THE FUTURE OF COAL: ECONOMICS AND PLANNING

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HARVARD GRADUATE SCHOOL OF ARTS AND SCIENCES: ENERGY 101

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1. CONTEXT

Coal in the U.S. is huge, with a long history and emerging challenges.

U.S. coal plants

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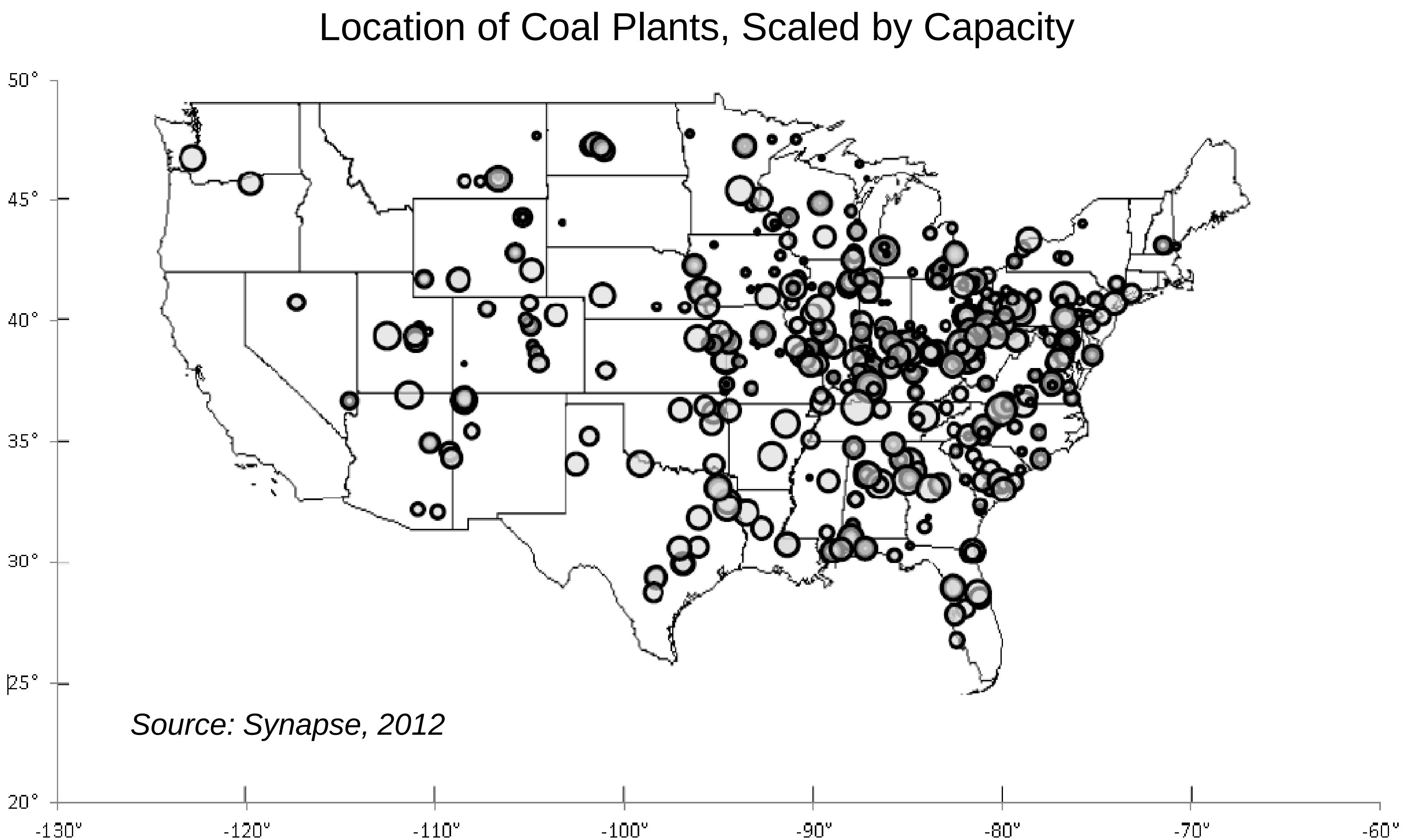
Existing coal generating capacity



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U.S. electric power CO_2 emissions

- U.S. CO_2 Emissions ≈ 22% of World Total
- U.S. Electric Sector ≈ 40% of U.S. Total
- U.S. Electric Sector ≈ 9% of World Total

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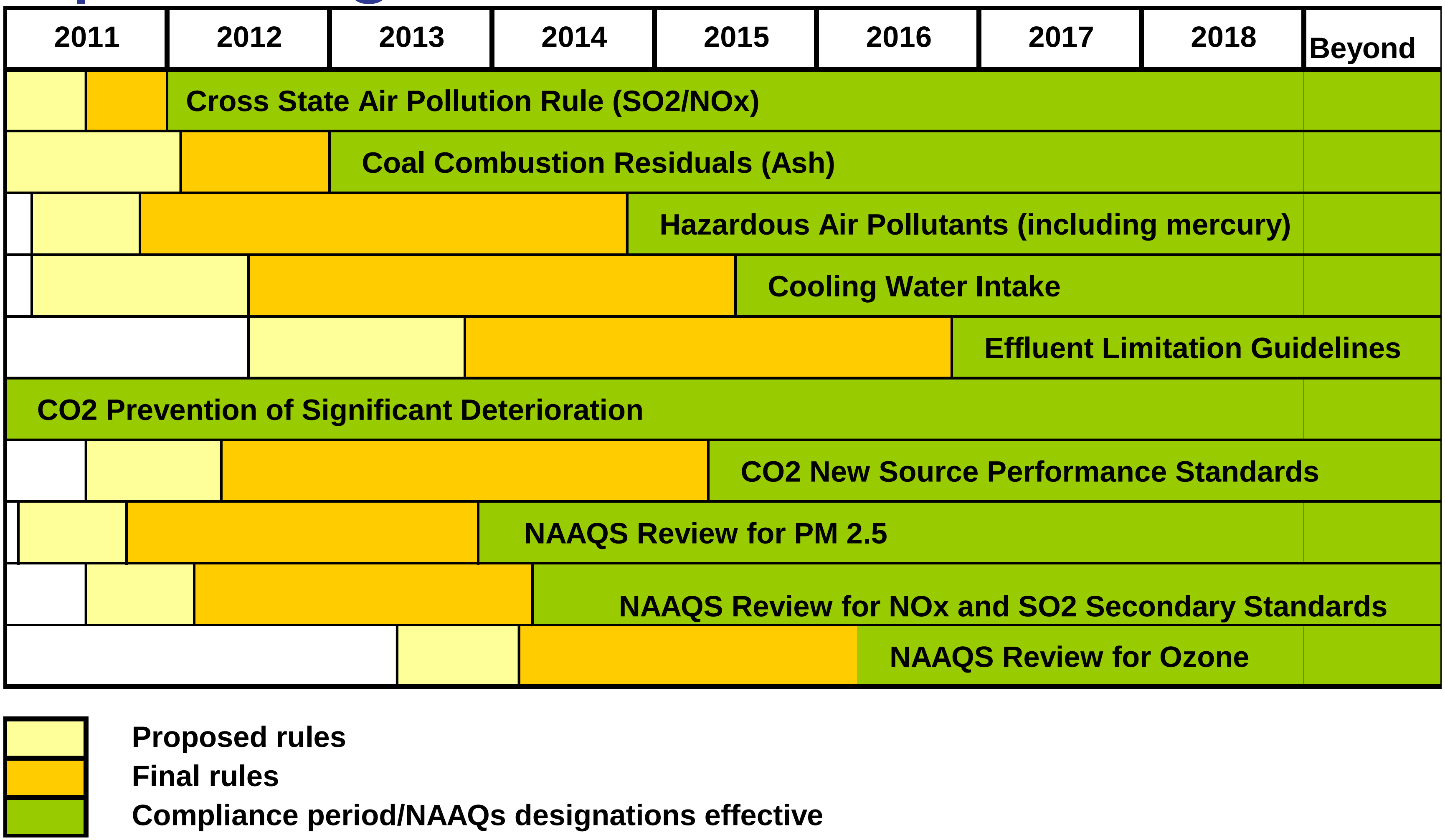
Upcoming EPA Rules



Source: Synapse. *Economics of Existing Coal Generation and Opportunities for Clean Electricity*. 2011.

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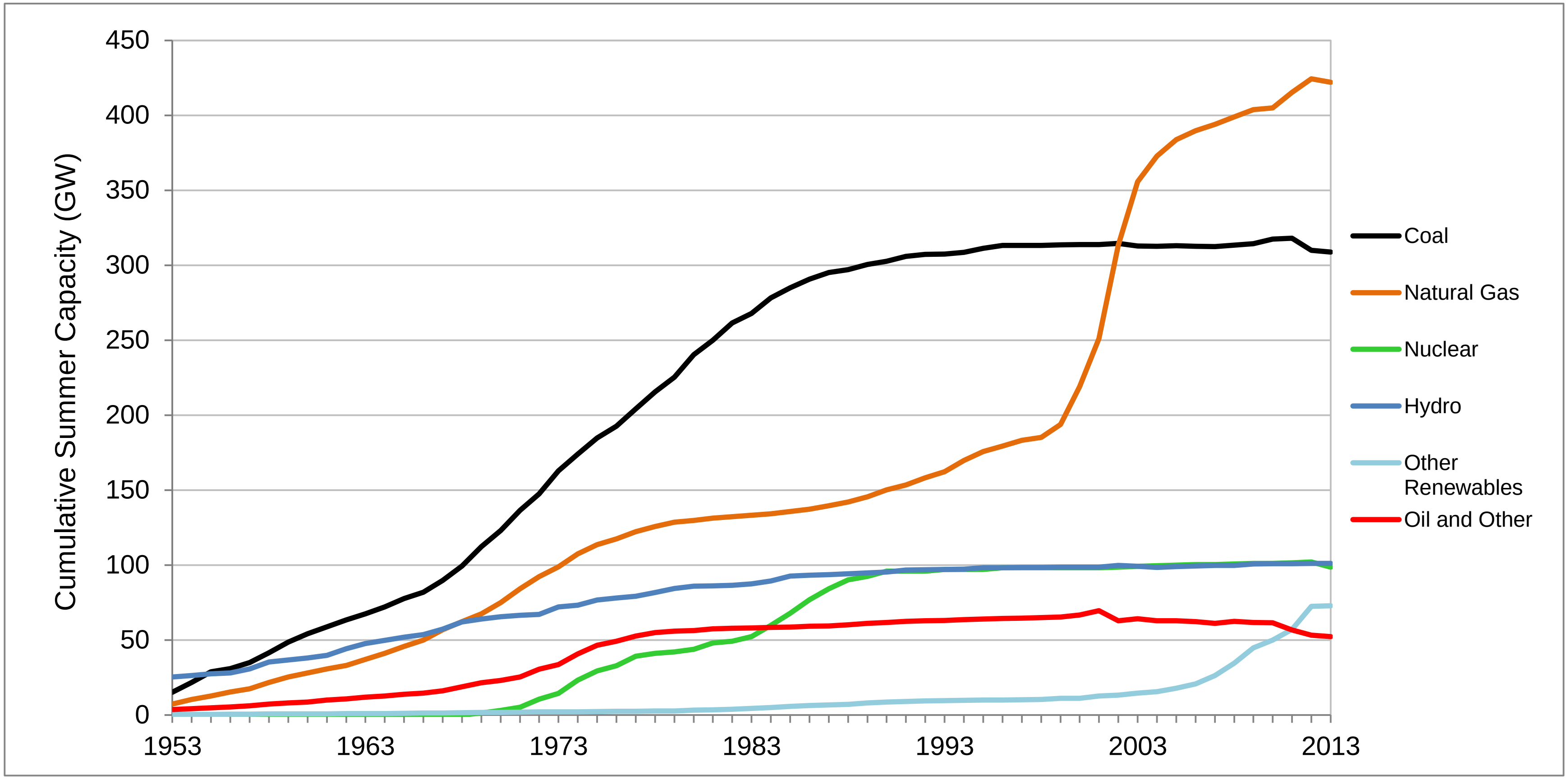
U.S. generating capacity by type



