MODERN GRID
STRATEGY

Smart Grid Basics

Joe Miller, Modern Grid Strategy Team Lead

Grid Econ – The Economics of a Smarter Electric Grid

March 16, 2009

Funded by the U.S. Department of Energy,
Office of Electricity Delivery and Energy Reliability

Conducted by the National Energy
Technology Laboratory

This material is based upon work supported by the Department of Energy under Award Number DE-AC26-04NT41817

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Agenda

- **Why modernize the grid?**
- **What is the Smart Grid?**
- **How do we get there?**
- **Is it a “good deal”?**
- **What are some of the challenges?**
- **Q&A**

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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Is there a “Case for Action”?

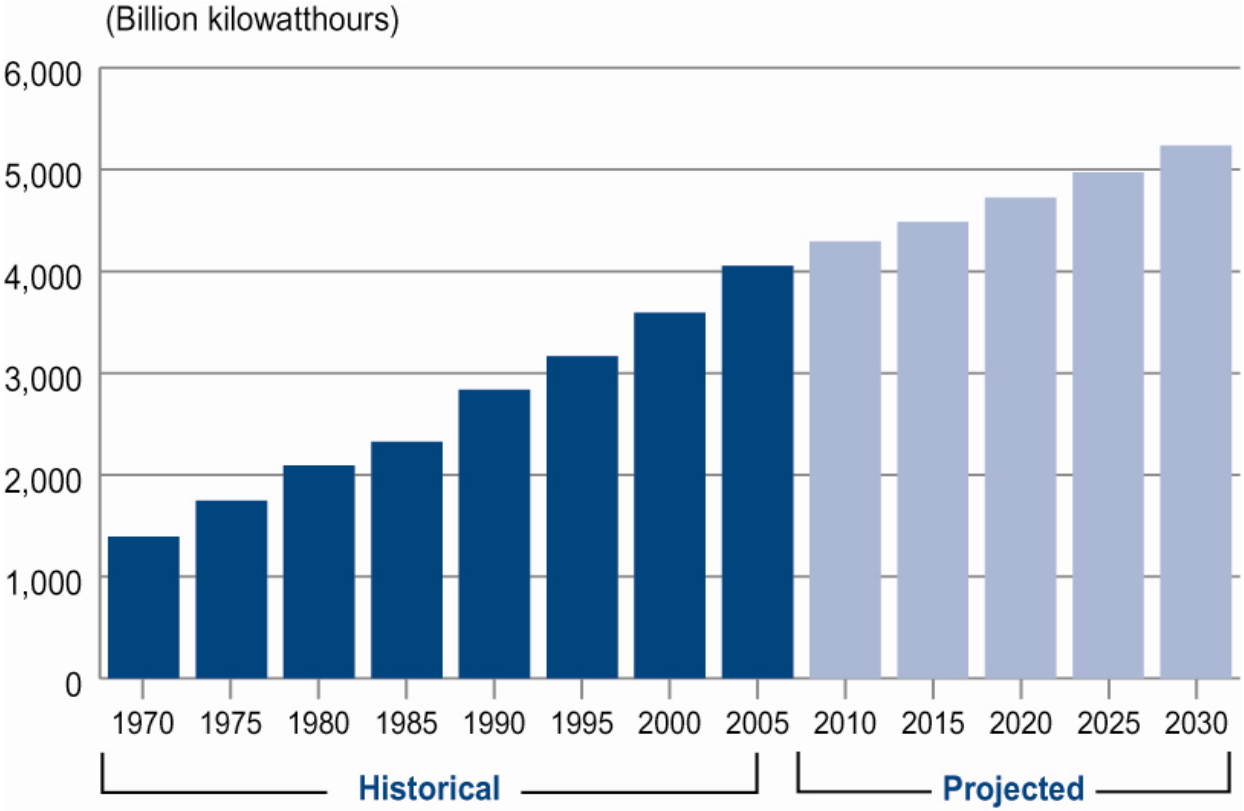
Why Modernize the Grid?

- 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 21st 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

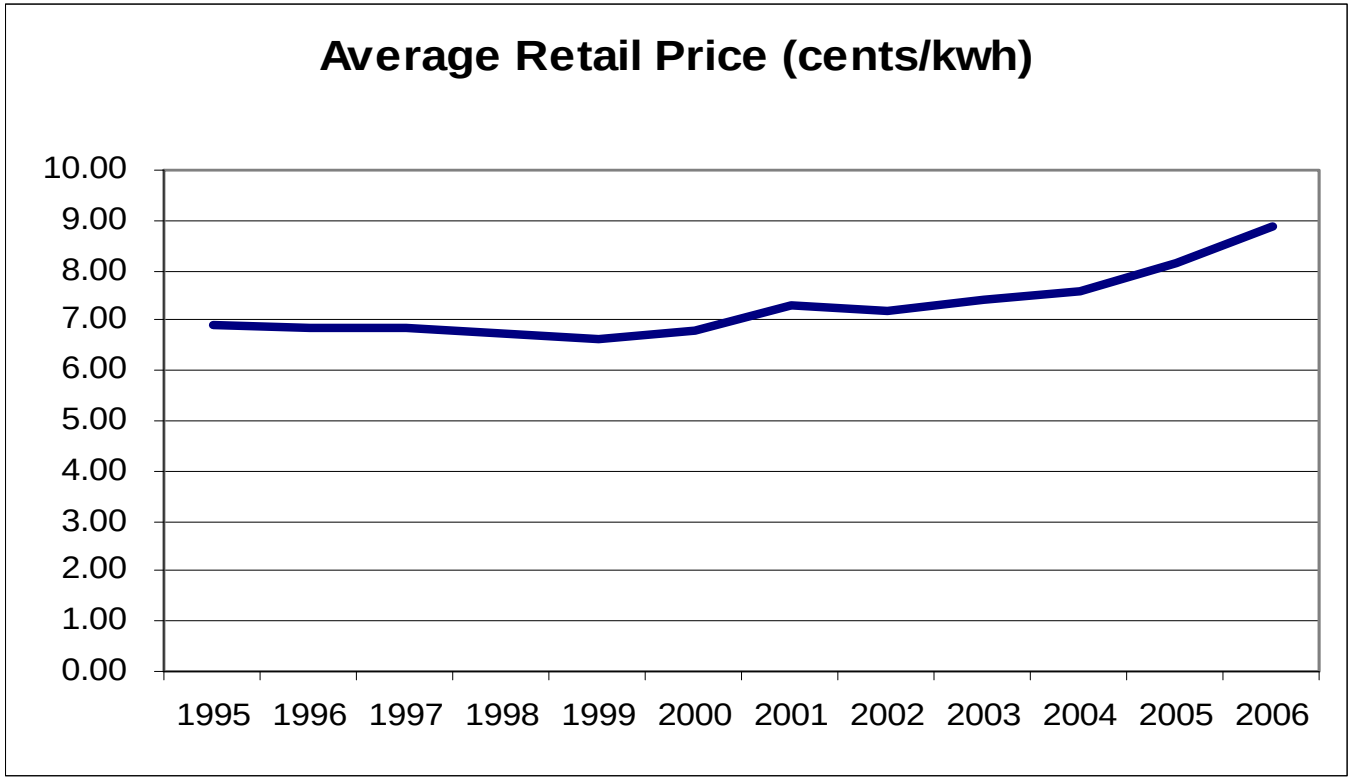
Demand for Electricity Will Increase 30% by 2030



*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).

