MODERN GRID
STRATEGY

Understanding the Smart Grid

Wabash Valley Power

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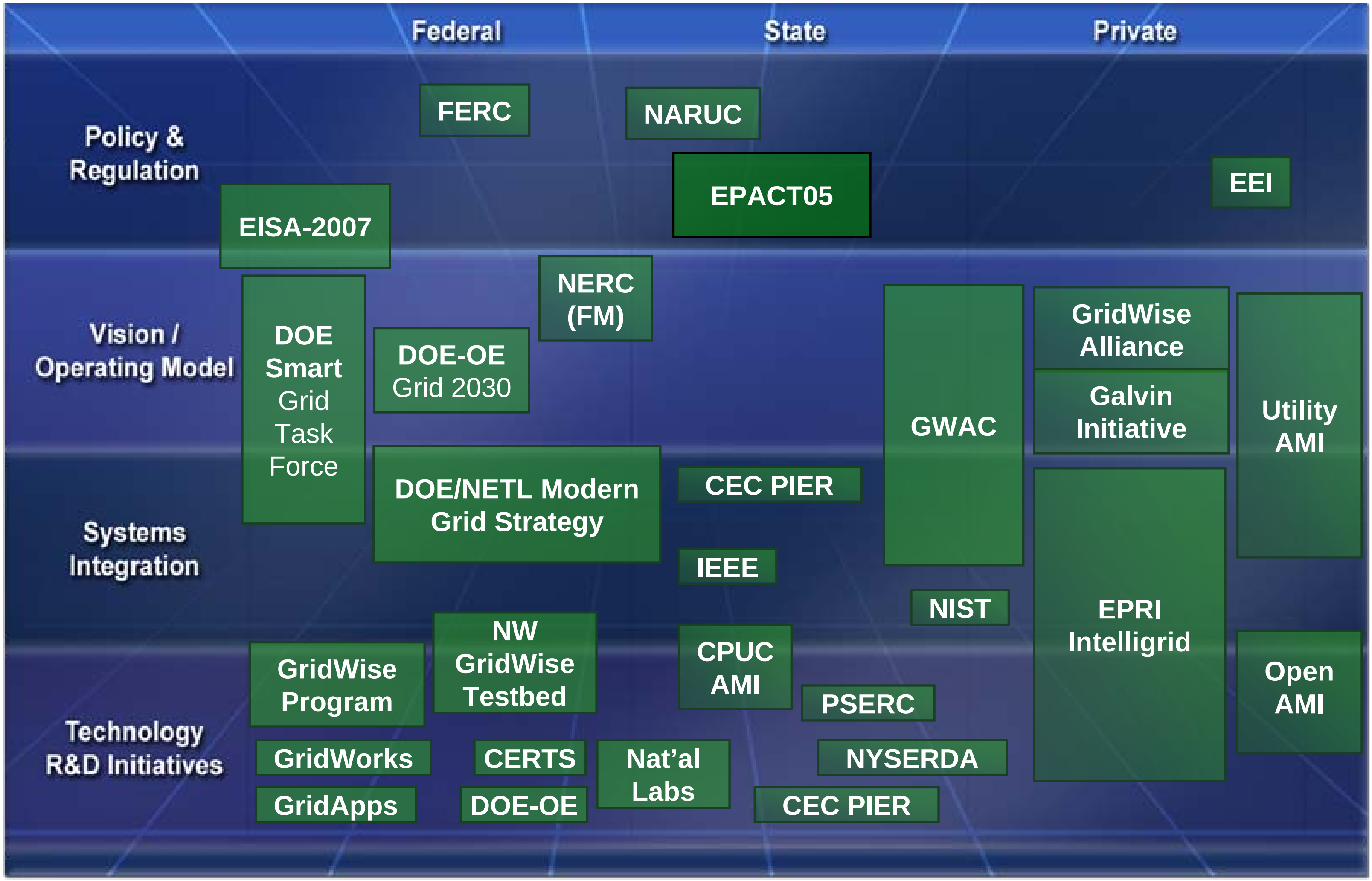
Today's topics

