MODERN GRID
STRATEGY

What's Driving the Smart Grid?

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Agenda

MODERN GRID STRATEGY

- The Smart Grid – a refresher
- “Push” drivers – a case for action
- “Pull” drivers - Smart Grid opportunities
- Some Smart Grid challenges
- Some programs underway

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What is the role of the MGS?

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- Define a vision for the Modern Grid
- Reach out to stakeholders for input
- Assist in the identification of benefits and barriers
- Facilitate resolution of issues
- Promote testing of integrated suites of technologies
- Communicate and educate stakeholders

MGS is an "Independent Broker" for the Smart Grid

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The Smart Grid – a refresher

It will "Enable active participation by consumers"

- **Consumers have access to new information, control, and options to engage in electricity markets**
  - See what they use, when they use it, and what it costs
  - Manage energy costs
  - Invest in new devices
  - Sell resources for revenue or environmental stewardship
- **Grid operators have new resource options**
  - Reduce peak load and prices
  - Improve grid reliability

Today	Tomorrow
Little price visibility, time-of-use pricing rare, few choices	Full price info, choose from many plans, prices and options, buy and sell, "E-Bay"

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.**

Today	Tomorrow
Dominated by central generation. Little DG, DR, storage or renewables	Many "plug and play" distributed energy resources complement central generation

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**

Today	Tomorrow
Limited wholesale markets, not well integrated	Mature, well-integrated wholesale markets, growth of new electricity markets

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**

Today	Tomorrow
Focus on outages not power quality	PQ a priority with variety of price/quality options based on needs

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**
  - 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)**

Today	Tomorrow
Limited grid information & minimal integration with asset management	Deep integration of grid intelligence with asset management applications

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**

Today	*Tomorrow*
Protects assets following disruption (e.g. trip relay)	Prevents disruptions, minimizes impact, restores rapidly

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**

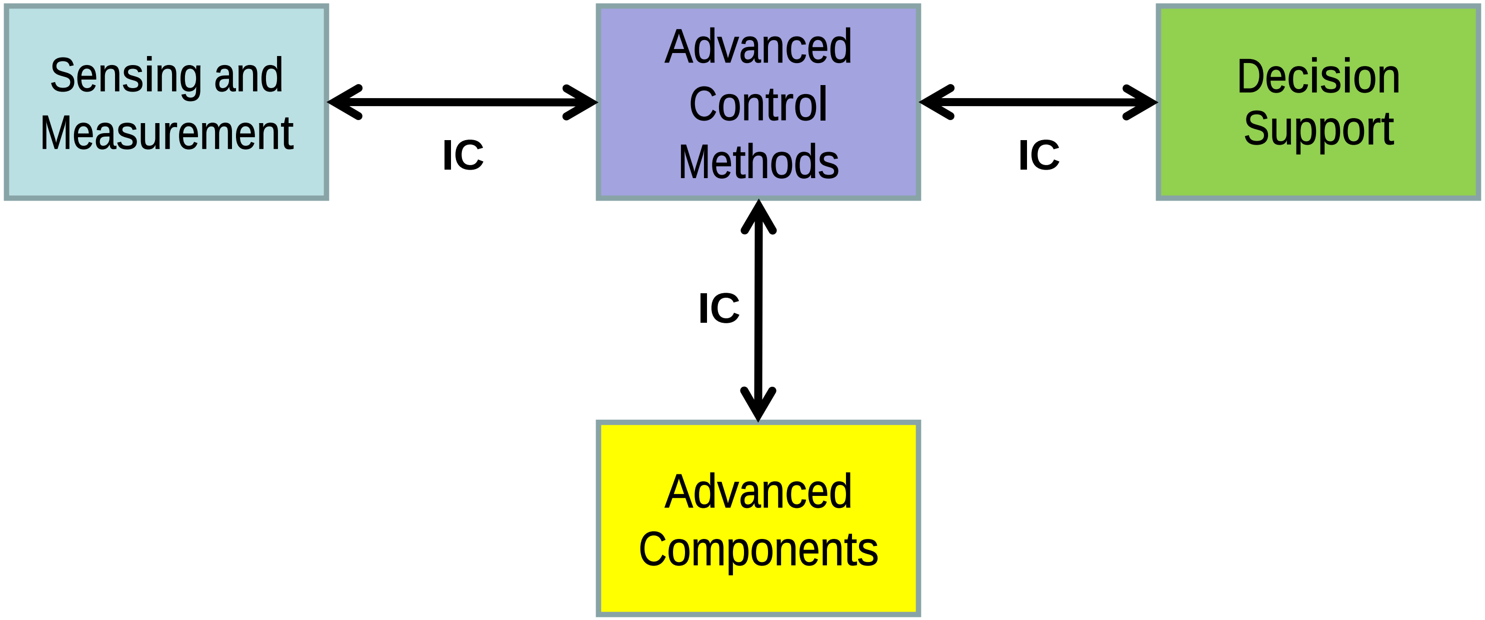
Today	Tomorrow
Vulnerable to terrorists and natural disasters	Deters, detects, mitigates, and restores rapidly and efficiently

In summary:

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

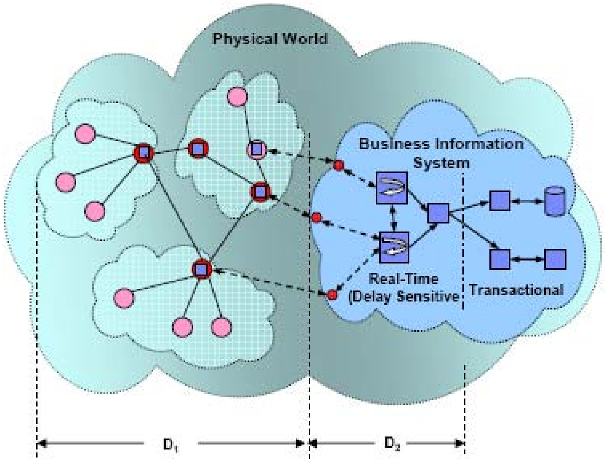
Smart Grid Key Technology Areas



MODERN GRID INITIATIVE

An effective, fully-integrated communications infrastructure is an essential component of the modern grid:

- **IC creates a dynamic, interactive "mega-infrastructure" for real-time information and power exchange**
- **IC allows the various intelligent electronic devices (smart meters, control centers, power electronic controllers, protection devices) and users to interact as an integrated system**



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Smart Grid Technologies

Sensing and Measurement

- Smart meters
- Smart sensors
  - Operating parameters
  - Asset Condition
- Wide area monitoring systems (WAMS)
- Dynamic rating of transmission lines

Smart Grid Technologies

Advanced Control Methods

Applications that:

- Monitor and collect data from sensors
- Analyze data to diagnose and provide solutions
- Real time and predictive
- Determine and take action autonomously or via operators
- Provide information and solutions to operators
- Integrate with enterprise-wide processes and technologies

Smart Grid Technologies

- Next generation FACTS/PQ devices
- Advanced distributed generation and energy storage
- PHEV - V2G mode
- Fault current limiters
- Superconducting transmission cable & rotating machines
- Microgrids
- Advanced switches and conductors

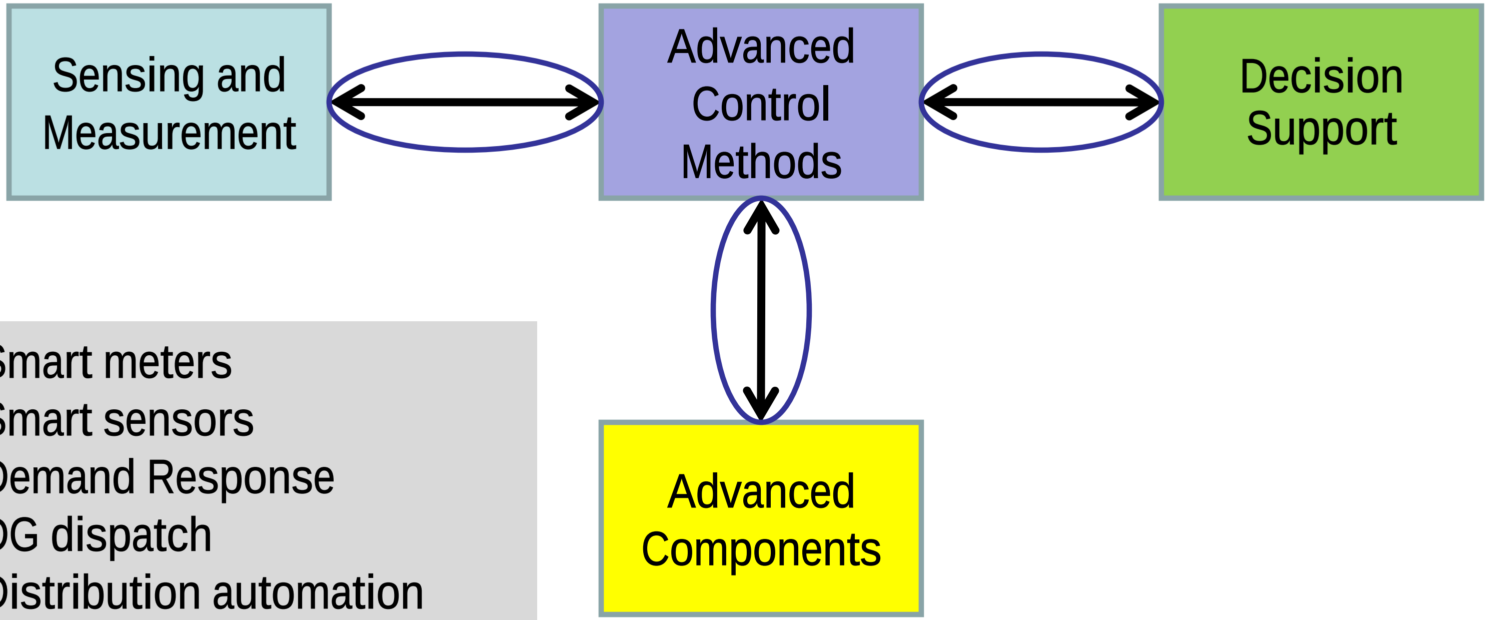
Advanced Components

Smart Grid Technologies

Data reduction
Data to information to action
Visualization
Speed of comprehension
System operator training

