

The Brattle Group

Potential Coal Plant Retirements and Retrofits Under Emerging Environmental Regulations

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Presented by

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Impending Regulatory Challenges

EPA actions over the next several years will confront owners of existing coal units with difficult choices.

- ◆ Stringent, technology-based requirements and potentially inflexible (and cascading) deadlines lead to a “comply or die” dilemma
 - Staggered compliance deadlines (and eventual possibility of CO₂ prices) make comprehensive analysis difficult
 - While incremental “one issue at a time” analysis may not capture important cumulative cost impacts
- ◆ Retrofit vs. retire decisions have to be made before all rules are finalized, because of the lead times involved with designing and installing controls or building new capacity.
- ◆ Some owners may face reliability problems, replacement supply constraints, or financial and ratemaking difficulties.

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Emerging EPA regulations

Cost of retrofits

Brattle's coal plant retirement model

Potential coal plant retirements and compliance costs

Compliance issues

Overview of environmental pressures

EPA is promulgating regulations to control (or tighten existing controls of) the following effluents:

- ◆ “Criteria air pollutants” especially NO_x, ozone, SO₂, and particulates
- ◆ Hazardous air pollutants (HAPs), such as mercury and acid gases
- ◆ Cooling water intake structures (316(b))
- ◆ Coal combustion byproducts ash disposal pathways
- ◆ Greenhouse gases (GHG) primarily CO₂ from new and “modified” sources
 - Or, potential legislation in the future to implement a federal climate policy

The nature of most of these regulations is expected to be tilted toward command-and-control (*i.e.*, with no choice but to comply or retire on a strict schedule)

Emerging EPA Regulations (excluding GHG regs)

Regulation	Status	Pollutant Targeted	Compliance Options	Expected Date of Compliance
Transport Rule 1	Final	NO _x , SO ₂	SCR/SNCR, FGD/DSI, fuel switch, allowance purchases	2012 and 2014
Transport Rule 2 (ozone)	Proposal expected in 2011	NO _x	SCR/SNCR, allowance purchases	tbd
SIP for revised SO ₂ standard	Non-attainment area plans expected in 2014	SO ₂	tbd	2017/2018
Utility MACT	Proposed	HAPs (mercury, acid gases, PM)	ACI, baghouse, FGD/DSI	2015/2016
316(b)	Proposed	Cooling water	<u>Impingement</u> : Mesh screens; <u>Entrainment</u> : Case-by-case, may include cooling towers	2013-2020
Combustion by-products	Proposed	Ash, control equipment waste	Bottom ash dewatering, dry fly ash silos, etc.	2014-2018

Transport Rule

New name: Cross-State Air Pollution Rule (CSAPR)

- ◆ Replaces CAIR (was vacated by courts)

Objective: Reduce SO₂ and NO_x emissions from local and transported pollution that contribute to ozone and PM_{2.5} nonattainment

- ◆ Compliance in two steps: 2012 and 2014

Regulatory Mechanism: cap & trade among states in each program, subject to state-specific hard caps on emissions

- ◆ Annual SO₂ program
 - Group 1 (16 states): 2012 and lower cap in 2014
 - Group 2 (7 states): 2012 cap only (AL, GA, KS, MN, NE, SC, TX)
- ◆ Annual NO_x program (starting in 2012)
- ◆ Summer NO_x program (starting in 2012)

Greenhouse Gas Performance Standards

EPA to issue draft rules by September 2011 covering new and modified sources (to be finalized May 2012)

- ◆ EPA analyses indicate that cost-effective control strategies exist
- ◆ Allowable control strategies may be unlike traditional “end-of-stack” controls, e.g., efficiency improvements
- ◆ The only known direct control technology (CCS) is not yet commercially available
- ◆ Can/will the Congress de-fund or delay this rulemaking?

Wild card may be “modified” sources – NSR for GHGs?

