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Remaking American Power

Preliminary Results

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Outline

- Overview of EPA Proposal
- Scope and Methodology
- Key Findings
- What Comes Next
- Appendix

Overview of EPA's Clean Power Plan

Process overview

Design:

- **October 16, 2014 (expected):** EPA CPP comment period ends
- **December 2014 (expected):** EPA finalizes New Source Performance Standards (NSPS)
- **June 2015 (expected):** EPA finalizes CPP

Implementation:

- **June 2016**: Initial deadline for state plan submittal
- **June 2017:** Extended deadline for state plan submittal at states' request
- **June 2018:** Extended deadline if states choose to submit multi-state plans

Compliance:

- **January 2020-December 2029:** States meet interim CPP goal on average
- **January 2030:** States must meet final CPP goal

Clean Power Plan (CPP) key design elements

- Requires each state to achieve a state-wide “adjusted” emissions rate (lbs./MWH) goals on average between 2020-2029 and final goal from 2030 onward
- States may submit multi-state plans (“cooperation”)
- States may implement virtually any program so long as they demonstrate that they can meet the goal and that standards are enforceable

“Building Blocks”

Coal Efficiency	Fuel Switching (Gas)
Fuel Switching (Renewables/Nuclear)	Energy Efficiency

CSIS – RHG Analysis: Scope and Methodology

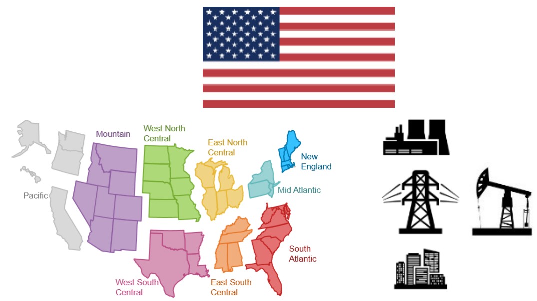
Our goal: assess the energy system impacts of EPA's proposal

EPA CPP Proposal

- Emissions rate targets
- Building blocks
- Compliance timeline

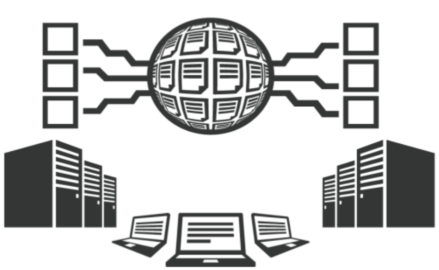
RHG/CSIS interpretation of proposal

National, Regional and Sectoral Results



RHG/CSIS analysis of outputs

National Energy Modeling System (NEMS)



- Industry standard multi-sector energy system model
- Detailed data on US technology costs and performance, energy supply and demand, electric power markets, macroeconomic factors, etc.
- Solves for the least-cost pathway to meet a given policy goal

Scenarios

Reference Case: AEO2014 plus EPA's proposed New Source Performance Standards (coal plants must meet emissions rate of 1,100 lbs./MWh).

Policy Scenarios: Given the uncertainty surrounding the final EPA guidelines and resulting State Implementation Plans, we analyze four scenarios to illustrate the potential economic and market impact of two particularly important variables – the level impacts of multi-state cooperation (national cooperation or regional fragmentation) and the inclusion of energy efficiency (w/ EE or w/o EE).

Policy Scenarios		
	National Cooperation	Regional Fragmentation
No States Include EE in Plans	National w/o EE	Regional w/o EE
All States Include EE in Plans	National w/ EE	Regional w/ EE

The regional fragmentation w/o EE analysis was not completed in time for this presentation, but will be included in our full report released this fall, along with side-cases that explore different baseline energy price and demand scenarios.

National cooperation vs. regional fragmentation

We model tradable performance standards with emission rate goals based on EPA's CPP proposal.

National Emission Rate Goals (lbs./MWh)	
2020-2029	1,103
2030 and later	1,030

NEMS Regions

U.S. Energy Information Administration, Office of Energy Analysis.

Regional Emission Rate Goals (lbs./MWh)					
Region	2020-2029	2030 and later	Region	2020-2029	2030 and later
1 ERCT	853	791	12 SRDA	945	883
2 FRCC	794	740	13 SRGW	1,494	1,408
3 MROE	1,274	1,198	14 SRSE	993	923
4 MROW	1,389	1,338	15 SRCE	1,509	1,429
5 NEWE	614	565	16 SRVC	973	896
6 NYCW	635	549	17 SPNO	1,587	1,509
7 NYLI	635	549	18 SPSO	901	848
8 NYUP	635	549	19 AZNM	742	705
9 RFCE	1,030	913	20 CAMX	556	537
10 RFCM	1,227	1,161	21 NWPP	1,266	1,200
11 RFCW	1,499	1,394	22 RMPA	1,408	1,336

Crediting energy efficiency (EE)

Key assumptions in scenarios including energy efficiency:

- Rely on EPA assumptions for EE deployment and costs with states ramping up to 1.5% incremental electricity savings by 2026 and then maintaining that level
- All savings are assumed to be real and verifiable and count towards compliance from 2020 onward

Incorporation into NEMS:

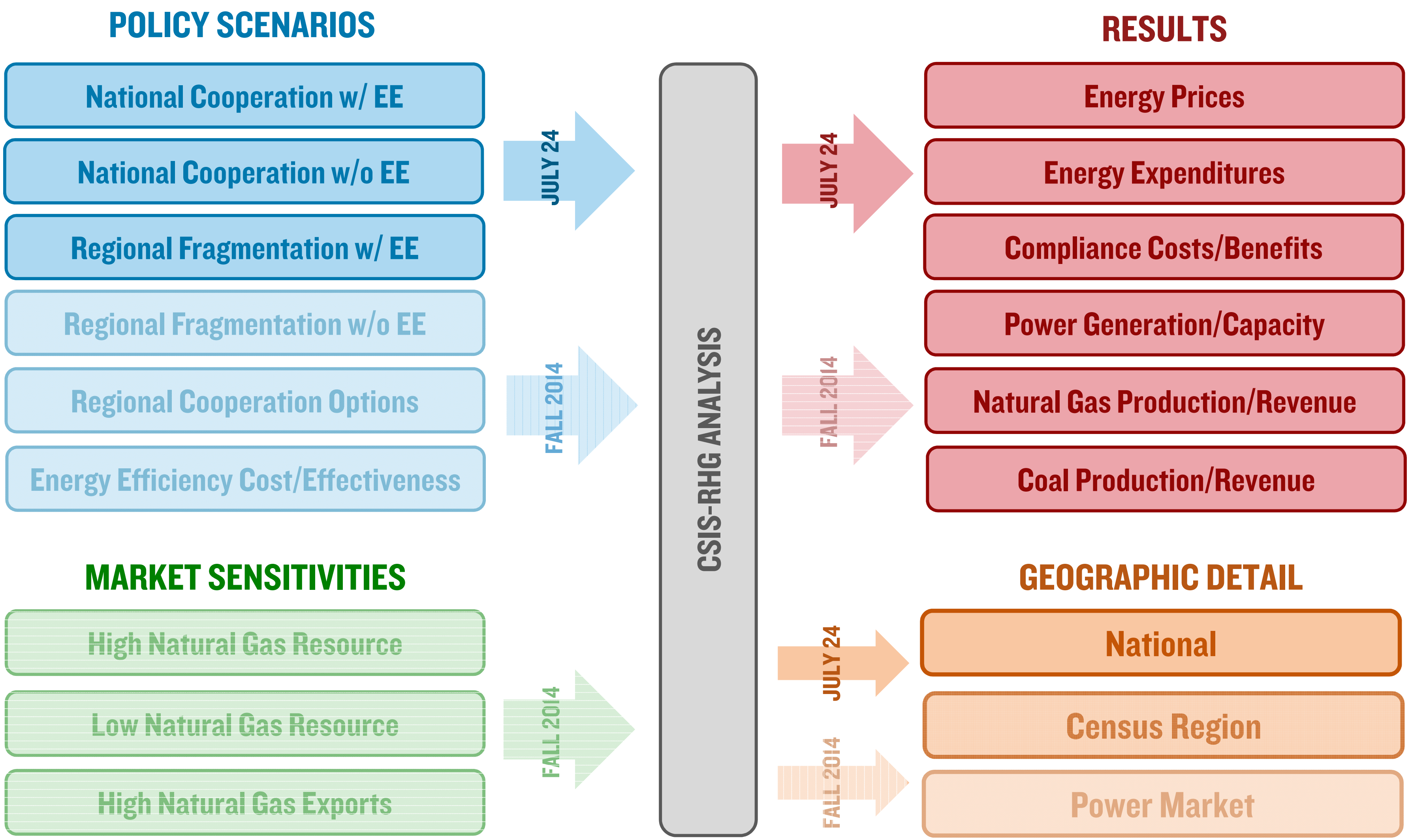
- Adjust TPS target and NEMS electricity demand forecast to reflect EE credits from energy savings
- Include the costs utilities incur in administering and implementing EE measures in endogenous NEMS electric rate calculations and low compliance cost estimates

Additional calculations:

- Calculate consumer share of first-year costs incurred when participating in utility EE programs and include in high compliance cost estimates

More information on our approach to EE can be found in the appendix

Preliminary results from the forthcoming CSIS/RHG full report



Other factors that will shape the ultimate impact of the CPP

This analysis considers the CPP proposal as currently constructed. The ultimate impact of the CPP could differ from this analysis for a number of reasons, including:

- **Changes in stringency due to:**
  - EPA changes in the final rule
  - Severability of components of EPA's assigned state goals
  - Possible delays in implementation (due to legal challenges or other reasons)
- **Differences between modeling assumptions and ultimate market developments:**
  - Fuel resources and prices
  - Cost and performance of generation technologies
  - Energy demand
  - EE availability and costs

