The Brattle Group

Environmental Retrofits: Costs and Supply Chain Constraints

Presented at MISO Annual Stakeholders' Meeting Indiana

Presented by

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The Brattle Group

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Agenda

- Emerging EPA regulations
- Description of the MISO coal fleet
- Description of environmental retrofit equipment
- Projected retrofits and retirements
- Supply-chain constraints for projected retrofits and new generation

Emerging EPA Regulations

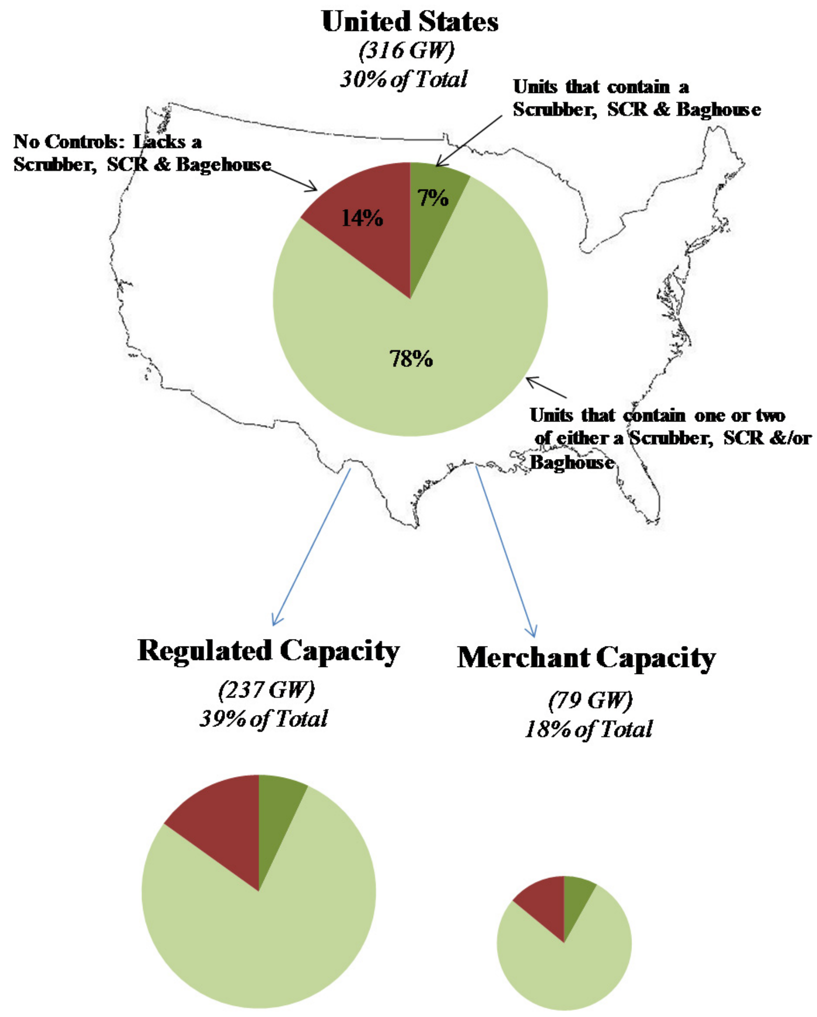
Regulation	Status	Pollutant Targeted	Compliance Options	Expected Date of Compliance
CSAPR	Final rule, delayed with court ruling	NO_x, SO_2	SCR/SNCR, FGD/DSI, fuel switch, allowance purchases	2012(?) and 2014
MATS	Final	HAPs (mercury, acid gases, PM)	ACI, baghouse, FGD/DSI	2015/2016
316(b)	Proposed, revisions likely	Cooling water	Impingement: Mesh screens; Entrainment: 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
Revised Ozone Standard	Potential revision in 2013	NO_x	SCR/SNCR (and allowance purchases under CSAPR)	???

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) owned by merchant companies

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

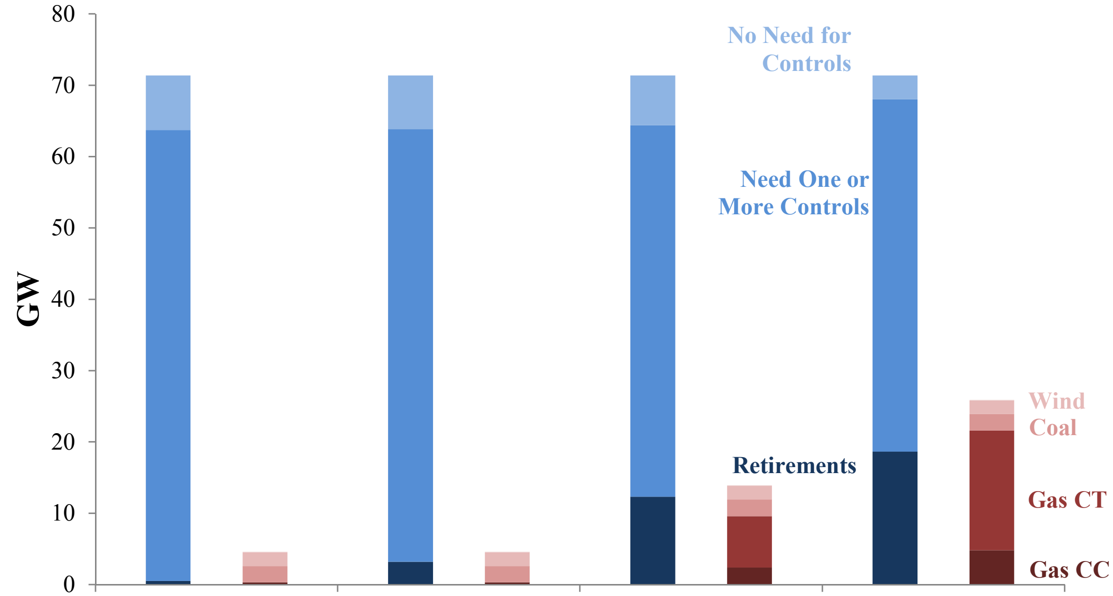


Projected Retrofits and Retirements in MISO to Comply with MATS

Retrofits: Out of the 71 GW coal fleet, 49-63 GW will likely need to install at least one control