- ◆ Decade-old NSR enforcement still working through cases for NO_x and SO₂, without clear resolution of important legal and analytical issues

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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 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)

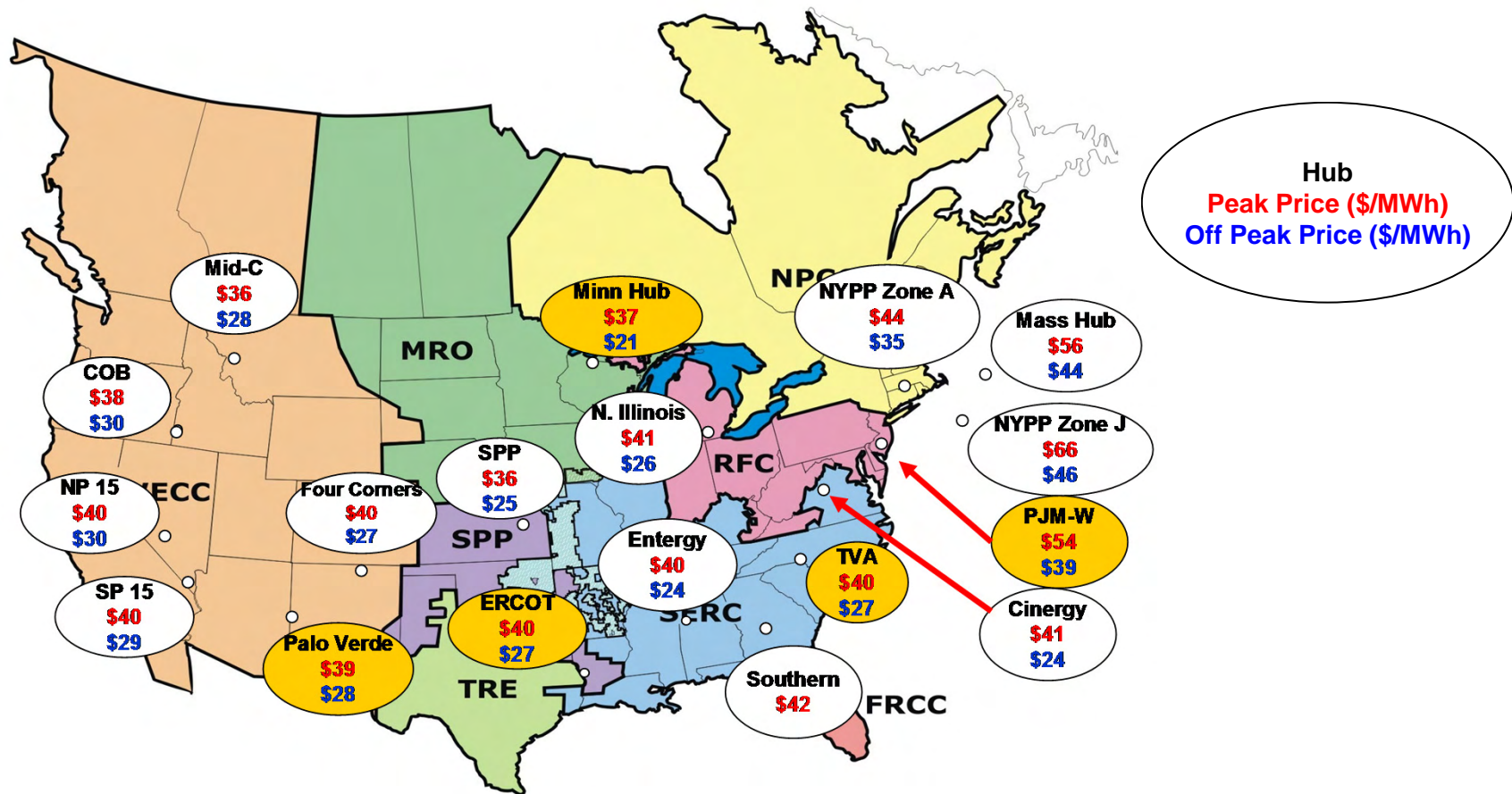
Equipment	Capacity Factor	
	30%	70%
Wet Scrubber	\$ 50.80	\$ 22.91
Dry Scrubber	\$ 43.57	\$ 20.13
DSI	\$ 10.10	\$ 8.15
SCR	\$ 15.40	\$ 7.37
SNCR	\$ 4.38	\$ 2.48
Baghouse	\$ 23.25	\$ 9.98
ACI	\$ 2.88	\$ 1.91

