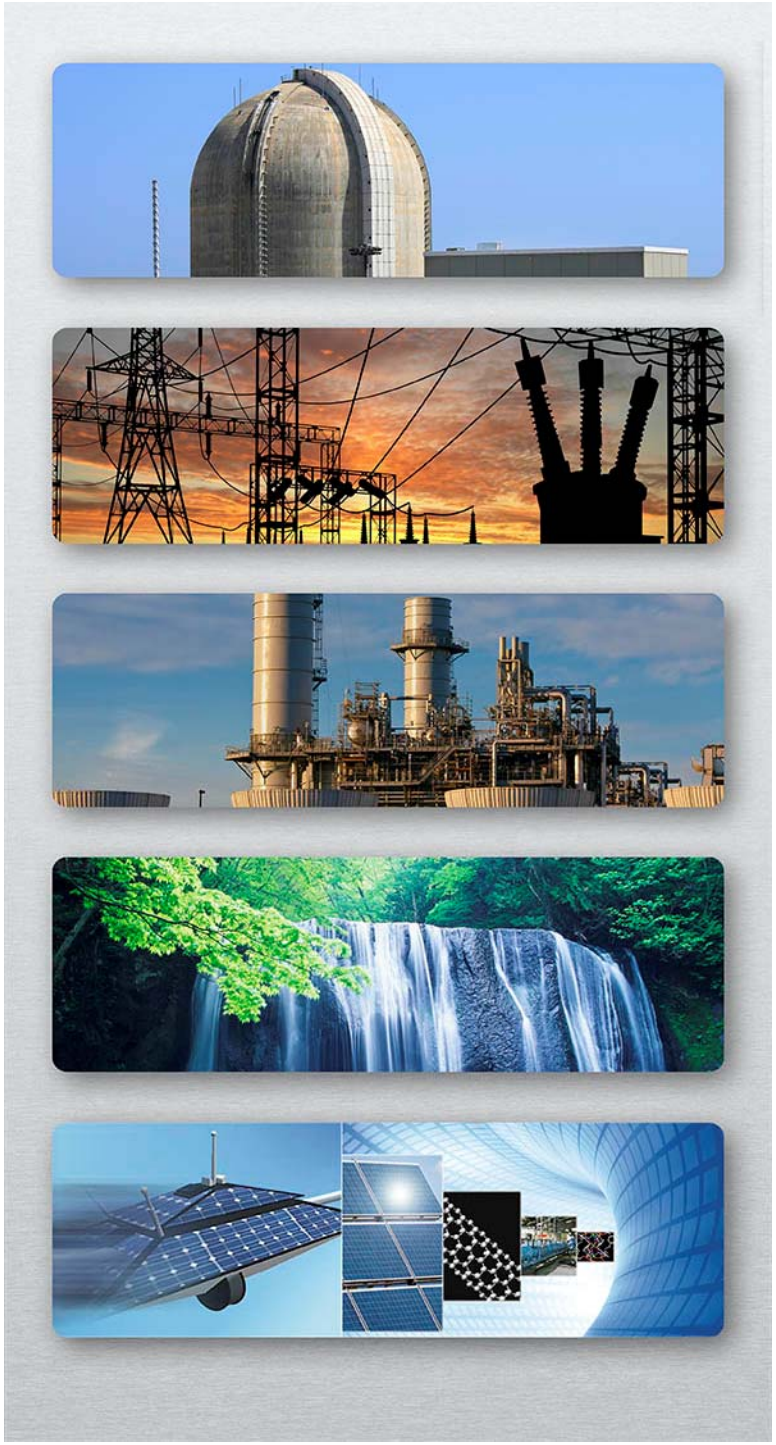

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Roadmap for Natural Gas Combined Cycle Power Generation

2011 University Turbine Systems Research Workshop

Rob Steele
Program Manager – Combustion Turbines and Combined Cycles

Electric Power Research Institute (EPRI)

R-D & Demonstration for the Electricity Industry

- Independent, unbiased, tax-exempt collaborative research organization
- Full spectrum industry coverage
  - Nuclear
  - Generation
  - Environment
  - Power Delivery & Utilization
- 460 participants in over 40 countries
- Manage > $ 350 million / year
- Three major offices in the US

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Next Step for EPRI Gas Generation Strategy

- Perspective on future use
- Highlights from EPRI Summer Seminar
- EPRI Roadmapping
- Gas Generation R&D Portfolio
  - Outcome of member survey
- Proposed program changes and strategies

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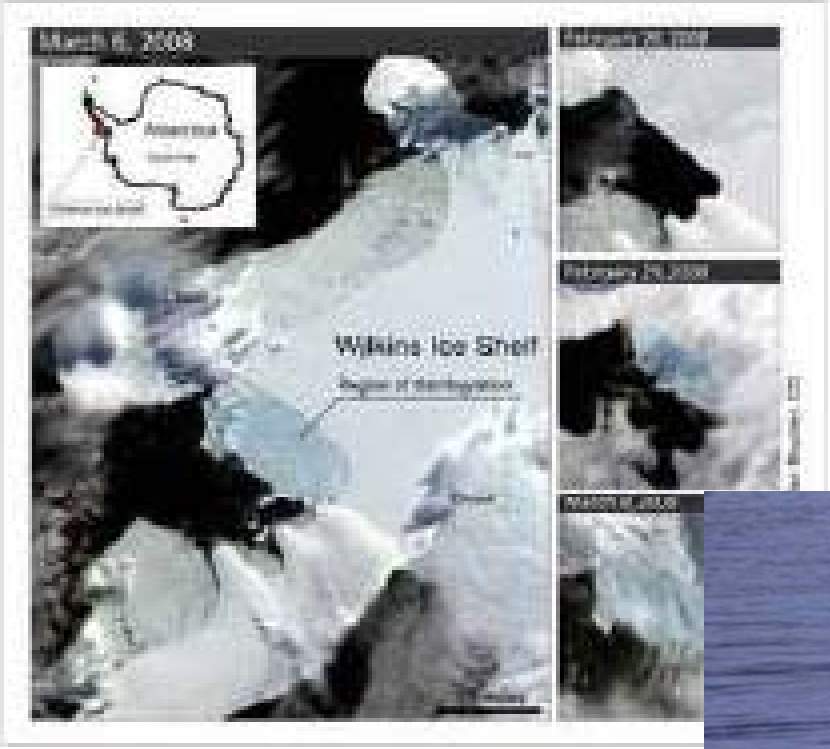
What About Global Warming?



