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Energy and Consumer Impacts of EPA's Clean Power Plan

Prepared for the American Coalition for Clean Coal Electricity

November 7, 2015

Insight in Economics™

Contents

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Executive Summary

NERA Approach to Analyzing the Final Clean Power Plan

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- NERA used a state-of-the-art energy/economy model ($N_{ew}ERA$) to assess the impacts of the CPP
  - Impacts are measured relative to projected baseline conditions (i.e., without CPP)
  - Baseline values for this analysis, including electricity demand and supply, capital costs, and fuel costs, are based on the *AEO 2015* reference case projections

- NERA analyzed two alternative scenarios for mass-based CPP compliance, differing in the extent of trading each assumes (state versus regional)*
  - Both scenarios identify least cost compliance from all available options within the assumed trading regions, including end-use energy efficiency
  - Results for both are presented for two cases on whether or not some of the value of allowances is used to lower electricity rate impacts

	Scenario	Trading
1	Mass-Based	Intra-State
2	Mass-Based with Regional Trading	Regional

(*) Appendix 2 provides results for a rate-based scenario

Scenarios Include Two Assumed Cases for Allocating the Value of Allowances

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- Two mass-based modeling scenarios present a range based on two assumptions on allocation of allowance value to electric local distribution companies (LDCs), which would reduce electricity system costs and thus retail electricity rates
  - **No LDC allocation:** Allowances are auctioned to generators with none of the proceeds distributed to LDCs, and thus electricity price impacts are not reduced
  - **50% LDC allocation**: Half of allowances are auctioned to generators, with the other half freely distributed to LDCs and used as credit to retail rates
- LDCs set regulated retail electricity rates on the basis of net costs, including any allowance allocation value that is provided
  - Thus LDCs "pass on" allowance value to electricity customers in the form of lower rates
  - In cost-of-service jurisdictions, providing "free" allowances to generators would have the same effect on electricity rates
- Note that in both cases the full value of allowances is returned to state households
  - **No LDC allocation:** All value provided to all households via means other than lowering electricity rate impacts
  - **50% LDC allocation:** Half the value provided to households via means other than lowering electricity rates, and the other half of the value is provided to LDCs and thus to electricity consumers in the form of lower electricity rate impacts

Key Findings

- All compliance scenarios lead to large reductions in average CO_2 emissions
  - Reductions range from 19% to 21% (relative to baseline emissions)
  - By 2031, annual emissions are 36% to 37% lower than they were in 2005
- Energy sector expenditure increases range from $220 to $292 billion (spending from 2022 through 2033, brought to a present value in 2016)
  - Annual average expenditures increases between $29 and $39 billion/year
  - Expenditures include changes in electricity generation costs (including allowance costs), energy efficiency costs, and increased natural gas costs for non-electric consumers
  - Expenditures do not include potential increased costs for electricity transmission and distribution and natural gas infrastructure
- Average annual U.S. retail electricity rate increases range from 11%/year to 14%/year (relative to baseline) over the same time period
- For the overall economy, losses to U.S. consumers range from $64 billion to $79 billion on a present value basis over the same time period

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Key Energy Impacts of Compliance Scenarios (2022-2033, 2015$)

	Present Value of Expenditures			Annual Average Expenditures			Retail Electricity Rate			Henry Hub Natural Gas Price			Total CO_2 Emissions		
	PV billion$			Annual avg billion$			¢/kWh			$/MMBtu			Annual avg MM metric tons		
Baseline			$2,143			$333			11.1			$5.7			2,038
Mass-Based	$2,384	to	$2,436	$364	to	$372	12.3	to	12.6	$5.7	to	$5.8	1,610	to	1,613
Change	+$241	to	+$292	+$32	to	+$39	+1.2	to	+1.6	+$0.0	to	+$0.0	(428)	to	(425)
% Change	+11%	to	+14%	+10%	to	+12%	+11%	to	+14%	+0%	to	+1%	-21%	to	-21%
Mass-Based with Regional Trading	$2,364	to	$2,408	$362	to	$368	12.3	to	12.6	$5.7	to	$5.7	1,637	to	1,641
Change	+$220	to	+$264	+$29	to	+$35	+1.2	to	+1.5	($0.1)	to	($0.0)	(400)	to	(396)
% Change	+10%	to	+12%	+9%	to	+11%	+11%	to	+14%	-1%	to	-1%	-20%	to	-19%

Source: N_{ew}ERA modeling results.

Note: Present value is from 2022 through 2033, taken in 2016 using a 5% real discount rate. Annual averages and retail electricity rates are averages over the same period. Dollars in constant 2015 dollars. The ranges on results for each alternative trading scenario reflect the proportion of allowances freely allocated to LDCs, which varies from no LDC allocation to 50% LDC allocation. By 2031, annual CO_2 emissions are 36% to 37% lower than they were in 2005.

State Electricity Price Impacts

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- Retail electricity prices were modeled from 2022-2033 (four model years) using N_{ew}ERA output and other information that contributes to estimating cost-of-service and competitive pricing
- State-level average electricity price increases demonstrate that many states could experience significant price increases relative to the baseline
  - 40 states could have average retail electricity price increases of 10% or more
  - 17 states could have average retail electricity price increases of 20% or more
  - 10 states could have average retail electricity price increases of 30% or more
- The highest annual increase in retail rates relative to the baseline also shows that many states could experience periods of significant price increases
  - 41 states could have "peak" retail electricity price increases of 10% or more
  - 28 states could have "peak" retail electricity price increases of 20% or more
  - 7 states could have "peak" retail electricity price increases of 40% or more

State Electricity Price Impacts

State-Level Electricity Price Increases (Relative to Baseline Prices)

	Number of States With Average Rate Increases			Number of States With "Peak" Model Year Rate Increases			
Scenario	**≥ 10%**	**≥ 20%**	**≥ 30%**	**≥ 10%**	**≥ 20%**	**≥ 30%**	**≥ 40%**
Mass-Based							
No Allocation	37	16	9	41	24	12	3
50% Allocation	30	6	1	36	14	3	0
Mass-Based with Regional Trading							
No Allocation	37	14	4	41	25	10	7
50% Allocation	31	8	0	37	15	6	2
Across Any Scenario	40	17	10	41	28	14	7

Notes: Retail electricity prices were modeled from 2022-2033 using NewERA output and other information that contributes to estimating cost-of-service and competitive pricing. The average rate increase is calculated at the state-level by comparing the price under the policy to the price in the baseline. The “peak” rate increase is calculated at the state-level by comparing, across model years, the percent increase in the price under the policy relative to the baseline price during that model year. The highest percent increase across all model years is the “peak” price increase. Results across any scenario include the four scenario/case combinations above.