Source: EIA Form 860, 2001 – 2012, Electric Power Monthly

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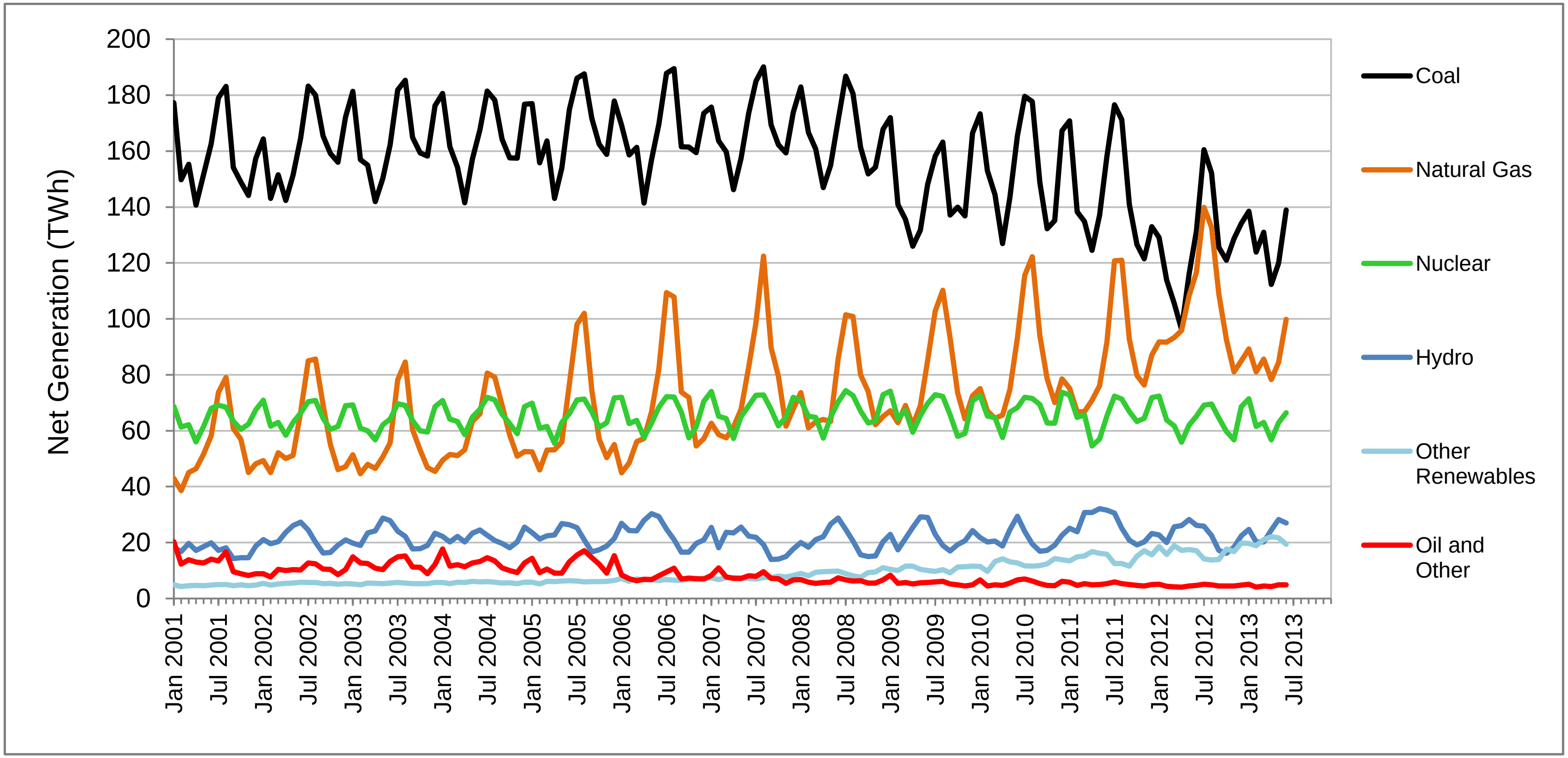
U.S. quarterly generation by fuel type



Source: EIA Form 923, 2001 - 2013

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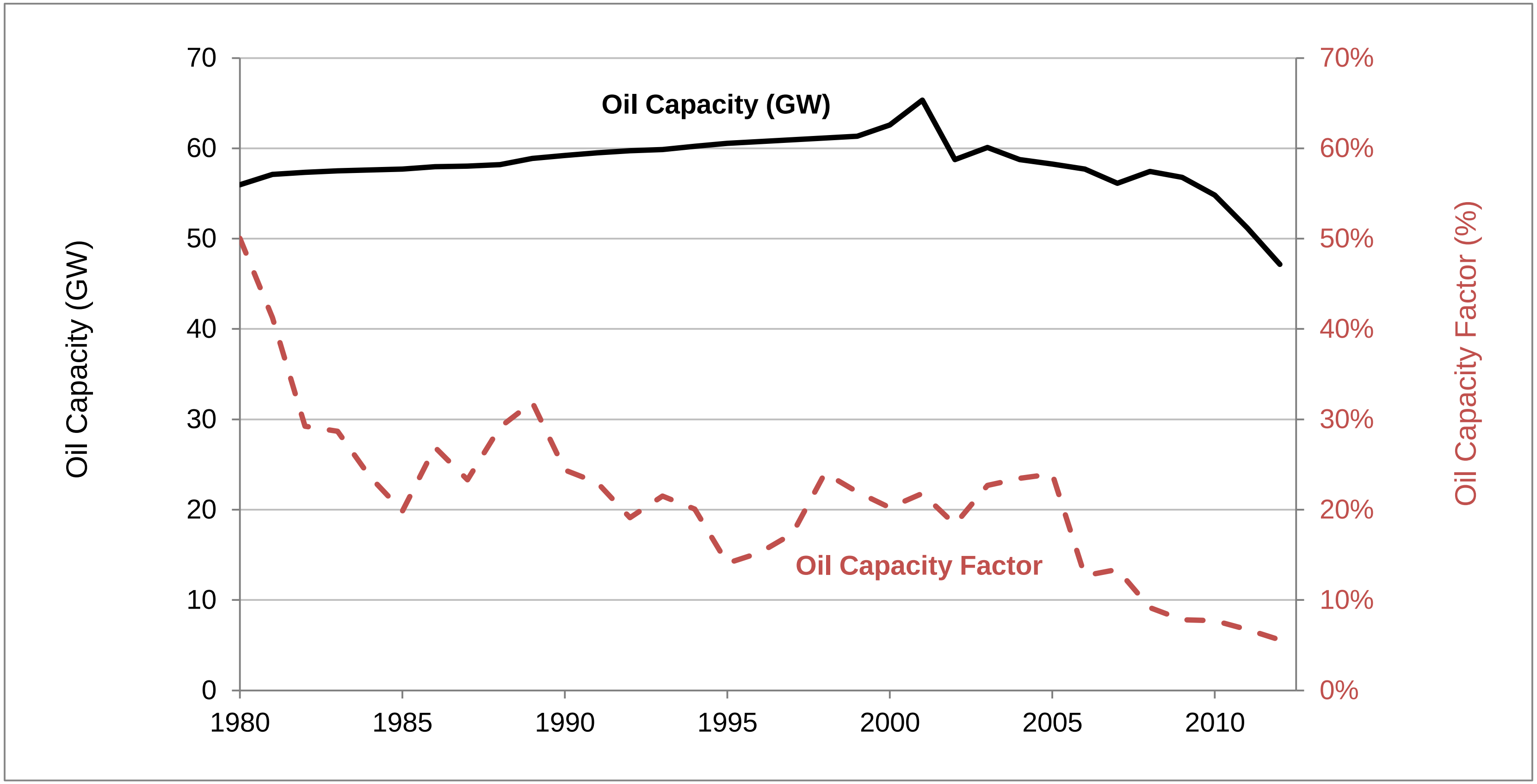
Oil power plant capacity factor decline



Sources: EIA 860 2001-2012; EIA 923 2001-2012 (2001-2012 generation); EIA Annual Energy Review 2012 (1980-2000 generation)

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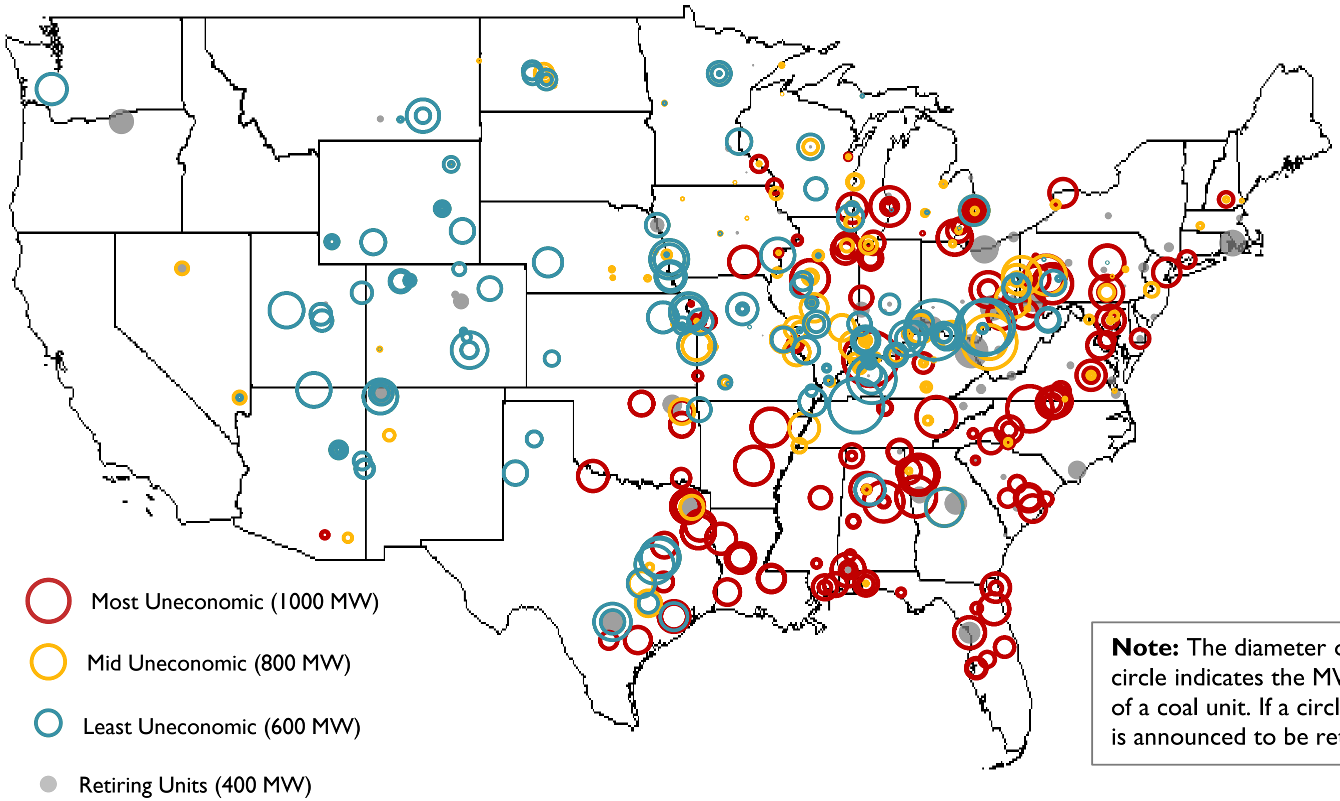
U.S. coal units by economic viability



Note: The diameter of each circle indicates the MW capacity of a coal unit. If a circle is filled, it is announced to be retired.

Source: Synapse CAVT Analysis

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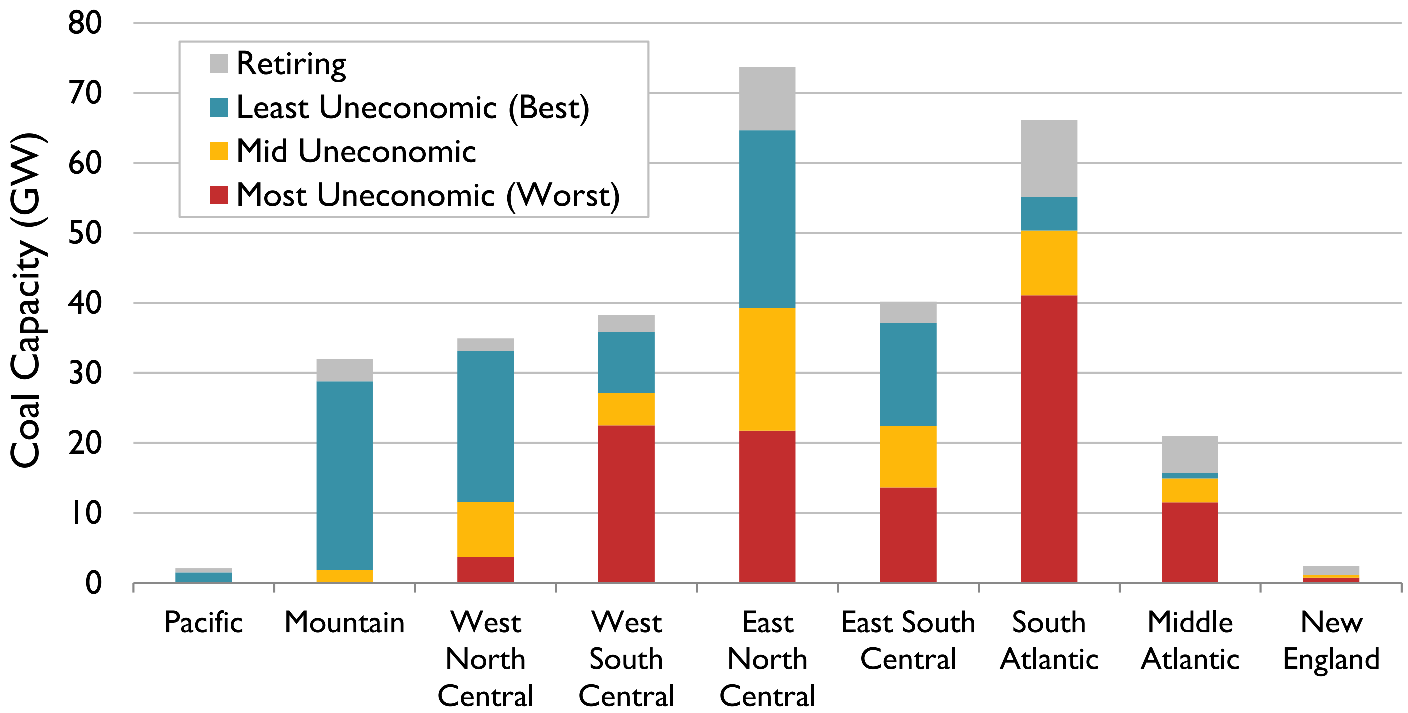
U.S. coal units by economic viability and region



Source: Synapse CAVT Analysis

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2. ECONOMICS: COAL VS. GAS

Natural gas prices can be volatile, but can be economically attractive compared to coal, even when the coal plant construction costs are not considered.