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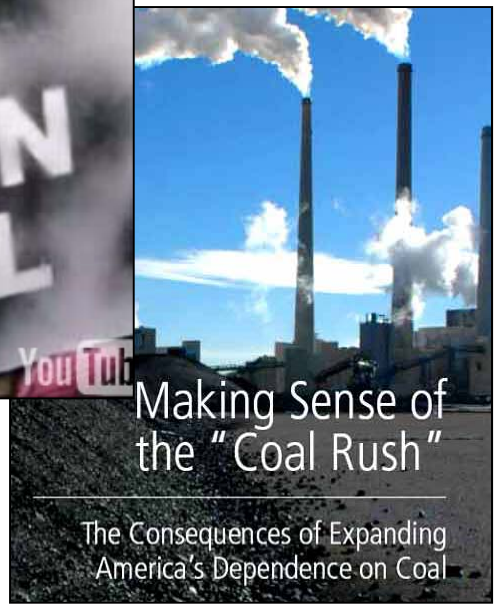
What About Future Coal Power Generation ?



OR

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What About Worldwide Electric Power Demand?

Image courtesy of NASA Visible Earth

Worldwide electric power demand will double by 2050

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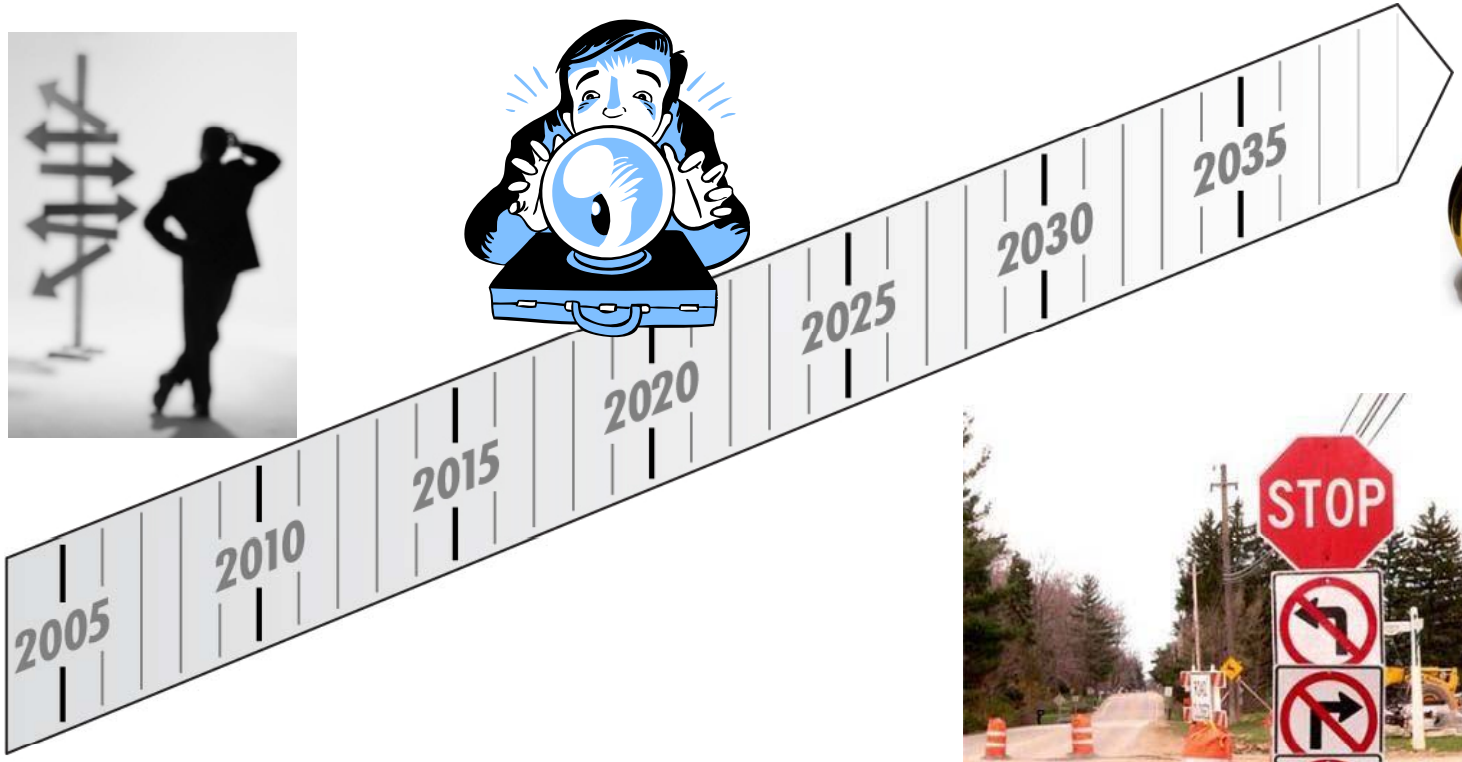
So What About Gas Generation? Next Step??