The CPP could potentially generate significant average and “peak” retail electricity rate increases, with most states experiencing double-digit increases

Impacts to U.S. Consumers

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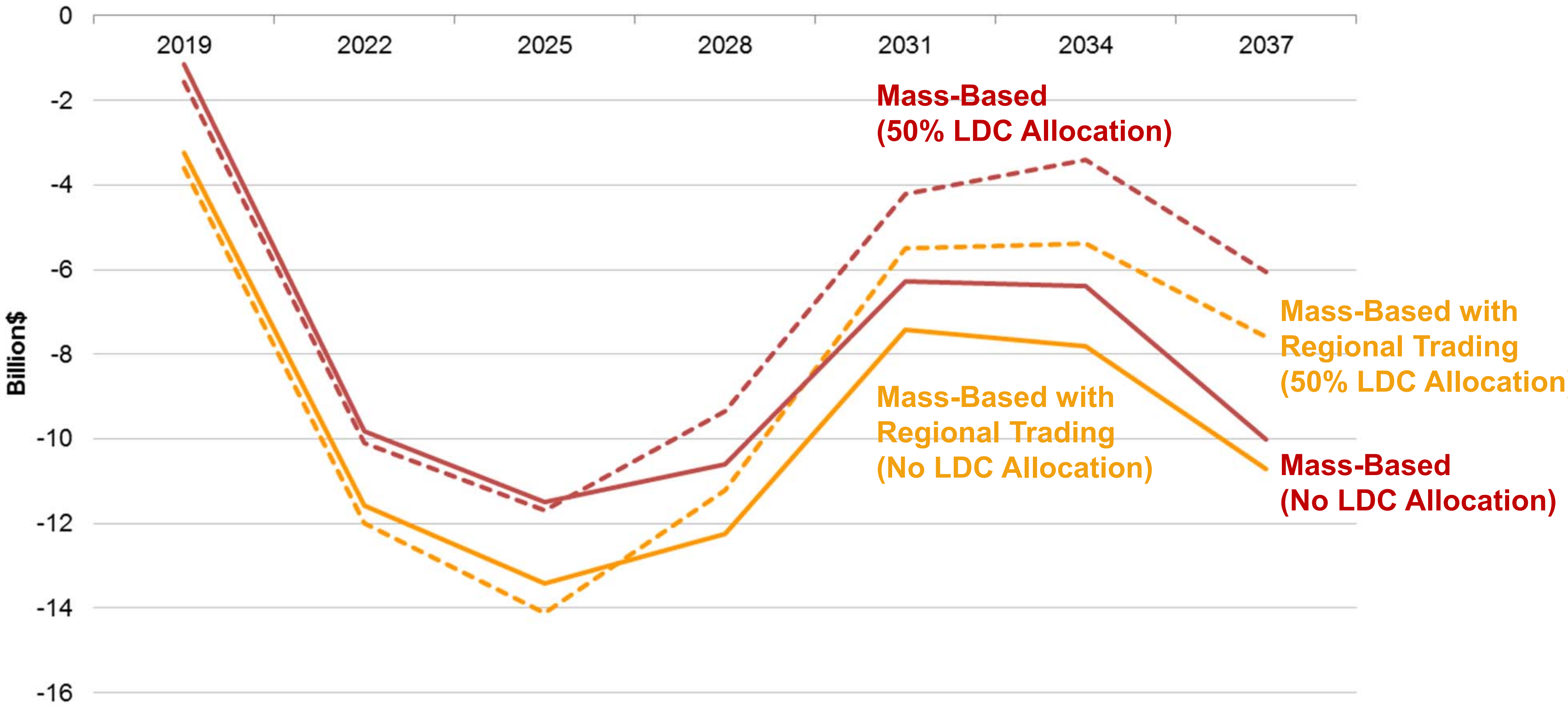
Differences in Total U.S. Consumption (2015$)



Source: NewERA modeling results, relative to baseline.
Notes: Net effects on U.S. spending power, including return to households of full value of allowances, either all through means other than lower electric rates (no allocation case) or half through reductions in electricity rates and half through another means (50% LDC allocation case).

Present value of total consumption loss—reflecting reduced economic well-being—over the period from 2022 to 2033 ranges from $64B to $79B

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Overview of Clean Power Plan

Overview of CPP

- The CPP aims to reduce CO_2 emissions from existing fossil-fueled power plants
- The CPP establishes interim (2022-2029) and final (2030) statewide goals in three forms:
  - Mass-based state goal measured in total short tons
  - Mass-based state goal with a new source complement measured in total short tons
  - Rate-based state goal measured in pounds per megawatt hour (lb/MWh)
- States have responsibility to implement plans to ensure that power plants in their states (individually or in combination with other measures) achieve the interim performance rates over 2022-2029 and the final goals by 2030
- States have the option to work with other states on multi-state approaches, including emissions trading

Basic Elements of the CPP

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	Final Rule
Program Timing	Starts in 2022 with “glide path” to final standards in 2030
Bases for Setting State Limits	State-specific emissions rates based on EPA’s estimates of three “building block” options (increases in plant efficiency, natural gas & renewables). Emission rate limits converted to equivalent mass caps if states choose that compliance scenario.
Bases for State Compliance	Although not a “building block” for calculating state emissions limits, end-use energy efficiency can be used in state compliance plans
Trading Mechanisms	Intra-state trading and well as inter-state trading
Deadline for State Implementation Plan	September 2018, after initial submittal by September 2016
Federal Plan	EPA authorized to promulgate federal implementation plan if a state fails to submit a plan or submits a plan that does not comply.

Source: EPA (2015). *Overview of the Clean Power Plan.* http://www2.epa.gov/sites/production/files/2015-08/documents/fs-cpp-overview.pdf.

