

# Coal Plant Retirements and Market Impacts

**PRESENTED TO**

Wartsila Flexible Power Symposium 2014 – Vail, Colorado

**PRESENTED BY**

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THE **Brattle** GROUP

# Agenda

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- 1. Key Environmental Regulations**
- 2. U.S. Coal Fleet**
- 3. Economics of Retirement/Retrofit Decisions**
- 4. Impact on Gas Demand and Power Prices**

# Key Environmental Regulations

## Summary

Regulation	Status	Pollutant Targeted	Compliance Options	Expected Date of Compliance	Impacts
<b>MATS</b>	Final	HAPs (mercury, acid gases, PM)	ACI, baghouse, FGD/DSI	2015/2016	Coal (large)
<b>GHG Standards for Existing Plants</b>	Expected proposal in June 2014	GHG	Unknown, potential for trading of allowances	Uncertain, potentially ~2020	Coal (large) Gas steam (moderate)
<b>316(b)</b>	Proposed	Cooling water intake structures	<u>Impingement</u> : Mesh screens; <u>Entrainment</u> : Case-by-case, may include cooling towers	Uncertain, potentially ~2018	Coal (moderate) Gas steam (moderate)
<b>Combustion by-products (ash)</b>	Final expected in Dec 2014	Ash, control equipment waste	Bottom ash dewatering, dry fly ash silos, etc.	Uncertain, potentially ~2020	Coal (moderate)
<b>Regional Haze</b>	Final	NO <sub>x</sub> , SO <sub>2</sub> , PM	SCR/SNCR, FGD/DSI, Baghouse/ESP, combustion controls	Typically 5 years after ruling	Coal (could be large depending on state)
<b>CSAPR</b>	Vacated by Court	NO <sub>x</sub> , SO <sub>2</sub>	SCR/SNCR, FGD/DSI, fuel switch, allowance purchases	Potential replacement rule after 2015?	Coal (moderate)

# Key Environmental Regulations

## Mercury and Air Toxics Standards (MATS)

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**Single-most important environmental regulation driving the expected coal plant retirements in the U.S. (along with low gas prices)**

**Covers Hazardous Air Pollutants (HAPs) such as mercury, phosphoric acid, lead and selenium compounds that are associated with cancer or other serious health affects.**

**Requires power plants to install Maximum Achievable Control Technology -- MACT, with little flexibility for sources to comply.**

**Compliance date: April 2015**

- with 1 year extension from state permitting agencies, and another possible 1-year extension from EPA to maintain grid reliability

**Compliance options: combinations of baghouse (\$200-\$500/kW), ESP upgrades (\$55-100/kW), scrubber (\$450-900/kW), DSI (~\$40/kW), ACI (\$20-30/kW), and switch to gas/biomass**

**Most coal-fired plants need to either**

- add some controls, or
- change fuel to gas/biomass

# Key Environmental Regulations

## GHG Performance Standards

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### **New units: standards proposed in Sep 2013 under CAA §111(b)**

- Gas Turbines
  - 1,000 lbs/MWh for large units (> 850 MMBtu/hr)
  - 1,100 lbs/MWh for small units (<= 850 MMBtu/hr)
- Fossil-fuel Boilers and IGCCs: based on partial CCS on a coal unit
  - 1-year average less than 1,000 lbs/MWh,
  - 7-year average less than 1,000-1,050 lbs/MWh
- Not applicable to small units (< 25 MW), oil CTs, and low CF units selling less than 1/3<sup>rd</sup> of power to the grid

### **Existing units: proposed standards in June 2014 under CAA §111(d)**

- Unclear how to approach in the absence of retrofit technology – credits/allowances from efficiency programs and renewables?
- One proposal (from NRDC) is to create state-level emission standards for EGUs that would be tradable and include end-use efficiency credits
- Schedule: EPA final rule in June 2015, SIPs submitted by June 2016

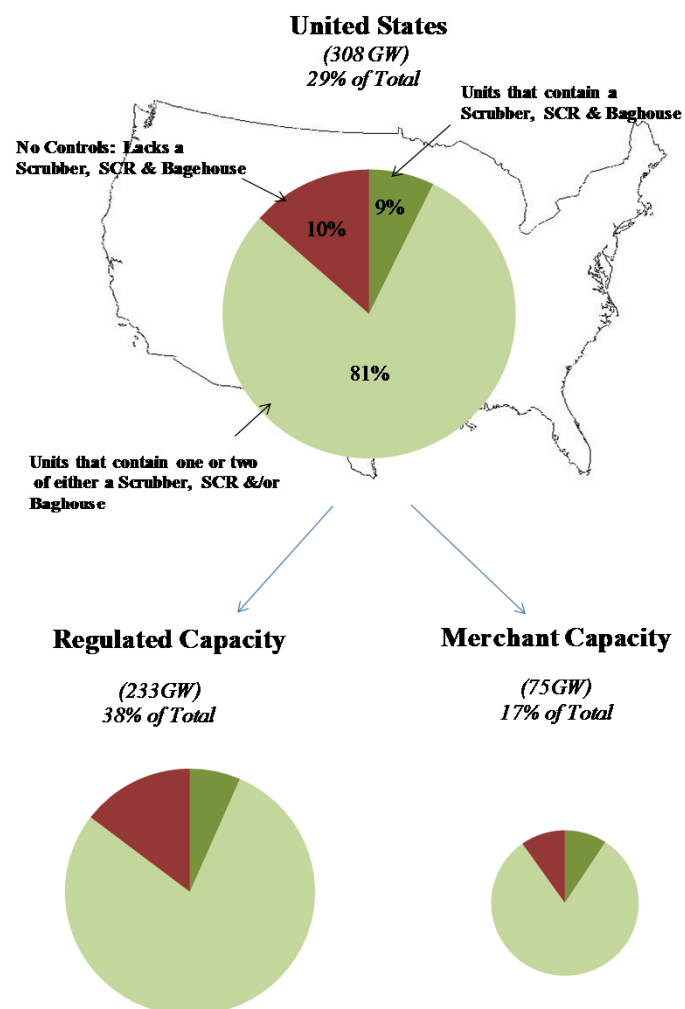
# U.S. Coal Fleet

## Summary

**Coal-fired capacity (308 GW) represents about 1/3<sup>rd</sup> of the total generation capacity**

- Majority of coal capacity (233 GW) is owned by regulated companies (IOUs, munis/coops, etc.), and the rest (75 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**



