RAP Energy solutions for a changing world

Module 6
Other Energy Issues, Developments, and Emerging Technologies

Electric Energy Training for Air Regulatory & Planning Staff
US EPA OAQPS – August 15-16, 2011

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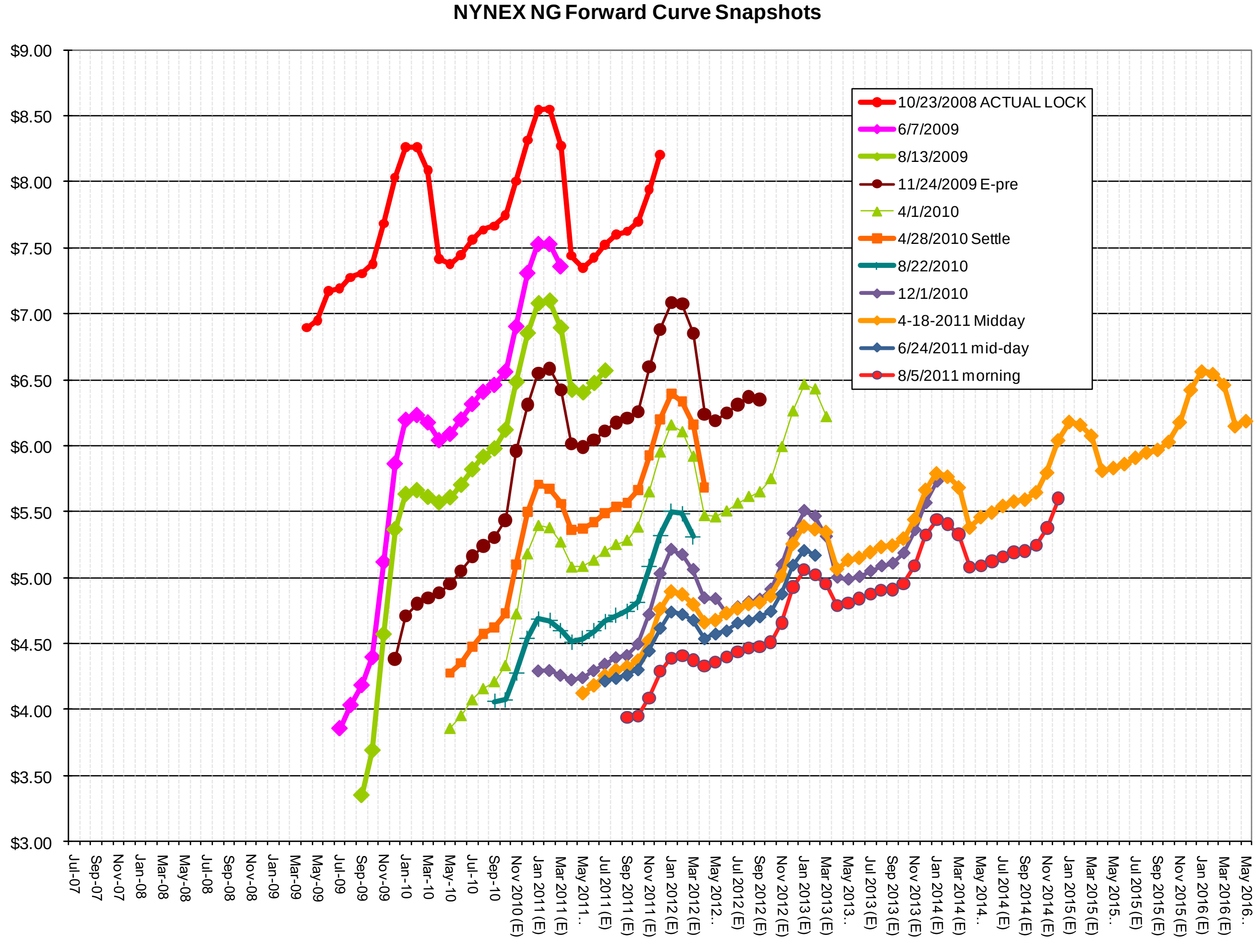
Other Key Issues & Topics