Retail prices are increasing



30% increase over last decade

DOE EIA Energy Outlook 2007

Today's grid is:

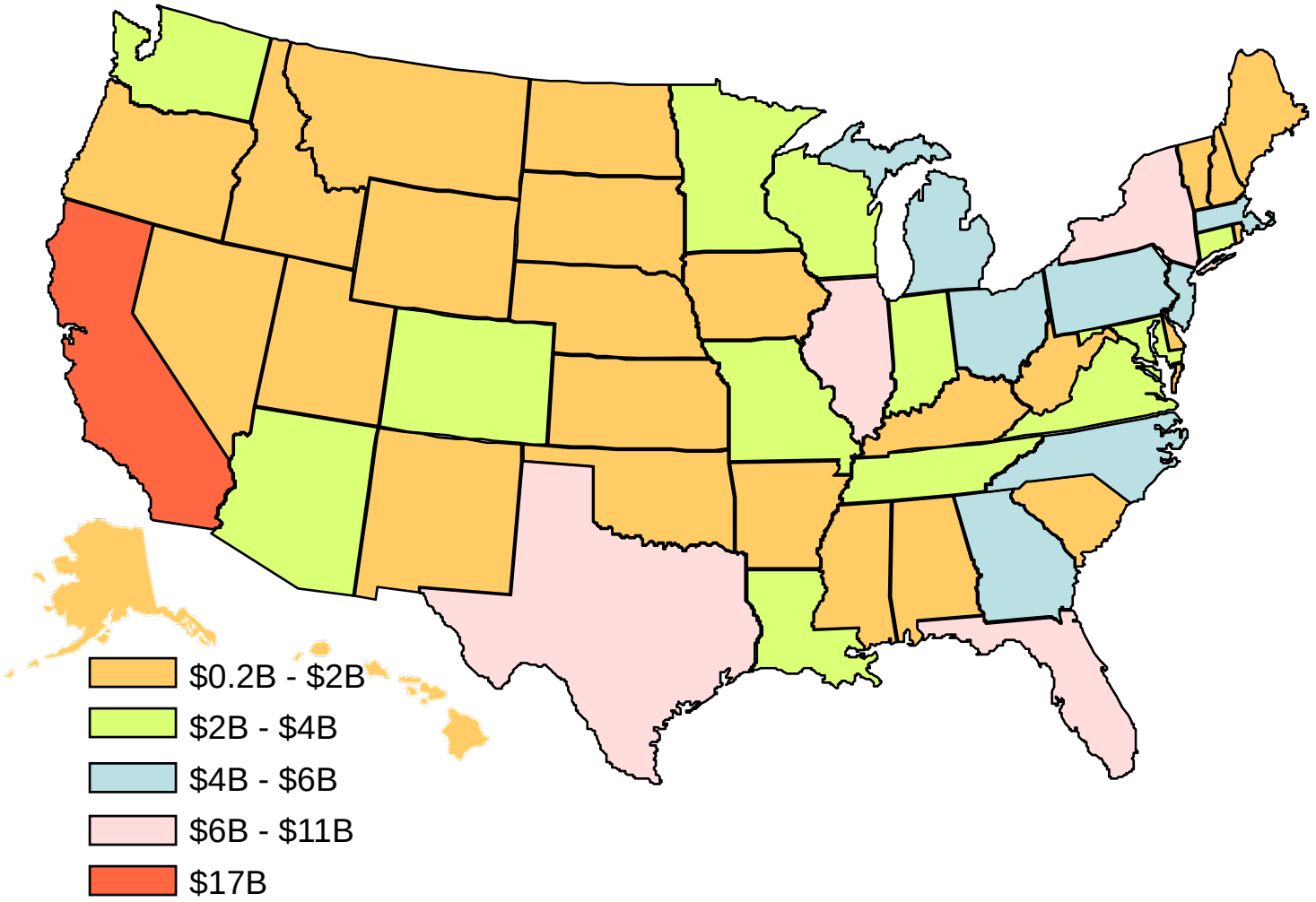
- **Aging**
  - **70% of transmission lines are 25 years or older**
  - **70% of transformers are 25 years or older**
  - **60% of circuit breakers are 30 years or older**
- **Outmoded**
  - **Designed in the 50s and installed in the 60s and 70s, before the era of the microprocessor.**
- **Stressed**
  - **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

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



Other considerations

- **Jobs and the economic downturn**
- **US dependence on foreign energy sources**
- **Climate change**
- **National security**
- **50 coal plants canceled / delayed since January 2007**
- **Impact of electric vehicles**

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What is the Smart Grid?

The Big Picture

Smart Grid Vision includes:

- Key Success Factors
- Principal Characteristics
- Key Technology Areas
- Value Proposition
- Implementation Plan
- Metrics

Smart Grid Key Success Factors

The Smart Grid is MORE:

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

These values define the goals for grid modernization and suggest where benefits will be realized

Principal Characteristics

The Smart Grid is "trans-active" and 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"

- **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 integrate 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**