- **Smart Grid background**
- **Why modernize the grid?**
- **What is the Smart Grid?**
- **What is the value proposition?**
- **How do we get there?**
- **What are some of the barriers?**
- **Questions**

Smart Grid Background

Many are working on the Smart Grid



Modern Grid Strategy Team's Role

Mission – Accelerate the modernization of the Grid in the US

- Develop a vision for the Smart Grid
- Reach out to stakeholders to get input and consensus
- Assist in the identification and resolution issues
- Act as an "independent broker"
- 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)
- Vetted with stakeholders at 7 regional summits
- White papers published on website
- Regulatory support in Ohio, MO, and with NARUC
- Communication of concepts in various forums
- Smart Grid Implementation Workshop

Smart Grid Characteristics are well vetted!

EISA 2007 – Title XIII – The Smart Grid

- **US policy is to support grid modernization**
- **Smart Grid Advisory Committee (thru 2020)**
- **Smart Grid Task Force (thru 2020)**
- **Smart Grid Interoperability Framework (NIST)**
- **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

EISA 2007 – Title XIII – The Smart Grid

- **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

Why modernize the grid?

Platform for Prosperity

- **Economy now based on electricity**
  - Computers, networks, phone system, devices, robotic manufacturing, stock markets
- **Lifestyle now based on electricity**
  - Medical devices, appliances, air conditioners, computers
- **Must have infrastructure that facilitates growth**
  - The digital economy is vulnerable
  - 20 years ago semi-conductor load negligible. 10 years ago 10%. Today, past 20% and climbing (EPRI, 2006)
- **Key to global competitiveness**
  - Other regions upgrading to create competitive advantage

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

Reid Detchon, Energy Future Coalition

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The Grid Is aging, outmoded, stressed

- **Aging**
  - 70% of transmission lines are 25 years or older
  - 70% of transformers are 25 years or older
  - 60% of circuit breakers are 30 years or older
- **Outmoded**
  - Designed in the 50s and installed in the 60s and 70s, before the era of the microprocessor.
- **Stressed**
  - Never designed for bulk power shipments
  - Wholesale power transactions jumped 300% from 2000 to 2005. *Insight Magazine, Oct. 2005*

Much of the equipment that makes up the North American grid is reaching the end of its design life.

EnergyBiz Magazine, Sept. 2005

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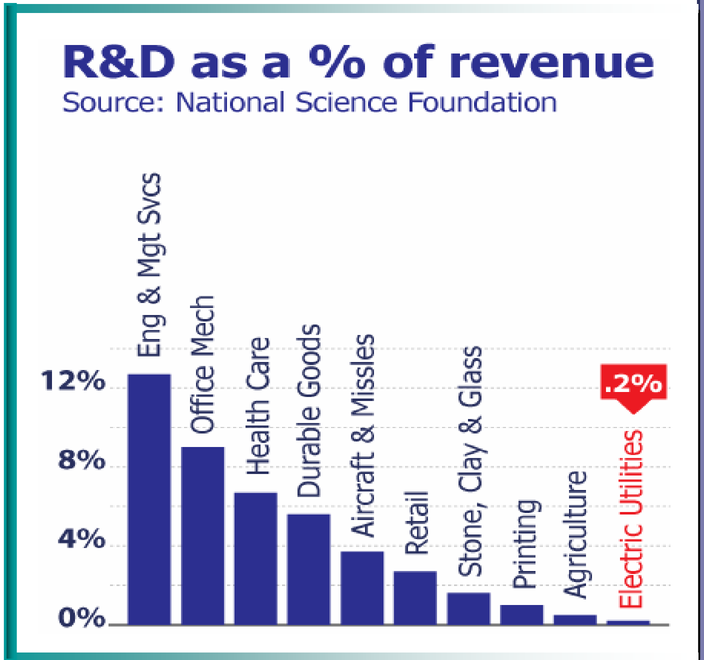
The Grid Is Under-Funded