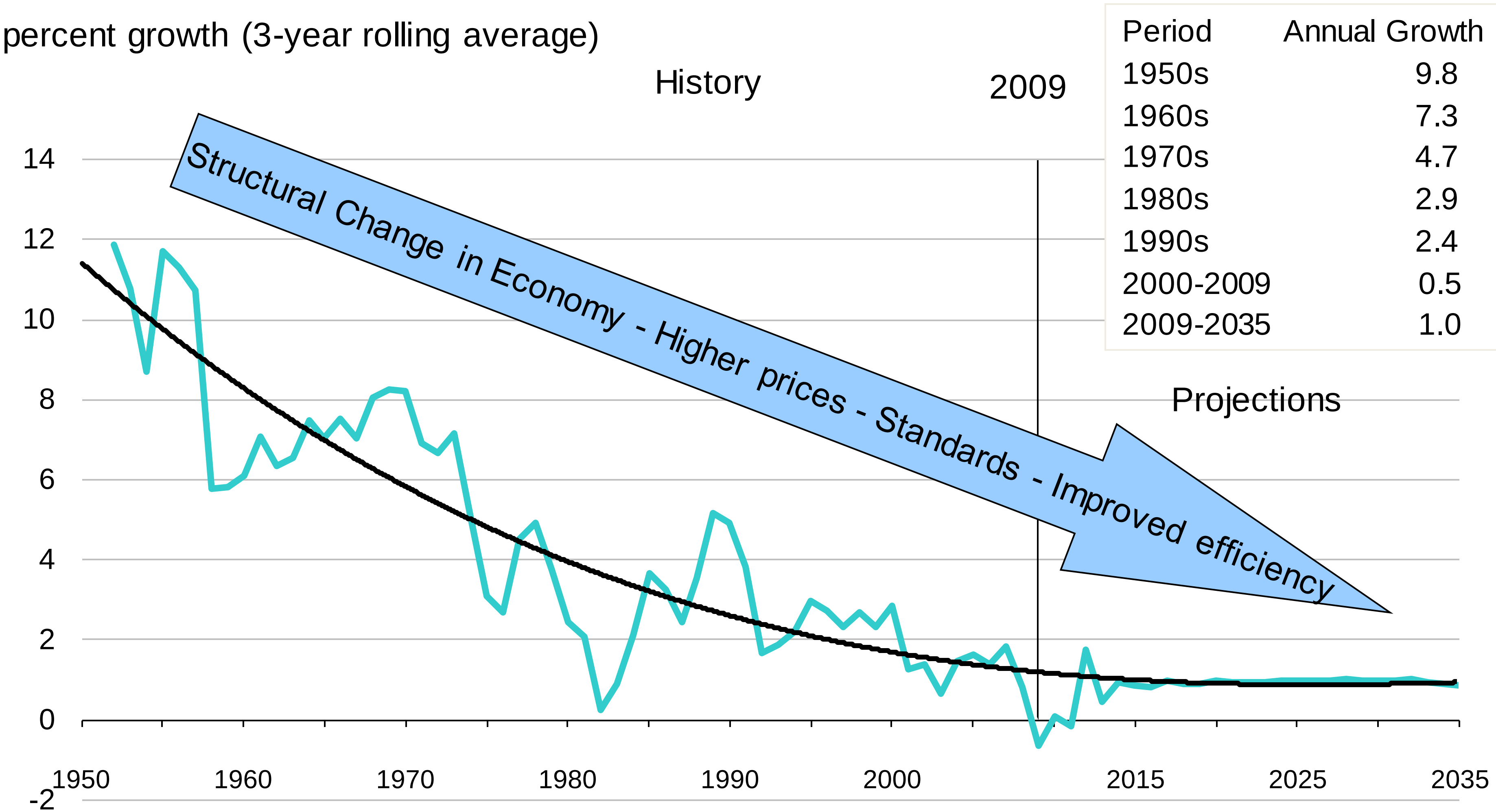
- Consumption Trend
- "Smart Grid"
- Electrification of Transportation
- Energy Storage
- T&D Issues
- Distributed Generation (DG)

• A Consumption Trend Inflection Point?

Gas Forward Curve Has Continued Sliding Down

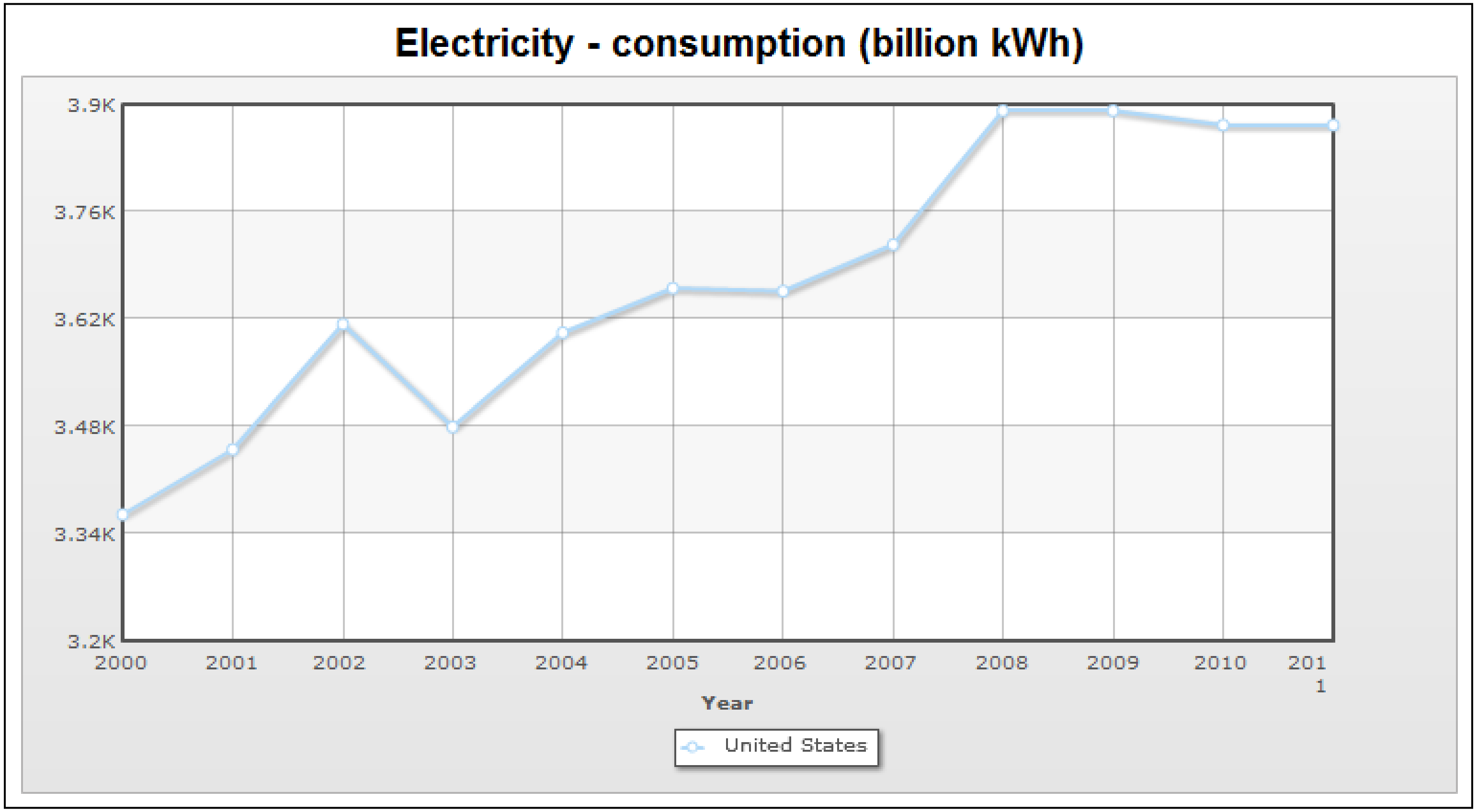


While projected electricity consumption grows by 30% by 2035, the rate of growth has slowed



Source: EIA, *Annual Energy Outlook 2011*

U.S. Electricity Consumption



Source: CIA World Factbook, 2011, from
http://www.indexmundi.com/g/g.aspx?c=us&v=81

EIA Electric Power Annual

(Rev April 2011)

- 2009 Year in Review:
  - Electricity generation down 4.1%
    - Lowest level since 2003
    - Largest annual decline in 60 years
    - Follows 0.9% drop in 2008
  - Reflects 2.6% decline in economy (GDP)
  - Delta = -1.5%; indicator of paradigm shift?