Retirements: Up to 19 GW by 2016, though likely in 3-13 GW range

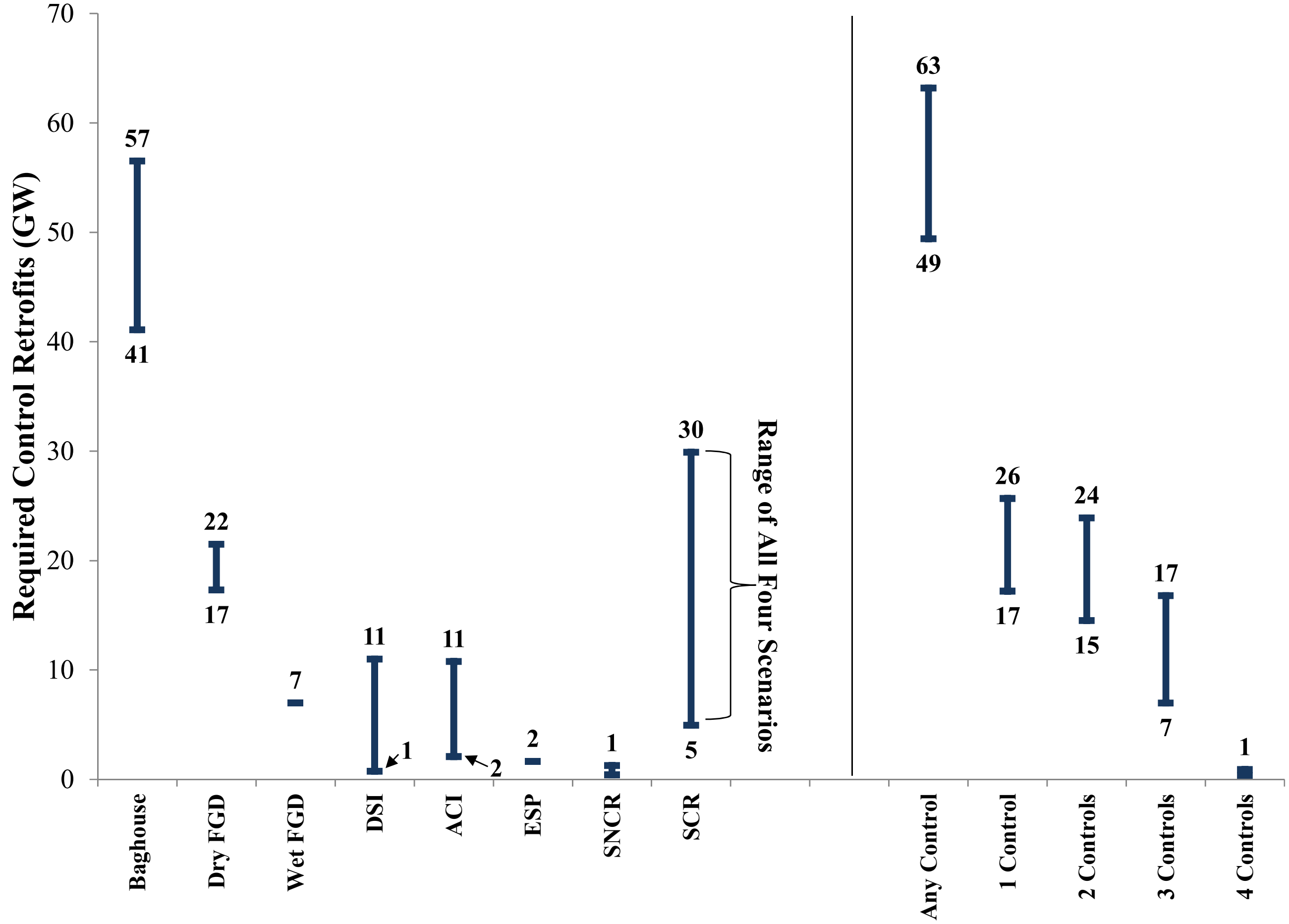
New Gen: Up to 26 GW needed by 2016, likely in 5-14 GW range



	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Existing Coal Fleet	New Builds	Existing Coal Fleet	New Builds	Existing Coal Fleet	New Builds	Existing Coal Fleet	New Builds
No Need for Control	8		7		7		3	
Need 1 or More Control	63		61		52		49	
Retirement	1		3		12		19	
Total	**71**		**71**		**71**		**71**	
Renewable - Wind		2		2		2		2
Coal		2		2		2		2
Gas - CT		0		0		7		17
Gas - CC		0		0		2		5
Other		0		0		0		0
Total		**5**		**5**		**14**		**26**

Required Controls for MISO Coal Fleet

49-63 GW of coal capacity is likely to require at least one control retrofit to comply with MATS.



Description of Key Control Equipment

Decreasing capital cost ↓

	Targeted Pollutant	
Technology	**Primary**	**Co-benefit**
Wet/Dry FGD	SO_2, acid gases	Mercury, particulates
SCR	NOx	Mercury
Baghouse	Particulates	Mercury
SNCR	NOx	
DSI	SO_2, acid gases	Mercury, NOx
ACI	Mercury	

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)

	Unit Size (MW)		
Equipment	**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)

