Coal Capacity at Risk for Retirement in PJM:

Potential Impacts of the Finalized EPA Cross State Air Pollution Rule and Proposed National Emissions Standards for Hazardous Air Pollutants

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Central Question:
How Much Coal Generation is at Risk for Retirement?

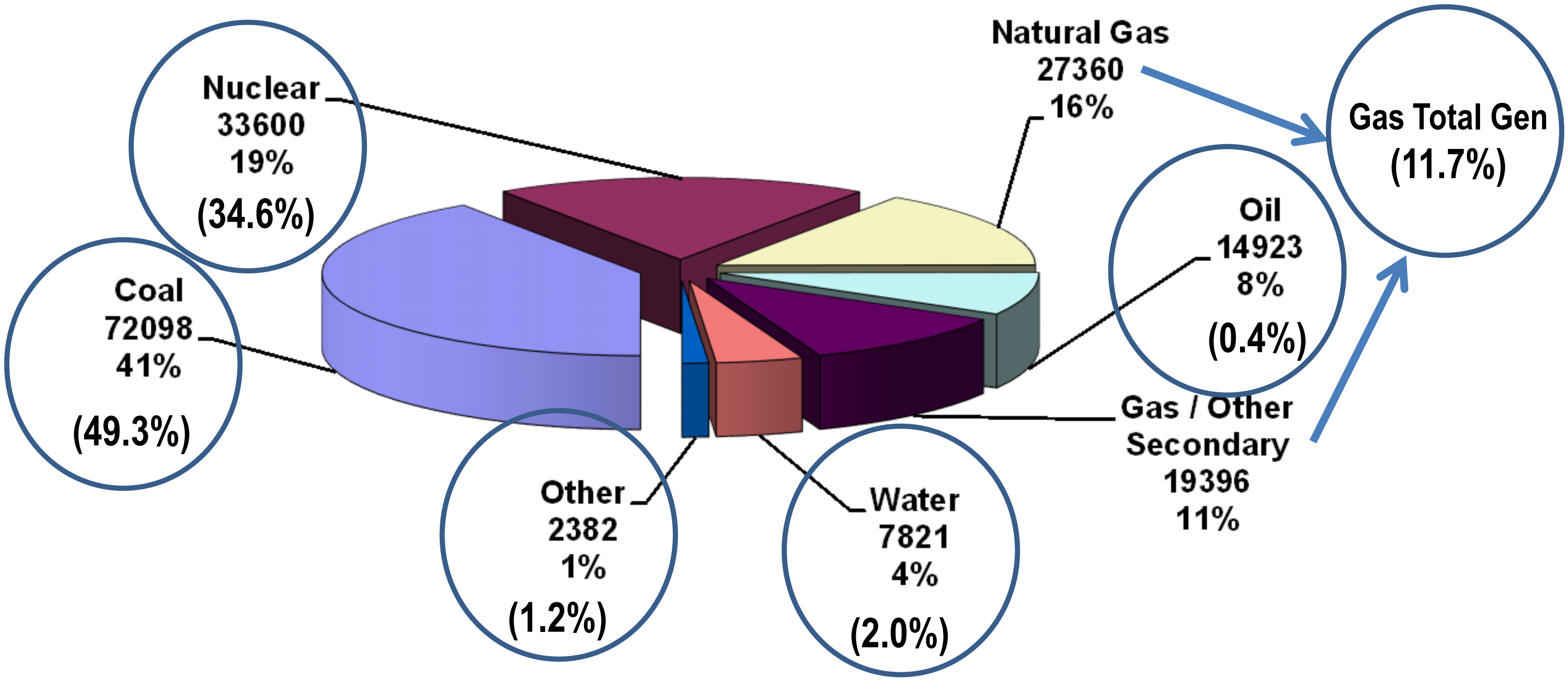
- How many megawatts (MW) of coal-fired generation are at risk for retirement?
  - Proposed EPA rules would effectively require costly environmental retrofits or force units to retire
  - How many coal units will retire, repower, or retrofit?
  - What are the prospects for retaining existing coal units?
  - Is there a resource adequacy problem in the future?
  - Impacts have been seen in the upcoming 2014/2015 capacity market auction in May 2011 and will be seen again in the 2015/2016 auction
- This presentation will look at the possible effects of the proposed Transport and Hazardous Air Pollutant rules

Broad Policy Context

PJM RTO

(MidAtlantic, AP, ComEd, AEP, Dayton, Duquesne, Dominion, & ATSI Regions)

Capacity By Fuel Type -- 177,579 MW installed generation capacity

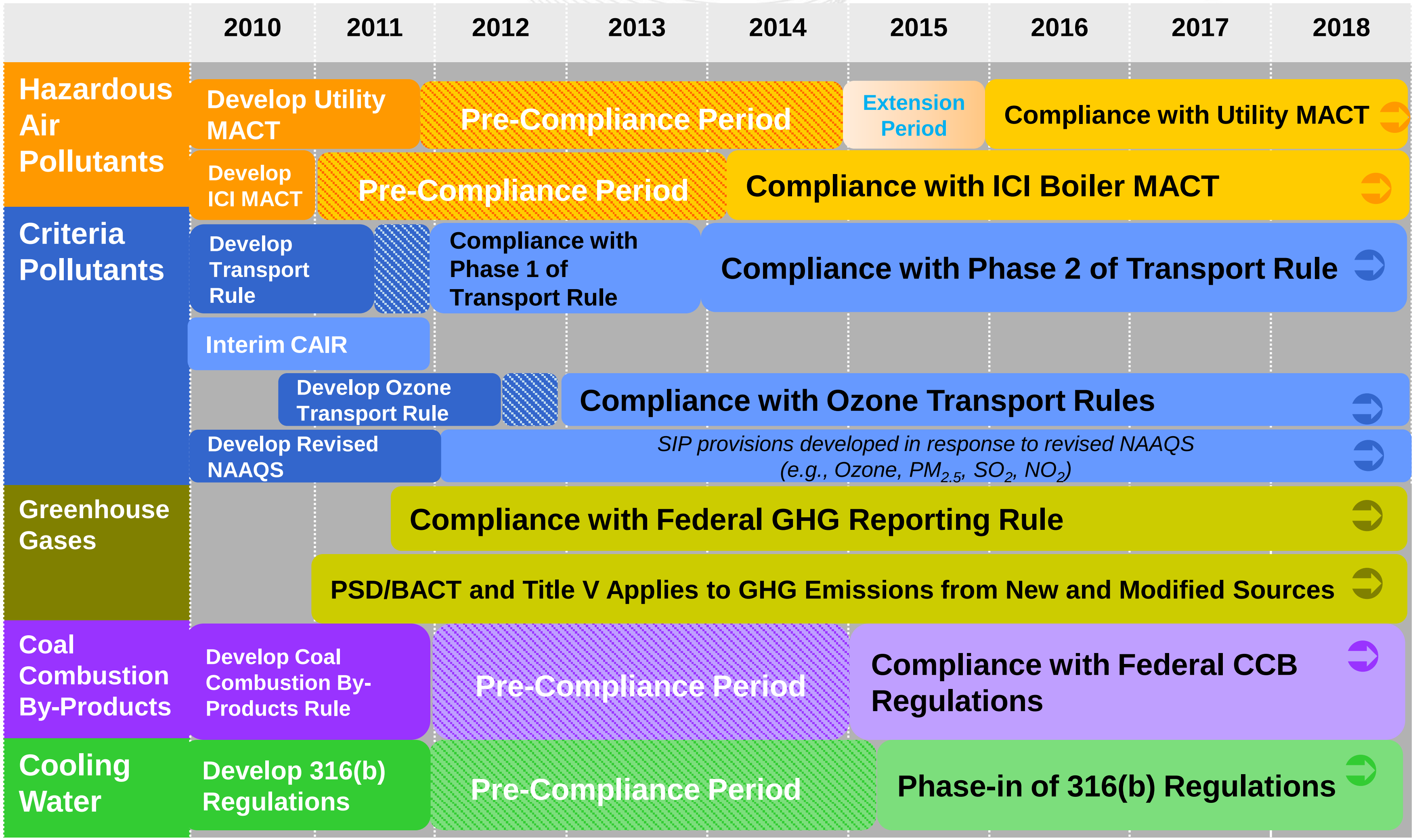


Percentage of 2010 Generation in parentheses

Stylized Summary of Environmentally Related Rules Impacting Resource Adequacy

	GHG Tailoring Rule	Cross State Air Pollution Rule	NESHAP	CWA 316(b)	High Electricity Demand Day	Renewable Portfolio Standards
Pollutant or target issue	CO_2 and other GHG	SO_2 and NO_x annual limits No_x seasonal limit	Mercury, other Heavy Metals, and Acid Gases	Cooling water intake structures	Ozone formation from NO_x on hot days	Ensure a certain percentage of renewables
Relevant Dates	1/1/2011	1/1/2012: Phase 1 1/1/2014: Phase 2	2011 rulemaking, 1/1/2015, extension to 2016 in some cases	2011 2015-2018	NJ currently 2015-2018	various
Units impacted	All fossil units	All fossil units Primarily coal	Coal and oil, primarily coal	All existing units	Oil and gas peaking	All units
Standard	BACT case-by-case, state-by-state	Limited cap & trade. Use of FGD or DSI and SCR likely	MACT to be defined, likely FGD or DSI, ACI, fabric filter	BTA to be defined, likely not once thru cooling	NO_x rate standard. Use of SCR and other controls likely	Mandated percentage of electricity sales from renewables
Impact on Units	**Mostly fixed costs**	**Fixed and variable costs -- allowance prices**	**Mostly fixed costs, but also some VOM**	**Mostly fixed costs**	**Mostly fixed costs**	**Reduced net energy market revenues**