Where do we go from today?

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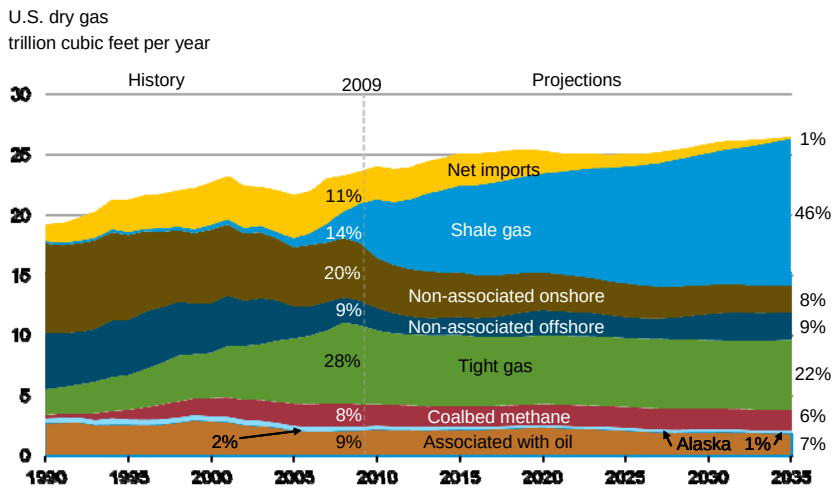
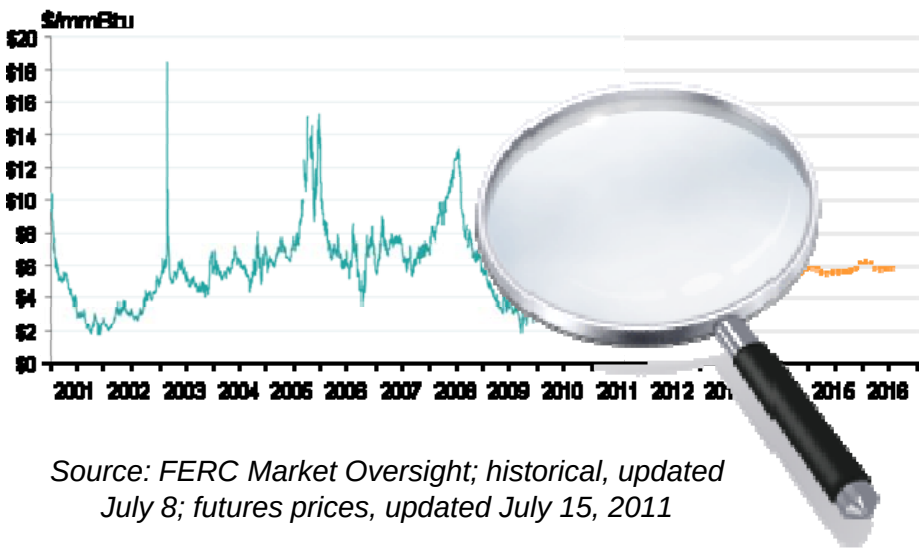
Natural Gas Supply and Demand

Natural Gas Supply Outlook



Source: EIA, Annual Energy Outlook 2011

Henry Hub Spot and NYMEX Futures Natural Gas Prices



Source: FERC Market Oversight; historical, updated July 8; futures prices, updated July 15, 2011

Stable supply @ $4-6/mmBtu over next ?? years

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Technology Advancements Improve Performance

- Energy conversion system approaching 65% efficiency
- Easier to site may replace existing facilities – smaller footprint
  - Permitting may be easier
  - Lower capital costs
  - Shorter construction schedules
- Less overall emissions
- Potential long term contracts

Installing NG facilities may be the easy decision

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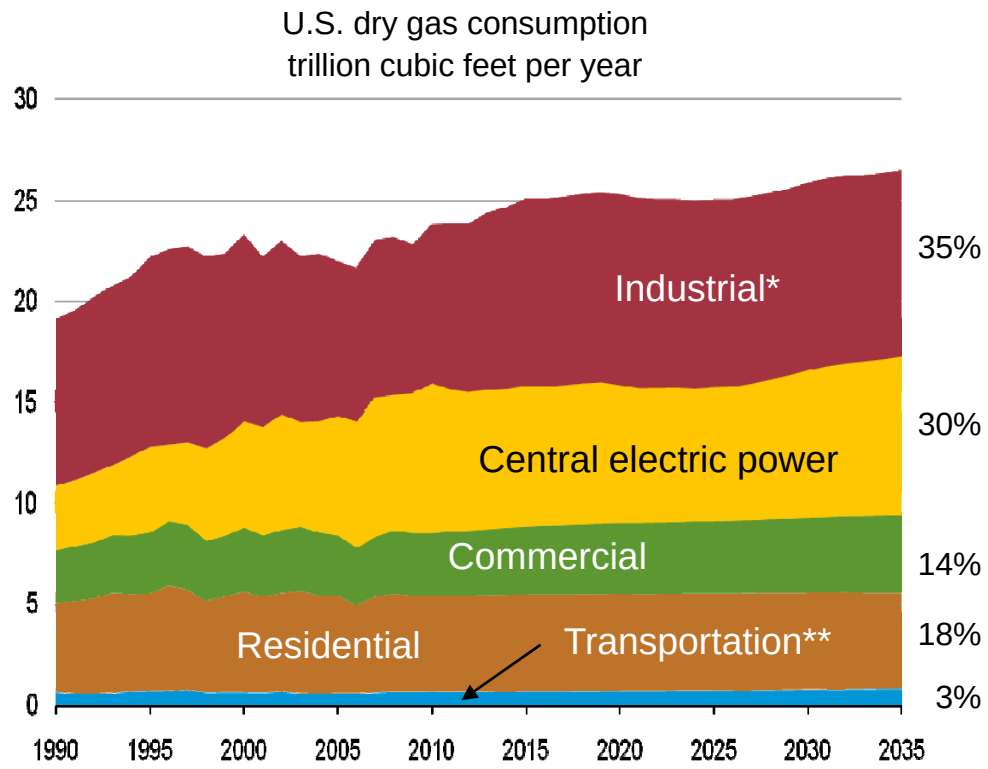
HOWEVER – Natural Gas Dynamics