NERA Methodology

Analysis Uses NERA’s N$_{ew}$ERA Model

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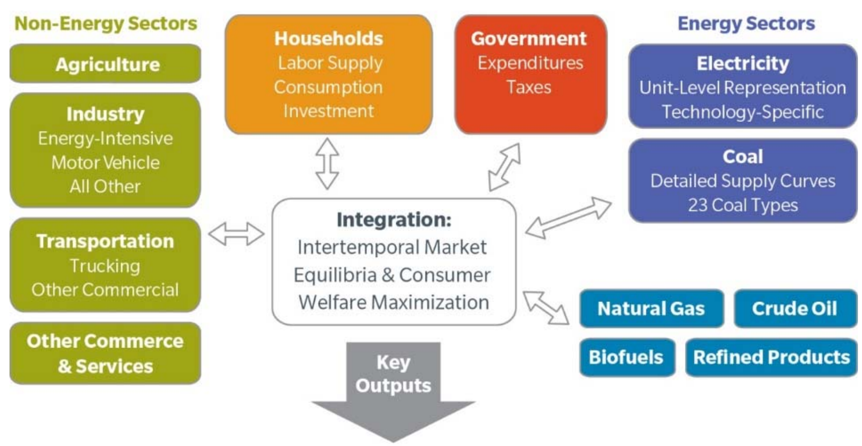
- N$_{ew}$ERA combines a bottom-up electricity sector model with a top-down model of the full U.S. (macro)economy
  - Electricity sector model optimizes compliance with CPP and estimates electricity rate impacts and other system operational changes such as natural gas and coal usage
  - Macroeconomic model incorporates demand response to electricity price changes, and natural gas and coal price responses to changes in fuel usage
- Economic impact analysis thus offers a comprehensive understanding of not just electricity sector compliance but also overall impacts on consumer spending power
- Appendix 1 provides more details on the N$_{ew}$ERA model

The N$_{ew}$ERA Model



Macroeconomic (National/Regional)	Primary Energy (National/Regional)	Electricity (National/Regional/Generating Unit)
Welfare	Demand	Prices
GDP, consumption, investment	Prices	Builds, retrofits, retirements
Output by sector	Production	Load and Dispatch

NERA Baseline

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- N$_{ew}$ERA model and its baseline projections are calibrated to the Department of Energy's *AEO 2015* reference case
  - Power plant retirements were updated based on public announcements of firm closures as of August 2015
- Baseline includes effects of existing environmental regulations, including RGGI and California AB 32
  - Baseline does not reflect the possibilities of proposed or future regulations (similar to AEO methodology)
- Baseline does not include the additional end-use energy efficiency that EPA assumes is available for CPP compliance
  - Exception is that NERA assumes California adopts end-use energy efficiency as part of its compliance with the AB 32 program, and thus these costs and demand effects are assumed to be in the baseline

NERA CPP Compliance Scenarios

1. Mass-Based
   – State compliance with emissions targets (includes new sources)
   – Intra-state trading (least-cost compliance)
   – Range based on two assumed allowance allocations to LDCs

2. Mass-Based with Regional Trading
   – Same as Mass-Based except six trading regions
   – Regional boundaries same as EPA used in its draft Regulatory Impact Analysis (See Slide 32)
   – Range based on two assumed allowance allocations to LDCs

NERA Assumptions Related to CPP Compliance Options

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1. **Coal Efficiency Retrofits**
   - EPA assumptions on the cost and effectiveness of coal heat rate improvements (4.3% for the Eastern Interconnection, 2.1% for the Western Interconnection, and 2.3% for the Texas Interconnection)
   - Units undertaking unit efficiency improvements are subject to New Source Review
2. **Natural Gas Generation**
   - Natural gas generation based upon least-cost generation mix using *AEO 2015* information on fuel prices and costs for alternative generation
3. **Renewable Generation**
   - Renewable generation based on least-cost generation mix using *AEO 2015* information on fuel prices and costs for alternative generation
4. **Energy Efficiency**
   - Use EPA assumption on initial cost ($1,100/MWh), which NERA applies to all energy efficiency programs (split 50/50 between utilities and consumers)
   - Use EPA assumptions on total potential for energy efficiency in each state

Detailed Results: Mass-Based Scenario with Intra-State Trading Only

Impacts on U.S. Energy Markets: Mass-Based Scenario

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Annual Averages, 2022-2033

	Total Coal Retirements Through 2033	Coal-Fired Generation	Natural Gas-Fired Generation	Total Generation	Delivered Electricity Price
	GW	TWh	TWh	TWh	2015 ¢/kWh
Baseline	38	1,687	1,118	4,354	11.1
No LDC Allocation	85	1,254	1,121	3,919	12.6
Change	+47	(434)	+3	(435)	+1.6
% Change	+19%	-26%	+0%	-10%	+14%
50% LDC Allocation	82	1,249	1,141	3,945	12.3
Change	+45	(438)	+23	(408)	+1.2
% Change	+18%	-26%	+2%	-9%	+11%

Note: Coal retirements are cumulative from 2016-2033, with percentage change relative to baseline 2033 capacity. Other columns show annual average from 2022-2033. Natural gas-fired generation includes only existing and new combined cycle generation.

Mass-based CPP scenario leads to substantial changes in the U.S. energy system, including reductions in electricity generation and increases in electricity rates

U.S. Energy Sector Expenditure Impacts: Mass-Based Scenario

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Changes in Energy Sector Expenditures (2015$)

	No LDC Allocation	*50% LDC Allocation*
Present Value (Billion 2015$)		
Cost of Electricity, Excluding EE	($128)	($111)
Cost of Energy Efficiency	$268	$268
Cost of Non-Electricity Natural Gas	$1	$3
Cost of Allowances	$152	$80
Total Expenditures	$292	$241

Note: Present value is from 2022 through 2033, taken in 2016 using a 5% real discount rate. Note that energy efficiency costs reflect the combined costs to utilities and consumers. Costs do not include any additional transmission and distribution expenditures or any increased natural gas infrastructure costs All costs are presented relative to the baseline.

