

The Brattle Group

U.S. Coal Plant Retirements: Outlook and Implications

Presented by

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Agenda

- ◆ Emerging EPA regulations
- ◆ Description of the U.S. coal fleet
- ◆ Cost of compliance
- ◆ Economics of retirement/retrofit decisions
- ◆ Impact on gas demand and power prices

Emerging EPA Regulations for Existing Coal Units

Potential implications of MATS and a potential replacement rule for the vacated CSAPR on coal plant retire/retrofit decisions are examined.



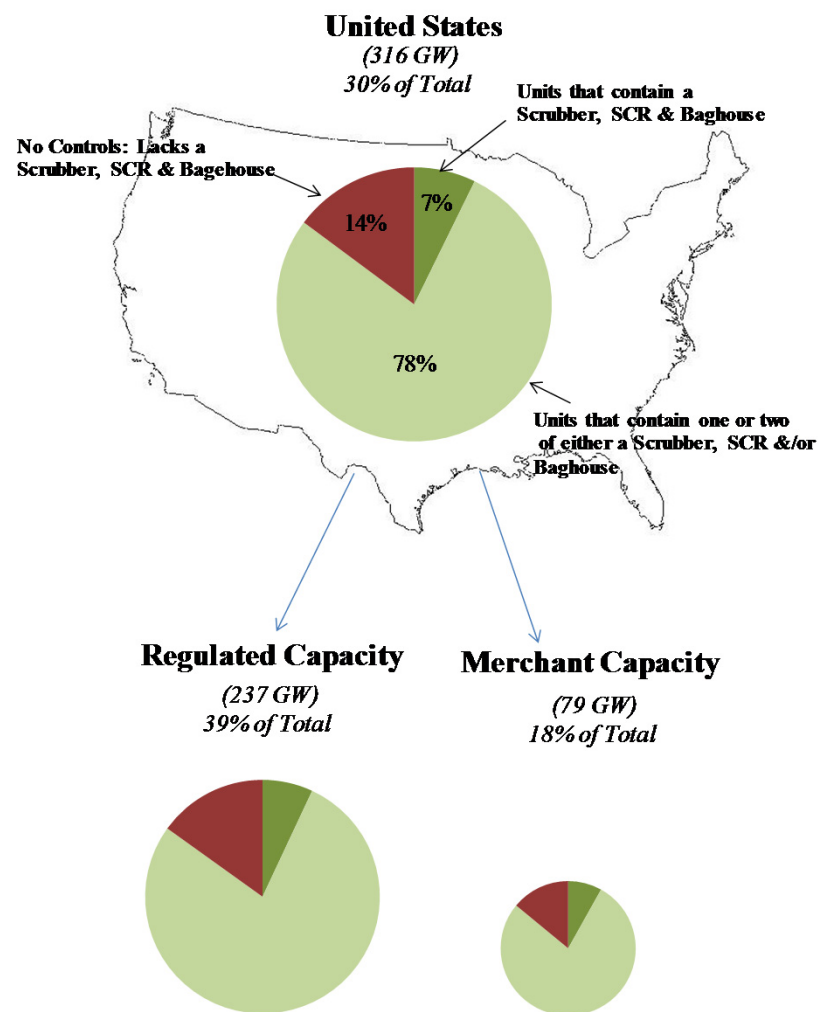
Regulation	Status	Pollutant Targeted	Compliance Options	Expected Date of Compliance
Revised CSAPR	Vacated by Court	NO _x , SO ₂	SCR/SNCR, FGD/DSI, fuel switch, allowance purchases	After 2015?
MATS	Final	HAPs (mercury, acid gases, PM)	ACI, baghouse, FGD/DSI	2015/2016
Regional Haze	Final	NO _x , SO ₂ , PM	SCR/SNCR, FGD/DSI, Baghouse/ESP, combustion controls	Typically in 5 years
316(b)	Proposed	Cooling water	<u>Impingement</u> : Mesh screens; <u>Entrainment</u> : Case-by-case, may include cooling towers	2018
Combustion by-products (ash)	Proposed	Ash, control equipment waste	Bottom ash dewatering, dry fly ash silos, etc.	2015

U.S. Coal Fleet

Coal-fired capacity (316 GW) represents about 1/3rd of the total generation capacity

- ♦ Majority of coal capacity (237 GW) is owned by regulated companies (IOUs, munis/coops, etc.), and the rest (79 GW) is owned by merchant companies

Majority (93%) of the coal capacity lacks at least one major equipment (scrubber, SCR and baghouse) to control air emissions