# U.S. Coal Fleet

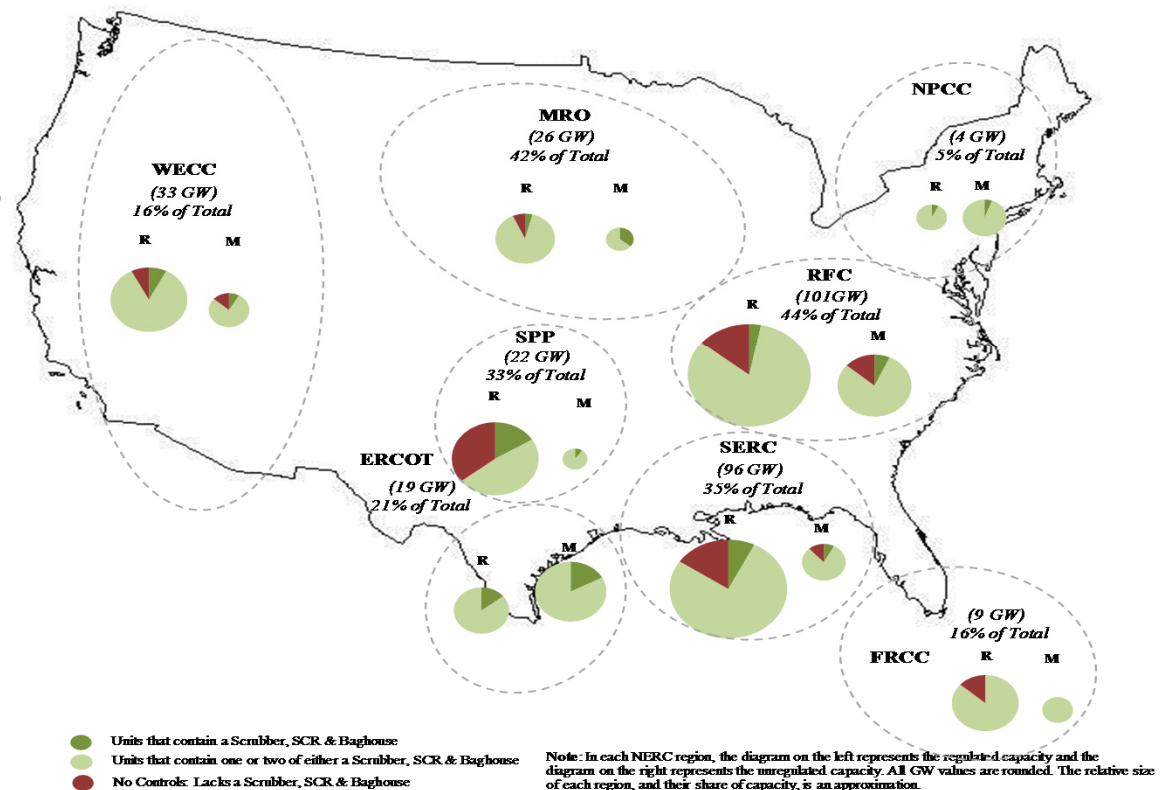
## Regional View

Coal-fired capacity is largely in the eastern interconnect (~235 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 (44% in RFC, 35% in SERC)

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



# Economics of Retirement/Retrofit Decisions

## Capital Costs of Major Control Equipment

Capital costs are significantly more expensive for smaller units, and costs vary widely depending on type of equipment needed

- 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
- Some units can comply with only DSI+ACI+ESP upgrades, with total cost of about \$150/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