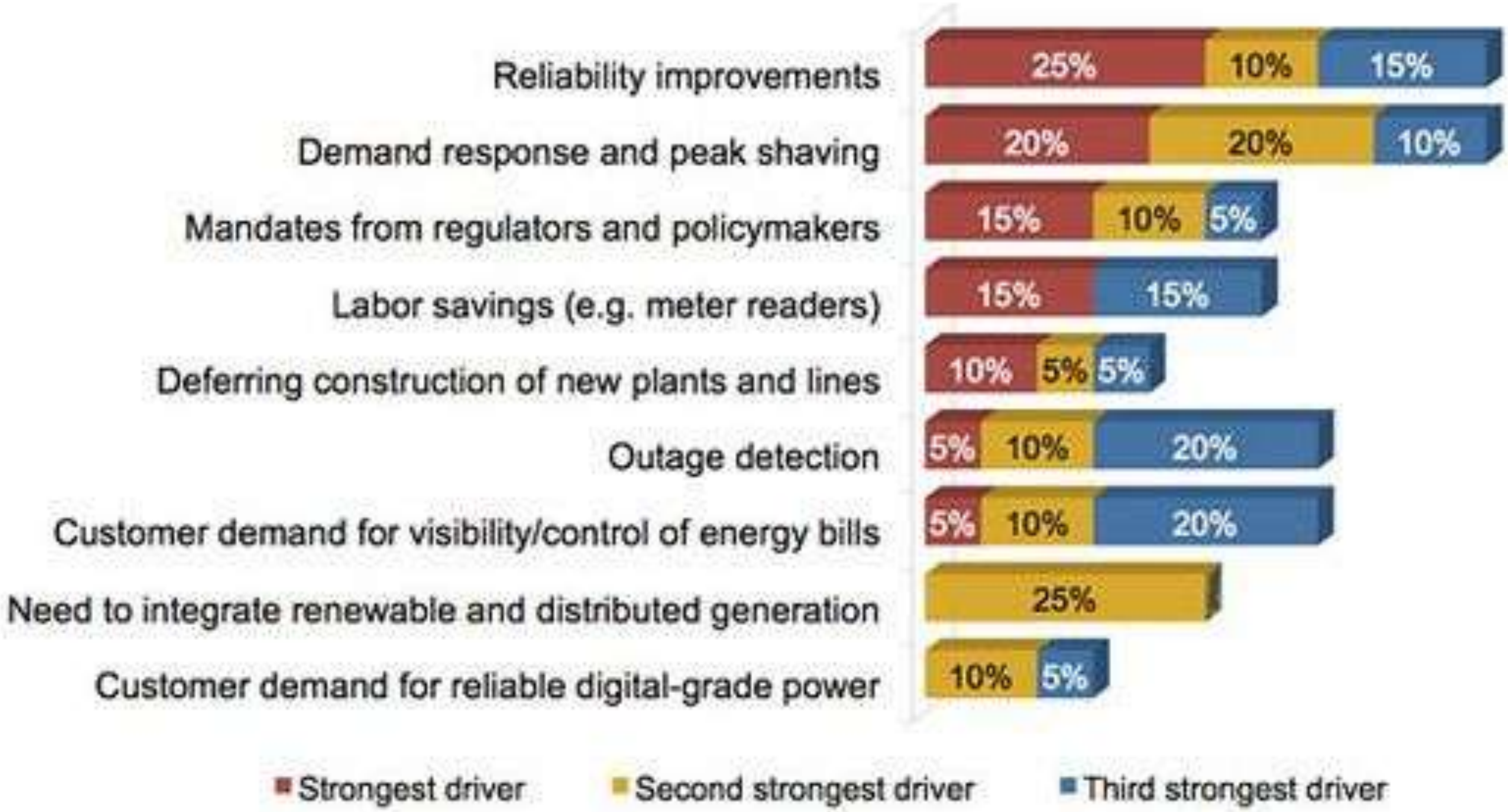
• What is "Smart Grid"?

- An interconnected system of information and communication technologies that works with other technologies throughout the electricity system that can do good things:
  - Help utilities and consumers manage energy use
  - Increase system reliability through automation
  - Improve integration of clean energy resources
- Distinguishing features of smart grid:
  - (1) Engaging the customer, and
  - (2) Integrating supply and demand

Promise of Smart Grid

- Improved grid reliability, security and efficiency
- Timely information for consumers and new opportunities for saving energy and money
- Massive increases in demand response, energy efficiency, energy storage, distributed generation and large-scale renewable resources
- Electrification of the transportation sector

Why Do Utilities Want Smart Grid?



Increasing rate base is also certainly a driver.

