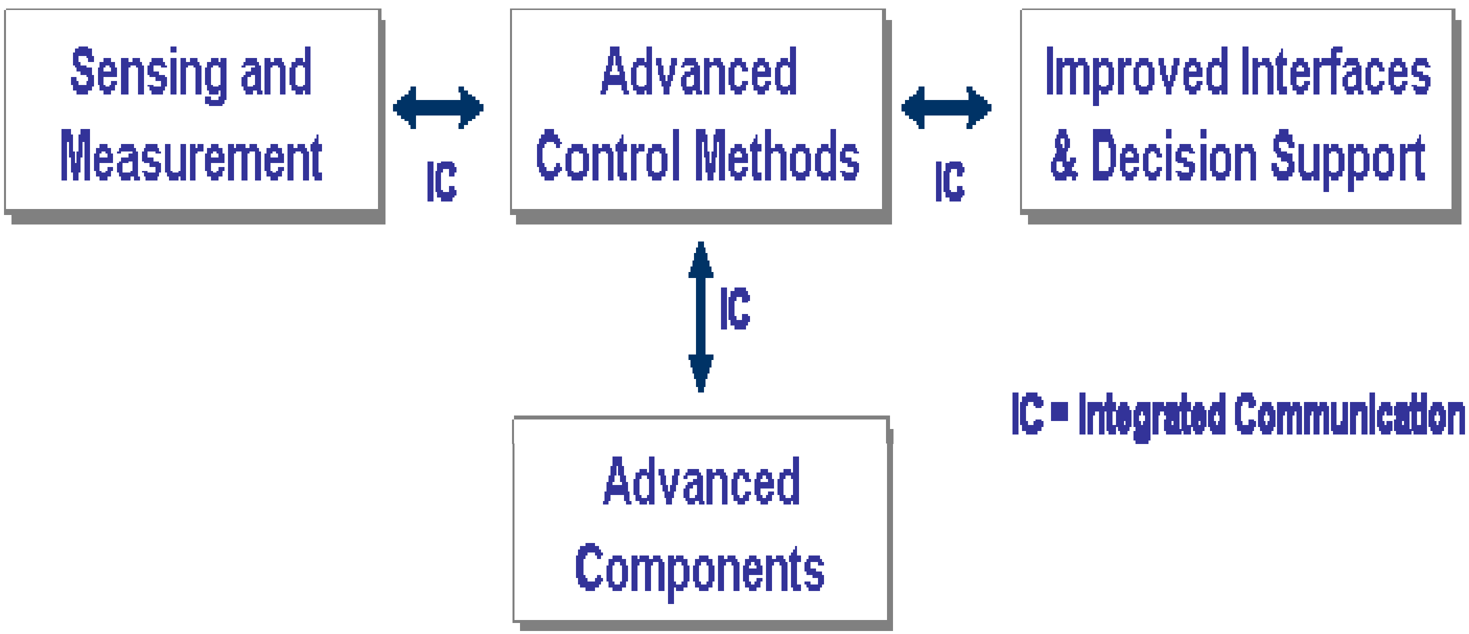
Summary of Smart Grid Characteristics

The Smart Grid will:

- 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

Smart Grid Key Technologies



The Milestone View

Smart Grid Milestones

- **Advanced Metering Infrastructure *(AMI)***
- **Advanced Distribution Operations *(ADO)***
- **Advanced Transmission Operations *(ATO)***
- **Advanced Asset Management *(AAM)***

Each Milestone requires the deployment and integration of various technologies and applications

AMI Technologies

- Smart Meters
- Two-way Communications
- Consumer Portal
- Home Area Network
- Meter Data Management
- Demand Response
- Customer Service Applications
- Operational Gateway Applications

AMI empowers the customer and supports grid operations

ADO Technologies and Applications

- Distribution Management System with advanced sensors
- Advanced Outage Management ("real-time")
- DER Operations
- Distribution Automation
- Distribution Geographic Information System
- Micro-grid operations (AC and DC)
- Advanced protection and control
- Advanced grid components for distribution

The functionality of ADO enables "Self Healing"

ATO Technologies and Applications

- Substation Automation
- Geographical Information System for Transmission
- Wide Area Measurement System (WAMS)
- Hi-speed information processing
- Advanced protection and control
- Modeling, simulation and visualization tools
- Advanced grid components for transmission
- Advanced regional operational applications

