MODERN GRID
STRATEGY

What's Driving the Smart Grid?

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Agenda

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

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What is the role of the MGS?

- **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
  - Investment 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

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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**
  - 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)**

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

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In summary:

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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

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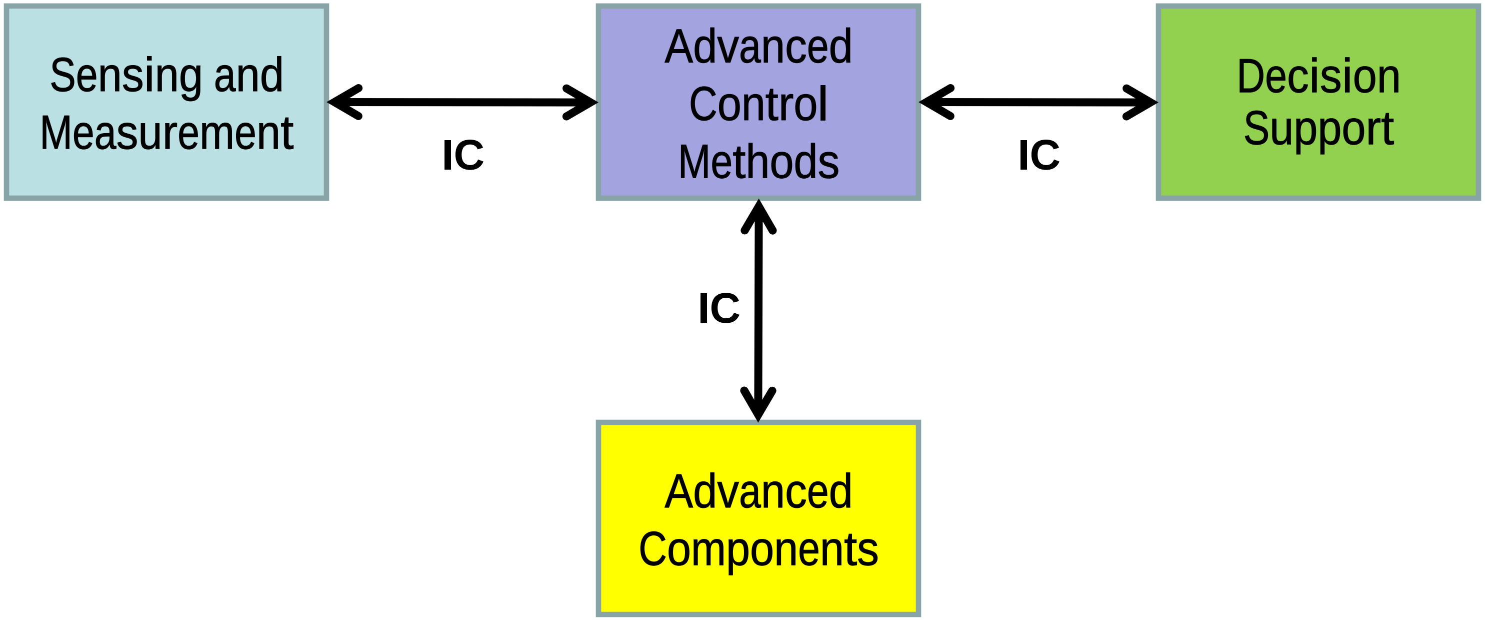
Smart Grid Technologies



Smart Grid Technologies

Smart meters
Smart sensors

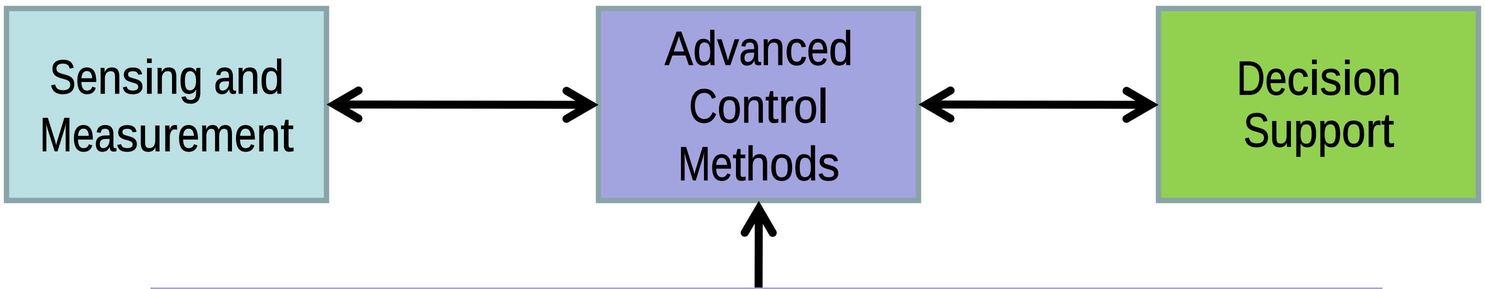
- Operating parameters
- Asset Condition