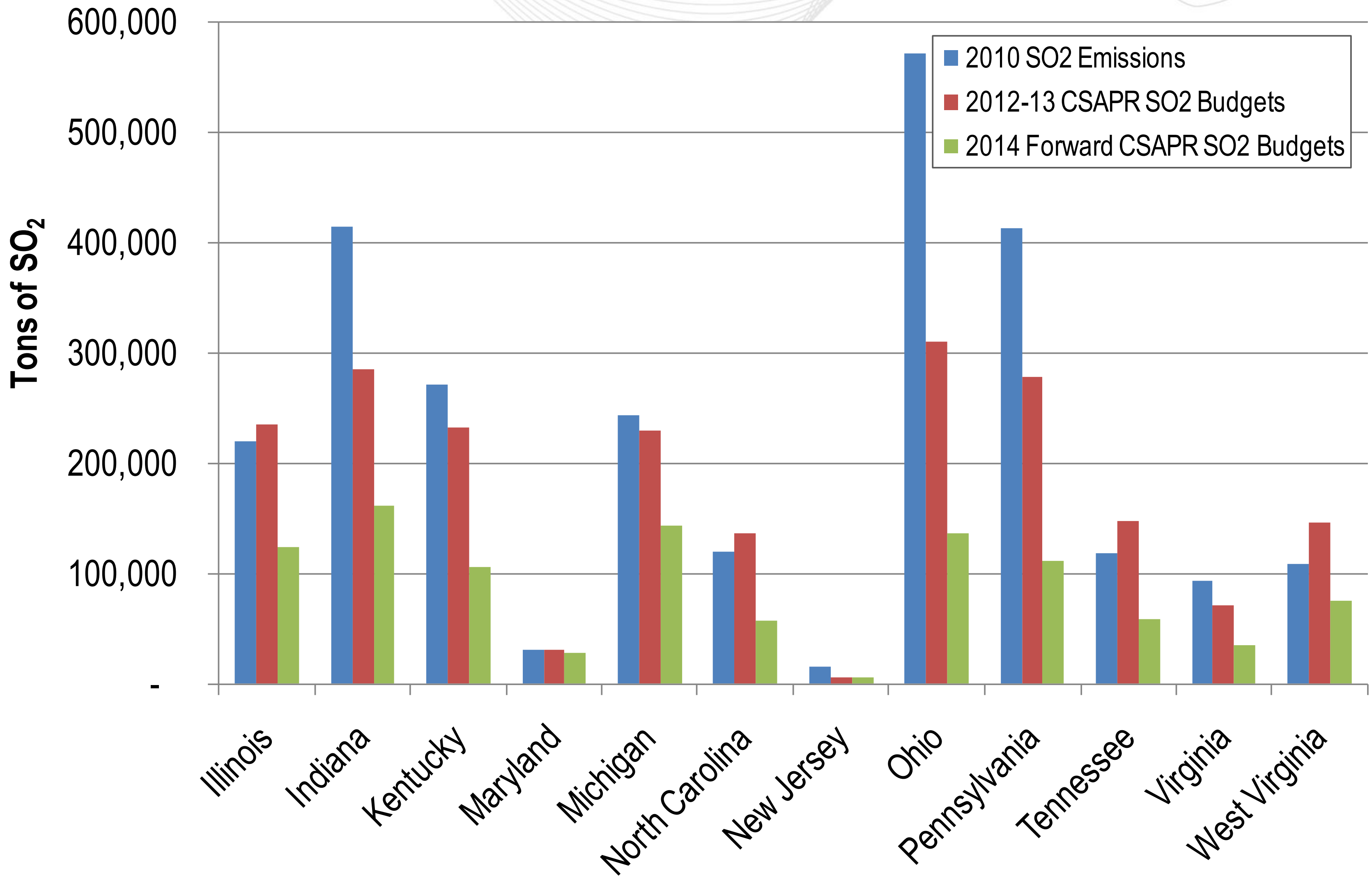
Environmental Regulation Timeframe



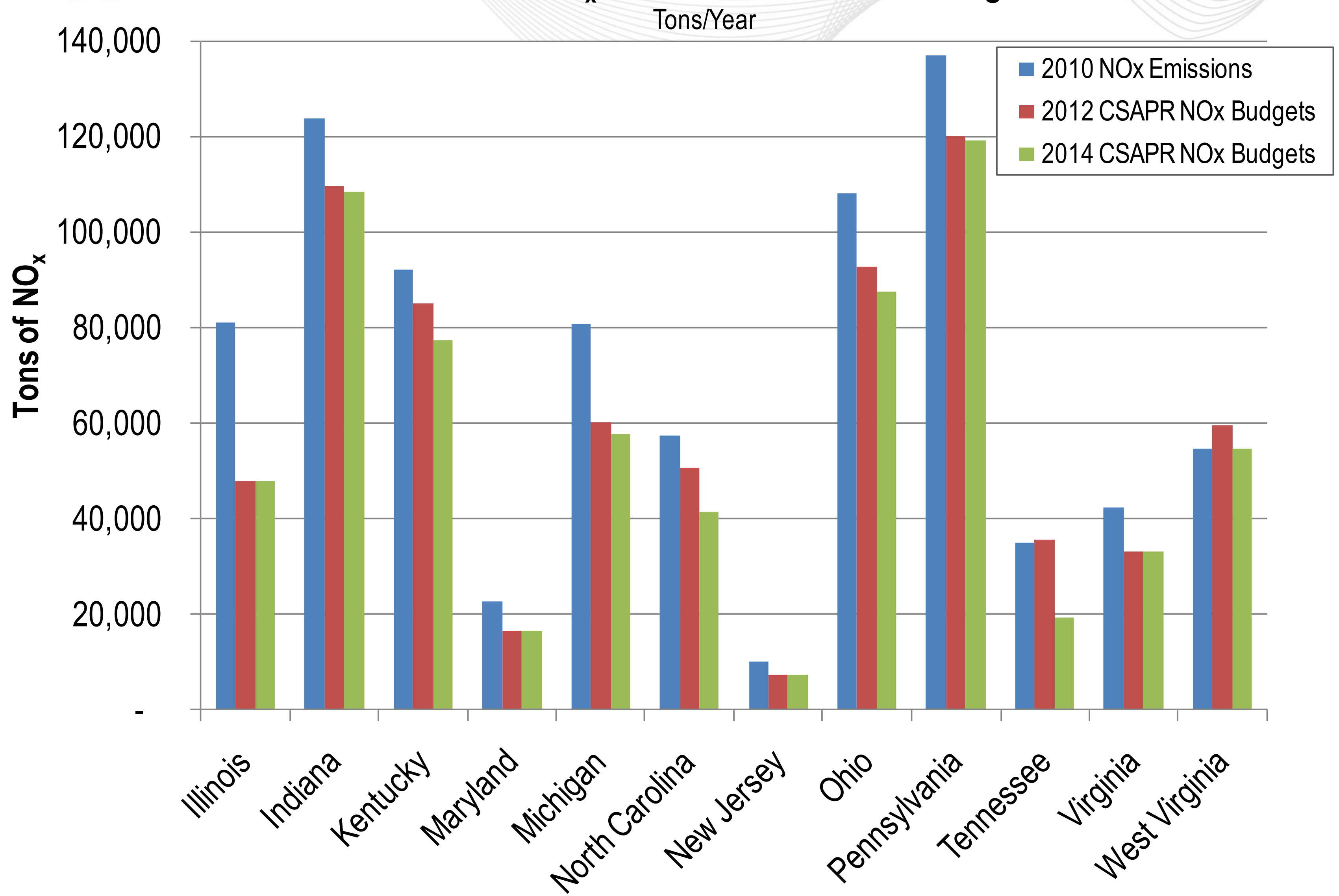
Adapted from M. J. Bradley & Associates LLC