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 2010
 - PJM West: ~\$47/MWh
 - Midwest (Illinois/Michigan): ~\$32-35/MWh
 - Southeast: ~\$30-35/MWh

Wholesale power prices in 2010

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



Energy Margins in Selected Regions

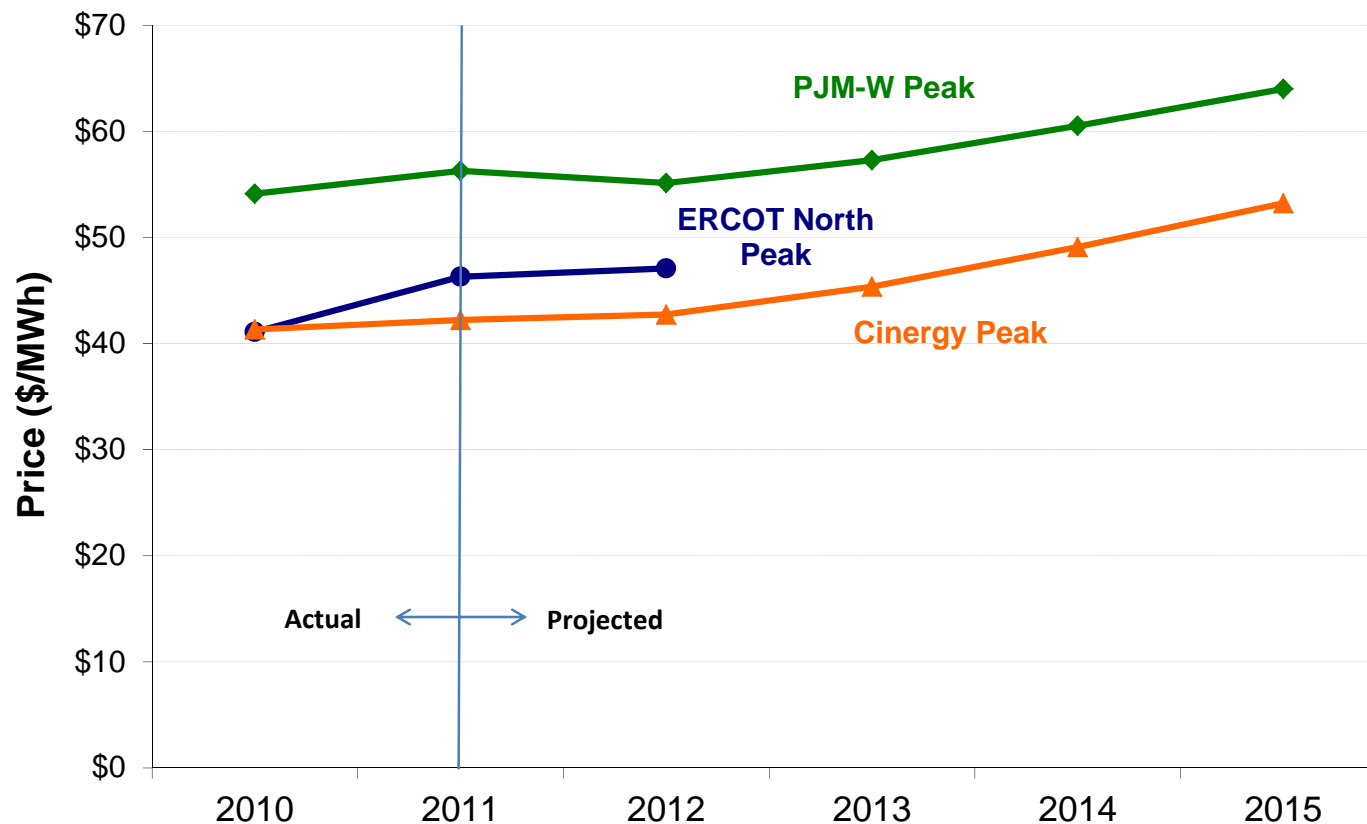
Energy margins for coal units in 2010 were in \$1-25/MWh range during on-peak hours and between -\$11/MWh to \$10/MWh during off-peak hours, depending on region and unit efficiency.