Wide area monitoring systems (WAMS)
Dynamic rating of transmission lines

Sensing and Measurement

Advanced Components

Smart Grid Technologies



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

Sensi
Measu

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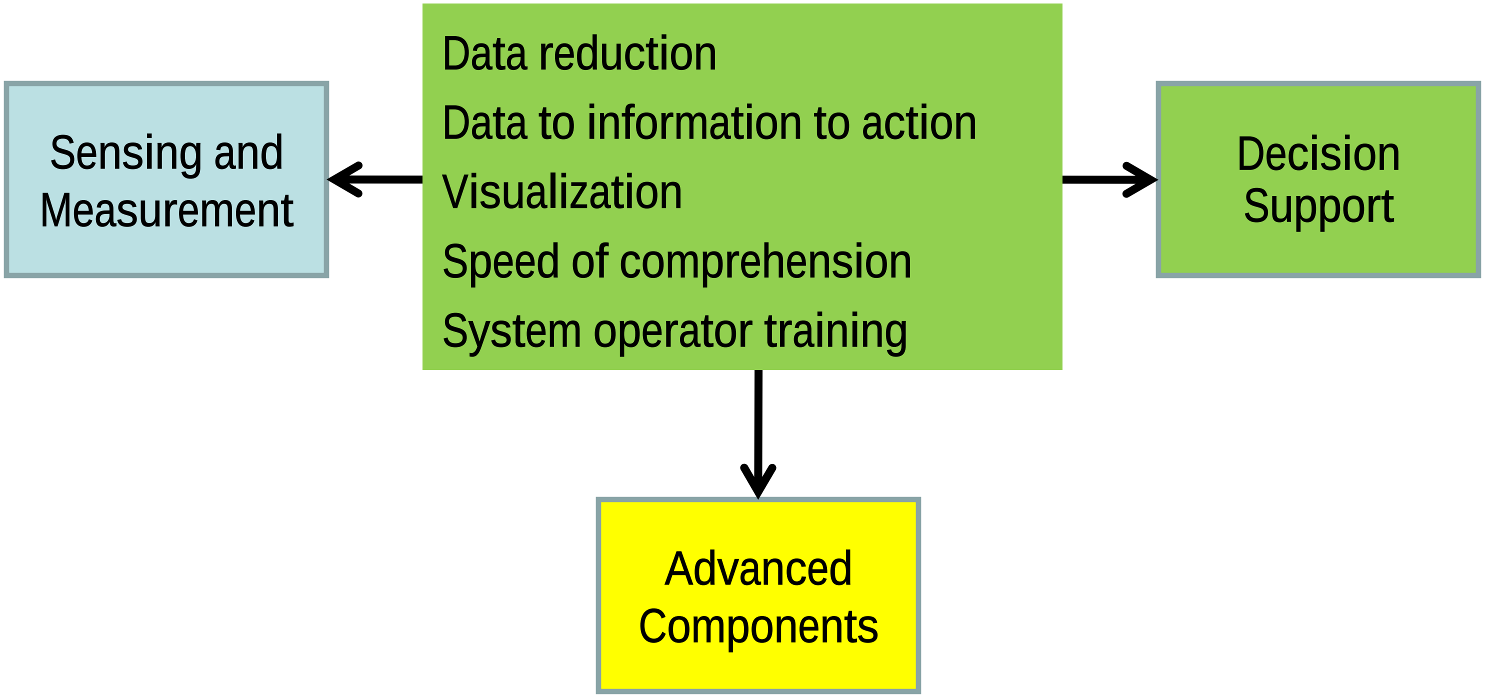
Advanced Components