- **Living off the investments of the 60s and 70s**
  - "Trust fund" is out of money
- **Less Utility R&D than almost any other industry**
  - 0.2% of net revenues
  - 1/20th the average of all U.S. industries



The Problem Is Urgent

- **Losing billions per year**
  - From disturbances, interruptions and grid congestion
- **Other regions are gaining on us**
  - China, Europe, Middle East
- **Missing the chance to lead a new industry**
  - Distribution automation, smart meters, advanced monitoring and control

Some major power corridors are at maximum capacity more than 80% of the time... equivalent to rush hour from 5am to midnight.

National Transmission Grid Study, 2003

We Are Losing Billions

We lose billions every year to blackouts, interruptions and congestion

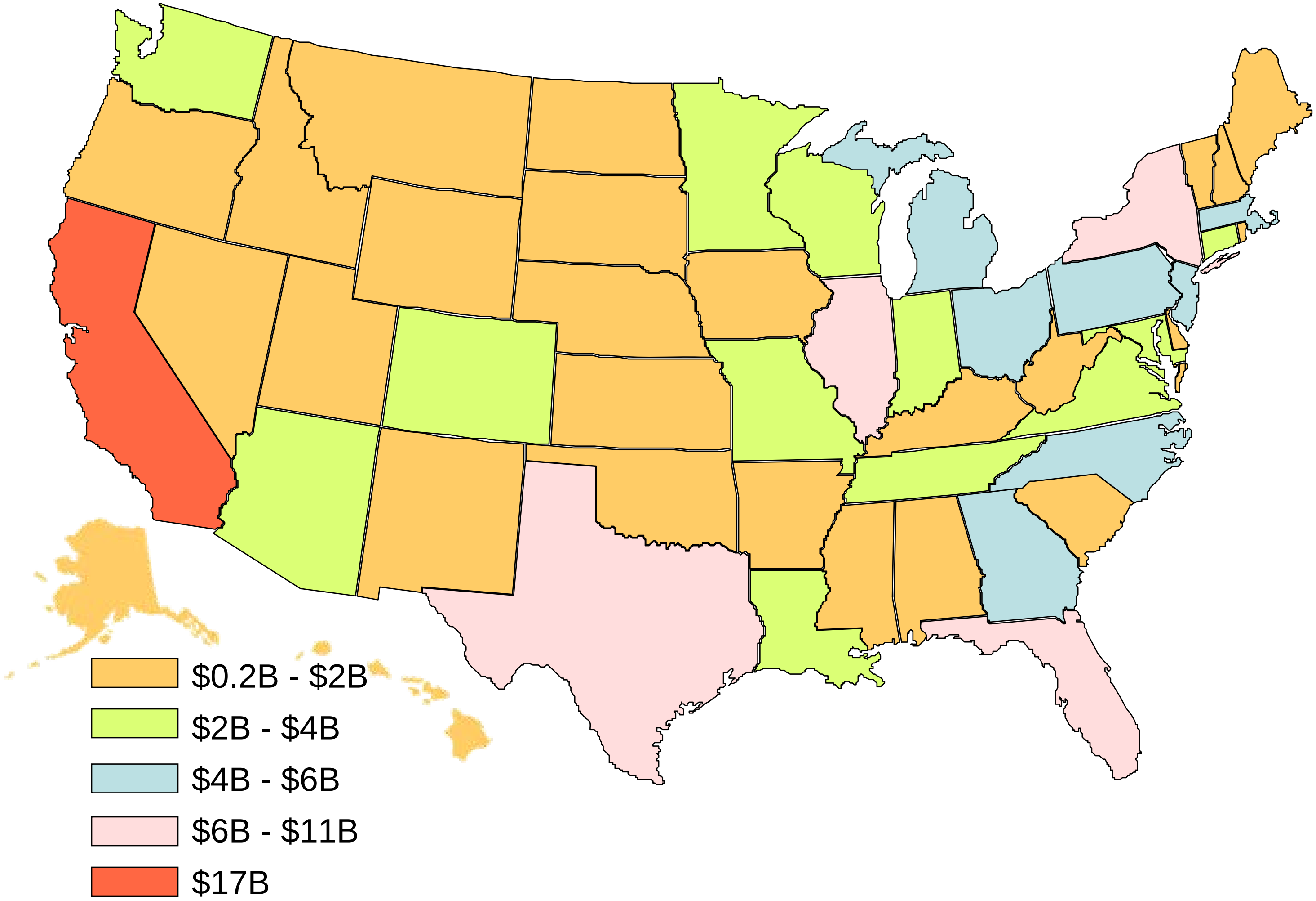
- **As much as $135B per year in consumer losses** ***(Primen, 2004)***
- **In the NY ISO, 23% of the wholesale price is congestion costs, which are passed along to consumers.** ***(PNNL, 2006)***
- **August 2003 blackout: $4-6B, 50M people affected**