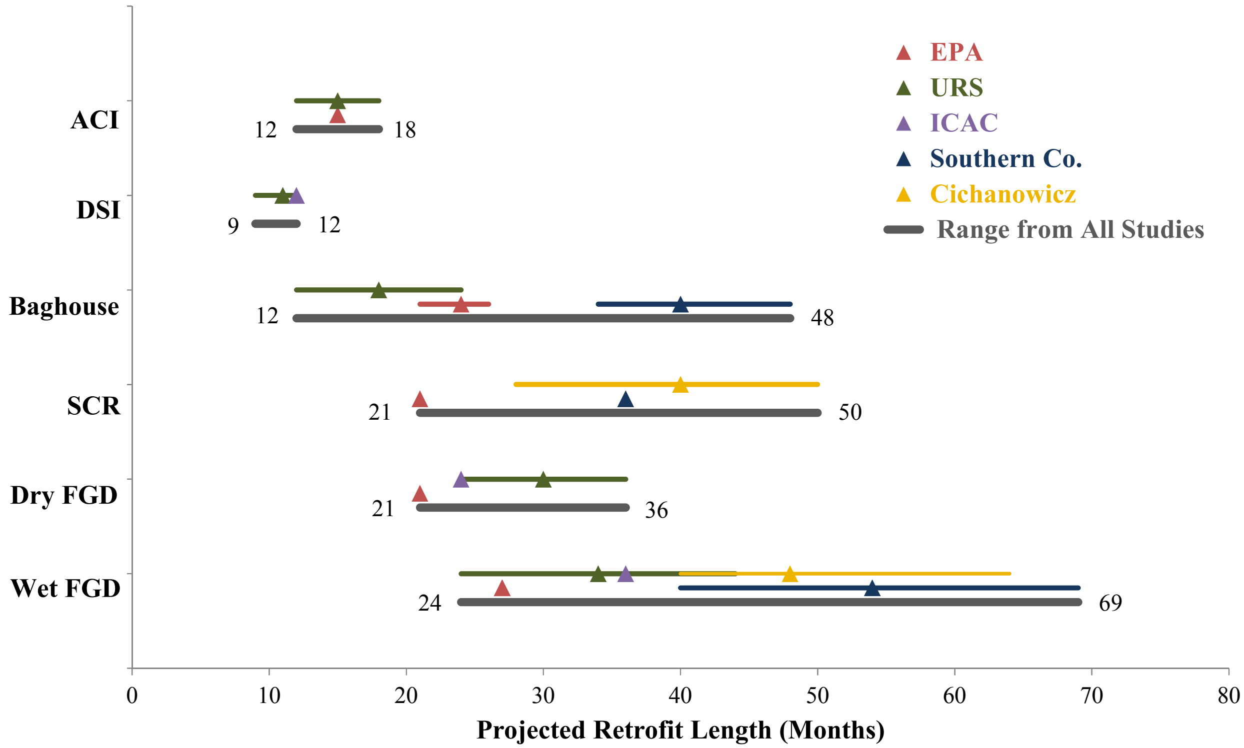
	Capacity Factor	
Equipment	**30%**	**70%**
Wet Scrubber	$ 50.80	$ 22.91
Dry Scrubber	$ 43.57	$ 20.13
DSI	$ 10.10	$ 8.15
SCR	$ 15.40	$ 7.37
SNCR	$ 4.38	$ 2.48
Baghouse	$ 23.25	$ 9.98
ACI	$ 2.88	$ 1.91

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 2011
  - PJM West: ~$47/MWh
  - Midwest (Illinois/Michigan): ~$33-35/MWh
  - Southeast: ~$32-35/MWh

Typical Timelines for Retrofit Technologies

ACI and DSI can be deployed in 1-1.5 years, while FGD and baghouse can take 3-5 years.



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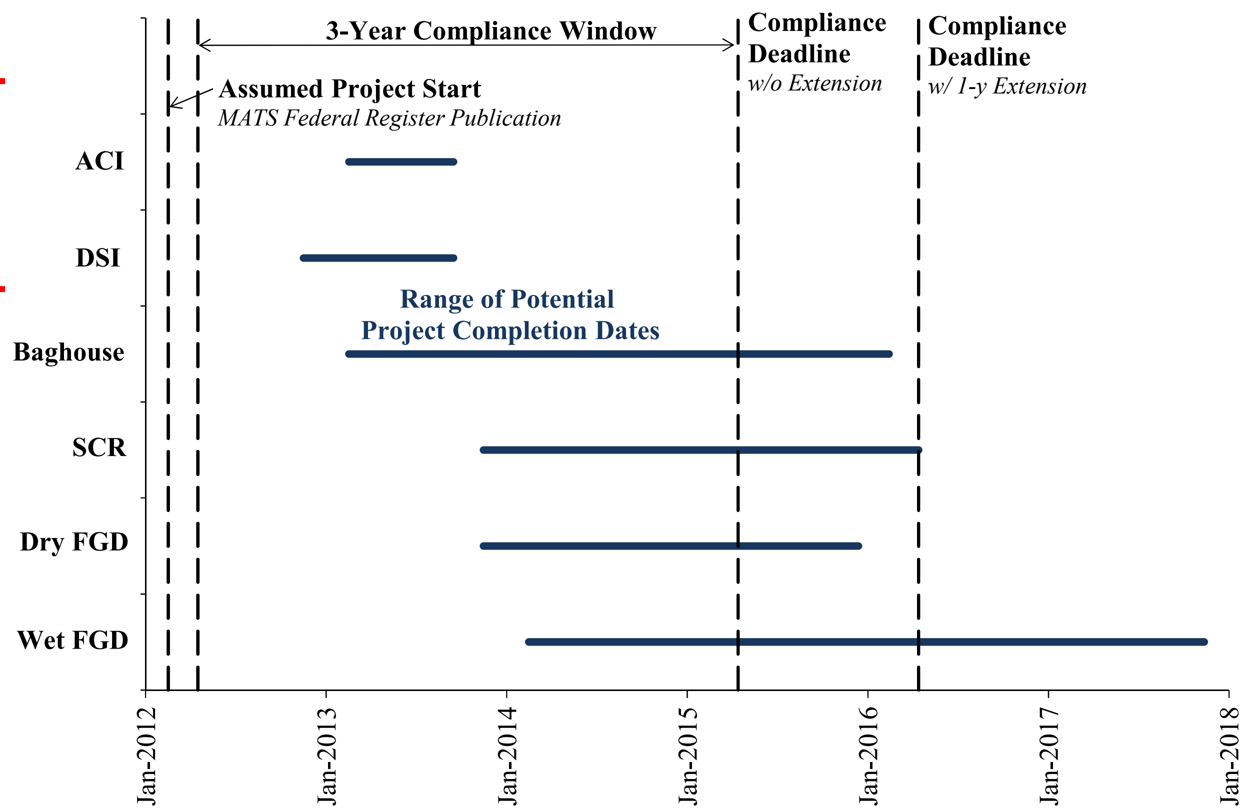
Feasibility of MATS Compliance -- Timeline

Unless the construction already started, meeting the 3-year deadline (April 2015) would be challenging for some controls.