Mass-based CPP scenario leads to large increases in energy sector expenditures, reflecting substantial increases in costs for energy efficiency and allowances (particularly with no LDC allocation) that exceed savings from a smaller electricity system

Other Energy and Consumer Impacts: Mass-Based Scenario

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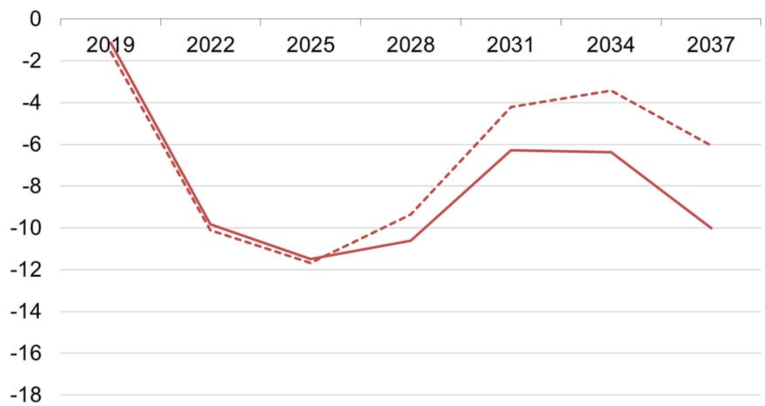
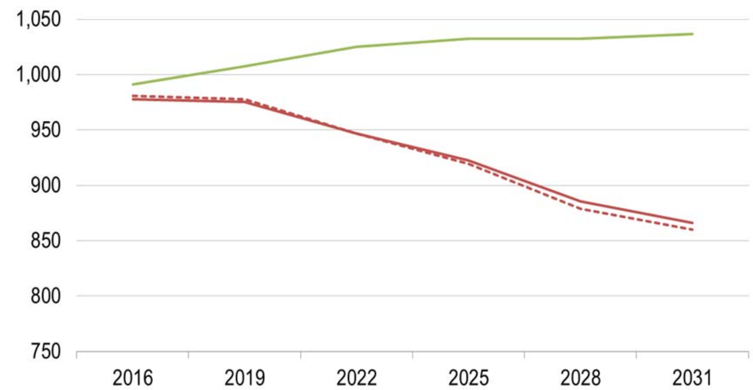
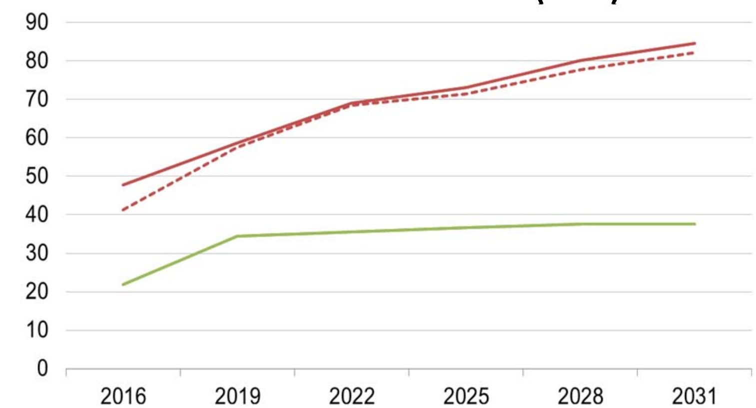
Differences in Total U.S. Consumption (Billion 2015$)*



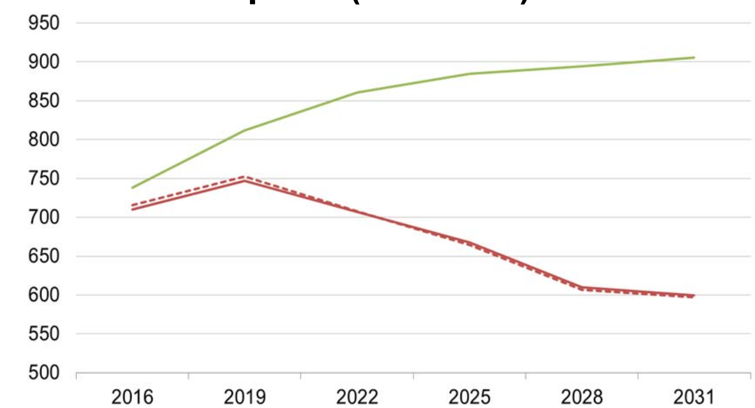
Electricity Sector Emissions Rate (lbs/MWh)



Cumulative Coal Retirements (GW)



Coal Consumption (MM Tons)



50% LDC Allocation **No LDC Allocation** **Baseline**

Source: N_{ew}ERA modeling results. Reported each model year (every three years).
* Consumption impacts are provided relative to Baseline scenario.

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Detailed Results: Mass-Based Scenario with Regional Trading

Impacts on U.S. Energy Markets: Mass-Based with Regional Trading Scenario

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Annual Averages, 2022-2033

	Total Coal Retirements Through 2033	Coal-Fired Generation	Natural Gas-Fired Generation	Total Generation	Delivered Electricity Price
	GW	TWh	TWh	TWh	2015 ¢/kWh
Baseline	38	1,687	1,118	4,354	11.1
No LDC Allocation	82	1,298	1,065	3,911	12.6
Change	+45	(389)	(53)	(443)	+1.5
% Change	+18%	-23%	-5%	-10%	14%
50% LDC Allocation	78	1,293	1,086	3,937	12.3
Change	+41	(394)	(32)	(416)	+1.2
% Change	+17%	-23%	-3%	-10%	+11%

Note: Coal retirements are cumulative from 2016-2033, with percentage change relative to baseline 2033 capacity. Other columns show annual average from 2022-2033. Natural gas-fired generation includes only existing and new combined cycle generation.

Mass-based with regional trading CPP scenario leads to substantial changes in the U.S. energy system, including reductions in electricity generation and increases in electricity rates

U.S. Energy Sector Expenditure Impacts: Mass-Based with Regional Trading Scenario

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Changes in Energy Sector Expenditures (2015$)

	No LDC Allocation	*50% LDC Allocation*
Present Value (Billion 2015$)		
Cost of Electricity, Excluding EE	($142)	($122)
Cost of Energy Efficiency	$268	$268
Cost of Non-Electricity Natural Gas	($4)	($2)
Cost of Allowances	$142	$76
Total Expenditures	$264	$220

Note: Present value is from 2022 through 2033, taken in 2016 using a 5% real discount rate. Note that energy efficiency costs reflect the combined costs to utilities and consumers. Costs do not include any additional transmission and distribution expenditures or any increased natural gas infrastructure costs . All costs are presented relative to the baseline.