- Gas is utilized by a variety of Industries
- Demand may be difficult to forecast
- Environmental aspects of harvesting unconventional gas are not yet defined
- Price may be influenced by international demand



*Includes combined heat-and-power and lease and plant fuel.
**Includes pipeline fuel.

Source: EIA, Annual Energy Outlook 2011

U.S. may become an exporter of energy?

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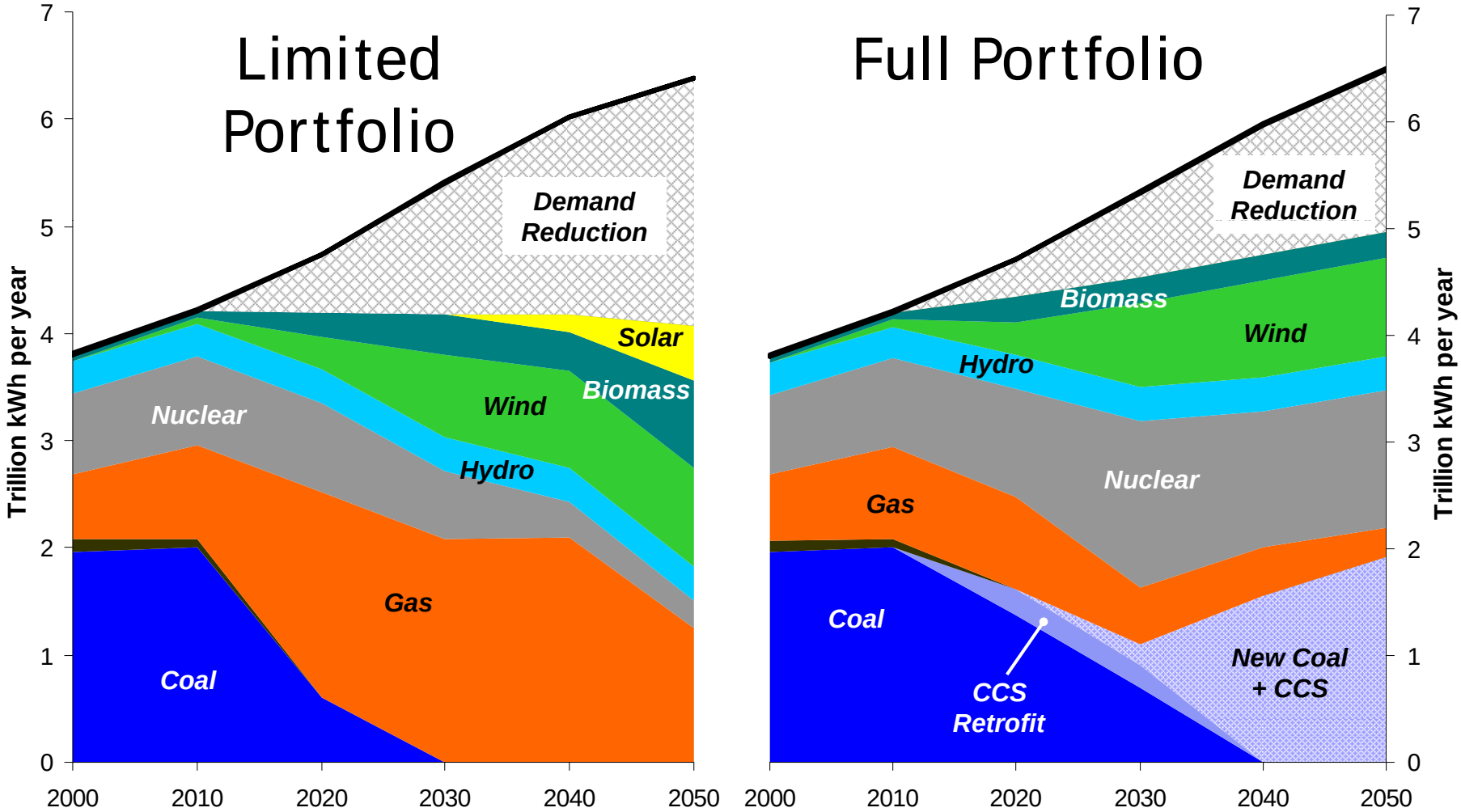
EPRI MERGE Analysis of U.S. Electric Generation Mix