Demand Response and Smart Grid

Traditional DR	Smart Grid DR
• Primarily utility control	• Customer control
• Focuses on a few end uses	• All end uses
• Limited customer options	• Unlimited options
• Participation incentives required	• Advanced meters enable dynamic pricing for all
• Primary focus on retail markets	• Wholesale and retail markets linked

Source: Levy, Goldman and Sedano

Consider Customer Resources in Distribution System Plans

- "Geo-target" energy efficiency, demand response, and distributed resources to reduce peak loads and defer distribution system upgrades
  - Guidelines for considering cost-effective alternatives
  - Incentives for investments in customer-side resources that can, together, defer costly upgrades

Clean Energy and Consumer Benefits Are Not Automatic

- Smart grid's interconnected system of technologies can engage many quickly, but it's only an enabler.
- Clean energy and consumer benefits require smart policies.
- Many policies should be adopted even without smart grid investments.
  - Example: "Direct Load Control" by utilities (A/C, pool heaters, etc.)
- Without the right policies, smart grid is likely to divert attention and funds from clean energy investments that can be made today.

Smart Policies to Match Smart Capabilities: Examples

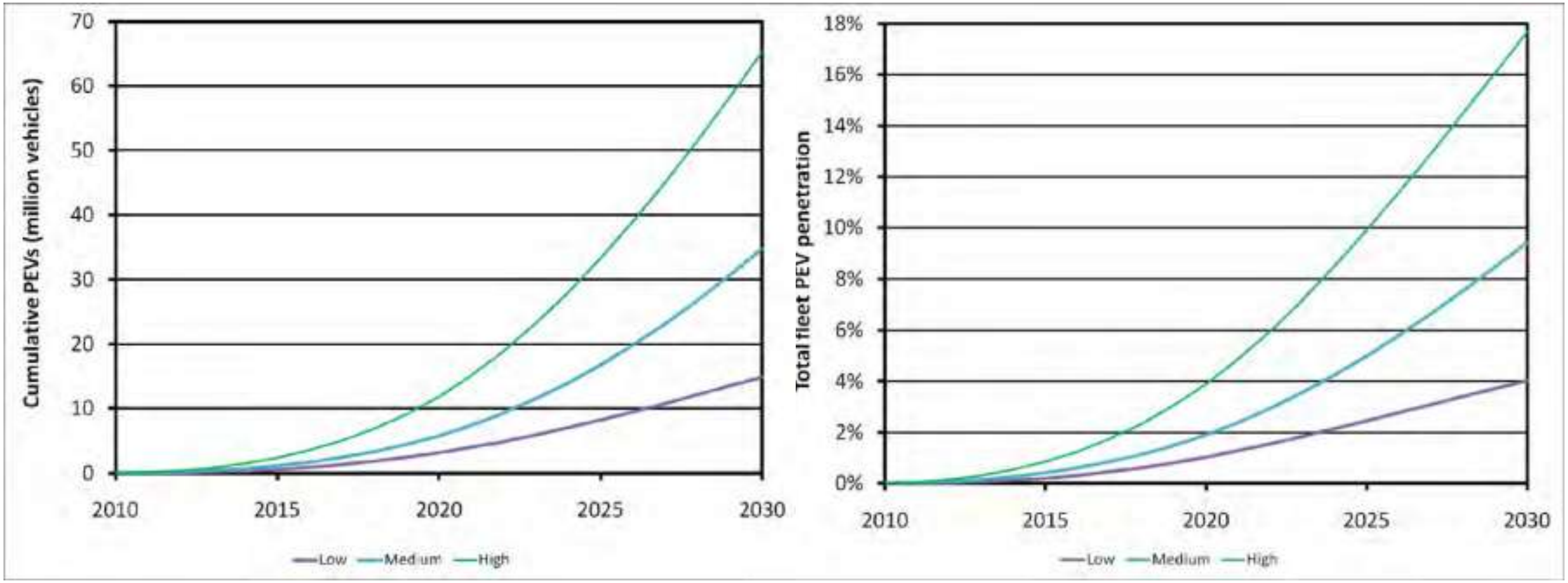
Smart Capabilities	Smart Policies
Allow interconnected distributed generators to run during utility outages	Support investments in clean distributed resources, simplify interconnection requirements and procedures, net metering, enable excess power sales
Dynamically integrate wind and solar resources	Better planning for renewable resources and transmission, support utility investments
Continuous building diagnostics	Invest in efficiency programs for buildings and major energy-consuming equipment for all customer classes
Optimize voltage and reactive power	Remove barriers for utility investments to improve distribution system efficiency
Increase demand response	Supportive rates or incentives, consumer access to energy usage data, support for automated controls

• Electrification of Transportation

Non-Road Equipment Examples

Equipment	Primary Industry	Primary Fuel
Ships (Crude oil tankers and Container Ships)	Seaport	Residual Fuel
Cargo Handling Equipment (Yard Tractors)	Seaport, Warehouse	Diesel
Cranes (Ship to Shore and Rubber Tired Gantry)	Seaport, Intermodal/Rail	Diesel
Dredge	Seaport	Diesel
Forklifts	Warehouse	Diesel, Liquid Propane Gas, Electric
Mining equipment (Shuttle Cars, Ram Cars, Haulage Systems, Draglines and Electric Shovels)	Mining	Diesel
Overland Conveyer	Mining	Diesel
Locomotives	Rail	Diesel
Passenger Rail	Rail	Diesel
Tugboats	Seaport	Diesel
Farm Tractors	Agriculture	Diesel
Ground Support Equipment	Airport	Diesel
Aircraft Ground Power	Airport	Diesel
Lawn and Garden	Agriculture	Gasoline
All-Terrain Vehicles	Agriculture	Gasoline
Truck Refrigeration Units	Trucking	Diesel
Long Haul Trucks (idling)	Trucking	Diesel