PJM States' SO_2 Emissions vs CSAPR Budgets

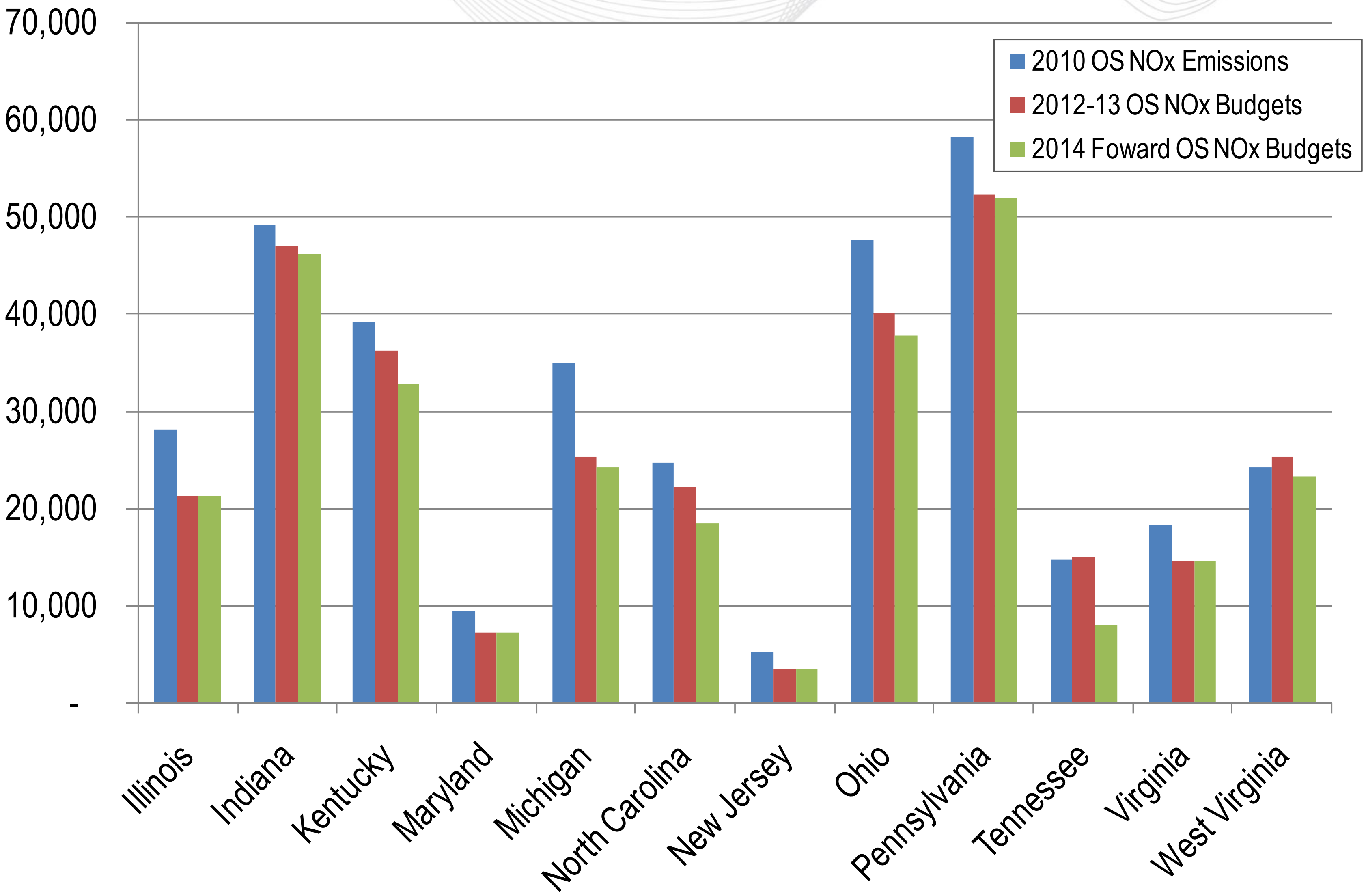
Tons/Year



PJM States' NO_x Emissions vs CSAPR Budgets

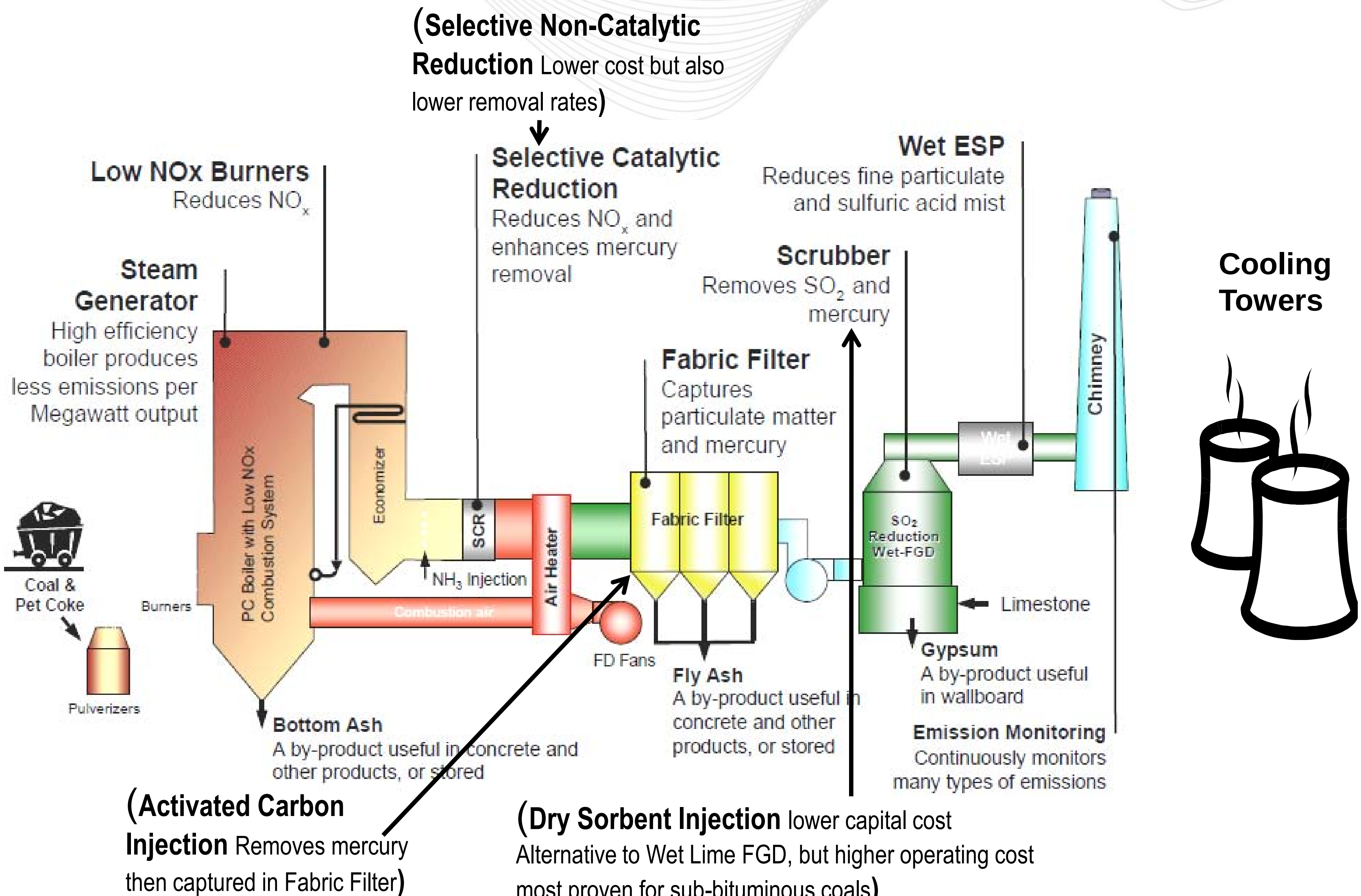


PJM States' Ozone Season NOx Emissions vs CSAPR Budgets



Compliance Alternatives and Costs

Environmental Regulations - Control Implications



Total Coal Capacity in PJM without Pollution Controls

	PJM RTO	MAAC	Rest of PJM
Total Coal	78,613	18,761	59,852
No SO_2 Controls	30,069	4,281	25,788
No SCR for NO_x Reduction	36,618	8,805	27,813
No Fabric Filter	69,115	13,020	56,095
No SO_2 and No SCR	22,866	2,723	20,143
No SO_2 and No Fabric Filter	29,457	3,756	25,701

Inclusive of DEOK and ATSI

Pollution Control Retrofit Costs for a 500 MW Coal Unit vs. Costs of New Natural Gas Technologies

Control Technology	Capital Cost ($/kW)	Fixed O&M ($/MW-yr)	Variable O&M ($/MWh)
FGD	$501	$8,150	$1.81
DSI	$40	$590	$7.92
SCR	$197	$720	$0.66
SNCR	$19	$260	$1.33
Fabric Filter + ACI	$155+$9	$630+$40	$0.15+$0.93

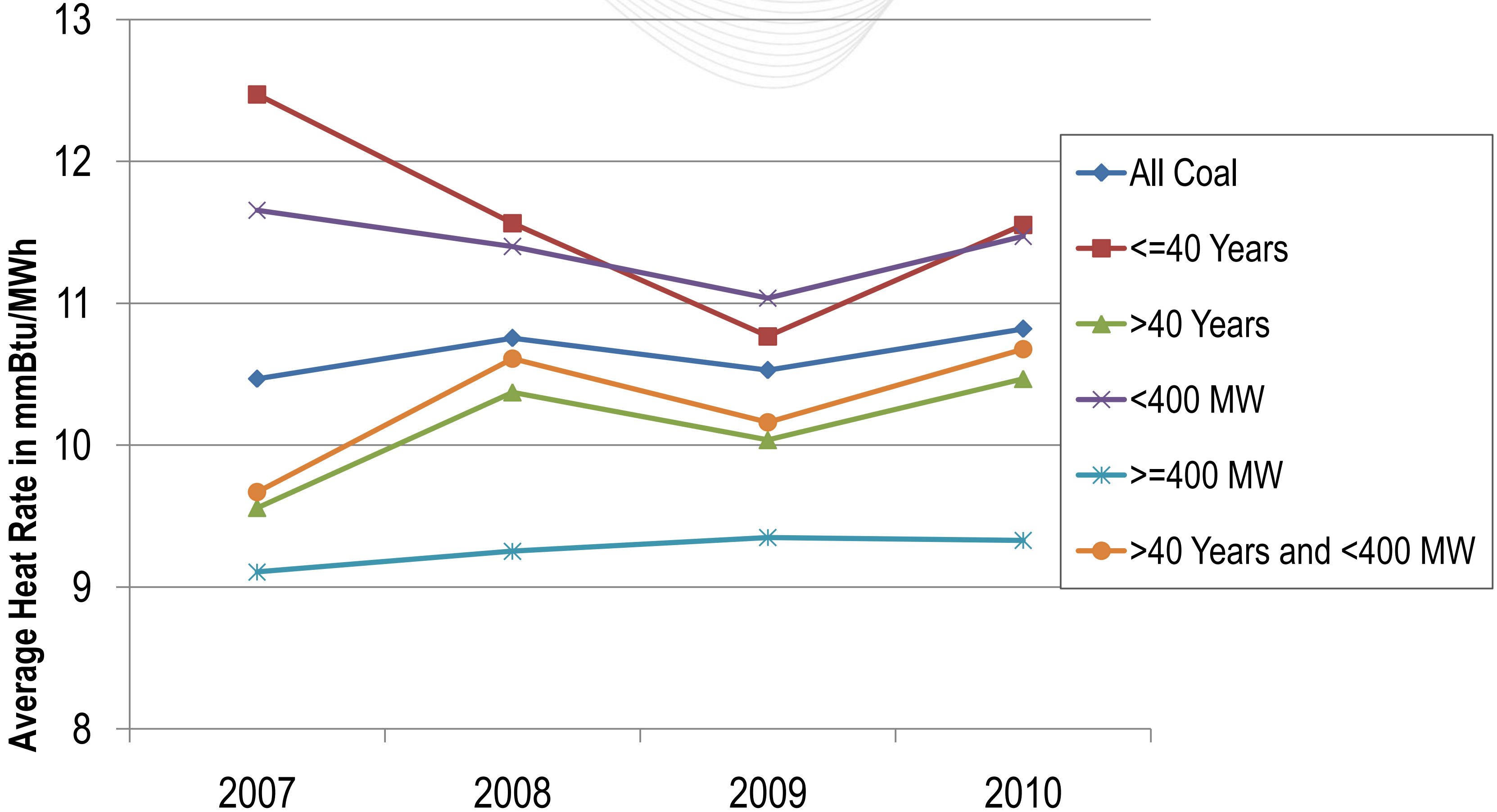
	Capital Cost ($/kW)	Fixed O&M ($/MW-yr)	Variable O&M ($/MWh)
Simple Cycle CT	$665-$975	$6,700-$6,980	$9.87-$14.60
Combined Cycle CT	$1,000-$1,150	$21,600	$3.23