Smart Grid Technologies



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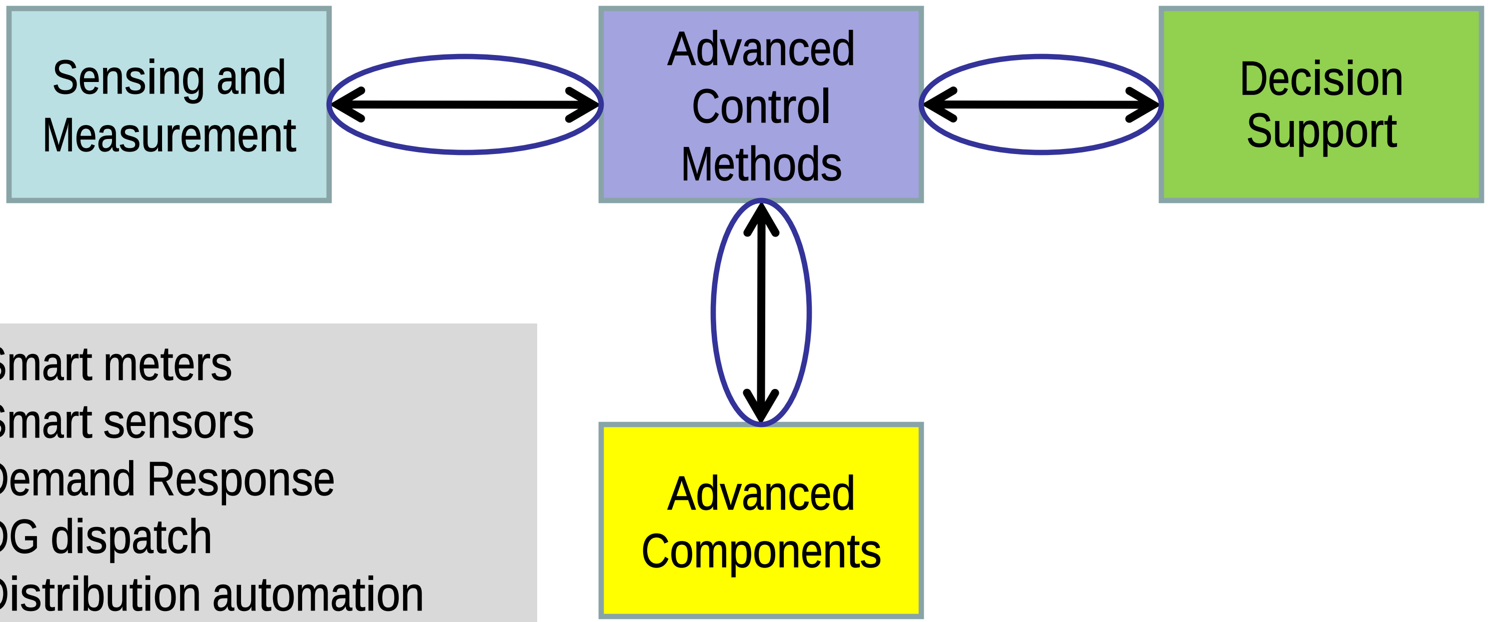
Fully Integrated Communications Infrastructure



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

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

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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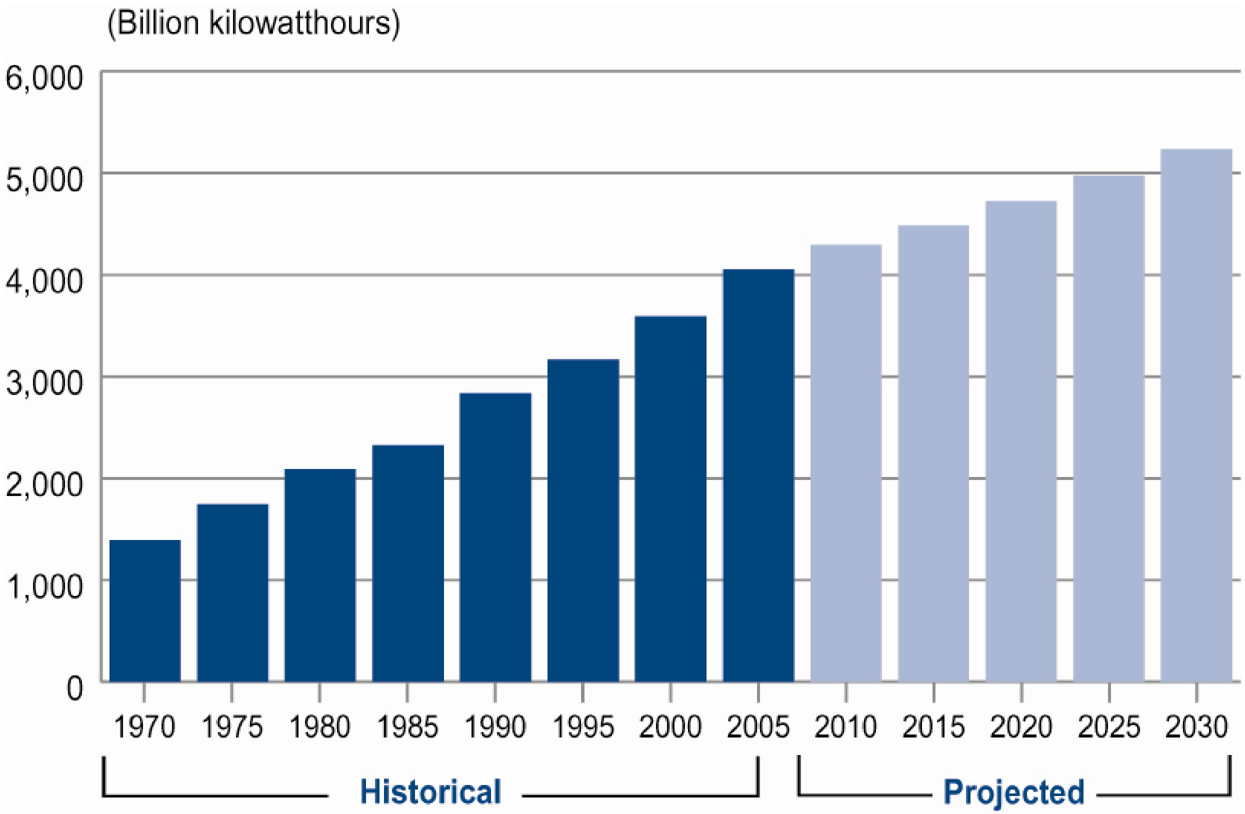
“Push” drivers – a case for action