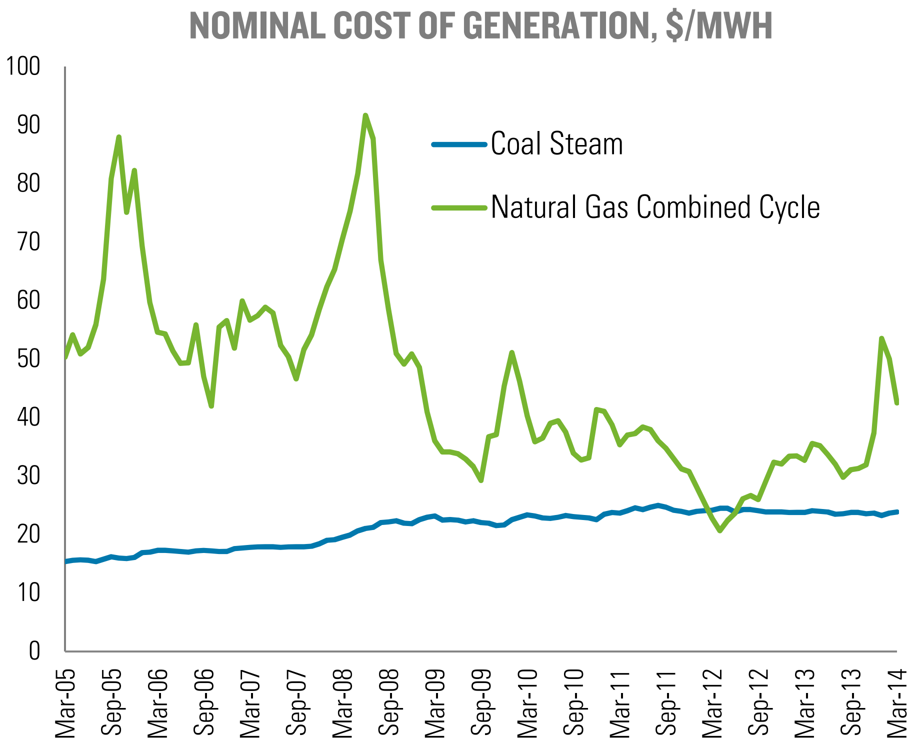
Key Findings

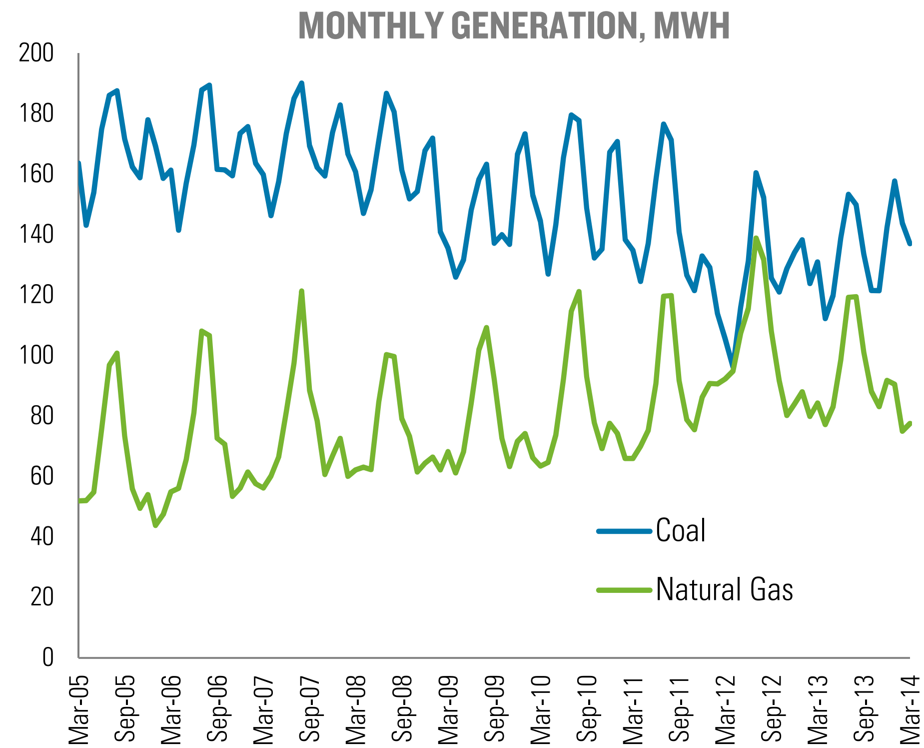
Key Findings

1. The shale boom makes compliance relatively affordable

The shale boom has lowered the cost of gas-fired generation

Coal vs. natural gas, costs and generation



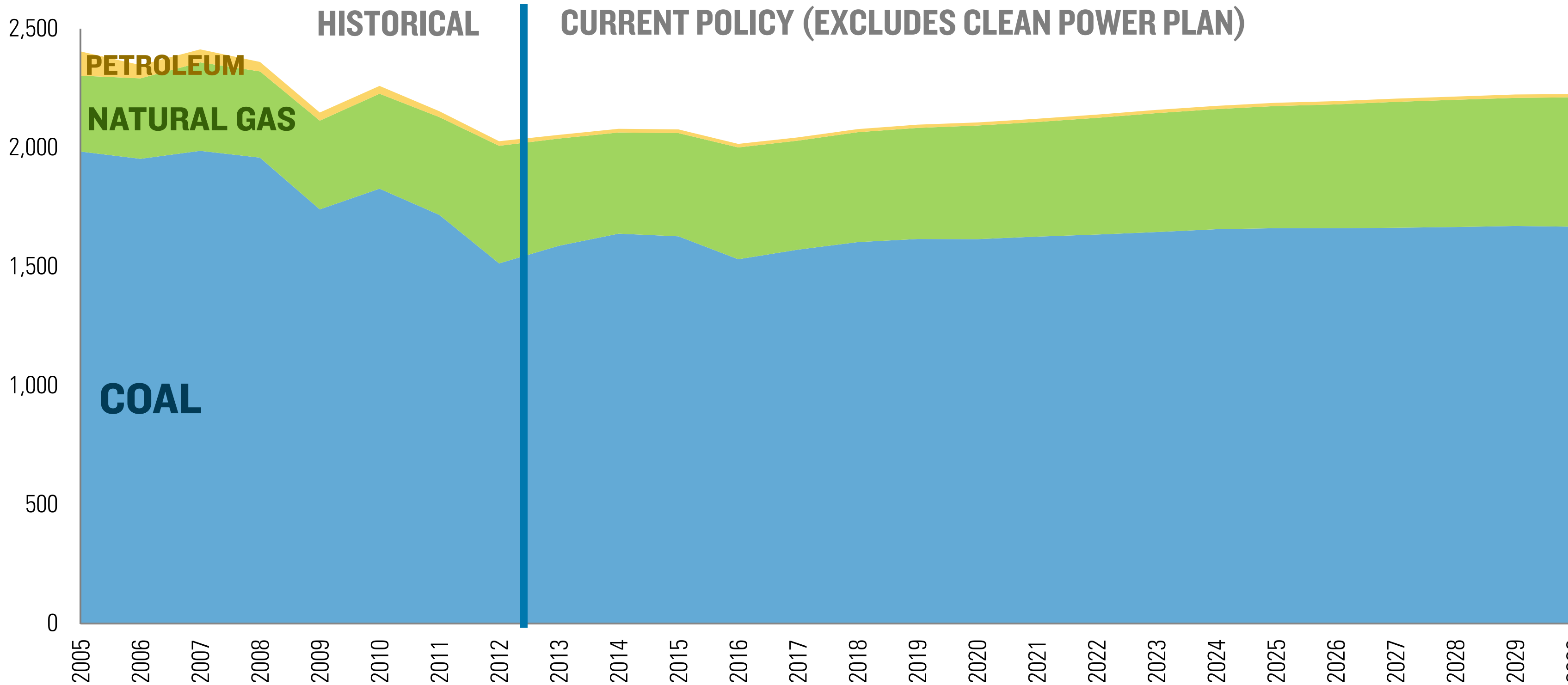


Source: EIA

Assessing the potential economic impact of the CPP requires understanding the energy landscape into which it is being introduced. The dramatic growth in US shale gas production over the past decade has reduced the cost of power generated with natural gas, particularly from high-efficiency natural gas combined cycle (NGCC) plants, relative to the cost of coal-fired power. As a result, a growing share of US electricity supply in recent years has been powered by natural gas. The price-sensitivity of dispatch in the US power sector works both ways, of course. As natural gas prices have recovered a little over the past year and a half, so has coal-fired power generation.

Coal-gas switch has helped reduce US CO2 emissions

Power sector CO2 emissions

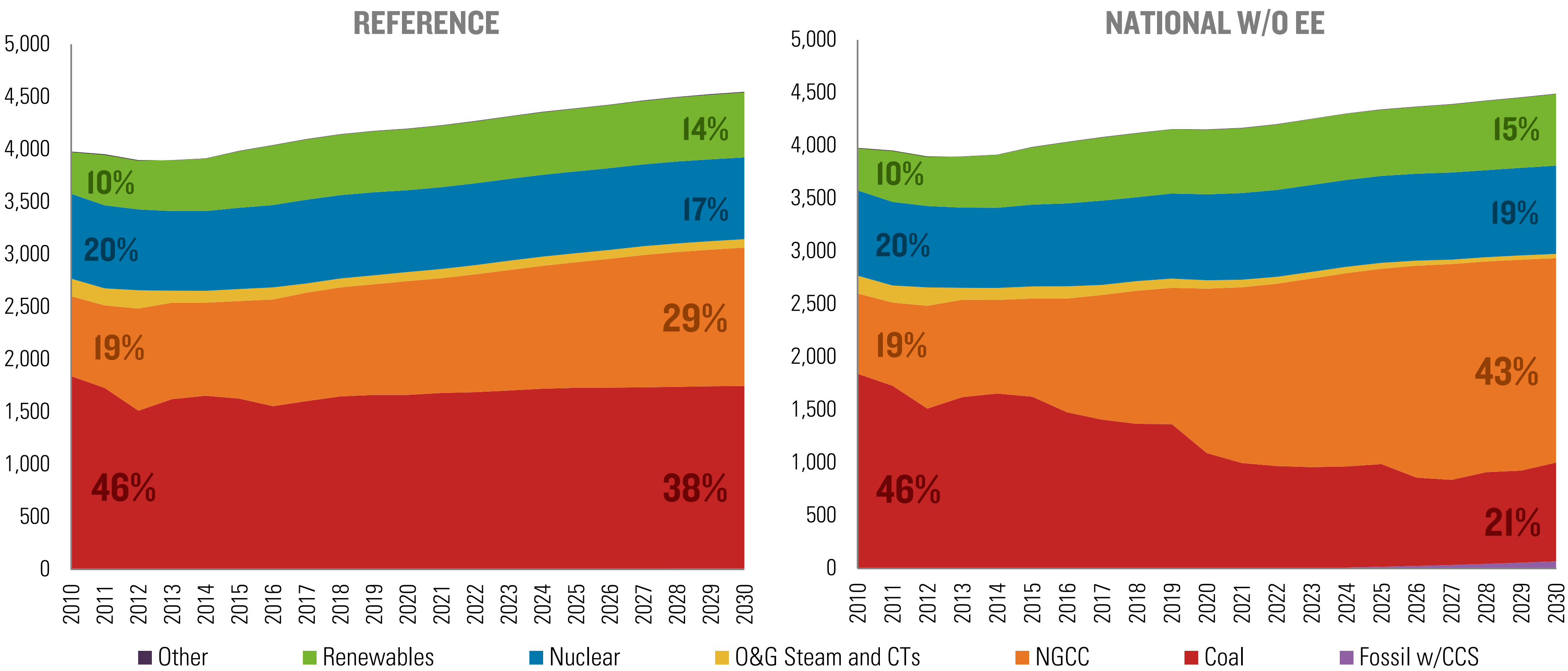


Source: EIA Annual Energy Review and Annual Energy Outlook 2014

The price-driven switch from coal to natural gas shown in slide 15, along-side weak energy demand due to the recession and increased renewable energy deployment, contributed to a sharp drop in CO2 emissions from the US electric power sector between 2007 and 2012. As natural gas prices rose in 2013, so did US CO2 emissions. Absent additional policy, the EIA projects a modest increase in power sector CO2 emissions in the years ahead. The real significance of the shale boom from a climate change standpoint is not its direct impact on CO2 emissions, but how it changes the economic impact of climate policy, including the CPP.

EPA's CPP proposal: small changes in incentives, big impact

US power generation, billion kWhs

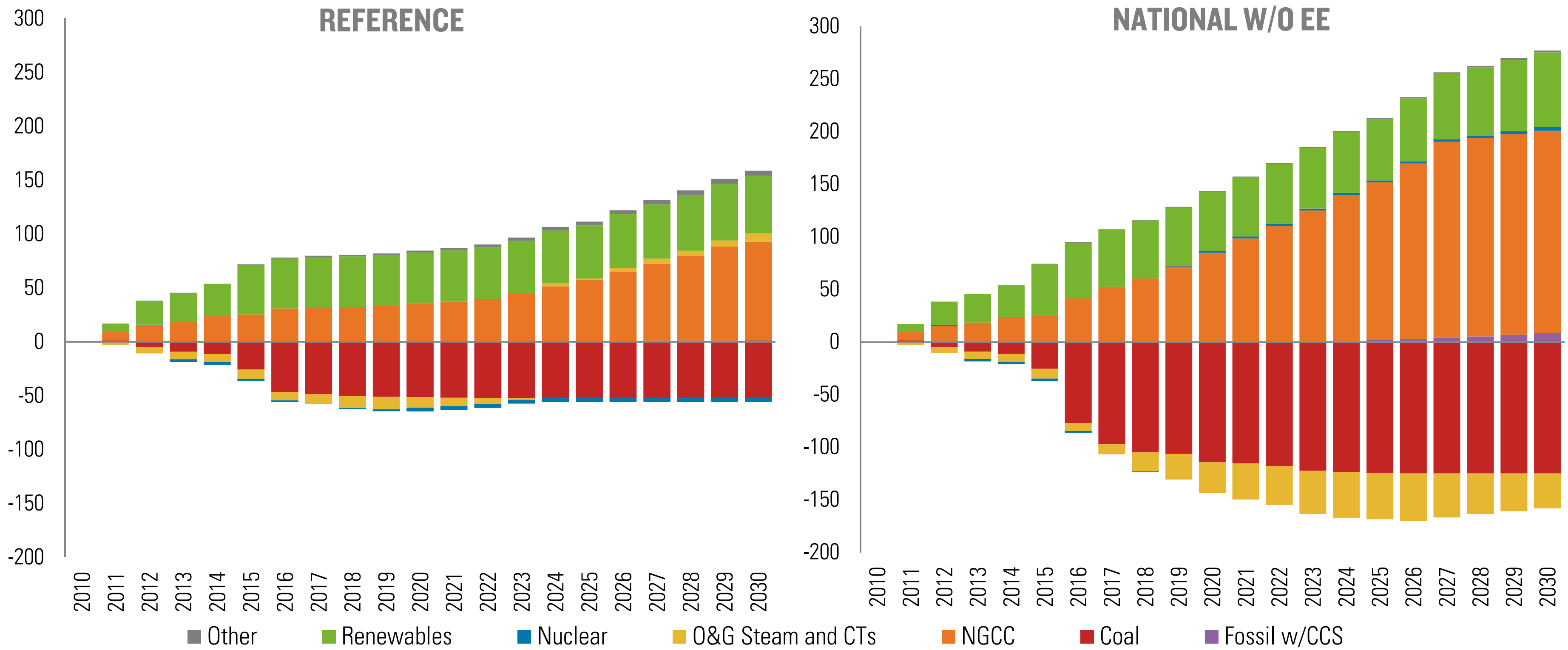


Source: EIA, Rhodium Group/CSIS

Under current policy (pre-CPP), the EIA projects US coal generation will remain relatively flat in absolute terms in the years ahead, with NGCC and renewables satisfying projected electricity demand growth (Reference). An emission-rate standard like that proposed in the CPP, has the potential to significantly alter this outlook by raising the effective cost of coal generation and lowering the effective cost of natural gas and renewable generation. At currently projected natural gas prices, switching from coal to gas is the most cost-effective means of meeting CPP requirements (at least on the generation side), as shown above in our National w/o EE scenario. For potential generation changes under other scenarios see slides 22 and 26.

Gas drives changes in capacity as well as generation

Change in capacity relative to 2010, GWs

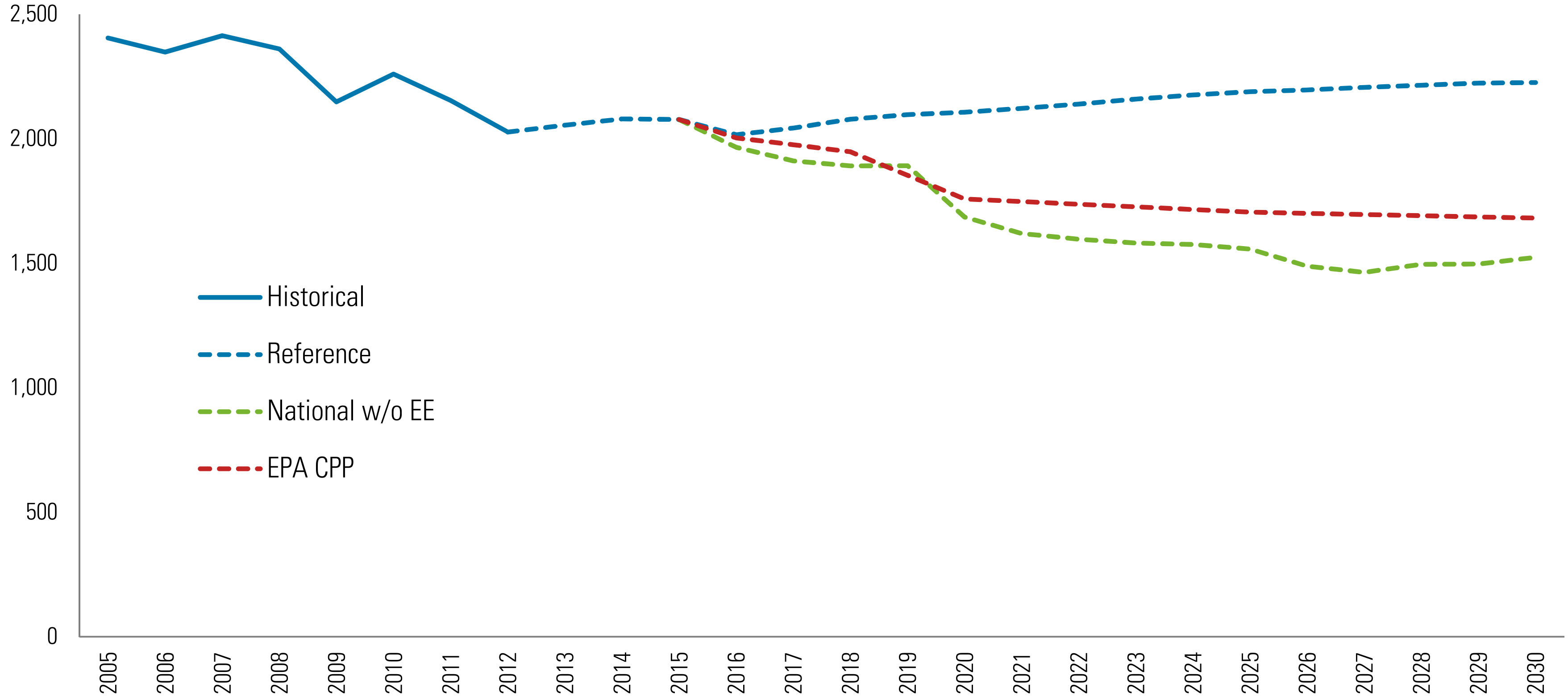


Source; EIA and Rhodium Group/CSIS

Much of the increase in natural gas generation due to CPP implementation in our analysis comes from existing NGCC plants with spare generation capacity. The CPP-driven change in the relative cost of natural gas generation also incentivizes the construction of new NGCC capacity beyond what is projected to occur in our Reference scenario. Likewise, the CPP prompts additional coal and low-efficiency oil and gas plant retirements. This occurs in all implementation scenarios we analyzed, though is more pronounced when efficiency crediting is excluded (such as the National w/o EE scenario above). Changes in renewable capacity are more scenario-dependent (but relatively small compared to NGCCs).