Deeply integrated with AMI, ADO and AAM – ATO optimizes transmission operations

AAM Technologies and Applications

- **Advanced sensors**
  - System Parameters
  - Asset “health”
- **Integration of real time information with other processes:**
  - Operations to optimize asset utilization
  - T&D planning
  - Condition based maintenance
  - Engineering, design and construction
  - Work and resource management

Integration of AMI, ADO, and ATO with asset management processes will dramatically improve grid operations and efficiency

Milestone Sequence

AMI and DR

AMI empowers the customer and establishes communications to the loads

Distribution (ADO)

ADO enables self healing

Transmission (ATO)

ATO addresses congestion

Asset Management (AAM)

AAM greatly improves the performance of today's asset management programs

Keeping the "End in Mind"

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Characteristic	*AMI*	*ADO*	*ATO*	*AAM*
Enables Active Consumer Participation	✓	✓		
Accommodates All Generation & Storage Options	✓	✓	✓	
Enables New Products, Services and Markets	✓	✓	✓	
Provides PQ for Digital Economy	✓	✓	✓	✓
Optimizes Assets & Operates Efficiently	✓	✓	✓	✓
Anticipates and Responds to System Disturbances	✓	✓	✓	✓
Operates Resiliently Against Attack and Natural Disaster	✓	✓	✓	

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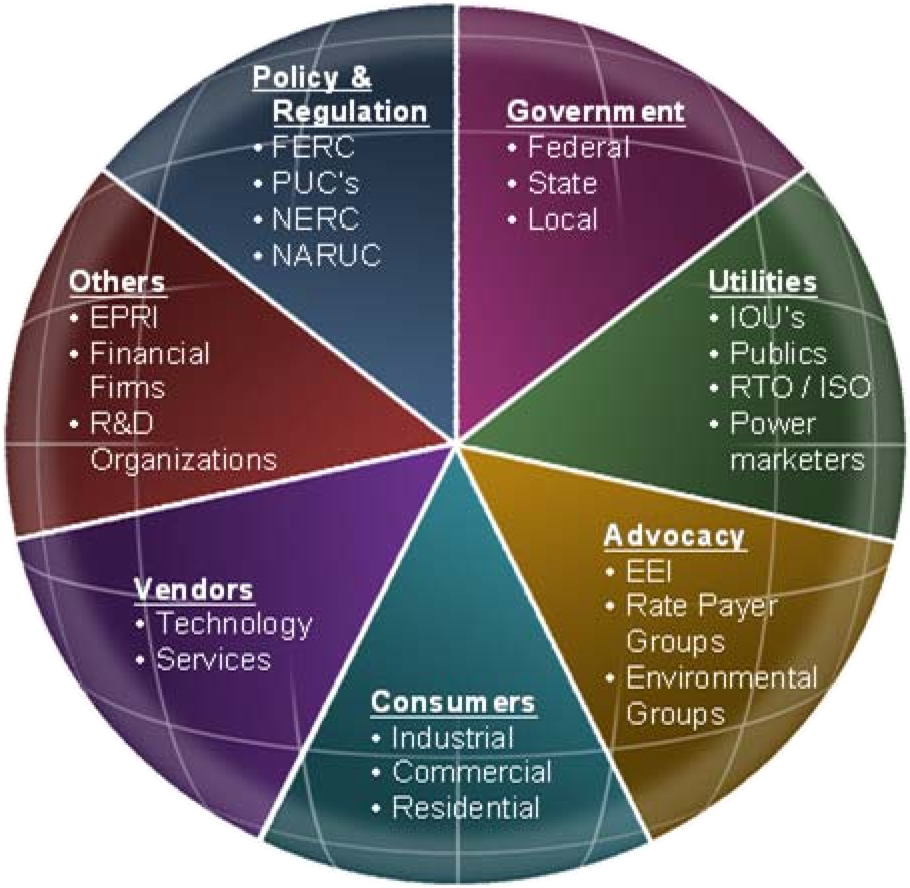
What are the challenges?

- Change Management
- Regulatory Policy
- Technical
- Other?