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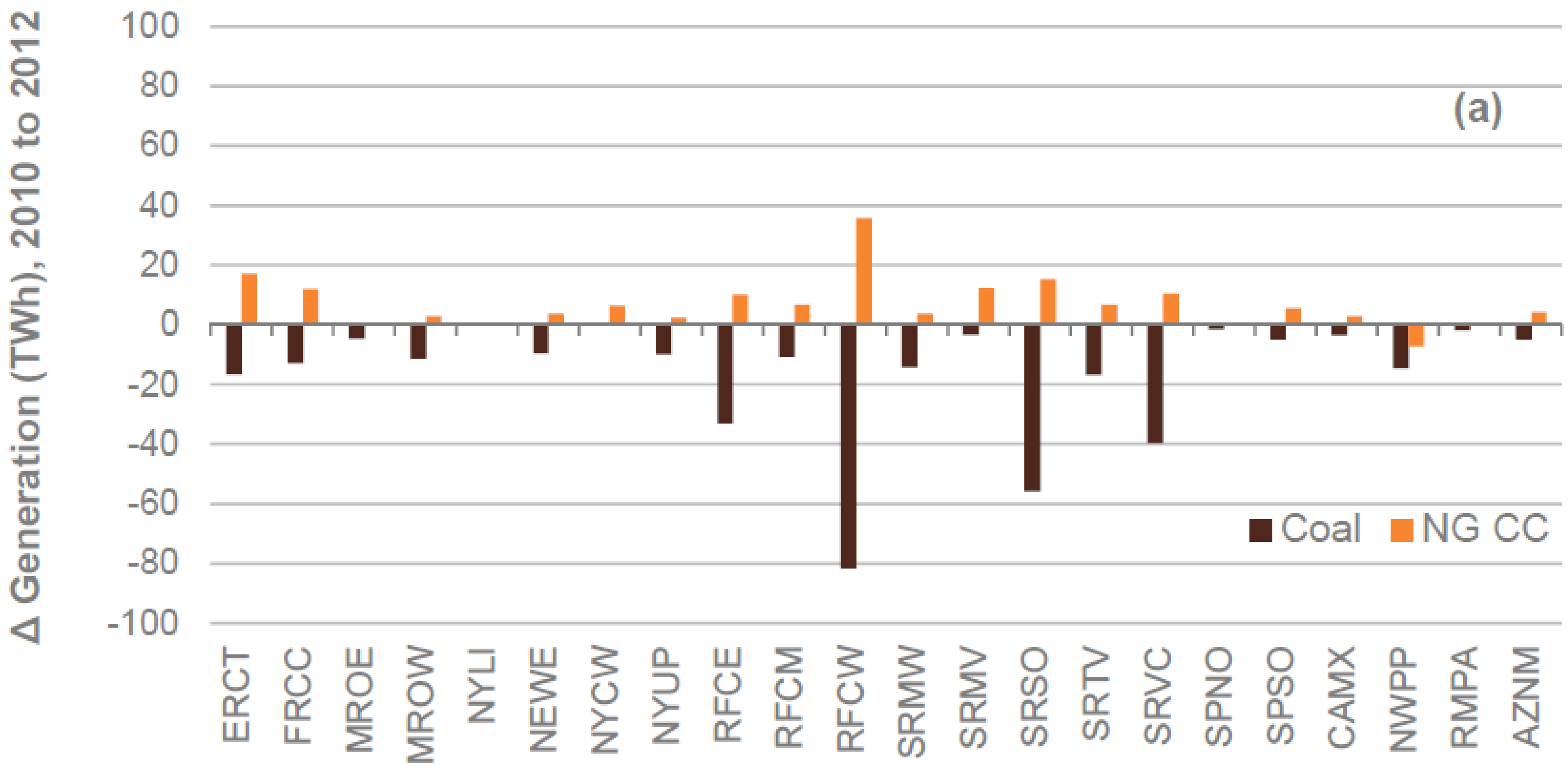
Change in coal and natural gas CC generation by region



Source: EPA Air Markets Program Data, 2010-2012

Source: Knight, Patrick, Bruce Biewald, and Joe Daniel, August 12, 2013, “Displacing Coal: An Analysis of Natural Gas Potential in the 2012 Electric System Dispatch,” prepared by Synapse Energy Economics for the Energy Foundation.

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Uneconomic U.S. coal capacity compared to market purchases

Uneconomic Coal Capacity Compared to All-In Purchases (GW)

		Environmental Retrofit		
		Lenient	Mid	Strict
Natural Gas Price	High	63 (20%)		230 (74%)
	Mid		228 (73%)	
	Low	101 (33%)		274 (88%)

Note: Percentages indicate the share of the capacity of the uneconomic units compared to total coal capacity.

Source: Knight, Patrick, Elizabeth A. Stanton, Jeremy Fisher, and Bruce Biewald, October 11, 2013, "Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT)."

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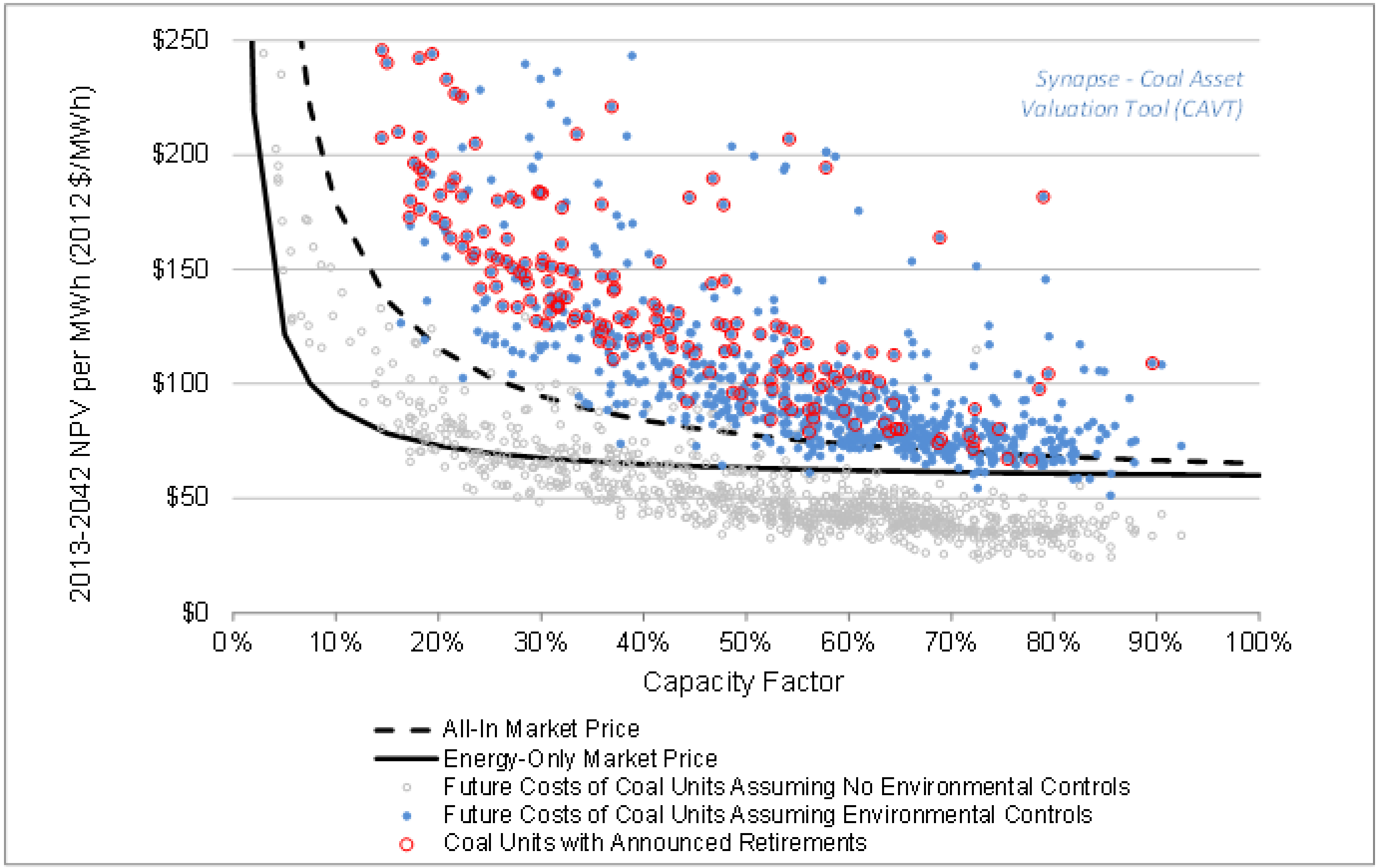
Projected net present value of coal units assuming environmental retrofits, compared to typical national market electricity prices, 2013-2042



Note: The y-axis in Figure 2 is truncated at $250/MWh; some units with capacity factors of 15 percent or less have net present value costs that are higher than $250/MWh when assuming new environmental controls.

Source: Knight, Patrick, Elizabeth A. Stanton, Jeremy Fisher, and Bruce Biewald, October 11, 2013, "Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT)."

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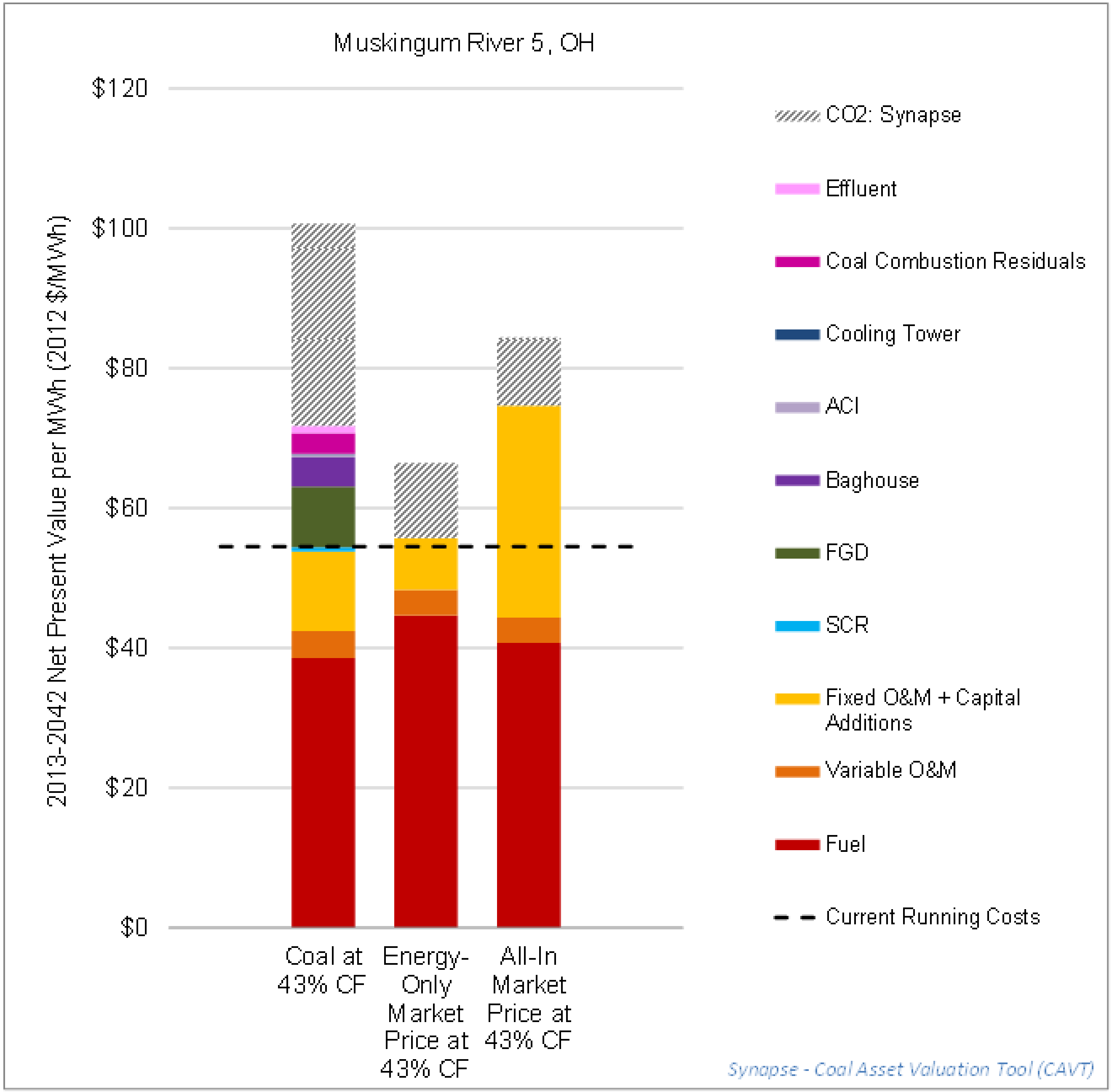
Muskingum River 5's current and future costs as compared to market prices



Source: Knight, Patrick, Elizabeth A. Stanton, Jeremy Fisher, and Bruce Biewald, October 11, 2013, "Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT)."