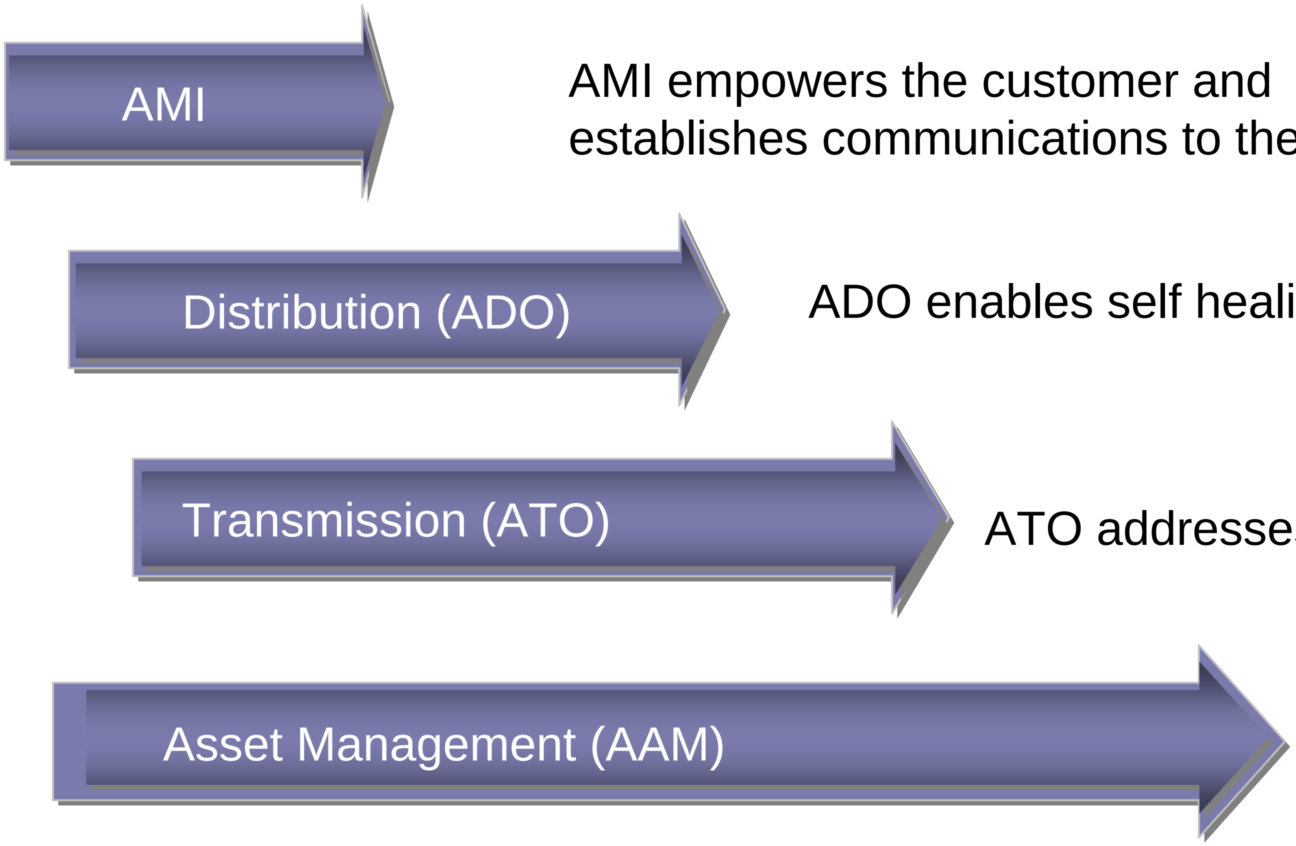
Decision Support

Fully Integrated Communications Infrastructure



Smart meters
Smart sensors
Demand Response
DG dispatch
Distribution automation
Micro-grids
Markets
Work force management
Mobile premises (PHEV’s)

Steps to the Smart Grid



AMI empowers the customer and establishes communications to the loads

ADO enables self healing

ATO addresses congestion

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

Steps to the Smart Grid

AMI

AMI empowers the customer and establishes communications to the loads

Distribution (ADO)

ADO enables self healing

Advanced Distribution Operations

Distribution Management System

Smart sensors

DER Operations – including PHEV V2G

Distribution Automation

Micro-grid operations (AC and DC)

Advanced protection and control

Advanced grid components for distribution

Steps to the Smart Grid

Advanced Transmission Operations

Substation Automation

Advanced regional operational applications

Modeling, simulation and visualization tools

Wide Area Measurement System (WAMS)

Hi-speed information processing

Advanced materials and power electronics

Transmission (ATO)

ATO addresses congestion

Asset Management (AAM)

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

Steps to the Smart Grid

Advanced Asset Management

Integration with other Smart Grid technologies:

Advanced Outage Management

System planning (T&D)

Condition-based maintenance

Work and resource management

Customer service

Geographical Information Systems

Engineering and operations

Asset Management (AAM)

