



## Proposed CATR + MACT

Prepared for:  
American Coalition for Clean Coal Electricity

# Outline



- Glossary
- Executive Summary
- Methodology
- Assumptions and Uncertainties
- Energy Market Impacts
- Economic Impacts

# Glossary



- Present value (PV) of costs
  - **Present value**, also known as **present discounted value**, is the value on a given date of a future cost or series of future costs, discounted to reflect the time value of money and other factors such as investment risk. Present value calculations are widely used in business and economics to provide a means to compare costs at different times on a meaningful "like to like" basis
- Annualized value (AV) of costs
  - **Annualized value**, also known as **annualized net present value**, is calculated from a given present value as the average annual value in each future year taking into account the discount rate and the number of years over which costs are calculated. Annualized value calculations are widely used in business and economics to compare costs at different times on a meaningful "like to like" basis, particularly when two cost streams have different lifetimes.
- 2010 dollars
  - Constant value of money based on price levels in 2010
  - Costs or prices reported in 2010 dollars for future years control for inflation between 2010 and future years, so any changes reflect real changes in market conditions
- Henry Hub
  - Henry Hub is the pricing point for natural gas used by the New York Mercantile Exchange (NYMEX) and widely used in the industry. It is a point on the natural gas pipeline system in Louisiana.

# Summary of Key Results



- Evaluated impacts of EPA's Clean Air Transport Rule (CATR) and Utility Maximum Achievable Control Technology (MACT) proposals
- Coal unit retirements would increase by about 48 GW
- Electricity sector costs would increase by \$184 billion (present value over 2011-2030 in 2010\$) or \$17.8 billion per year
  - Includes coal unit compliance costs (including \$72 billion in overnight capital costs), fuel price impacts, and costs of replacement energy and capacity
- Coal-fired generation in 2016 would decrease by about 13% and electricity sector coal demand in 2016 would decrease by about 10%
- Natural gas-fired generation in 2016 would increase by about 26% and Henry Hub natural gas prices 2016 would increase by about 17%
  - Increased natural gas prices would increase natural gas expenditures by residential, commercial, and industrial sectors by \$85 billion (present value over 2011-2030 in 2010\$) or \$8.2 billion per year
- Average U.S. retail electricity prices in 2016 would increase by about 12%, with regional increases as much as about 24%
- Net employment in the U.S. would be reduced by more than 1.4 million job-years over the 2013-2020 period, with sector losses outnumbering sector gains by more than 4 to 1.

# Comparison of EPA and NERA Modeling of CATR and MACT



**NERA**  
Economic Consulting

	EPA		NERA
	CATR	MACT	CATR+MACT
Proposed Regulations	EPA	EPA	Electricity companies
Source of Technologies	EPA	EPA	EPA
Source of Control Cost	IPM	IPM	NEMS
Model			
Coal Units			
Retirements by 2015 (GW)	1.2	9.9	47.9
Annual Costs (billion 2010\$)	NA	\$8.4	\$14.2
Present Value of Costs (billion 2010\$)	NA	\$77-\$86	\$118
Electricity Sector			
Annual Costs (billion 2007\$)	\$2.8	\$10.9	Not relevant
Annual Costs (billion 2010\$)	\$3.0	\$11.4	\$17.8
Present Value of Costs (billion 2010\$)	\$27-\$35	\$97-\$133	\$184

IPM = ICF Integrated Planning Model

NEMS = EIA National Energy Modeling System

NA = Not available

Electricity system costs reflect all generation and transmission costs.

Dollar conversions use the GDP deflator.

EPA CATR projections relate to the preferred policy alternative (state budgets with limited interstate trading).

NERA coal unit retirements and costs reflect medians from Monte Carlo uncertainty analysis ranges developed by NERA for all coal units.

EPA provides annual costs (including annualized capital costs) only for selected years (2012, 2015, 2020, and 2025 for CATR and 2015, 2020, and 2030 for MACT). EPA annual costs in the table relate to 2015. All present values are calculated between 2011 and 2030 as of 2011. Calculation of EPA PV costs include the assumption that costs begin in 2011 at the earliest available annual value. NERA annual costs are annualized costs derived from present values. EPA PV cost ranges reflect discount rates between 11.3% (EPA's capital charge rate) and 6.15% (EPA's discount rate for non-capital costs). NERA annual and PV costs for coal units reflect discount rates of 7% for public units and 11.8% for merchant units. NERA annual and PV costs for the electricity sector reflect a discount rate of 7%.

# Energy Market Impacts Summary for 2016



**NERA**  
Economic Consulting

## 2016 CATR+MACT Impacts

	<b>Coal Retirements</b> (GW)	<b>Coal-Fired Generation</b> (million MWh)	<b>Elec Sector Coal Demand</b> (million tons)	<b>Gas-Fired Generation</b> (million MWh)	<b>Elec Sector Gas Demand</b> (trillion cu ft)	<b>Gas Price at Henry Hub</b> (2010\$/MMBtu)	<b>Avg Retail Elec Price</b> (2010\$/MWh)
<b>2016 Projections</b>							
Reference (No CAIR or State Hg)	5.0	1,910	1,018	603	5.9	\$4.50	\$87.13
CATR+MACT	52.7	1,658	918	760	7.0	\$5.28	\$97.18
<b>Change from 2016 Reference Projections</b>							
CATR+MACT	+47.8	-253	-100	+157	+1.1	+\$0.78	+\$10.05
<b>% Change from 2016 Reference Projections</b>							
CATR+MACT	+958%	-13.2%	-9.8%	+26.0%	+18.5%	+17.3%	+11.5%