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).

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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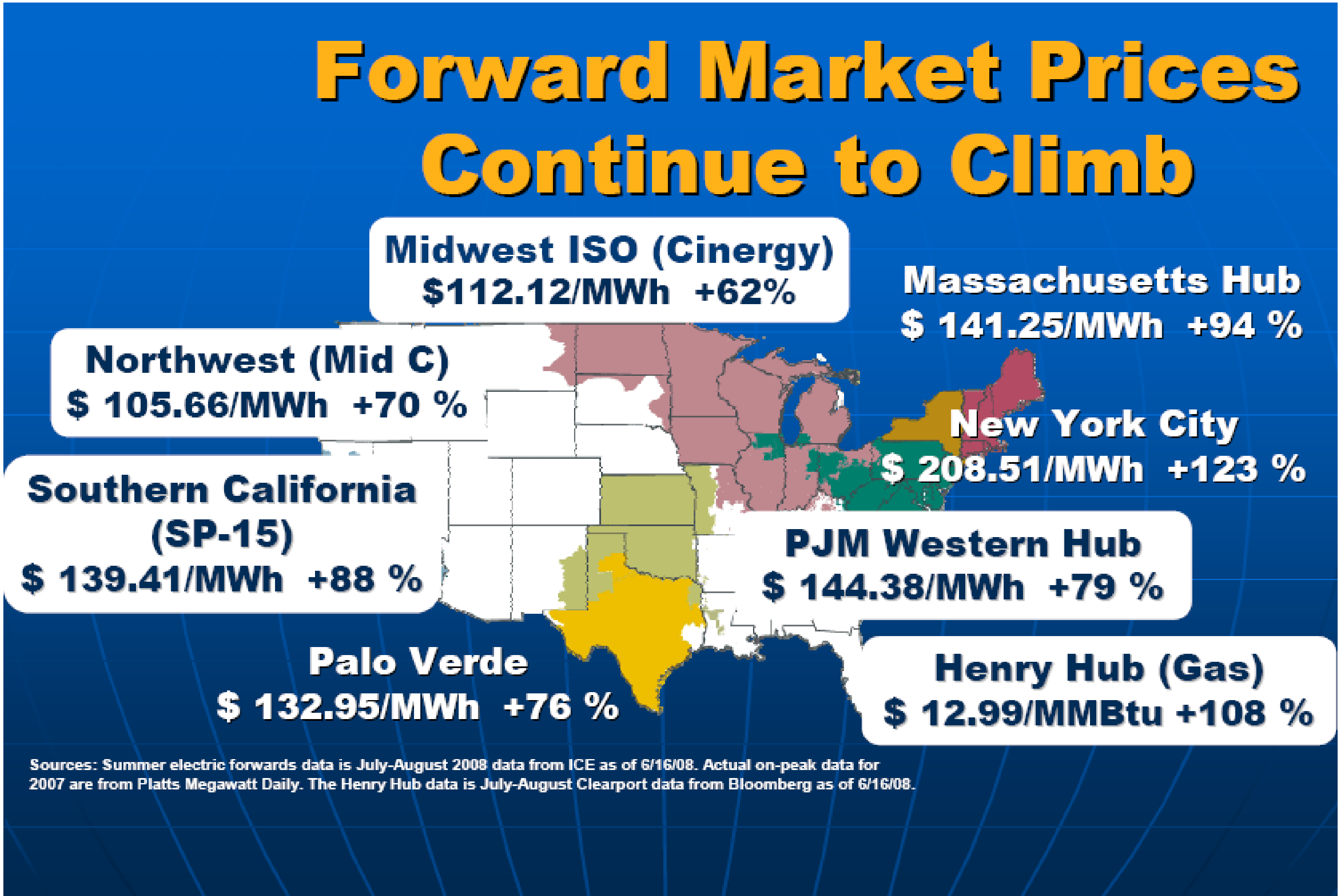