# Economics of Retirement/Retrofit Decisions

## 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

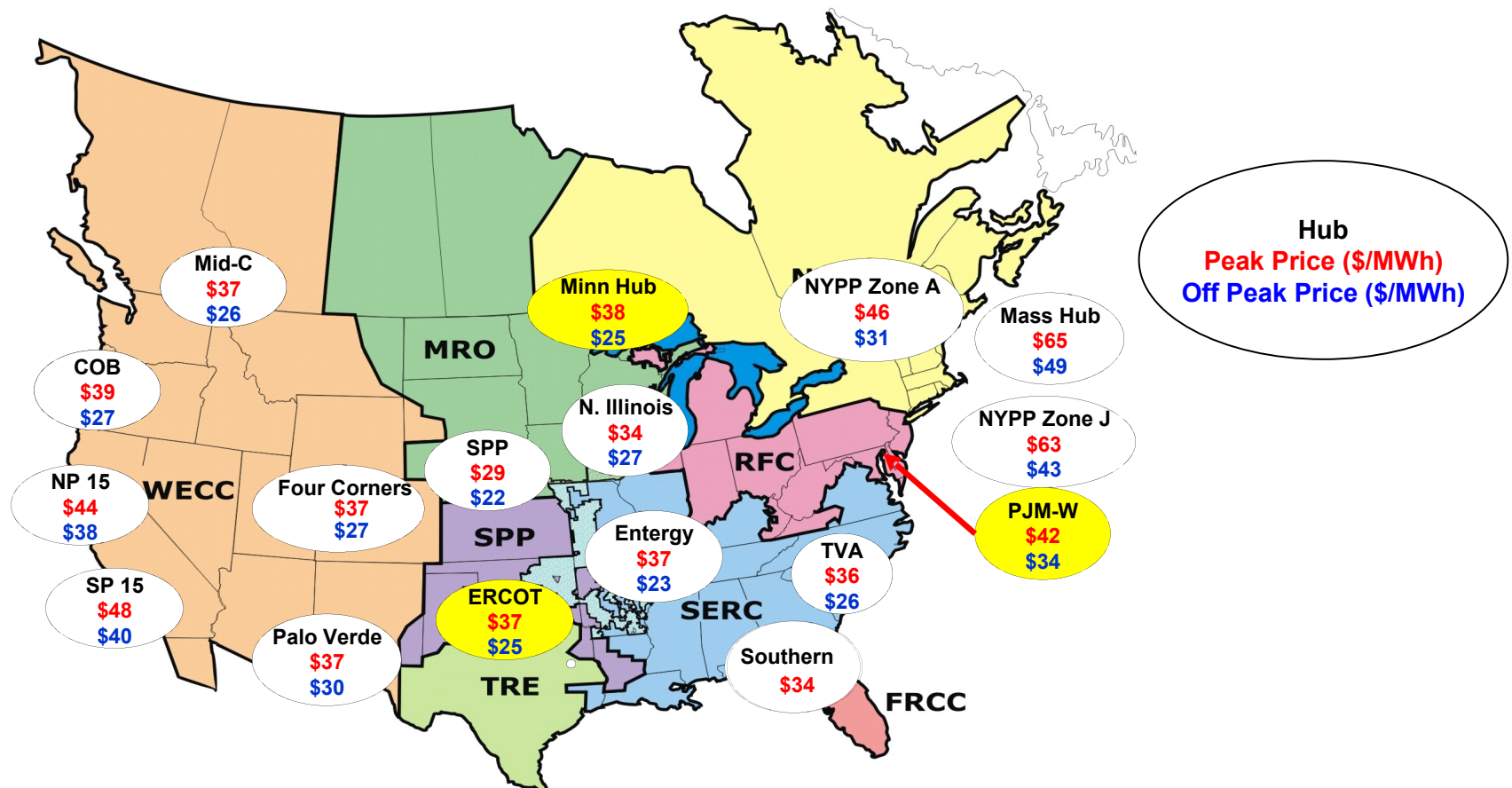
Current energy margins (excluding capacity revenues) already low for merchant coal plants due to low gas prices, low demand growth, and new renewables

- Current dispatch costs for an existing coal plant ~\$20-35/MWh
- Low wholesale power prices in 2013 (peak)
  - PJM West: ~\$45/MWh
  - Midwest (Illinois/Michigan): ~\$35/MWh
  - Southeast: ~\$35/MWh

# Economics of Retirement/Retrofit Decisions

## Wholesale power prices in 2013

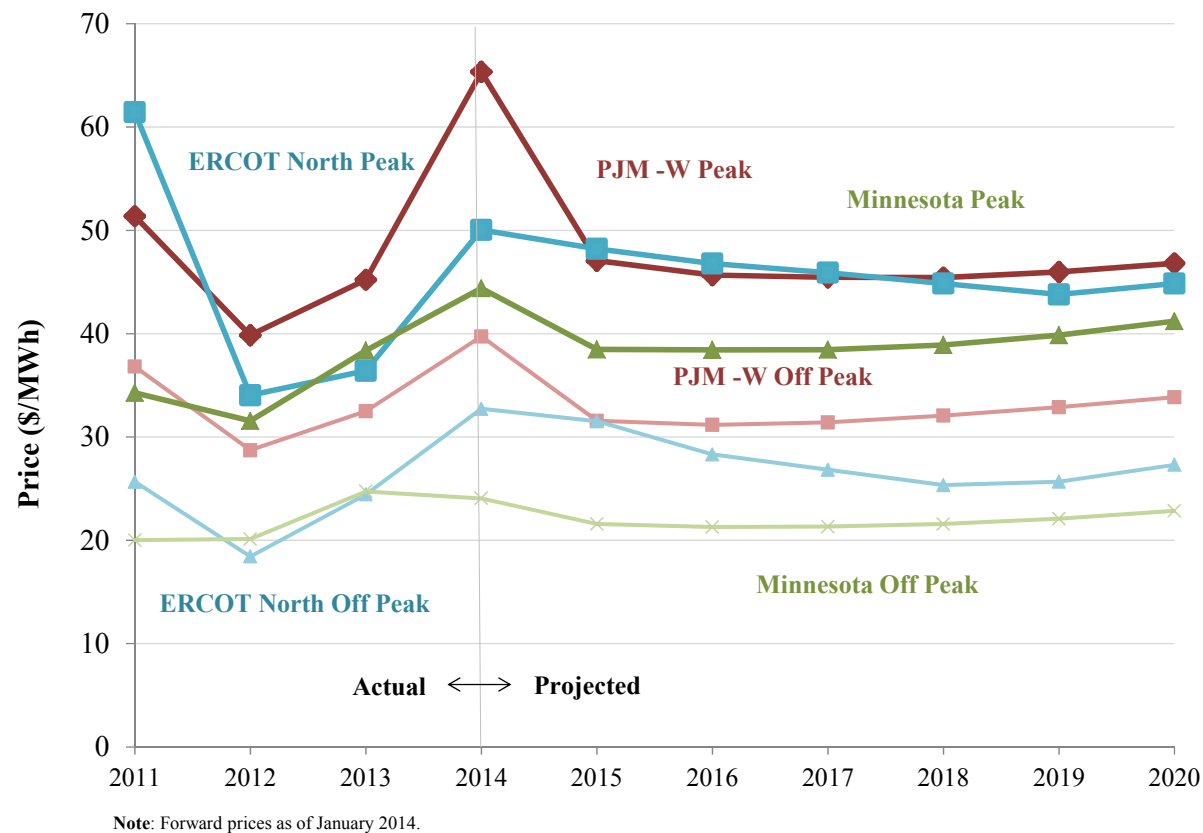
Power prices in 2013 continued to be low in coal-heavy regions due to low gas prices and depressed load conditions, although higher than 2012 prices.