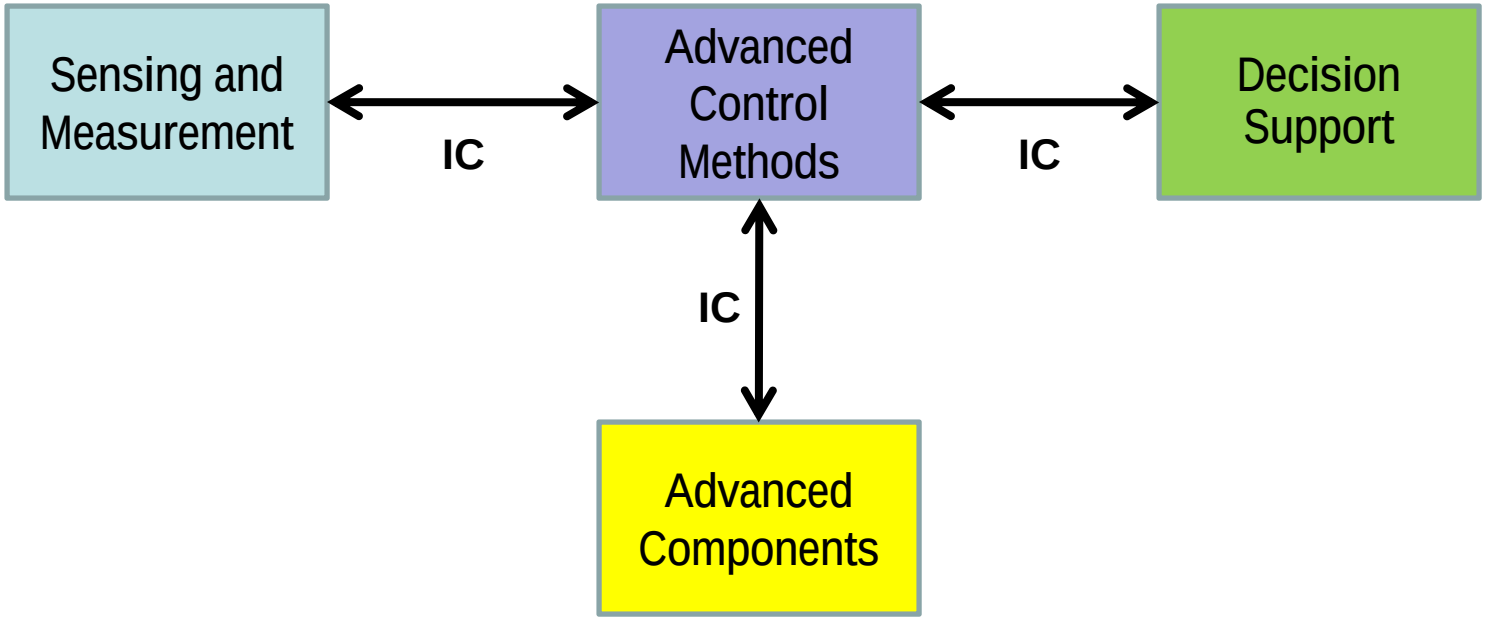
Today	*Tomorrow*
Protects assets following disruption (e.g. trip relay)	**Prevents disruptions, minimizes impact, restores rapidly**

It will "Operate resiliently against attack and natural disaster"

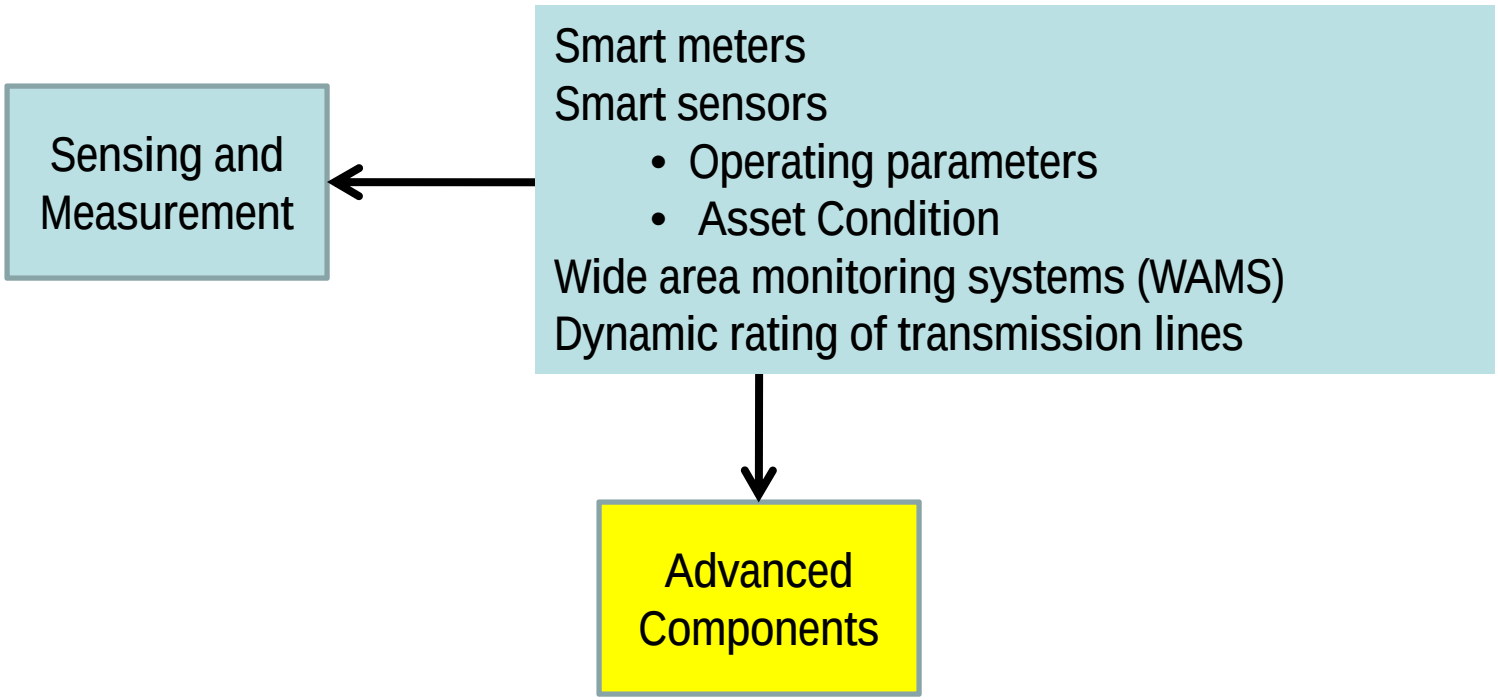
- **System-wide solution to physical and cyber security**
- **Reduces threats, vulnerability, consequences**
- **Deters, detects, mitigates, responds, and restores**
- **"Fort Knox" image**
- **Decentralization and self-healing enabled**

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

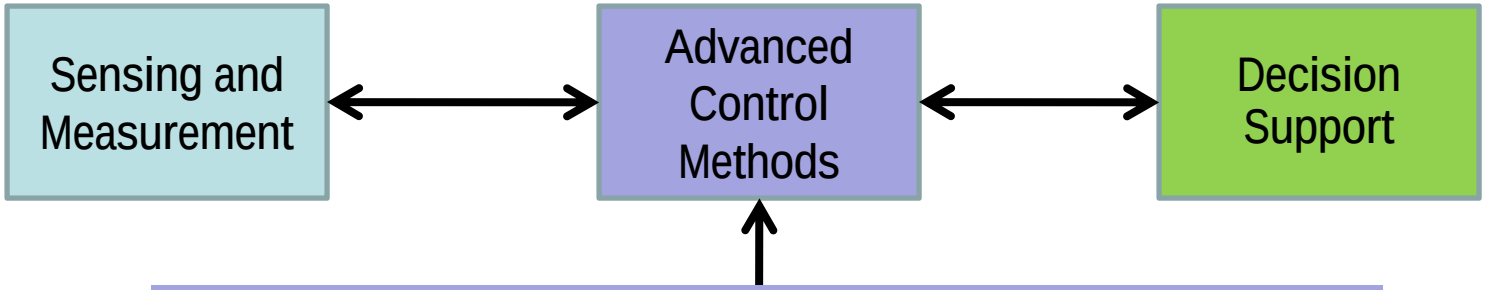
Smart Grid Key Technology Areas



Sensing and Measurement



Advanced Control Methods

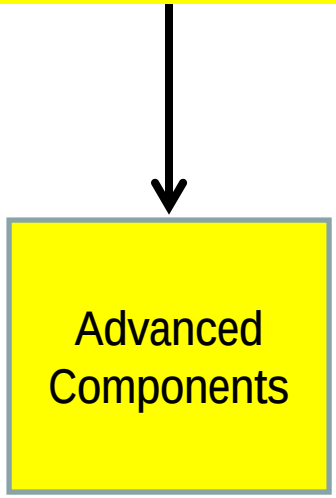


Applications that:

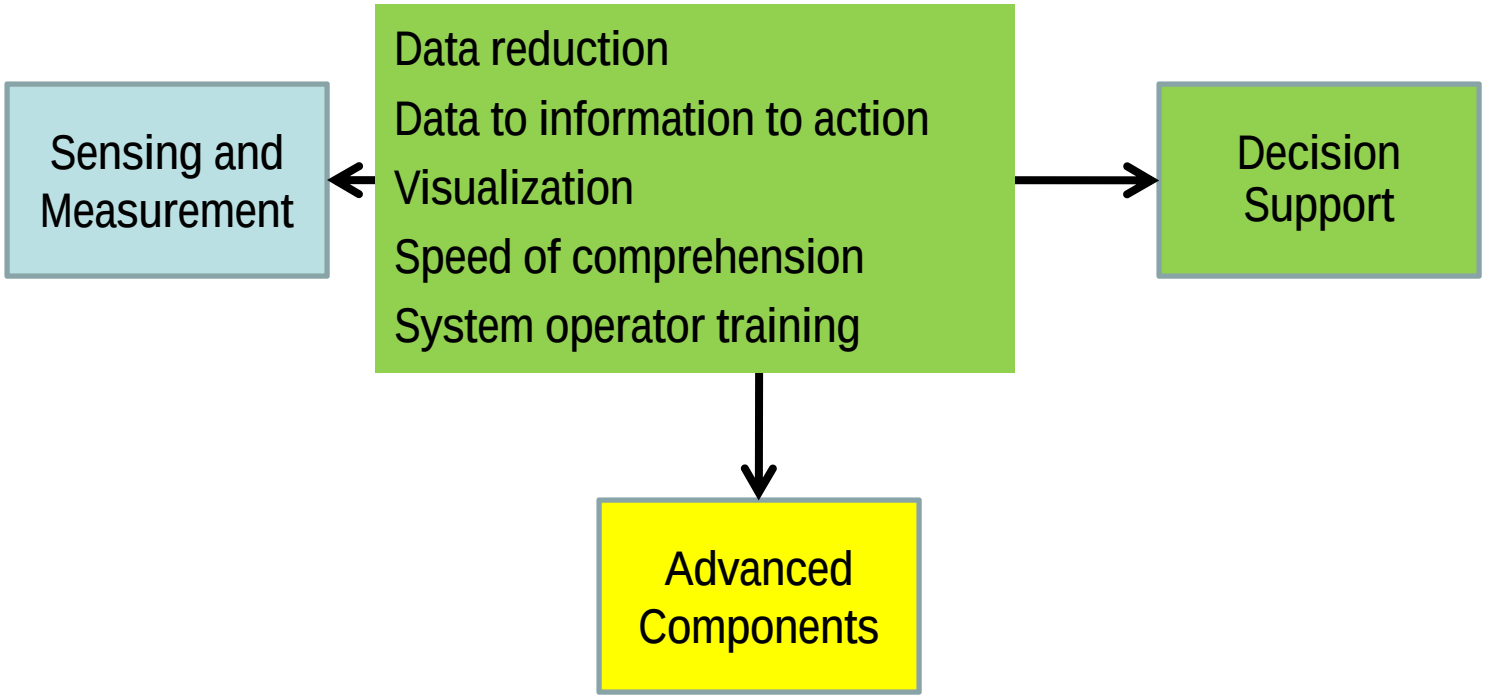
- Monitor and collect data from sensors
- Analyze data to diagnose and provide solutions
- Real time and predictive
- Determine and take action autonomously or via operators
- Provide information and solutions to operators
- Integrate with enterprise-wide processes and technologies

Advanced Components

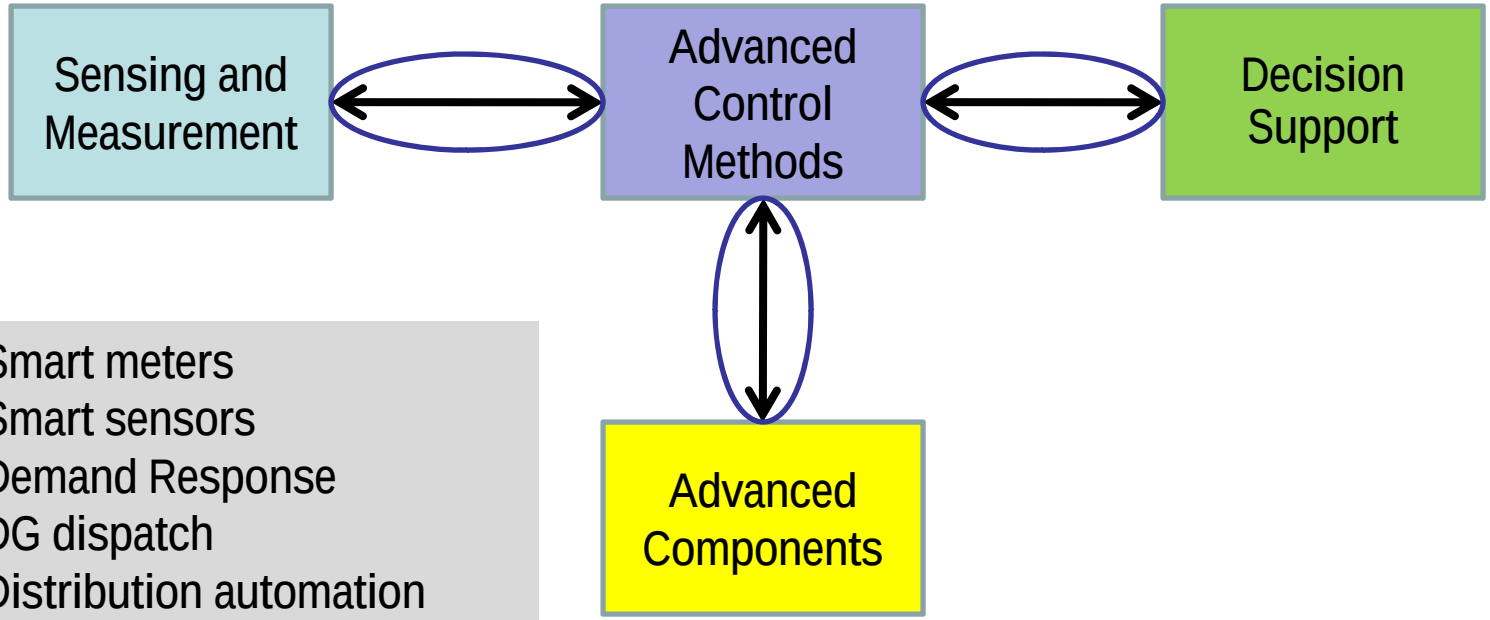
Next generation FACTS/PQ devices
Advanced distributed generation and energy storage
PHEV - V2G mode
Fault current limiters
Superconducting transmission cable & rotating machines
Microgrids
Advanced switches and conductors



Decision Support



Integrated Communications



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

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How do we get there?