Pollution Control Retrofit Costs: Estimated Ranges for Coal Units in PJM

Control Technology	MW Size Range	Capital Cost ($/kW)	Fixed O&M ($/MW-yr)	Variable O&M ($/MWh)
FGD Range (Average)	28-1,300 MW (211 MW)	$331-$1,149 ($677)	$1,580-$44,710 ($12,100)	$1.01-$3.81 ($1.93)
DSI Range (Average)	43 – 1,320 MW (408 MW)	$9-$273 ($89)	$170-$5,670 ($1,780)	$2.00-$15.54 ($5.71)
SCR Range (Average)	16 – 554 MW (161 MW)	$175-$427 ($263)	$550-$15,600 ($4,130)	$0.20-$1.41 ($0.47)
SNCR Range (Average)	45 – 1,300 MW (256 MW)	$11-$136 ($48)	$140-$4,900 ($1,190)	$0.34-$2.16 ($1.12)
Fabric Filter + ACI Range (Average)	16 – 1,320 MW (299 MW)	$118-$468 ($225)	$520-$9,340 ($1,990)	$0.52-$1.59 ($1.09)

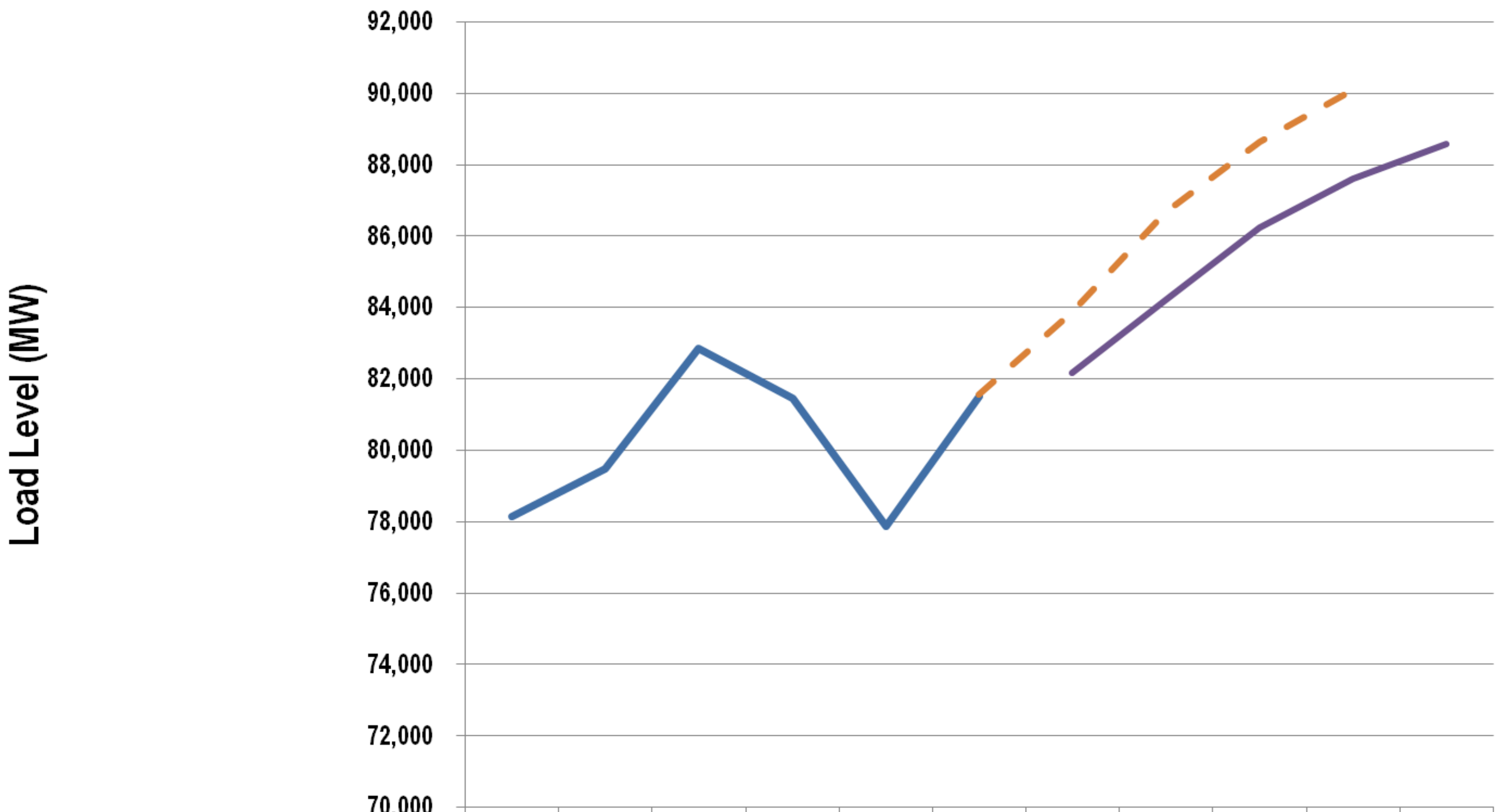
Economic Environment for Compliance Decisions