ACI and DSI projects are relatively short, so no time constraints expected.

But, even a 1-year extension may not be enough for Wet FGD projects that have not yet started.



Outage Days to Install Retrofits

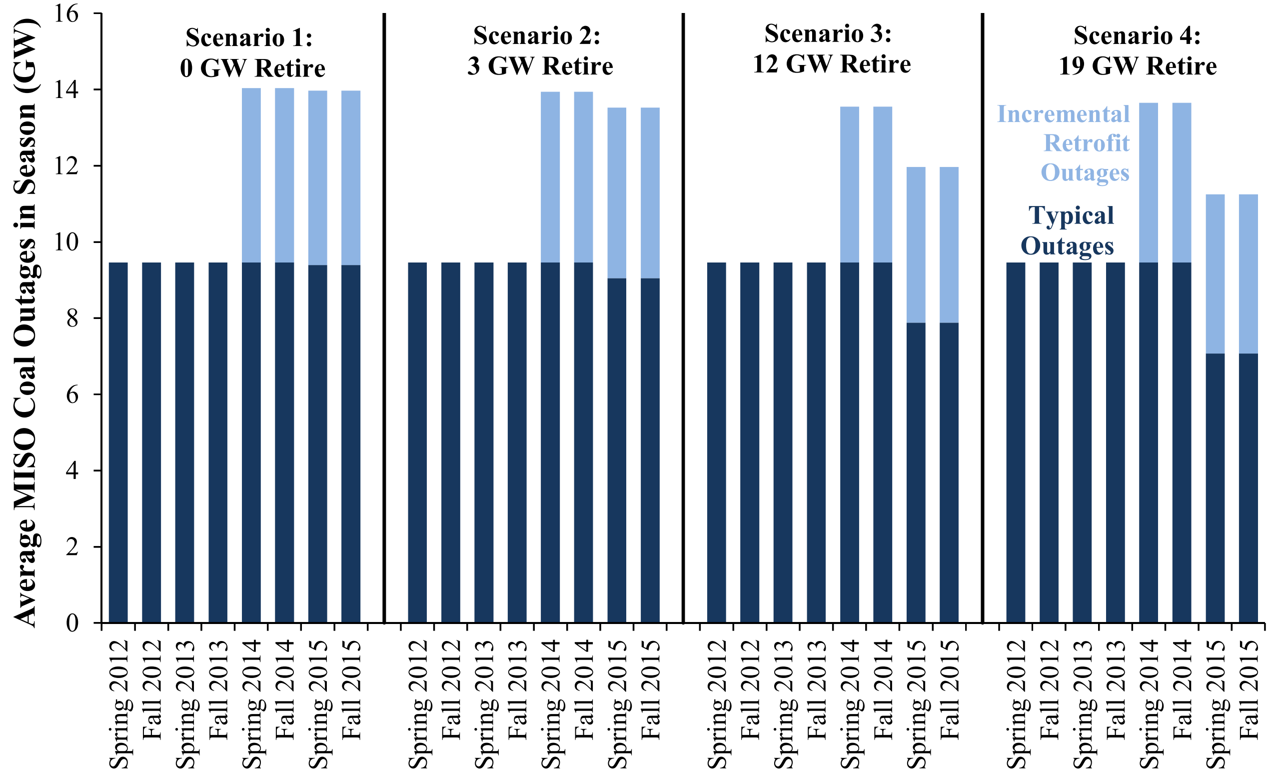
Incremental outage days are as low as less than a week for ACI, DSI, SNCR and DSI, while baghouse installation requires more than three additional weeks.

Outage Type	Average Outage Length *(days)*	Incremental Outage Time *(days)*
Without Retrofit	30.4	n/a
With Retrofit		
Wet FGD	50.5	20.1
Dry FGD	38.2	7.8
DSI	36.0	5.6
Baghouse	54.7	24.2
SCR	49.3	18.8
SNCR	31.8	1.3
ACI	36.4	6.0

Projected Outage Needs in MISO

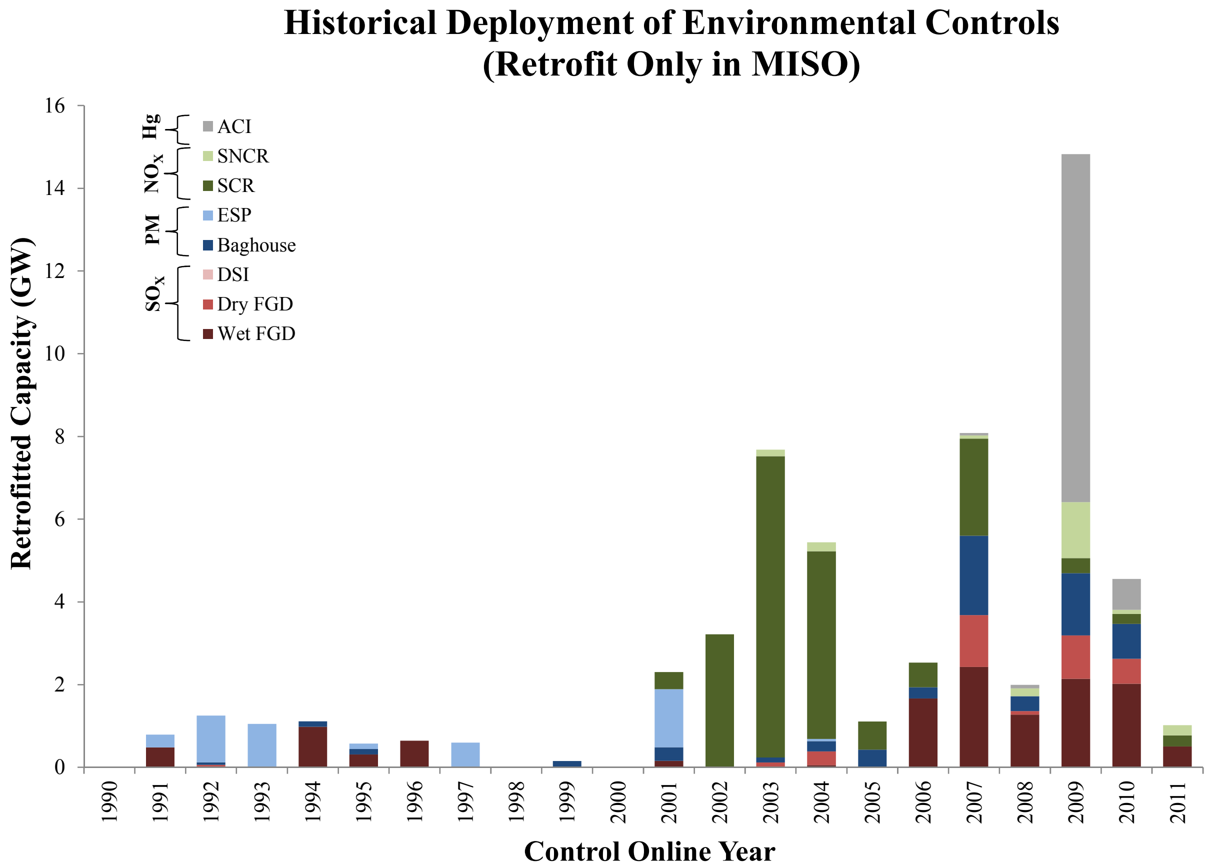
About 4 GW of additional outages needed during the last four outage seasons prior to the 1-year extension deadline.