Mass-based with regional trading CPP scenario leads to large increases in energy sector expenditures, reflecting substantial increases in costs for energy efficiency and allowances (particularly with no LDC allocation) that exceed savings from a smaller electricity system

Impacts to U.S. Consumers: Mass-Based with Regional Trading Scenario

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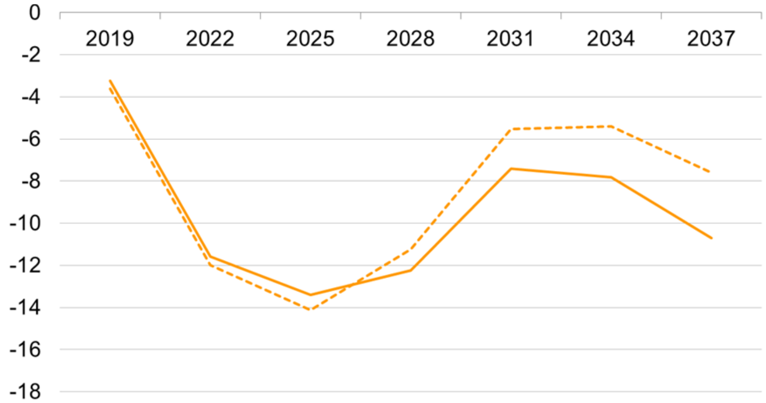
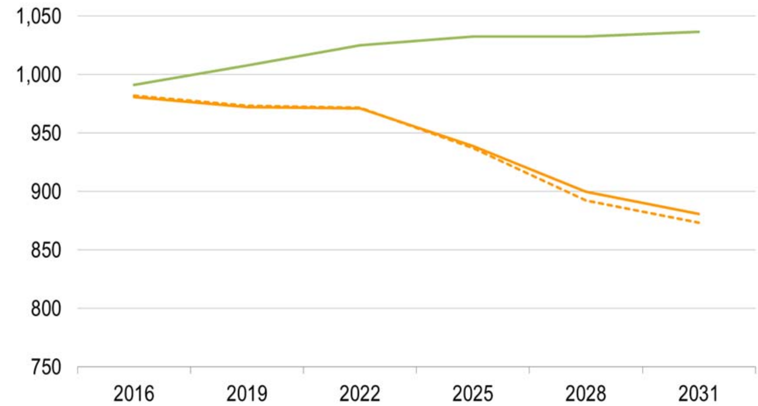
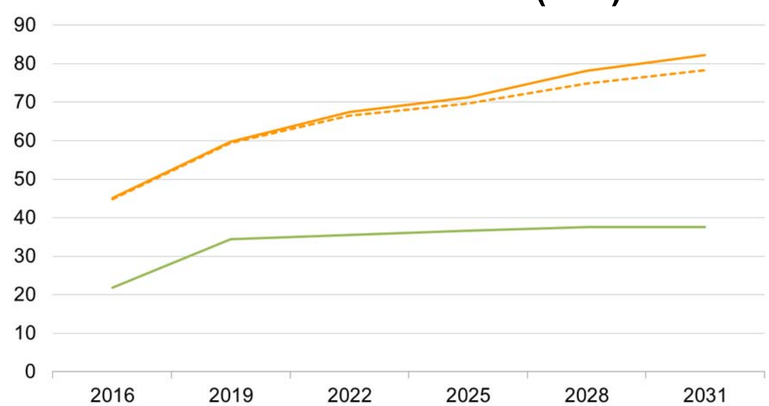
Differences in Total U.S. Consumption (Billion 2015$)*



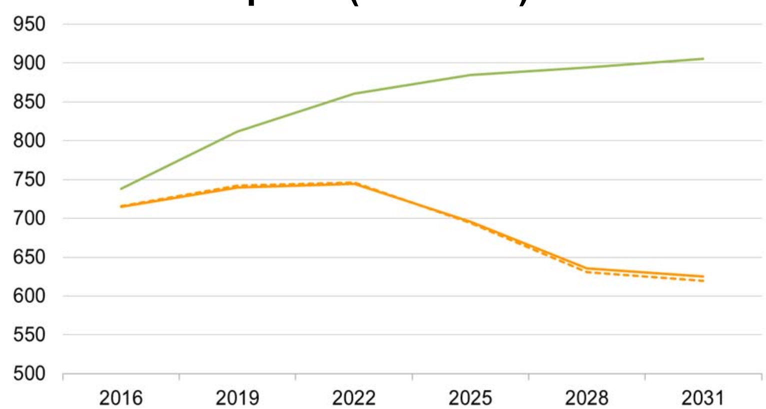
Electricity Sector Emissions Rate (lbs/MWh)



Cumulative Coal Retirements (GW)



Coal Consumption (MM Tons)



50% LDC Allocation **No LDC Allocation** **Baseline**

Source: N$_{ew}$ERA modeling results. Reported each model year (every three years).
* Relative to baseline consumption

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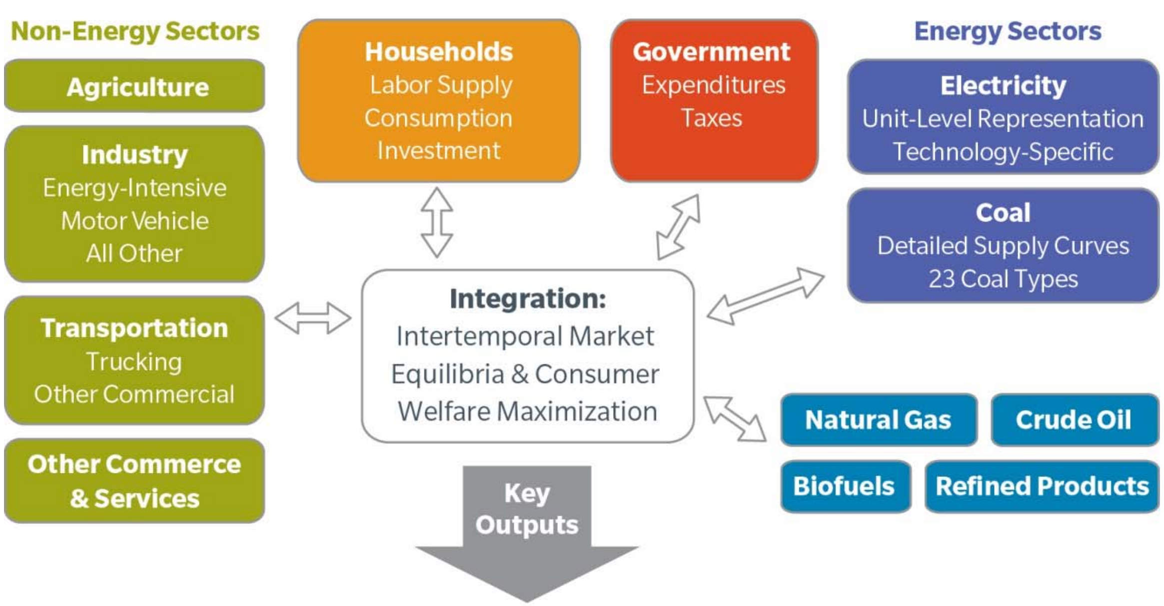
Appendix 1: Overview of N$_{ew}$ERA Model