Coal Unit Heat Rates Inclusive of ATSI and DEOK



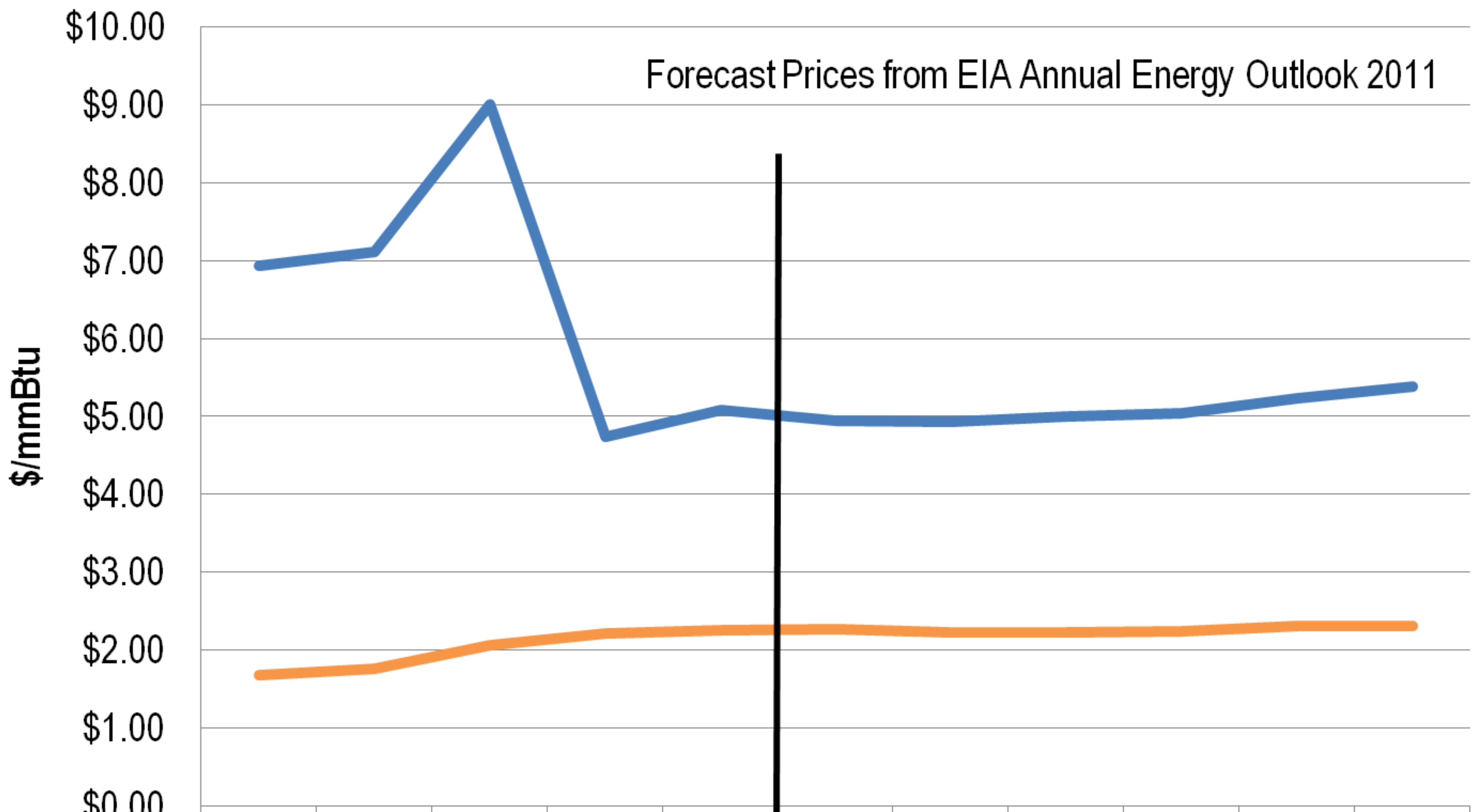
Trends in Average Hourly Loads in PJM

PJM Average Hourly Loads 2005-2010 and Forecasts to 2015



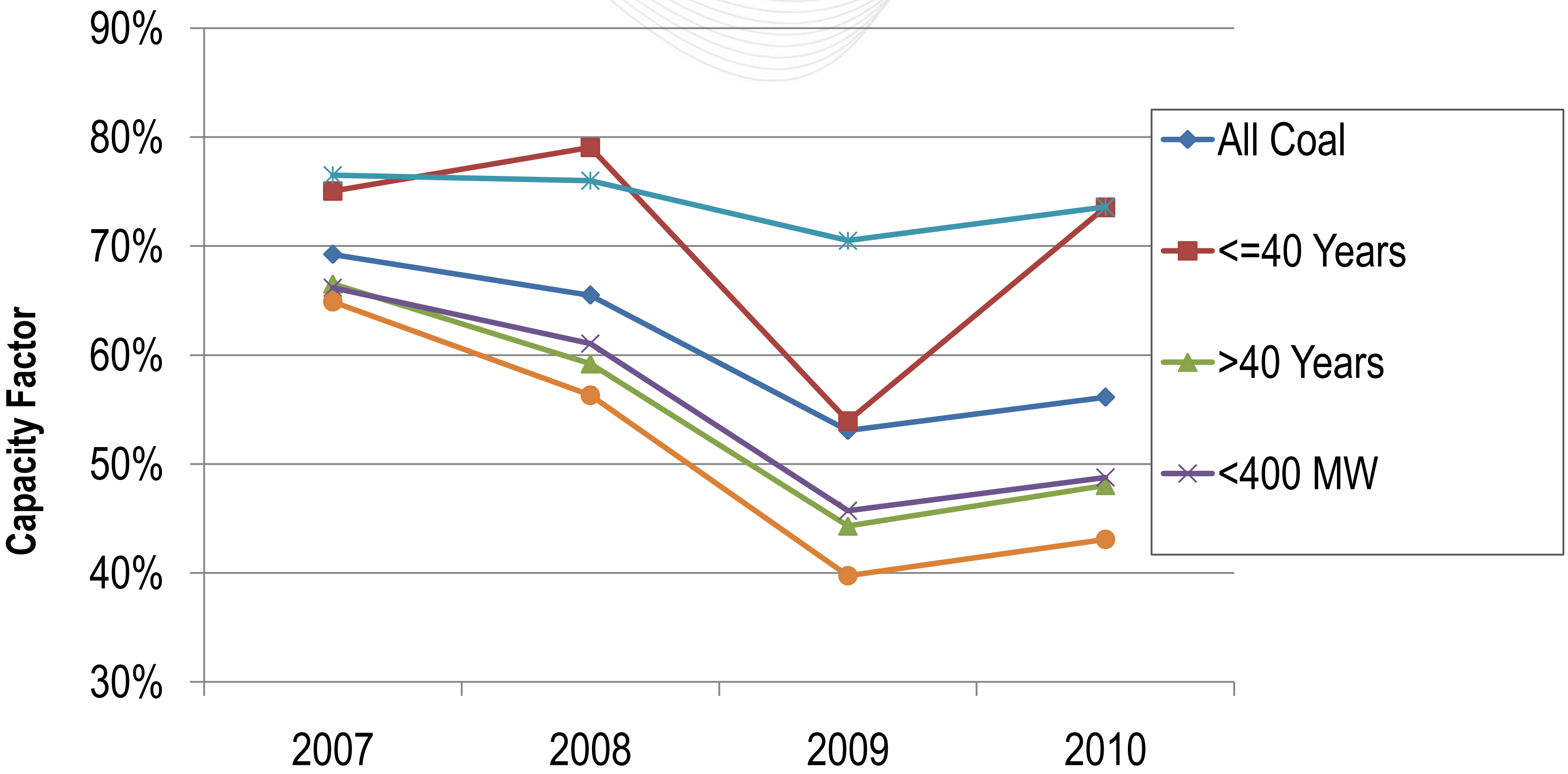
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Actual Average Hourly Load	78,150	79,471	82,857	81,442	77,862	81,510					
2011 Forecast Average Hourly Load							82,167	84,206	86,240	87,596	88,564
2010 Forecast Average Hourly Load						81,557	83,874	86,676	88,632	90,106	

National Average Annual Delivered Price of Coal and Natural Gas 2006-2010

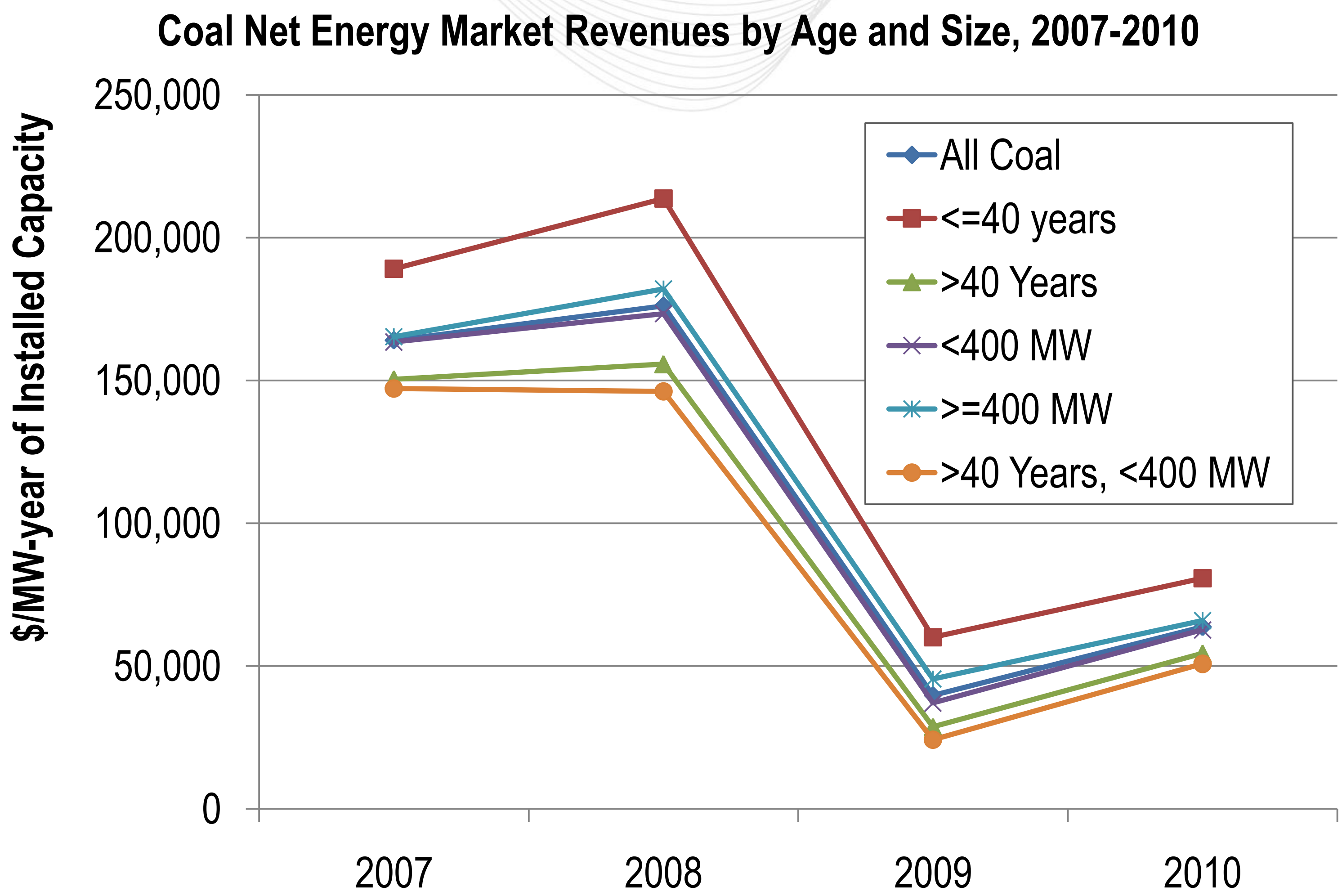


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gas	$6.94	$7.11	$9.01	$4.74	$5.08	$4.94	$4.93	$5.00	$5.04	$5.23	$5.38
Coal	$1.69	$1.77	$2.07	$2.21	$2.26	$2.27	$2.23	$2.23	$2.24	$2.31	$2.31

Coal Capacity Factors Inclusive of ATSI and DEOK



Net Energy Market Revenue Trends w/o DEOK and ATSI



Compliance Cost and Economic Environment: Key Takeaways

- Retrofits to comply with air rules are very costly putting pressure on fixed costs
  - Economies of scale to retrofit costs…cost/MW is higher for smaller units
- Significantly reduced gas-coal spreads and demand are adding pressure on the revenue side of the equation
  - Some controls also have significant variable costs and add to this pressure
  - Smaller, older units have lower revenues per MW
- <u>Conjecture:</u>
  - Older, smaller units will be at greater risk for retirement if they require retrofits

Screening by Operational and Physical Characteristics for Units At Risk

Physical Screen Data Requirements

- 217 coal units
  - Size
  - In-service date (age)
  - Heat input (2007-2010)
  - Gross generation (2007-2010)
  - SO_2 and NO_x emissions (2007-2010)
  - Pollution control retrofits installed and in-service dates
  - Deactivations (actual and requested)
- Calculations
  - Emissions rates
  - Gross heat rates

Composition of Coal-fired Capacity in PJM Less Recent and Planned Deactivations (w/ATSI and DEOK)

	PJM RTO	MAAC	Rest of PJM
Total Coal	78,613	18,761	59,852
Coal > 40 years	41,815	12,334	29,481
Coal < 400 MW	26,645	7,162	19,483
Coal > 40 years, < 400 MW	22,907	5,769	17,138

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests and actual deactivations. Does not include 340 MW of coal repowered to natural gas. (MW of Summer Net Dependable Capacity)

Composition of Coal-fired Capacity in PJM without Emissions Controls (w/ATSI and DEOK)

No SO_2 Controls: Post-combustion or CFB

	PJM RTO	MAAC	Rest of PJM
Total Coal	30,069	4,281	25,788
Coal > 40 years	24,217	3,794	20,423
Coal < 400 MW	17,444	2,617	14,827
Coal > 40 years, < 400 MW	17,387	2,560	14,827

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests
United States Environmental Protection Agency Database of Emissions and Unit Characteristics
Updated for retrofits reported and confirmed through emissions data through 2010 (MW of Summer Net Dependable Capacity)

Composition of Coal-fired Capacity in PJM without Emissions Controls (w/ATSI and DEOK)

No Fabric Filter

	PJM RTO	MAAC	Rest of PJM
Total Coal	69,115	13,020	56,095
Coal > 40 years	37,796	9,736	28,060
Coal < 400 MW	21,035	3,786	17,249
Coal > 40 years, < 400 MW	20,104	3,729	16,375

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests
United States Environmental Protection Agency Database of Emissions and Unit Characteristics
Updated for retrofits reported and confirmed through emissions data through 2010 (MW of Summer Net Dependable Capacity)

Composition of Coal-fired Capacity in PJM without Emissions Controls (w/ATSI and DEOK)

No SCR to Control NO_x

	PJM RTO	MAAC	Rest of PJM
Total Coal	36,618	8,805	27,813
Coal > 40 years	26,481	6,905	19,576
Coal < 400 MW	21,818	5,405	16,413
Coal > 40 years, < 400 MW	18,762	4,456	14,306

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests
United States Environmental Protection Agency Database of Emissions and Unit Characteristics
Updated for retrofits reported and confirmed through emissions data through 2010 (MW of Summer Net Dependable Capacity)

Composition of Coal-fired Capacity in PJM without Emissions Controls (w/ATSI and DEOK)