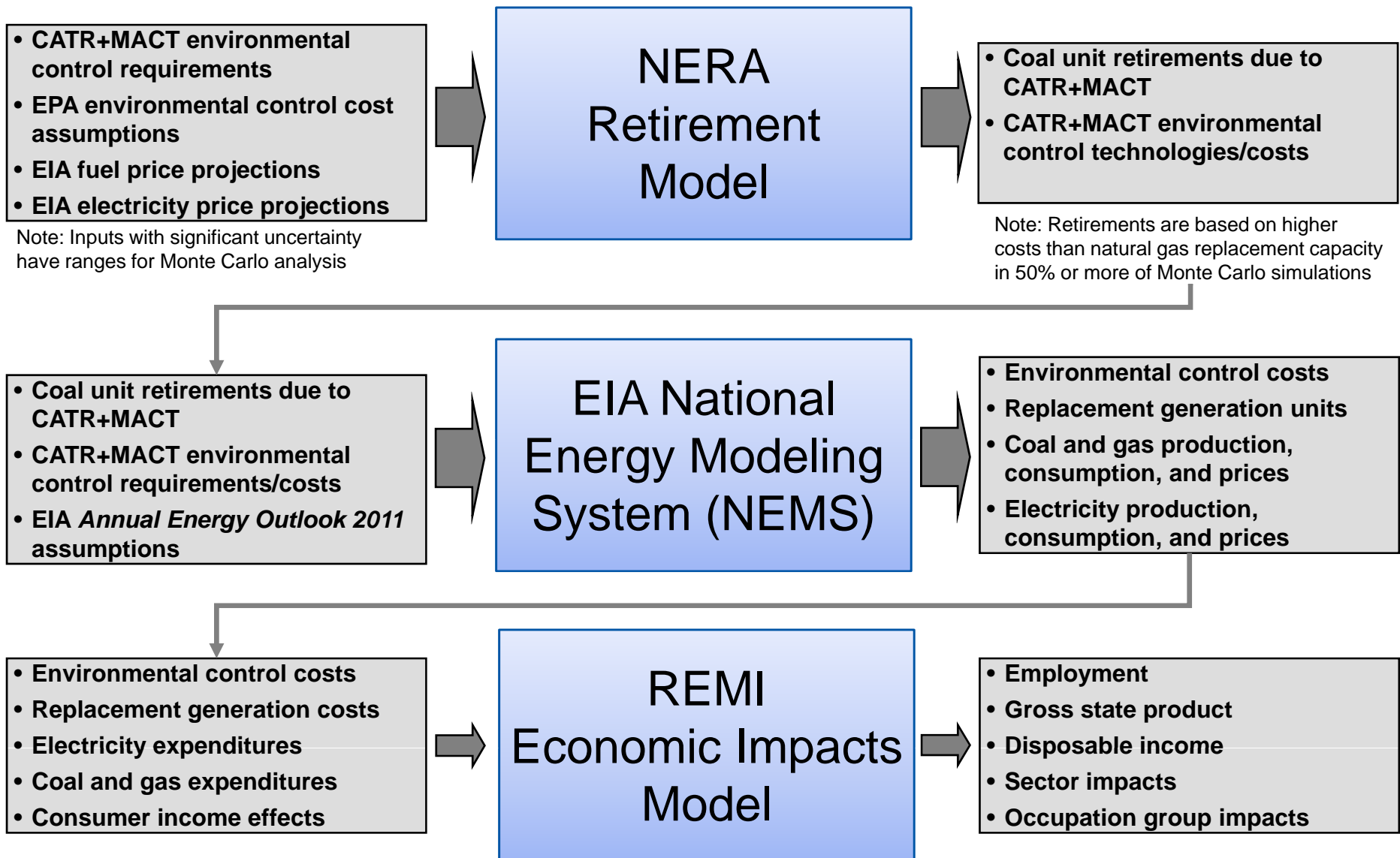
Notes: Summary results are provided for 2016 rather than 2015 to show the full potential effect on electricity prices. Electricity price impacts reflect levelized capital costs for environmental controls and new capacity.



# Methodology

# Overview of Modeling Methodology

(Note: Simplification of inputs and outputs)





# Overview of Rationale for Models



- NERA Retirement Model
  - Monte Carlo formulation allows for inclusion of uncertainty in key parameters (e.g., fuel prices) and development of ranges of costs and retirements
  
- NEMS
  - State-of-the-art model of the energy system
  - Used extensively by EIA and others
  - Not proprietary with NERA in-house modeling capability
  
- REMI
  - State-of-the-art regional economic model
  - Ability to model impacts in individual states as well as U.S.
  - Used extensively by government agencies and others
  - Not proprietary with NERA in-house modeling capability



# Assumptions and Uncertainties

# Control Cost and Penalty Assumptions from EPA and EIA



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	500 MW		300 MW		100 MW	
	EPA	EIA	EPA	EIA	EPA	EIA
<b>Wet Scrubber</b>						
Capital (2010\$/kW)	\$538	\$485	\$622	\$580	\$850	\$762
Fixed O&M (2010\$/kW-year)	\$8.35	\$24.99	\$11.20	\$24.99	\$24.40	\$24.99
Variable O&M (2010\$/MWh)	\$2.11	\$0.44	\$2.11	\$0.44	\$2.11	\$0.44
Capacity Penalty	-1.84%	-5.00%	-1.84%	-5.00%	-1.84%	-5.00%
Heat Rate Penalty	1.87%	5.26%	1.87%	5.26%	1.87%	5.26%
<b>Dry Scrubber</b>						
Capital	\$460		\$532		\$727	
FOM	\$6.76		\$8.86		\$17.71	
VOM	\$2.70		\$2.70		\$2.70	
Capacity Penalty	-1.45%		-1.45%		-1.45%	
Heat Rate Penalty	1.47%		1.47%		1.47%	
<b>SCR</b>						
Capital (2010\$/kW)	\$201	\$165	\$217	\$184	\$268	\$225
Fixed O&M (2010\$/kW-year)	\$0.73	\$1.66	\$0.83	\$1.88	\$2.60	\$2.25
Variable O&M (2010\$/MWh)	\$1.38	\$0.34	\$1.38	\$0.34	\$1.38	\$0.34
Capacity Penalty	-0.58%	0.00%	-0.58%	0.00%	-0.58%	0.00%
Heat Rate Penalty	0.59%	0.00%	0.59%	0.00%	0.59%	0.00%
<b>ACI</b>						
Capital (2010\$/kW)	\$8	\$6	\$12	\$6	\$30	\$6
Fixed O&M (2010\$/kW-year)	\$0.03	\$1.71	\$0.05	\$1.71	\$0.12	\$1.71
Variable O&M (2010\$/MWh)	\$0.60	\$0.00	\$0.56	\$0.00	\$0.52	\$0.00
Capacity Penalty	-0.06%	0.00%	-0.06%	0.00%	-0.06%	0.00%
Heat Rate Penalty	0.06%	0.00%	0.06%	0.00%	0.06%	0.00%
<b>Fabric Filter</b>						
Capital (2010\$/kW)	\$170	\$78	\$187	\$78	\$230	\$78
Fixed O&M (2010\$/kW-year)	\$0.73	\$5.97	\$0.83	\$5.97	\$0.94	\$5.97
Variable O&M (2010\$/MWh)	\$0.16	\$0.00	\$0.16	\$0.00	\$0.16	\$0.00
Capacity Penalty	-0.60%	0.00%	-0.60%	0.00%	-0.60%	0.00%
Heat Rate Penalty	0.60%	0.00%	0.60%	0.00%	0.60%	0.00%
<b>DSI</b>						
Capital (2010\$/kW)	\$43		\$61		\$134	
Fixed O&M (2010\$/kW-year)	\$0.61		\$0.94		\$2.39	
Variable O&M (2010\$/MWh)	\$7.70		\$7.70		\$7.70	
Capacity Penalty	-0.79%		-0.79%		-0.79%	
Heat Rate Penalty	0.79%		0.79%		0.79%	

Notes: Heat rate of 11,000 Btu/kWh is assumed. EIA does not model dry scrubber retrofits.

# Assumptions used for Annualization Period



- Coal unit lifetime assumptions for annualizing the overnight capital costs of control technologies depend on unit age in 2015:
  - Less than 45 years old: 20 years (NEMS baseline assumption)
  - 45 to 54 years old: 15 years
  - 55 years or older: 10 years

# Reference Energy Market Conditions: Coal, Natural Gas, and Electricity Prices



## EIA Coal, Natural Gas, and Electricity Prices

	2015	2020	2025	2030	2035
<b>Coal</b>					
Minemouth (2010\$/ton)	\$33.04	\$34.23	\$35.11	\$35.30	\$35.60
Delivered to Elec Sector (2010\$/MMBtu)	\$2.19	\$2.23	\$2.31	\$2.35	\$2.42
<b>Natural Gas</b>					
Henry Hub (2010\$/MMBtu)	\$4.46	\$4.88	\$6.05	\$6.57	\$7.26
Delivered to Elec Sector (2010\$/MMBtu)	\$4.41	\$4.77	\$5.82	\$6.35	\$7.00
<b>Electricity</b>					
Wholesale (2010\$/MWh)	\$48.35	\$49.89	\$54.66	\$57.05	\$59.97
Retail (2010\$/MWh)	\$87.04	\$85.83	\$88.47	\$89.35	\$91.81

Note: Projections reflect EIA's *Annual Energy Outlook 2011: Early Release* (December 2010). Projections are similar in the final version.