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

Putting it all together – T, D, & M impacted

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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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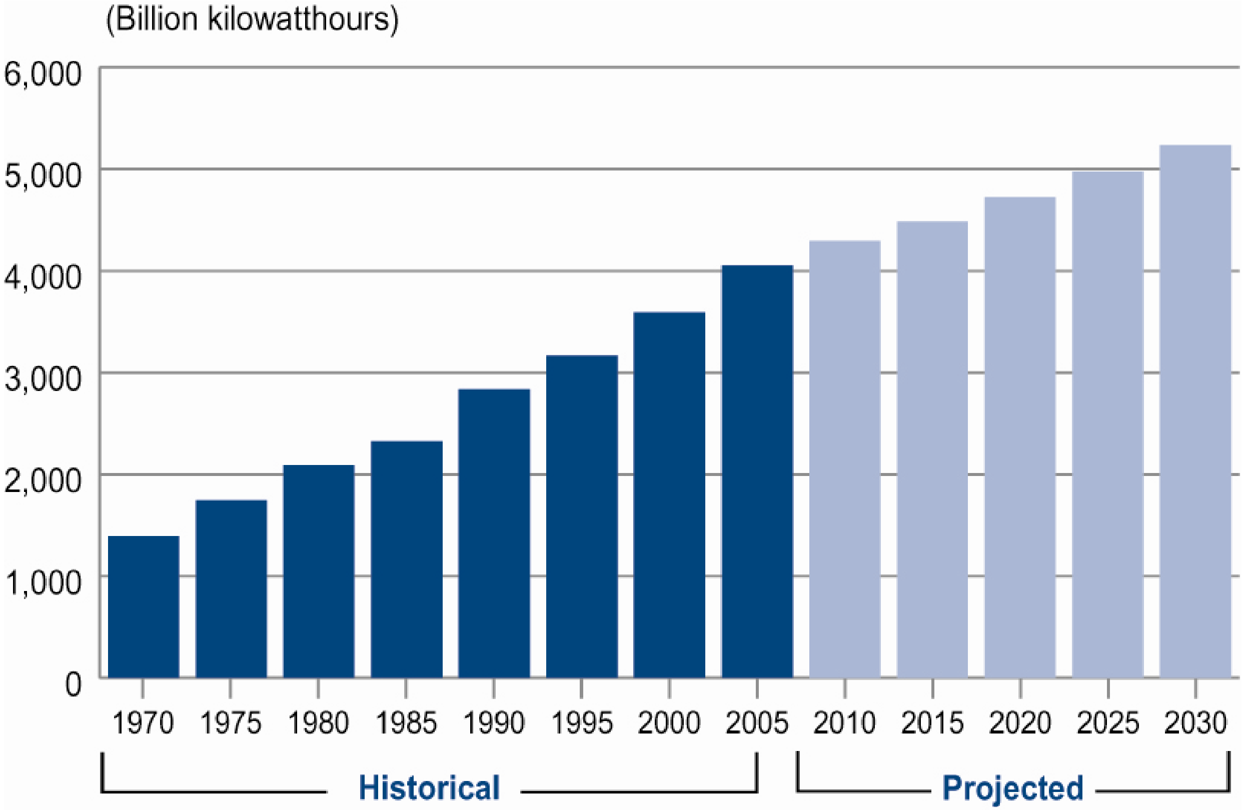
"Push" drivers – a case for action

Demand for Electricity Is Projected to Increase 30% by 2030



*Electricity demand projections based on expected growth between 2006 and 2030.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2006* and *Annual Energy Outlook 2008* (early release).

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Cost of new generation is increasing

Generation Type	2003-04 ($/KW)	2008 ($/KW)
Nuclear	$1300 - $2300	$4500 - $7500
Conventional Coal	$1000 - $1600	$1800 - $4000
IGCC Coal	$1400 - $1800	$1800 - $2000
Combined Cycle	$600 - $700	$900 - $1600
Combustion Turbine	$300 - $700	$600 - $1000
Wind	$1000 - $1400	$1400 - $2700
Geothermal	$1500 - $2500	$2600 - $3600
Concentrated Solar	$3100 - $5100	$3000 - $5000

IGCC costs from NETL May 2007 Cost and Performance Baseline for Fossil Energy Plants report. Remaining data compiled and reported June 2008 by FERC staff. Costs exclude carbon capture and sequestration costs.

Wholesale energy prices are rising

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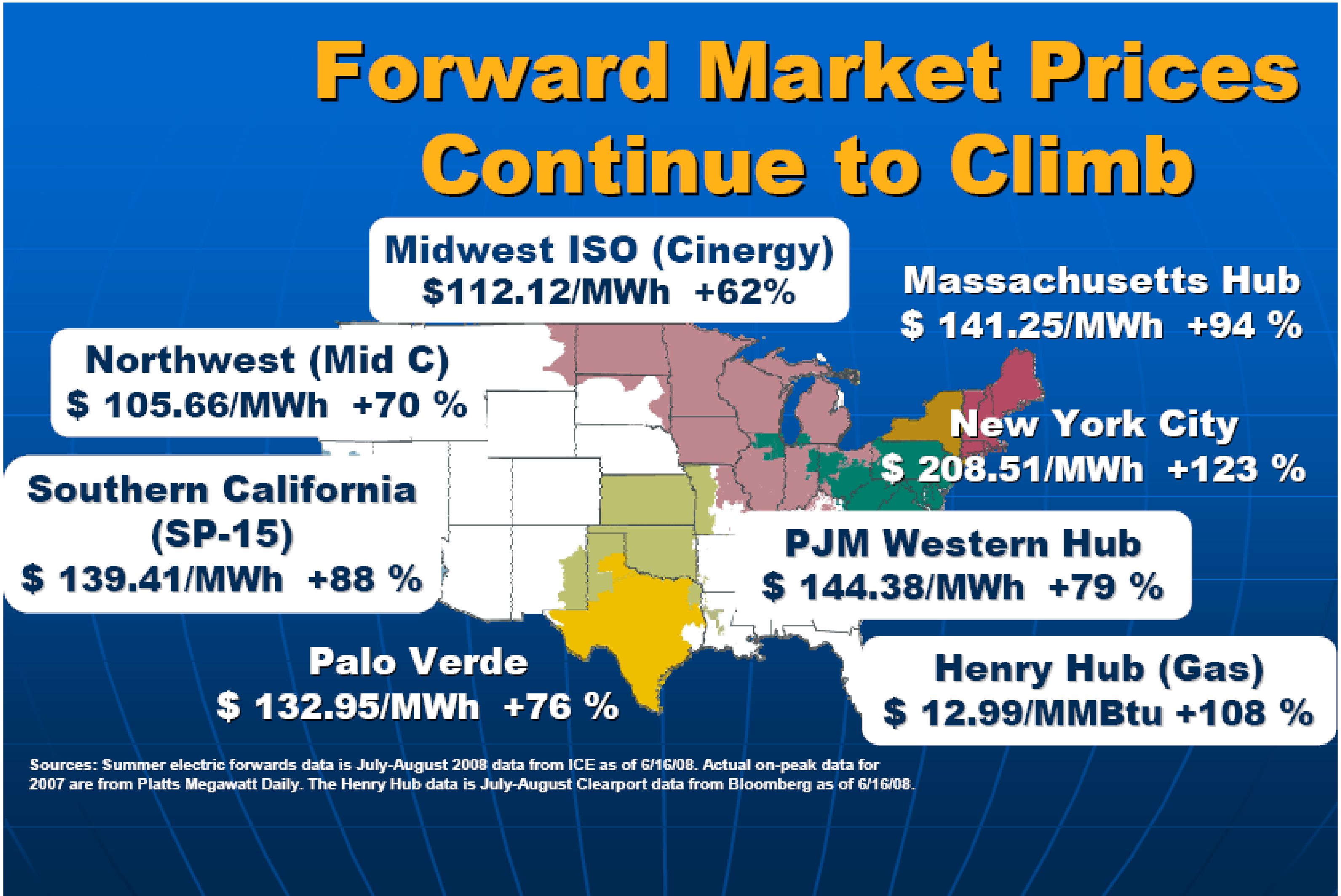