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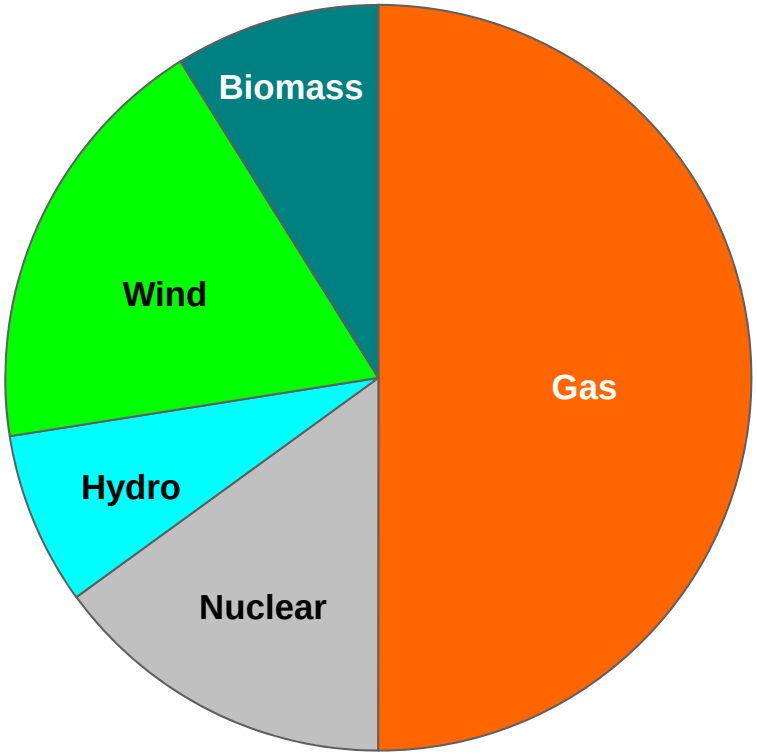
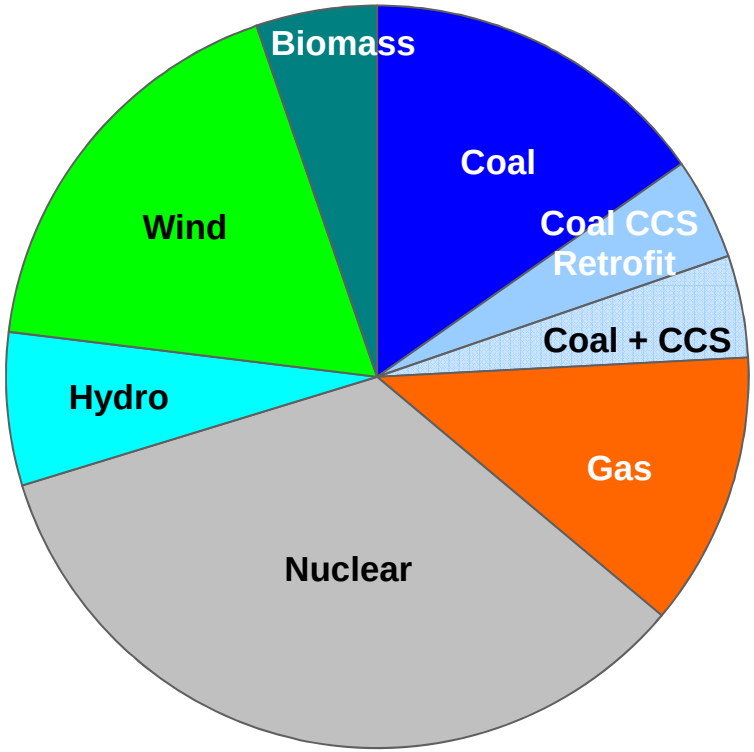
2030 Generation Mix



Limited Portfolio



Full Portfolio

Remarkable different futures and only 20 years away!

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Power Generation in 2011: Gas Up, Coal Down

Gas generation surged 62.9% in East North Central U.S.

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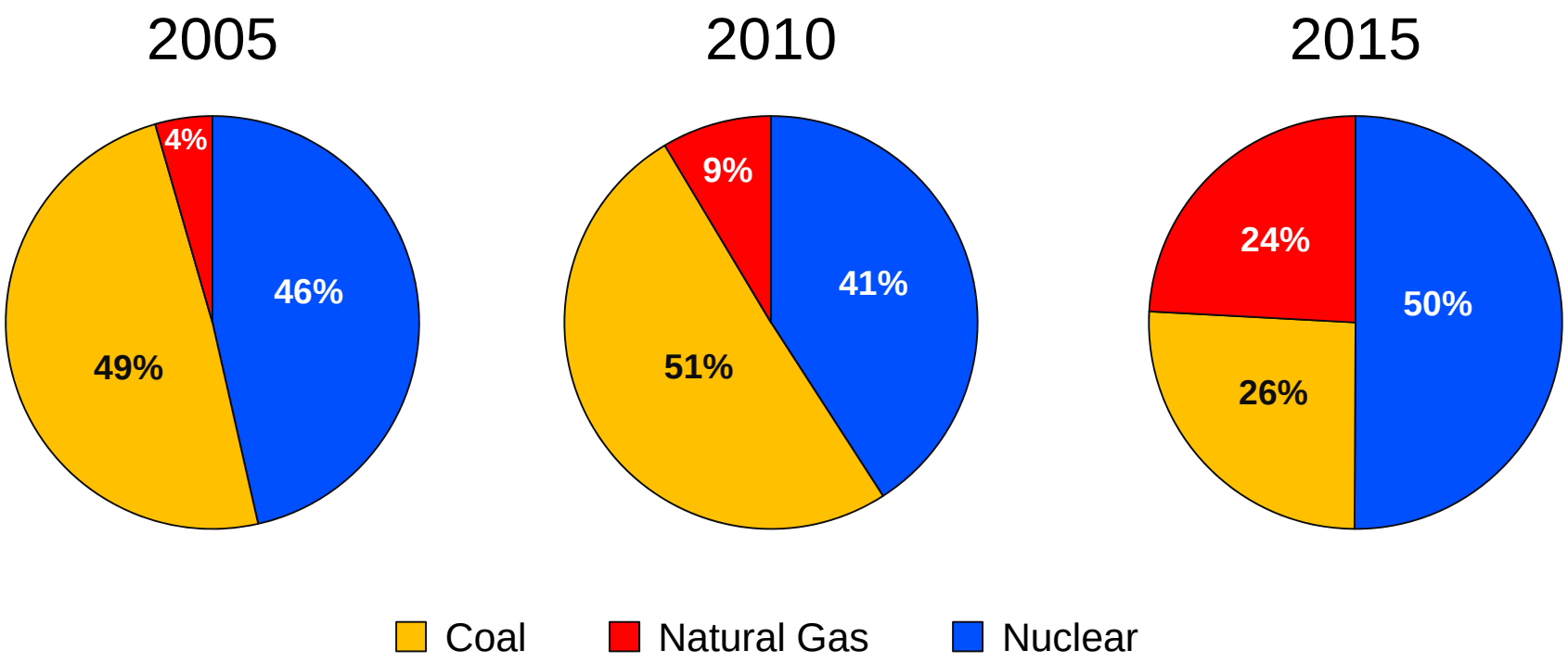
Progress Carolinas Fleet in Transition
Energy Generated by Fuel Type