# Economics of Retirement/Retrofit Decisions

## Current Electricity Futures

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



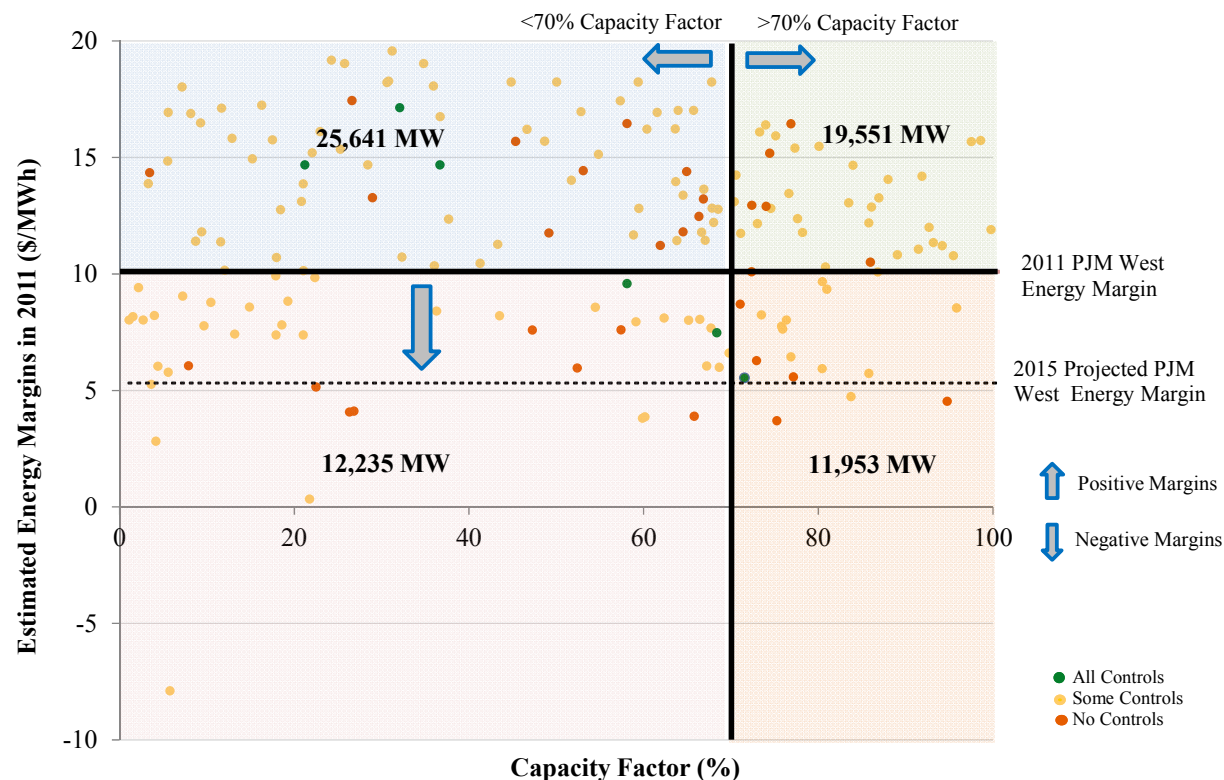
Forwards for 2015/16 and beyond may not be reflecting impact of future coal plant retirements.

# Economics of Retirement/Retrofit Decisions

## Energy Margins in PJM in 2011

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.

# Economics of Retirement/Retrofit Decisions

## Announced Coal Plant Retirements

**As of the end of December 2013, about 33 GW of coal capacity have been announced for retirements by 2021**

- 75% (25 GW) by 2016
- 40 GW has either retired since 2012 or has been announced to retire by the end of 2016
- Most lack major environmental controls