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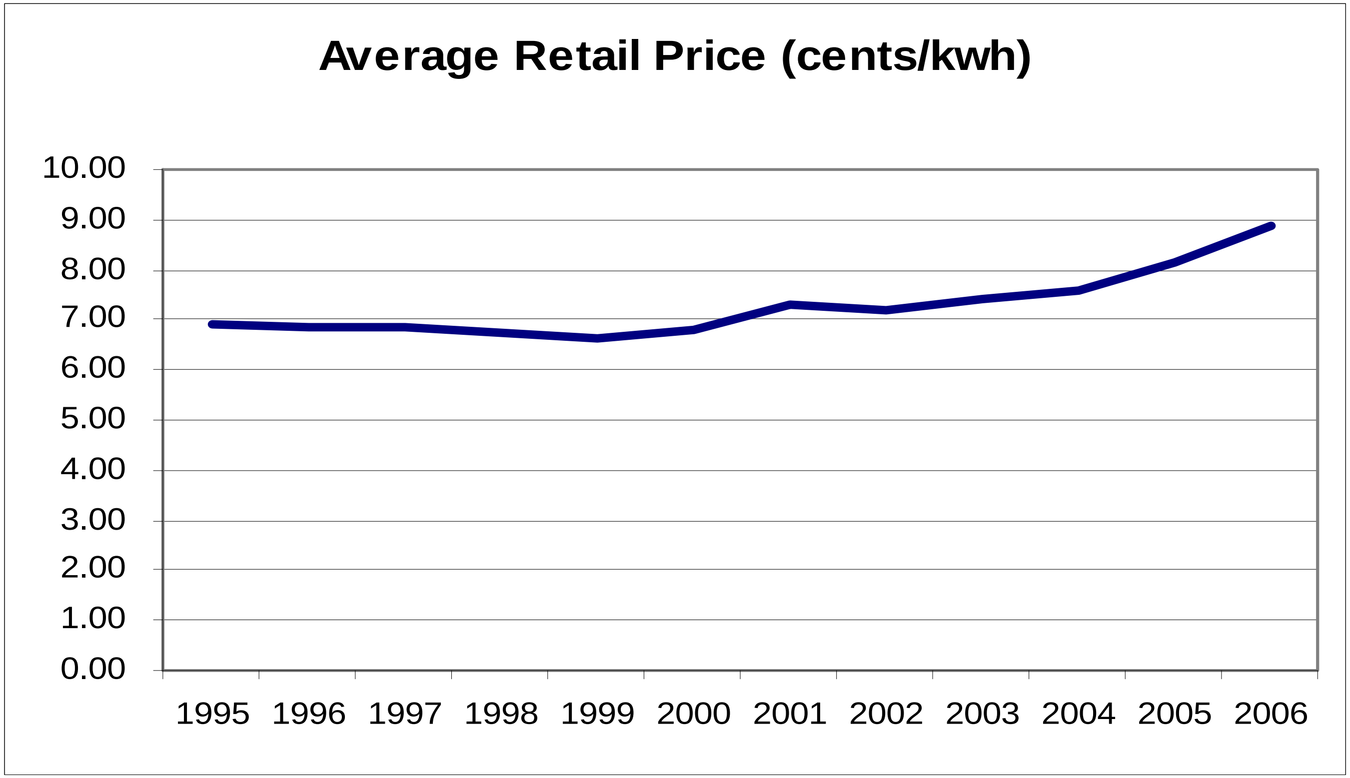
Retail prices are increasing