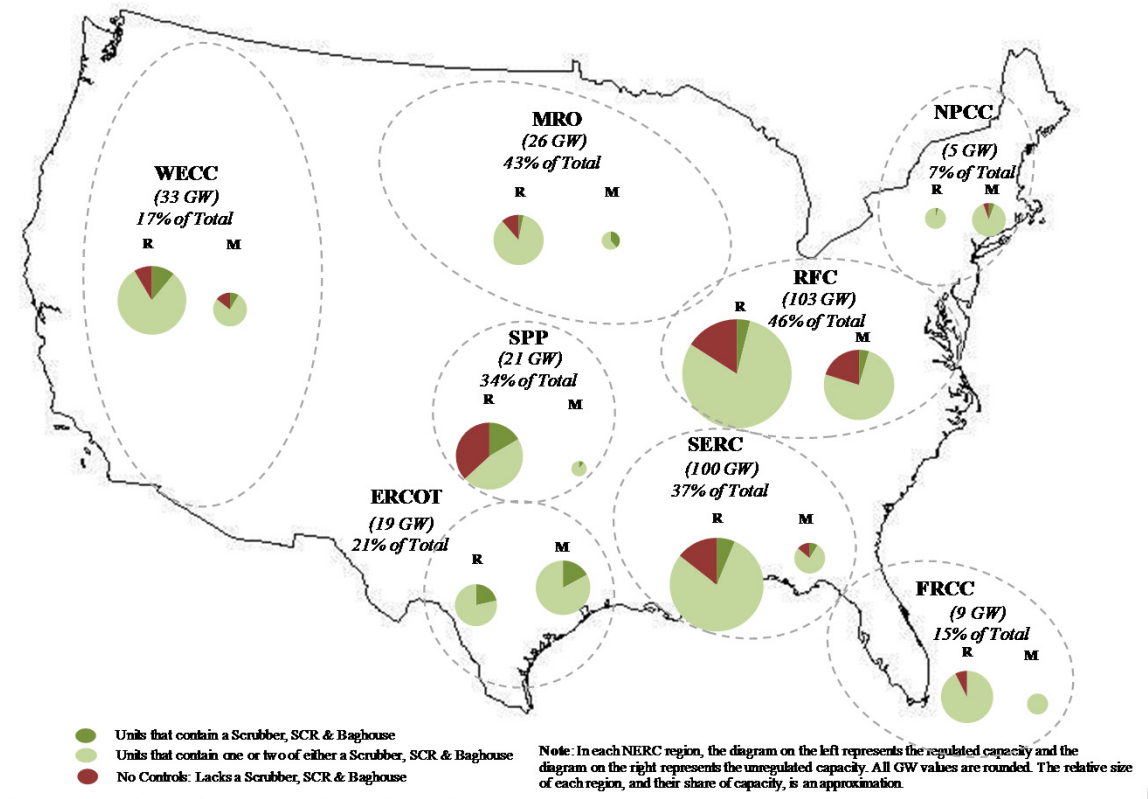
Regional View

Coal-fired capacity is largely in the eastern interconnect (~265 GW), and primarily in the RFC and SERC regions

RFC and SERC coal fleet faces two challenges:

- ◆ most of the capacity lacks at least one major equipment, and
- ◆ coal is a large share of regional capacity (46% in RFC, 37% in SERC)

Most of the US merchant coal capacity is in the RFC and ERCOT regions



Capital Costs of Major Control Equipment

Capital costs are significantly more expensive for smaller units

Retrofit costs for major equipment such as wet scrubber and SCR at a small/mid-size coal unit are comparable to cost of a new gas CC at about \$1000/kW

CAPITAL COST OF CONTROL EQUIPMENT (2011 \$/kW)

Equipment	Unit Size (MW)		
	50	200	600
Wet Scrubber	904	734	513
Dry Scrubber	774	628	448
DSI	42	39	39
SCR	273	234	188
SNCR	51	51	51
Baghouse	504	387	219
ACI	29	27	19

Source: EPA IPM 4.10 Basecase assumptions and EEI 2011 Study

Levelized Costs of Major Control Equipment

Levelized all-in (capital, FOM, VOM) cost of major control equipment for a 200 MW coal unit could be as high as \$50/MWh depending on capacity factor and type of equipment

LEVELIZED COST OF CONTROL EQUIPMENT (\$/MWh)

(200 MW Unit, 15-Year Recovery with 15% Capital Charge Rate)

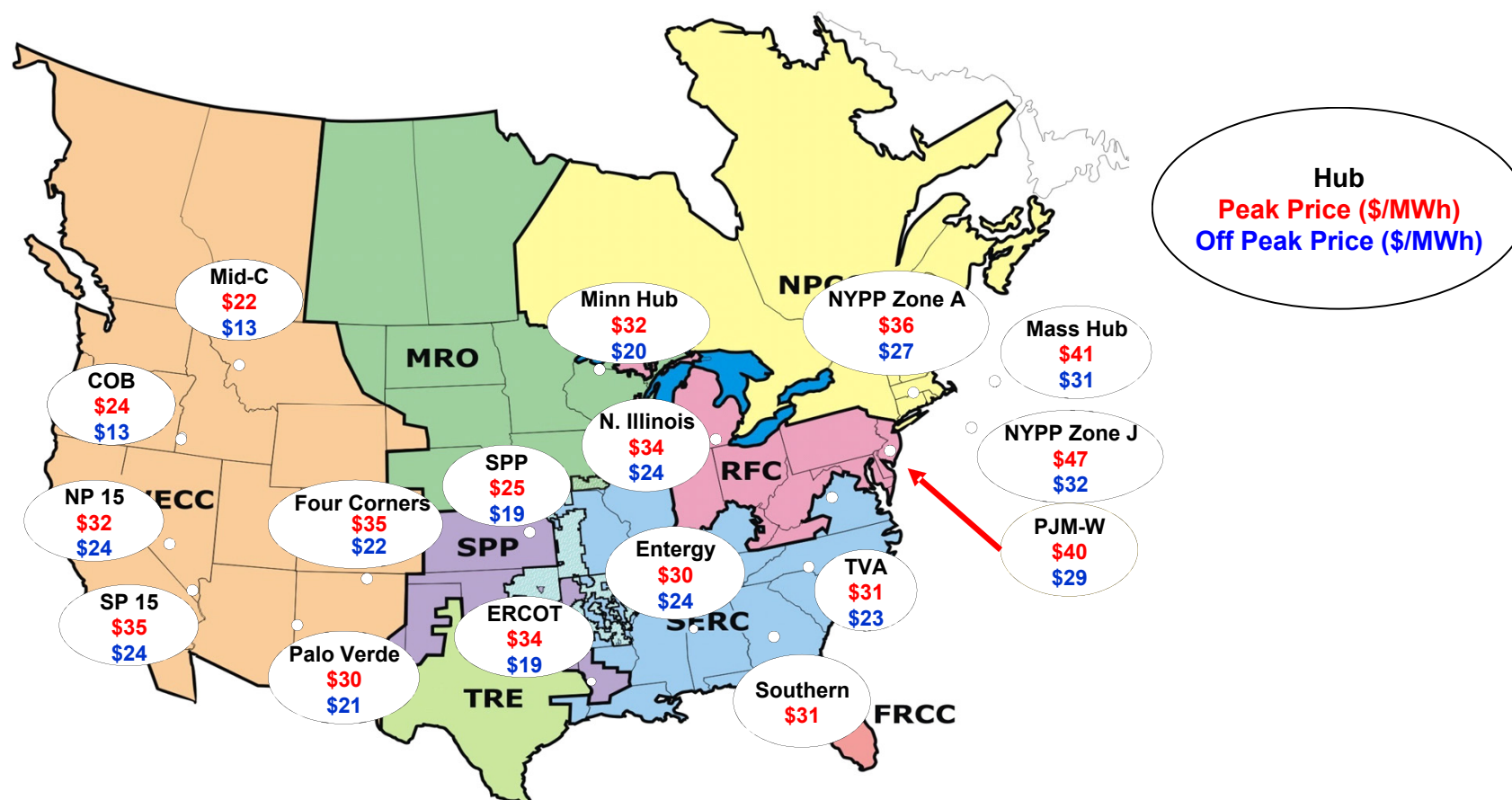
Equipment	Capacity Factor			
		30%		70%
Wet Scrubber	\$	50.80	\$	22.91
Dry Scrubber	\$	43.57	\$	20.13
DSI	\$	10.10	\$	8.15
SCR	\$	15.40	\$	7.37
SNCR	\$	4.38	\$	2.48
Baghouse	\$	23.25	\$	9.98
ACI	\$	2.88	\$	1.91