2005	2010	2015
Coal energy from scrubbed units 0%	Coal energy from scrubbed units 72%	Coal energy from scrubbed units 100%

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Highlights of Summer Seminar 2011

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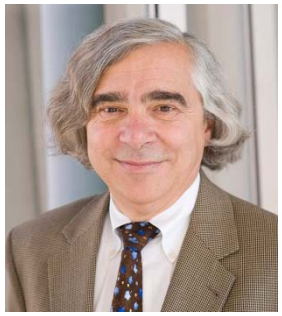
Natural Gas Generation Panelists at Summer Seminar



Ernie Moniz
Professor of Physics, MIT

Jen Snyder
Head of North American Gas Research, Wood MacKenzie

Scott Anderson
Senior Policy Advisor,
Environmental Defense Fund

Steve Bolze
President and Chief Executive Officer,
GE Power and Water

Bill Johnson
Chairman, President and Chief Executive Officer,
Progress Energy

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The “Gas” Question at the Summer Seminar

Is the “dash to gas” the bridge to a cleaner, more affordable and secure electricity future?

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Some Key Conclusions from the Panelists

- Agreed that shale gas is a game changer
- It is the bridge to a low carbon future
- U.S. natural gas price could stay below $6/million BTU at least until 2020
- Shale gas supply could drop by as much as 26% due to environmental constraints
- Water requirements for fracking process continue to rise
- Global dynamics favor natural gas
- Natural gas should be part of a balanced approach and not a panacea

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An Introduction to EPRI R&D Roadmap Development

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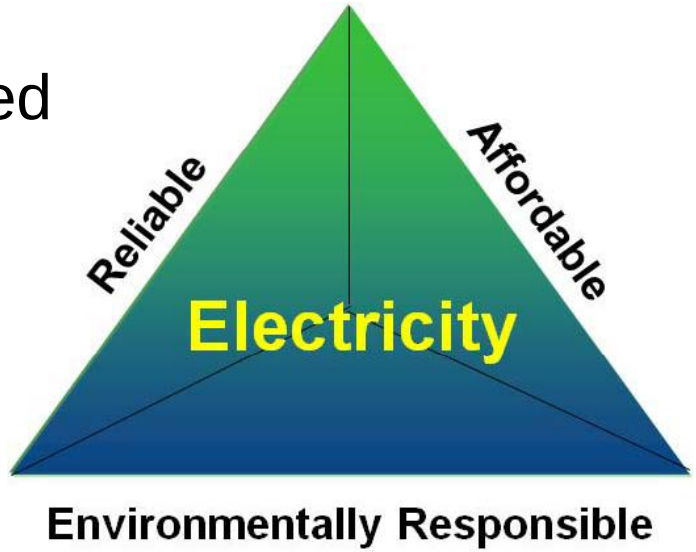
Roadmaps ARE…

Comprehensive research plans that…

- **Identify** critical issues and benefits
- **Expose** key "gaps" that must be solved to address issue
- **Specify** RD&D work required to expediently address issue
- **Propose** steps required to close research "gaps."



Roadmaps…constantly evolving and improving

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Roadmaps are NOT…

A new way to do the "same old thing"…

- Not a **"different way of packaging"** work EPRI is already doing
- Not a **"one size fits all''** approach to problem solving
- Not a way to promote the **"world according to EPRI"** view on an issue
- Not a **"one-way dialogue"** on future R&D.

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Sector Research Area Roadmaps

- Advanced Coal Generation
- Flexible Operation of Fossil Fleet
- **Gas Generation Technology**
- Generation Fleet Transition
- Long Term Operation
- Near-Zero Emissions
- Renewable Generation Technology
- Water Management.