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Change Management

A significant change management effort is needed:

- Communicate a vision
- Strengthen consumer education and sense of urgency
- Align stakeholders around the vision
- Provide the motivation (win-win)
- Develop metrics to monitor progress
- Keep the “end in mind”
- Active leadership by regulators

Regulatory Policy

Regulatory policy could incentivize investment in the Smart Grid:

- ***Time based rates -*** incentives for consumers to become actively involved
- ***More favorable depreciation rules –*** recovery of book value for assets that are retired early for "smart grid" reasons
- ***Policy changes that provide incentives and remove disincentives to utilities –*** investment in a Smart Grid should make business sense
- ***Clear cost recovery policies -*** uncertain cost recovery increases investment risk
- ***Societal benefits –*** business cases should include societal benefits to ensure informed decisions are made by the regulator

Technical

Some technical issues:

- Standards (interconnection and interoperability)
- Integration vs. "widgets"
- Distributed system behavior not well understood
- Loss of skilled human resources
- Minimal funding of R&D – new technologies

Why do we need metrics?

- **Keep us on track**
  - Identify successes and opportunities for improvement
  - Initiate Corrective Action to address problems
  - Reinforce good progress
  - Serve as an effective communication tool
  - Create alignment and motivation among stakeholders
- **Enable us to project future progress**
  - Establishes baseline for target setting
  - Provides insights for interdependent efforts
  - Keeps the “end in mind”

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EISA 2007 Highlights

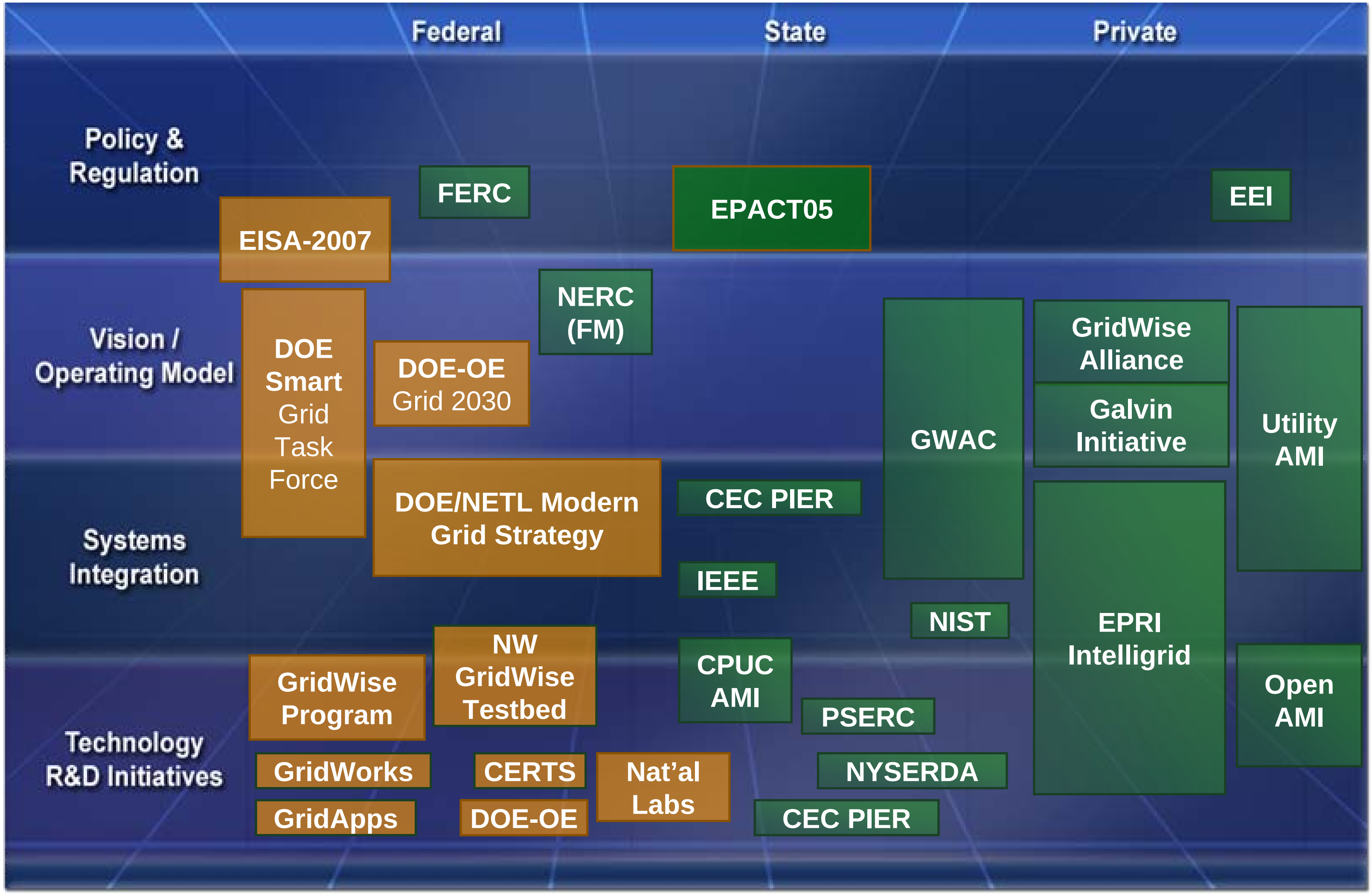
Energy Independence and Security Act of 2007