It is not the cost of electricity that drives our decisions. It is the cost of NOT having electricity.

Energy Director, Oracle Corporation, 2004

Annual Business Loss from Grid Problems

Primen Study: Up to $135B annually for power interruptions



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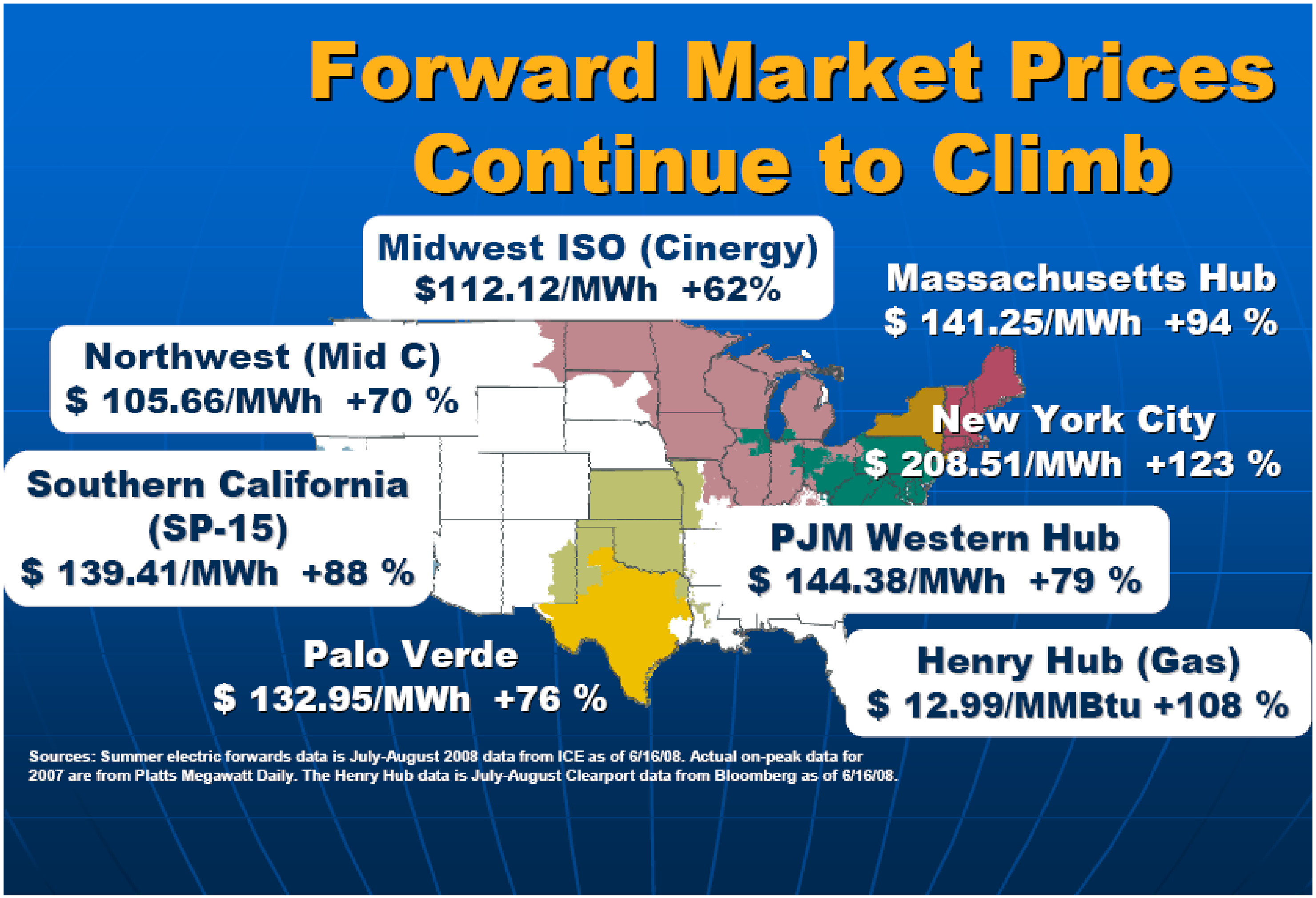
Energy Prices