Break it down

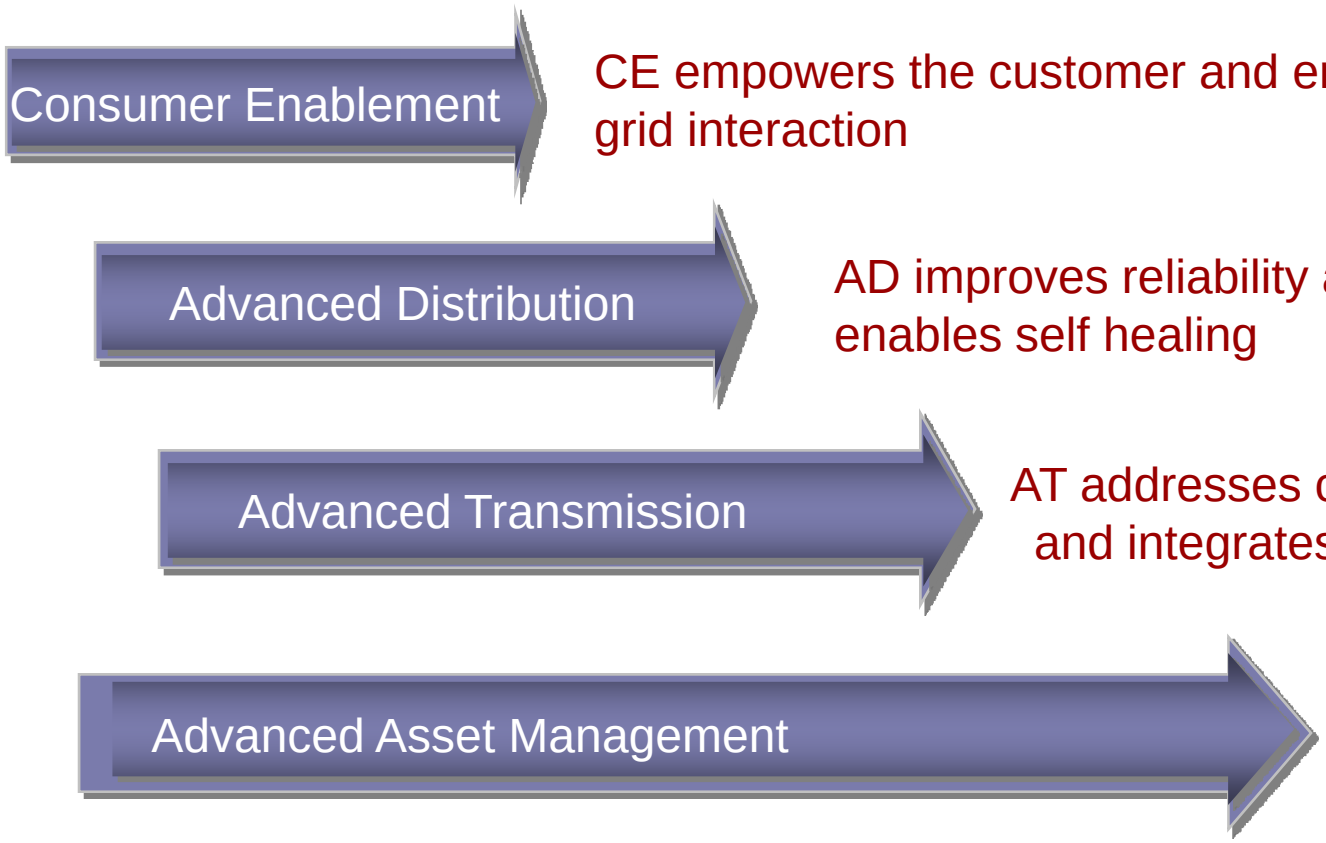
- **Understand the vision**
- **Create the roadmap (milestones)**
- **Define the value proposition**
- **Identify and resolve barriers**
- **Apply resources**
- **Create metrics to monitor progress**

Smart Grid Milestones

- **Consumer Enablement**
- **Advanced Distribution**
- **Advanced Transmission**
- **Advanced Asset Management**

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

Steps to the Smart Grid



Consumer Enablement Solutions

- **Smart Meters & 2–way communications**
- **Consumer Portal / Home area network**
- **Meter Data Management**
- **Time of Use Rates**
- **Customer Information System**
- **IT upgrades**
- **Customer Education**
- **Demand Response**

CE empowers the customer and supports grid operations

Advanced Distribution Solutions

- **Smart sensors and control devices**
- **Distribution Management System**
- **Advanced Outage Management**
- **Distribution Automation**
- **Geographic Information System (GIS)**
- **Micro-grid operations**
- **Advanced protection and control**

Advanced Distribution enables “Self Healing”

Advanced Transmission Solutions

- **Substation Automation**
- **Advanced regional operating applications (RTO)**
- **Wide Area Measurement System (WAMS)**
- **Advance materials and power electronics**
- **Hi-speed information processing**
- **Modeling, simulation and visualization tools**
- **Advanced digital protection**