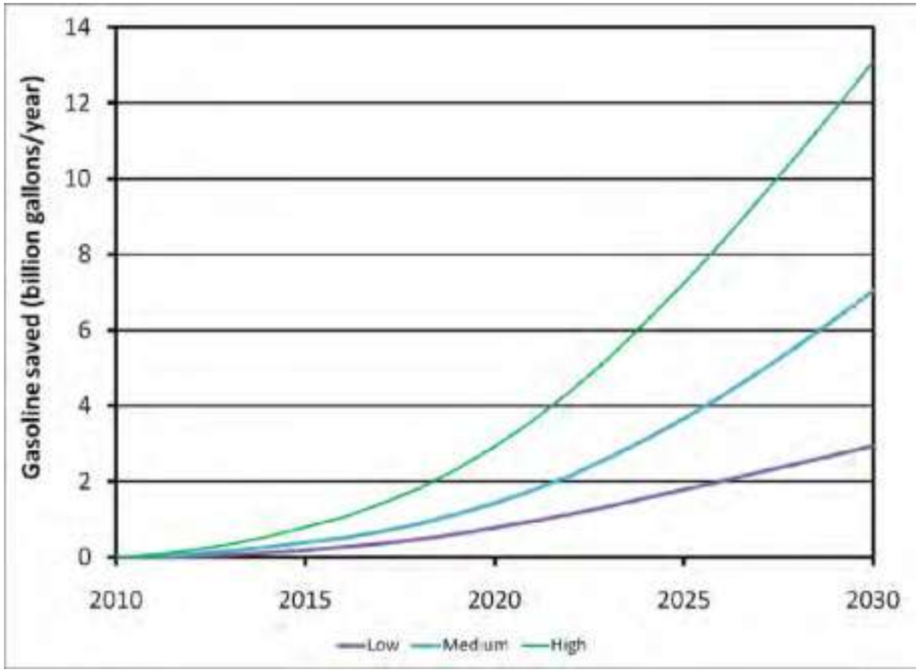
Penetration of PEVs

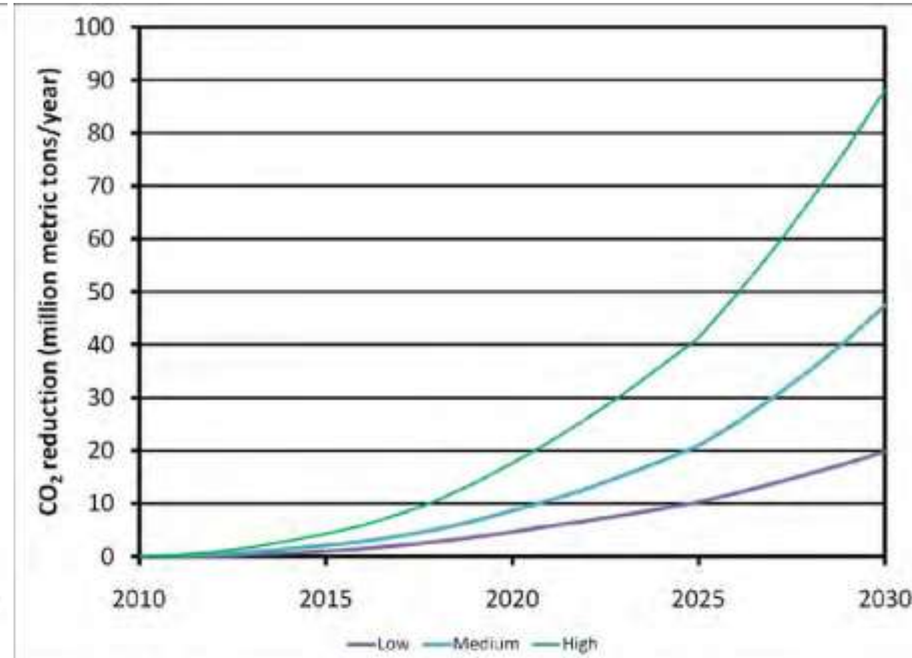


Scenarios: Low based on past sales; Medium based on "ground up" estimates; High based on forecasts.

Source: EPRI 2011 Technical Report, Transportation Electrification Technology Overview.

Gasoline Savings & CO2 Reductions





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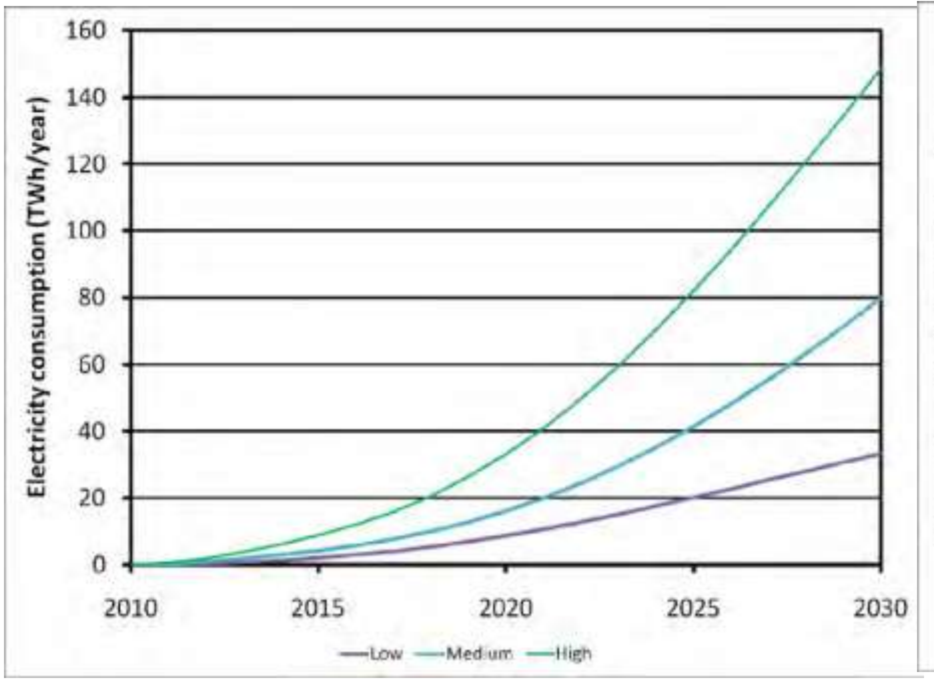
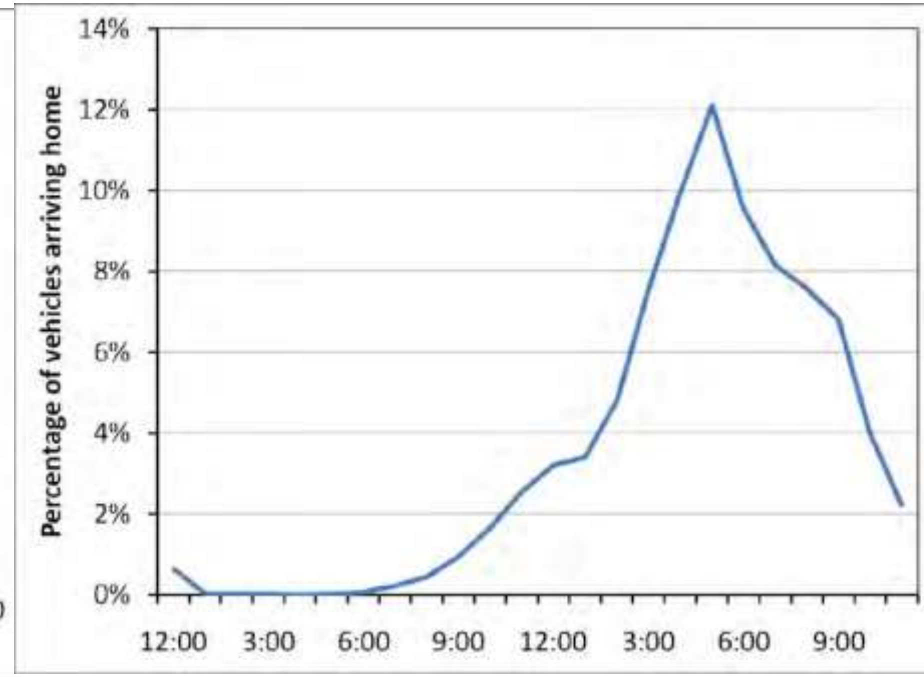
Electricity Consumption and Timing