Region	Heat Rate (Btu/kWh)	On Peak		Off Peak	
		Revenue (\$/MWh)	Energy Margins (\$/MWh)	Revenue (\$/MWh)	Energy Margins (\$/MWh)
ERCOT	10,000	\$40.01	\$16.43	\$26.76	\$3.18
	13,000	\$40.01	\$10.85	\$26.76	-\$2.40
Minn Hub	10,000	\$36.72	\$16.31	\$20.88	\$0.47
	13,000	\$36.72	\$11.68	\$20.88	-\$4.15
Palo Verde	10,000	\$38.64	\$8.61	\$27.55	-\$2.48
	13,000	\$38.64	\$1.10	\$27.55	-\$9.99
PJM-W	10,000	\$53.81	\$24.52	\$39.01	\$9.72
	13,000	\$53.81	\$17.24	\$39.01	\$2.43
TVA	10,000	\$39.97	\$9.58	\$27.03	-\$3.37
	13,000	\$39.97	\$1.96	\$27.03	-\$10.98

On top of this, many coal plants have more than \$50/kW-yr of fixed O&M costs.

Current Peak Electricity Futures

Forward markets not showing much growth in electricity prices to improve coal operating margins.



Sources and Notes: Futures data from Ventyx the Velocity Suite as of July 25, 2011. Prices are average of previous 5 trading days.

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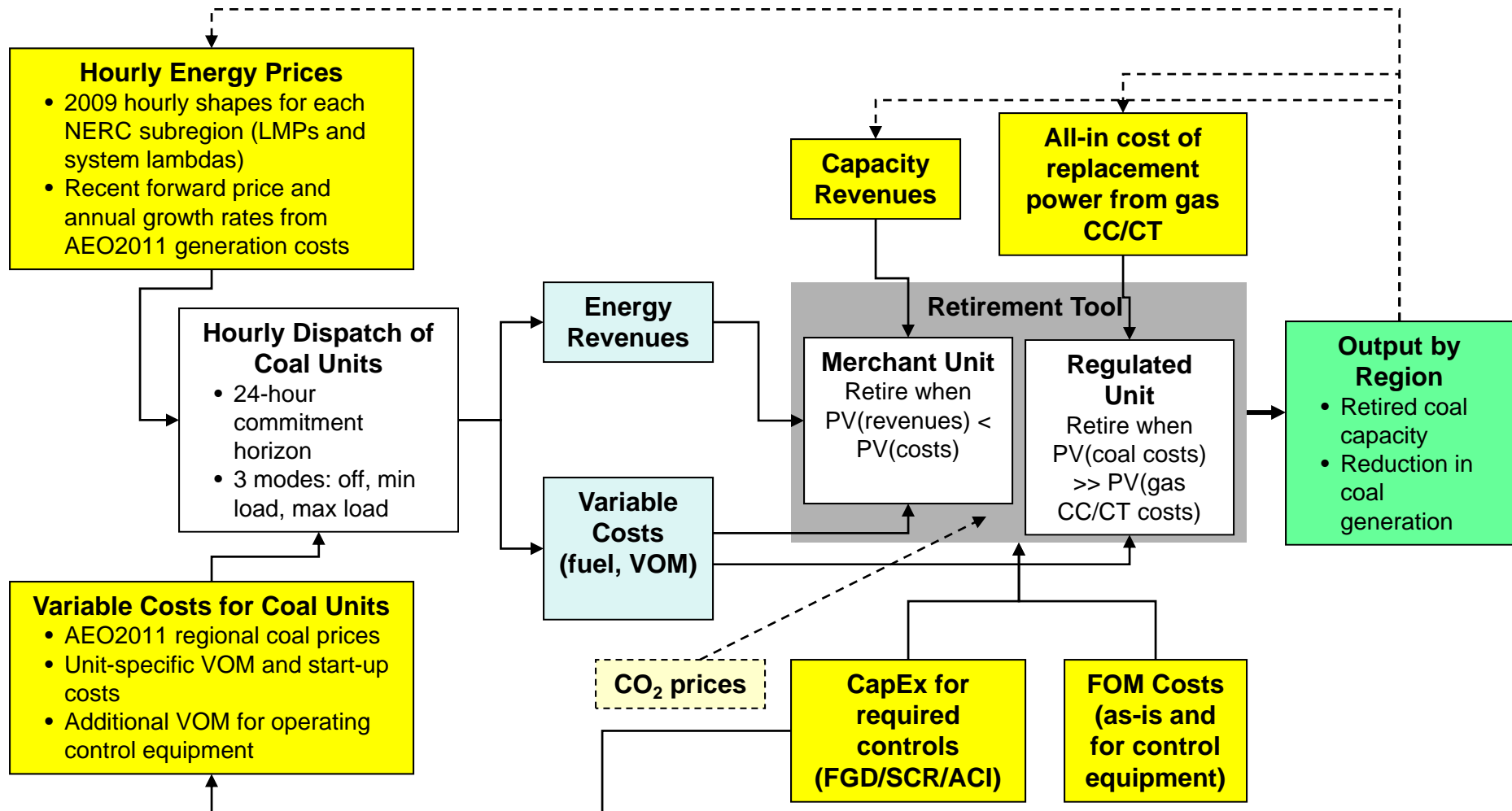
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Brattle analysis of coal plant retirement exposure