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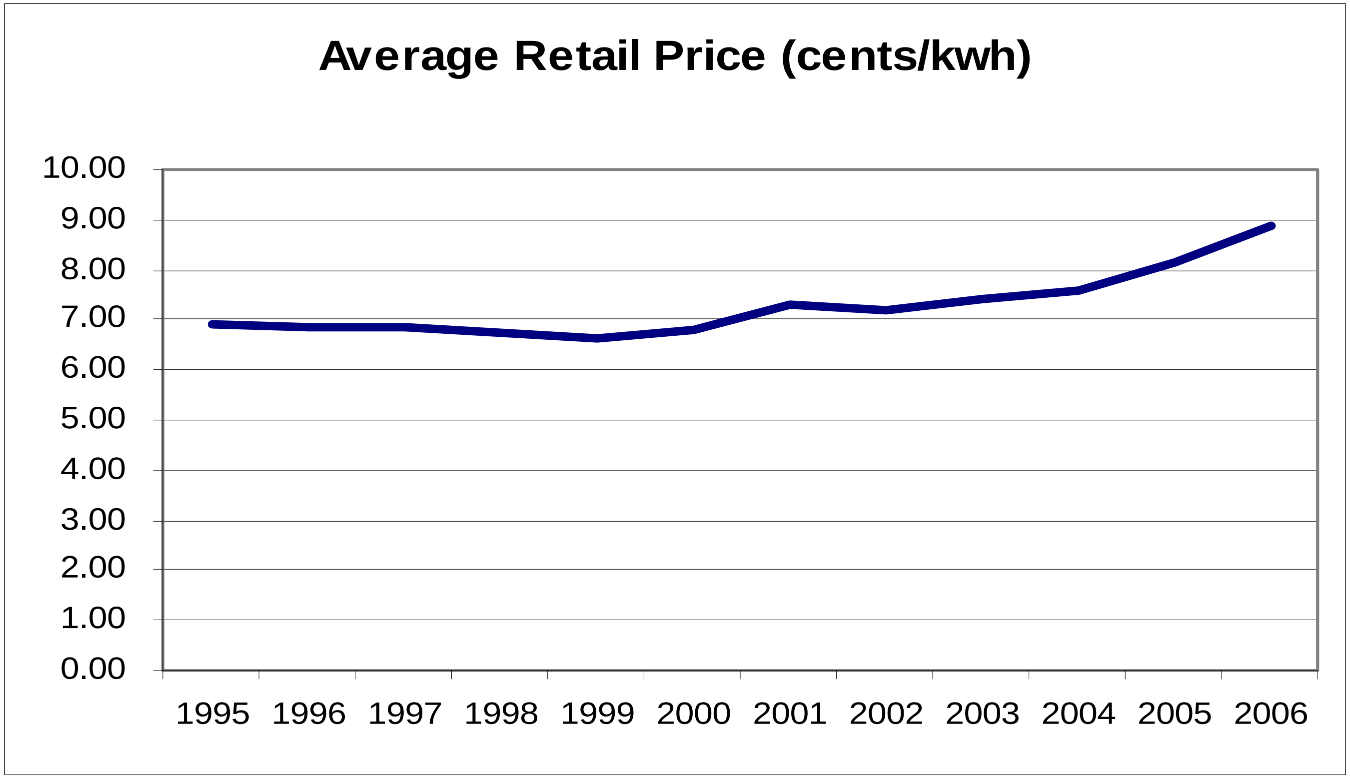
Retail prices are increasing