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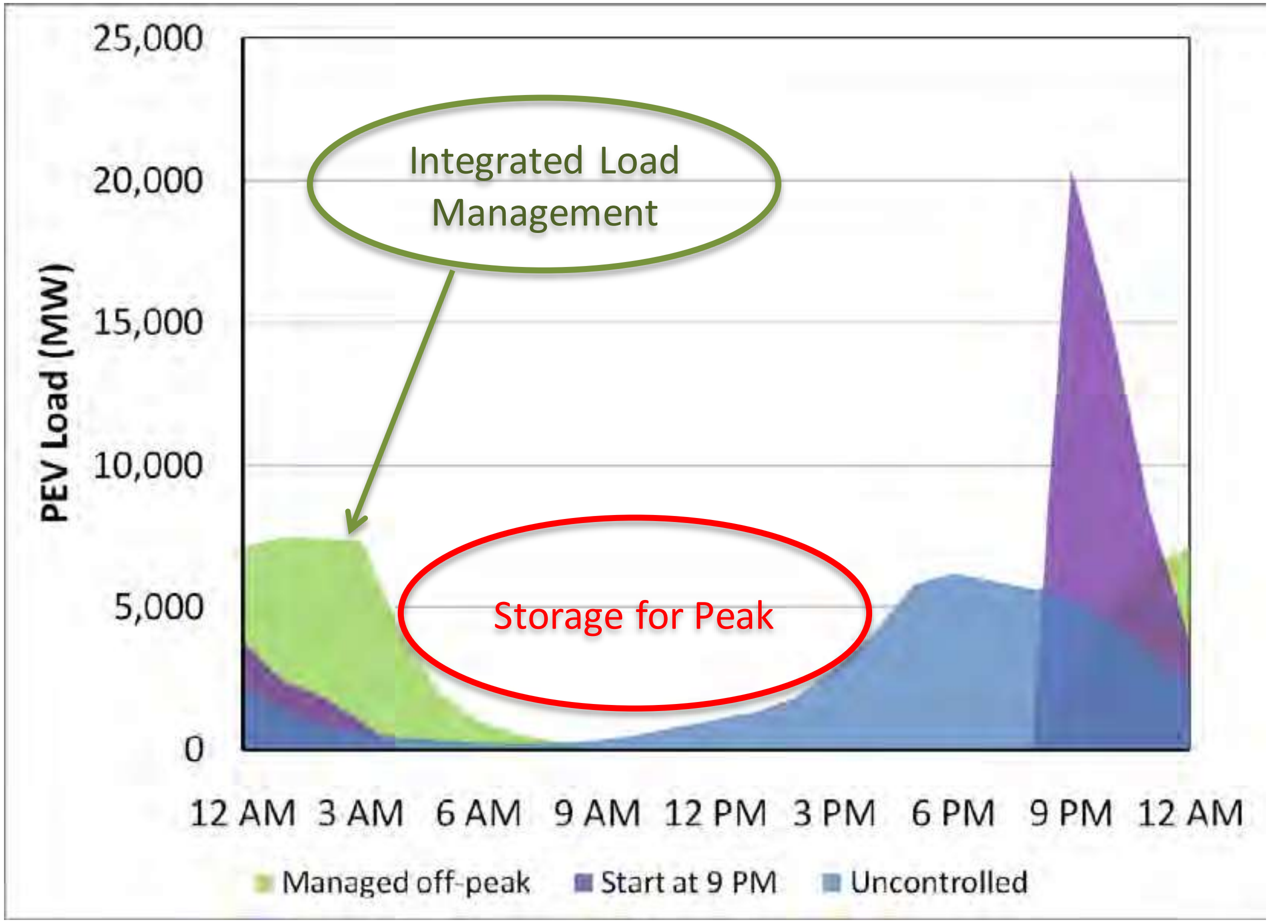
Smart Grid Integration Crucial



Source: EPRI 2011 Technical Report, Transportation Electrification Technology Overview.