Deeply integrated with CE, AD and AAM – AT optimizes transmission operations

Advanced Asset Management Solutions

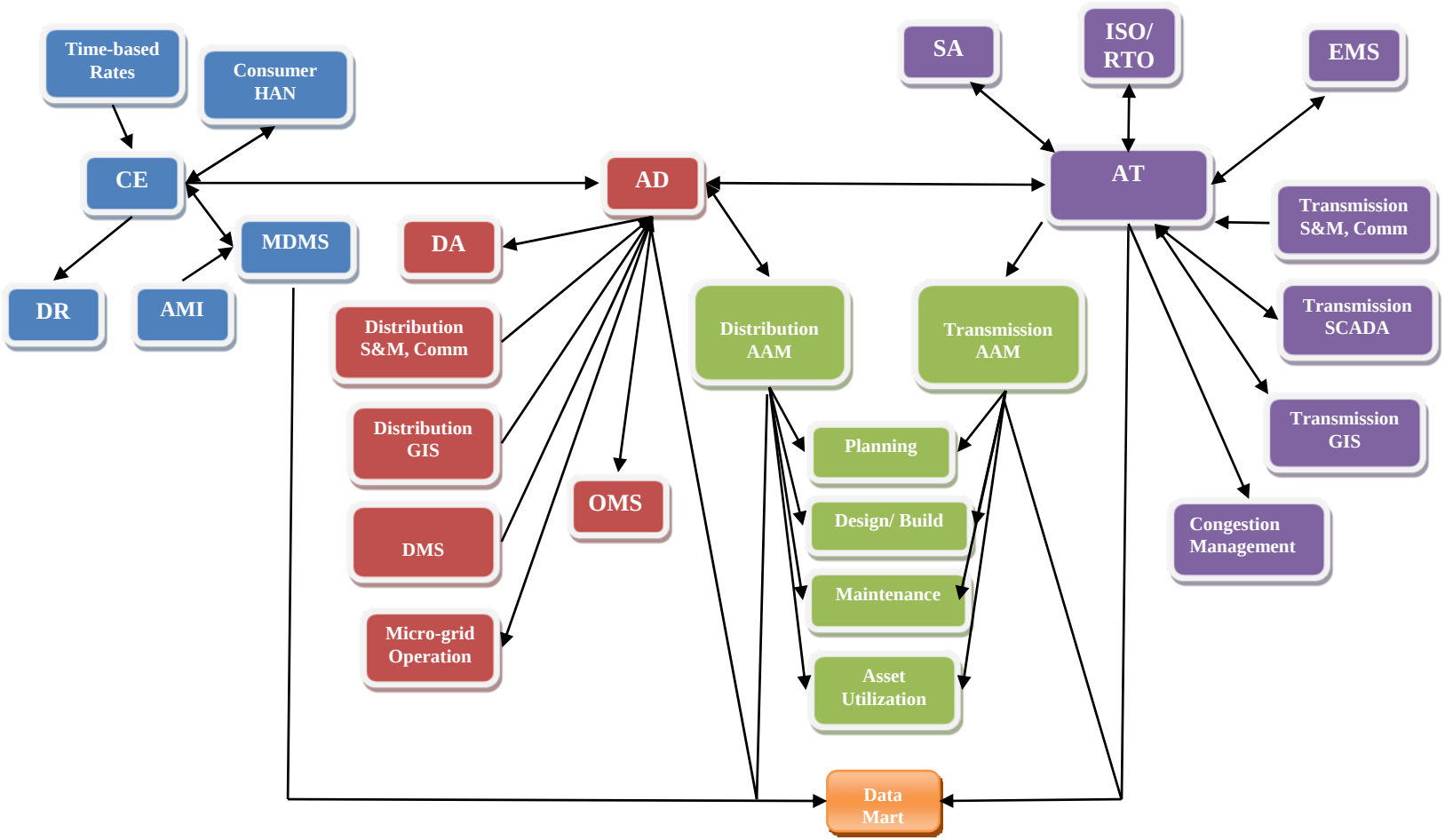
- **Advanced sensors**
  - **System Parameters**
  - **Asset “health”**
- **Integration of grid intelligence with other processes:**
  - **Operations to optimize asset utilization**
  - **T&D planning**
  - **Condition based maintenance**
  - **Engineering, design and construction**
  - **Work and resource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

Integration of CD, AD, and AT with asset management processes will dramatically improve grid operations and efficiency

Characteristic – Milestone Map

Characteristic	CE	AD	AT	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	✓	✓	✓	

The “Big Picture”



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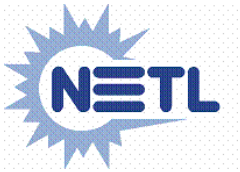
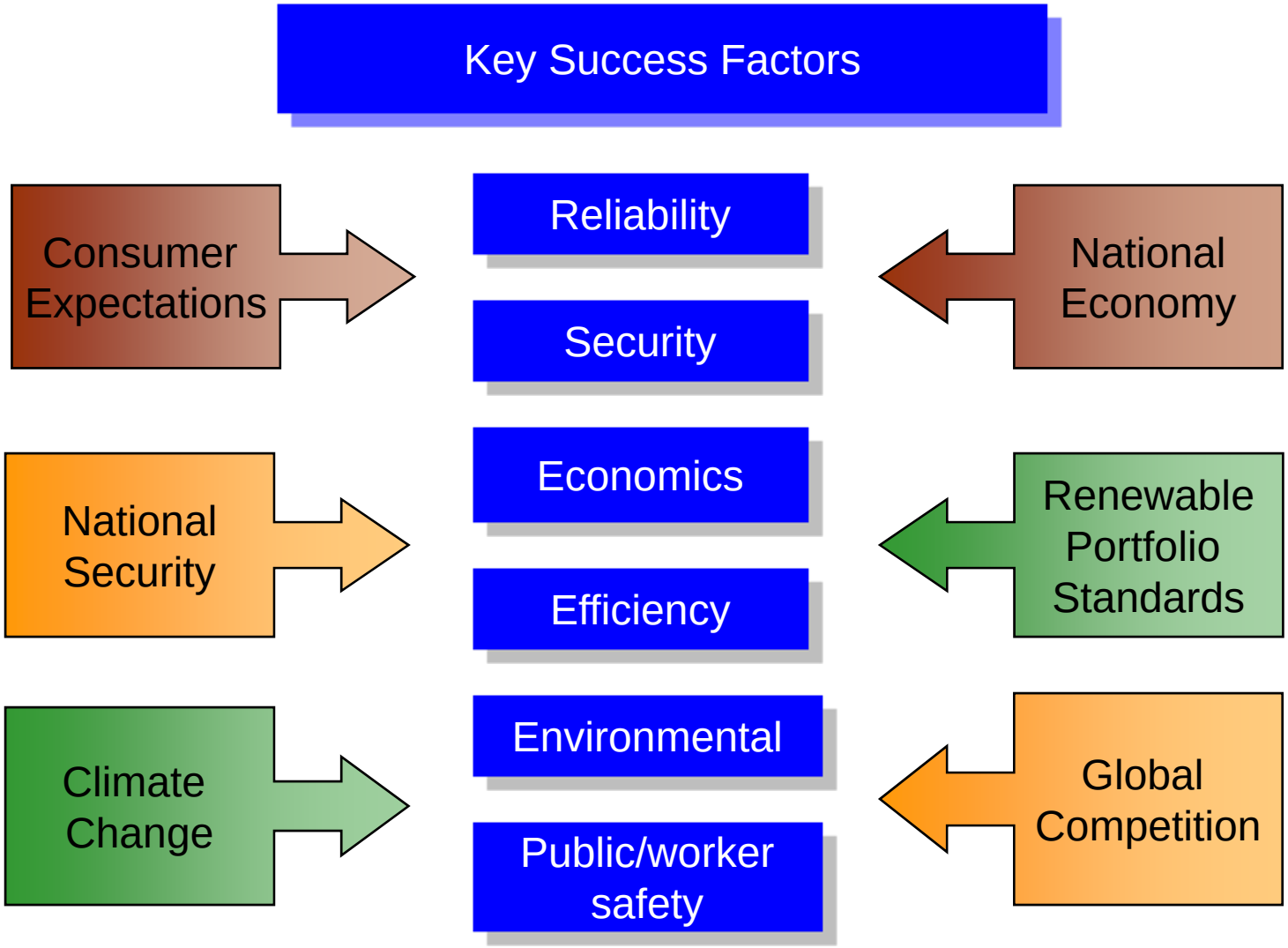
Is it a good deal?