30% increase over last decade

DOE EIA Energy Outlook 2007

Today's grid - status quo is not an option

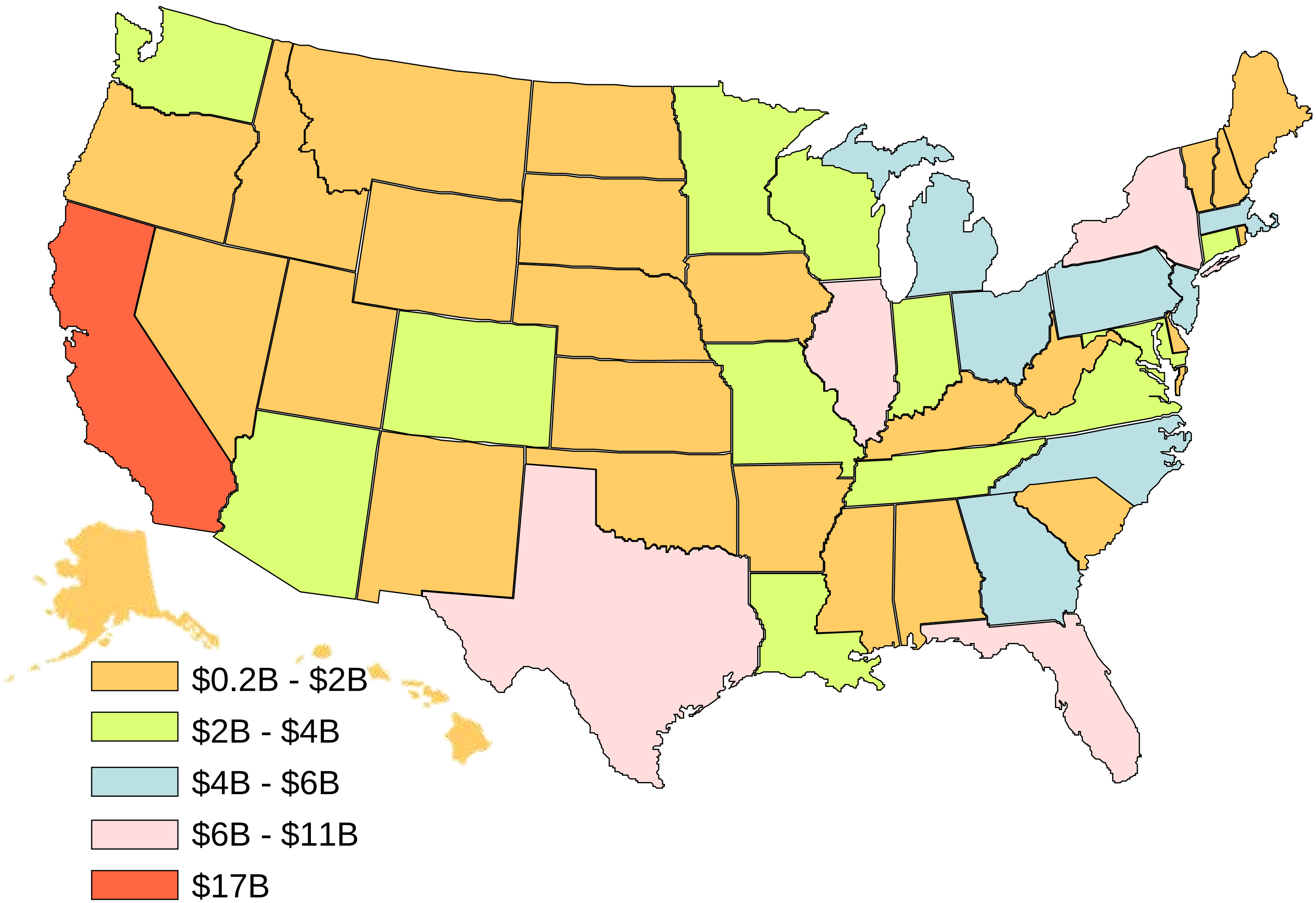
- **Aging**
  - 70% of transmission lines are 25 years or older
  - 70% of transformers are 25 years or older
  - 60% of circuit breakers are 30 years or older
- **Outmoded**
  - Designed in the 50s and installed in the 60s and 70s, before the era of the microprocessor.
- **Stressed**
  - Never designed 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

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



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Other considerations

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- 50 coal plants canceled 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