# Reference Energy Market Conditions: Costs for New Capacity



## EIA Overnight Capital Costs for New Capacity (2010\$/kW)

Supercritical Pulverized Coal	\$2,805
Natural Gas Combined Cycle	\$987
Nuclear	\$5,283
Wind	\$2,402
Solar Thermal	\$4,663
Solar Photovoltaic	\$4,672

Note: Projections reflect EIA's *Annual Energy Outlook 2011* (same projections in early release and final version).

# Input Assumptions for NERA Retirement Model



	Units	Expected Value			Uncertainty Range (Lognormal Distributions with Fat Right Tails)		
		Value	Notes	Source	Standard Deviation	95% Confidence Interval	Source
<b>Control Capital Costs</b>							
<b>Scrubber</b>	2010\$/kW	\$538	Varies by unit (value for 500 MW)	EPA	15% (\$80.70 for illustrative 500 MW)	\$403 - \$718	NEMS environmental control cost model documentation
<b>SCR</b>	2010\$/kW	\$201	Varies by unit (value for 500 MW)	EPA	15% (\$30.15 for illustrative 500 MW)	\$151 - \$268	NEMS environmental control cost model documentation
<b>ACI</b>	2010\$/kW	\$8	Same for all units	EPA	15% (\$1.20 for all units)	\$6 - \$11	NEMS environmental control cost model documentation
<b>Fabric Filter</b>	2010\$/kW	\$170	Same for all units	EPA	15% (\$25.50 for all units)	\$127 - \$227	NEMS environmental control cost model documentation
<b>Discount Rates</b>							
<b>Public</b>	Rate	0.07	Capital costs annualized over 10-20 years depending on unit age	EIA NEMS	0.005	0.06 - 0.08	Historical variation (www.snl.com)
<b>Private</b>	Rate	0.1183	Capital costs annualized over 10-20 years depending on unit age	EIA NEMS	0.005	0.109 - 0.129	Historical variation (www.snl.com)
<b>Prices</b>							
<b>Coal</b> (delivered to electricity sector)	2010\$/MMBtu	\$2.19	2015 U.S. Avg. (inputs are regional)	EIA NEMS	\$0.37 (2015 U.S. Avg.)	\$1.58 - \$3.03	Historical variation (Bloomberg)
<b>Natural Gas Price</b> (delivered to electricity sector)	2010\$/MMBtu	\$4.90	2015 U.S. Avg. (inputs are regional)	EIA NEMS	\$1.30 (2015 U.S. Avg.)	\$2.71 - \$7.56	Historical variation (Bloomberg)
<b>Electricity Price</b> (wholesale)	2010\$/MWh	\$48.35	2015 U.S. Avg. (inputs are regional)	EIA NEMS	\$2.60 (2015 U.S. Avg.)	\$43.52 - \$53.71	Historical variation in gas price and relationship between gas and elec prices (Bloomberg)



# Energy Market Impacts



# Context for Coal Units

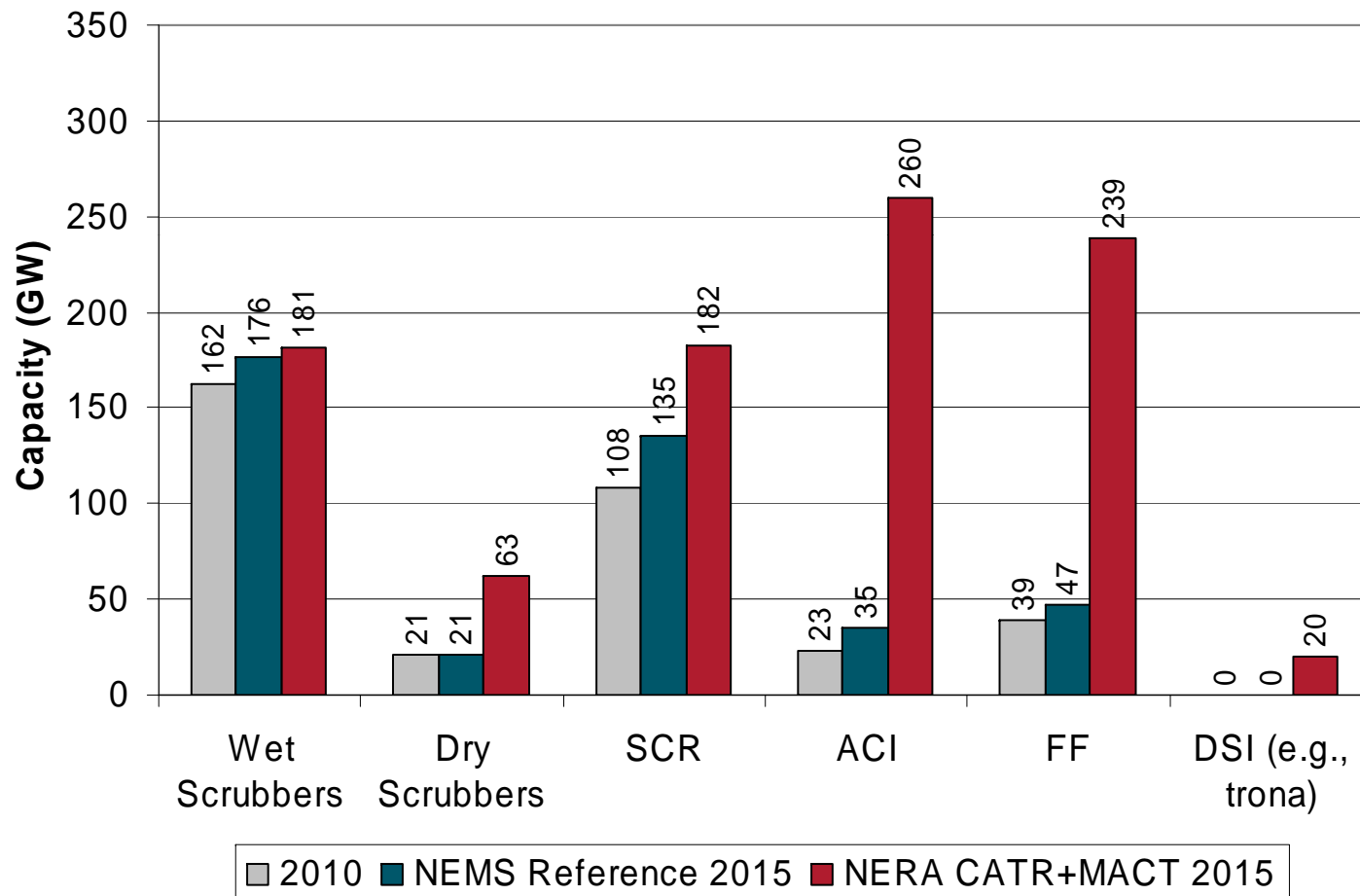


## Overview of U.S. Coal Units (> 25 MW) in 2010

	<b>Count</b>	<b>Capacity</b>	<b>Generation</b>
All Coal (> 25 MW)	1196 units	318 GW	1875 TWh
Unscrubbed	721 units 60%	136 GW 43%	739 TWh 39%
Unscrubbed & > 40 years	566 units 47%	74 GW 23%	358 TWh 19%
Unscrubbed & > 40 years & HR > 10	454 units 38%	47 GW 15%	221 TWh 12%

Note: CATR and MACT would exempt coal units smaller than 25 MW. There are 193 coal units smaller than 25 MW in the U.S. and their total capacity is 2.8 GW (EPA, MACT RIA, March 2010, p. 7-3).