No SO_2 Controls and No Fabric Filter

	PJM RTO	MAAC	Rest of PJM
Total Coal	29,457	3,756	25,701
Coal > 40 years	23,605	3,269	20,336
Coal < 400 MW	16,832	2,092	14,740
Coal > 40 years, < 400 MW	16,775	2,035	14,740

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests
United States Environmental Protection Agency Database of Emissions and Unit Characteristics
Updated for retrofits reported and confirmed through emissions data through 2010 (MW of Summer Net Dependable Capacity)

Composition of Coal-fired Capacity in PJM without Emissions Controls (w/ATSI and DEOK)

No SO_2 Controls and No SCR to Control NO_x

	PJM RTO	MAAC	Rest of PJM
Total Coal	22,866	2,723	20,143
Coal > 40 years	17,644	2,236	15,408
Coal < 400 MW	14,598	2,293	12,305
Coal > 40 years, < 400 MW	14,541	2,236	12,305

Source: PJM EIA-411 Submittal as of January 1, 2009 and PJM list of Deactivation Requests
United States Environmental Protection Agency Database of Emissions and Unit Characteristics
Updated for retrofits reported and confirmed through emissions data through 2010 (MW of Summer Net Dependable Capacity)

Unit Characteristics Screen: Key Takeaways
Units More than 40 Years Old and Less than 400 MW

	PJM	MAAC	Rest of PJM
Total	22,907	5,769	17,138
No SO_2 Controls	17,387	2,560	14,827
No Fabric Filter Baghouse	20,104	3,729	16,375
No SO_2 Control and No Baghouse	16,775	2,035	14,740
No SCR	18,762	4,456	14,306
No SO_2 Control and No SCR	14,541	2,236	12,305

Unit Characteristics Screen: Key Takeaways

- With compliance options under NESHAP likely requiring a fabric filter for mercury and heavy metals and some kind of SO_2 control for acid gases, the older, smaller units without these controls are likely most at risk
  - Up to 20,000 MW are most at risk across PJM with 20-25 percent in MAAC and the remainder in the rest of PJM
  - Large overlap in units without SO_2 controls alone and without both SO_2 controls and a fabric filter baghouse
  - These older, smaller units also tend to be less efficient and operate fewer hours so their economics are likely not as attractive to support retrofits.

Screening by Economic Criteria for Capacity At Risk

Economic Screen Additional Data Requirements

- Emissions control costs
  - Equation-based used by EPA that consider fuel quality, unit size, and emissions rates
  - Allows for unit specific calculation of capital and fixed O&M costs
- Historic net energy market revenues (2007-2010)
  - Used in the calculation of Market Seller Offer Caps in RPM
- Technology type and Avoidable Cost Rates
  - Determines annual avoidable costs used in calculating Market Seller Offer Caps in RPM
- Tariff defined capital recovery factors (CRF)
  - Used in in RPM to determine the annual recovery of project investment for existing units in Market Seller Offer Caps
- Calculations—additional revenues beyond the net energy market revenues to be financially viable

Determination of Controls to be Installed

- SO_2 reduction to 0.15 lb/mmBtu
  - More than 50% reduction requires a wet limestone FGD
  - 20%-50% reduction requires DSI
  - SO_2 is used as a surrogate for acid gasses in the HAP MACT rule
- NO_x reduction to 0.15 lb/mmBtu
  - More than 60% reduction requires and SCR
  - 20% to 60% reduction requires SNCR
  - Reductions to comply with CATR caps
- Mercury reductions
  - ACI required unless a wet limestone FGD and SCR are already installed
- Particulates
  - Fabric filter baghouse required if installing DSI and/or ACI

Net CONE as a Benchmark for Economic Evaluation

- Net CONE is the benchmark price at which resource adequacy is achieved at the Reliability Requirement.
- For a regulated utility, this would be a reasonable benchmark for making the decision to either retrofit and existing coal unit, or retiring the coal unit and building a natural gas CT
- In the RPM Capacity Market, the price of capacity, and the quantity of capacity resources are determined within the auction framework

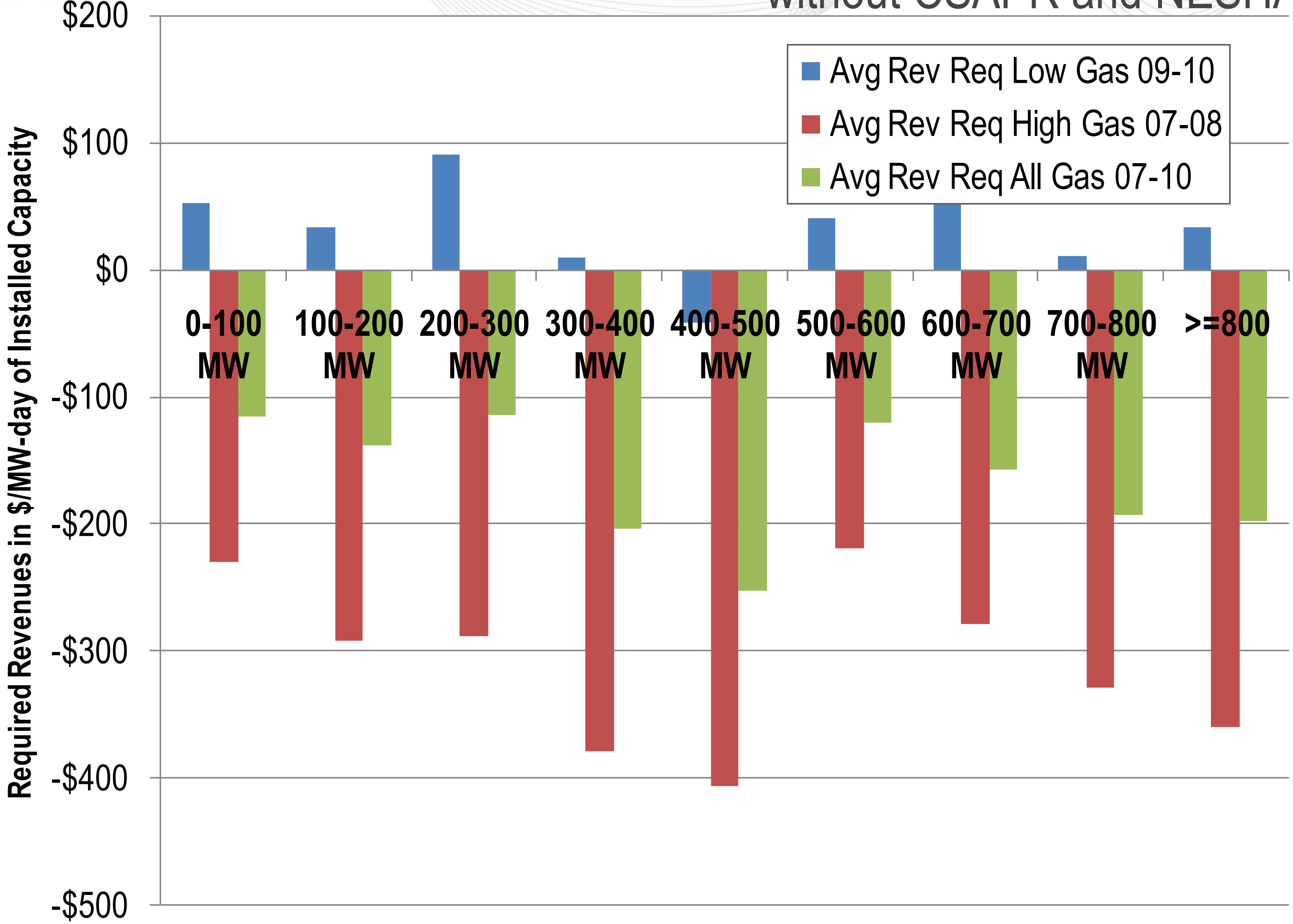
Net CONE as a Benchmark for Economic Evaluation

Given energy and ancillary service revenues to be expected (based on historical revenues) and a 20 year recovery of retrofit costs under the tariff defined CRF:

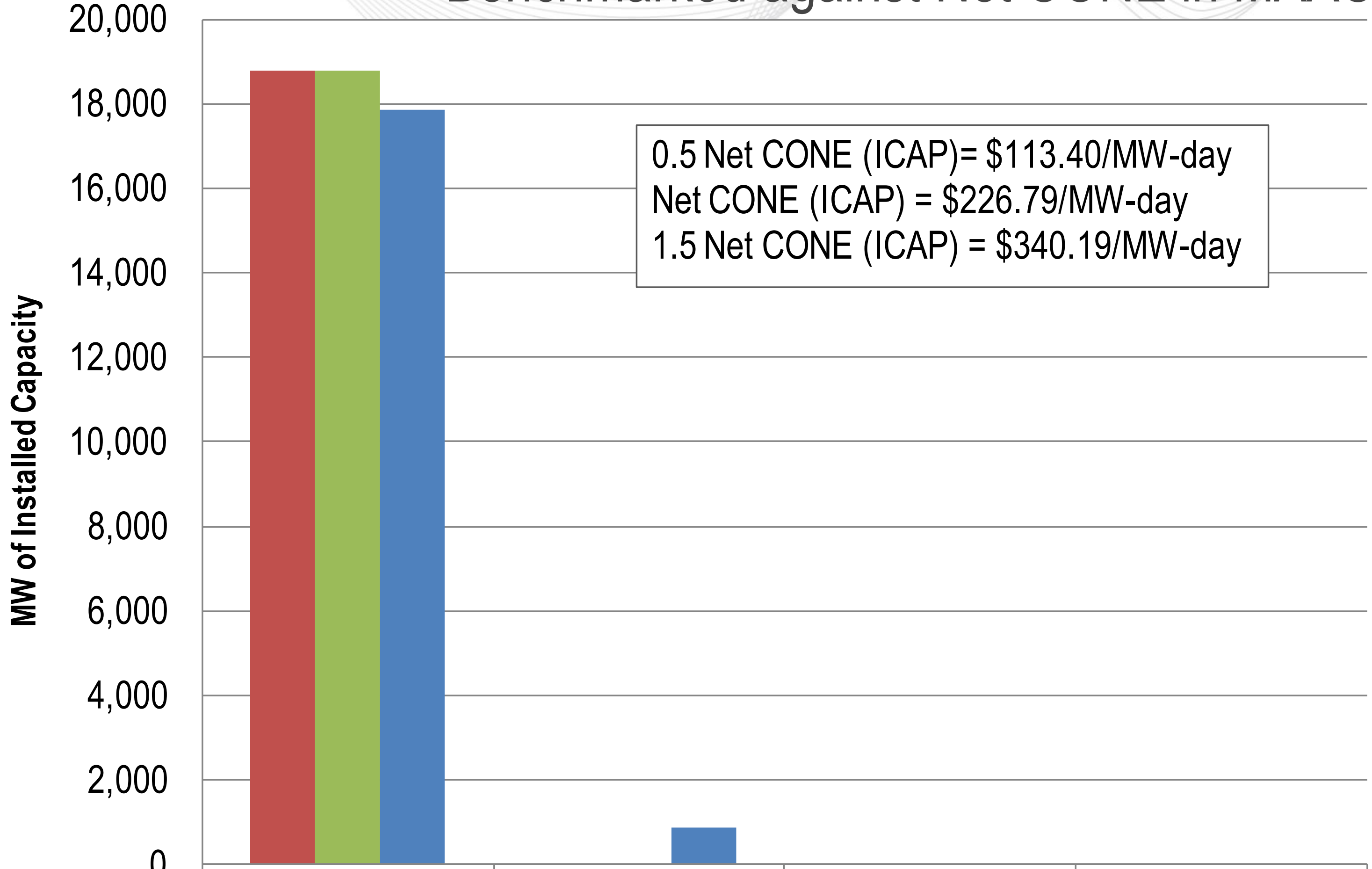
	> 1.5 Net CONE	Net CONE – 1.5 Net CONE	½ Net CONE – Net CONE	< ½ Net CONE
Financial Viability	Above max RPM LDA price	Above the cost of new entry gas CT	Would clear before new entry gas CT	Likely to clear if all units reflect retrofit costs
Risk	"Very High"	"High"	"at Risk"	"Low"