Current energy margins (excluding capacity revenues) already low for merchant coal plants due to low gas prices, low demand growth, and new renewables

- ◆ Current dispatch costs for an existing coal plant ~\$20-35/MWh
- ◆ Low wholesale power prices in 2012 (peak)
 - PJM West: ~\$40/MWh
 - Midwest (Illinois/Michigan): ~\$33-35/MWh
 - Southeast: ~\$30-32/MWh

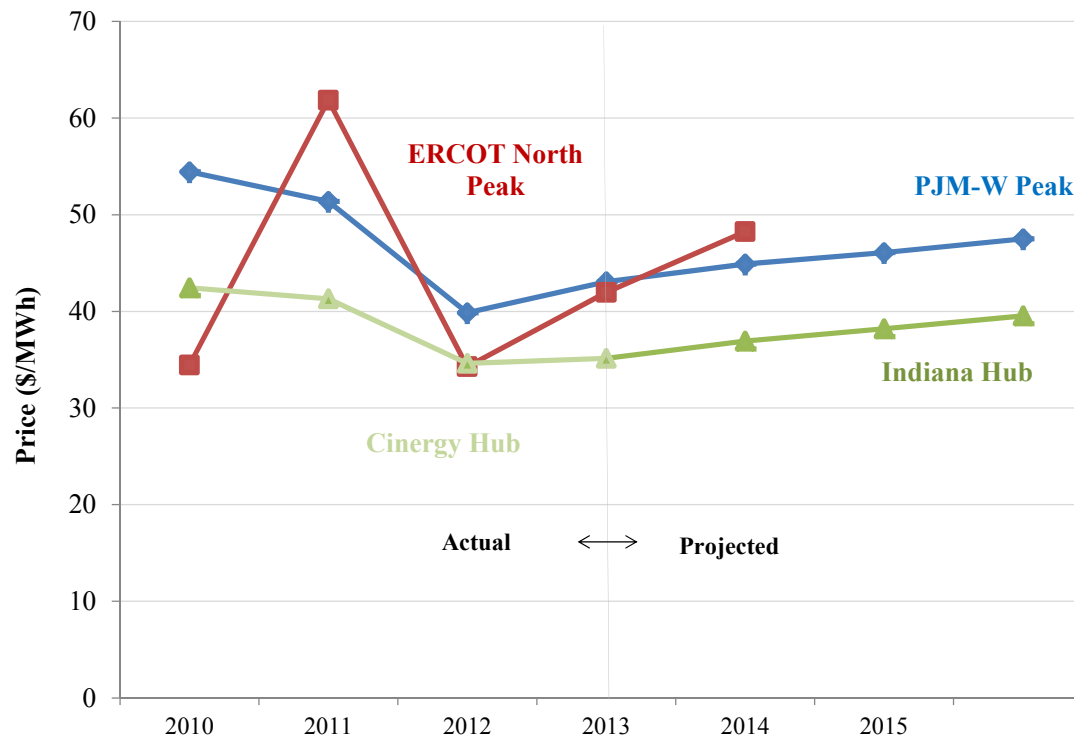
Wholesale power prices in 2012

Recent power prices are low due to low gas prices and depressed load conditions.



Current Peak Electricity Futures

Forward markets show very moderate price growth, potentially improving coal plant margins.