Total coal capacity on outage (12-14 GW) may create reliability concerns if coal retirements exceed 12 GW.



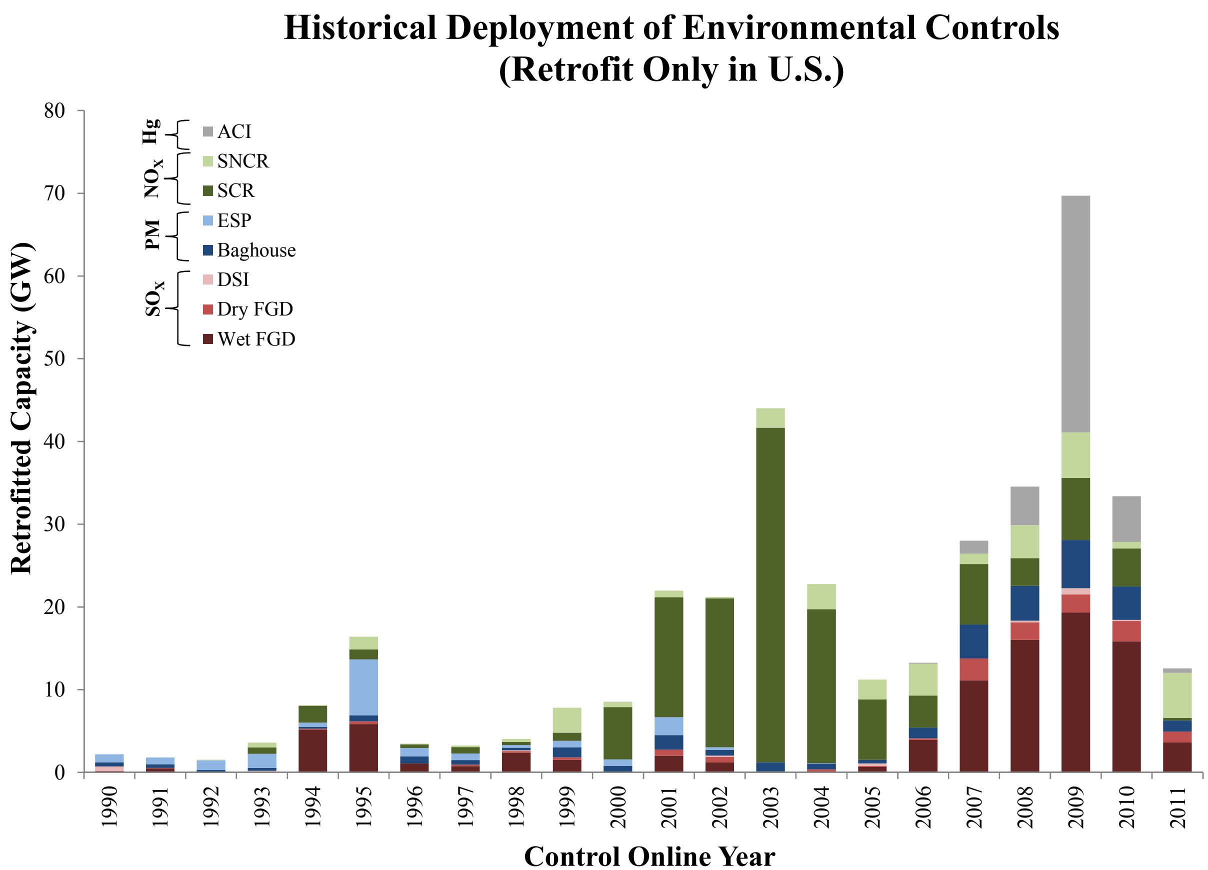
Historical Retrofits in Midwest

- Few retrofits in the 1990s, then reached as high as 15 GW per year in 2009
- More capital-intensive projects (SCR, FGDs) in 2007 relative to 2009 when ACI retrofits were the largest type.