Shifts in generation deliver significant CO2 emissions reductions

million metric tons



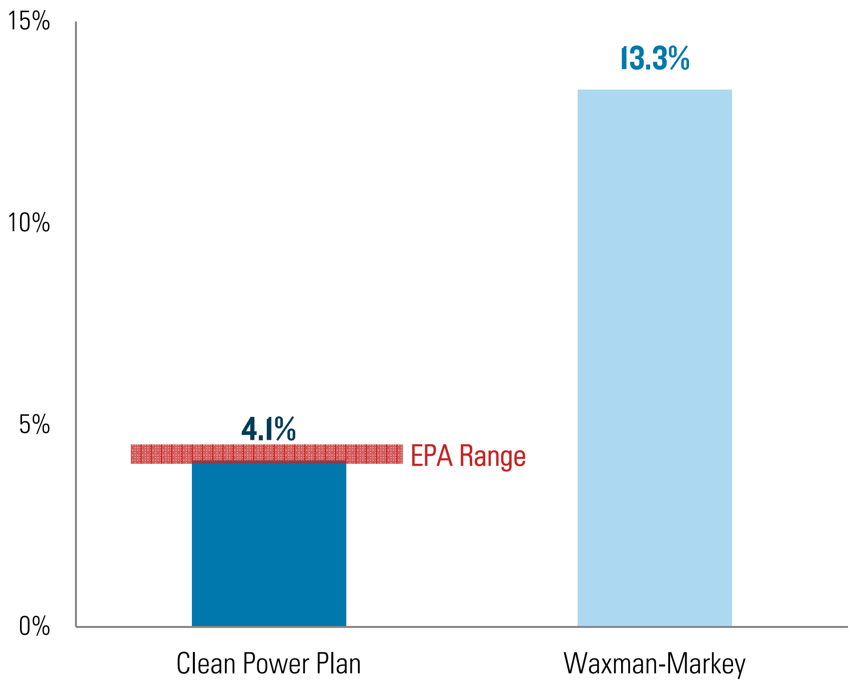
Source; EIA, EPA, Rhodium Group/CSIS. Note: EPA data reflect the "Option 1- State" scenario.

CPP-induced changes in dispatch, capacity additions and retirements can generate big reductions in power sector CO2 emissions. In the National w/o EE scenario shown above, power sector CO2 emissions fall to roughly 1,700 million metric tons by 2020 and 1,500 million metric tons by 2030, a 30% and 37% decline from 2005 levels respectively. Setting and meeting emission rate standards does not predetermine a specific emissions reduction pathway. Differences in policy implementation as well as market dynamics can impact the total emission reductions achieved under the CPP. For example, or National w/o EE scenario results in lower emissions than EPA's own CPP projection (see slides 23 and 27).

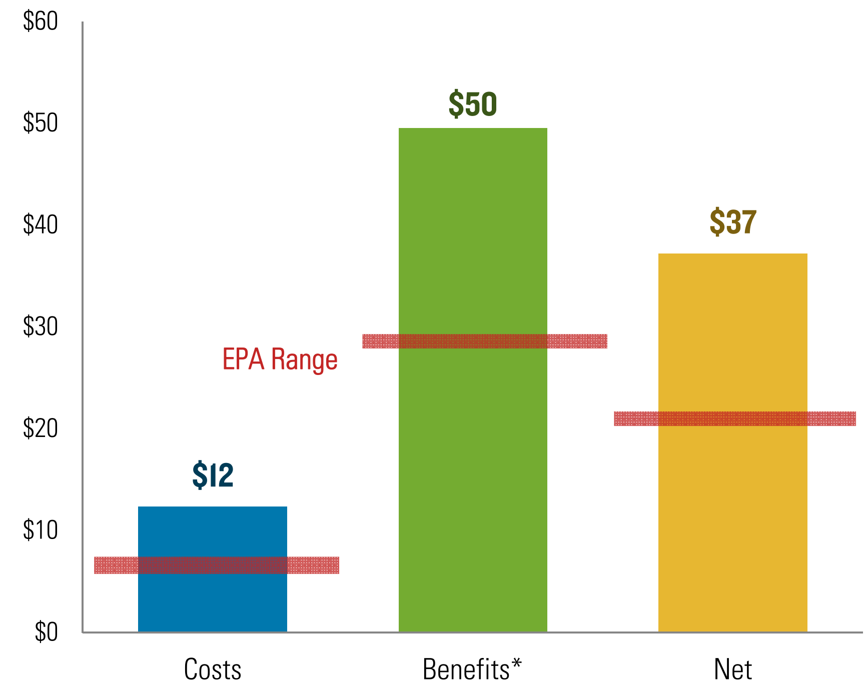
Electricity prices and compliance costs (and benefits)

2020-2030 average, national cooperation without EE

AVERAGE CHANGE IN ELECTRIC RATES, 2020-2030



CPP AVERAGE COSTS AND BENEFITS (BN 2012 USD)



Source: EPA, Rhodium Group/CSIS; Note: Clean Power Plan and EPA Rate values are a simple average, Waxman-Markey Value is a generation weighted average. Range reflects the difference between EPA's Option 1-State and Option 1-Regional scenarios. * We use the EPA's methodology in calculating benefits, using their most conservative assumptions

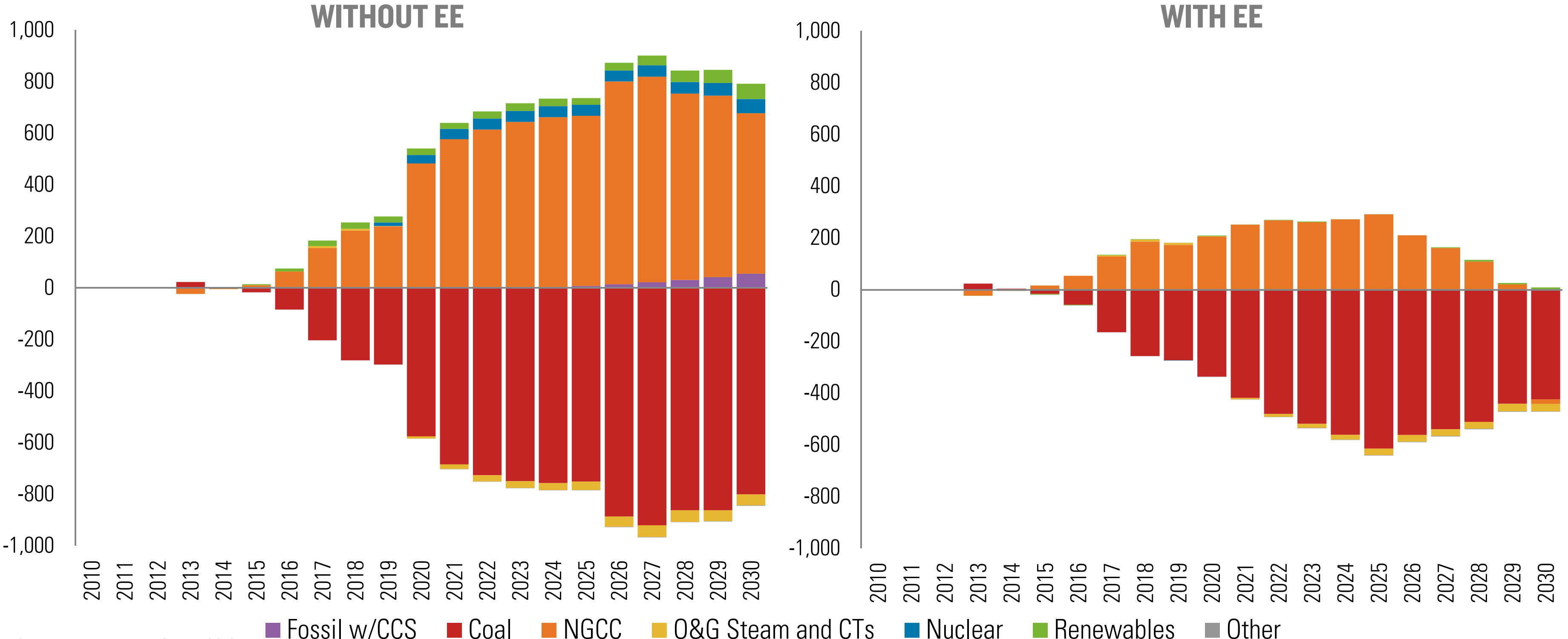
In the scenarios we analyzed, CPP implementation modestly increases electricity prices, from 4% to 10% depending on the scenario (above and slides 24 and 28). This is considerably lower than the projected impact of the 2009 Waxman-Markey legislation, though that bill would have covered the entire economy and delivered greater emission reductions than the CPP. In our National w/o EE scenario, total annual compliance costs average $12 billion between 2020 and 2030, compared to public health and climate benefits of $50 billion using EPA's methodology. Compared to the EPA analysis, our National w/o EE scenario costs more, but also delivers larger emission reductions, and thus larger public health and climate benefits.

Key Findings

2. Including efficiency reduces both costs and benefits

Crediting efficiency leads to less fuel switching…

National cooperation, billion kWhs

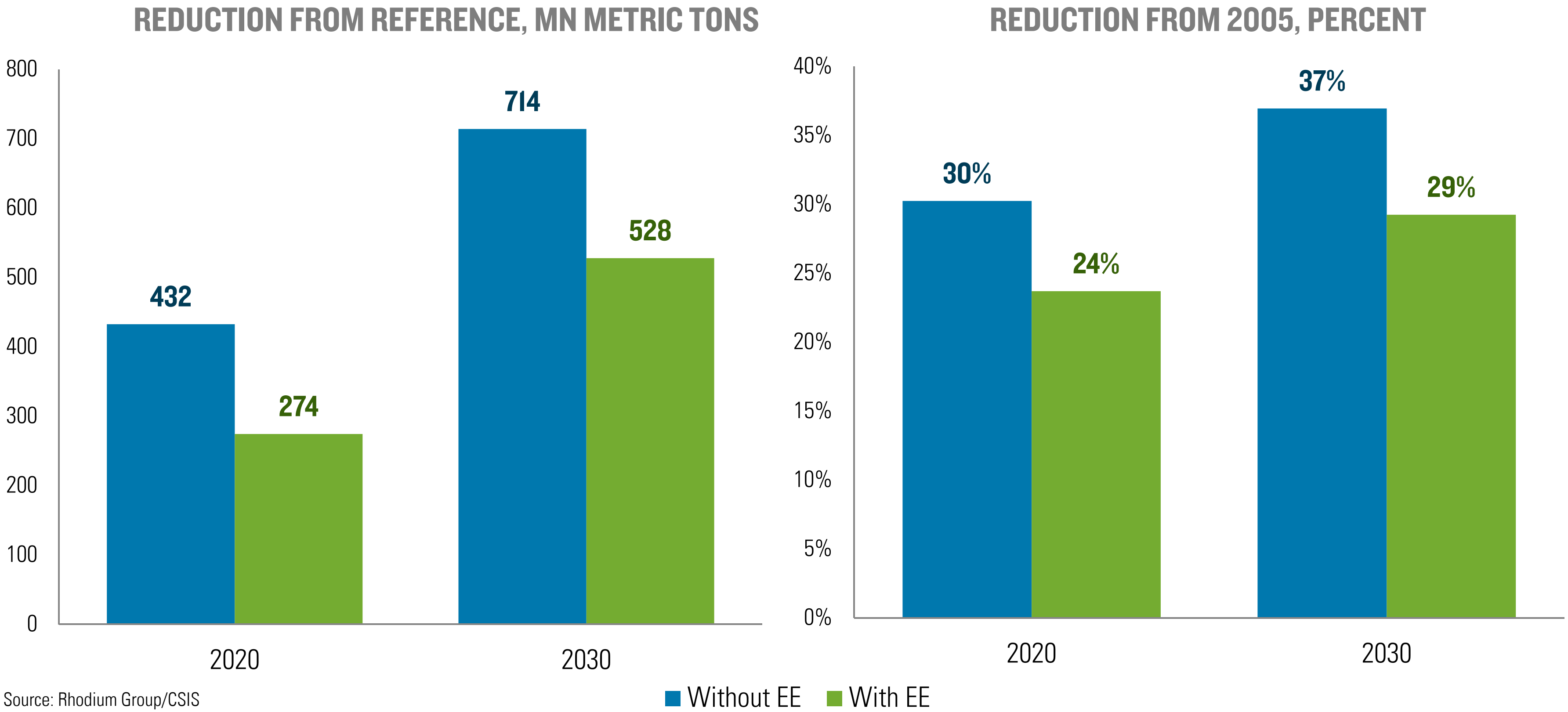


Source: EIA, Rhodium Group/CSIS

Including energy efficiency (EE) as a compliance option reduces the amount of abatement that needs to occur through changes in sources of power generation. Fuel switching from coal to natural gas continues to occur, but to a lesser extent than in the National w/o EE case. The modest CPP-driven increase in nuclear and renewable generation in the National w/o EE scenario all but disappears when efficiency is credited. States could well design implementation plans that explicitly favor renewables over natural gas, which would lead to power sector outcomes different than those shown above which are intended to illustrate the most cost-effective solution at currently projected natural gas prices and renewable energy costs.