### Announced and Actual Coal Plant Retirements

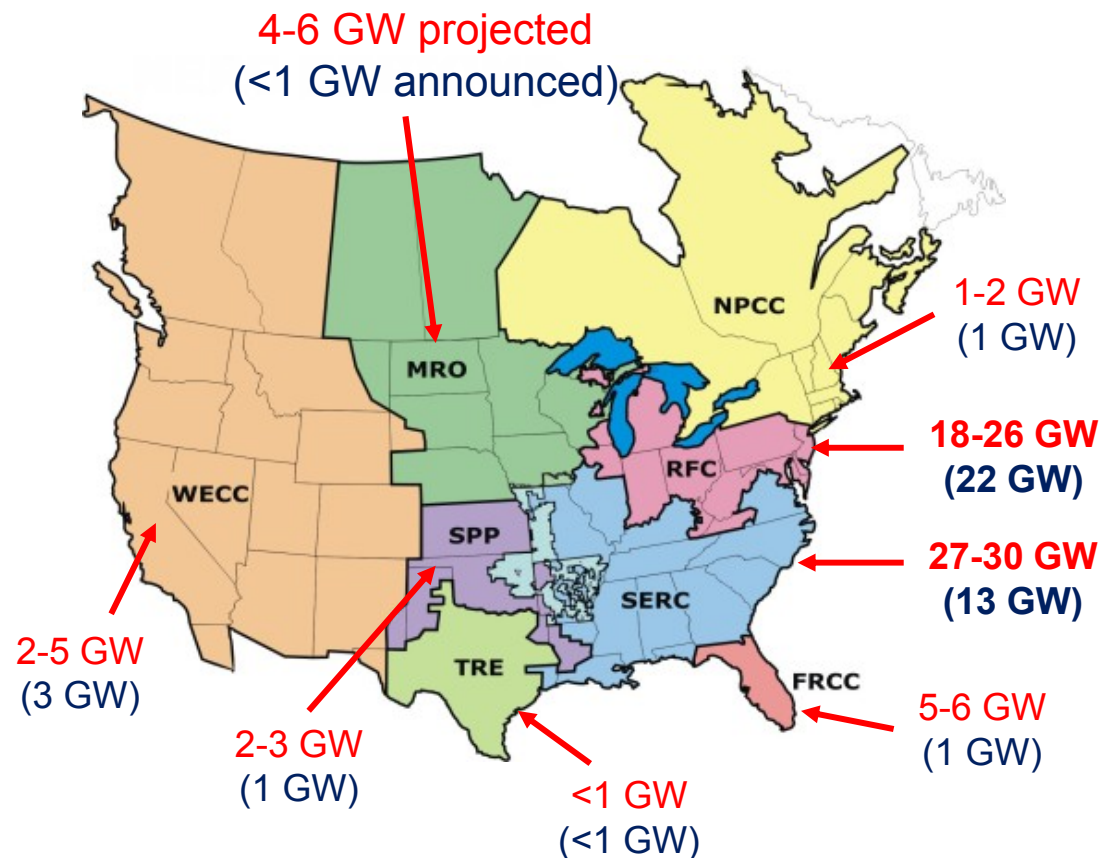
Year of Retirement	Number of Units	Capacity (MW)
2012	87	9,011
2013	47	6,041
<b>Total Actual</b>	<b>134</b>	<b>15,052</b>
2014	31	3,469
2015	101	16,919
2016	27	4,616
<b>Total 2014-2016</b>	<b>159</b>	<b>25,004</b>
2017	18	4,147
2018	6	1,898
2019	2	1,420
2020	2	780
2021	1	162
<b>Total 2012-2021</b>	<b>322</b>	<b>48,464</b>

# Economics of Retirement/Retrofit Decisions

## Projected (& announced) Coal Plant Retirements by NERC Region

In our Oct 2012 study\*, we projected 59-77 GW of coal plant capacity at risk for retirement during 2012-2016.

Most of the projected and announced retirements by 2016 are in SERC (27-30 GW, 13 GW announced) and RFC (18-26 GW, 22 GW announced) reliability regions.



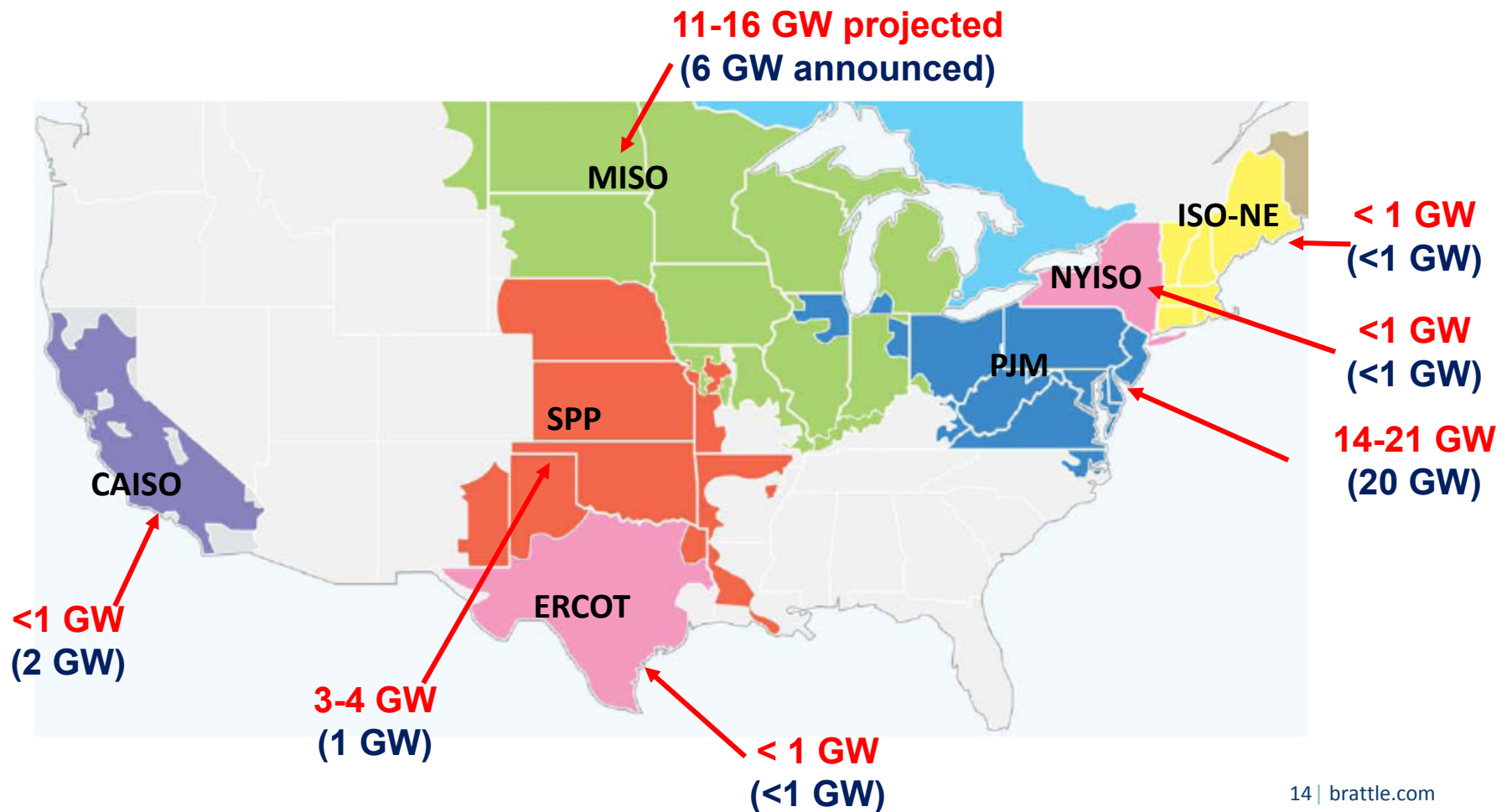
(\*): Metin Celebi, Frank C. Graves, and Charles Russell, "Potential Coal Plant Retirements: 2012 Update", October 2012, posted at [http://www.brattle.com/system/publications/pdfs/000/004/678/original/Potential\\_Coal\\_Plant\\_Retirements\\_-\\_2012\\_Update.pdf?1378772119](http://www.brattle.com/system/publications/pdfs/000/004/678/original/Potential_Coal_Plant_Retirements_-_2012_Update.pdf?1378772119) 13 | brattle.com