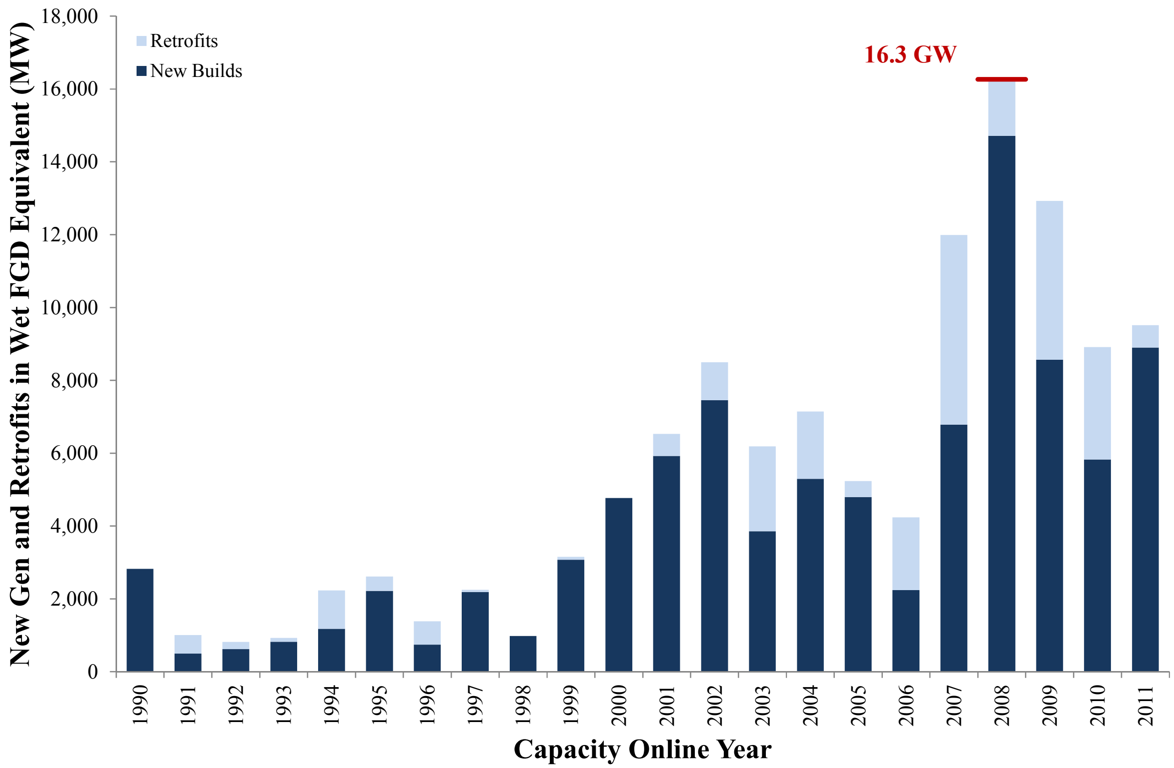
Historical Retrofits in U.S.

- Similar to Midwest, few retrofits in the 1990s nationwide, then reached as high as 70 GW per year in 2009
- Large fraction (~20 GW) of the retrofits in 2009 from FGDs, while SCR was the dominant retrofit type in early 2000s.



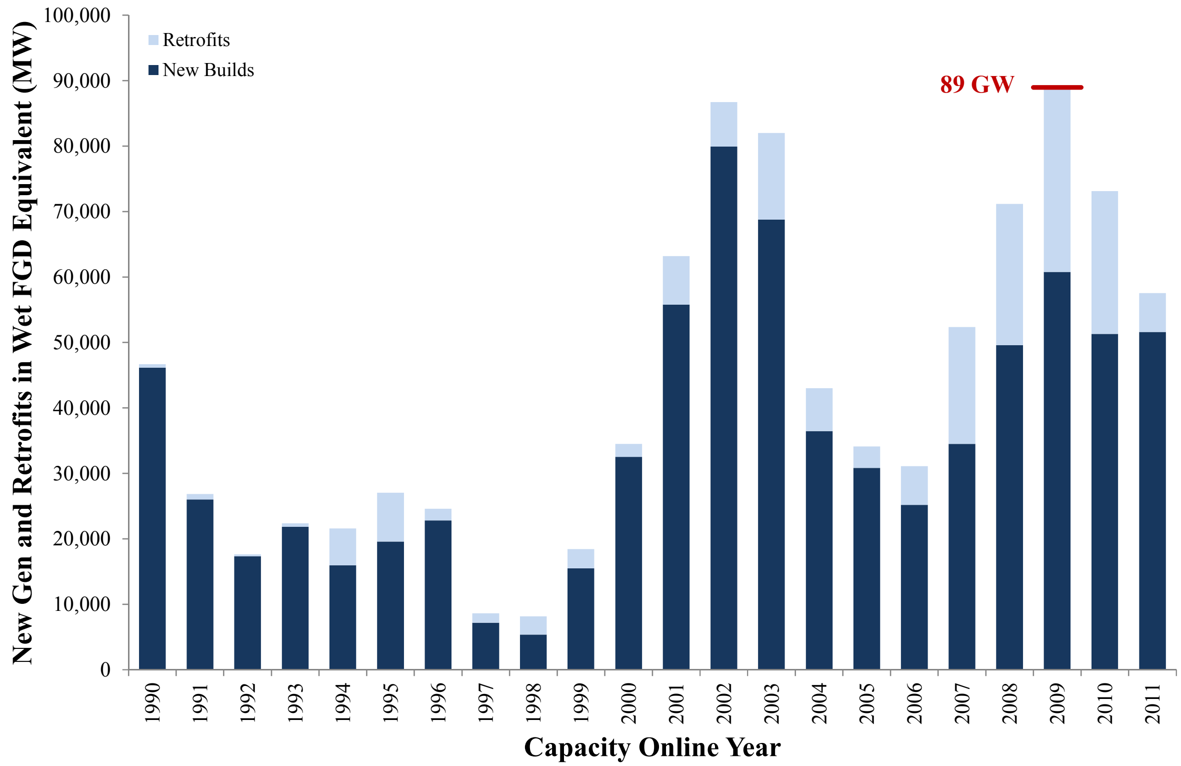
Historical Retrofits + New Gen in Midwest

- Historical retrofits and new builds in MISO reached a max of 16 GW ("wet FGD equivalent") in 2008, largely due to new wind plants
- Conversion to "wet FGD equivalent" capacity is done by using ratio of capital costs relative to wet FGD