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EPRI Gas Generation Strategy

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Gas Generation Strategy
Background

- Increased interest from international and domestic members
  - Increased interest in simple and combined cycle (SC/CC) related scope across Sector
- Opportunity to redefine scope of program(s) and points of coordination
- Opportunity to utilize coal-based technologies
  - Importance of active coordination
- Broad Gas Generation Roadmap
- Schedule and communication to minimize confusion, maintain transparency
- Generation Council guidance needed

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Generation Sector 2012 Portfolio

Existing Assets

Operations and Maintenance

68: Instrumentation, Controls, and Automation

69: Maintenance Management & Technology

108: Operations Management & Technology

Major Component Reliability

63: Boiler Life & Availability Improvement Program

65: Steam Turbines-Generators, & Auxiliary Systems

104: Generation Maintenance Applications Center

Materials and Chemistry

64: Boiler & Turbine Steam & Cycle Chemistry

87: Fossil Materials & Repair

Combustion Turbines

79: Combustion Turbine & Combined Cycle O&M

80: New Combustion Turbine/Combined-Cycle Plant Design and Technology Selection

88: Heat Recovery Steam Generator (HRSG) Dependability

Environmental Compliance

Environmental Controls

71: Combustion Performance & Emissions Control

73: Post-Combustion NO_x Control

75: Integrated Environmental Controls

76: Particulate and Opacity Control

77: Continuous Emissions Monitoring

78: Coal Combustion Product Use

Future Generation Options

Generation Planning

178A: Technology-Based Business Planning Information & Services (TAG)

178B: Power & Fuel Markets: Risk and Response

Renewable Generation

84A: Renewable Energy Economics and Technology Status

84B: Biomass

84C: Solar

84D: Wind

84E: Geothermal

Advanced Coal, Carbon Capture & Storage

66A: Engineering & Economic Evaluations and Market Assessments of Advanced Coal Generation Options

66B: Gasification-Based Power Plant Development & Deployment

66C: Combustion-Based Power Plant Development & Deployment

165: CO_2 Capture and Storage

Run existing units better, comply with regulations, aid new build decisions

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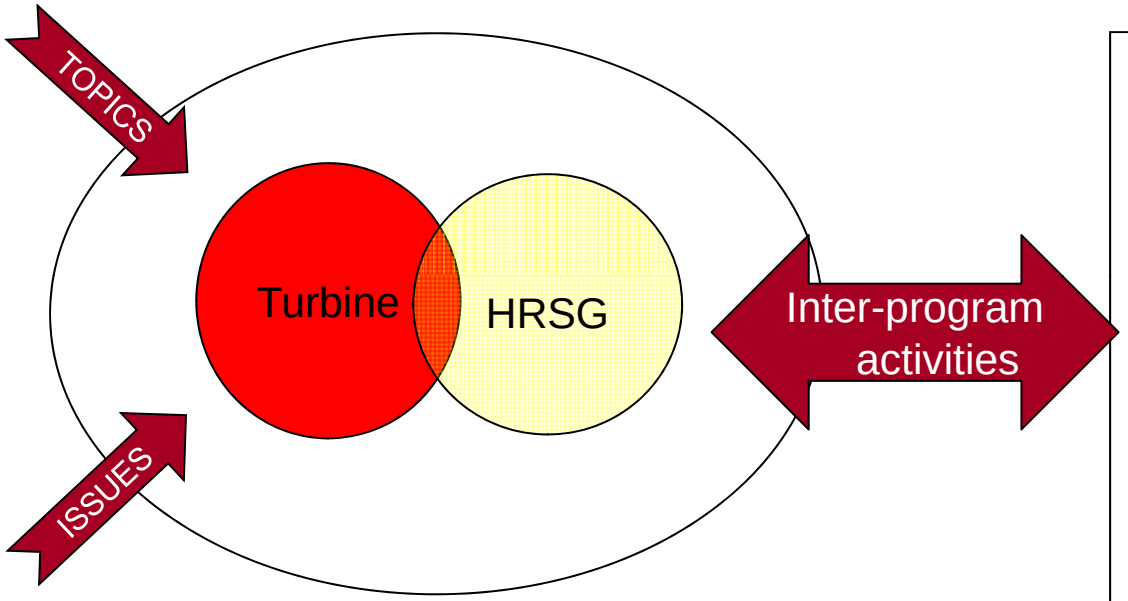
Proposed Approach to Manage Simple and Combined Cycle Activities



Examples of Inter-program Activities:

- CC Heat-Rate interest Group
- SCR Catalyst Regeneration
- CC Plant Maintenance Basis
- CC Operational Assessment

Supportive EPRI Programs and Activities

- P63 – Boiler
- P65 – ST/Gen
- P64 – Chemistry
- P68 – Instrumentation/Controls
- P87- Materials
- P71 – Performance/Emissions
- P73 – NOx Control
- P104 – Maintenance
- P108 – Operations
- P165 – CCS
- P178 – Fuel Markets
- Plant Managers Forum

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Redefined Topic Areas of New P79 and P88

New P79: Turbomachinery and Life Cycle Management for CC Plants

- SC/CC Plant Economics and Assessments
- SC/CC Plant Repowering
- Integrated SC/CC O&M, Cycling, and Plant Performance
- CT Design, Durability, and Performance
- CT-Gen O&M
  - Compressor
  - Combustor
  - Turbine
- Advanced SC and CC Plant Designs
- Steam Turbine-Gen-Auxiliary Systems O&M
- Advanced Steam Turbine-Gen Designs
- Life Assessment/Risk Management
- Co-generation with Renewables

New P88: HRSG and CC BOP Life and Availability Improvement

- Cycle Chemistry
- Tube Failures
- NDE and Repair
- HRSG O&M, Cycling, and Performance
- HRSG Life Assessment/Risk Management
- Advanced HRSG Designs
- Balance of Plant (i.e., pumps, piping, skids, expansion joints)
- Environmental

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SC/CC Plant-wide Assessments and Evaluations

Potential Topic Areas:

- Subsystem / component interface and integration
- Plant cycling and controls
- Repowering
- Fuel costs and market projections
- Engineering and economic analyses
- Plants of the future
  - Advanced CT and ST concepts (eg., CO_2 as working fluid)
  - With and without Carbon Capture
  - Other options?
- Cogeneration with renewable power sources
- Distributed generation CC power units
- Legislative issues and policies affecting NG industry
- Outreach issues and concerns
- Visits to plants and technology providers