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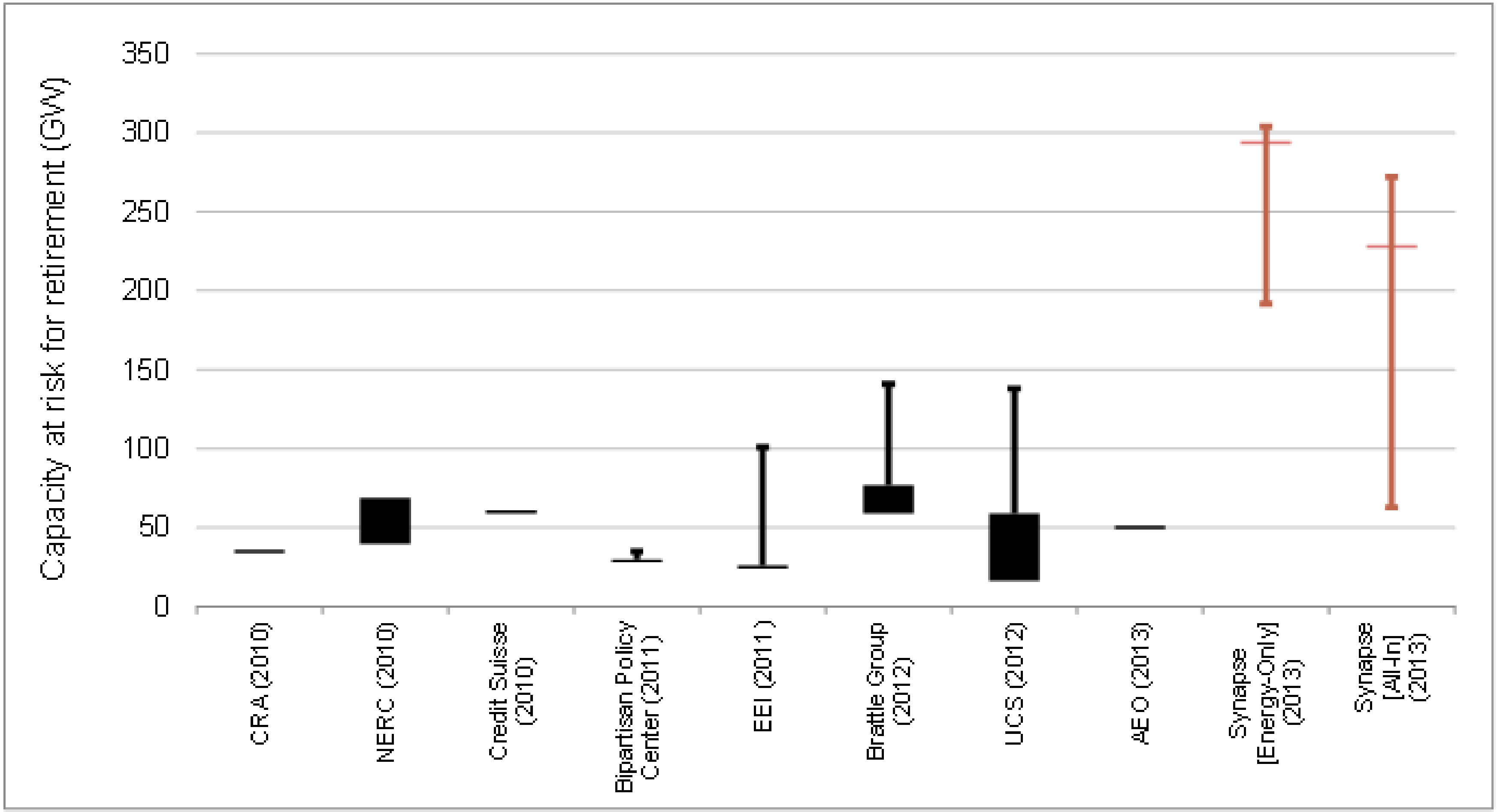
Comparison of coal retirement projection ranges



Note: Each projection uses different assumptions for environmental retrofits, natural gas prices, and CO_2 prices.

Source: Knight, Patrick, Elizabeth A. Stanton, Jeremy Fisher, and Bruce Biewald, October 11, 2013, “Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse’s Coal Asset Valuation Tool (CAVT).”

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Environmental retrofit and natural gas assumptions

Natural Gas Price	Very High	Natural gas prices grow at 130% of the AEO 2012 Reference Case rate of change
	High	Natural gas prices grow at the AEO 2012 Low Estimated Ultimate Recovery Case rate of change
	Mid	Natural gas prices grow at the AEO 2012 Reference Case rate of change
	Low	Natural gas prices grow at the AEO 2012 High Estimated Ultimate Recovery Case rate of change

Environmental Control Requirements	Strict	FGD, SCR, Baghouse, ACI, Impingement Controls and Recirculating Cooling on units with intakes > 125 MGD, Coal Combustion Residual (Subtitle C), Effluent Regulatory Option "4a," "Synapse Mid" CO_2 Price
	Mid	FGD, SCR, Baghouse, ACI, Impingement Controls and Recirculating Cooling on units with intakes > 125 MGD, Coal Combustion Residual (Subtitle D), Effluent Regulatory Option "3," "Synapse Mid" CO_2 Price
	Lenient	Baghouse, ACI, Impingement Controls, Effluent Regulatory Option "3a," "Synapse Low" CO_2 Price

Source: Knight, Patrick, Elizabeth A. Stanton, Jeremy Fisher, and Bruce Biewald, October 11, 2013, "Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT)."

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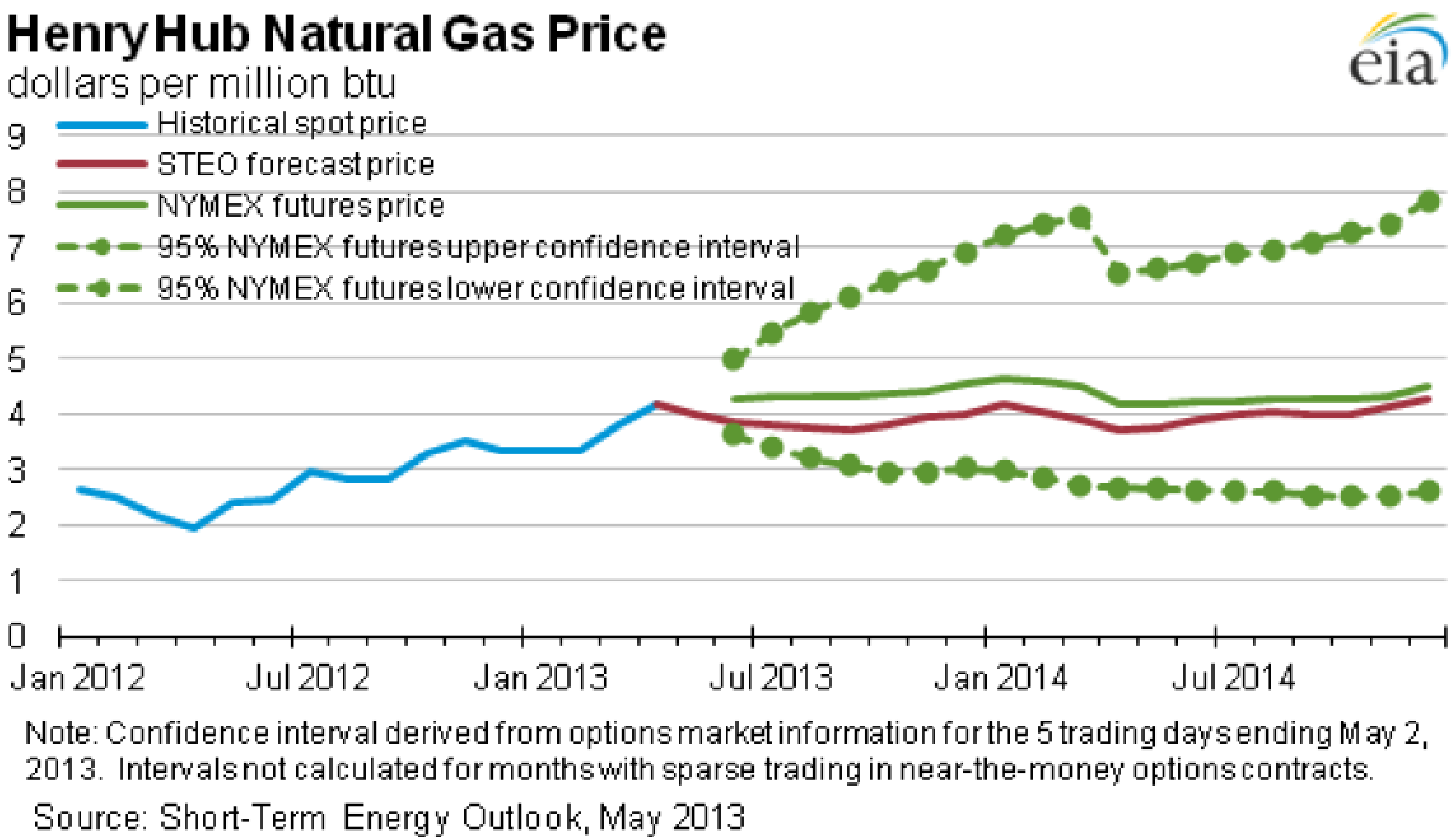
- Future confidence intervals are large



Source: National Association of Regulatory Commissioners: Risk Workshop for Regulators. Presented by The Regulatory Assistance Project and Synapse Energy Economics at the Mid-Atlantic Conference of Regulatory Utility Commissioners. June 24, 2013. Slide 12.

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3. ENERGY EFFICIENCY

EE is a cost-effective energy resource and environmental compliance option, but requires creative policy design and regulation.