# CATR + MACT Control Retrofits (Net of Retirements)



# Comparison of EPA and NERA Modeling of CATR and MACT



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Economic Consulting

## 2016 CATR+MACT Impacts

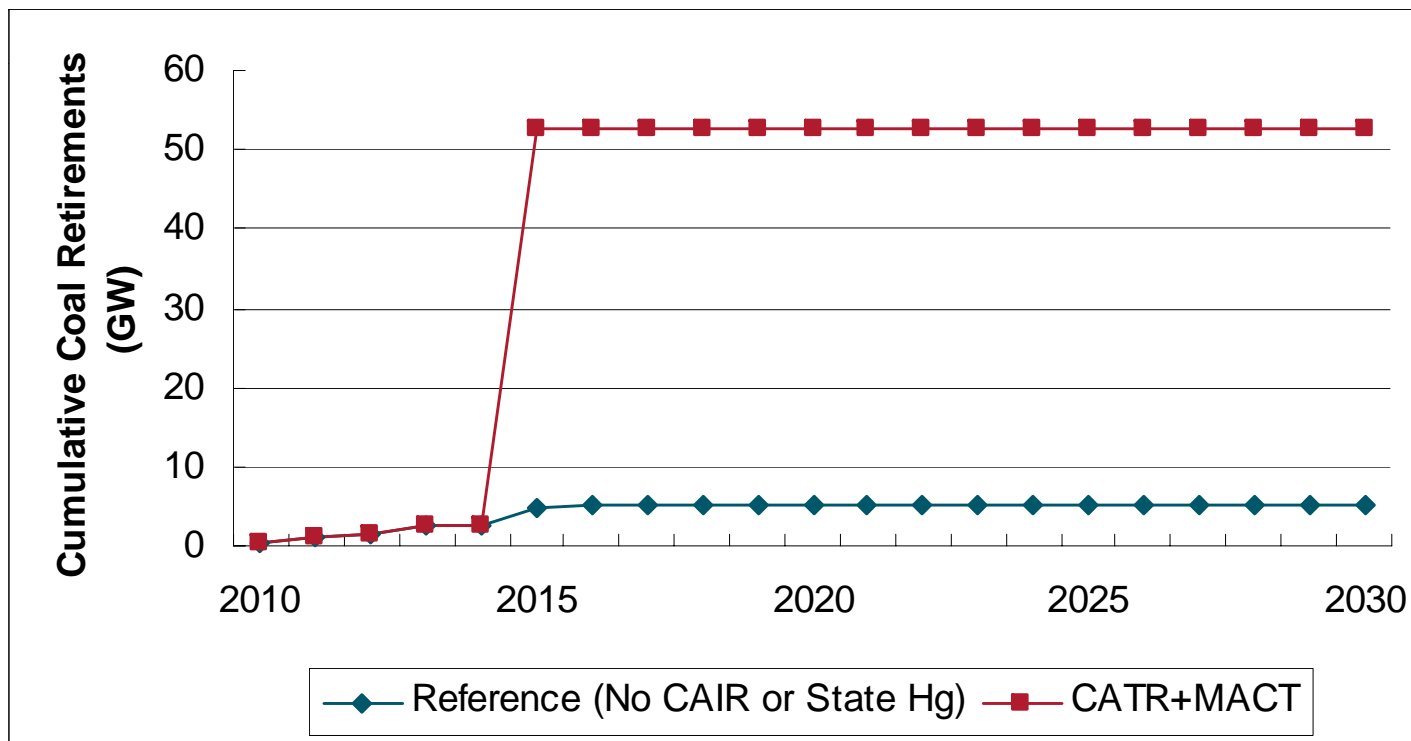
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Notes: Summary results are provided for 2016 rather than 2015 to show the full potential effect on electricity prices. Electricity price impacts reflect levelized capital costs for environmental controls and new capacity.

# U.S. Cumulative Coal Plant Retirements



U.S. Cumulative Coal Plant Retirements (GW)

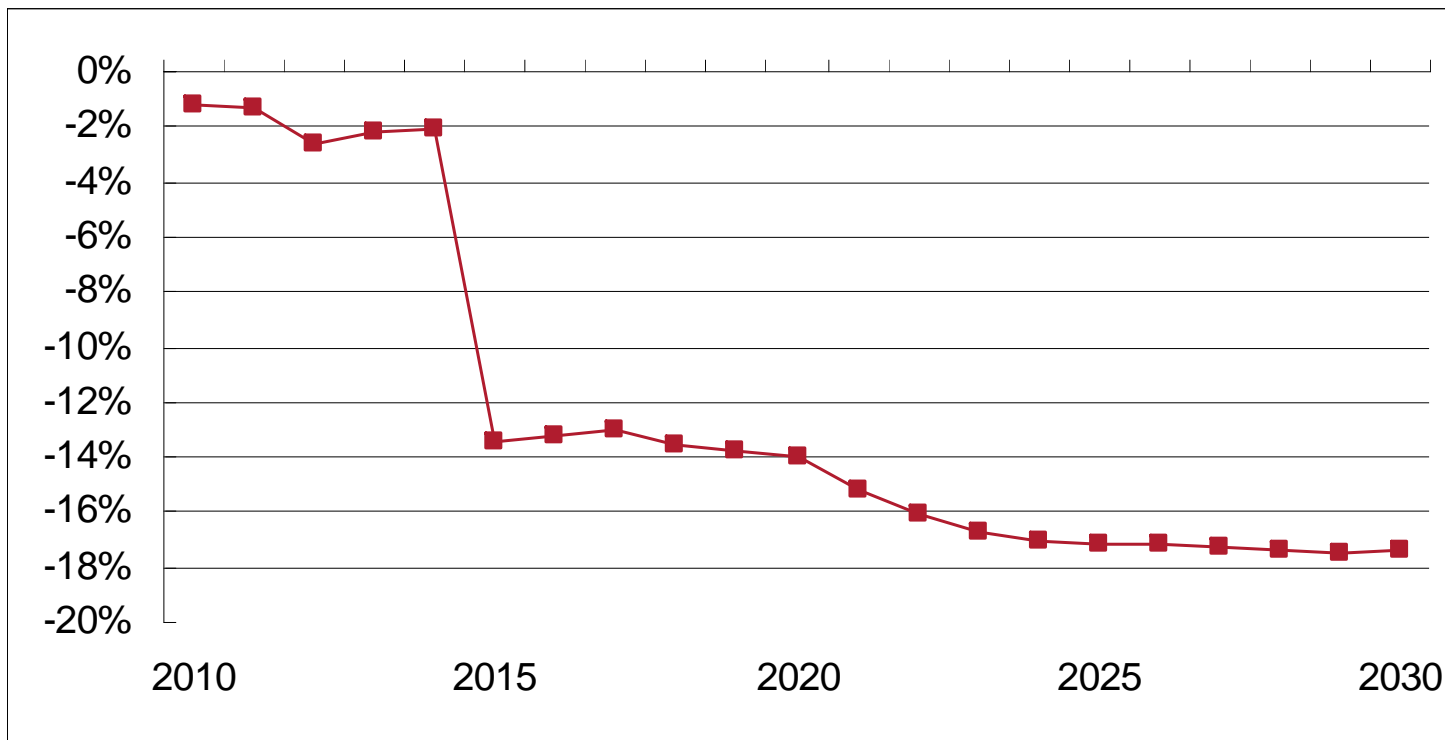


Note: Retirements are cumulative from 2010.