- **US policy is to support grid modernization**
- **Smart Grid System Report**
  - Status and prospects of development
  - Regulatory or government barriers
  - Technology Penetration
  - Communications network capabilities, costs, obstacles
  - Recommendations for state and federal policies
- **Smart Grid Advisory Committee (thru 2020)**
- **Smart Grid Task Force (thru 2020)**
- **Smart Grid Interoperability Framework (NIST)**

Energy Independence and Security Act of 2007

- **Smart Grid Technology RD&D**
- **Smart Grid Regional Demonstration Initiative**
  - 50% Cost Share
  - $100M per year – 2008-2012
- **Federal Matching Funds**
  - 20% reimbursement for qualifying Smart Grid investments
- **States shall consider:**
  - Requiring utilities to consider Smart Grid solutions including societal benefits
  - Allowing utilities to recover capital, O&M and other costs
  - Allowing recovery of book value of technologically obsolete assets

Modern Grid "Developers"



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For More Information

- The Modern Grid Strategy
- Smart Grid Newsletter
- EPRI Intelligrid
- Galvin Electricity Initiative
- GridWise Alliance
- GridWise Architecture Council
- European SmartGrid Technology Platform

Presenter's contact information:
Joe Miller
Sr. Vice President – Horizon Energy Group
jmiller@horizonenergygroup.com

Questions?

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Back-up Slides

The Smart Grid Gap

Characteristic	*Today*	*Tomorrow*
Enables Consumer Participation	Consumers are uninformed and non-participative with the power system	Informed, involved and active consumers – DR and DER
Accommodates Generation/Storage	Dominated by central generation – many obstacles exist for DER interconnection	Many distributed energy resources with "plug and play" convenience – focus on renewables
Enables New Markets	Limited wholesale markets, not well integrated – limited opportunities for consumers	Mature, well-integrated wholesale markets, growth of new electricity markets
Meets PQ Needs for 21st Century	Focus on outages – slow response to PQ issues	PQ a priority with a variety of quality/price options – rapid resolution of issues