N$_{ew}$ERA Model

N$_{ew}$ERA Model Structure

The N$_{ew}$ERA Model



Macroeconomic (National/Regional)	**Primary Energy** (National/Regional)	**Electricity** (National/Regional/Generating Unit)
Welfare	Demand	Prices
GDP, consumption, investment	Prices	Builds, retrofits, retirements
Output by sector	Production	Load and Dispatch

Electricity Sector
- Capacity
- Generation
- Retirements
- Wholesale and Delivered Electricity Prices
- Emissions

Other Energy Sectors
- Production
- Consumption
- Energy Prices

Economic Outputs
- GDP
- Consumption
- Employment

N_{ew}ERA Electricity Sector Model: Overview

- Bottom-up dispatch and capacity planning model
  - Unit-level information on generating units in 34 U.S. regions
  - Detailed coal supply curves by coal type
  - Regional electricity demand and capacity requirements
- Least-cost projection of market activity
  - Satisfies demand and all other constraints over model time horizon
  - Projects unit-level generation and investment decisions and regional fuel and electricity prices
- Data sources
  - Model calibrated to U.S. Energy Information Administration's *AEO 2015*
  - Other electricity sector data from EIA, EPA, NERC, NREL, NETL, Ventyx Velocity Suite, and HellerWorx

N_{ew}ERA Electricity Sector Model: Unit-Level Detail

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- Represents electricity capacity and generation at the unit level
  - 16 generating technologies, including renewables
  - Unit physical attributes: capacity, utilization, heat rate, outages, retrofits, emission rate
  - Unit costs: capital, fixed O&M, variable O&M, transmission and distribution, refurbishment
- Projects unit generation and investment decisions to minimize sector costs over projection period
  - Available actions include retirements, new builds, retrofits, coal type choice (for coal units), and fuel switching
  - Units will retire if they cannot remain profitable
  - Units can also be forced to take certain actions at specified times, or given a choice to act or retire

NewERA Electricity Sector Model: Fuel Supply

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- Model represents supply of five fuels: coal, natural gas, oil, biomass, and uranium
- Detailed supply curves for 23 coal types
  - At each "step" on supply curve, provides price, annual production limit, and total coal reserves available at that price
  - Transportation matrix determines coals that can be delivered to each unit and the cost of delivery
  - Coal units assigned an initial coal type, but can incur a capital costs to switch to other coal types when reasonable

N_{ew}ERA Electricity Sector Model: Electricity Demand

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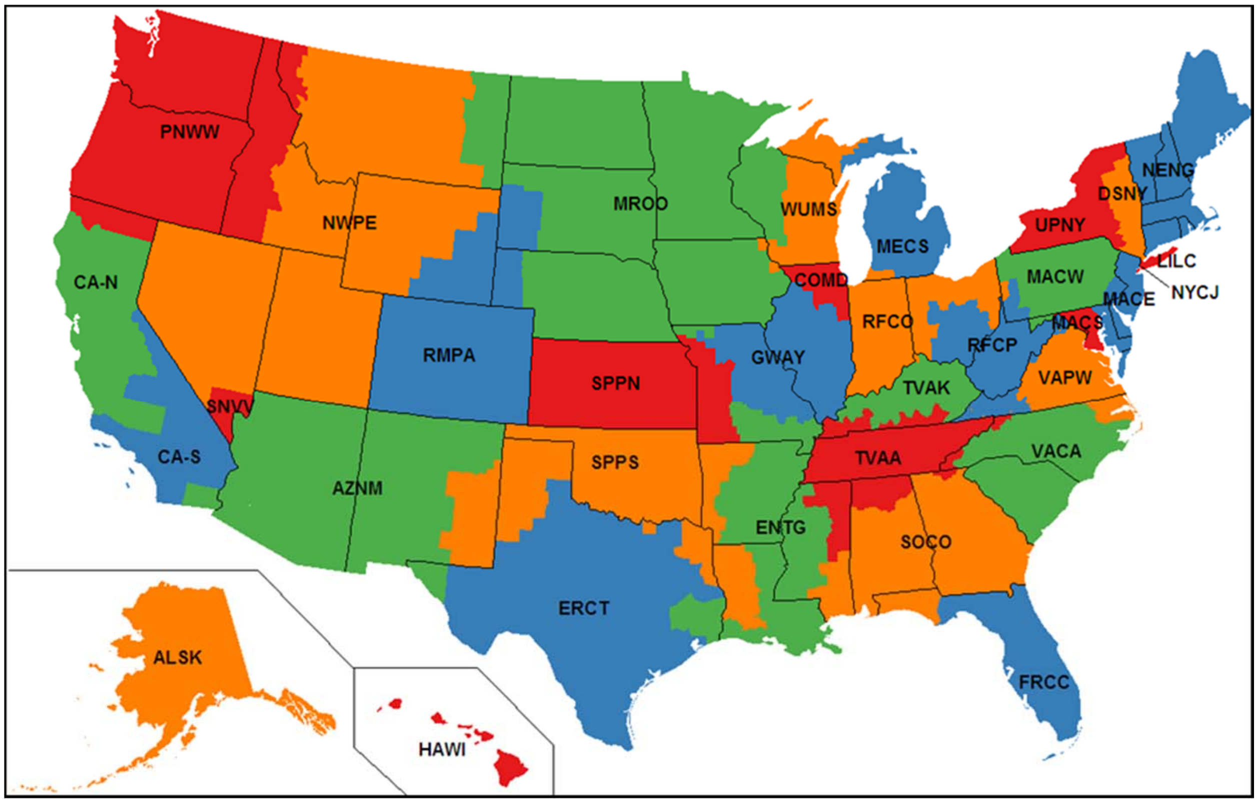

- Demand by region for 34 U.S. regions
- 25 electricity demand "load blocks"
  - Ten in summer and five each in winter, spring, and fall
  - Reflects peak vs. off-peak demand in each season
- Regional "reserve margins" based on peak demand
  - Regions required to have capacity in excess of peak demand for system reliability