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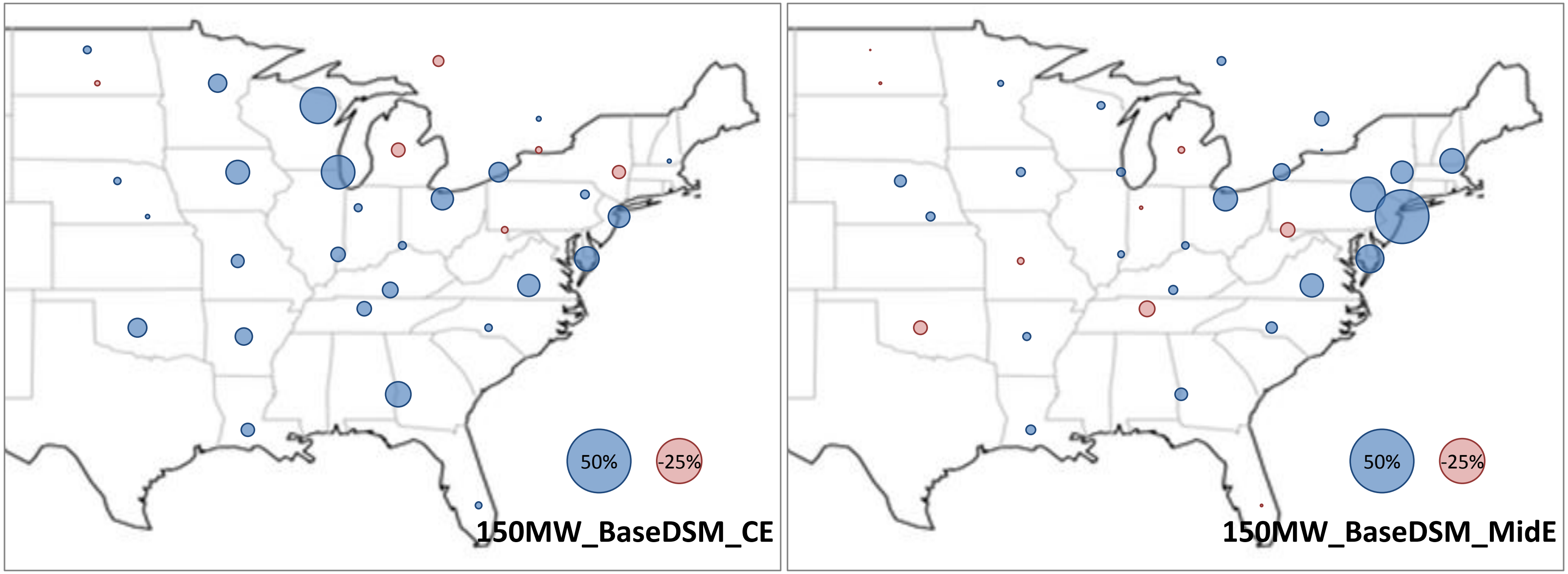
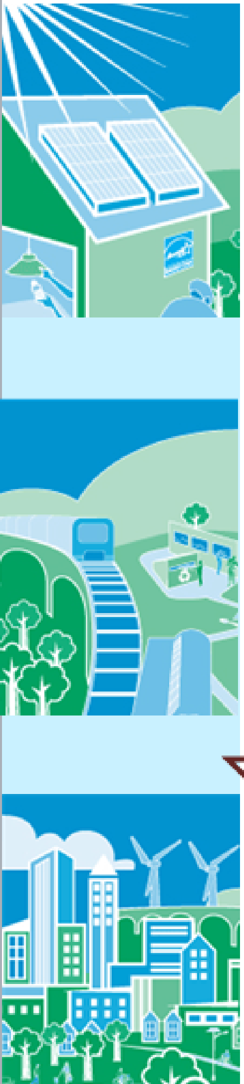
Generation displaced by EE in Chicago and New Jersey



Source: Synapse model runs based on materials from J. Buonocore, P. Luckow, G. Norris, J. Spengler, B. Biewald, J. Fisher, and J. Levy, "Public Health and Climate Impacts Offset by Energy Efficiency and Renewable Energy Measures." Unpublished.

Four Quantification Approaches and Tools



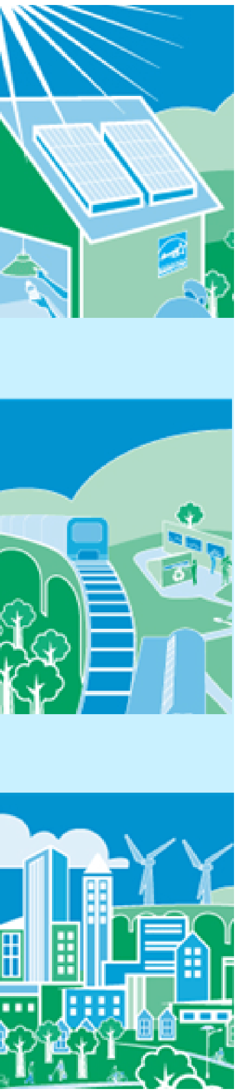
Sophistication increases

Approach	Available Tools	Temporal	Geographic
eGrid approach	Power Plant Profiler and Portfolio Manager	Annual and ozone season Historical	Average eGRID regional emissions
Capacity factor approach	Power Plant Emissions Calculator P-PEC (Draft)	Annual and ozone season Historical	Power plant and county level
Reported Hourly emissions approach	*AVoided Emissions and geRation Tool AVERT (in beta)*	Hourly, monthly, annual Historical	Electric Generating Unit (EGU), county, state, regional
Energy modeling approach	IPM, MARKAL, Ventyx	Annual, ozone season, varies forecasted	EGU, hourly, regional

All four approaches can be found in Appendix I of the EE/RE SIP Roadmap

Source: Presentation by Robyn DeYoung, U.S. EPA, August 13, 2013, “AVERT Training for Beta Testers,” slide 5.

AVERT Uses and Status



Goal: States can use AVERT to estimate emissions impacts of EE/RE for SIPs

- Outputs are hourly, unit level, compatible with SMOKE processing and air quality modeling
- Understand hourly emission reductions during peak demand days (e.g., High Electric Demand Days (HEDD))
- Compare impacts of different EE/RE scenarios (EE programs, Solar and Wind installations)
- This is not a projection tool – not intended for analysis more than 5 yrs

Status:

- Draft tool, peer review and revisions - complete
- Benchmarking tool outputs with standard dispatch model – in progress
- Beta Testing - August 2013
  - Test usability, functionality, appropriate uses, clarity of user manual
- Public version expected by Fall 2013

Source: Presentation by Robyn DeYoung, U.S. EPA, August 13, 2013, “AVERT Training for Beta Testers,” slide 6.

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4. RELIABILITY

Electric system reliability is essential, and with a few years of lead time is generally not a problem.

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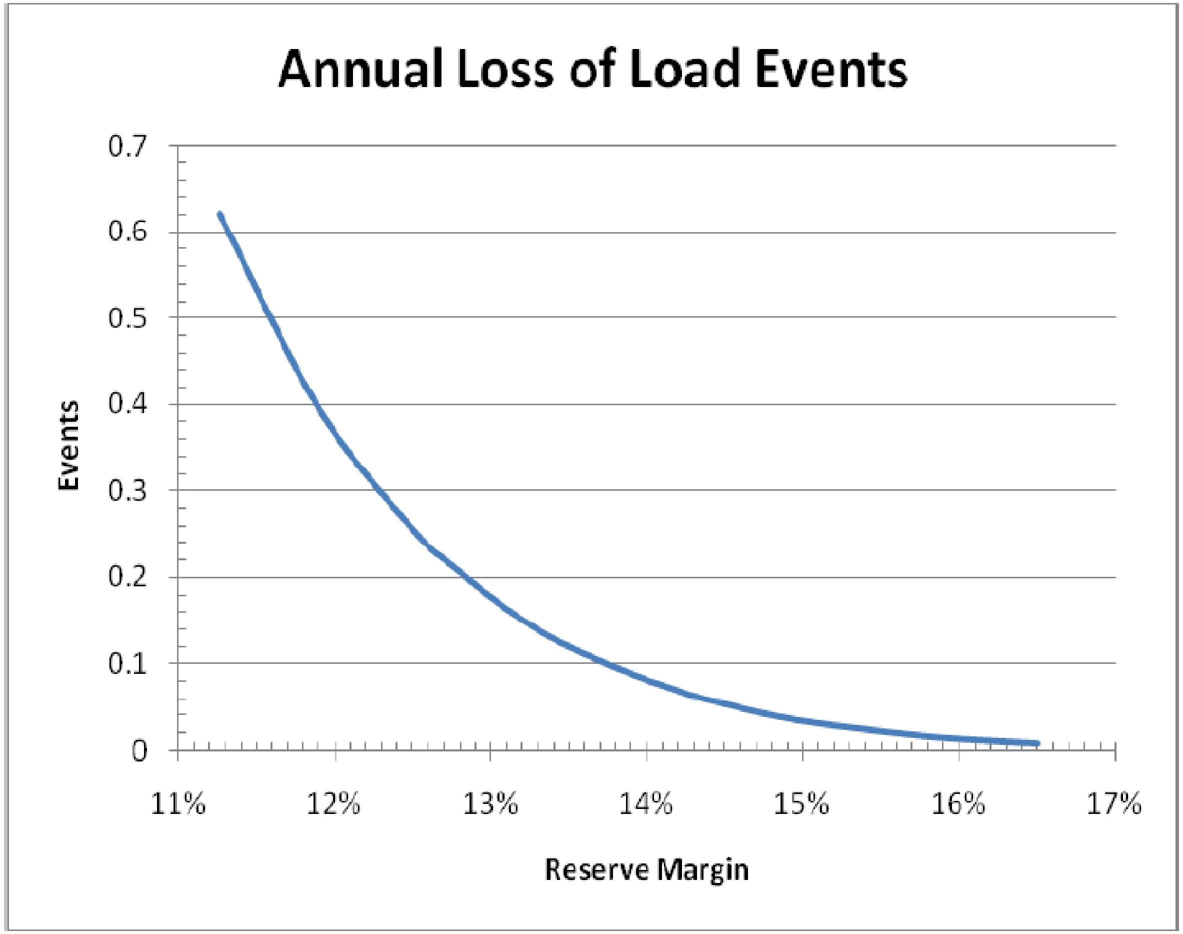

Source: ERCOT 2010

Source: National Association of Regulatory Commissioners: Risk Workshop for Regulators. Presented by The Regulatory Assistance Project and Synapse Energy Economics at the Mid-Atlantic Conference of Regulatory Utility Commissioners. June 24, 2013. Slide 83.

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"The fraction of time… will be called the *loss of load duration*… expressed in terms of "so many days upon which loss of load may be expected to occur during a given number of years," say 10 or 100.

This number of days provides a first index for measuring and comparing service reliabilities."

- Giuseppe Calabrese, 1947

Source: National Association of Regulatory Commissioners: Risk Workshop for Regulators. Presented by The Regulatory Assistance Project and Synapse Energy Economics at the Mid-Atlantic Conference of Regulatory Utility Commissioners. June 24, 2013. Slide 84.

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5. EASTERN INTERCONNECT PLANNING

Coal capacity can be retired in the U.S. at low or zero net cost.

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Eastern Interconnection Planning Collaborative

- Synapse's new study estimated costs/benefits of EIPC's CO_2 reduction future vs. "business as usual"
- Conclusion: overall costs are essentially the same through 2050, and CO_2 future is cheaper if you factor in emissions reductions or other benefits

"S1" = Combined policy case; CO_2 reduction case

"S3" = Business as usual case

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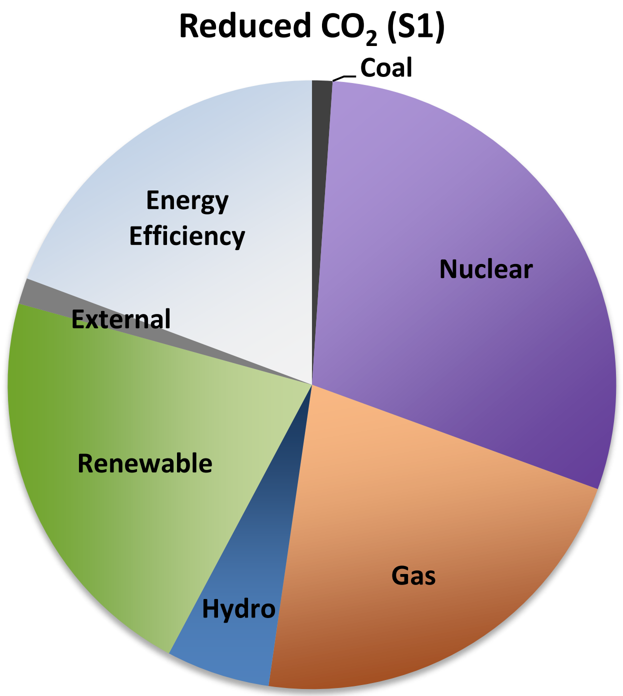
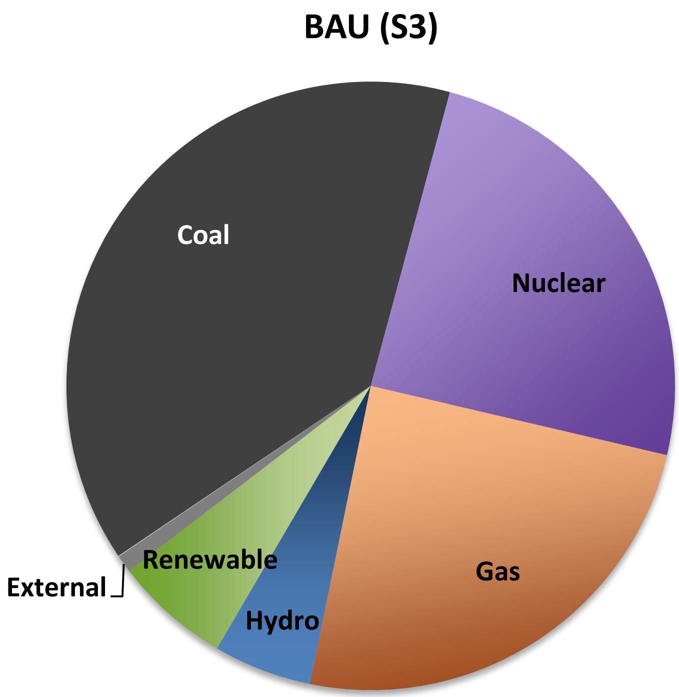
Generation Mix: S1 (carbon reduction) and S3 (BAU) cases