# Economics of Retirement/Retrofit Decisions

## Projected (& announced) Coal Plant Retirements by RTO Region

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

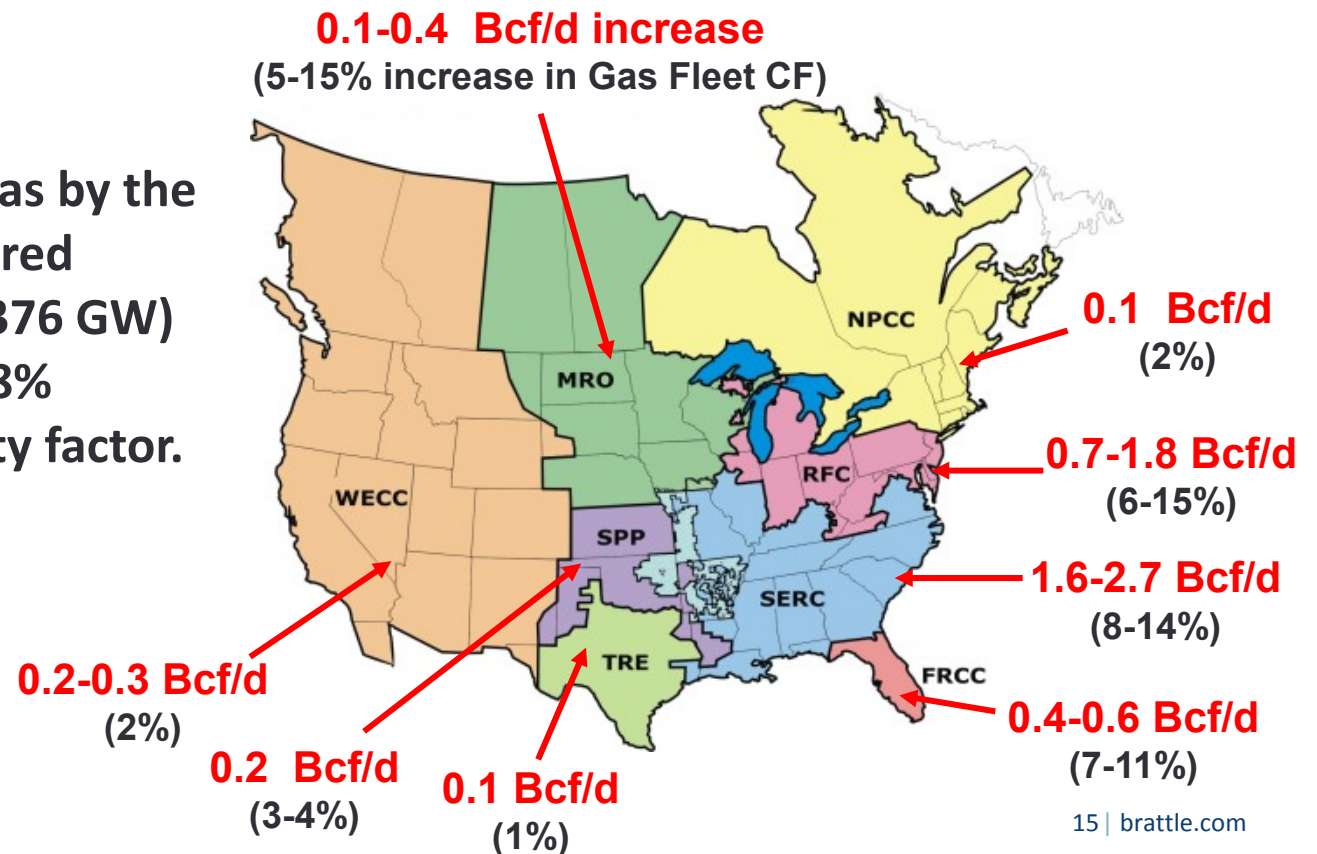


# Impact of Retirements on Gas and Power Prices

## Gas Demand

Retirement of 59 GW of coal capacity (280 TWh generation in 2011) by 2016 could result in 3.3-6.1 Bcf/d increase in gas demand, depending on share of gas in marginal fuel mix.