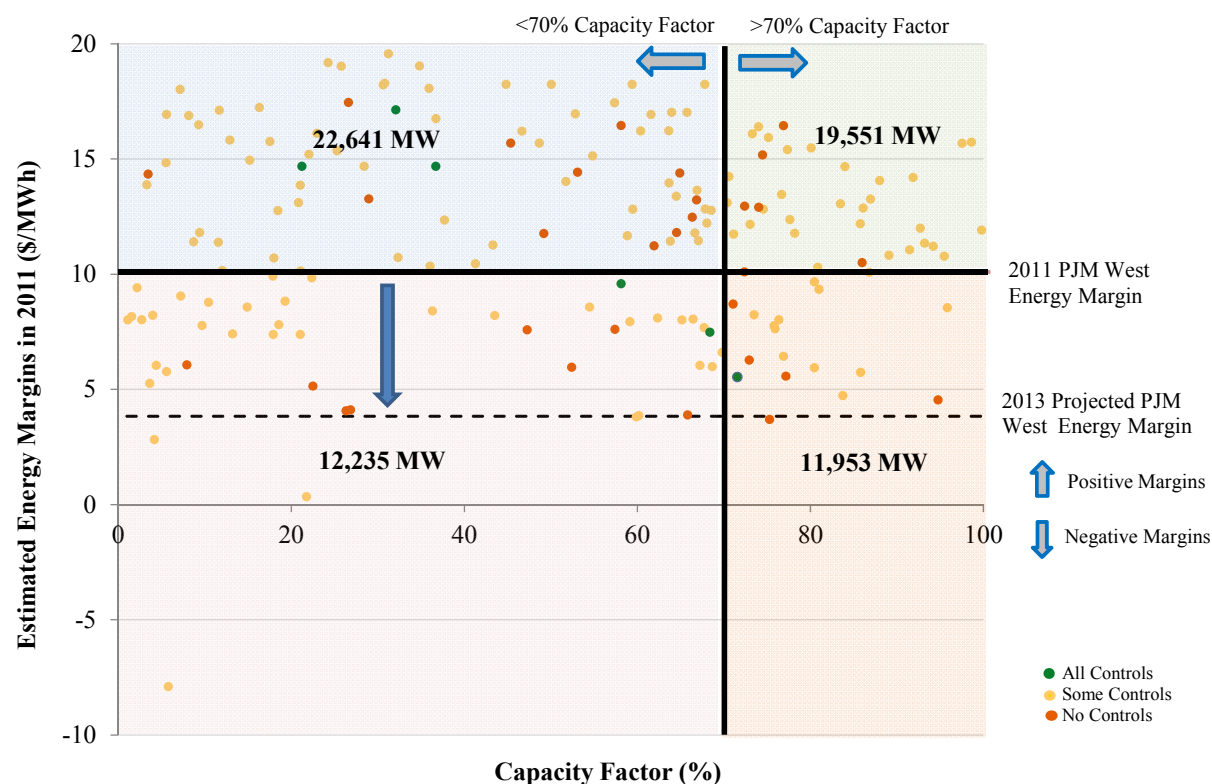
Note: Forward prices as of January 2013 trading days.

Forwards for 2015/16 may not be reflecting impact of future coal plant retirements

Energy Margins in PJM

Estimated energy margins for 24 GW of coal capacity (~1/3rd of total coal) in PJM were less than \$10/MWh in 2011 (= margins at PJM West prices)

- Most missing key control equipment (scrubber, SCR, baghouse)
- Half (12 GW) operating at low capacity factor (< 70%)



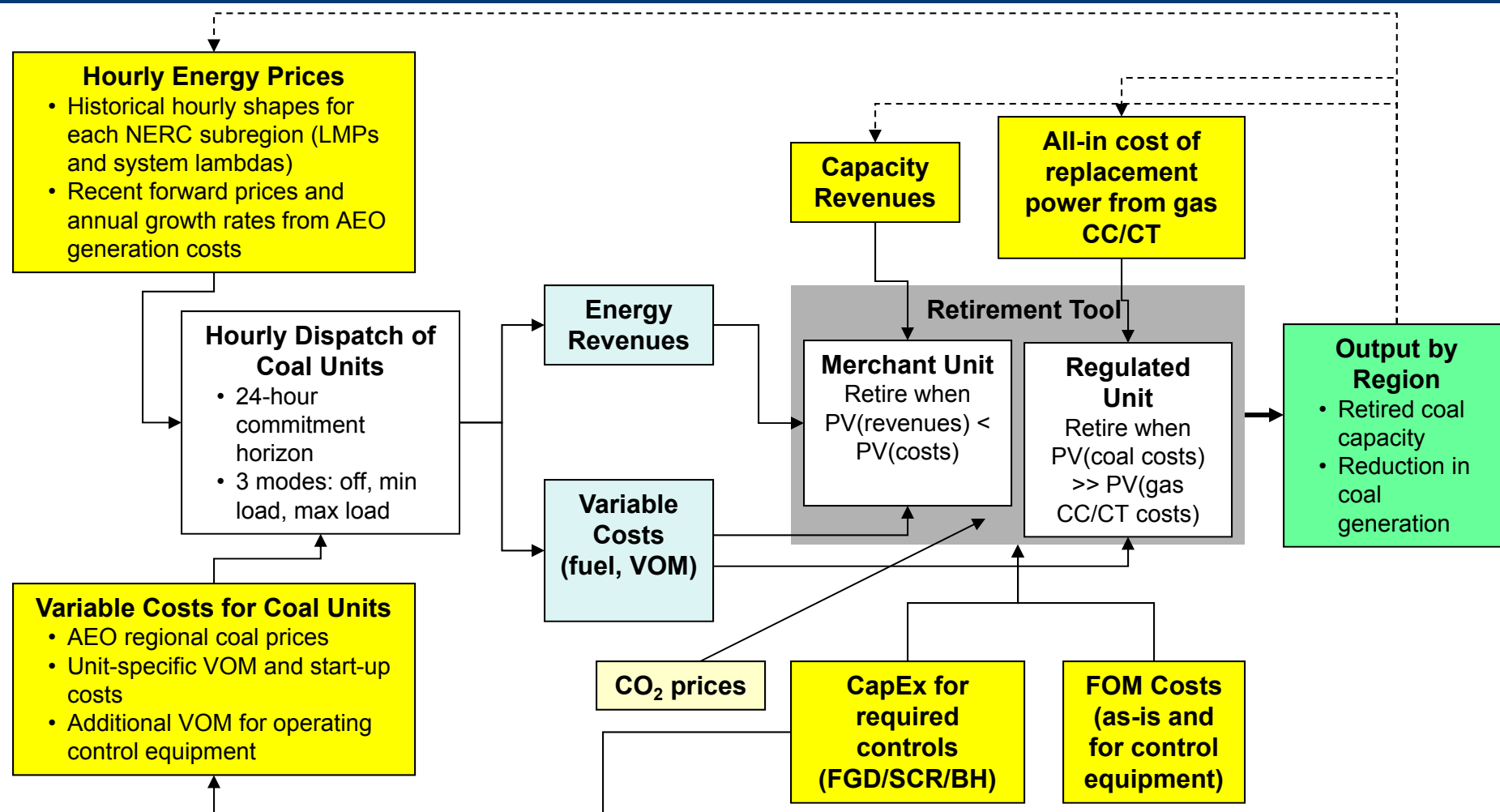
Assumptions: \$4/MWh variable O&M and the current wt. average fuel cost reported by Ventyx, Energy Velocity
 PJM West Energy Margin estimated based on 10,000 btu/kWh heat rate
 Capacity figures reflect total capacity in four quadrants defined by 70% capacity factor and PJM West margins. About 14 GW not shown due to missing data on capacity factor.