N_{ew}ERA Electricity Sector Model: Regional Emission Trading Regions

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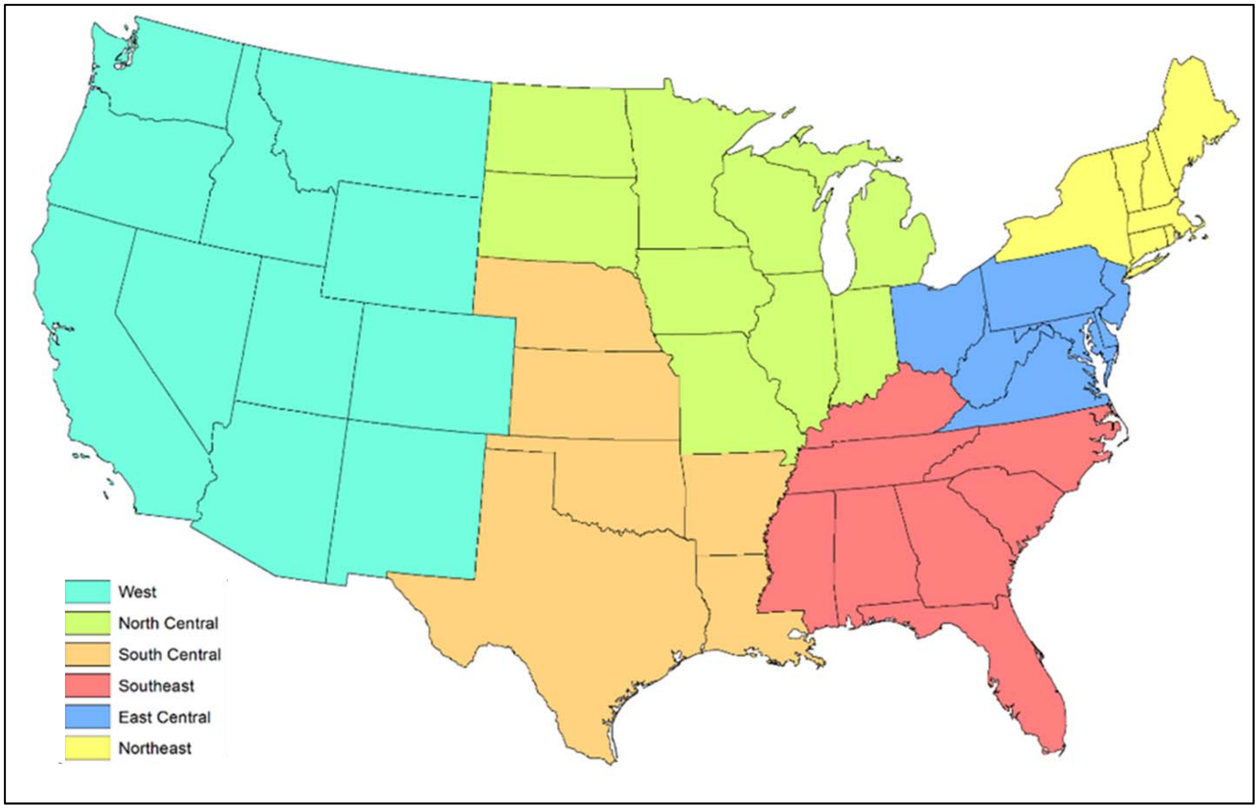

- Regions for the mass-based scenario with regional trading are based on the six regions developed by EPA in its RIA for the proposed Clean Power Plan

N_{ew}ERA Electricity Sector Model: Model Solution

- Model is required to meet many electricity market and regulatory constraints
  - Regional demand, reserve capacity requirements, fuel availability, forced retrofits, RPS or emissions regulations
  - Flexible to a variety of user-specified constraints, from unit-specific actions to market-wide regulations
- Finds the least-cost way to satisfy all constraints
  - Uses perfect foresight of market conditions
  - Chooses investments and operation of units to minimize present value of costs over the entire model period

N$_{ew}$ERA Electricity Sector Model: Model Outputs

- Model period 2016 – 2037 with outputs for every 3rd year (flexible to user specification)
- Unit-level and regional activity
  - Generation, investments in retrofits or capacity, retirements, operational costs, and revenues from generating and capacity services
- Regional prices
  - Minemouth and delivered coal, non-coal fuels, wholesale electricity, capacity, renewable energy credits, and emissions credit where applicable
  - Separate cost-of-service calculation reflects delivered prices in regulated jurisdictions

INPUTS

- Unit-level characteristics
- Detailed coal supply
- Regional demand
- Regulatory environment

↓

N$_{ew}$ERA Model

↓

OUTPUTS

- Load and dispatch
- Other unit actions
- Prices (fuel, electricity, capacity, tradable permits)

The Comprehensiveness and Flexibility of the N$_{ew}$ERA Model is Well Suited to Modeling the CPP

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- N$_{ew}$ERA models CO_2 emission rates or mass-based caps at national, regional, state, or other aggregation level, accounting for changes in standards over time
- Includes an option for coal efficiency “upgrades”
  - The cost and availability can be varied by unit
- Models end-use energy efficiency as an economic decision within the model
  - Cost and availability of end-use energy efficiency are among the most significant modeling uncertainties
- Includes full suite of state options for new renewables
- Captures expected changes in natural gas prices based on changes in demand from the electricity sector
- Although this study has made simplifying alternative assumptions regarding state implementation of the CPP, N$_{ew}$ERA can be used to develop estimates for specific implementation plans for individual states

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Appendix 2: Detailed Results for Rate-Based Scenario

Energy Sector Impacts: Rate-Based Scenario

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Key Energy Impacts of Compliance (2022-2033, 2015$)

	Present Value of Expenditures	Annual Average Expenditures	Retail Electricity Rate	Henry Hub Natural Gas Price	Total CO_2 Emissions
	PV billion$	Annual avg billion$	¢/kWh	$/MMBtu	Annual avg MM metric tons
Baseline	$2,143	$333	11.1	$5.7	2,038
Rate-Based	$2,336	$358	12.1	$6.0	1,503
Change	+$192	+$25	+1.1	+$0.2	(535)
% Change	+9%	+7%	+10%	+4%	-26%

Source: N_{ew}ERA modeling results.
Note: Present value is from 2022 through 2033, taken in 2016 using a 5% real discount rate. Annual averages and retail electricity rates are averages over the same period. Dollars in constant 2015 dollars. By 2031, annual CO_2 emissions are 41% lower than they were in 2005.