Source: Synapse

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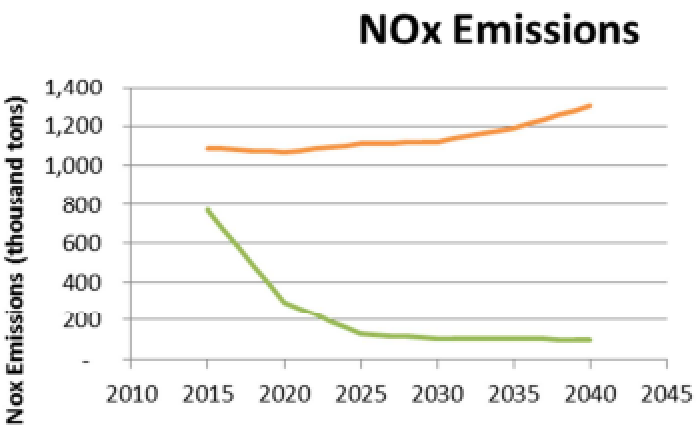
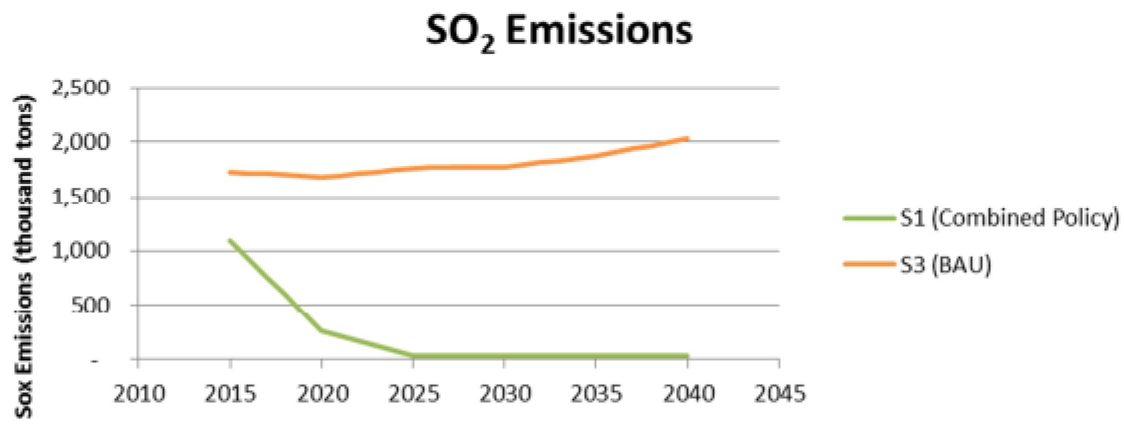
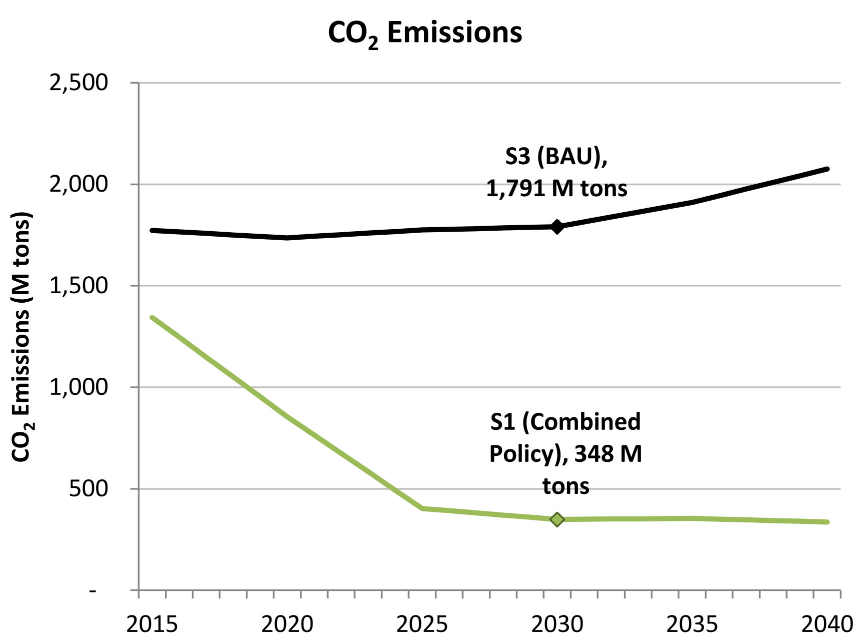
NOx, SO_2, and CO_2 emissions in S1 (carbon reduction) and S3 (BAU) cases







Source: Fagan et al., 2013.

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Present value of revenue requirements for S1 (carbon reduction) and S3 (BAU) cases

Net Present Value (B 2010$)	Scenario 1	Scenario 3
Fuel Cost, Adjusted	790	1,134
Base FOM	494	648
Base VOM, Adjusted	104	243
Emissions Costs, Adjusted	487	3
Gen. Capital, Annualized	794	319
Trans. Capital	85	12
EE Cost	150	0
Coal Retrofit Costs	7	20
Total	2,911	2,379
Total Without CO_2 Price	2,424	2,376

Source: Fagan et al., 2013.

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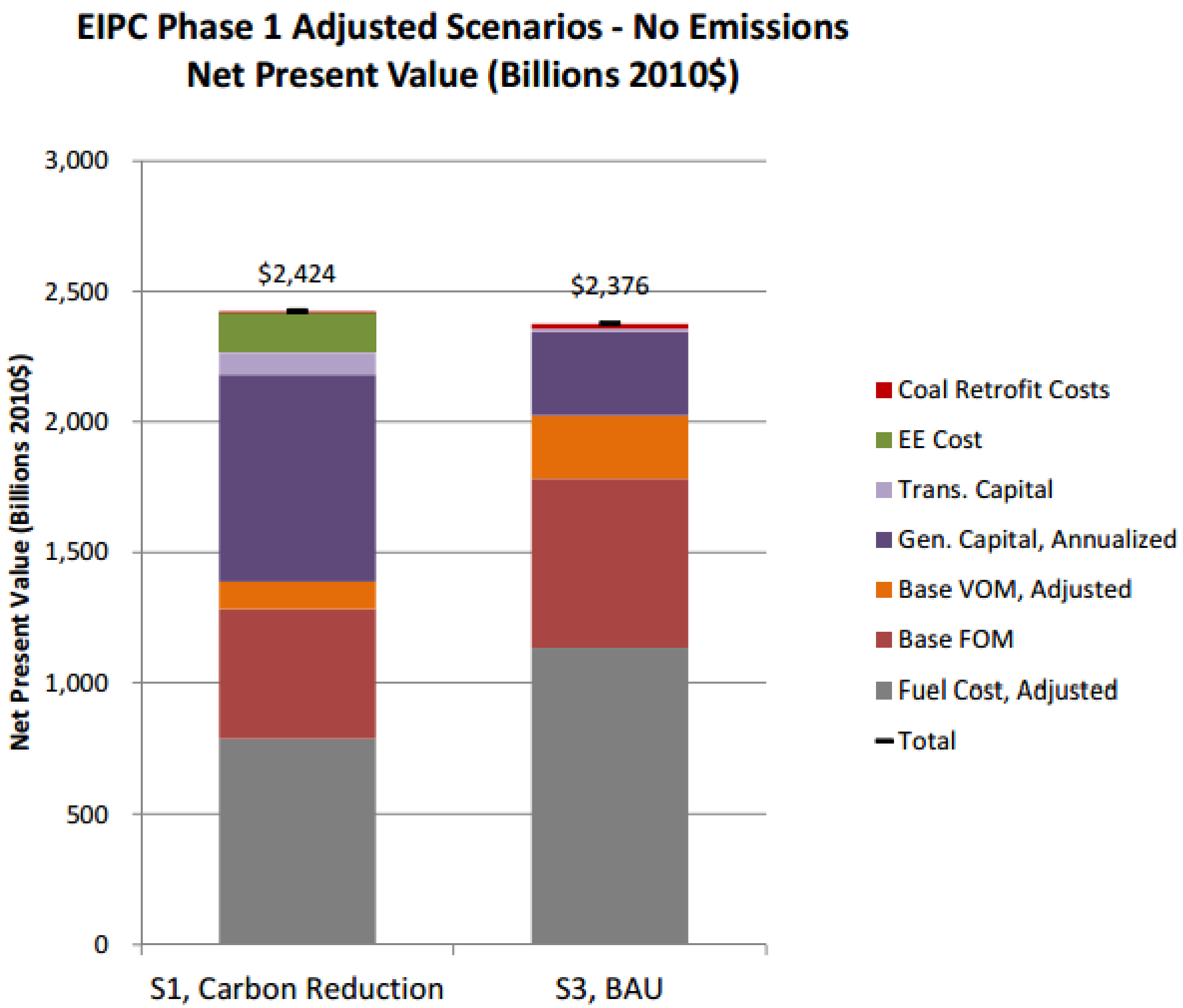
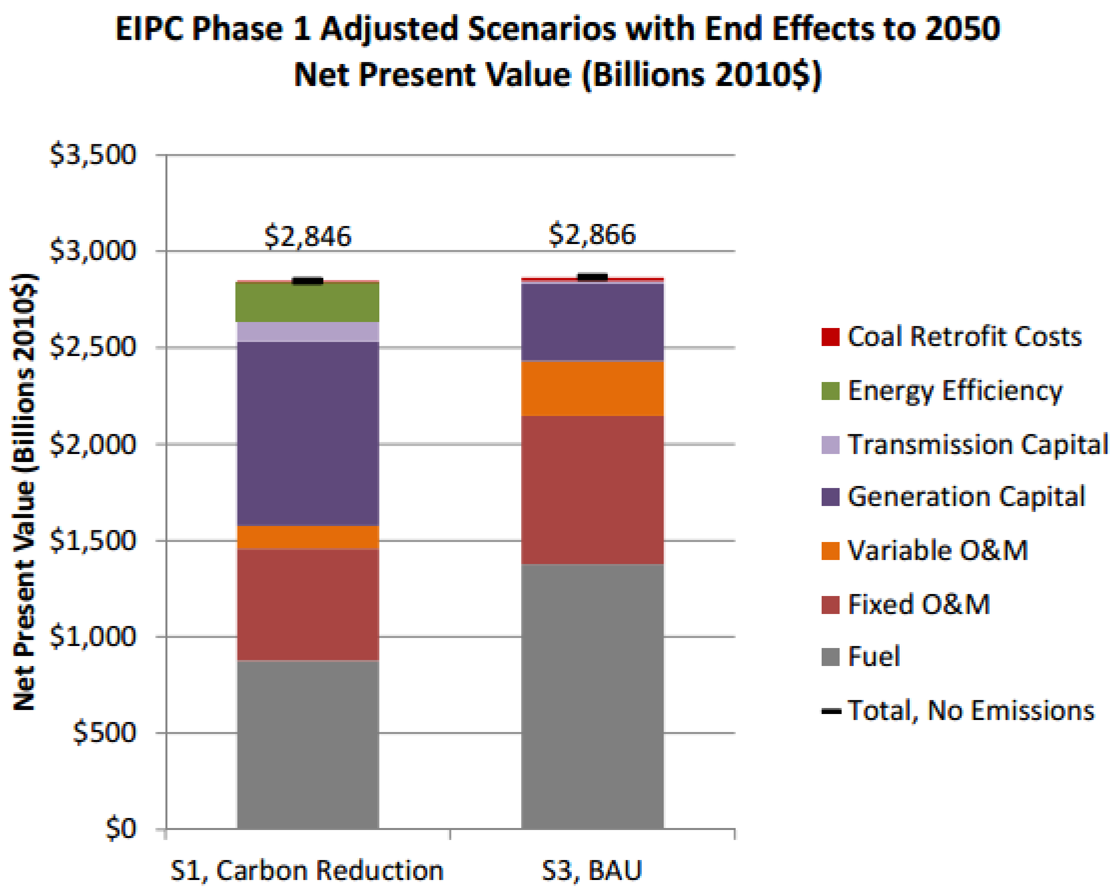
Net present value of revenue requirements of S1 (carbon reduction) and S3 (BAU) cases, excluding CO_2 cost