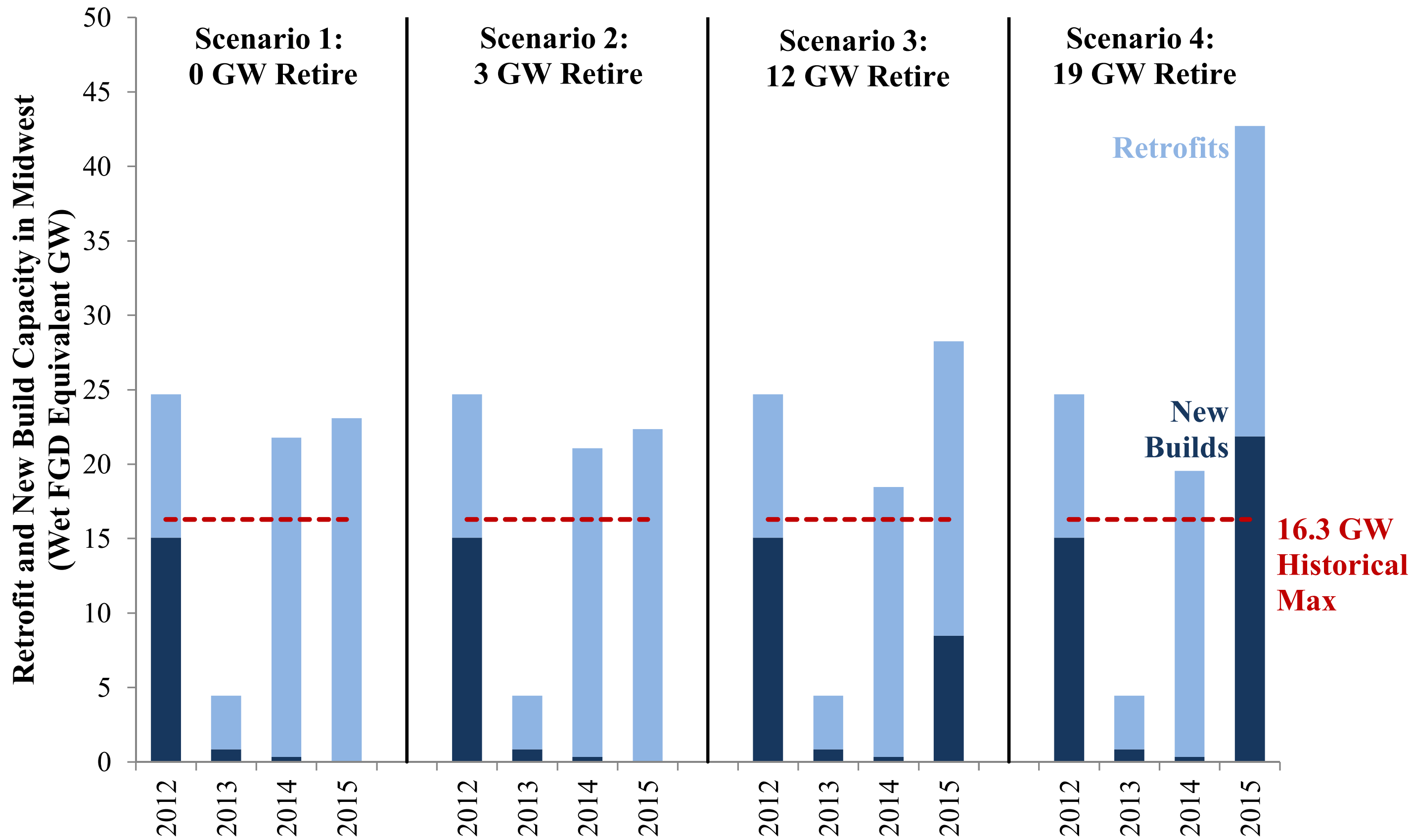
Historical Retrofits + New Gen in U.S.

- Historical max of 89 GW (wet FGD equivalent) in the U.S. for retrofits and new builds was in 2009 (with a close second in 2002)
- Large fraction of the historical activity from new builds, mostly from gas and wind plants since 2000



Historical vs. Projected Retrofits + New Gen in MISO

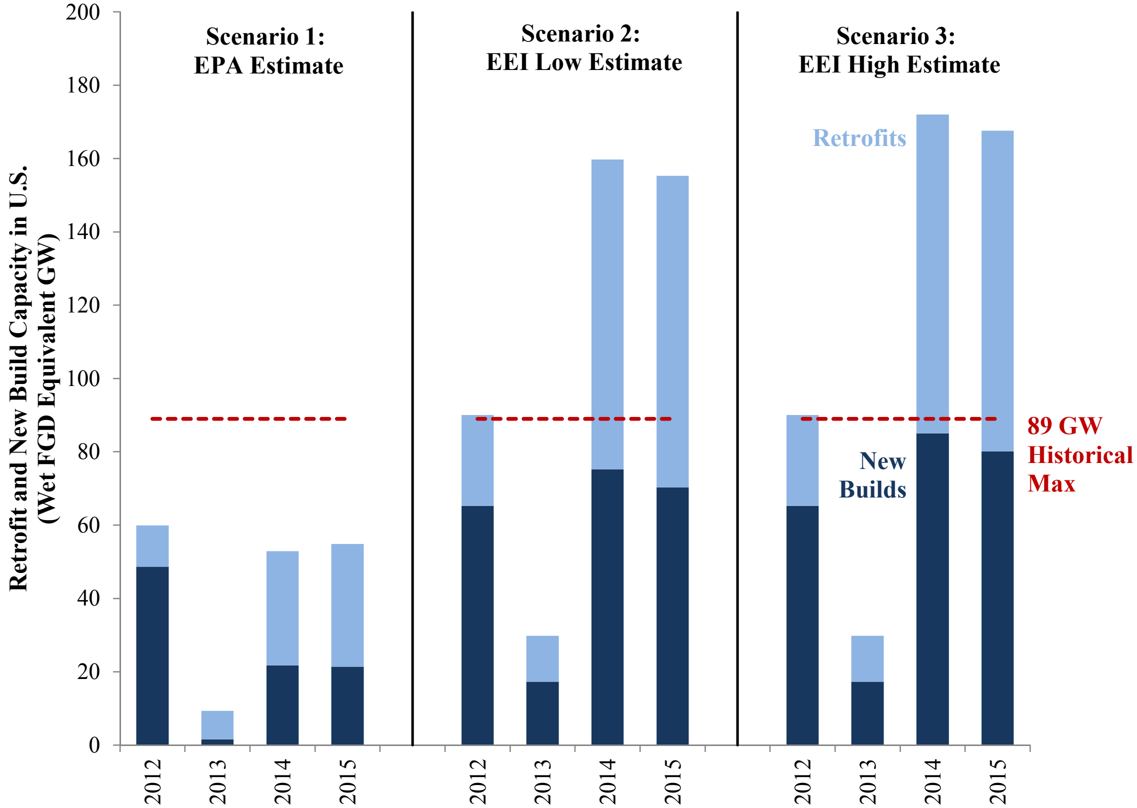
In all four MISO scenarios, projected retrofits plus new gen to meet the 3-year MATS deadline substantially exceed the historical max of 16 GW.