# U.S. Coal-Fired Generation



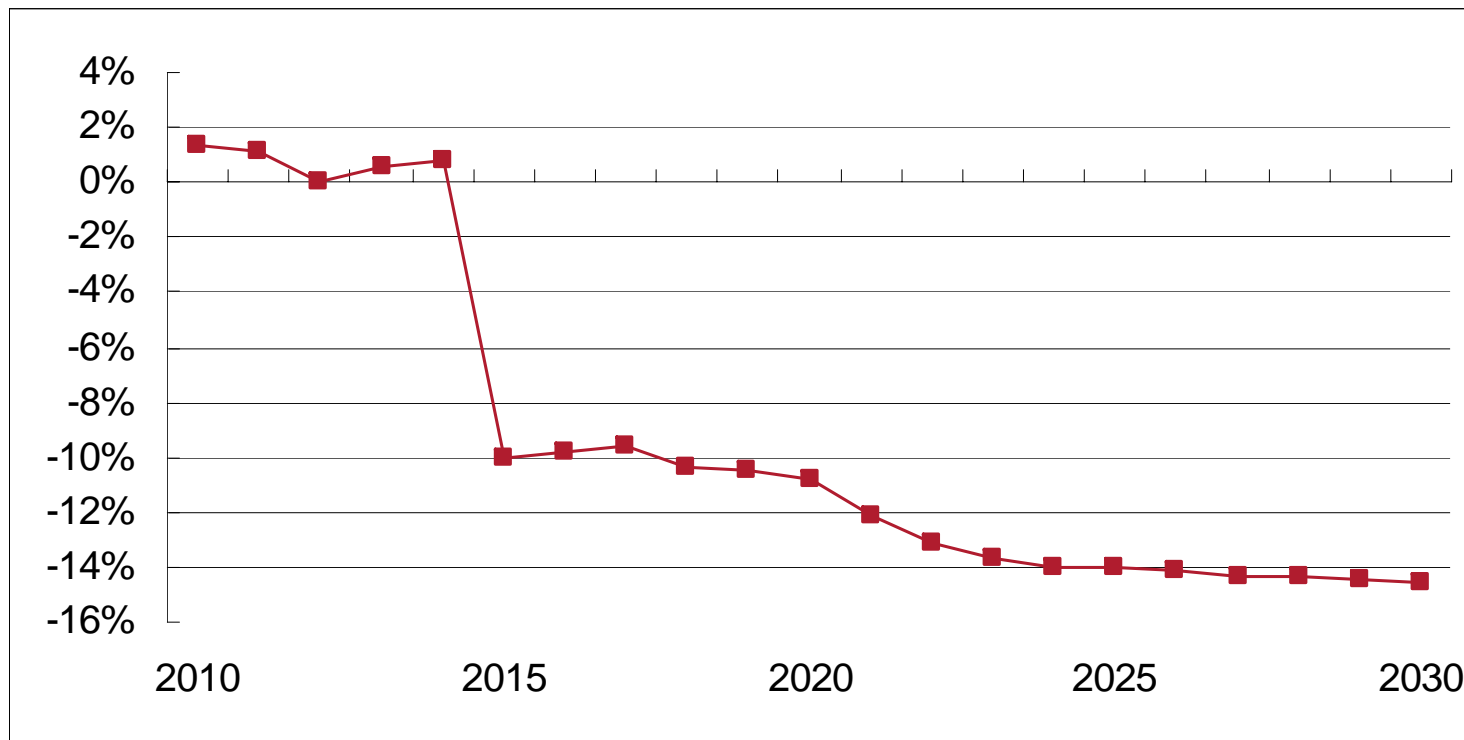
Percentage Change in U.S. Coal-Fired Generation



# U.S. Electricity Sector Coal Demand



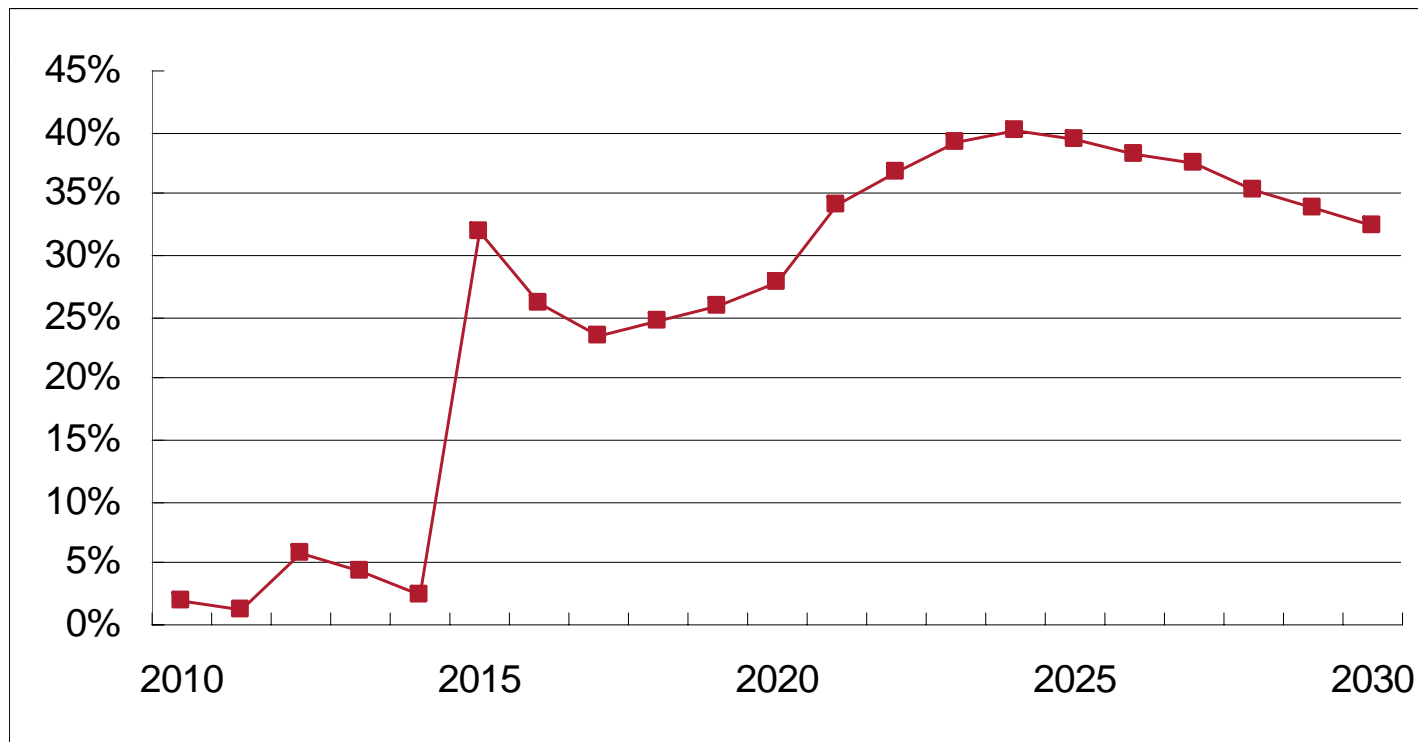
Percentage Change in U.S. Electricity Sector Coal Demand