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.

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Potential Coal Plant Retirements

Most of the recent studies estimate 30-60 GW of coal capacity (10-20% of existing fleet) at risk for retirement by 2020 due to cumulative effects of emerging EPA regulations.

RECENT STUDIES ON THE EFFECTS OF EMERGING EPA REGULATIONS FOR AIR QUALITY AND WATER

Study	Date	Projected coal capacity to retire or "at risk"	Criteria to identify coal capacity at risk
EIA	April 2011	9-73 GW by 2035	Future margins
Fitch	February 2011	51 GW	Unit size and age
EE/ICF	January 2011	46-55 GW by 2020 (without CO2 prices)	System cost minimization
Brattle	December 2010	50-65 GW by 2020	Future margins and cost of replacement power
CRA	December 2010	39 GW by 2015	System cost minimization
FBR Capital	December 2010	30-70 GW	Unit age, size, coal type, and existing controls
NERC/EVA	October 2010	10-35 GW by 2018 (+20 GW already committed or not a capacity resource)	Cost of replacement power
Credit Suisse	September 2010	60 GW	Unit size and existing controls
ICF/INGAA	May 2010	50 GW	Unit age, efficiency and existing controls

Estimates on Total Cost of Compliance

Retrofit capital expenditures of \$70-\$130 Billion expected to comply with emerging suite of EPA regulations

Annualized total cost of compliance will likely exceed \$10 Billion per year.

ESTIMATES FOR COST OF COMPLIANCE WITH EMERGING EPA REGULATIONS

Study	Covered Regulations	Additional Compliance Costs by 2020	
		CapEx for Retrofits	Total Costs
EPA	Transport	not available	~\$1 Billion per year
EPA	Utility MACT	\$5.2 Billion per year	\$10.9 Billion per year
Brattle	Utility MACT and Transport	\$70-130 Billion	not available
EEI/ICF	Utility MACT, Transport, Ash, and Cooling Water	85-113 Billion	not available
Bipartisan Policy Center	Utility MACT, Transport, Ash, and Cooling Water	~\$10 Billion per year	\$14.5-18.1 Billion per year

Existing coal fleet owned by Coops

Coops own 25 GW of coal-fired capacity, about 8 % of the U.S. coal fleet (316 GW).

- ◆ 4 GW older than 40 years, of which 3.5 GW are small (< 500 MW)
- ◆ 14 GW smaller than 500 MW

Coal Generation Capacity (GW)		
NERC Region	Total	Coops
RFC	105	3
SERC	100	10
WECC	32	4
MRO	27	5
SPP	20	1
ERCOT	18	0
FRCC	10	1
NPCC	6	0
Total	316	25

Significant portion of the coop coal fleet lacks major environmental controls

- ◆ 5 GW (20%) uncontrolled

Coop Coal Capacity <u>without</u> :				
	FGD	SCR	Baghouse	One of FGD, SCR, Baghouse
GW	10	15	18	24
% of Coop Coal Fleet	40%	60%	72%	95%

Coop coal capacity at risk for retirement or retrofits

Coops face \$5-10B of retrofit costs for about 17 GW of coal capacity.