Brattle analysis of coal plant retirement exposure

A tool to analyze economics of retrofit vs. retirement for every coal unit in the U.S. under various scenarios of environmental regulation.

- ◆ Estimate future capacity factor for each unit by dispatching against projected hourly power prices
- ◆ Decide each year whether to retire based on comparing 15-year projected avoidable costs of retrofit against:
 - Revenues from energy and capacity markets for merchant units (on an after-tax basis),
 - Cost of replacement power from gas CCs or CTs for regulated units.

Brattle coal plant retirement screening tool – details



Note: Dashed lines and boxes represent factors and feedback effects that are planned to be incorporated into the model.

Regulation and Market Scenarios

Regulation Scenarios

1. Lenient regulations
 - Units < 25 MW exempt
 - SNCR and ACI on all units
 - DSI and Baghouse on units in WECC and on small units (< 200 MW) in other regions
 - Wet FGD on large (\geq 200 MW) units outside WECC
2. Stricter regulations
 - Units < 25 MW exempt
 - SCR on all units
 - DSI, ACI and Baghouse on units in WECC and on small (< 200 MW) units in other regions
 - Wet FGD on large (\geq 200 MW) units outside WECC

Market Scenarios

1. April 2012 gas forwards
2. April 2012 gas forwards minus \$1/MMBtu
3. April 2012 gas forwards plus \$1/MMBtu
4. April 2012 gas forwards with \$5/MWh adder to power prices in 2015 decreasing to zero by 2020
5. April 2012 gas forwards + \$30/ton CO₂ in 2020

Announced Coal Plant Retirements

As of January 2013, about 32 GW of coal capacity have been announced for retirements by 2021

- ◆ About 80% (24 GW) by 2015
- ◆ Most lack major environmental controls

Year of Retirement	Number of Units	Summer Capacity (MW)
2013	29	3,447
2014	48	6,730
2015	89	14,309
2016	9	1,138
2017	16	2,787
2018	5	991
2019	1	670
2020	7	1,653
2021	1	162
Total	205	31,886

Potential Coal Plant Retirements

Projected Retirements by 2016 (GW)

	Market Scenario				
	Base (Recent Fwds)	Base Gas \$-1/MMBtu	Base Gas \$+1/MMBtu	Base \$+5/MWh in Power Prices	Base \$+30/ton CO ₂ in 2020
Retirements under EPA Regulations (GW)	59-77	115-141	21-35	61-77	127-149
CapEx on Retrofits and Replacement Capacity (\$ Billion)	\$126-144	\$142-158	\$112-139	\$130-150	\$156-169

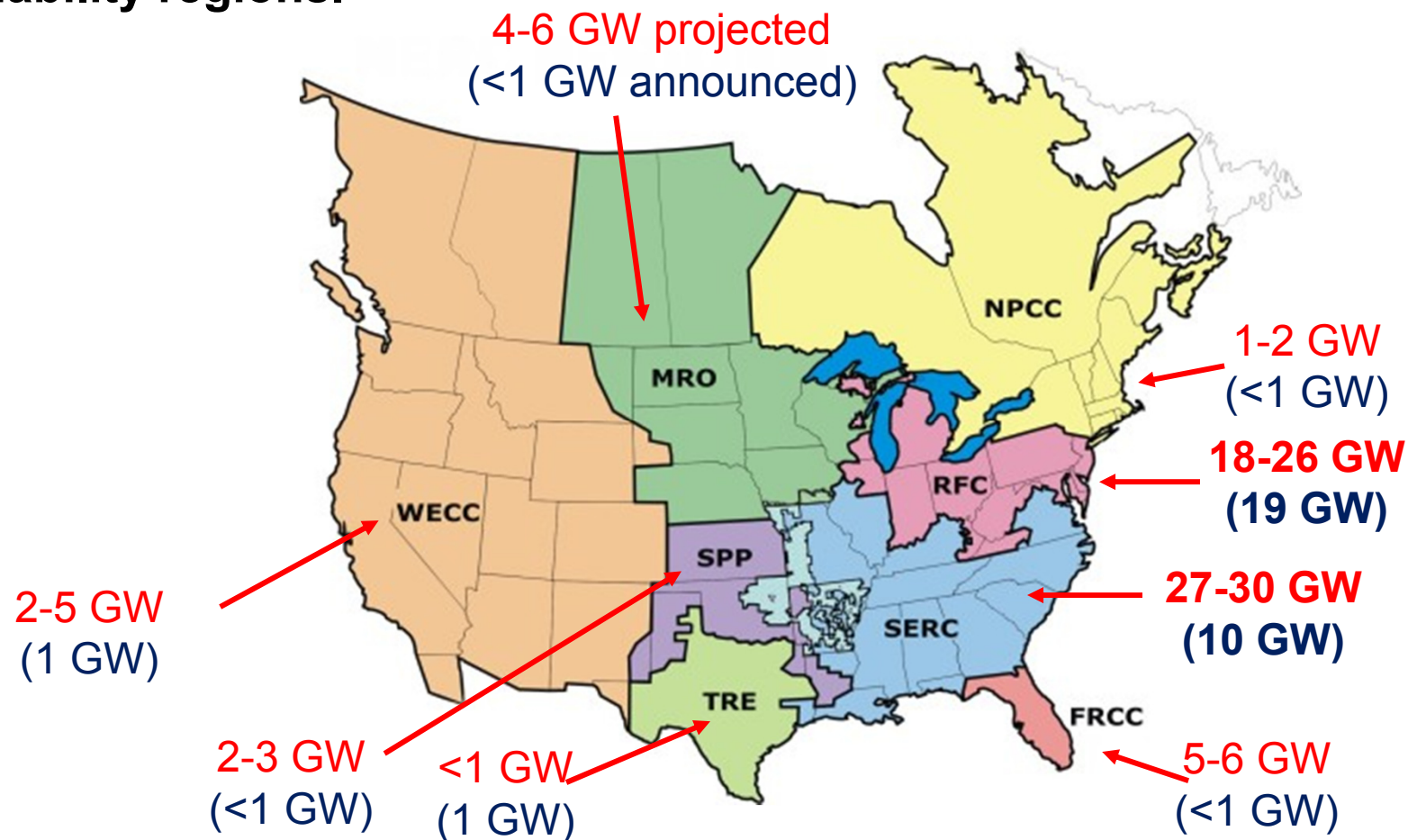
Projected Retrofits and Replacement Capacity