# U.S. Gas-Fired Generation



Percentage Change in U.S. Gas-Fired Generation

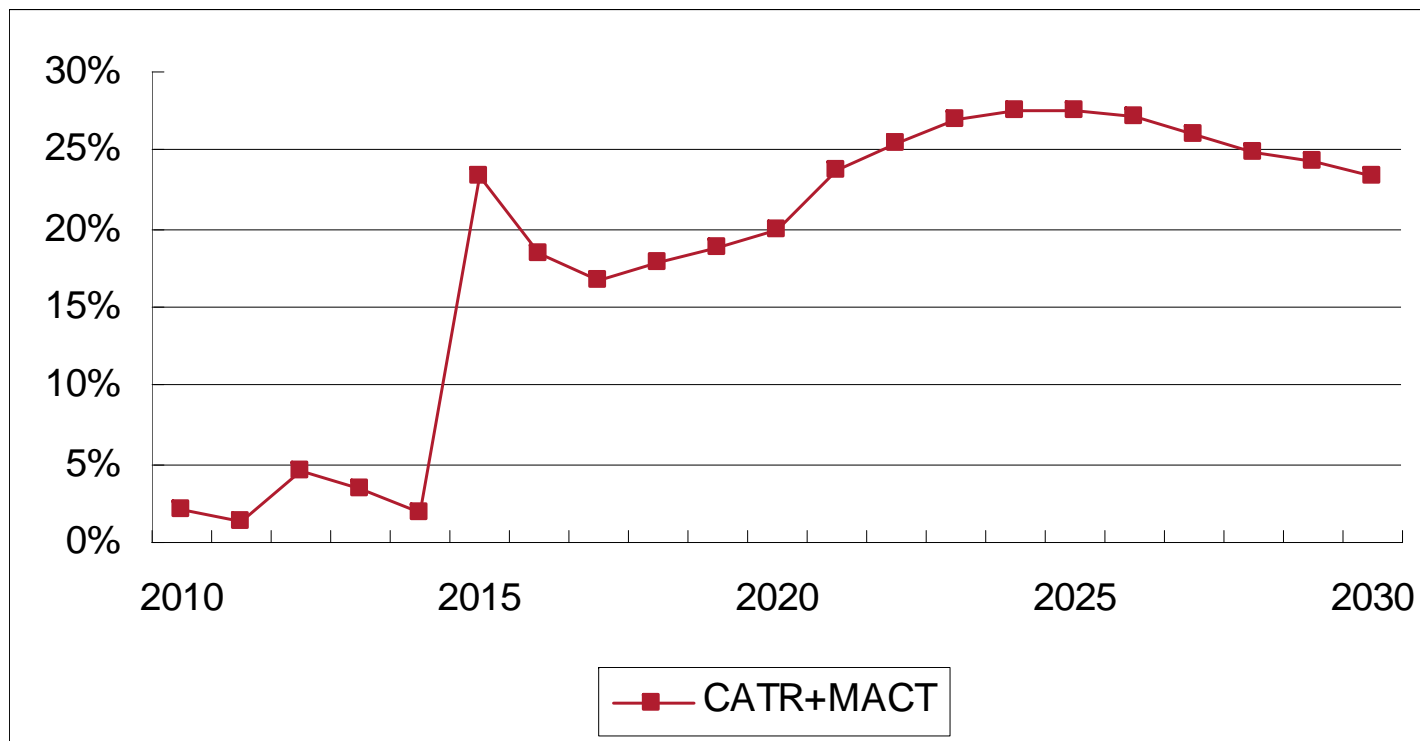




# U.S. Electricity Sector Gas Demand



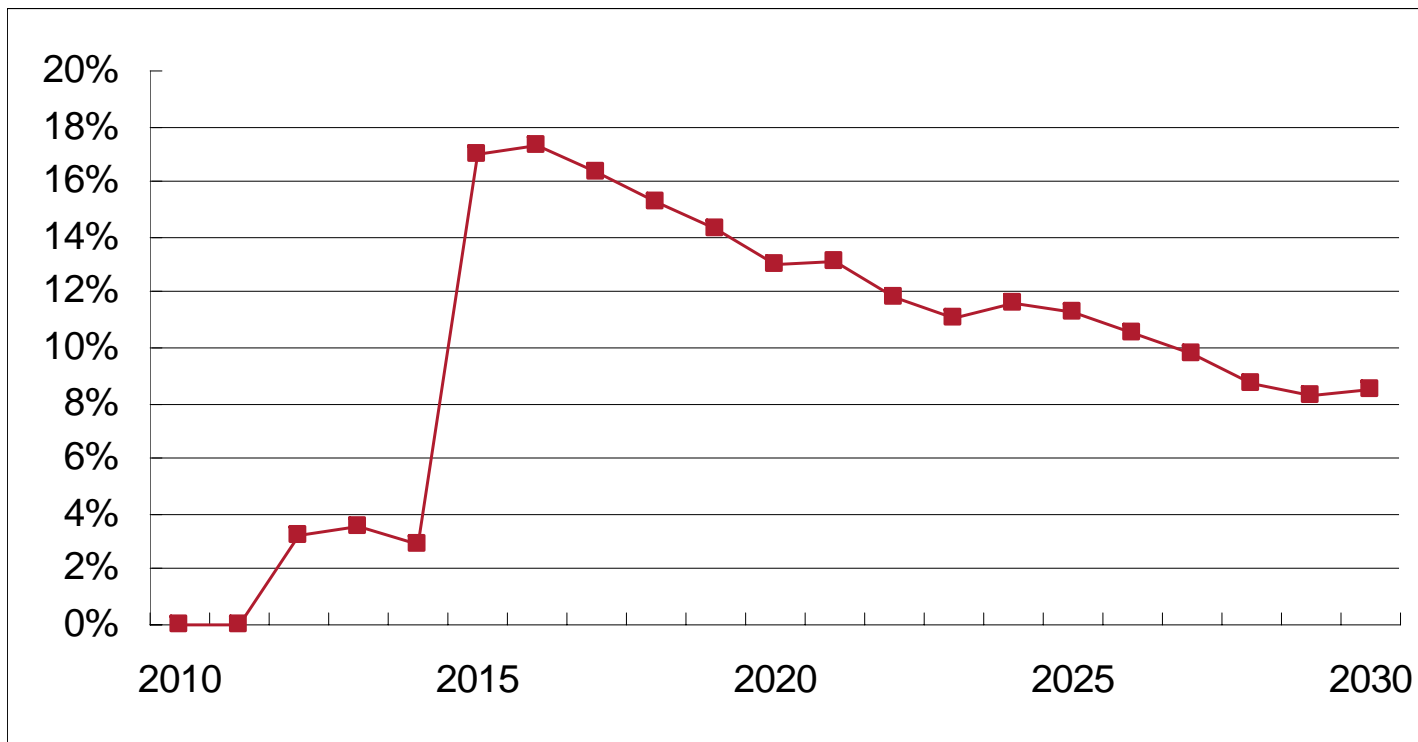
Percentage Change in U.S. Electricity Sector Gas Demand