POTENTIAL RETIREMENTS AND RETROFITS FOR COOPs WITH COAL UNITS

Region	Coal Capacity (GW)	Low Retrofit Costs			High Retrofit Costs			# of Coops in Region (count)	Shutdown > 25% of Fleet (count)	Shutdown + Retrofit > 25% of Fleet (count)
		Capacity to Retire (GW)	Capacity to Retrofit (GW)	Retrofit Costs (Mil \$)	Capacity to Retire (GW)	Capacity to Retrofit (GW)	Retrofit Costs (Mil \$)			
RFC	3	0.3	0.9	312	0.3	0.9	624	4	1	3
SERC	10	0.2	7.3	2,495	0.2	7.3	4,990	14	0	12
WECC	4	0.0	3.1	612	0.0	3.1	1,225	5	0	5
MRO	5	0.3	4.6	1,356	0.3	4.6	2,712	10	3	10
SPP	1	0.0	1.4	476	0.0	1.4	952	5	0	5
Total	23	0.7	17.3	5,252	0.7	17.3	10,503	38	4	35

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Compliance Complications

Planning Criterion =	PV (to-go \$)	vs. PV (Next Best Alternative)
Uncertainties	<ul style="list-style-type: none"> • Strength, timing of regs <ul style="list-style-type: none"> • Include CO₂? • Cost of controls? 	<ul style="list-style-type: none"> • Replacement power? <ul style="list-style-type: none"> • Impact of compliance on market prices? • Gas plant? <ul style="list-style-type: none"> • Costs to build? • Fuel costs?
Constraints	<ul style="list-style-type: none"> • Limited equipment and engineering personnel for installation • Financing 	<ul style="list-style-type: none"> • Permits/siting • Time to build infrastructure <ul style="list-style-type: none"> • Pipeline spur • Transmission lines • Financing
Other Issues	<ul style="list-style-type: none"> • Reliability risks • Down-time 	<ul style="list-style-type: none"> • Ratemaking impacts

Conclusions

***The Brattle Group* and many other studies find 30-60 GW of coal plant retirements likely by or around 2015**

- ◆ **About 15-20% of coal fleet**, more than 5% of U.S. total generation
- ◆ Some regions hit harder: ERCOT, Midwest ISO, PJM
- ◆ **In addition, \$70 - \$130B of compliance expenditures** at 190 GW

Coops not especially hard hit for retirements, but large portion of the fleet would require retrofits

- ◆ 1 GW retired out of 25 GW coal fleet
- ◆ 17 GW to be retrofitted, at a cost of \$5-10B

For several coops, the affected coal plant(s) are a material large portion of their owned generation → significant engineering and financial impacts

Feasibility of entire industry satisfying 2015 compliance with regulations is a question.

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

"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.

"Resource Adequacy and Renewable Energy in Competitive Wholesale Electricity Markets," by Serena Hesmondhalgh, Johannes P. Pfeifenberger, and David Robinson, *The Brattle Group, Inc.*, presented at the 8th Annual British Institute of Economics Academic Conference, September 23, 2010.

"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.

"Midwest ISO's Resource Adequacy Construct: An Evaluation of Market Design Elements," by Samuel A. Newell, Kathleen Spees, and Attila Hajos, *The Brattle Group, Inc.*, January 19, 2010.

"Cross-RTO Survey of Capacity Markets: What is Working and What is Not," by Attila Hajos and Samuel A. Newell, *The Brattle Group, Inc.*, November 9, 2009.

"EU Climate and Energy Policy to 2030 and the Implications for Carbon Capture and Storage: A Report for ALSTOM Power Systems," by Serena Hesmondhalgh, Toby Brown, and David Robinson, *The Brattle Group, Inc.*, March 2009.

"Volatile CO₂ Prices Discourage CCS Investment," by Metin Celebi and Frank C. Graves, *The Brattle Group, Inc.*, January 2009.

"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.

"Review of PJM's Reliability Pricing Model (RPM)," by Johannes P. Pfeifenberger, Samuel A. Newell, Robert L. Earle, Attila Hajos, and Mariko Geronimo, *The Brattle Group, Inc.*, June 30, 2008.

"Resource Planning and Procurement in Evolving Electricity Markets, prepared for the Edison Electric Institute," by Frank C. Graves, James A. Read, Jr., and Joseph B. Wharton, *The Brattle Group, Inc.*, January 31, 2004.

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