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What is the Smart Grid?

We need options

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 central station generation**
- **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**

The Smart Grid can make this "world" real!

Smart Grid is Defined by its 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

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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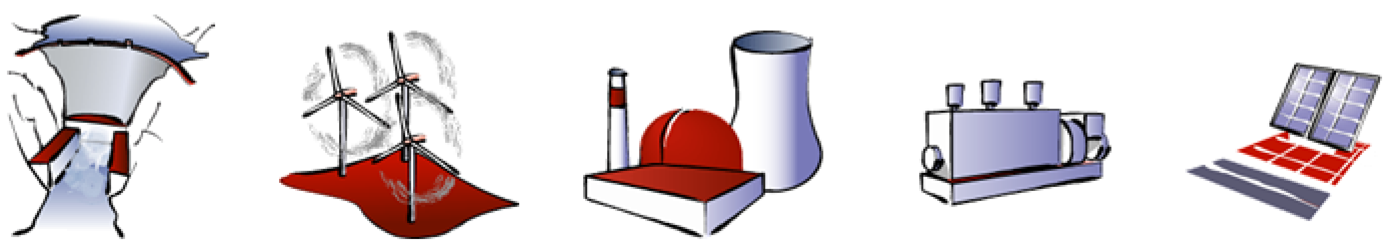
It will "Accommodate all generation and storage options"

- **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!

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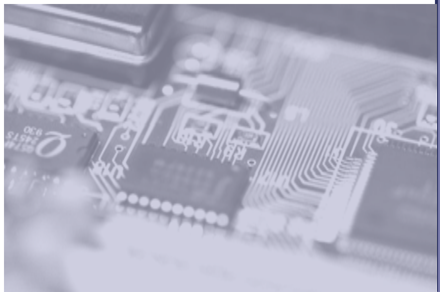
It will "Provide power quality for the digital economy"

- **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**

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"

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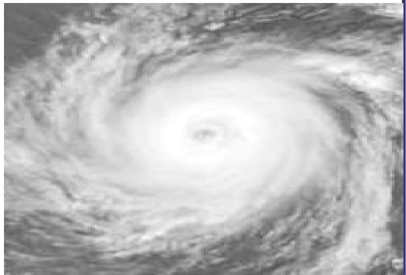
- **System-wide solution to physical and cyber security**
- **Reduces threat, vulnerability, consequences**
- **Deters, detects, mitigates, responds, and restores**
- **"Fort Knox" image**
- **Decentralization and self-healing enabled**