... and also less abatement

National cooperation

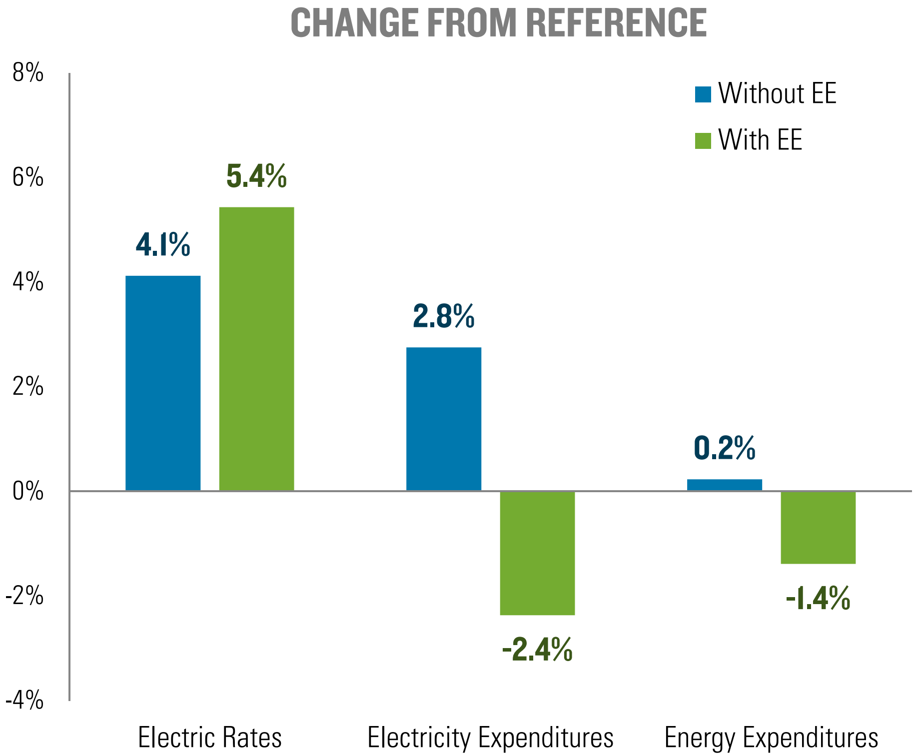


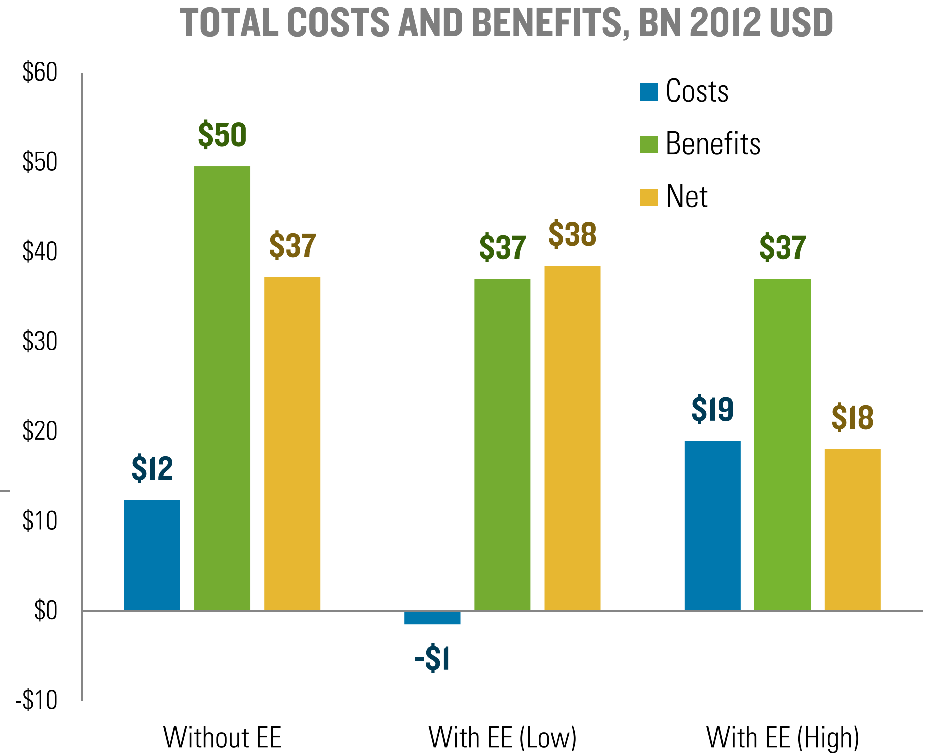
Source: Rhodium Group/CSIS

Should states choose to meet their CPP emission rate targets in part by crediting efficiency improvements, total CO2 emission reductions could be lower, for two reasons. First, there is a risk states will claim credit for EE improvements that would have occurred absent the CPP (see appendix). Second, the EPA goal was designed assuming efficiency proportionally reduces other forms of generation. In our analysis, displacement is not proportional due to power market dynamics.

EE reduces energy expenditures (but not necessarily total costs)

2020-2030 average, national cooperation





Source: Rhodium Group/CSIS. * We use the EPA's methodology in calculating benefits, using their most conservative assumptions. Low EE costs only include utility EE costs, high EE costs include both utility and participant EE costs. See appendix for more information.

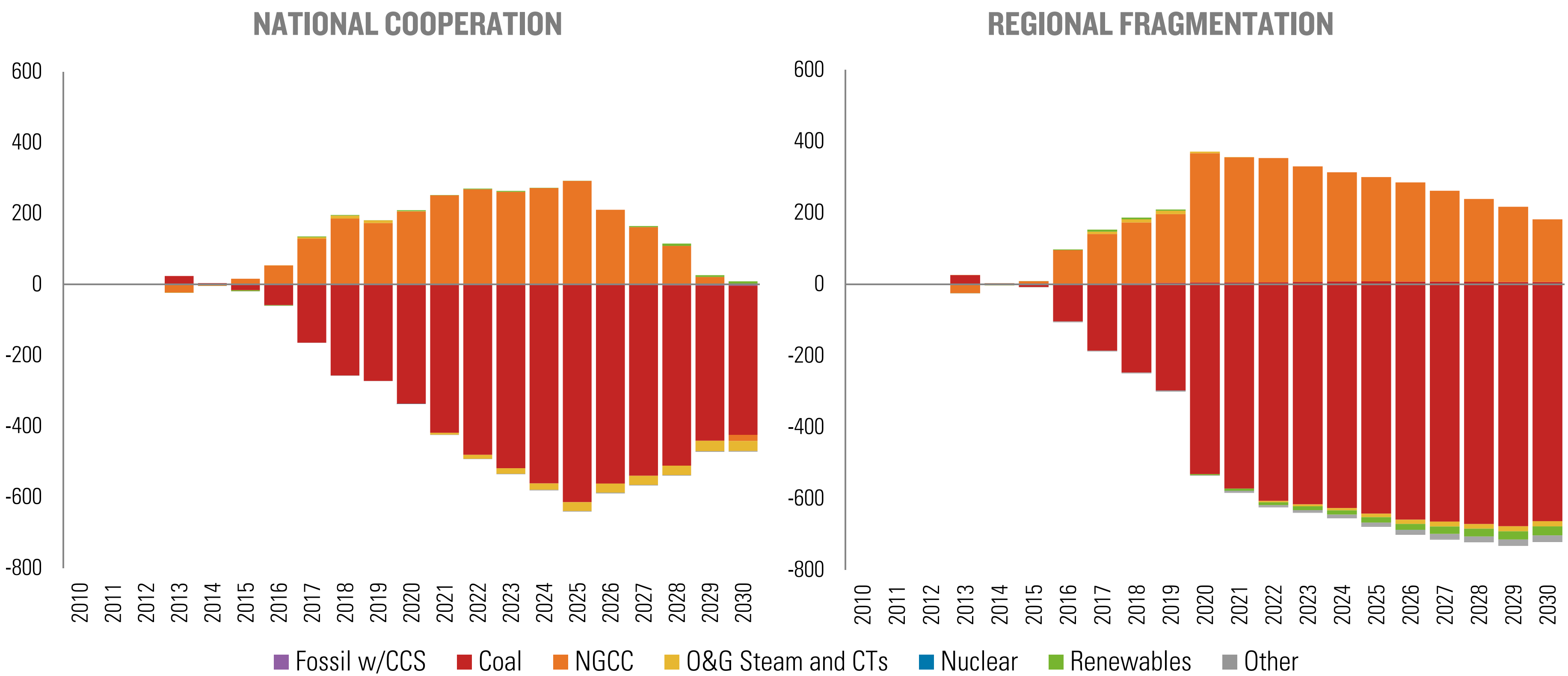
Crediting EE could likely *increase* electricity prices, as utilities add the cost of efficiency programs to their customers' electricity bills, but could *decrease* overall energy costs as those customers buy less electricity. Estimating total compliance costs when efficiency crediting is included requires accounting for increased spending on building efficiency improvements and energy efficient appliances alongside the resulting decrease in energy expenditures. There is wide variation in how such costs are calculated, as shown above. Additional discussion of this point is available in the appendix.

Key Findings

3. Cooperation lowers costs

Less cooperation means more fuel switching...

Includes efficiency crediting, billion kWhs

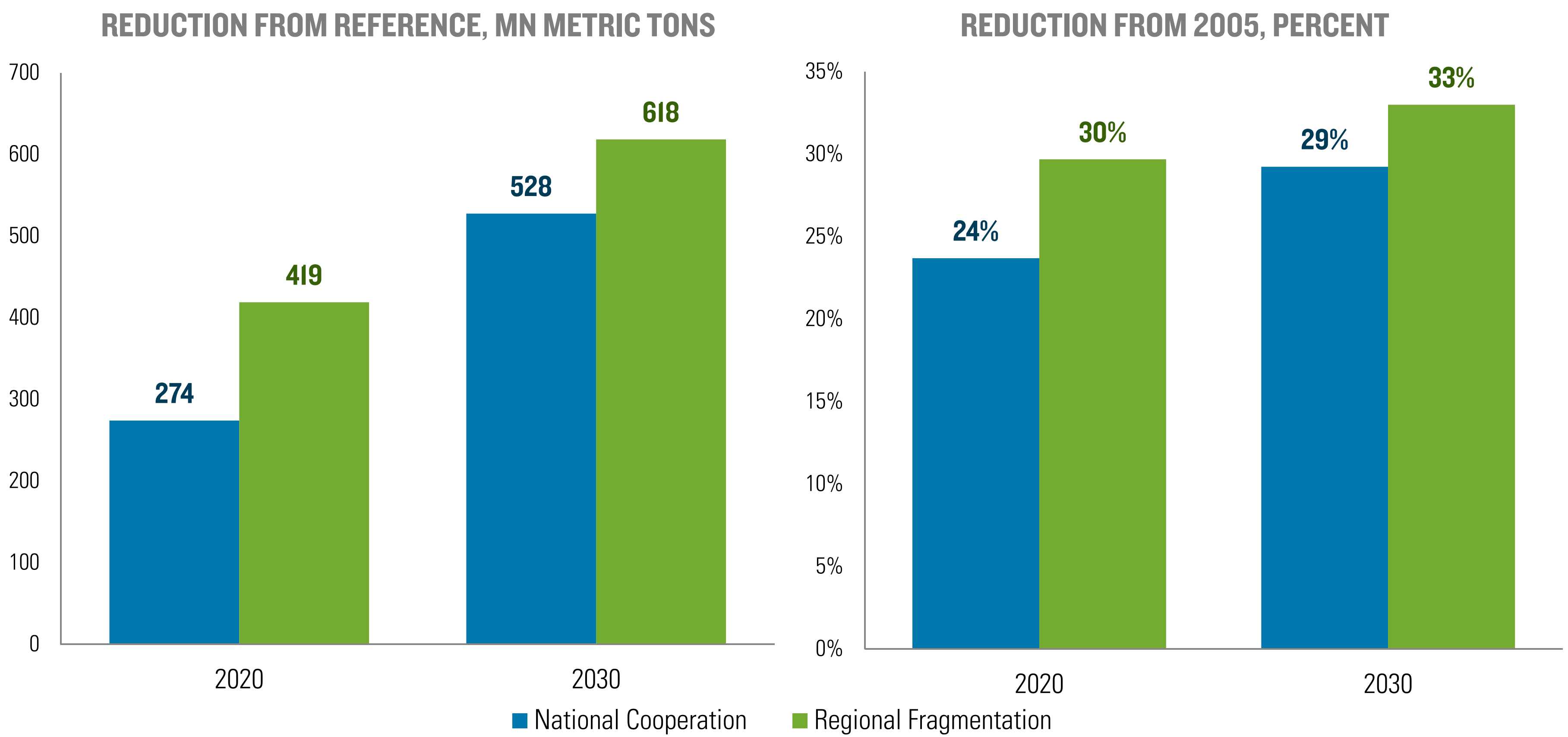


Source: EIA, Rhodium Group

In our National Cooperation scenarios, all states are allowed to trade compliance credits. When such trading is excluded, and each of the 22 power market regions included in our analysis meet their CPP obligations independently, more coal-gas fuel switching is required to meet the CPP targets. Natural gas generation increases further to offset a slight decline in renewable generation, as the regions with the best renewable resources have less opportunity to utilize them in achieving combined state-level emission rate targets.