30% increase over last decade

DOE EIA Energy Outlook 2007

Today's grid - status quo is not an option

- **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

Businesses losing billions from interruptions

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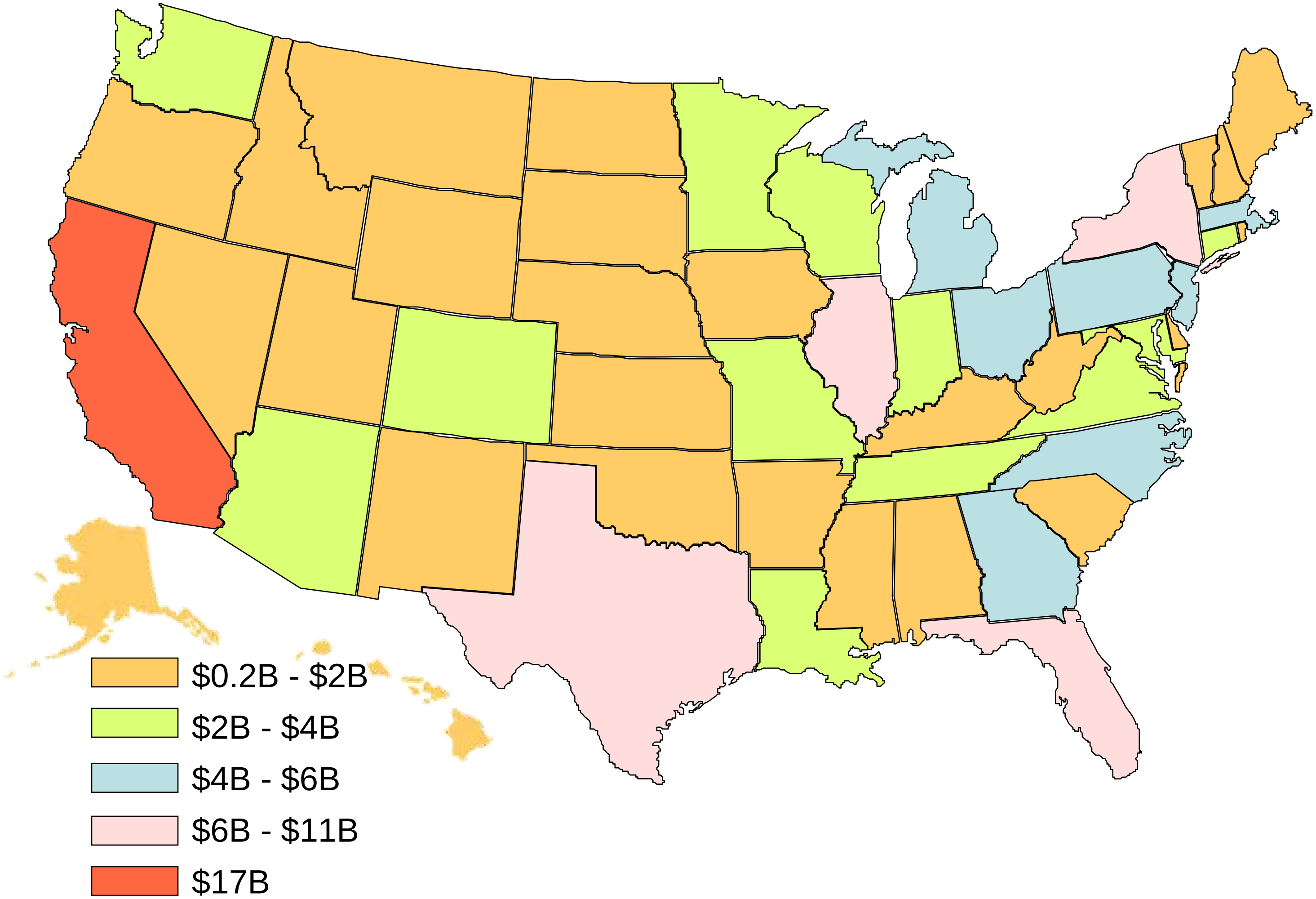
Primen Study: Up to $135B annually for power interruptions



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Other considerations

- **50 coal plants cancelled or delayed since January 2007**
- **Jobs and the economic downturn**
- **US dependence on foreign energy sources**
- **Rising oil and gasoline prices**
- **Climate change**
- **National security**
- **Cost of renewable generation more competitive**
- **Impact of electric vehicles**

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“Pull” drivers - Smart Grid opportunities

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

Authorized but not yet appropriated!

Value Proposition

Cost to Modernize

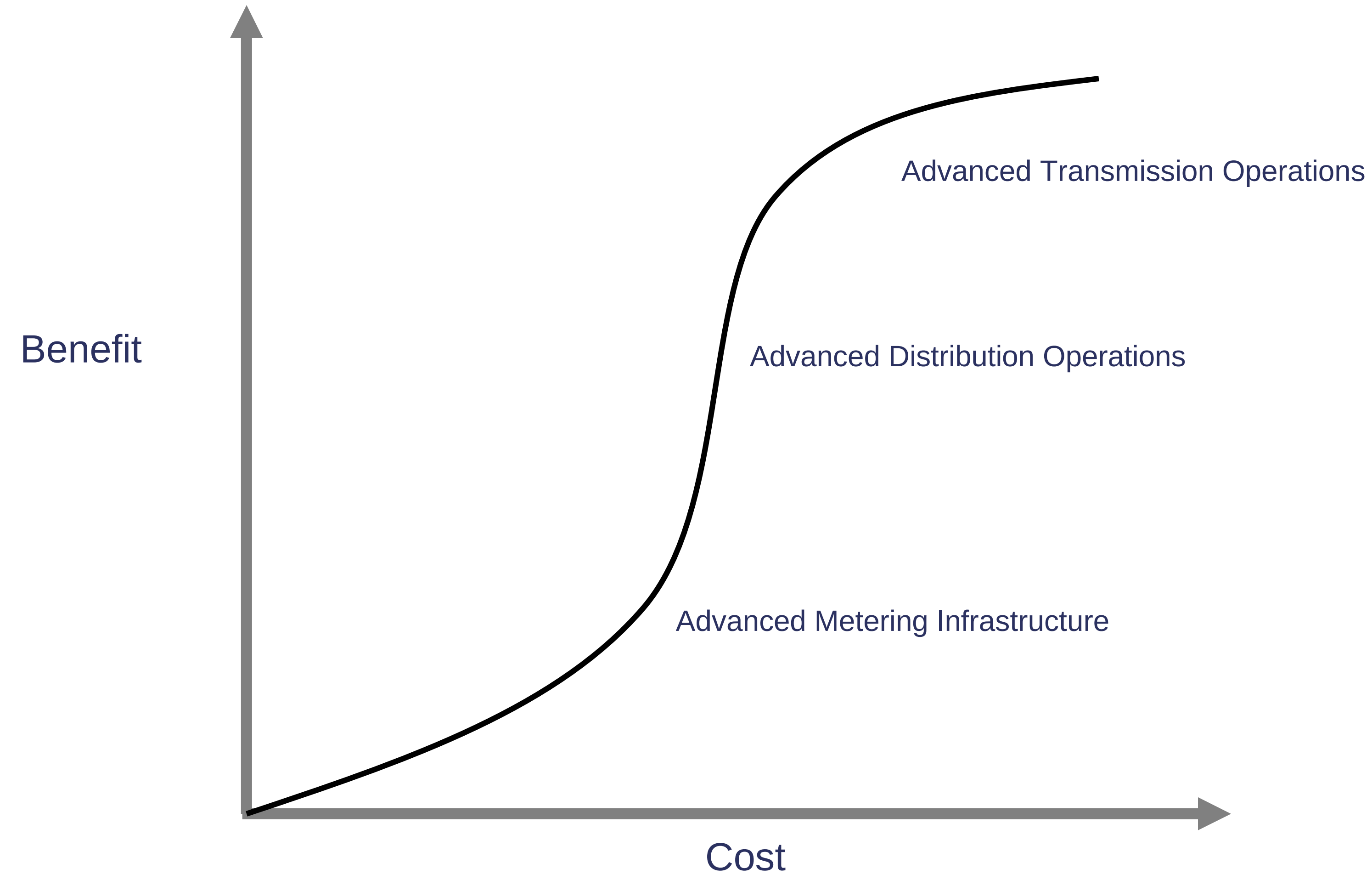
- **$165B over 20 years**
  - $127B for Distribution
  - $38B for Transmission
- **~$8.3B per year (incremental to business-as-usual)**
- **Current annual investment - $18B**