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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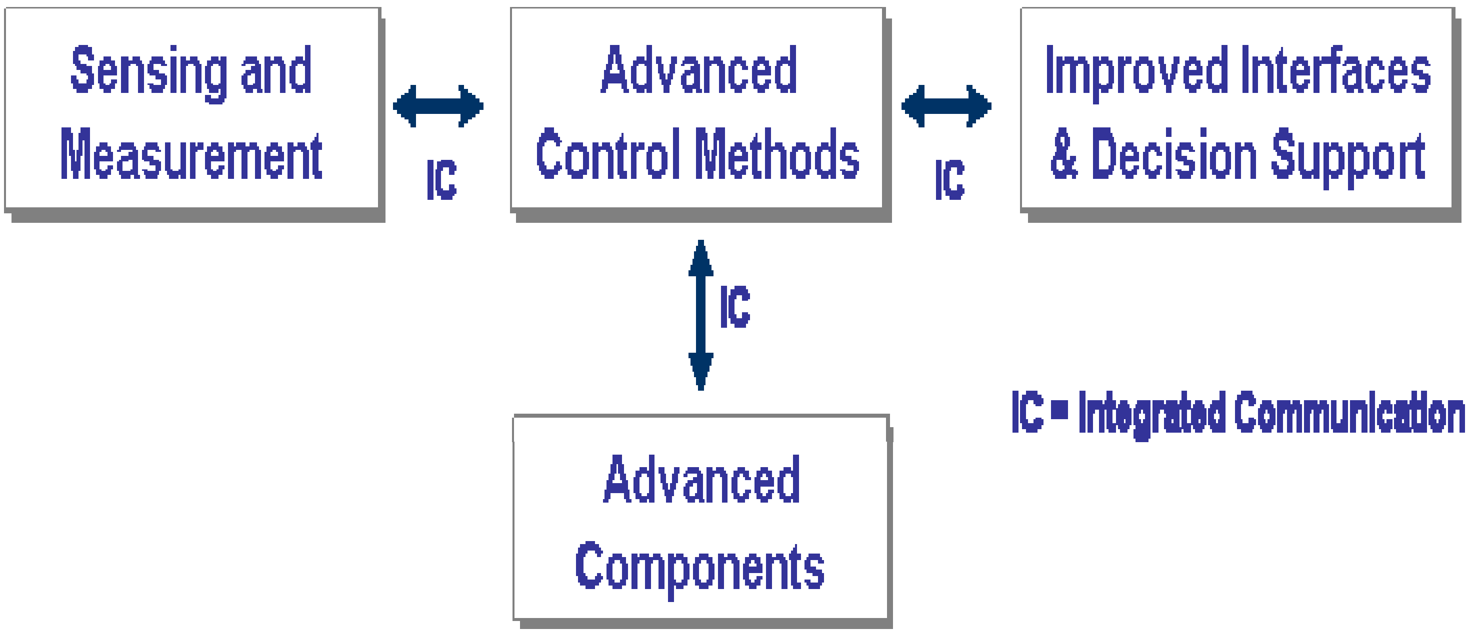
The Smart Grid Gap

Characteristic	*Today's Grid*	*Smart Grid*
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's Grid*	*Smart Grid*
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

Smart Grid Key Technologies



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What is the value proposition?

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)*

Benefit Categories

- Utility
- Consumer
- Societal
- Others?

Utility Benefits

Operational efficiencies

- *Metering and billing*
- *Outage management*
- *Process improvement*
- *Work force management*
- *Reduced losses (energy)*
- *Asset utilization*

Asset Management improvements

- *System planning*
- *Maintenance practices*
- *Engineering*

These benefits are expected to improve customer satisfaction and reduce O&M and capital costs.