Projected Retrofits and Replacement Capacity by 2016 (GW)

		SCR	SNCR	Wet Scrubber	Baghouse	ACI	DSI	Total*	Replacement Capacity
Regulatory Scenario	Lenient	0	99	52	132	183	15	226	49
	Strict	106	0	48	121	136	8	212	57

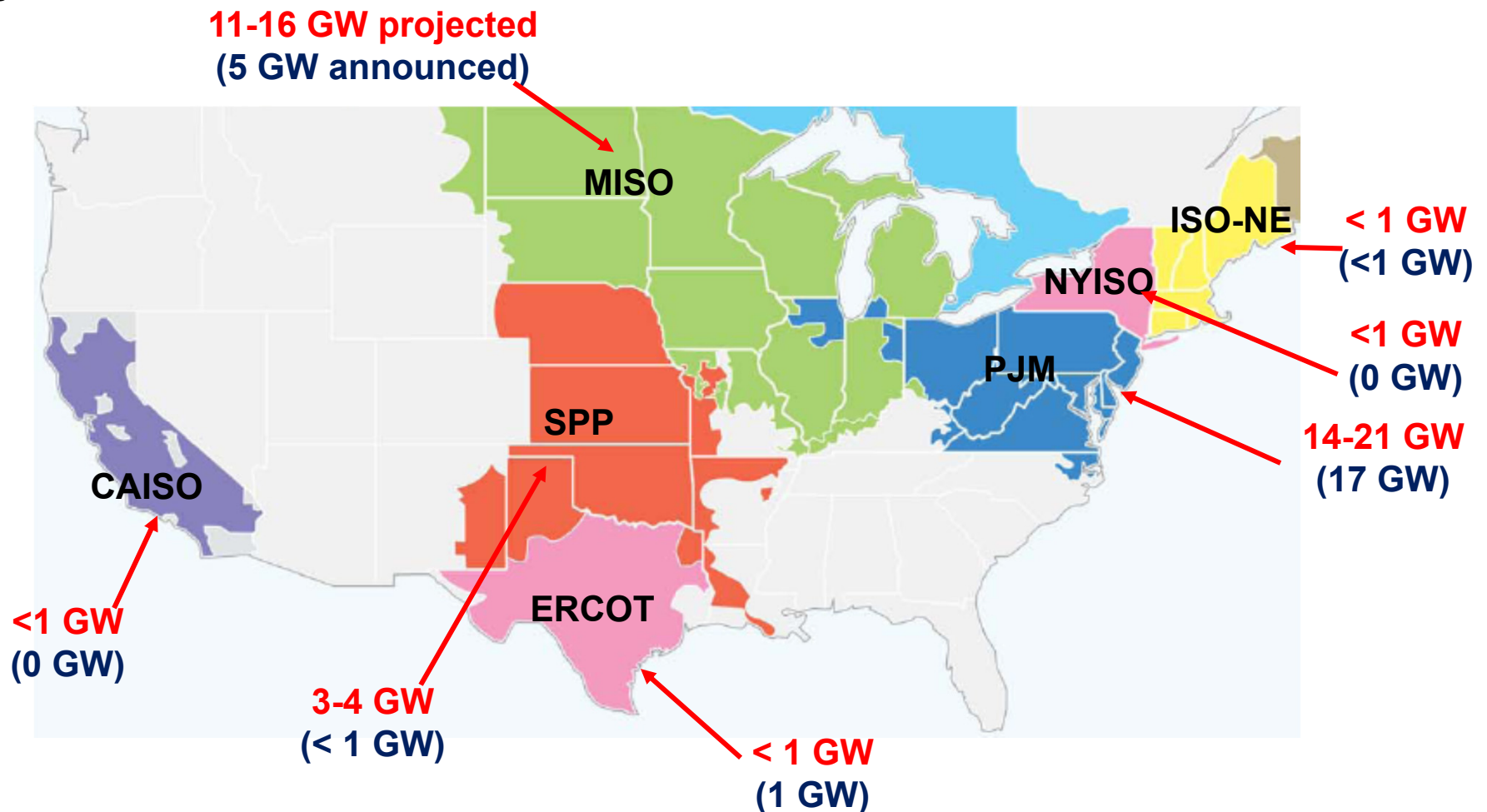
Projected (& announced) Coal Plant Retirements NERC Regions

Most of the projected and announced coal retirements are in SERC (27-30 GW, 10 GW announced) and RFC (18-26 GW, 19 GW announced) reliability regions.