# Henry Hub Natural Gas Price



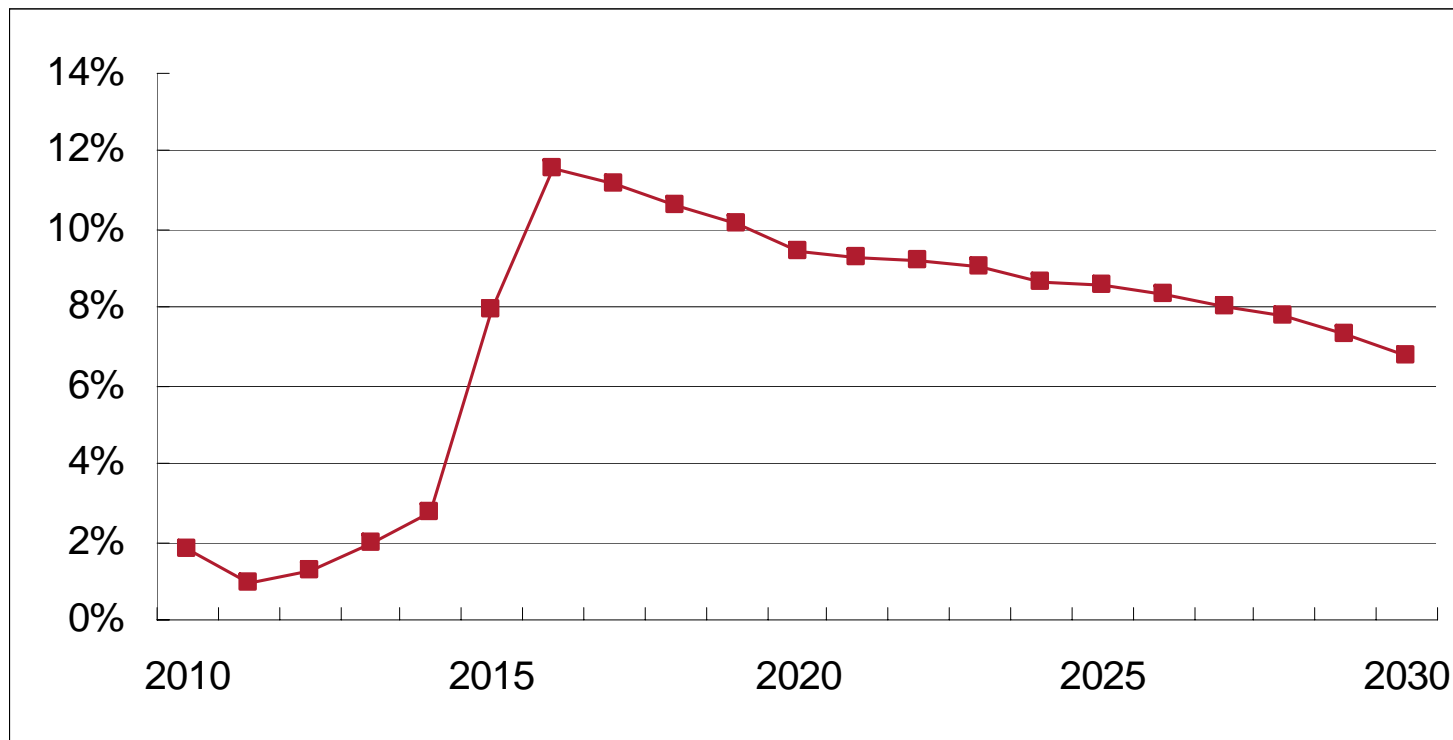
Percentage Change in Henry Hub Natural Gas Price