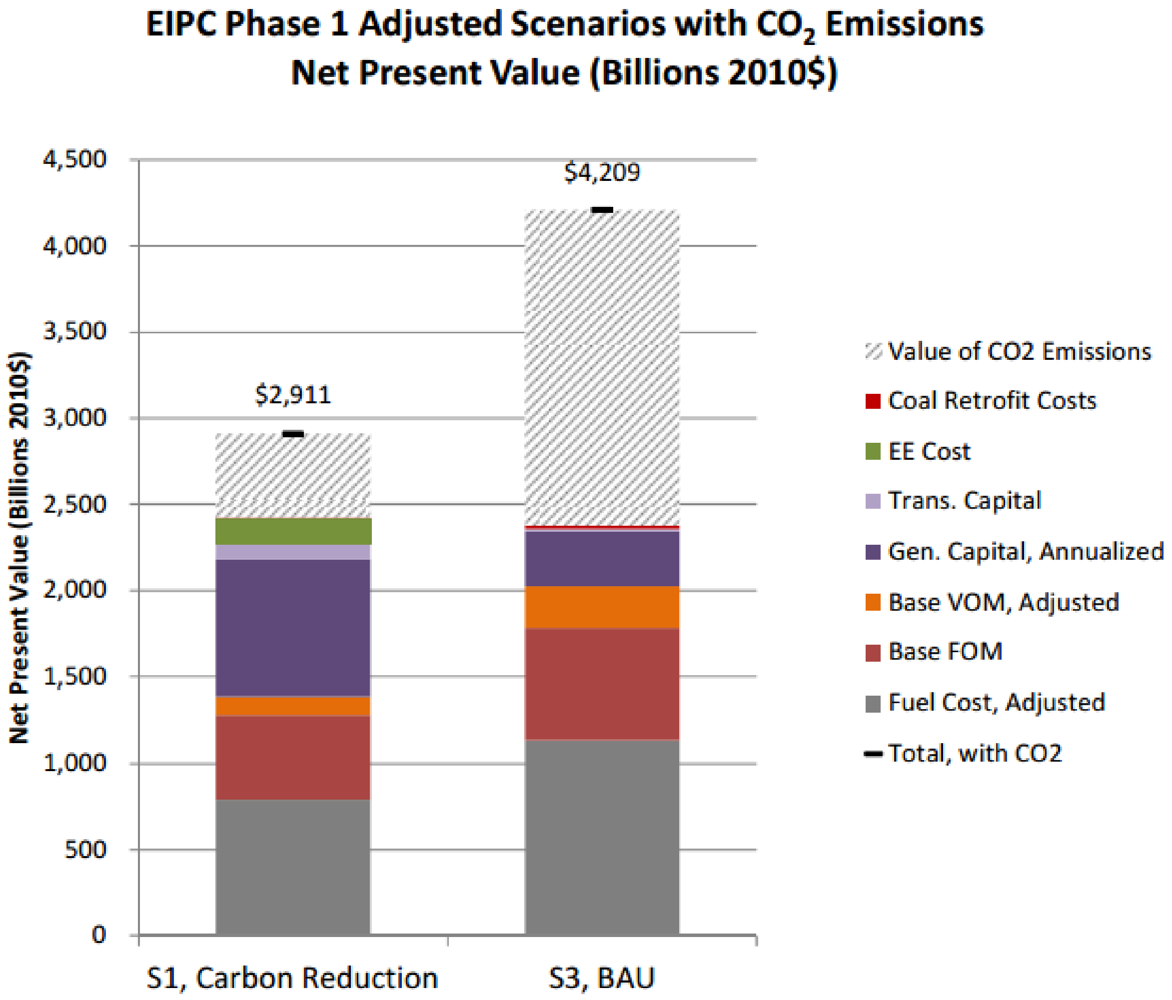
Source: Fagan et al., 2013.

Net present value of revenue requirements of S1 (carbon reduction) and S3 (BAU) cases, including extension period to 2050



Source: Fagan et al., 2013.

Net present value of revenue requirements of S1 (carbon reduction) and S3 (BAU) cases, with consistent valuation of CO_2 emissions



Source: Fagan et al., 2013.

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6. REGULATION: PLANNING

Utility planning practice is abysmal.

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Utility integrated resource planning (IRP)

- What is an IRP, and what is it for?
- State IRP rules
- Energy prices and environmental compliance planning
- Restructured markets
- Ratemaking and cost recovery

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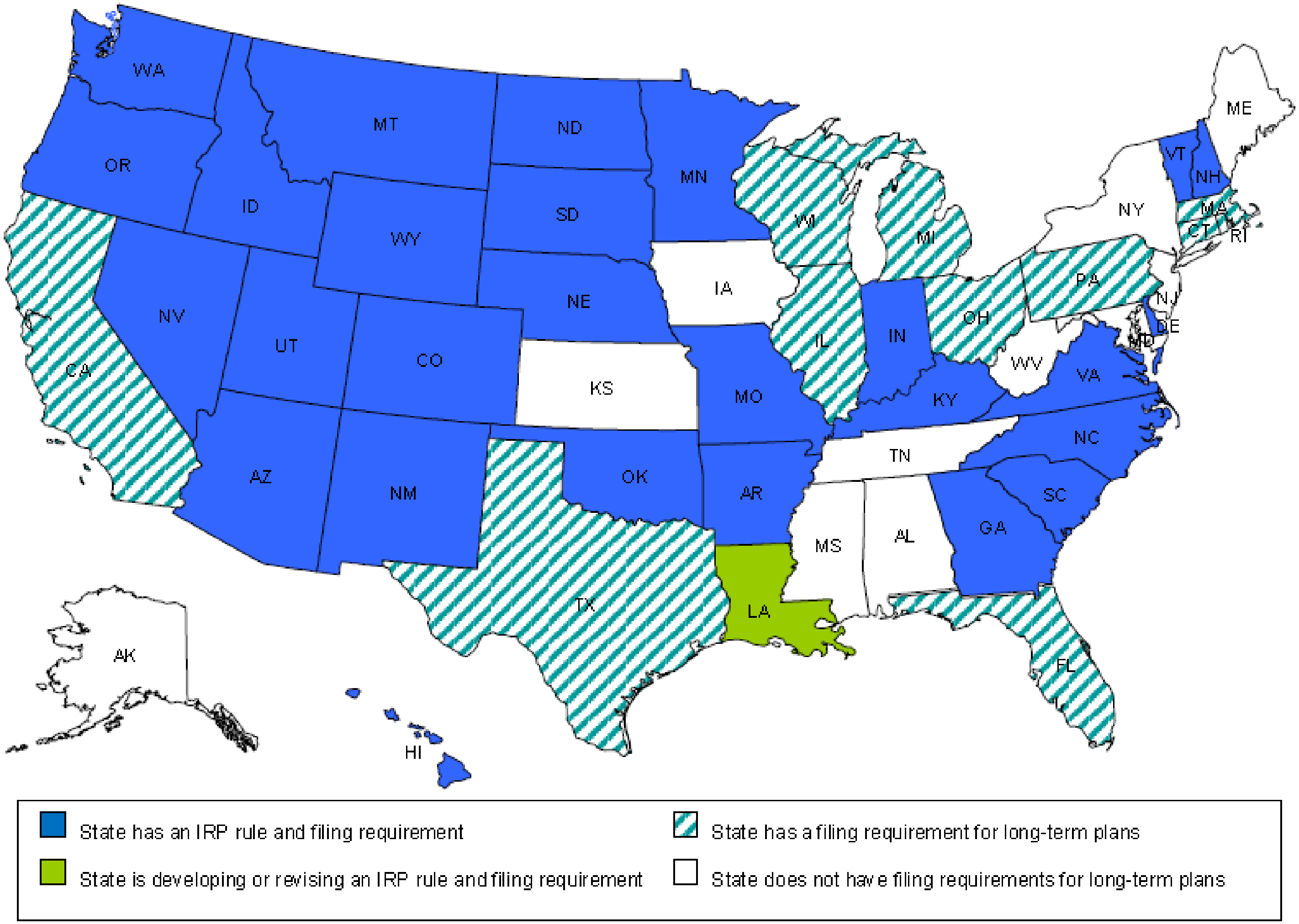
Presence or absence of state IRP rules and procurement plan filing requirements



Source: Synapse. *A Brief Survey of State Integrated Resource Planning Rules and Requirements*. 2011.

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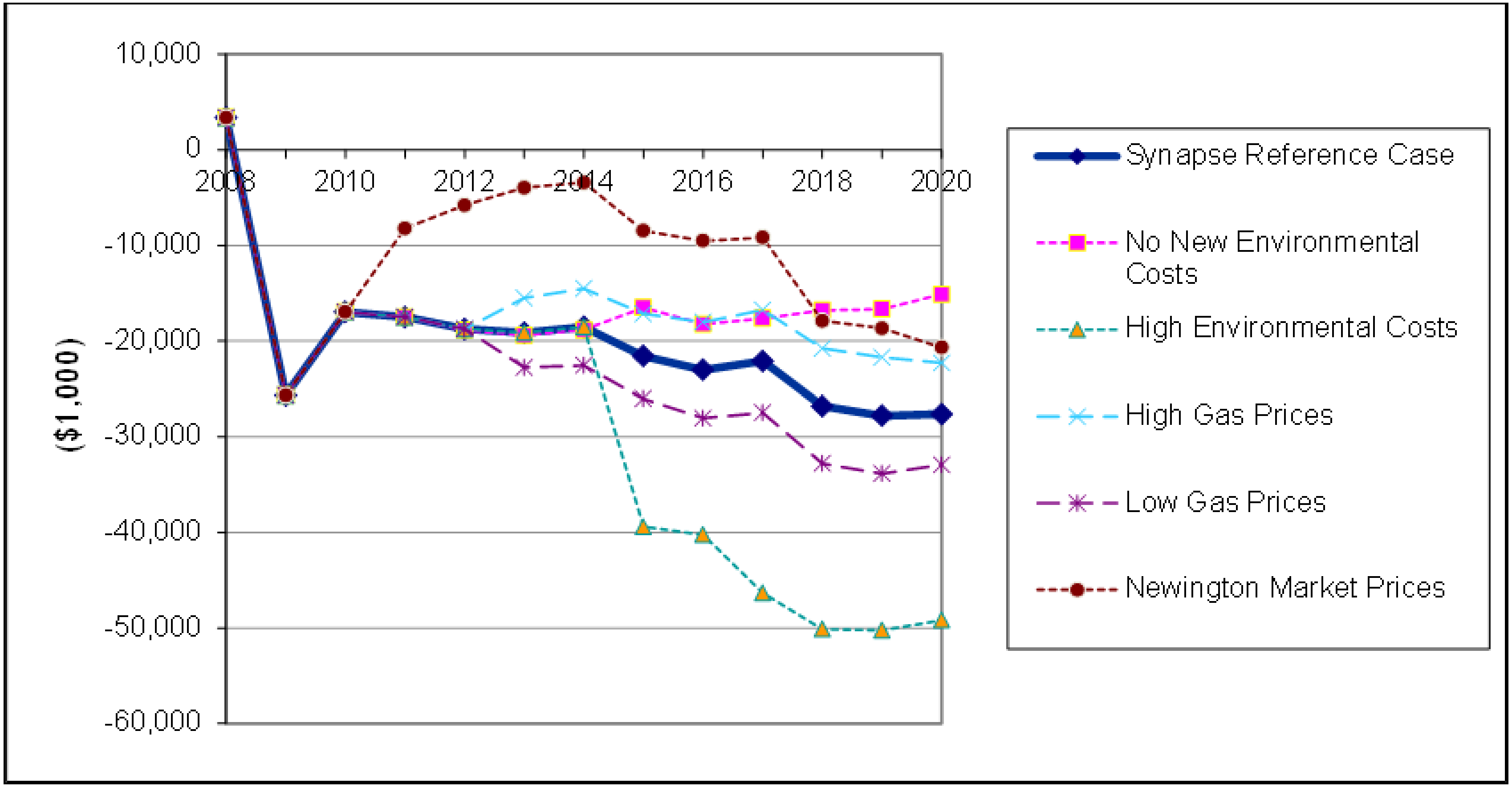
Schiller 4 and 6 net revenue



Source: Synapse. *Economic Analysis of Schiller Station Coal Units*. 2011.