Increased use of gas by the existing U.S. gas-fired generation fleet (376 GW) would result in 5-8% increase in capacity factor.



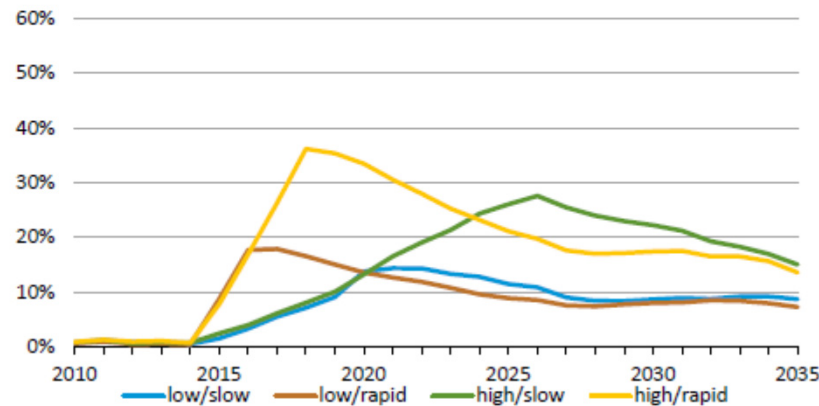


# Impact of Retirements on Gas and Power Prices

## Gas Price Impact

A 2012 EIA study<sup>(\*)</sup> 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 on Gas and Power Prices

## Energy Price Impact

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### **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.

### **Forward energy prices may not reflect all of these impacts (or may have overshoot):**

- Forwards are traded only a few years into future
- Forward prices depend on market expectations on a few key factors, such as gas prices w/ and w/o retirements, future environmental regulations, timing and mix of replacement capacity
- Forward prices may also be too high if the environmental regulations turn out to be more lenient than expected

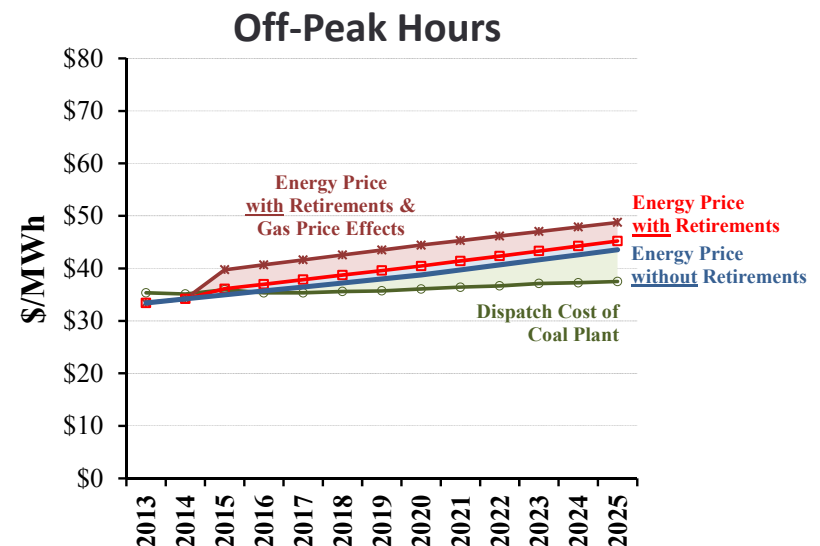
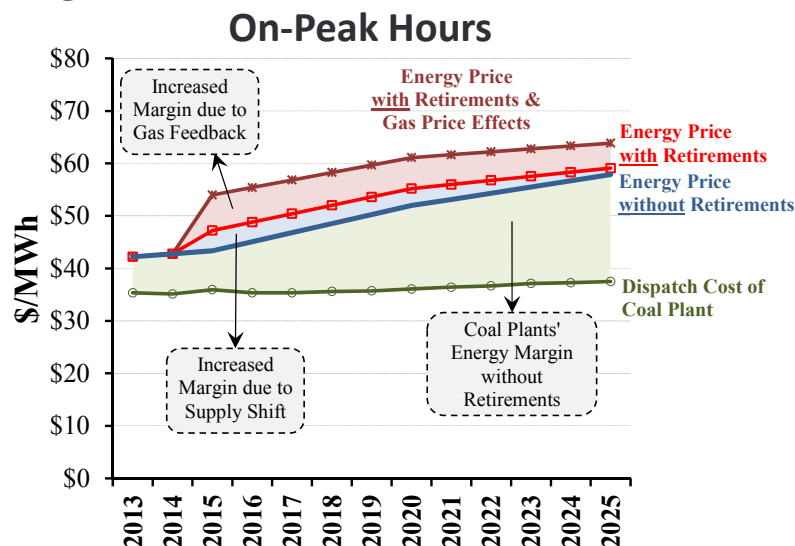
# Impact of Retirements on Gas and Power Prices

## Energy Price Impact – Regional Studies

MISO<sup>[1]</sup> -- 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)

Eastern PJM<sup>[2]</sup> -- With 2.8 GW (15%) of coal capacity retiring, PJM-MAAC energy prices could increase by \$5-10/MWh until replacement capacity comes online



[1]: Rebuttal Testimony Of Metin Celebi for Wisconsin Public Service Corporation, Docket 6690-CE-197, December 14, 2012.