# U.S. Average Retail Electricity Prices



Percentage Change in U.S. Average Retail Electricity Price

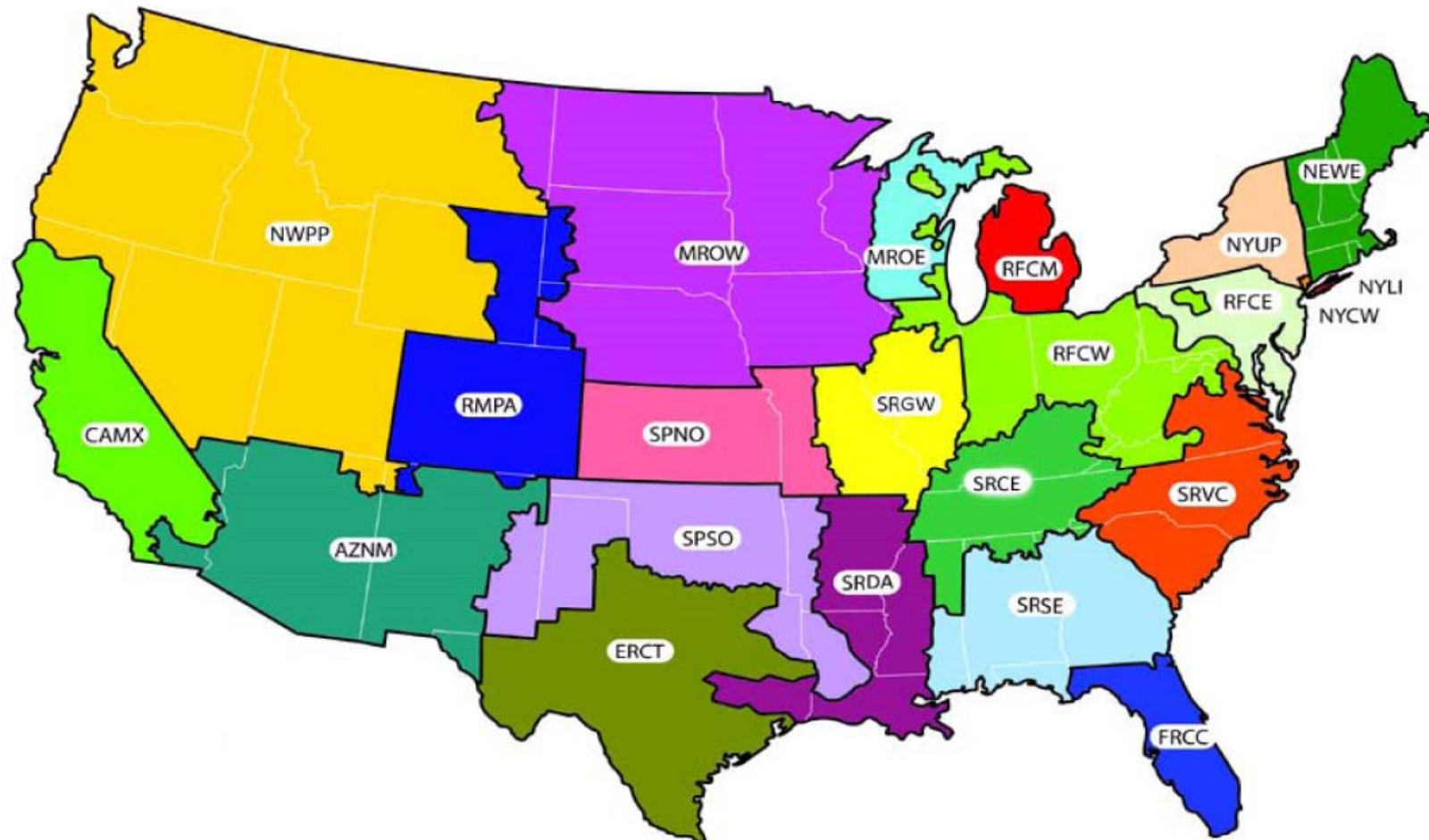


Note: Electricity price impacts reflect levelized capital costs for environmental controls and new capacity.

# Electricity Regions in NEMS (AEO 2011)



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Source: EIA

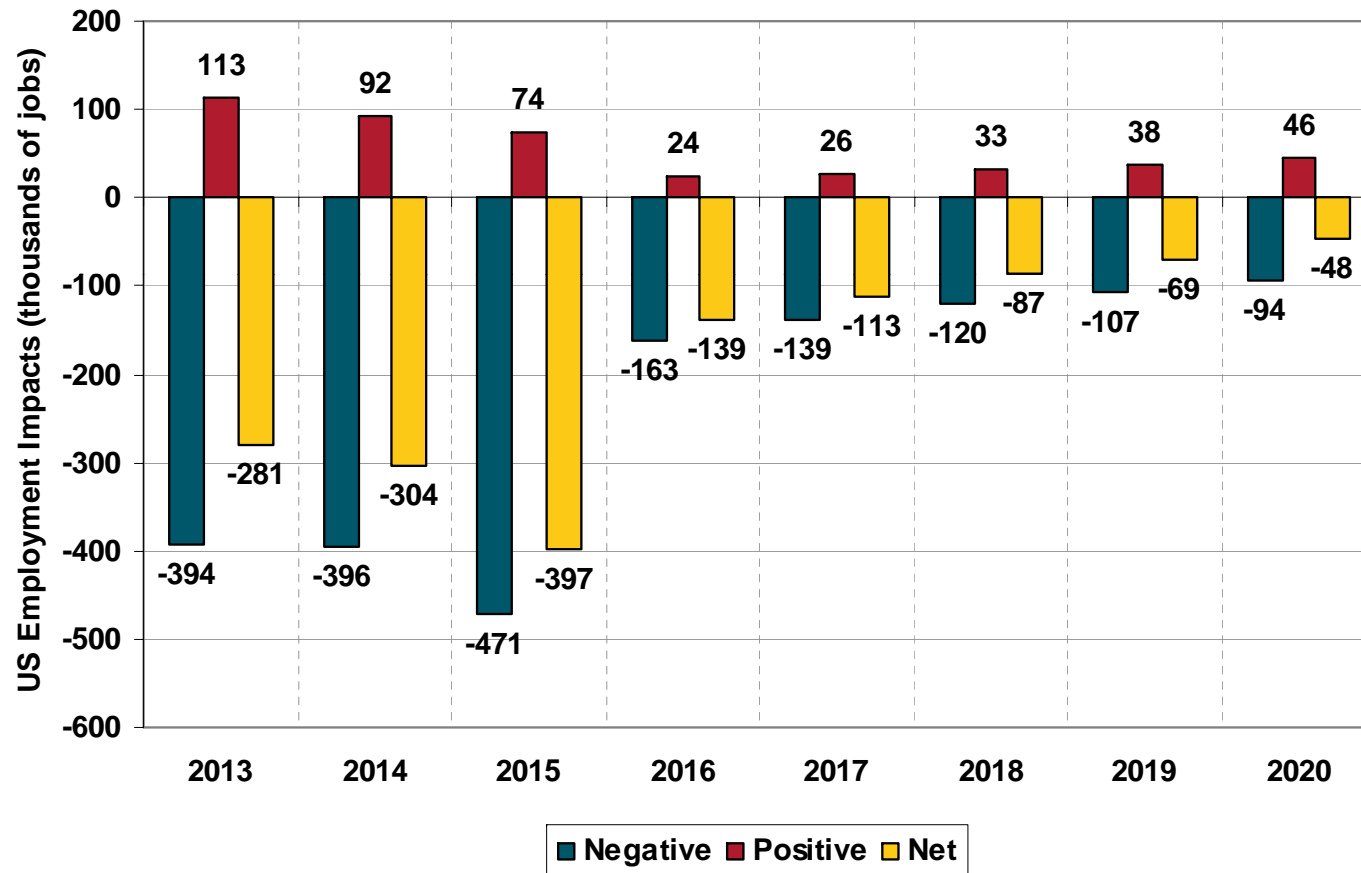
# Regional Retail Electricity Prices



## Percentage Change in Average Retail Electricity Prices

		<b>2016</b>	<b>2020</b>	<b>2025</b>
	US Average	+11.5%	+9.5%	+8.5%
NEWE	New England	+7.5%	+7.7%	+5.4%
NYCW	NYC	+5.5%	+5.0%	+7.6%
NYLI	NY Long Island	+6.5%	+4.8%	+6.6%
NYUP	NY Upstate	+8.0%	+6.4%	+8.1%
RFCE	Mid-Atlantic	+17.1%	+9.9%	+7.8%
SRVC	VA & Carolinas	+12.7%	+9.9%	+8.2%
SRSE	Southeast	+14.5%	+9.4%	+9.8%
FRCC	Florida	+8.8%	+8.9%	+8.5%
RFCM	Lower MI	+20.5%	+17.7%	+13.4%
RFCW	OH, IN, & WV	+12.9%	+12.1%	+11.9%
SRCE	KY & TN	+23.5%	+17.8%	+13.3%
MROE	WI & Upper MI	+21.7%	+17.3%	+12.6%
MROW	Upper Midwest	+17.6%	+14.1%	+10.2%
SRGW	South IL & East MO	+23.1%	+18.8%	+16.3%
SPNO	KS & West MO	+12.8%	+12.0%	+14.6%
SRDA	AR, LA, & West MS	+9.0%	+8.0%	+7.5%
SPSO	Oklahoma	+15.8%	+12.8%	+10.9%
ERCT	Texas	+12.1%	+9.4%	+9.5%
RMPA	CO & East WY	+6.1%	+7.3%	+8.8%
NWPP	Northwest	+2.0%	+4.0%	+7.9%
AZNM	AZ & NM	+6.1%	+5.2%	+3.6%
CAMX	California	+1.8%	+1.9%	+0.8%

# Economic Impacts: U.S. Employment 2013-2020



U.S. Total 2013-2020:  
 Negative: -1.88 million  
 Positive: 0.45 million  
 Net: -1.44 million

Note: Negative employment impacts are the sums of employment impacts in sectors with net losses.  
 Positive employment impacts are the sums of employment impacts in sectors with net gains.