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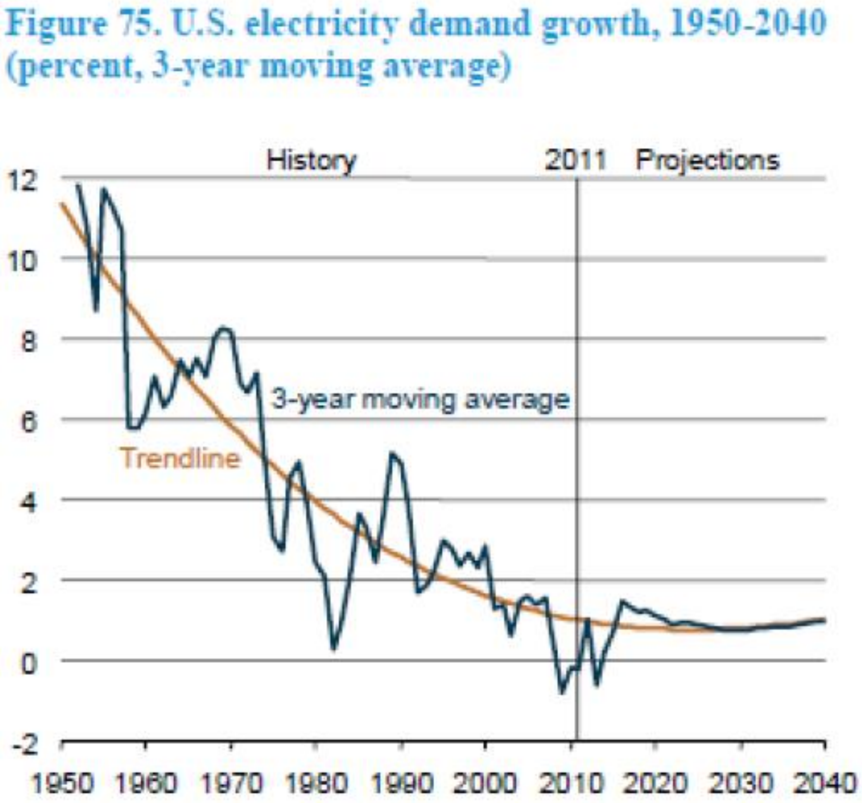
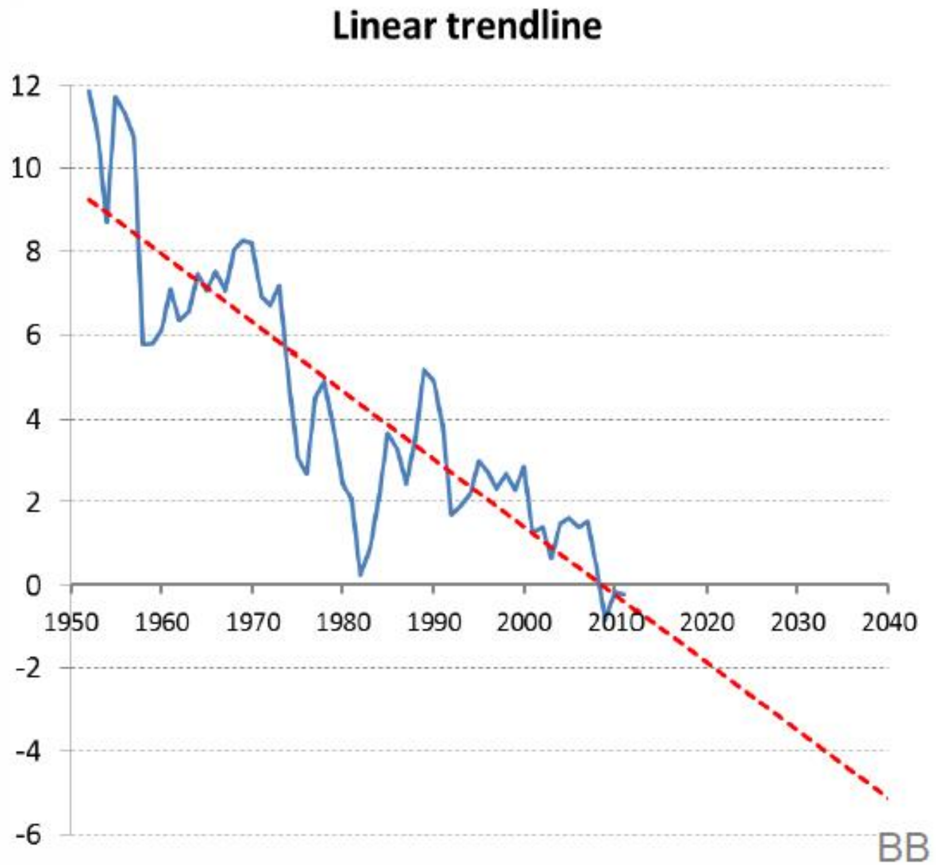
Example: National load forecast

How will national electricity demand change in the future?





Source: Presentation by Bruce Biewald, August 8, 2013, “Synapse 2013 Technical Training. Session 2: Best and Worst Practices in IRP and CPCN.”

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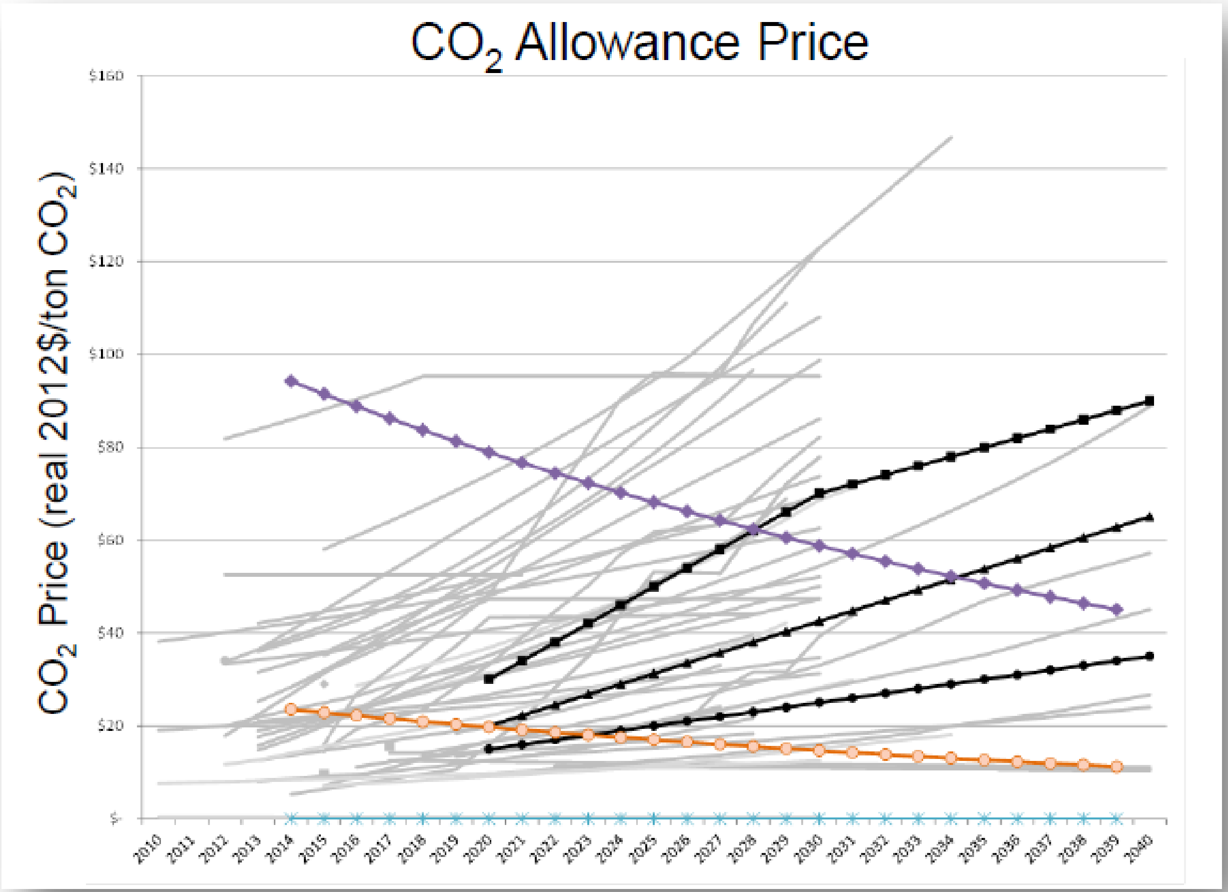
Commodity Prices

Hawaii Electric Company (HECO) 2013 IRP



Source: Hawaii Electric Company, 2013

Review of CO_2 price assumptions are critical.

Does price include “allowances.” If so, what assumptions underlie those allowances? Does it rise faster than inflation? Or much, much slower?

Zero is a strong forecast.

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Poor electric system planning practice

- Passive attitude toward information
- Rely on out-of-date construction cost estimates
- Consider only "existing" environmental regulations
- Ignore CO_2 price, or treat it "at the end" as a sensitivity case
- Assume existing plants continue to operate
- Overly constrain alternatives such as renewables and energy efficiency

IMPRUDENT!

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Good electric system planning practice

- Actively seek out relevant information
- Rely on up-to-date and realistic construction cost estimates
- Anticipate reasonably likely future environmental regulations
- Include reasonable CO_2 price forecast in the reference case, and analyze high and low sensitivities
- Evaluate continued operation vs. retirement options for existing plants
- Include full consideration of alternatives

PRUDENT

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7. REGULATION: RATEMAKING

Utilities have problematic incentives and do not behave like normal businesses.

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Utility ratemaking

- Regulated Monopoly Economics
- Electric utility prices are not set by "the market." They are set by state public utility commissions in "rate cases"
- Fuel, O&M, purchased power, and administrative costs are passed through as expenses
- Power plant investments are put into "ratebase" and recovered over time with an allowed administratively determined return on equity
- Plant investment that is not prudently incurred should be removed from rates
- Plan investment that is not "used and useful" should be removed from rates

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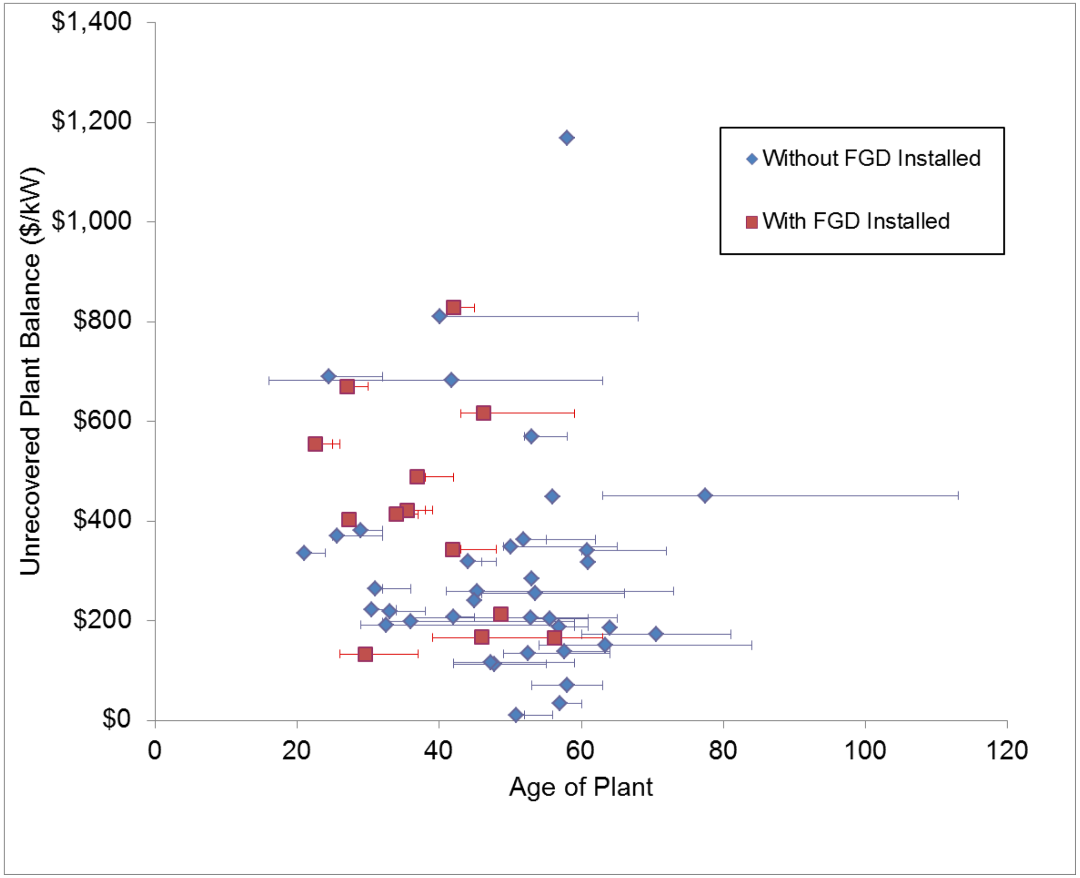
Utility incentives:
Old coal plants have significant investment in rate base



- Data from data collected from 52 coal plants owned by 11 utilities
- Average plant age weighted by capacity: ~47 years
- Average plant capacity: ~675 MW
- Average unrecovered plant balance: ~$336/kW
- Average unrecovered balance as a percentage of Total Plant Balance: 50%

Source: Presentation by Bruce Biewald, August 8, 2013, "Synapse 2013 Technical Training. Session 3: Components of Good Planning IRP and CPCN," slide 19.

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Regulatory treatment of retired power plant(s)

Ohio

- Docket 10-1454-EL-RDR
- Order: January 12, 2012
- Ohio Power sought approval for a rider to recover unamortized plant balance of $58.7 million for Sporn Unit 5 (450 MW, 1960)
- Commission dismissed the case, citing closure not subject to approval and no statutory basis for recovery of closure costs

Alabama

- Docket U-5033
- Order: September 7, 2011
- Alabama Power sought authorization to establish regulatory asset treatment and amortization schedule for generating units to be retired early as a result of EPA regulations
- Commission approved request

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8. REFERENCE LIST

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