… and also more abatement

Includes efficiency crediting



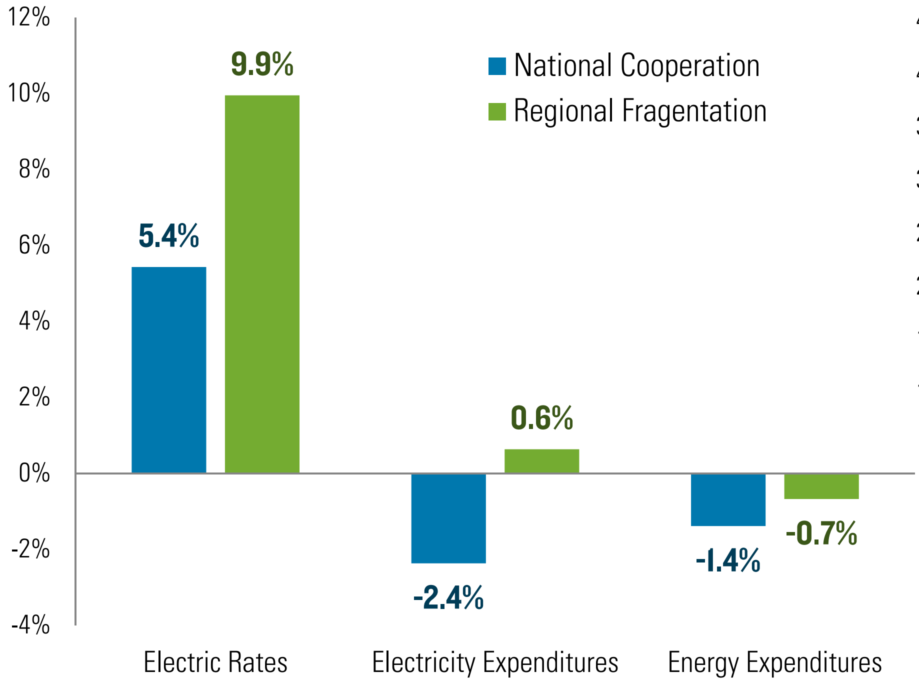
Source: Rhodium Group/CSIS

Greater fuel switching when interstate credit trading is excluded (Regional Fragmentation), along with higher electricity prices (see slide 28), yields emission reductions greater than in our National Cooperation scenario. This is particularly true in the first part of the compliance period.

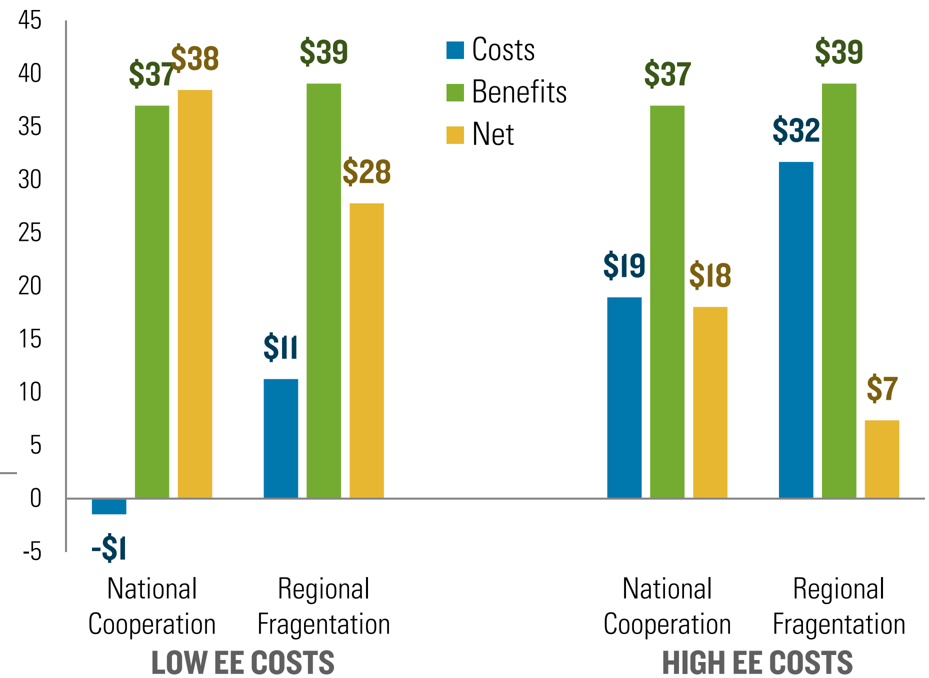
Cooperation reduces both energy and compliance costs

2020-2030 average, includes energy efficiency

CHANGE FROM REFERENCE



TOTAL COSTS AND BENEFITS, BN 2012 USD



Source: Rhodium Group/CSIS. * We use the EPA's methodology in calculating benefits, using their most conservative assumptions. Low EE costs only include utility EE costs, high EE costs include both utility and participant EE costs. See appendix for more information.

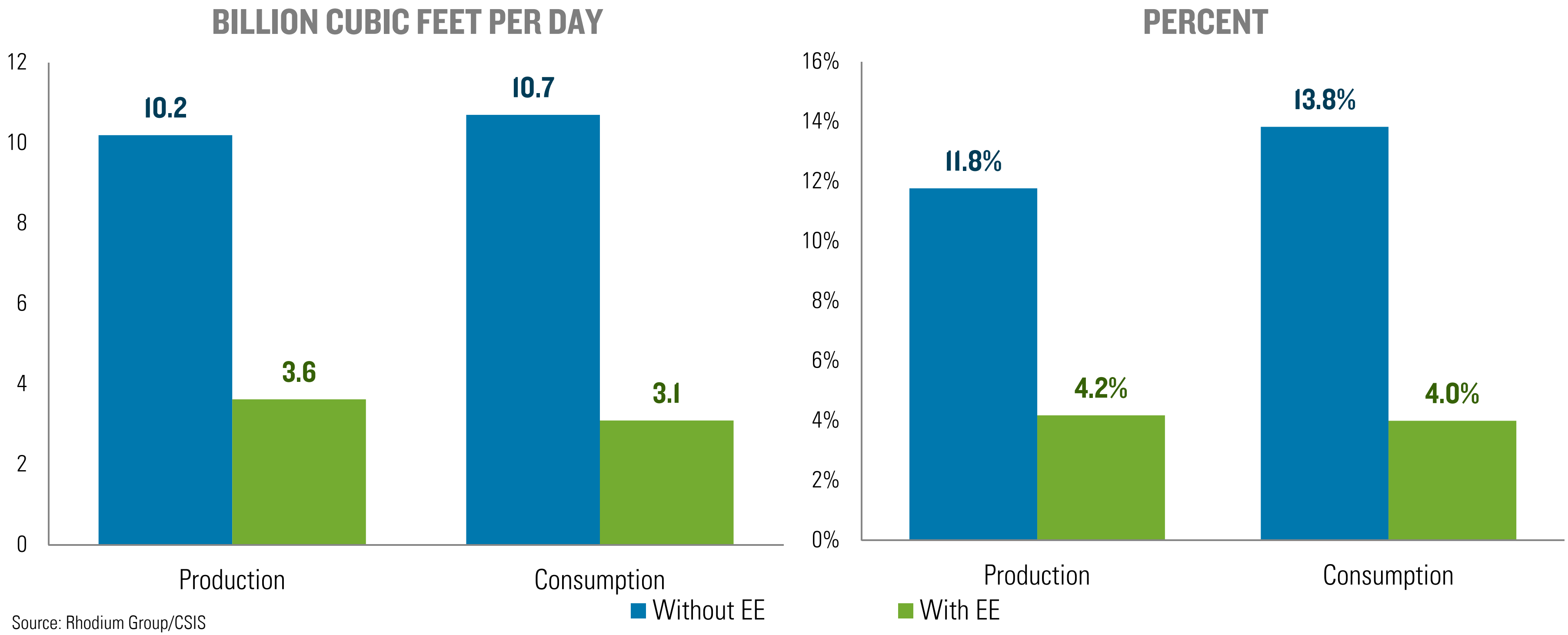
The increased abatement shown on slide 27 comes at a cost. CPP-driven changes in electric prices are higher, and potential EE-related energy cost savings lower, when the level of interstate cooperation is reduced. Total compliance costs are more than $10 billion higher, on average, between 2020 and 2030 in the Regional Fragmentation scenario relative to the National Cooperation case. While some fragmentation is likely under the CPP, the more state cooperate that occurs the lower the plan's national cost will be.

Key Findings

4. The energy market impacts of the CPP are potentially significant

The CPP could result in a large increase in natural gas demand...

Change in average annual natural gas production and consumption, 2020-2030, national coordination vs. reference scenario

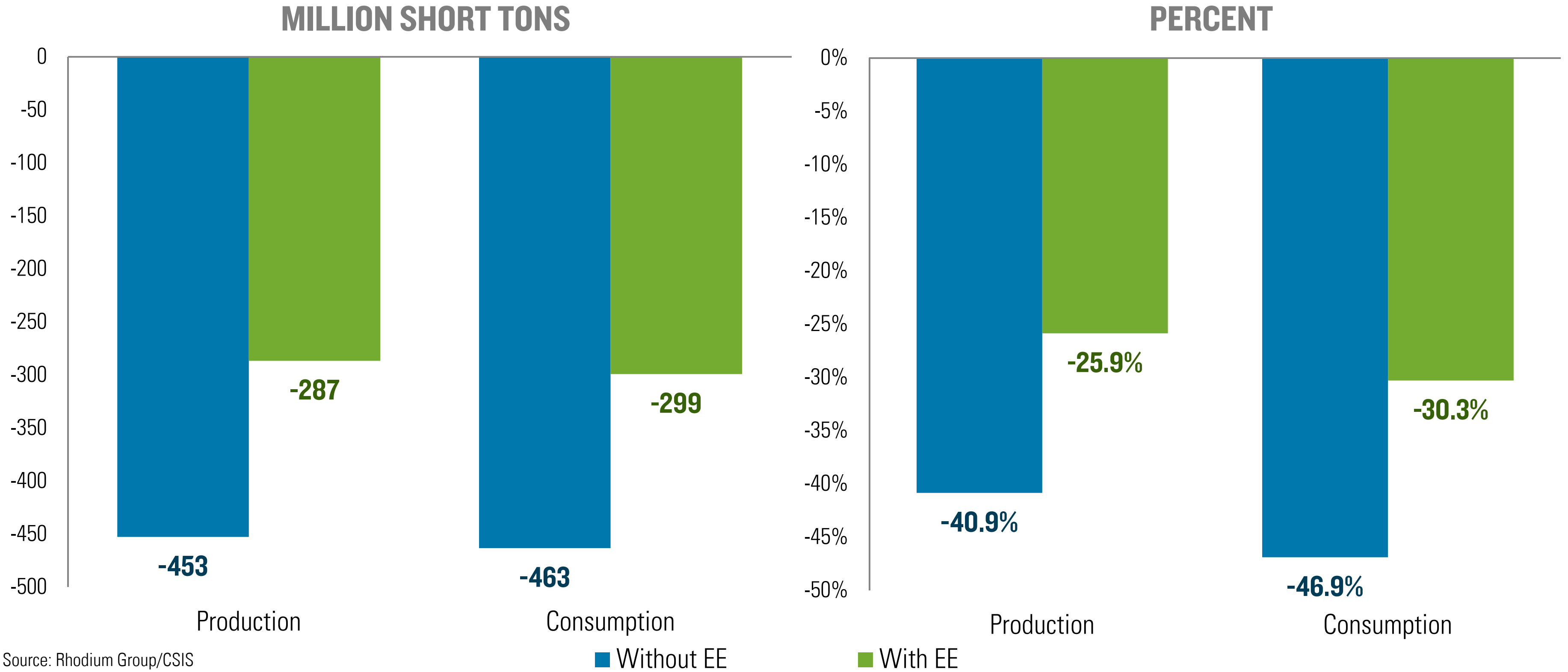


Source: Rhodium Group/CSIS

CPP-driven changes in the electric power sector have significant implications for the US energy market as a whole. Meeting EPA's emission rate targets by switching from coal to natural gas – the most cost-effective generation solution at currently projected prices – results in a 14% average increase in US natural gas demand between 2020 and 2030 in our National w/o EE scenario. The vast majority of this is met through an increase in domestic production, with a small reduction in exports to Mexico and small increase in imports from Canada. Crediting efficiency, however, could reduce this increase in US gas demand by more than two thirds.