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One Current EPRI Activity

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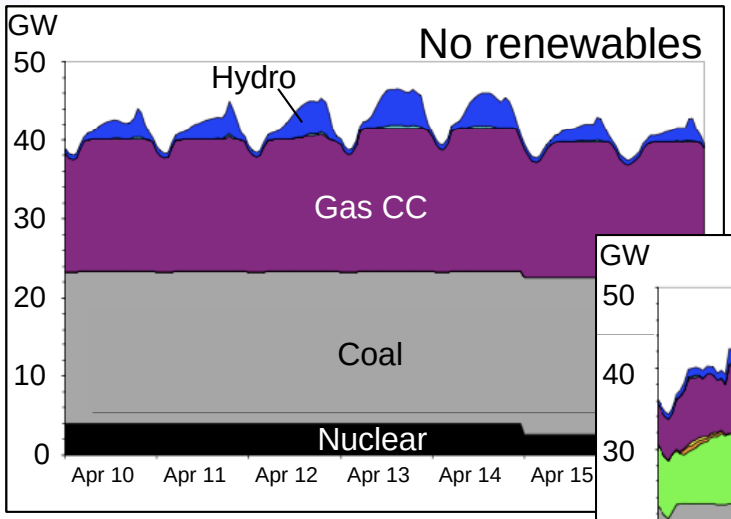
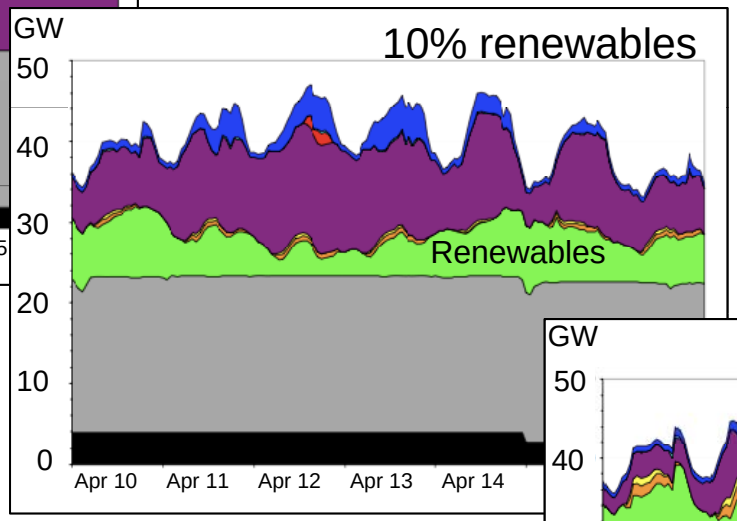
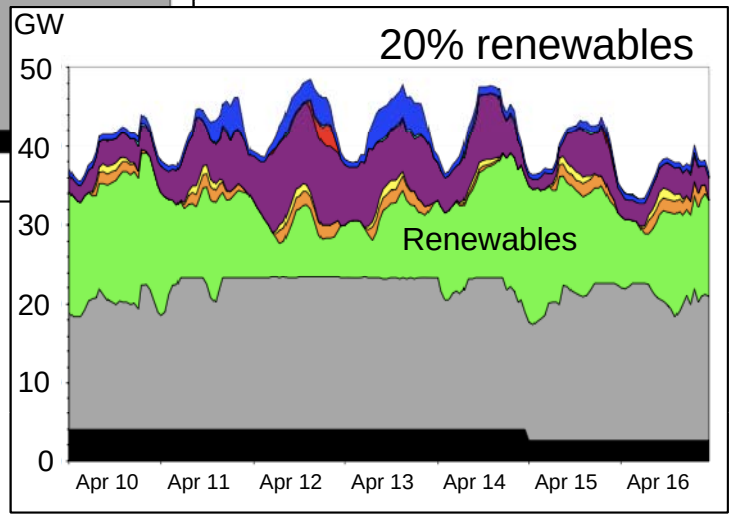
Impact of Renewable Penetration



How do Wind and Solar Power Affect Grid Operations: The Western Wind and Solar Integration Study





Gas Generation Must:

- Ramp faster and more often
- Cycle on/off faster and more often
- Spend more time at part loads
- Provide more short-term reserves

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FlexEfficiency* 50 Combined Cycle Power Plant

510 MW, 50 Hz… 61%+ baseload efficiency

Start-up to full load 28 minutes

Ramp-rate >50 MW/minute

Plant turn-down to 40% load

A new standard in efficiency AND flexibility enabling integration of more renewable resources onto the power grid

a product of
ecomagination

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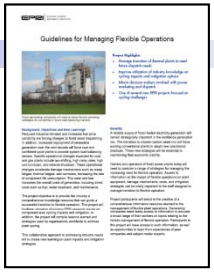
EPRI Supplemental Projects – Flexible Operation

Reference Guide on Cycling Impacts



Guidelines for Managing Flexible Operation (**1023539**)

Mitigating Impacts of Flexible Operation

Operations

Operational Flexibility Implementation: Case Studies (**1022811**)

Controls

HRSG Damage Reduction Through Improved Controls (**1023346**)

Controls Strategies to Improve Rankine Cycle Plant Flexibility (**1023553**)

Assessing Cost Impact of Flexible Operation

Flexible Operation Cost Assessment Framework (**1024454**)

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Summary Comments

- Gas is the bridge to low carbon future
- Continue to develop comprehensive gas R&D Portfolio
  - Staff and advisors across Generation Sector
- Initially, Generation Council will oversee plan
  - Involve multiple sector programs
- Include domestic and international collaboration
- EPRI will reach out to existing forums and groups for input
- Plan will be completed by 2Q 2012

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Together…Shaping the Future of Electricity

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