Economic Assessment of Capacity At Risk for Retirement

Necessary Revenue to Continue Operating without CSAPR and NESHAP

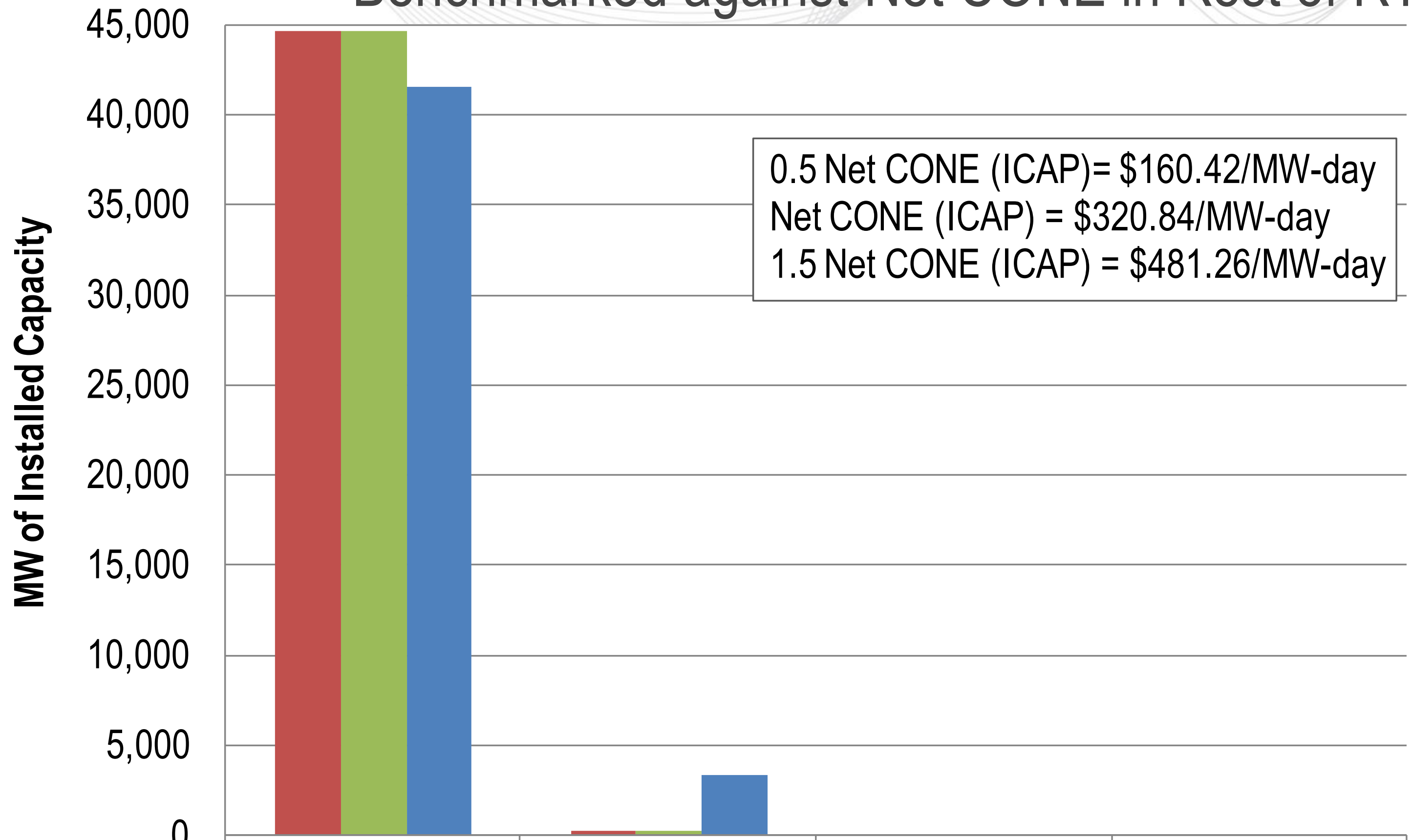


Capacity with Needed Revenues w/o CSAPR and NESHAP Benchmarked against Net CONE in MAAC



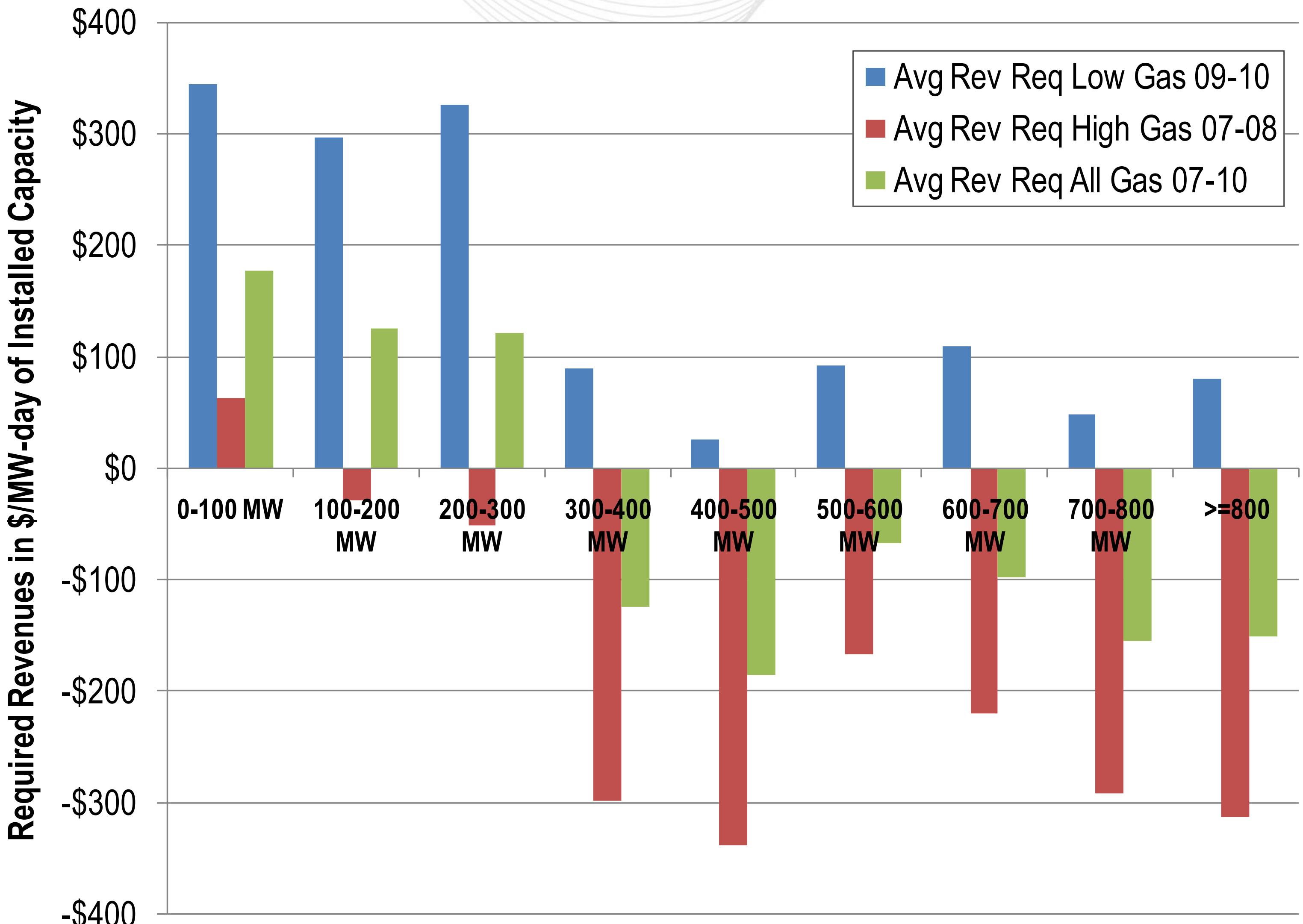
	< 0.5 Net CONE	0.5-1.0 Net CONE	1.0 - 1.5 Net CONE	> 1.5 Net CONE
20 Yr High Gas	18,754.80	0.00	0.00	0.00
20 Yr All Gas 07-10	18,754.80	0.00	0.00	0.00
20 Yr Low Gas	17,861.70	893.10	0.00	0.00

Capacity with Needed Revenues w/o CSAPR and NESHAP Benchmarked against Net CONE in Rest of RTO