Project Get Ready
Project Get Ready
• Partnership with Rocky Mountain Institute to set up an electric vehicle charging infrastructure.
Raleigh
Indianapolis
Portland
Progress Energy
SUSTAINABLE Raleigh
Advanced ENERGY
Project Get Ready positions the Triangle to be an early market for Electric Vehicle Distribution.

• Electricity Storage

- Why Storage? (demand vs. generation timing, cost, source variability (e.g., RE))
- Evolution of Electricity Storage (pumped storage)
- New Capabilities Provided by Advanced Storage Technologies
- Application Areas for Advanced Electricity Storage
- Supporting Renewable Deployment and Emission Reductions
- Smart Grid - Key to Full Utilization of Electricity Storage

Electricity Storage Applications

- Generation Applications
  - Regulation or Automatic Generation Control Service
  - Primary or Governor Response
  - Real-time Dispatch/Balancing Energy
  - Renewables Balancing
  - Diurnal and Longer Time Shifting
  - Reserves; Distributed Generation
- Transmission & Distribution
  - Voltage Support
  - Transmission Time/Load Shifting
  - Stability-Related Applications
  - Transmission/Distribution Deferral
  - Radial System Reliability Improvement
- Electrification of Transportation

Electricity Storage Technologies (Examples)

- Batteries
  - Lead-Acid
  - Nickel-Cadmium and Nickel-Metal Hydride
  - Lithium-Ion
  - Sodium-Sulfur (NaS)
  - Zinc-Bromine
  - Vanadium Redox
- Flywheels
- Compressed Air (CAES)
- Pumped Hydro; Ice
- More Technologies in Development

Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Pumped Storage	High Capacity, Low Cost	Special Site Requirement		●
CAES	High Capacity, Low Cost	Special Site Requirement, Need Gas Fuel		●
Flow Batteries: PSB VRB ZnBr	High Capacity, Independent Power and Energy Ratings	Low Energy Density	◐	●
Metal-Air	Very High Energy Density	Electric Charging is Difficult		●
NaS	High Power & Energy Densities, High Efficiency	Production Cost, Safety Concerns (addressed in design)	●	●
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◐
Other Advanced Batteries	High Power & Energy Densities, High Efficiency	High Production Cost	●	○
Lead-Acid	Low Capital Cost	Limited Cycle Life when Deeply Discharged	●	○
Flywheels	High Power	Low Energy density	●	○
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◐

• Transmission & Distribution Issues

- Largely discussed previously (e.g, losses)
- Technology rapidly developing
- Example: Wireless PEV recharging (BMW & Siemens; others)

• Distributed Generation (DG) - Definition

- Distributed generation (DG) is the use of smaller-scale power generation technologies located close to the load being served.
- For many customers, DG can lower costs, improve reliability, reduce emissions, or expand their energy options.
- DG stakeholders include energy companies, energy users, regulators, equipment suppliers, and financial and supporting companies.
- Only 0.5% of U.S. electric generation in 2000, expected to be 11% of capacity additions through 2025 (CBO, EIA)

DG Drivers

- Technologies – New small-scale, efficient power generation technologies are promising to provide generating performance that previously was available only from large central station plants
- Customer Needs – Changes in electric customer needs for power reliability are creating an increased value for high quality power.
- Restructuring – Electric utility restructuring is creating new opportunities for self-generation as well as concerns over the future cost and/or reliability of the central power generating system.

DG Technologies (1)

- Typical today:
  - Internal Combustion Engines
  - Combined Heat & Power
  - Wind Turbines
  - Microturbines
  - Fuel Cells
  - Photovoltaics
  - Anerobic Digestion

- Note: Emissions vary greatly; heavy interplay with RE

DG Technologies (2)

- Rapidly developing new technologies and improvements:
  – Tidal and wave energy
  – Thermo-electric effect (Chen, MIT & Ren, BC)
  – Fast-charging batteries (Braun, UI-UC)
  – PV efficiency (e.g, silver scattering)
- “Next Great Decentralization”
  – As already seen in computing, telephony
  – Will see both supply-side and demand-side innovation
  – Will policies obstruct or encourage?

Question & Answer Period

- Thank You!

About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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Additional Slides

Smart Grid Discussion Questions

- How should we frame smart grid with decision-makers?
  - How do we get our main theme (smart policies before smart grids) across to key players?
  - What other themes and policy ideas should RAP pursue?
- What are the most important actions regulators can take to guide smart grid toward energy and carbon savings?
- What are the key opportunities and venues for RAP to get results?
- What smart grid issues are hot in the EU and India?