Smart Grid Value Drivers



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**

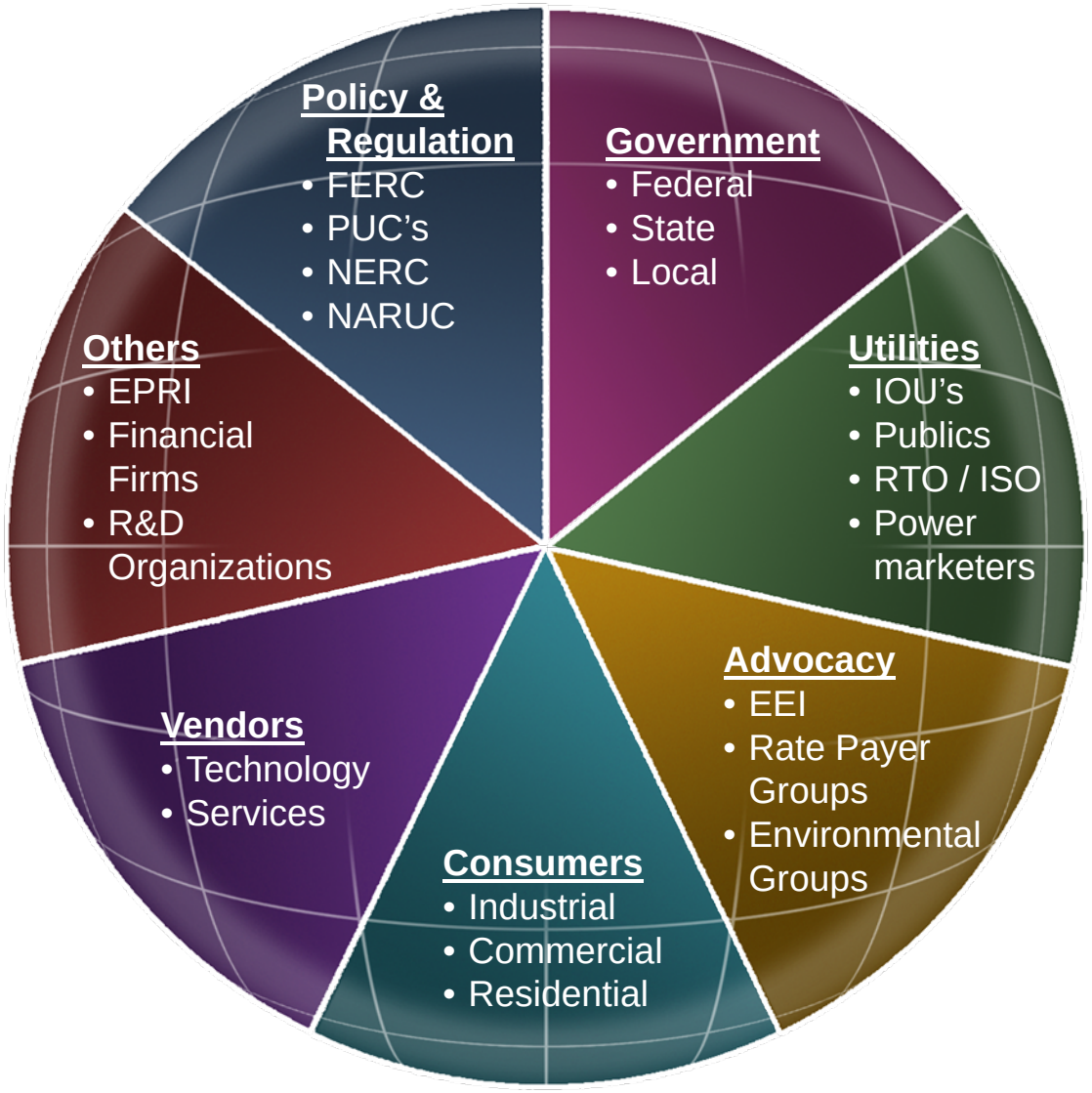
(Source: EPRI, 2004)

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)

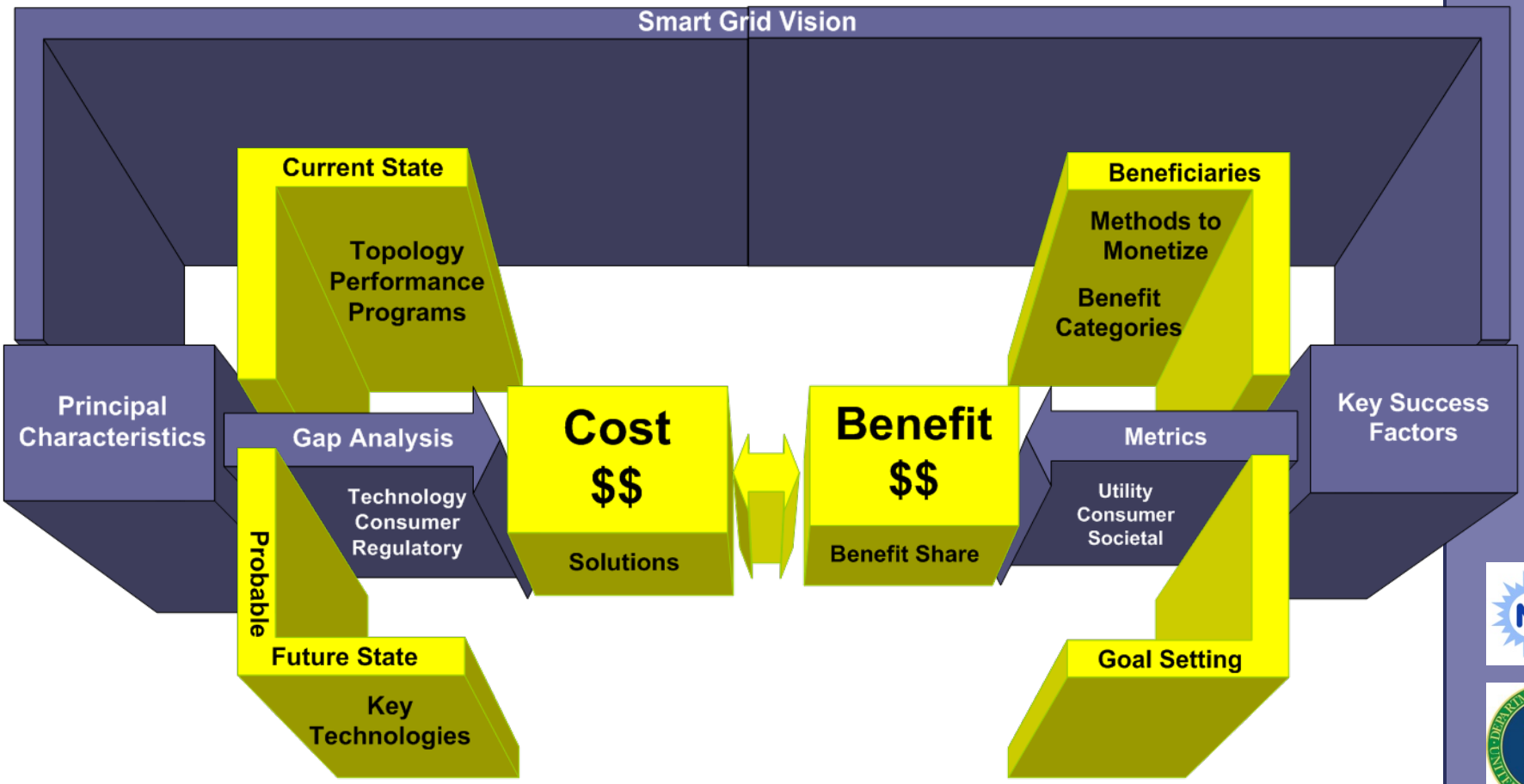
Many stakeholders



Many Beneficiaries

- **Utilities**
- **Consumers**
- **Society**
- **Stakeholders**

Business Case Framework



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Value Metrics – Work to date