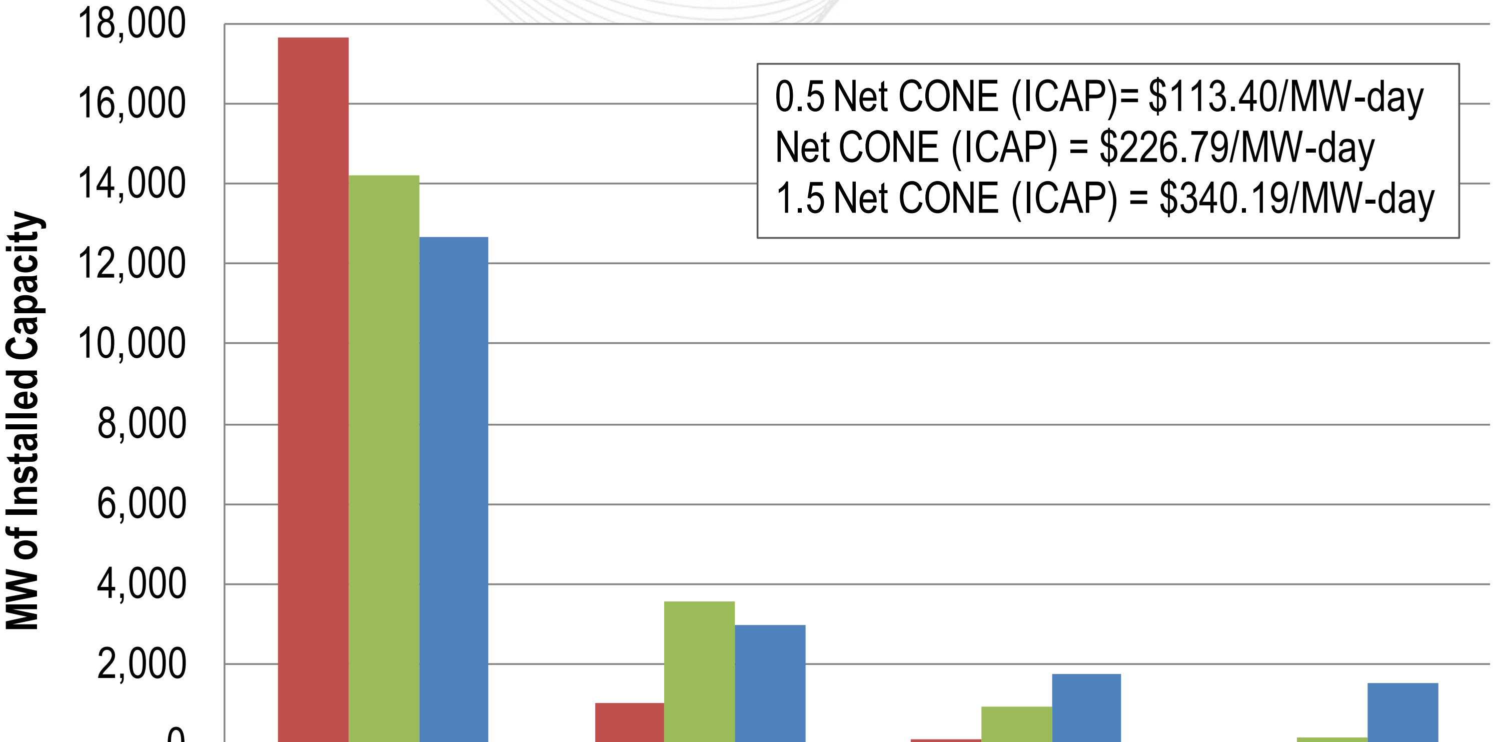


	< 0.5 Net CONE	0.5-1.0 Net CONE	1.0 - 1.5 Net CONE	> 1.5 Net CONE
20 Yr High Gas	44,613.40	183.00	0.00	0.00
20 Yr All Gas 07-10	44,613.40	183.00	0.00	0.00
20 Yr Low Gas	41,512.40	3,284.00	0.00	0.00

Necessary Revenue to Continue Operating under CSAPR and NESHAP

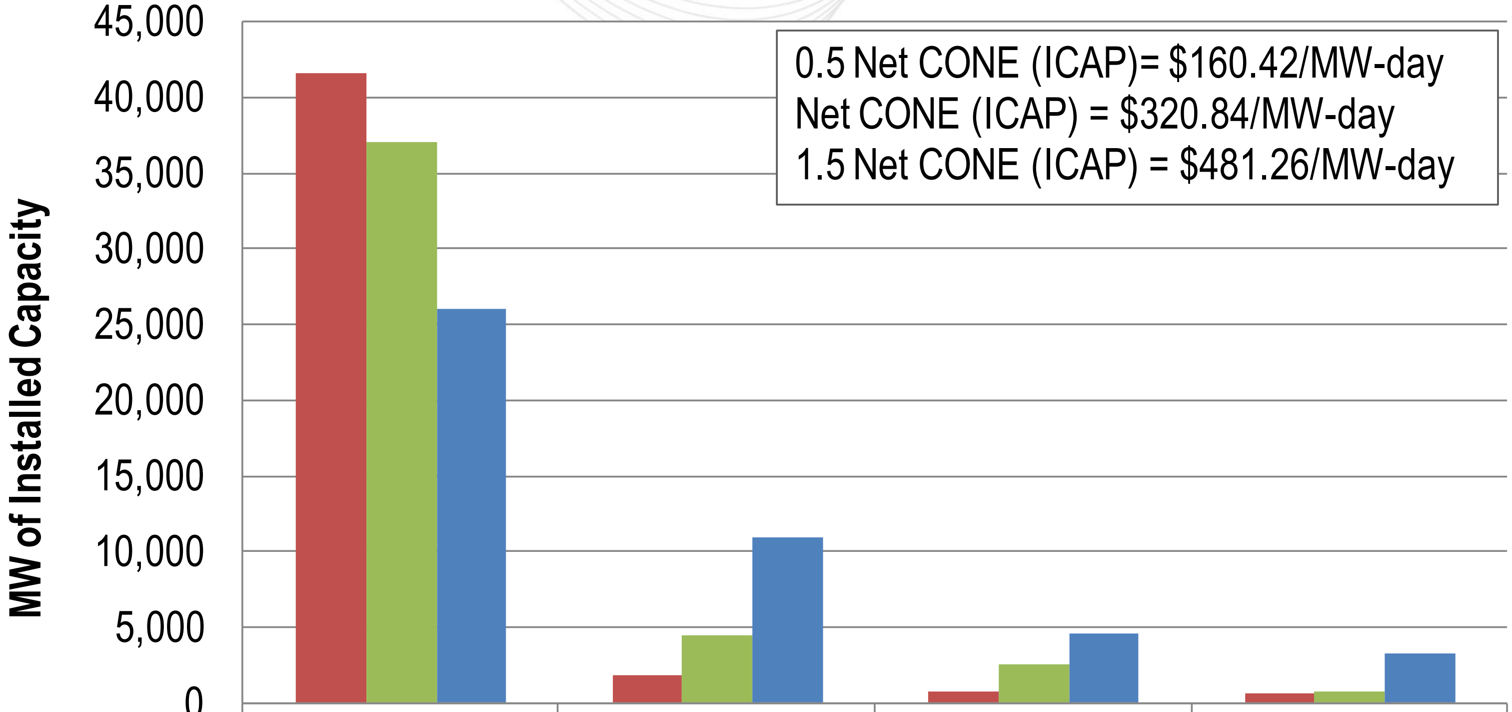


Capacity with Needed Revenues under CSAPR and NESHAP Benchmarked against Net CONE in MAAC



	< 0.5 Net CONE	0.5-1.0 Net CONE	1.0 - 1.5 Net CONE	> 1.5 Net CONE
20 Yr High Gas	17,625.70	1,016.10	113.00	0.00
20 Yr All Gas 07-10	14,194.70	3,543.00	888.00	129.10
20 Yr Low Gas	12,634.70	2,926.00	1,705.00	1,489.10

Capacity with Needed Revenues under CSAPR and NESHAP Benchmarked against Net CONE in Rest of RTO



	< 0.5 Net CONE	0.5-1.0 Net CONE	1.0 - 1.5 Net CONE	> 1.5 Net CONE
20 Yr High Gas	41,654.40	1,801.00	696.00	645.00
20 Yr All Gas 07-10	37,065.40	4,409.00	2,554.00	768.00
20 Yr Low Gas	26,010.40	10,929.00	4,595.00	3,262.00

Summary of Additional Revenues Needed Relative to Net CONE with 20 Yr Recovery—Low Gas

Additional Revenue Needed	PJM	MAAC	Rest of PJM
< 0.5 Net CONE	38,334	12,634	25,700
0.5 Net CONE – 1.0 Net CONE	14,147	2,908	11,239
> 1.0 Net CONE	11,051	3,194	7,857

•For the 11,051 MW at “high” or “very high risk”, the average age is more than 50, average size less than 200 MW.

•For the 14,147 “at risk” the average age is 37, average size almost 400 MW

•For the remaining capacity “at low risk”, average age is 34, average size almost 500 MW

- 6,985 MW UCAP (7,350 MW ICAP) less coal capacity cleared in the 2014/15 BRA than in the 2013/2014 BRA
- Approximately 7,000 MW of FRR coal capacity (outside RPM) has been announced as retiring by 2015
  - Most of this capacity falls into the high or very high risk categories

- Reserve margin for 2014/2015 is projected at 19.6%, even with less coal capacity clearing
- Accounting for FRR announcements still leaves PJM above the 15.3% target

Change in Cleared Capacity (UCAP) by Fuel Type from 2013/2014 to 2014/2015

	2013/2014	2014/2015	Change
Coal	49,110	42,215	-6,895
Natural Gas	44,288	43,672	-616
Nuclear	30,890	30,627	-263
Oil (all types)	8,902	8,947	+45
Renewable (all types)	7,734	7,963	+229
Energy Efficiency	679	822	+43
Demand Response	9,282	14,118	+4,836
Total	152,743	149,975	-2,769

- In one word, it is "uncertainty"
- It is still unclear how many units will retrofit to meet the more stringent emissions requirements
  - Owner specific beliefs about any future profitability
  - Final form of rules under consideration at EPA including rules not studied here
  - Unit/site specific considerations
  - Economics of natural gas effects retrofit/retire decisions! Will this change again?
  - How much more new natural gas capacity will enter?
  - How much more demand response will enter?
  - What is the shape of future climate policy?