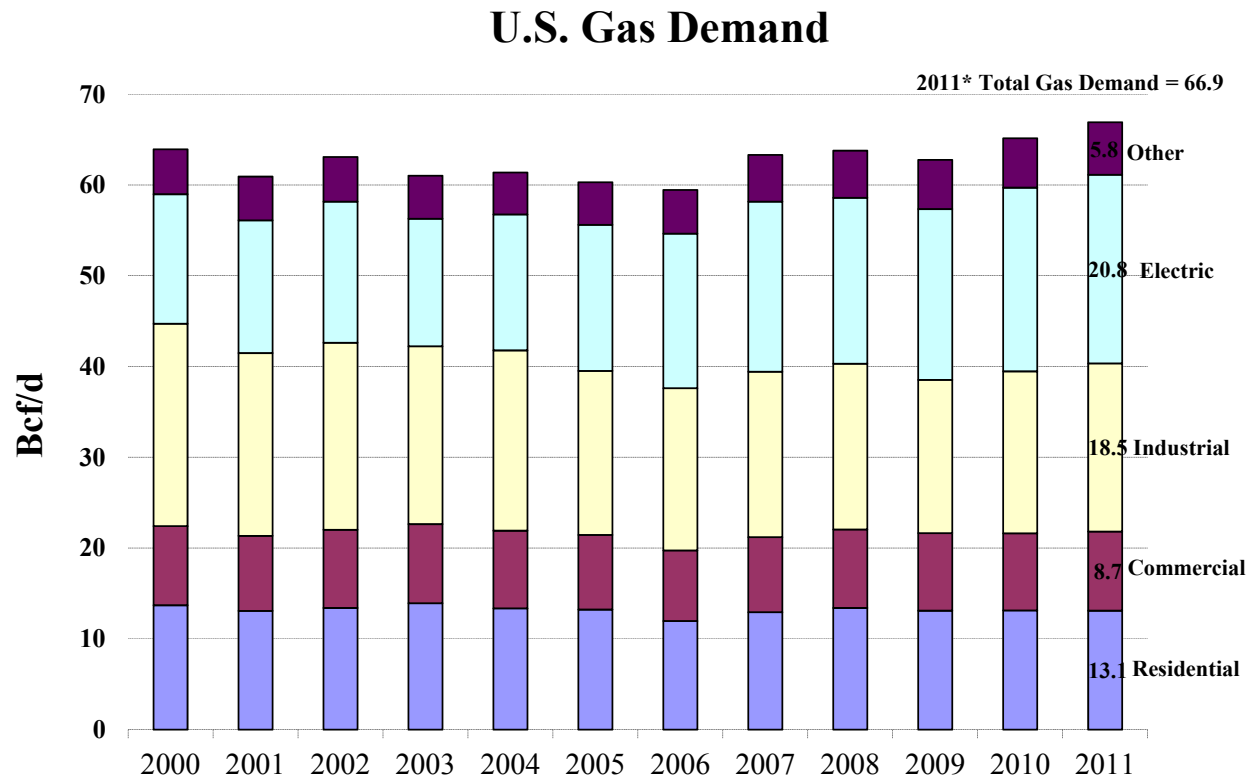
Projected (& announced) Coal Plant Retirements RTO Regions

PJM and MISO have the largest projected coal retirements among RTO regions.



Overview of U.S. Gas Demand

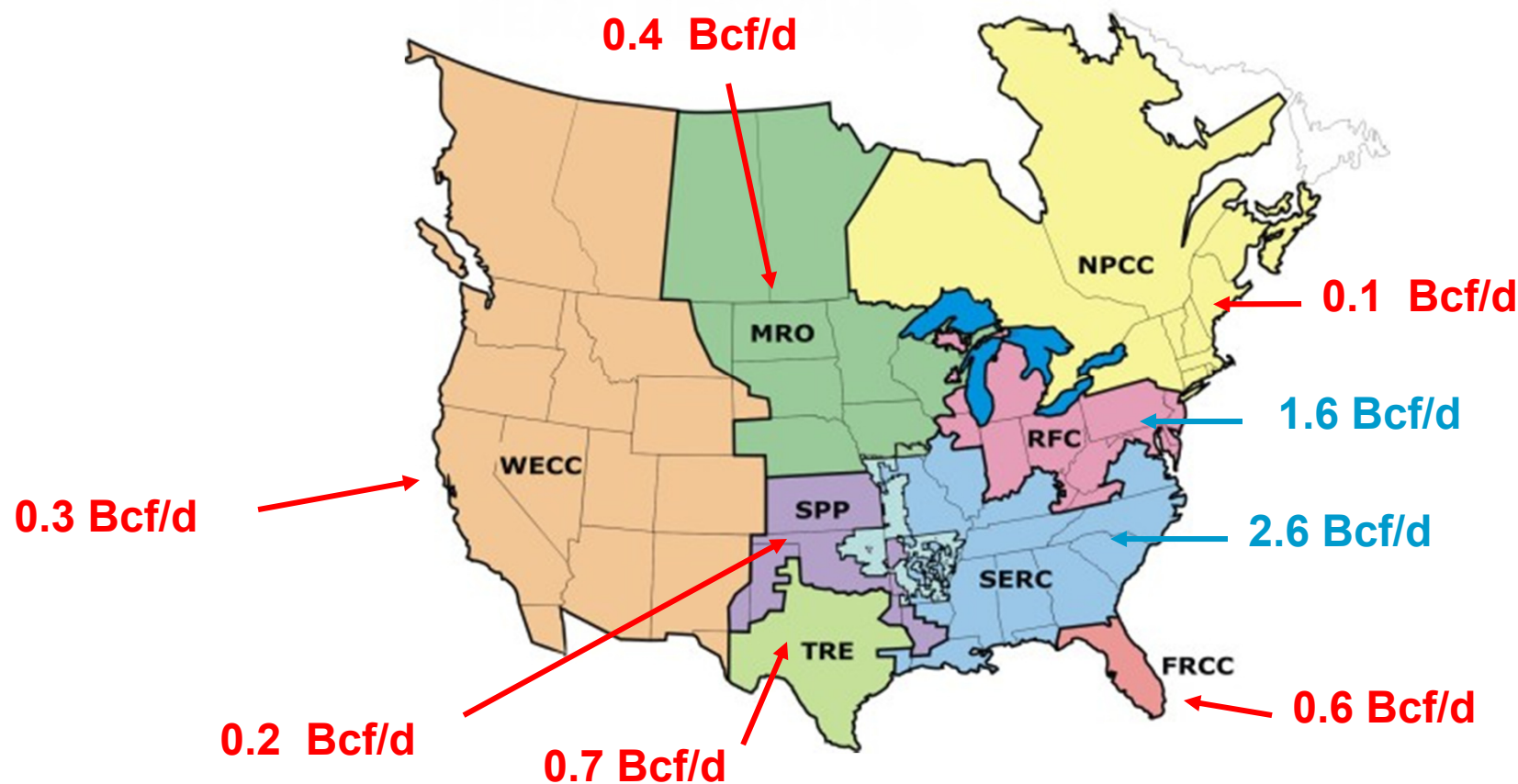
- ◆ 2011 demand ~67 Bcf/d, non-electric demand ~46 Bcf/d
- ◆ Flat demand in past decade
- ◆ Historically, demand has grown ~1.1% per year (1990-2010)