The Smart Grid Gap

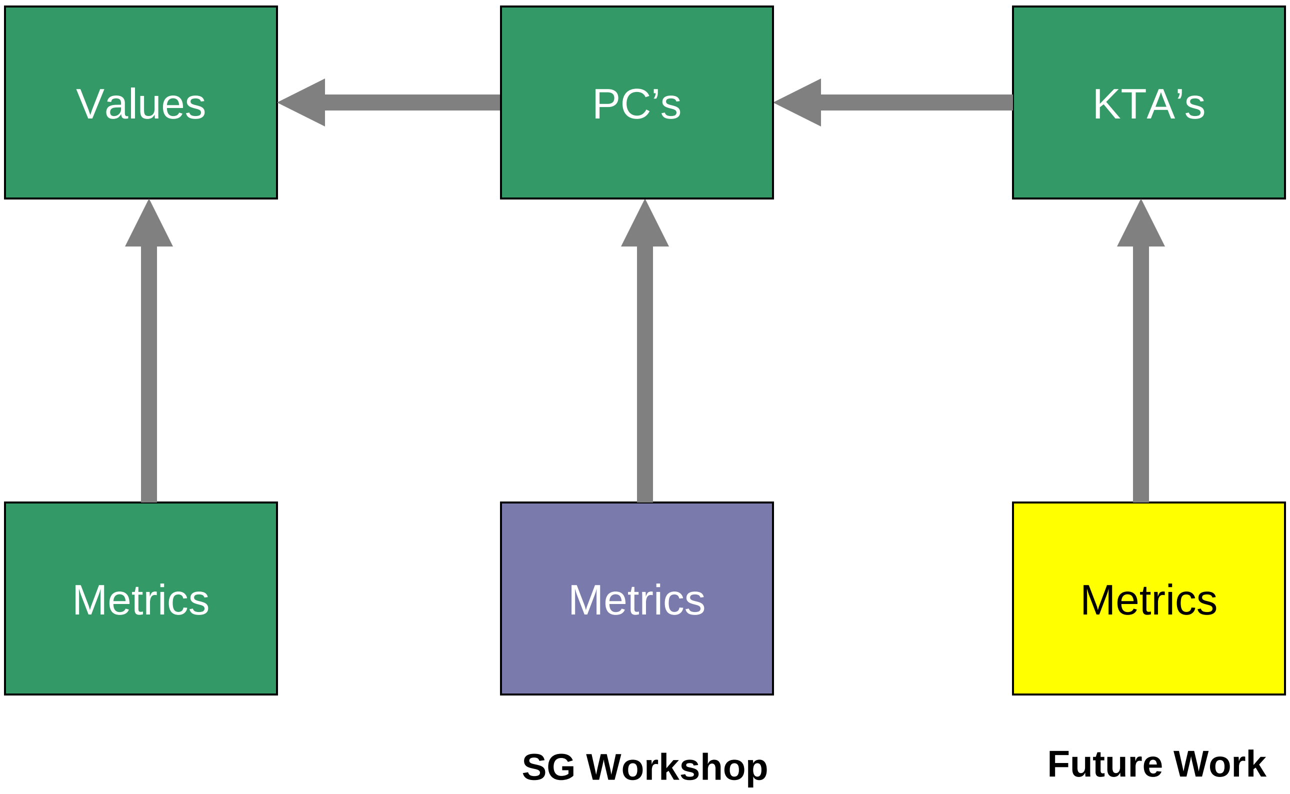
Characteristic	*Today*	*Tomorrow*
Optimizes Assets & Operates Efficiently	Little integration of operational data with asset management – business process silos	Greatly expanded data acquisition of grid parameters – deeply integrated with asset management processes
Self Heals	Responds to prevent further damage – focus is on protecting assets following fault	Automatically detects and responds to problems – focus on prevention, minimizing impact to consumer
Resists Attack	Vulnerable to malicious acts of terror and natural disasters	Resilient to attack and natural disasters with rapid restoration capabilities

Action Areas

Further work is needed:

- **Communication of Smart Grid concepts to stakeholders**
- **Metrics and their ownership**
- **Interconnection and Interoperability**
- **Regulatory model**
- **Comprehensive National Business Case**
- **Compelling value prop for consumers**
- **Clear link to environmental benefits and reducing US dependence on foreign oil**

Smart Grid Metric Map



Improved Reliability

- **Major reduction in outage duration and frequency**
  - Reduces losses to consumers (>$100B/year)
  - Improves customer satisfaction
- **Far fewer Power Quality disturbances**
  - Reduces manufacturing losses
  - Improves safety
- **Virtual Elimination of Regional Blackouts**
  - Reduces huge societal costs by minimizing occurrences (>$10B per event)

Improved Security and Safety

- **Significantly reduced vulnerability to terrorist attack and natural disasters**
  - Intelligent networking and deployment of Distributed Energy Resources improves the resiliency of the grid
    - Decentralization of DER
    - Diversity of fuels and size
- **Improved Public and Worker Safety**
  - Improved monitoring and decision system support systems will quickly identify problems and hazards
  - Reduced number and duration of outages reduces public safety and crime issues proportionately

Improved Economics

- **Reduction or mitigation of electricity prices**
  - Consumer response to market prices will reduce peak demand leading to a reduction in peak prices
  - Deferral of capital investments will mitigate upward pressure on rates
  - Increased grid robustness and efficiency will also mitigate rate increases
- **New options for market participants**
  - Home energy management systems
  - Investment in resources
  - Sale of energy, capacity, ancillary services
- **Supports a growing national economy**

Improved Efficiency

- **Reduced O&M costs from more efficient operation and improved asset management**
  - Optimal loading of assets to prevent overloads and extending life
  - Improved planning process leading to “just in time” capacity additions
  - Improved understanding of asset health leading to more efficient maintenance practices
- **Reduction of electrical losses**
  - Reduces generation requirements
  - Extends life of assets

Reduced Environmental Impact

- **Much wider deployment of environmentally friendly resources**
  - "Plug and Play" simplifies interconnection of DER including renewables
  - Distributed renewable generation reduces the need for less environmentally friendly central generation
- **Electrical losses reduced leading to a corresponding reduction in system generation**
  - Less generation means less emissions