Consumer Benefits

- **Access to information**
- **Ability to manage energy consumption**
- **Option to participate in demand response**
- **Convenient interconnection of distributed generation**
- **Option to bid (sell) into electricity markets**
- **Reduction in outages (number and duration)**
  - Fewer losses
  - Fewer inconveniences
- **Improved overall level of service**

Consumers receive information, control and options

Societal Benefits

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- Improved operating and marketing efficiencies leading to downward pressure on electricity prices
- Improved reliability leading to reduction in consumer losses (~$135B)
- Increased grid robustness improving grid security
- Integration of renewables and reduction in energy losses leading to a reduction of emissions
- Improved public and worker safety
- Job and GDP growth
- Opportunity to revolutionize the transportation sector

Achieving the Smart Grid Vision depends on consumer involvement – and the benefits are significant!

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Is the SG Value Proposition Compelling?

- **Would you wash your clothes at 9pm to save 10 cents?**
- **Would you drive an extra quarter mile for 10% cheaper gas (that's 40 cents less)?**
- **Would you rather fill your vehicle with less carbon, while you sleep, work, shop for 75% less per gallon?**
- **Would you like it if your car had the intelligence to sell that power back during a peak and pay for your driving all week long?**
- **What value do you place on societal benefits?**

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How Do We Get There?

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

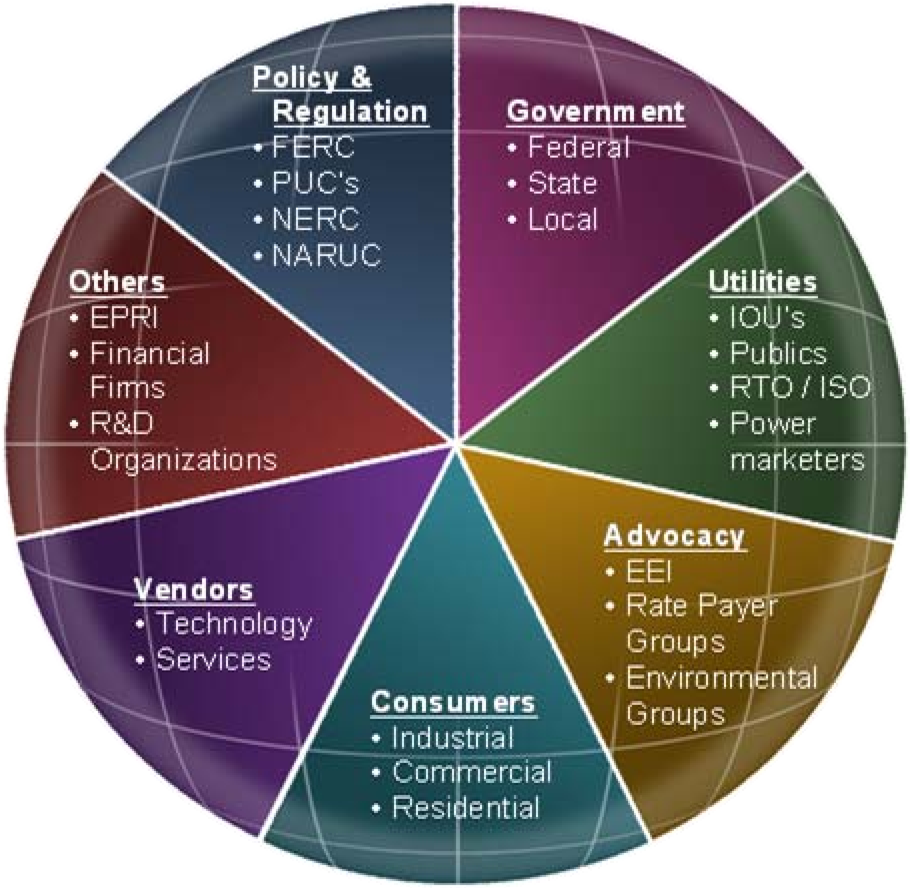
Keeping the "End in Mind"

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	✓	✓	✓	

What are some of the barriers?

Barrier Categories

- Change Management
- Regulatory Policy
- Technical
- Other?



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
- Active leadership by regulators
- Keep the “end in mind”

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

For More Information

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

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Questions?