Source: EIA. 2011 gas demand excludes December 2011.

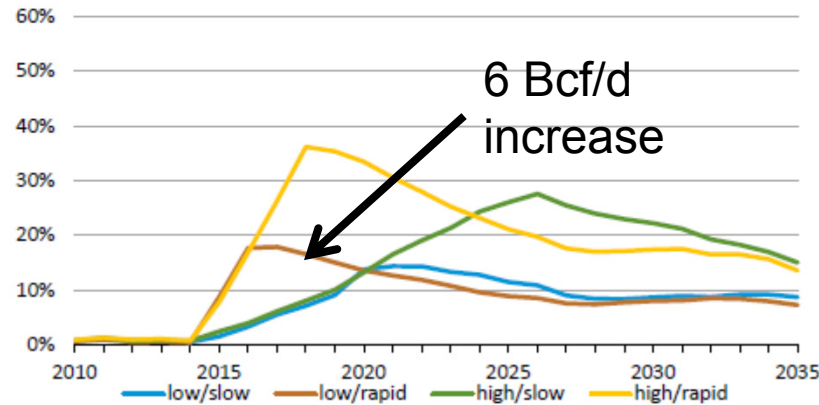
Potential Gas Demand Impacts of Coal Plant Retirements

Retirement of 60 GW of coal capacity by 2016 could result in a 6 Bcf/d increase in gas demand nationwide (less with renewables).



Impact of Increased Demand on Gas Prices

- ◆ A recent EIA study^(*) estimated the impact of a 6 Bcf/d increase in gas demand on gas prices.
 - ~15% increase in gas prices initially, and ~10% afterwards



Source: U.S. Energy Information Administration, National Energy Modeling System

- ◆ At the current gas forwards for 2015-2020 period, the estimated impact on gas prices would be \$0.5-0.7/MMbtu

(*): U.S. Energy Information Administration, "Effect of Increased Natural Gas Exports on Domestic Energy Markets," January 2012.

Impact of Retirements and Retrofits on Power Prices

- ◆ Coal retirements would likely result in higher energy prices due to:
 - Removing low-cost resources from the regional supply curve, hence dispatching higher-cost (gas) units;
 - Increased gas prices (see previous slide) making dispatch costs of gas units higher; and
 - Increased variable O&M and heat rates at retrofitted coal units

- ◆ In a recent study, we found that MISO energy prices may increase by \$8/MWh in on-peak and by \$4/MWh off-peak in 2017 as a result of 11 GW of coal retirements by 2016
 - Similar results in studies by MISO (+\$5/MWh) and Exelon (+\$3-6/MWh relative to forwards)



Questions?

Presenter



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[Dr. Celebi](#) provides expertise in electricity markets and analysis of environmental and climate policy. He has consulted primarily in the areas of electricity spot pricing and market design, and has experience in developing and analyzing climate policies, assessing generation market power, LMP modeling, and merger analysis.

Additional Reading

"Potential Coal Plant Retirements: 2012 Update," by Metin Celebi, Frank C. Graves, and Charles Russell, The Brattle Group, Inc., October 2012.

"Supply Chain and Outage Analysis of MISO Coal Retrofits for MATS," by Metin Celebi, Kathleen Spees, Quincy Liao, and Steve Eisenhart, The Brattle Group, Inc., May 2012.

"Potential Coal Plant Retirements Under Emerging Environmental Regulations," by Metin Celebi, Frank C. Graves, Gunjan Bathla and Lucas Bressan, The Brattle Group, Inc., December 8, 2010.

"Managing Natural Gas Price Volatility: Principles and Practices Across the Industry," by Steven H. Levine and Frank C. Graves, *The Brattle Group, Inc., prepared for the American Clean Skies Foundation*, forthcoming in Spring 2011.

"Prospects for Natural Gas Under Climate Policy Legislation: Will There Be a Boom in Gas Demand?," by Steven H. Levine, Frank C. Graves, and Metin Celebi, *The Brattle Group, Inc.*, March 2010.

"Transforming America's Power Industry: The Investment Challenge 2010-2030," by Marc Chupka, Robert L. Earle, Peter S. Fox-Penner, and Ryan Hledik, Prepared for The Edison Foundation, November 2008.

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