Impacts on U.S. Energy Markets: Rate-Based Scenario

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Annual Averages, 2022-2033

	Total Coal Retirements Through 2033	Coal-Fired Generation	Natural Gas-Fired Generation	Total Generation	Delivered Electricity Price
	GW	TWh	TWh	TWh	2015 ¢/kWh
Baseline	38	1,687	1,118	4,354	11.1
Rate-Based	79	1,071	1,302	3,966	12.1
Change	+41	(616)	+184	(387)	+1.1
% Change	+17%	-37%	+16%	-9%	+10%

Note: Coal retirements are cumulative from 2016-2033, with percentage change relative to baseline 2033 capacity. Other columns show annual average from 2022-2033. Natural gas-fired generation includes only existing and new combined cycle generation.

CPP leads to major changes in the U.S. energy system under rate-based compliance scenario

U.S. Energy Sector Expenditure Impacts: Rate-Based Scenario

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Changes in Energy Sector Expenditures (2015$)

	Rate-Based
Present Value (Billion 2015$)	
Cost of Electricity, Excluding EE	($95)
Cost of Energy Efficiency	$268
Cost of Non-Electricity Natural Gas	$19
Cost of Allowances	$0
Total Expenditures	$192

Note: Present value is from 2022 through 2033, taken in 2016 using a 5% real discount rate. Note that energy efficiency costs reflect the combined costs to utilities and consumers. All costs are presented relative to the baseline.

CPP leads to large expenditures for energy efficiency that overwhelm savings from a smaller electricity system

Impacts to U.S. Consumers: Rate-Based Scenario

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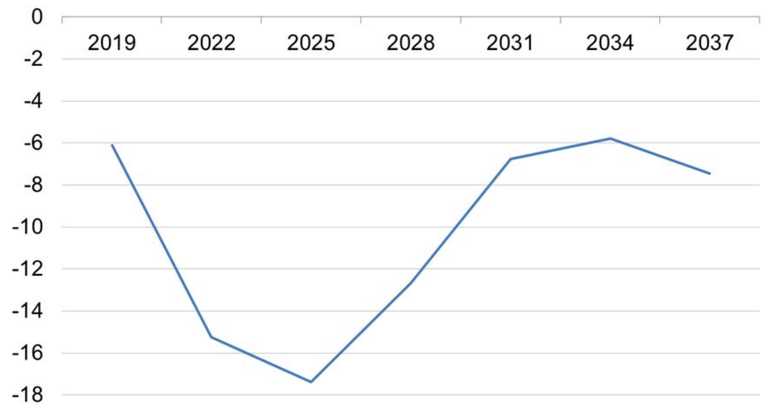
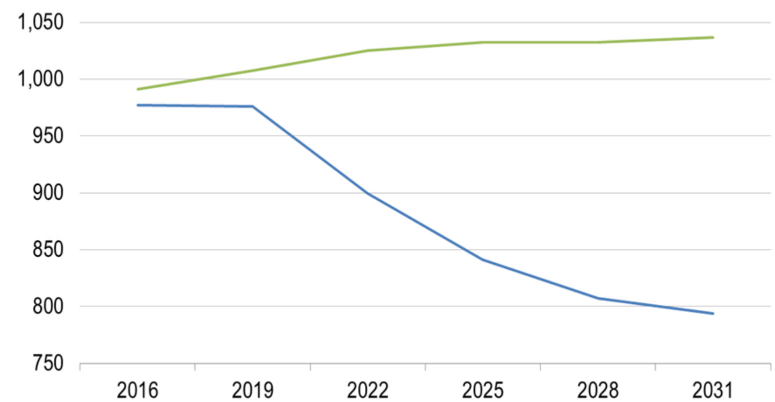
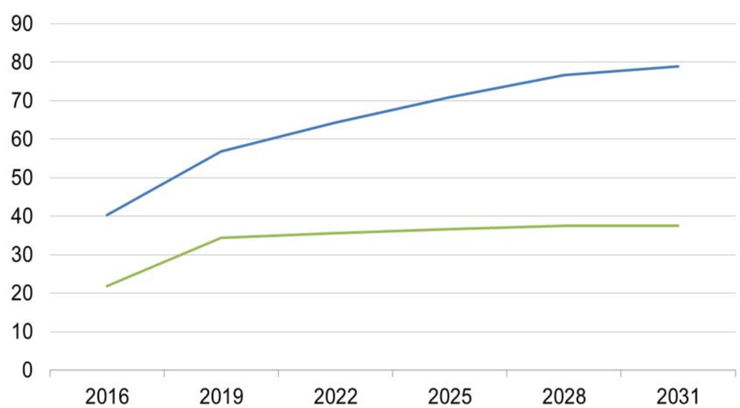
Differences in Total U.S. Consumption (Billion 2015$)*



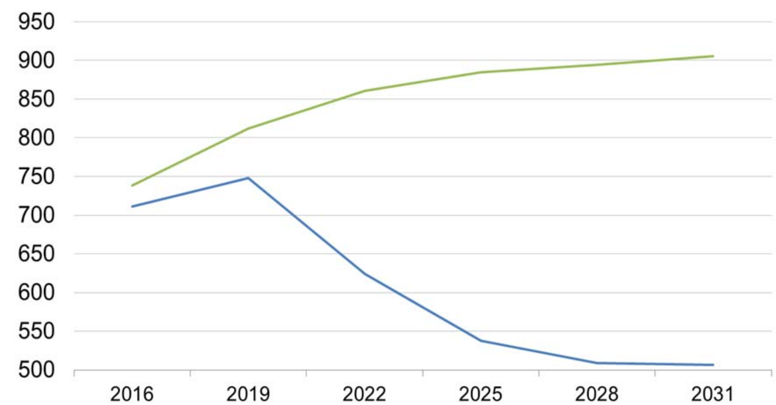
Electricity Sector Emissions Rate (lbs/MWh)



Cumulative Coal Retirements (GW)



Coal Consumption (MM Tons)



Rate-Based **Baseline**

Source: N_{ew}ERA modeling results. Reported each model year (every three years) relative to baseline consumption.
* Consumption impacts are provided relative to Baseline scenario.

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