Value Proposition

Cost to Modernize

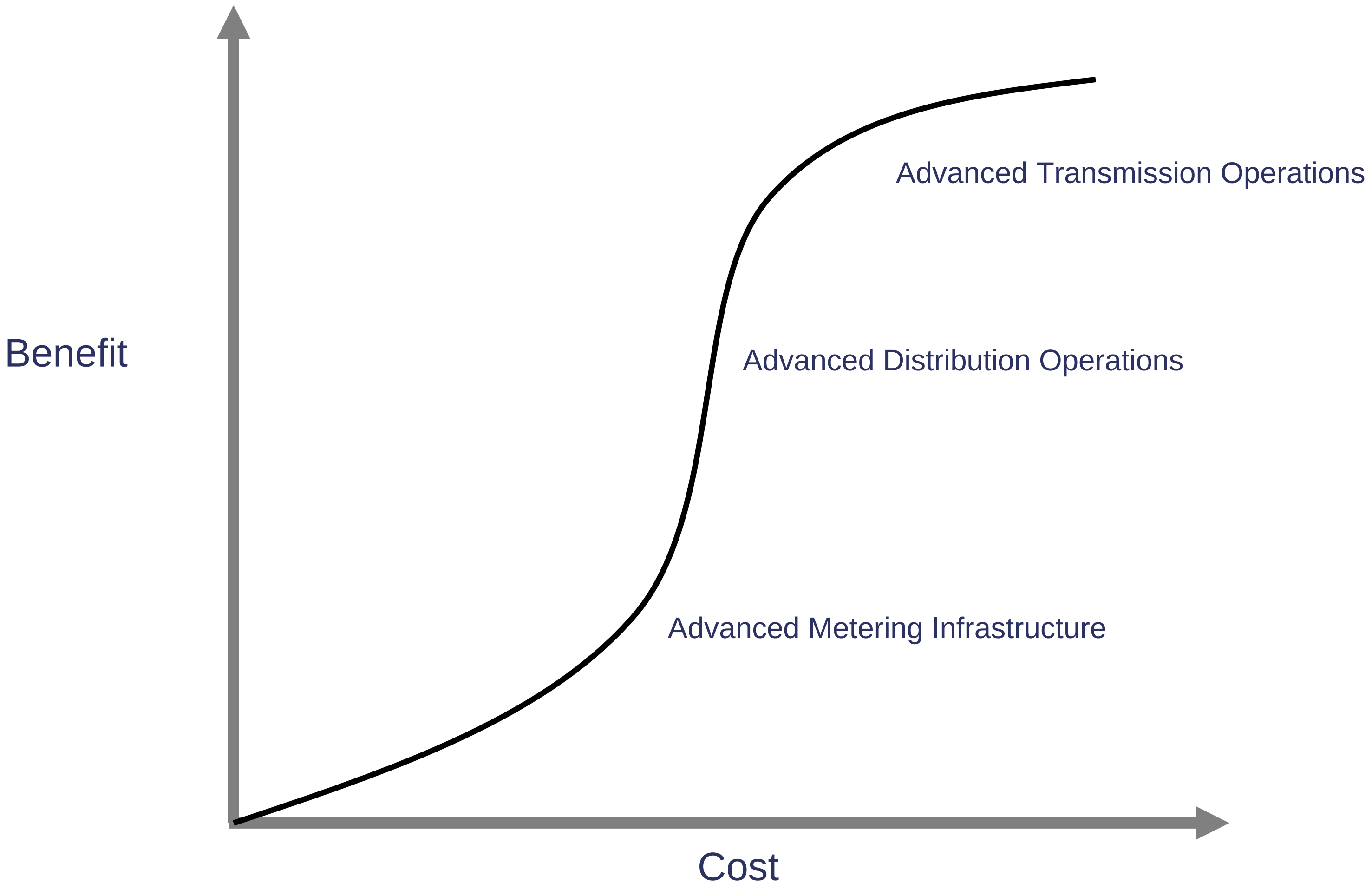
- **$165B over 20 years**
  - $127B for Distribution
  - $38B for Transmission
- **~$8.3B per year (incremental to business-as-usual)**
- **Current annual investment - $18B**