Benefit of Modernization

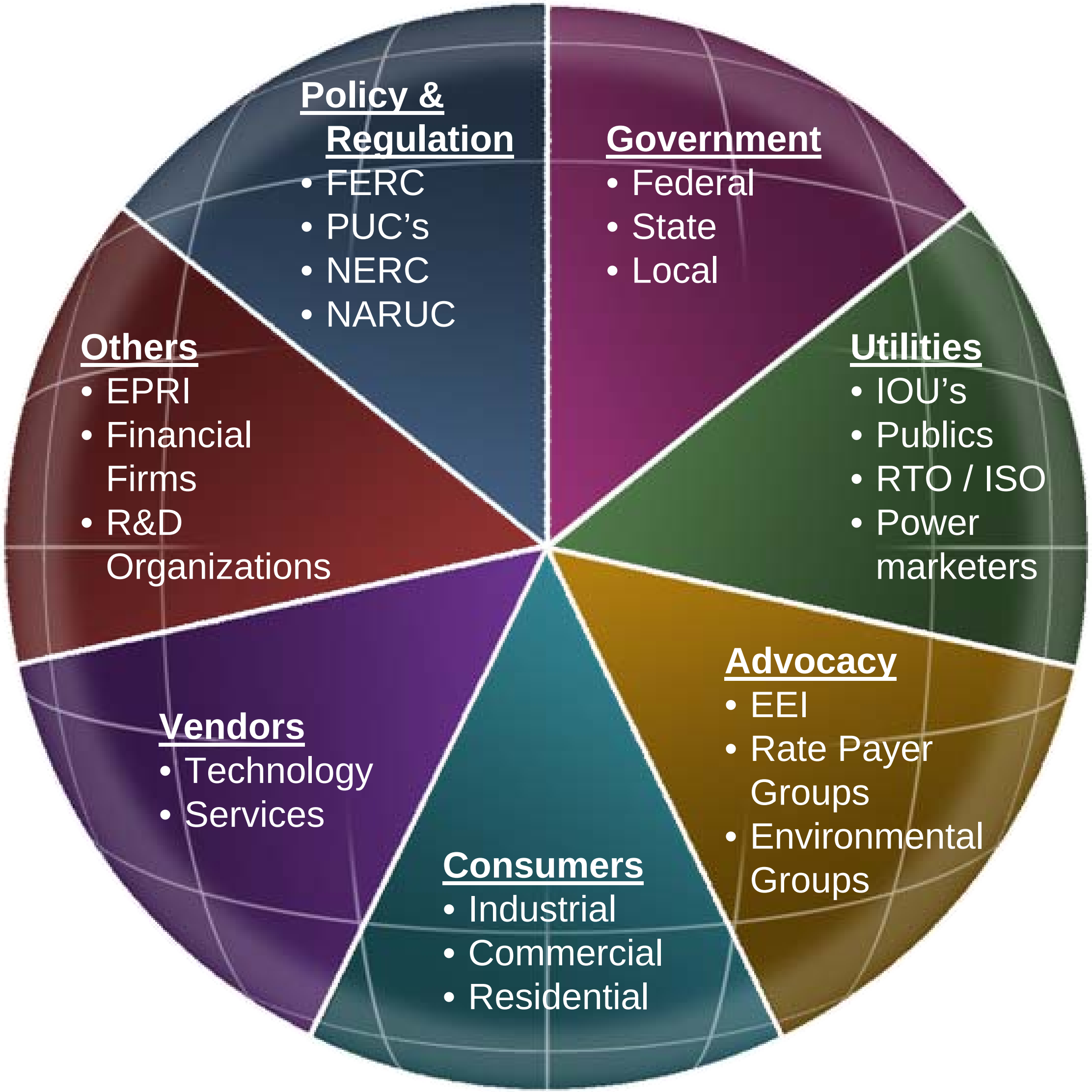
- **$638B - $802B over 20 years**
- **Overall benefit to cost ratio is 4:1 to 5:1**

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)

Generally speaking…



Who are the Smart Grid Stakeholders?