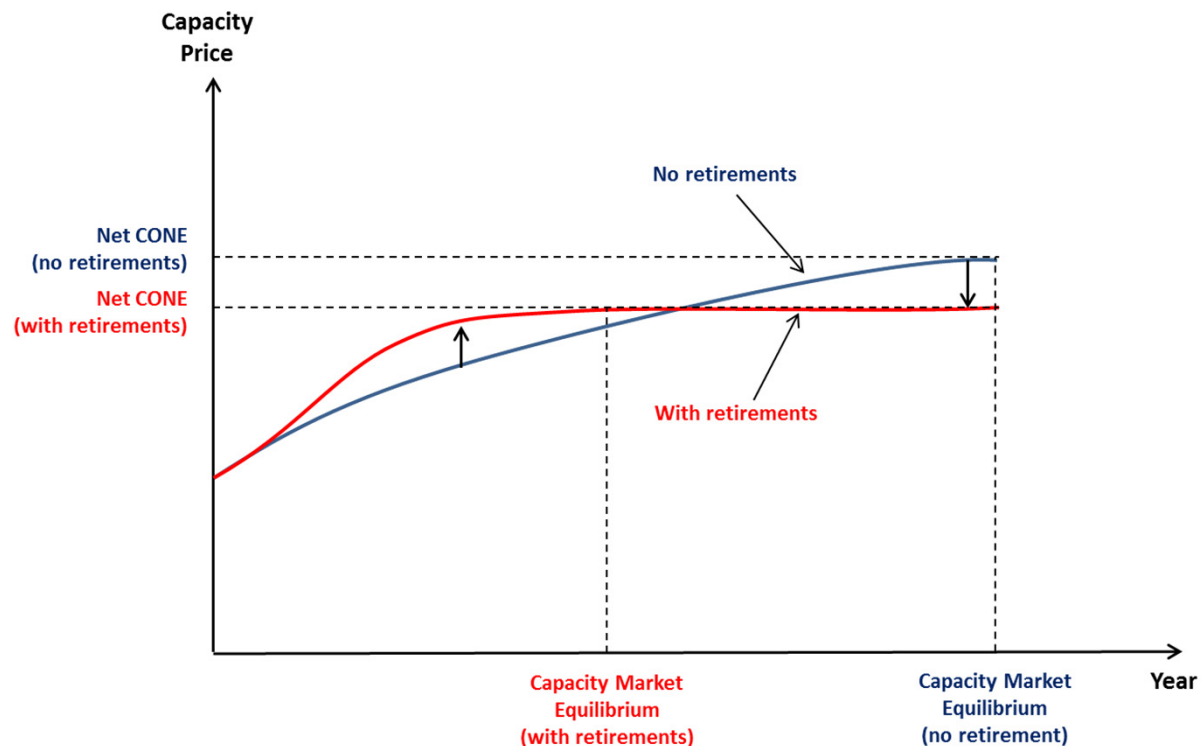
[2]: Onur Aydin, Frank C. Graves, and Metin Celebi, "Coal Plant Retirements: Feedback Effects on Wholesale Electricity Prices", The Brattle Group, Inc., November 2013.

# Impact of Retirements on Gas and Power Prices

## Capacity Price Impact

In regions with auction-based capacity markets, retirements would:

- Increase near-term capacity prices until replacement capacity comes online
- Decrease long-term capacity prices as the higher margins from energy prices reduce Net CONE (long-term marginal cost of capacity)





# APPENDIX

# Key Environmental Regulations

## Cooling water intake structures (316(b))

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**EPA proposed a rule in March 2011 to regulate cooling water intake structures (CWITs) at large power plants to reduce injury and death of fish and aquatic life**

- Applies to 670 power plants using more than 2 million gallons per day of cooling water

**The proposed rule does not require closed-loop cooling (cooling tower) for all existing facilities**

- Impingement: limits on mortality (through modified traveling screens) or speed of water intake
- Entrainment: Applies to large plants (> 125 million gallons per day), decided by state permitting agencies on a case-by-case basis, may include cooling towers

**Final rule was expected on January 14, 2014 (with compliance deadlines still uncertain), but is delayed**

# Combustion by-products (ash) regulations

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Covers the handling of combustion by-products at coal plants including bottom ash, fly ash, boiler slag and FGD materials (*e.g.*, gypsum)

**EPA proposed two options in 2010:**

- ◆ Regulate as hazardous waste under Subtitle C of Resource Conservation and Recovery Act (RCRA)
- ◆ Regulate under Subtitle D similar to those for municipal and non-hazardous solid waste, hence less stringent than the first option.

**In both options, it is likely that by the end of this decade:**

- ◆ Wet ash ponds will be eliminated or converted to dry landfills for most plants
- ◆ Dry collection systems for bottom ash and fly ash will be installed

**Final rule is expected to be under the non-hazardous Subtitle D, and will be issued by December 19, 2014**

# Regional Haze Rule

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**Aims to reduce haze-forming pollution (primarily due to emissions of particulate matter and its precursors SO<sub>2</sub> and NO<sub>x</sub>) that reduces visibility in parks and wilderness areas, especially in the Western U.S.**

**Each state develops State Implementation Plans (SIPs) to reduce haze through requirements at certain coal-fired generation plants to install proven, cost effective and commercially available emission control equipment (Best Available Retrofit Technology, or BART).**

- Certain plants built during 1962-1977 are covered

**EPA may either approve (fully or partially) or disapprove the SIP, or issue a Federal Implementation Plan (FIP).**

**Compliance date: Typically five years after EPA's ruling for each plant (ongoing, most recent proposed ruling was for Wyoming in June 2013)**

**Compliance options (cost range due to unit size):**

- NO<sub>x</sub> reductions: SCR (\$200-300/kW), SNCR (~\$50/kW), or combustion controls
- PM: baghouse (\$200-\$500/kW),
- SO<sub>2</sub>: scrubber (\$450-900/kW), DSI (~\$40/kW)



## Presenter Information

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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.

The views expressed in this presentation are strictly those of the presenter(s) and do not necessarily state or reflect the views of The Brattle Group, Inc.

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