Benefit of Modernization

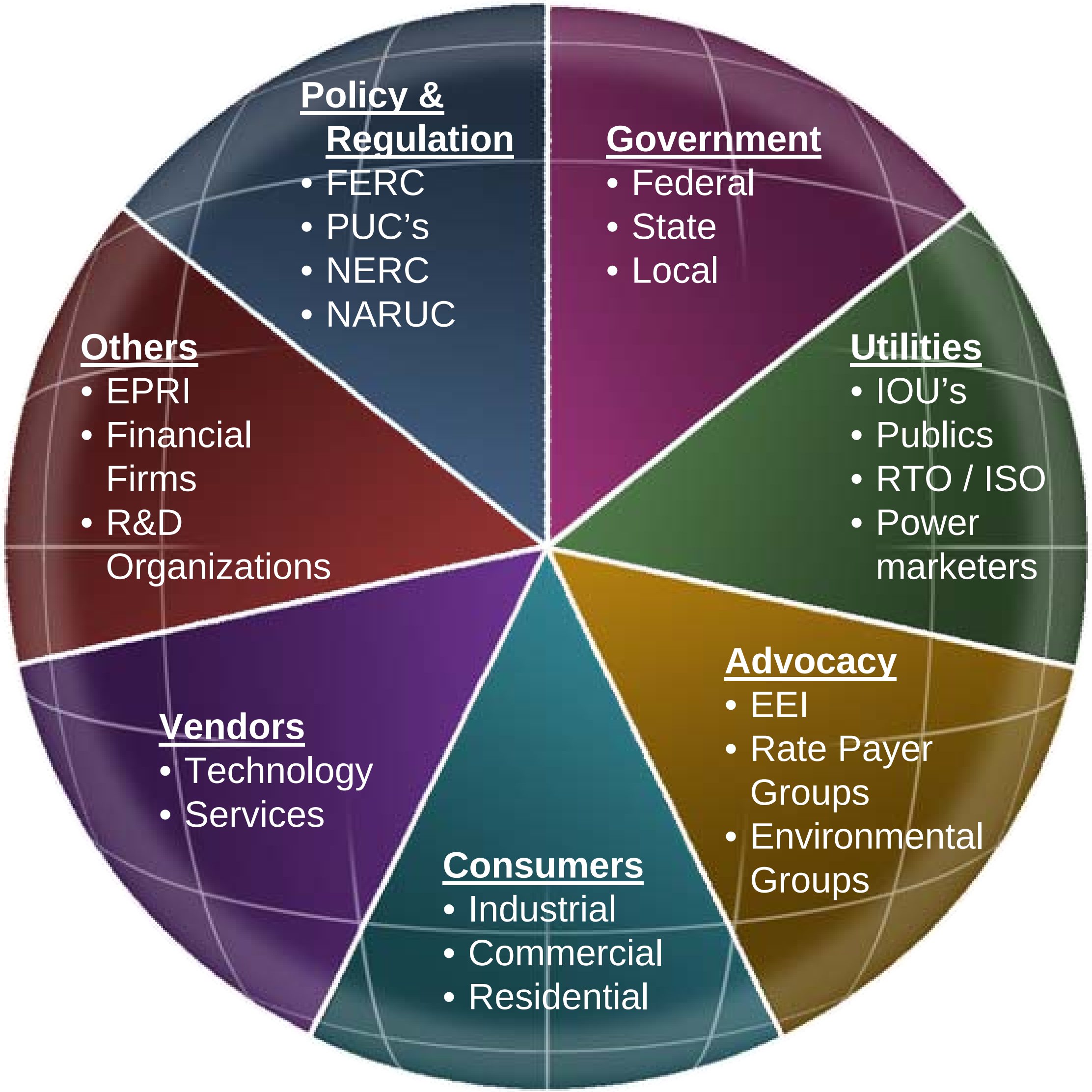
- **$638B - $802B over 20 years**
- **Overall benefit to cost ratio is 4:1 to 5:1**

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 "benefactors"?



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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*
- **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

Some Smart Grid Impacts

Change will be constant

- 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

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 right

Other considerations

- Management of huge volumes of data
- Conversion of data to information to action
- Autonomous decision making by agents
- Diagnosis time reduced enabling more rapid response by operations
- Human factors engineering

"If you are sure you understand everything that is going on, you are hopelessly confused"

Walter F. Mondale

Questions

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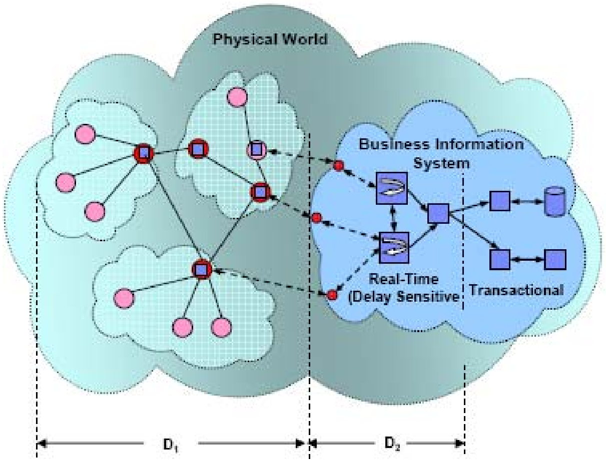
Back-up Slides

Regulatory Policies

- ***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

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



IC: Key Requirements and Examples

- **Open universal communication standards to enable information to be understood by a wide assortment of senders and receivers (e.g. CIM, IEEE P1901, IEC 61850…)**
- **Appropriate media to enable information to be transmitted accurately, securely and with the required throughput. Media examples include:**
  - Powerline communications (PLC and BPL)
  - Wireless (WiFi, WiMAX, 800 MHz, ,Satellite, Microwave…)
  - OPGW
  - Fiber
  - Land lines
- **Hybrid combinations of the above media, having differing capabilities, will be needed**