Reliability

- Outage duration and frequency
- Momentary outages
- Power Quality

Security

- Ratio of distributed generation to total generation
- Consumers participating in energy markets

Economics

- Peak and average energy prices by region
- Transmission congestion costs
- Cost of interruptions and power quality disturbances
- Total cost of delivered energy

Value Metrics – Work to date

Efficient

- System electrical losses
- Peak-to-average load ratio
- Duration congested transmission lines loaded >90%

Environmentally Friendly

- Ratio of renewable generation to total generation
- Emissions per kilowatt-hour delivered

Safety

- Injuries and deaths to workers and public

Smart Grid Workshop in June – Developed “build metrics” for achieving the principal characteristics

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 emissions** *through integration of renewable generation and reduced losses*
- **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

What are some of the Challenges?

Change Management

A significant change management effort is needed:

- Why do we need to change?
- What is the vision?
- What is the value proposition?
- 300 Million consumers affected
- Consumer education, alignment and motivation is critical
- Metrics needed for accountability and to monitor progress
- Active leadership by stakeholder groups needed

Our challenge is to align under a common long term vision and make our short term investment decisions consistent with the "end in mind".

Regulatory

- ***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 regulatory models**

Technical

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

Contact Information

Additional information on the Smart Grid is available:

http://www.netl.doe.gov/moderngrid/

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Questions?

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Back-up Slides

Smart Grid and the Environment

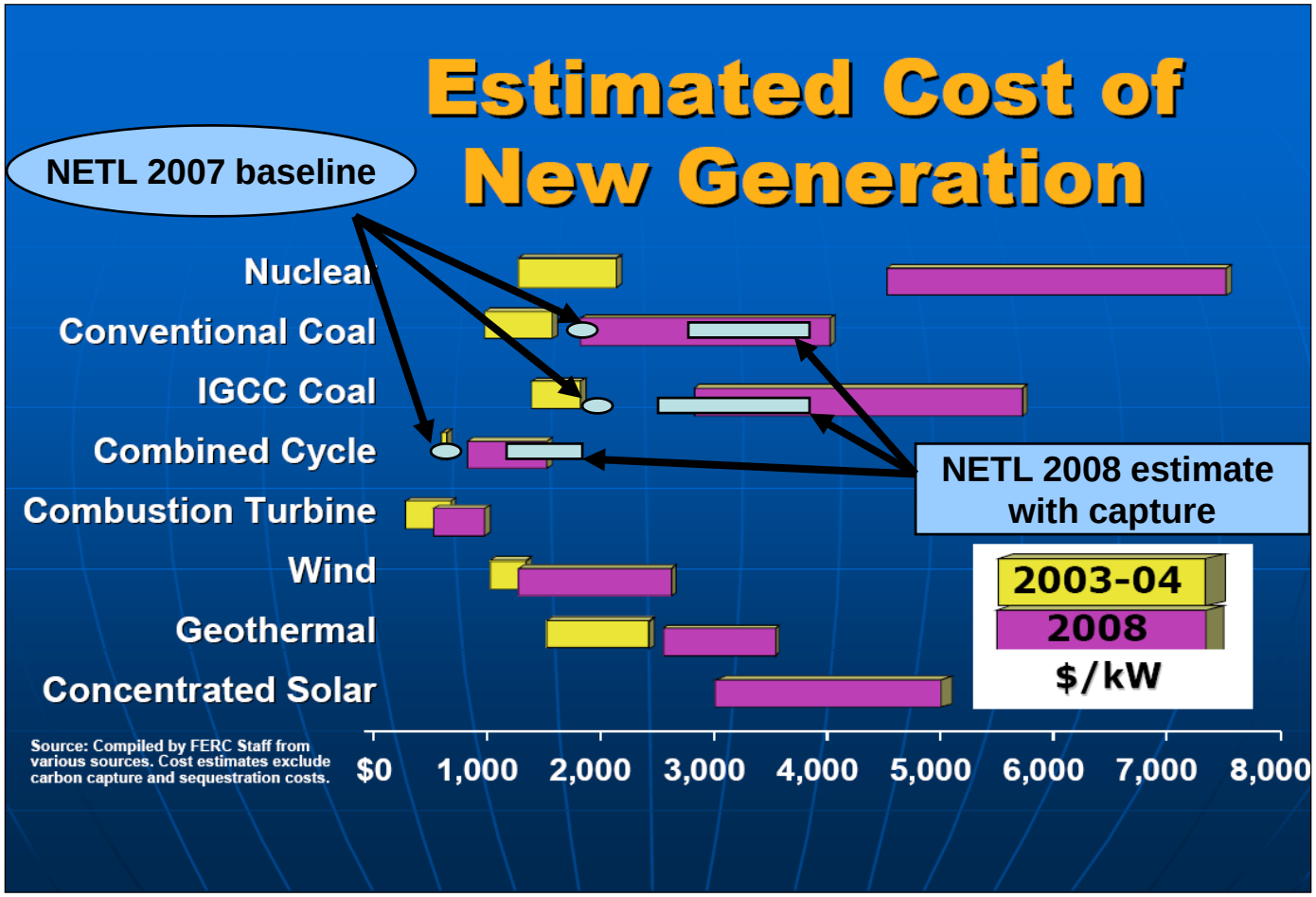
- **Smart Grid is a key enabler to help reduce CO2 and other emissions through**
  - Reduced consumption from demand response
  - Reduce losses and increased grid efficiency
  - Integration of renewables and CHP DG
  - Enabling energy system diagnostics
  - Enabling PHEV adoption

- **Will provide a "window" for concerned consumers to assess and react to their personal environmental desires (Prius effect)**

Smart Grid could reduce global power system emissions of CO2 14% by 2020

Climate Group, 2008

Cost of new generation is increasing



FERC, "Increasing Costs in Electric Markets," June 19, 2008

The Smart Grid and Reliability

- **Rapid detection of degraded conditions**
- **Distributed generation and micro-grids**
- **Automatic isolation and reconfiguration**
- **Rapid damage assessment and diagnosis**
- **Rapid dispatch of repair crews**
- **Overall self-healing capability**