… and a large decrease in coal consumption

Change in average annual coal production and consumption, 2020-2030, national coordination vs. reference scenario

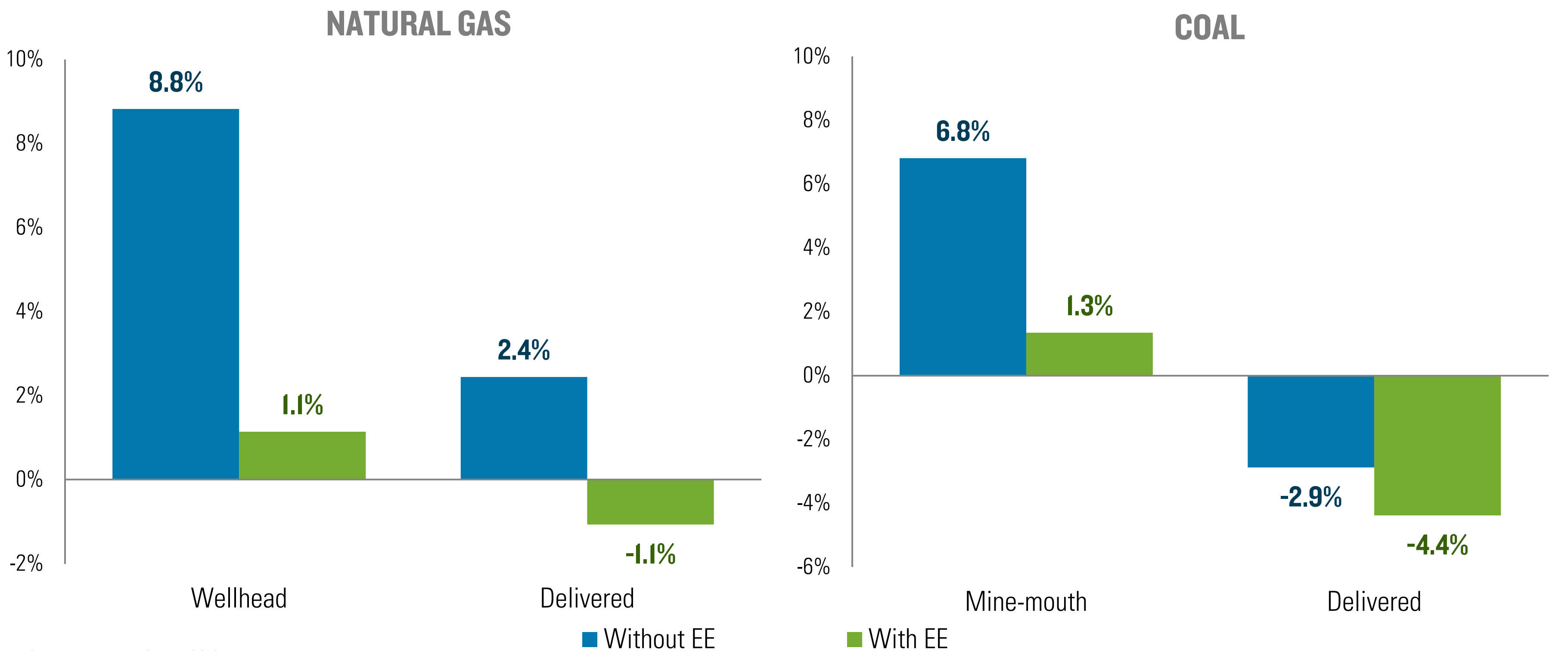


Source: Rhodium Group/CSIS

CPP implementation could result in a similarly large change in domestic US coal markets. In our National w/o EE scenario, domestic coal consumption falls by 47% on average between 2020 and 2030 relative to Reference. While increased exports (limited to currently available export infrastructure) offset some of the impact of this decline in domestic sales on US coal producers, total coal output still falls by 41%. Crediting efficiency mitigates coal production declines, with a 30% reduction in consumption and 26% reduction in production on average between 2020 and 2030 in our National w/ EE scenario.

Shale resources limit the price response to changes in demand

Change in annual average natural gas and coal price, 2020-2030, national coordination vs. reference scenario

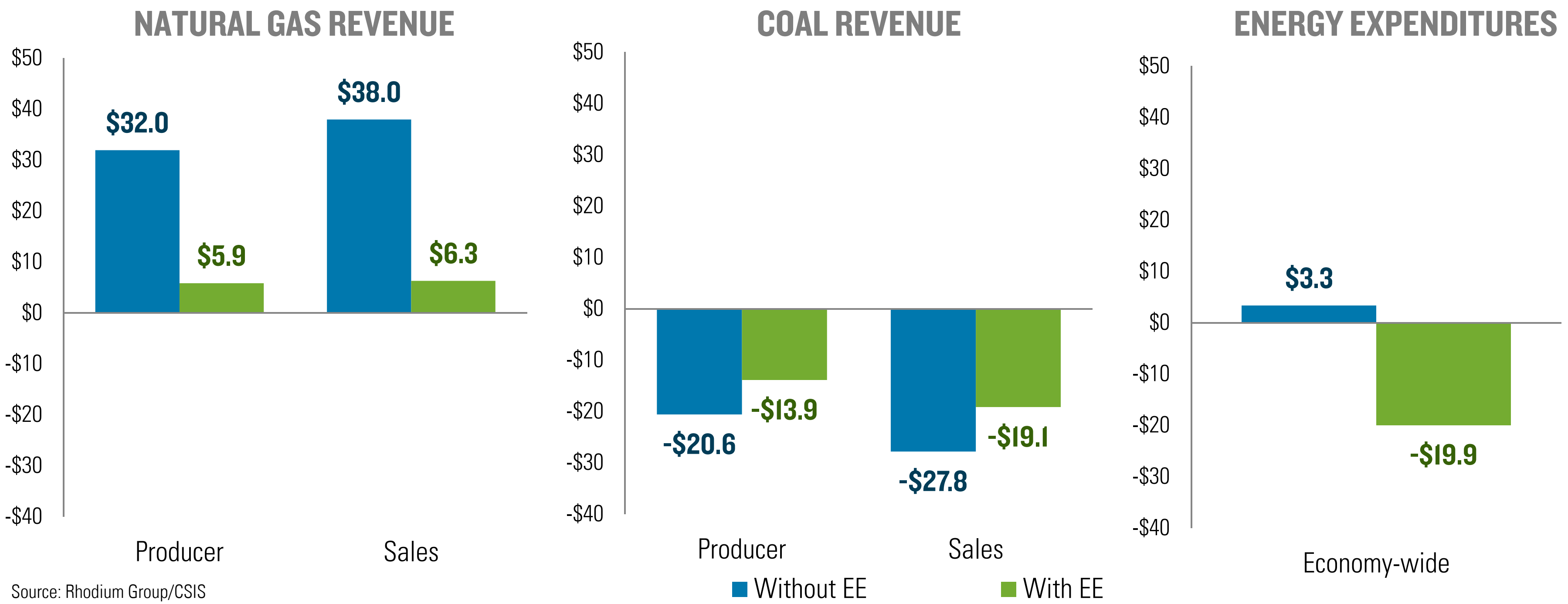


Source: Rhodium Group/CSIS

Using current EIA estimates for shale gas resource availability and cost, the CPP-driven increase in gas demand shown in slide 30 results in a relatively modest increase in natural gas prices. In our National w/ EE scenario, wellhead prices rise by 9% on average between 2020 and 2030, while delivered prices increase by less than 3%. With efficiency crediting the change in price is even smaller. Lower thermal coal demand increases average mine-mouth coal prices, as high-value metallurgical coal accounts for a greater share of total coal production. Delivered coal prices, however, fall.

Upstream impacts are potentially larger than downstream effects

Change in annual average natural gas and coal production revenue and total energy expenditures, 2020-2030, national cooperation vs. reference scenario, billion 2012 USD



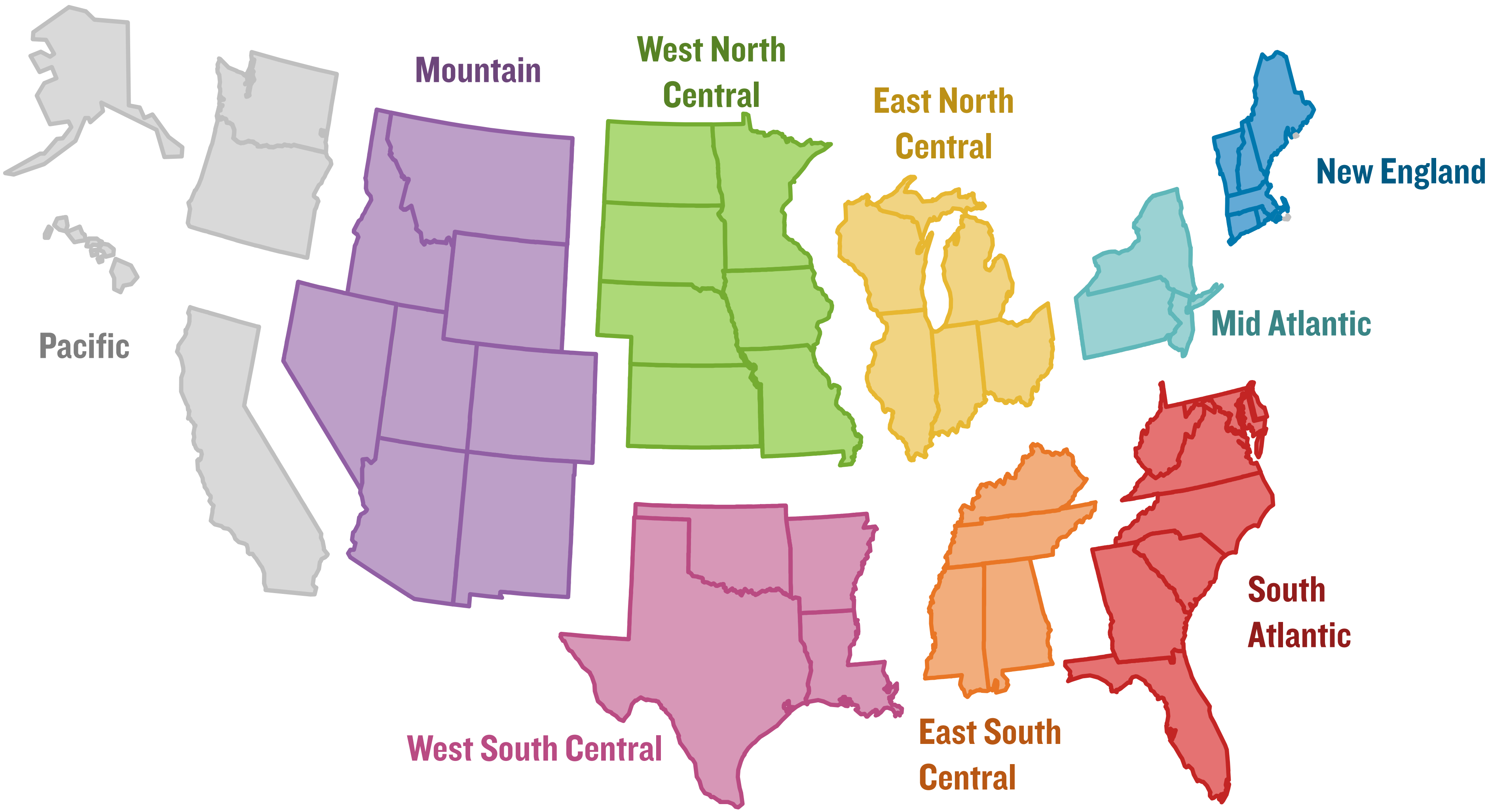
Source: Rhodium Group/CSIS

Meaningfully higher gas production, and slightly higher gas prices, boosts natural gas production revenue in our National w/o EE scenario by $32 billion on average between 2020 and 2030, a 20% increase relative to the Reference scenario. Including distribution costs, average annual natural gas sales revenue increases by $38 billion. This is matched by a similarly large decrease in coal production and sales revenue. From a regional economic standpoint, this shift in upstream fuel production revenue is potentially far more significant than changes in electricity prices or consumer energy costs.

Key Findings

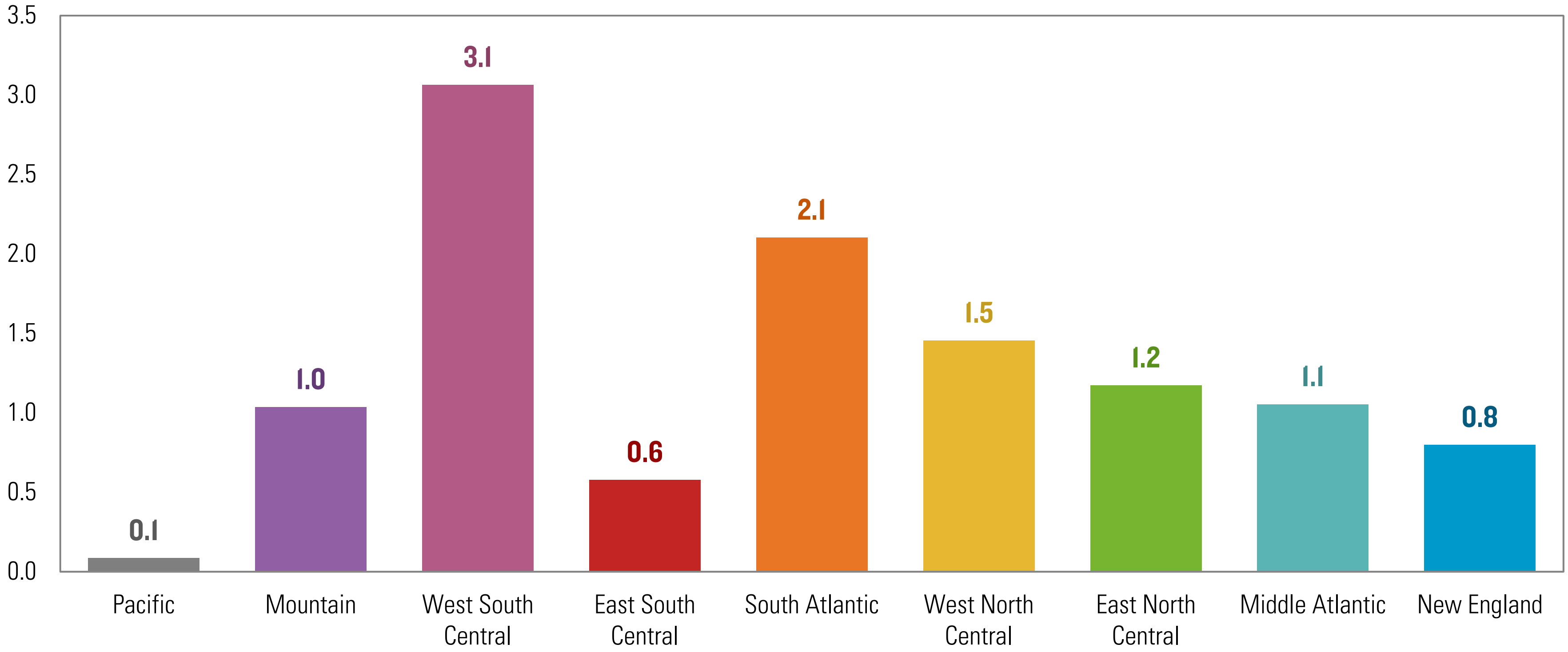
5. Compliance costs are not the same as economic impact