Historical vs. Projected Retrofits + New Gen in U.S.

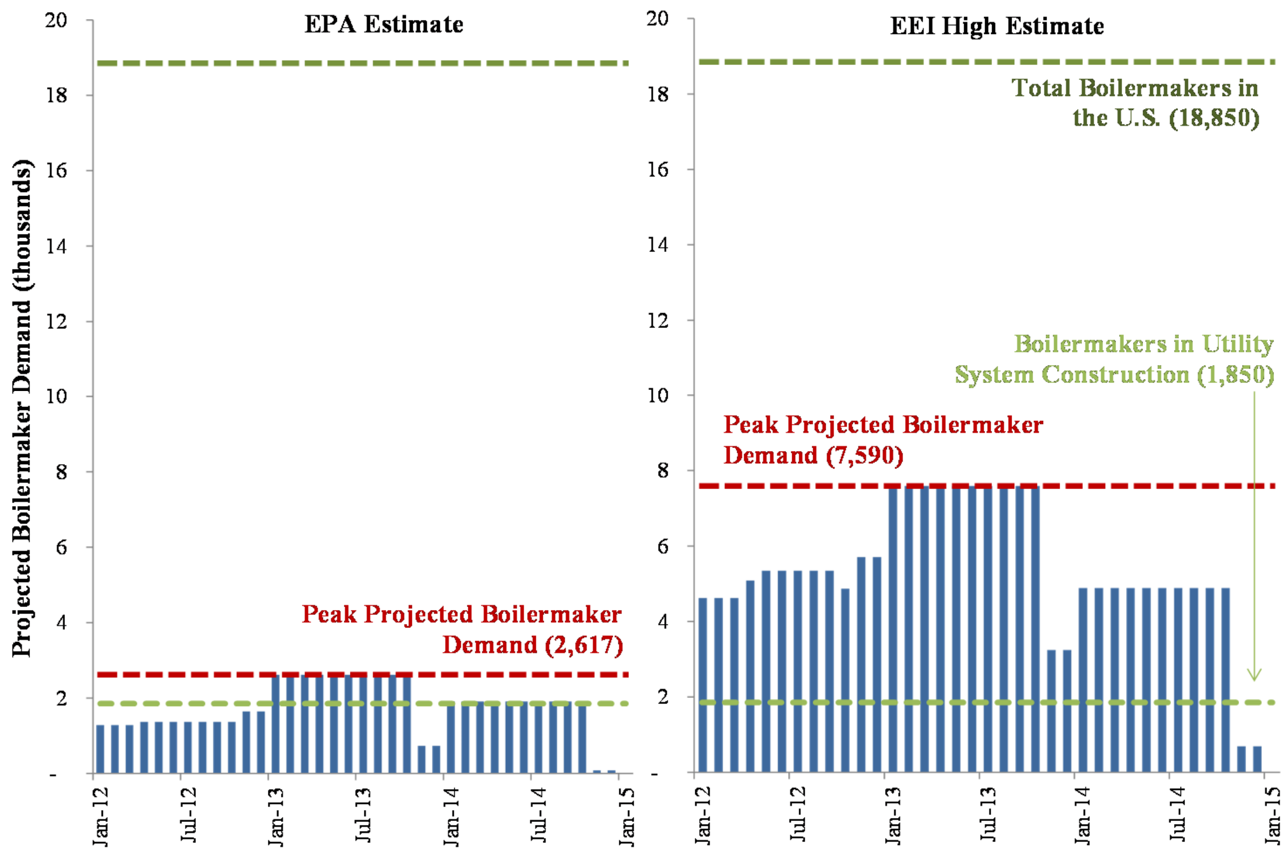
EPA's projection of retrofits plus new gen to comply with MATS is well below historical max of 89 GW.

However, EEI's projections for the retrofit plus new gen is almost double the historical max.



Projected Demand for Boilermakers in U.S.

MATS compliance could require as many as 40% of current boilermakers (7,590 out of 18,850) under the EEI's projected needs for retrofits and new gen, but only less than 15% under the EPA projections.



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Conclusions

Coal fleet in MISO is facing a substantial amount of retrofit installations (49-63 GW) to comply with EPA's MATS rule over the next 3-4 years

- Compliance planning is difficult due to other emerging regulations (CSAPR, 316(b), ash handling, CO_2) as well as uncertain future market conditions

Unless the construction already started, meeting the 3-year deadline (April 2015) under MATS would be challenging for some controls such as baghouses and FGDs.

Conclusions (cont'd)

Incremental outages of 4 GW per season needed to tie-in retrofits in MISO, which may require extending the outage season to 9 months as well as a potential need for extending compliance deadline beyond 2016.

To meet the 3-year MATS deadline, projected retrofits plus new gen in MISO substantially exceed the historical maximum of 16 GW (wet FGD equivalent) in 2008.

Nationwide, MATS compliance could require 15-40% of the current boilermakers working on retrofits and new generation.

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.

He holds a Ph.D. in Economics from Boston College and B.Sc. in Industrial Engineering from METU, Turkey.

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