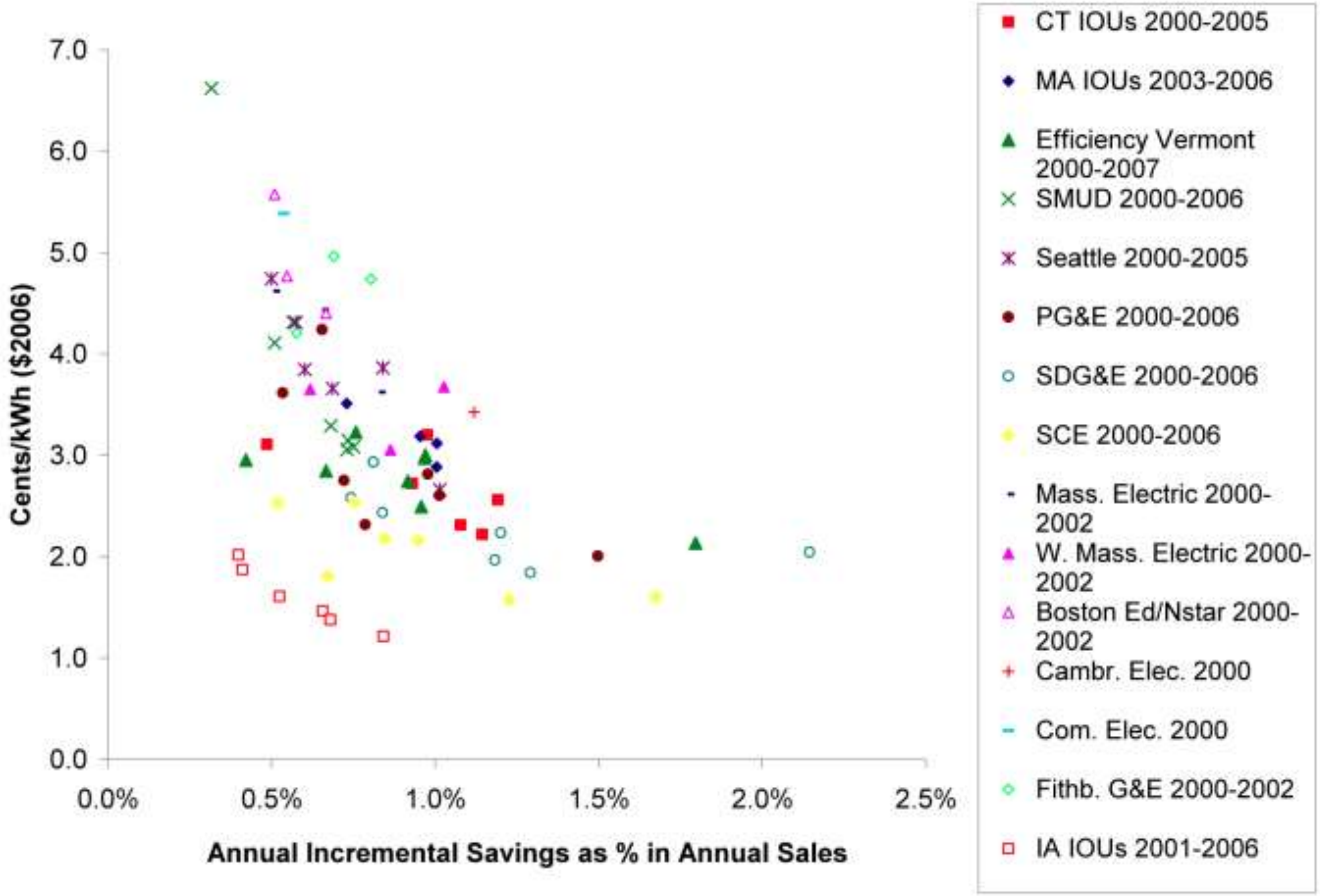
Smart Grid Discussion Questions (2)

- What's the timing of key decisions for smart grid investments and requisite policies?
- How can we better engage consumers?
  - Where have utilities and regulators gone?
  - As we move ahead, how can we engage customers effectively?
- What's the role of utilities vs. third parties?
- How should we pay for utility investments needed to get smart grid-enabled savings?
  - What's gone wrong – and right – with utility cost recovery processes?

Smart Grid Discussion Questions (3)

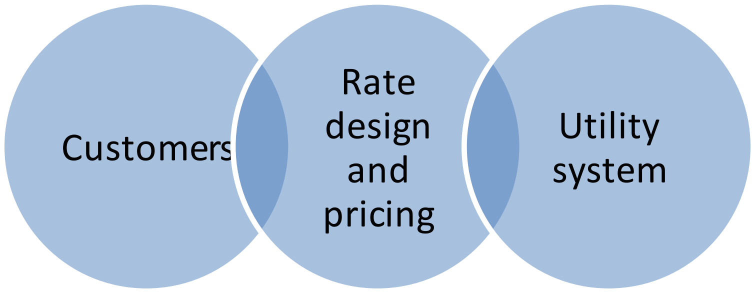
- What's needed to make dynamic pricing programs successful?
  - Success = $ savings for participants and ratepayers overall, carbon reductions, helping to integrate variable renewable energy resources, what else?
- How do coal plant retirements fit in?
  - As natural gas and renewables help fill in, demand response should yield cleaner results and will help integrate variable renewable energy resources. Should we make this link?
- What are RAP's next steps?
  - Research, papers, meetings, public forums, areas where we need to further develop our thinking, etc.

“BHAG” vs. the Cost of Saved Energy



Integrate Smart Grid With Rate Design and Demand-Side Programs

- Smart grid allows customers to become more involved in how and when they use energy.
  - They won't respond just because they get shiny new meters.
- Let customers choose a dynamic pricing option that varies according to market prices and system conditions.
  - Rates that reduce utility costs, encourage *long-term* reductions in peak loads and support distributed resources
- Make it easy for customers
  - Controls that respond automatically to prices
- Right-time charging and discharging of electric vehicles



Energy Efficiency and Smart Grid

- Optimize voltage and reactive power on distribution systems
  - Reduced line losses and energy use in homes and businesses
- Continuous building diagnostics
  - Alert owners about problems with energy-consuming equipment

Renewable Resources and Smart Grid

- Improved integration
  - Awareness of grid conditions
  - Fast operational changes
  - Voltage support
  - Monitor line loading and wind turbine curtailment

- More system flexibility
  - Demand response – Decrease *and increase* loads
  - Energy storage
  - Plug-in electric vehicles – Charge when wind levels are high, provide energy storage, provide ancillary services

Distributed Resources and Smart Grid

- Intelligent sensors, software, two-way communications, and advanced controls can dynamically integrate distributed generation and energy storage with other resources – and loads
  - Minimize losses, provide voltage support and improve reliability
- Microgrids – Interconnected network of loads, generation, and energy storage that works connected to or separate from grid

- Plug-in electric vehicles
  - Charge off-peak
  - Provide energy storage and ancillary services

Source: Chris King, eMeter Strategic Consulting

- Information-driven behavior changes
  - Data from smart meters and smart thermostats
  - Customized analysis, comparisons, and recommendations to consumers via Web, in-premise devices, phone, e-mail or snail-mail
- Better evaluation
  - Less money needed for analysis, more money spent on measures