Census Regions



Compliance obligation is only part of the picture

EPA expected per capita emission reductions by region, 2020-2030 average

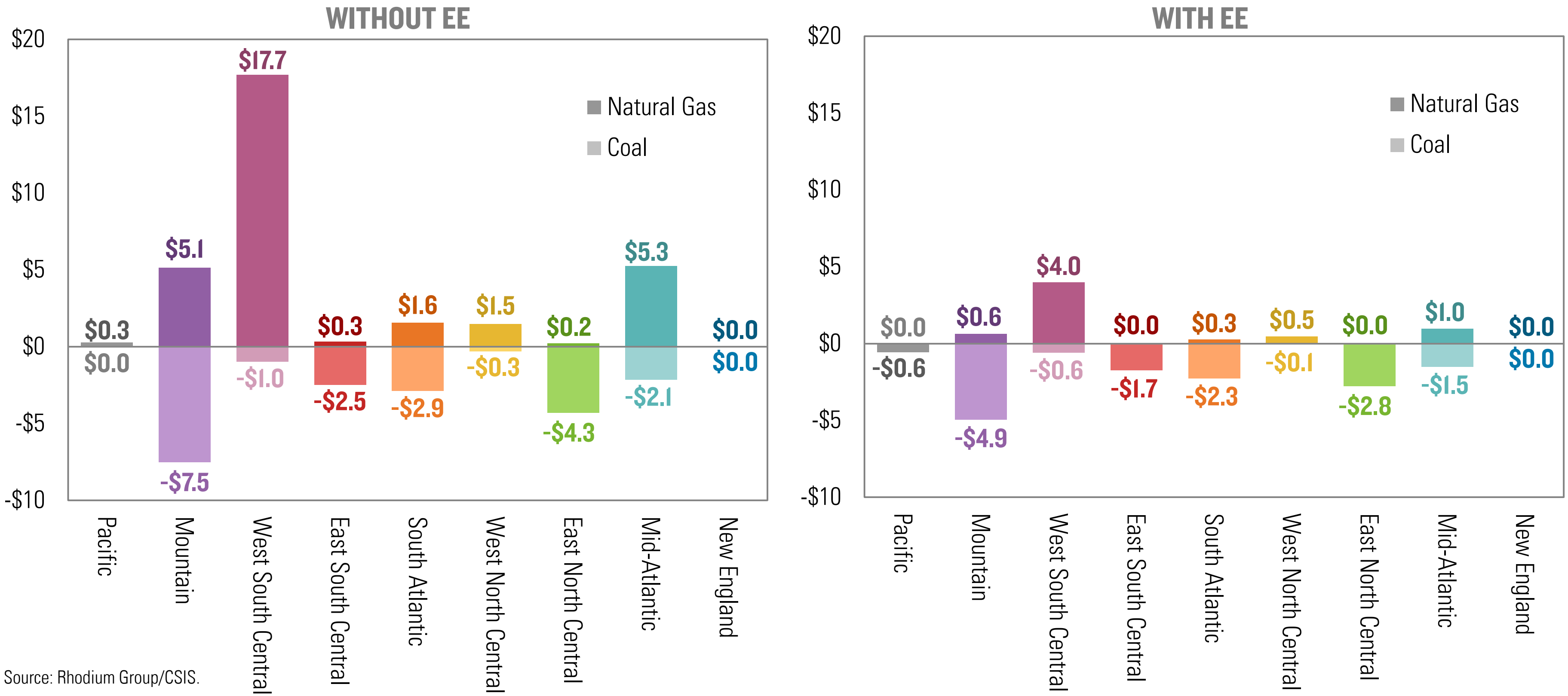


Source: EPA

EPA developed the state-level emission rate targets included in the CPP based on an assessment of the opportunity for cost-effective emission reductions in each state (the "building blocks" discussed on slide 5). This results in emission reduction expectations that are regionally uneven, as shown above, raising the prospect of regional disparities in the cost of CPP implementation and resulting changes in electricity prices and energy bills. A complete assessment of the regional economic impact of the CPP, however, requires looking at potential changes in upstream fuel supply, as well as downstream electricity costs.

Upstream impacts are important, and also vary by region

Change in average annual production revenue, 2012 billion USD, 2020-2030, national cooperation

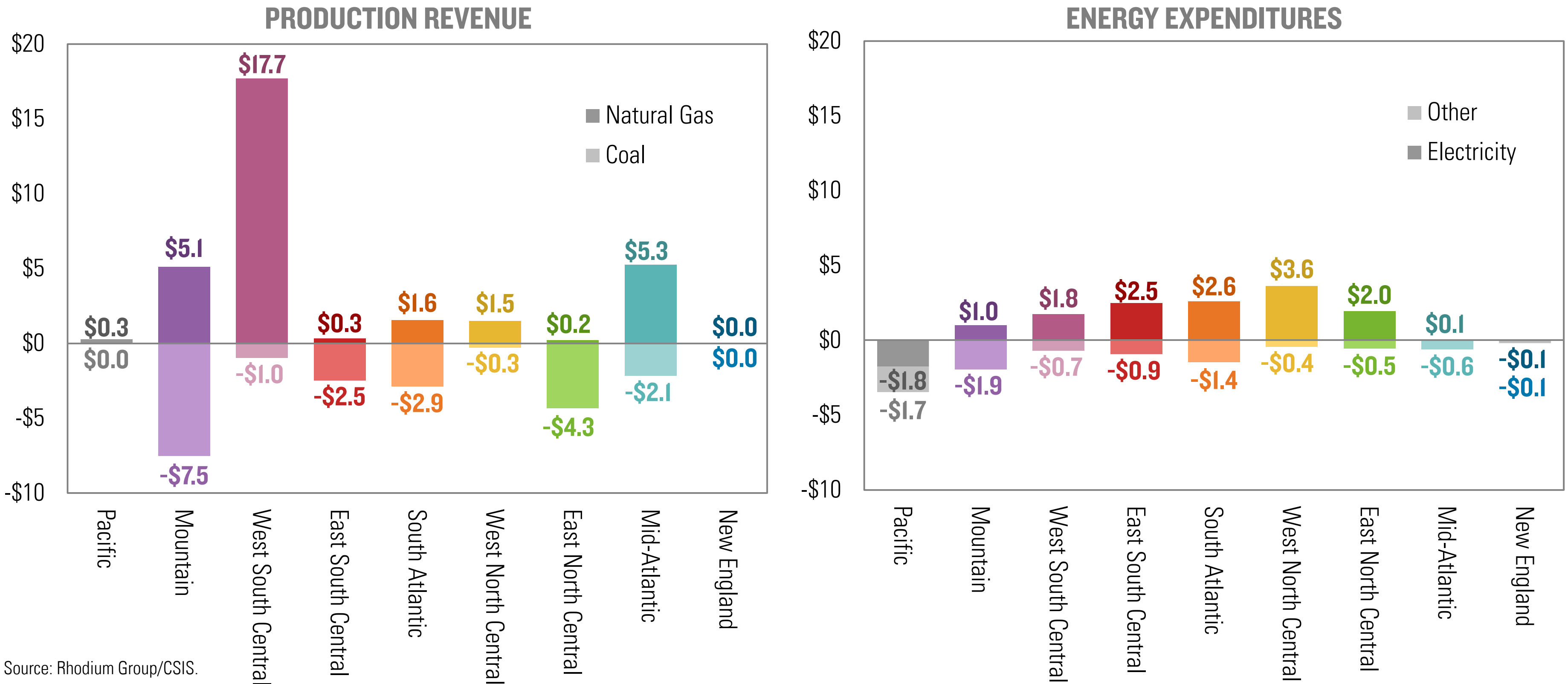


Source: Rhodium Group/CSIS.

Some parts of the country could see a significant increase in natural gas production revenue as a result of the CPP, benefiting not just gas companies and employees, but also private land owners, state budgets and sectors of the economy directly tied to natural gas production. The potential upside is largest in the West South Central region (Texas, Arkansas, Oklahoma and Louisiana) which also has the highest emission reduction expectations under the CPP. Likewise, some parts of the country could see a significant decline in coal production revenue, including Powder River and Illinois Basin producers.

Including upstream impacts changes the economic picture

Change in average annual production revenue and energy expenditures, 2012 billion USD, 2020-2030, national cooperation without EE



Source: Rhodium Group/CSIS.

In some regions, these changes in coal and natural gas production revenue are considerably larger than potential CPP-driven changes in electricity and other energy costs. For example, in our National w/o EE scenario, the West South Central census region sees a $16.7 billion net increase in annual coal and gas production revenue relative to Reference vs. a $1.1 billion net increase in household and business energy costs. For the East North Central region, the decline in Illinois Basin coal production revenue is more than twice as large as the projected increase in region-wide energy expenditures.

What Comes Next

Additional analysis in the full report

POLICY SCENARIOS

- National Cooperation w/ EE
- National Cooperation w/o EE
- Regional Fragmentation w/ EE
- Regional Fragmentation w/o EE
- Regional Cooperation Options
- Energy Efficiency Cost/Effectiveness

JULY 24

FALL 2014

MARKET SENSITIVITIES

- High Natural Gas Resource
- Low Natural Gas Resource
- High Natural Gas Exports

FALL 2014

CSIS-RHG ANALYSIS

JULY 24

FALL 2014

RESULTS

- Energy Prices
- Energy Expenditures
- Compliance Costs/Benefits
- Power Generation/Capacity
- Natural Gas Production/Revenue
- Coal Production/Revenue

JULY 24

FALL 2014

GEOGRAPHIC DETAIL

- National
- Census Region
- Power Market

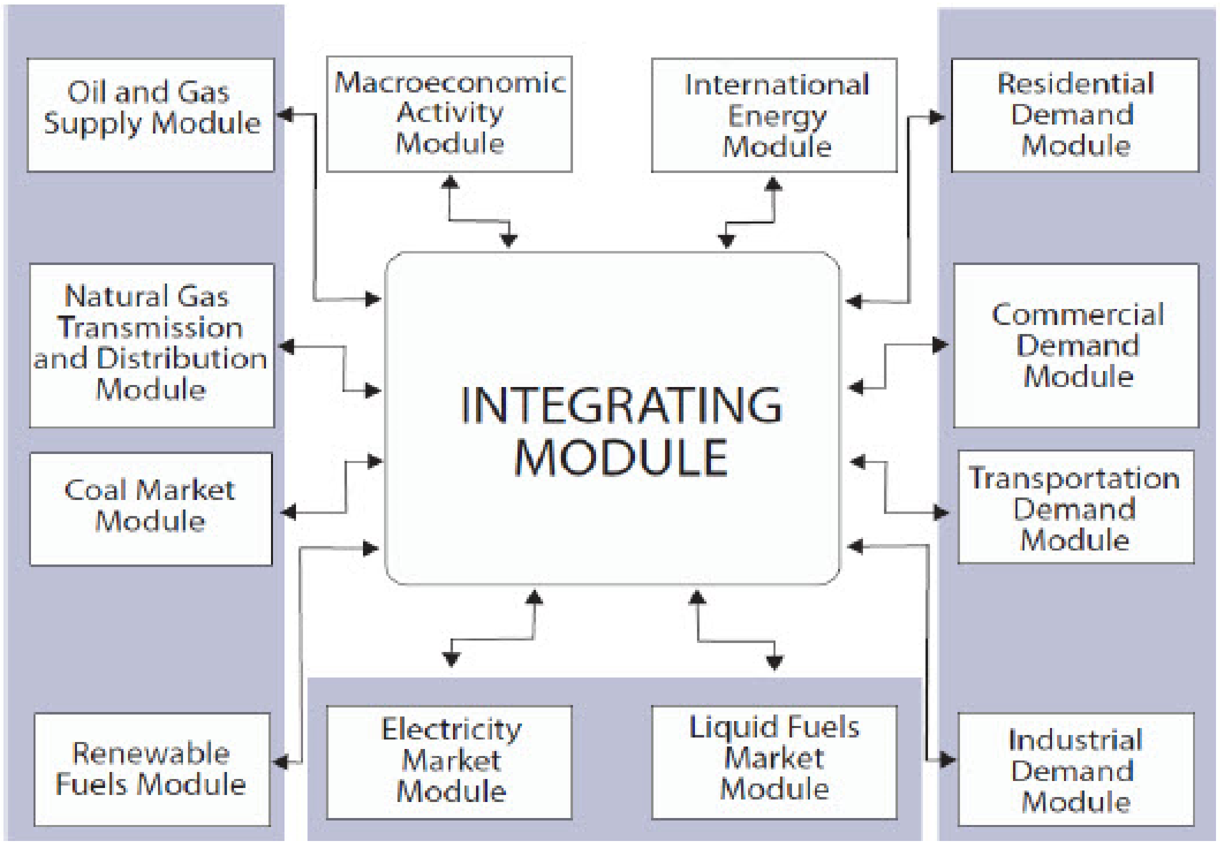
Appendix

How EPA proposal elements are addressed

EPA CPP Proposal Element		Analytical Treatment
State by state or multi-state implementation plans		Implementation nationally or implementation in 22 separate regions depending on scenario
State specific adjusted emission rate goals		Aggregated state goals as appropriate for each scenario
2020-2029 and 2030 and later compliance periods		Included
Requirement that plans must contain enforceable standards on existing fossil generators that achieve state specified goals at a minimum		Impose tradable performance standards on existing fossil generators to achieve state goals at least cost
Market-based mechanisms in states plans is permitted		National cases assumes nationwide trading of tradable performance standard compliance credits. Regional case allows trading within a region but not between regions
Abatement Options Considered	Heat rate improvements at coal plants	Not included due to model limitations
	Dispatch shifts from coal to existing Natural Gas Combined Cycle (NGCC) plants	Included, can count towards goals
	Displace existing fossil generation with zero-emitting generation (e.g. nuclear and renewables)	Utility scale and distributed generation included, only utility scale generation receives credit towards goals
	Displace existing fossil generation with demand-side EE	Included in EE scenarios (see appendix) using EPA's assumptions and counts towards goals
	Anything else that displaces emissions from existing fossil generation	CCS retrofits and displacement of existing fossil with new fossil are included but do not count towards goals

National Energy Modeling System (NEMS)

Captures the full impact of electric power sector policies by assessing the interactive effects of supply and demand across the entire US energy system