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Utility Benefits

Operational improvements

- *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

- **Improved reliability**
- **Improved overall level of service**
- **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**
- **Potential to dramatically reduce transportation costs (PHEV)**

Consumers have access to information, control and options

Societal Benefits

- **Downward pressure on electricity prices** *through improved operating and market efficiencies, consumer involvement*
- **Improved reliability** *leading to reduction in consumer losses (~$135B)*
- **Increased grid robustness** *improving grid security*
- **Reduced losses and emissions** *through integration of renewables and a more efficient grid*
- **New jobs and growth in GDP**
- **Opportunity to revolutionize the transportation sector** *through integration of electric vehicles as generation and storage devices*

Societal benefits must be included in the value proposition

Societal Benefits – an example

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**

But we need a Smart Grid to enable this world

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Some Smart Grid Challenges

Regulatory Challenges

- ***Time based rates -*** incentives for consumers to become actively involved
- ***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 –*** quantified and included in business cases
- **New regulation models-** Decoupling?

Technical challenges

- Lack of resources to “change” and also “keep the lights on”
- Shortage of skilled human resources
- Incorporating 2-way power flow into operations
- Simplifying interconnection standards while maintaining safety
- More focus on R&D – breakthrough technologies
- Integration of disruptive technologies
- Sharing successes and “lessons learned”
- Getting the communications system right

Change Management Challenge

- Significant focus on "change management"
- Process and technology "re-engineering"
- Utility business model – "decoupling?"
- More consumer education
- Increased consumer influence
- More accountability (metrics and reports)
- New opportunities

DOE RDSI Program

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- Nine DOE funded projects to develop Renewable and Distributed Systems Integration
- $50 million to be invested over five years*
- Will reduce peak load electricity demand by at least 15 percent at distribution
- Nine Projects of which Fort Collins' is one

*Cost and Schedule figures are estimated.

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Consumer-related Projects

Interactive Home

- **Participants:** The University of Nevada, Pulte Homes, Nevada Power Company, and GE
- **Objective:** **Address the construction of energy efficient homes that overcome electricity grid integration, control, and communications issues**
- **Duration:** 5 years*
- **Cost:** $6.9 million federal/$13.9 million non-federal)*

Grid-Customer Interoperability

- **Participants**: Consolidated Edison, Verizon, Innovative Power, Infotility, and Enernex.
- **Objective:** **Develop and demonstrate methodologies to achieve true interoperability between a delivery company and end-use retail electric customers, enhancing the reliability of the distribution grid and the efficiency of its operations.**
- **Duration**: 3 years*
- **Cost**: $6.8 million federal/6.2 million non-federal*

Perfect Power

- **Participants:** The Illinois Institute of Technology (IIT), Exelon, Galvin Electricity Initiative, S&C Electric, and others
- **Objective:** **Develop and demonstrate a system that will achieve "perfect power" at the main campus of IIT through the implementation of distributed resources, advanced sensing, switching, feeder reconfiguration, and controls.**
- **Duration:** 5 years*
- **Cost:** $7 million federal/$5.2 million non-federal*

*Cost and Schedule figures are estimated.

Smart Circuits

Dispatchable Distribution Feeder

- **Participants:** San Diego Gas and Electric, Horizon Energy Group, Advanced Control Systems and others
- **Objective:** **Prove the effectiveness of integrating multiple distributed energy resources with advanced controls and communication systems to improve stability and reduce peak loads on feeders/substations.**
- **Duration:** 3 years*
- **Cost:** $6.9 million federal/$4 million non-federal*

West Virginia Super Circuit

- **Participants:** Allegheny Power , West Virginia University and others
- **Objective:** **Improve distribution system performance, reliability, and security of electric supply through the integration of distributed resources and advanced technologies.**
- **Duration: 5 years***
- **Cost:** $5.4 million federal/4 million non-federal*

Transmission Congestion Relief

- **Participants:** The University of Hawaii, General Electric, Hawaiian Electric Company, New Mexico Institute of Mining and Technology and others
- **Objective:** **Explore the management of distribution system resources for improved service quality and reliability, transmission congestion relief, and grid support functions.**
- **Duration:** 3 years*
- **Cost:** $7 million federal/$8 million non-federal*

*Cost and Schedule figures are estimated.

DER Integration

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Smart Jail

- **Participants:** Chevron Energy Solutions , Alameda County, PG&E, University of Wisconsin, the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, and others
- **Objective:** **Significantly reduce peak load and measurably improve power reliability at the Santa Rita Jail. The project will integrate solar energy, fuel cell, energy storage and control systems.**
- **Duration:** 3 years*
- **Cost:** $7 million federal/$7 million non-federal*

Renewable DER Integration

- **Participants:** ATK Launch Systems, Rocky Mountain Power, and P&E Automation
- **Objective:** **Integrate renewable generation and energy storage resources, including a novel compressed-air generation technology, wind-turbines, heat recovery systems, solar trough booster technology, a steam turbine, and hydro-turbine resources.**
- **Duration:** 5 years*
- **Cost:** $1.6 million federal/$2 million non-federal*

Mixed Distributed Resources

- **Participants**: The City of Fort Collins, Larimer County, Colorado State University, and others
- **Objective**: **Demonstrate a 3.5 megawatt coordinated and integrated system of Mixed Distributed Resources to Achieve a 20-30 percent peak load reduction on multiple distribution feeders.**
- **Duration**: 3 years*
- **Cost**: $6.3 million federal/$4.9 million non-federal*

*Cost and Schedule figures are estimated.

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Questions