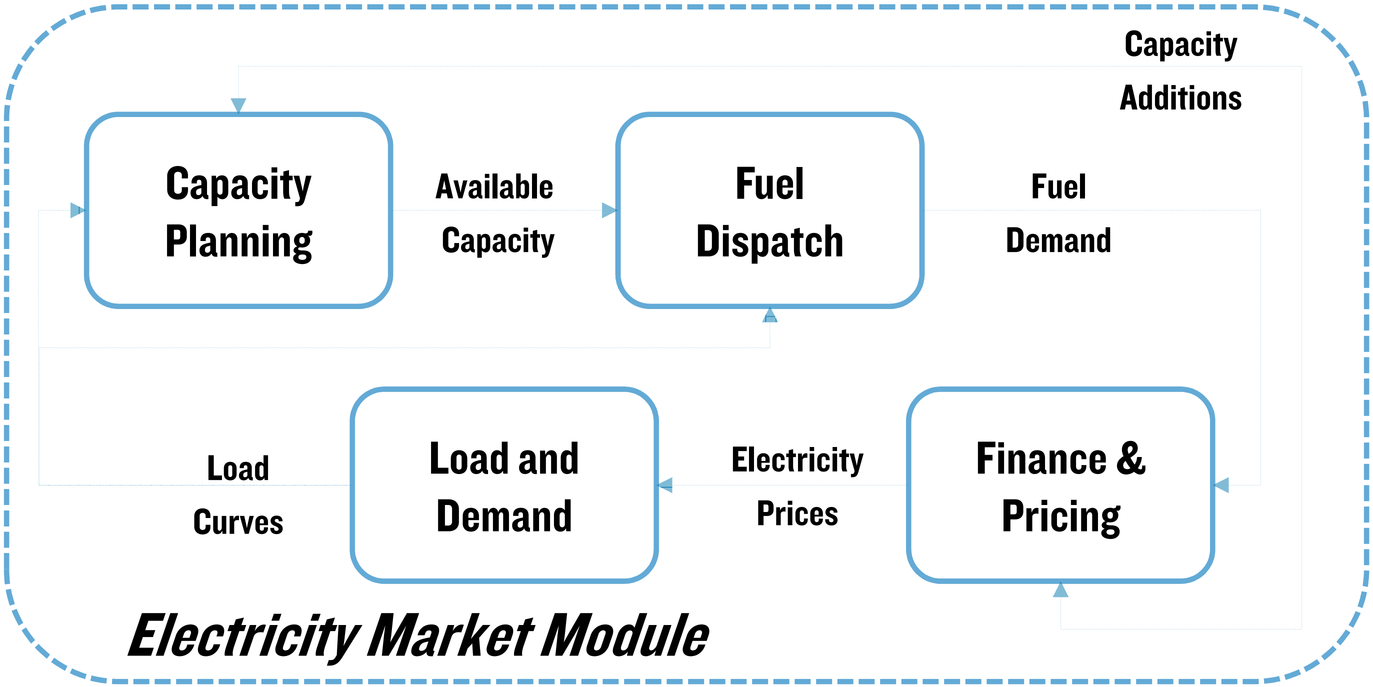


U.S. Energy Information Administration, Office of Energy Analysis.

Overview the NEMS Electricity Market Module

Exogenous Inputs

Financial data Tax assumptions Capital costs O&M costs Operating parameters
Emission rates New technologies Existing facilities Transmission constraints



Outputs

Electricity prices
Price components
Fuel demand
Capacity additions
Capital requirements
Emissions

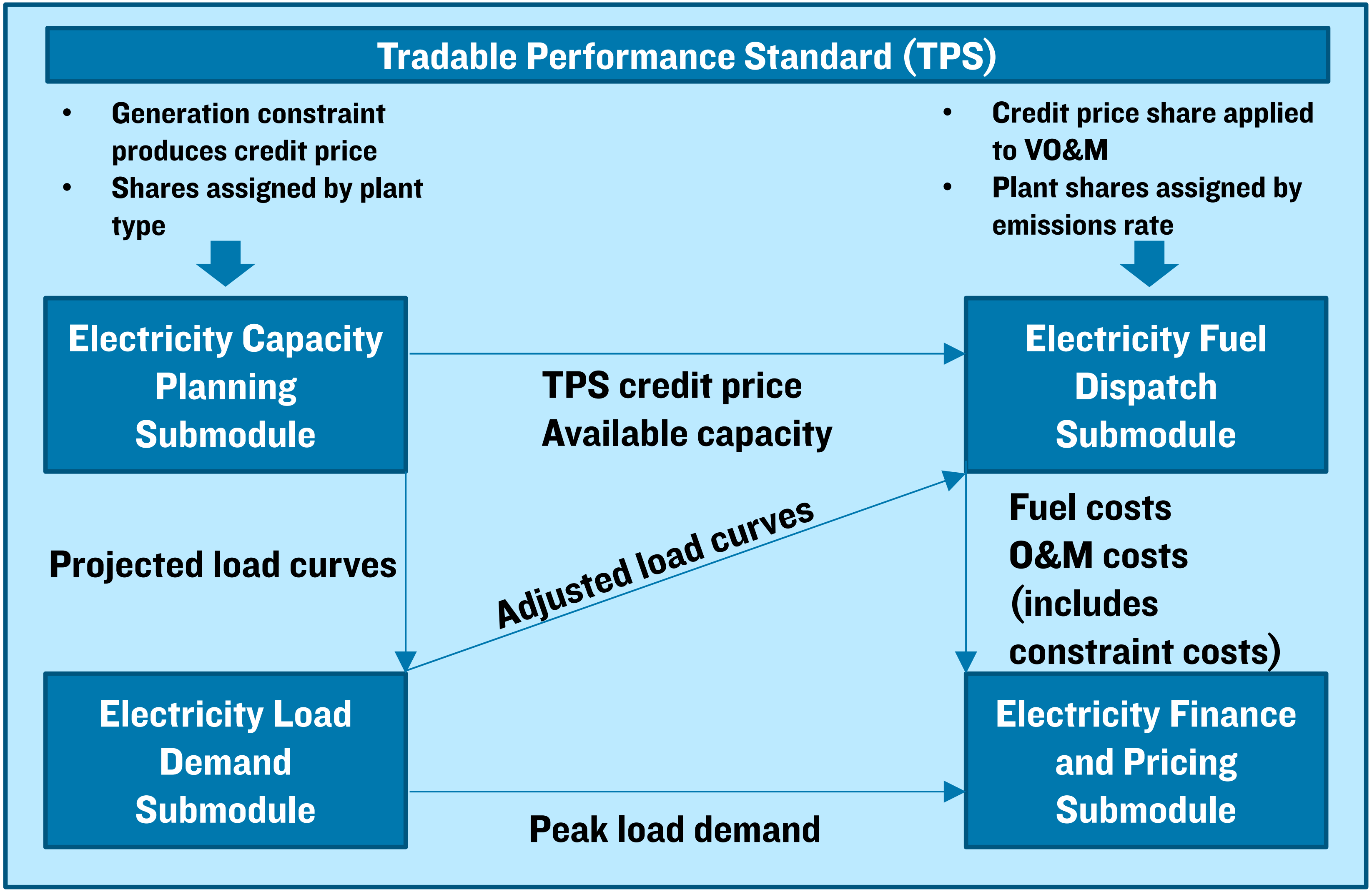
With perfect foresight

Inputs from other modules

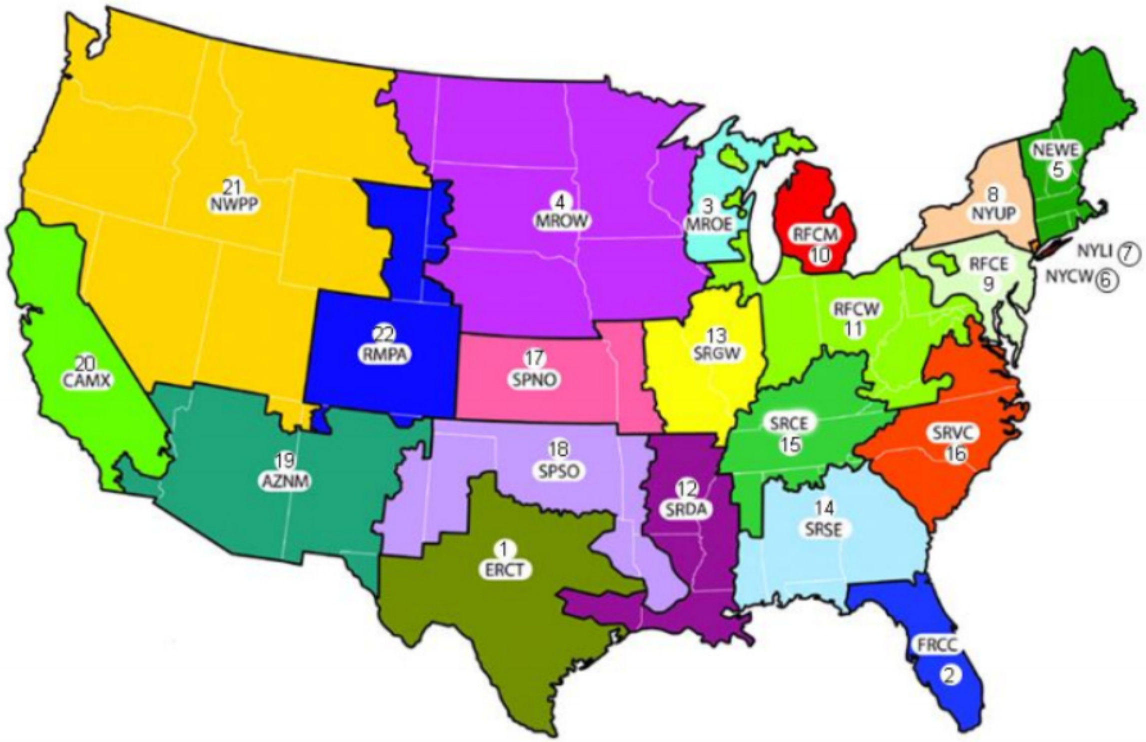
Electricity sales Fuel prices Cogeneration
Renewable technology parameters GDP Interest rates

Modeling a tradable performance standard

Coding enhancements in the Electric Market Module (EMM) in NEMS



NEMS Electricity Market Module regions



U.S. Energy Information Administration, Office of Energy Analysis.

Crediting energy efficiency

NEMS is not capable of including EE as an explicit compliance option that can be chosen endogenously by the model. Instead, an approach similar to the one used by EPA in its Regulatory Impact Analysis of the CPP was used. This approach was implemented in the following steps.

Incorporate EPA's cost and deployment assumptions into NEMS:

- Include EPA's cost values for first-year utility and participant costs including cost escalators as well as measure-life assumptions.
- Include EPA's assumption that all states ramp up to 1.5% incremental savings per year by 2026. Calculate savings by census region using retail sales weighted averages of EPA's state-by-state annual targets.
- Adjust incremental savings goals to account for implicit savings from state EE programs captured in the reference case. These adjustments vary from region to region but add up to .18% annual average incremental retail sales nationally.
- All energy savings are assumed to be real and verfiable.
- Adjust reference case NEMS electricity demand forecast to include EE program energy savings.
- Adjust reference case NEMS electric rates to include first-year utility EE costs in rate recovery calculations.

Credit EE energy savings in TPS

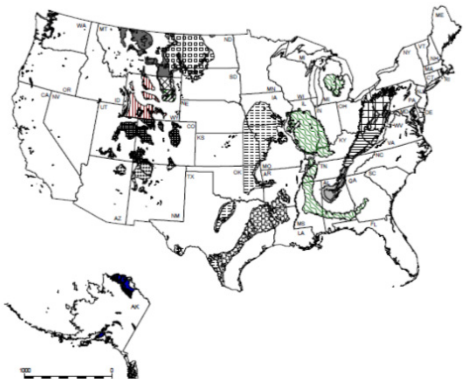
- From 2020 onward, credits from energy savings (including implicit savings) are assumed to be used for compliance in the year the savings are achieved.
- TPS targets are adjusted to account for EE credits

Account for EE costs

- Assume costs of implicit savings are already included in reference case electricity forecast
- Low EE cost estimates: Reflect annual national utility EE cost rate recovery amount only. This amount will vary from the total first-year cost due to NEMS rate recovery calculations but all first year costs are typically recovered over two years.
- High EE cost estimates: Include Low EE costs estimate plus all first-year participant costs, which are assumed to be incurred in year one and not financed.

Rescaling NEMS fuel production output

Coal Supply Regions



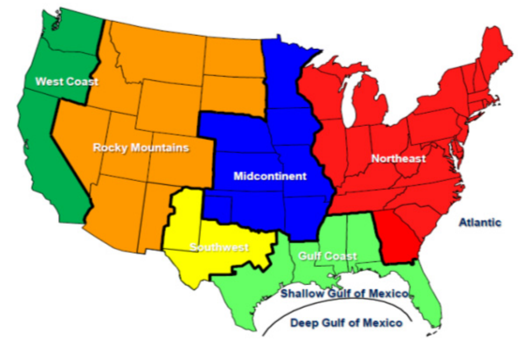
Based on current distribution of mine production

Differentiate by coal rank

Census Regions

All other regional output is reported by Census Region

Oil & Gas Supply Regions



Based on current distribution of proven reserves

Differentiate by resource type

Source: EIA and Rhodium Group/CSIS

Calculating benefits

Climate Benefits

- Social Cost of Carbon (SCC) values were sourced from the latest guidance from the US Office of Management and Budget
- Low estimates presented in this document relied on the 5% discount rate SCC values. High estimates based on the 2.5% discount rate SCC will be included in the final release.
- Annual SCC values were multiplied by annual CO_2 abatement output from NEMS to produce an annual climate benefits value.

Public Health Benefits

- National per-ton benefit values for SO_2 and NO_x abatement in the electric power sector were sourced from the latest relevant EPA technical support document.
- Low estimates presented in this document relied on 7% discount rate, low mortality estimate values. High estimates based on 3% discount rate high mortality estimate values will be included in the final release.
- Values were interpolated between reported years and multiplied by annual SO_2 and NO_x abatement output from NEMS to produce annual public health benefit values.

All benefit values are reported in real 2012 dollars

Remaking American Power

Preliminary Results

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