BIPARTISAN POLICY CENTER

Power Sector Transition: GHG Policy and Other Key Drivers

JENNIFER MACEDONIA, BLAIR BEASLEY,
MEGHAN MCGUINNESS, STUART ILER

MAY 2014

WWW.BIPARTISANPOLICY.ORG

Purpose of Analysis: Impacts of GHG Regulation of Power Plants

- **Scoping/bounding analysis on power sector future w/ GHG regulation**
  - Not intended to predict/propose/endorse a level of stringency
- **Examine and compare impacts under a range of assumptions**
  - Range of emission limitation levels
  - Range of natural gas prices
  - Range of cost estimates for demand side energy efficiency
  - Range of potential future for existing nuclear fleet
- **BPC analysis is based on economic modeling of the power sector**
  - Using the Integrated Planning Model (IPM) run by ICF International
  - With assumptions and policy scenarios defined by BPC
  - On-going analysis will adapt to proposal after EPA guidelines in June 2014

GHG: Greenhouse Gas
BPC: Bipartisan Policy Center

Key Take-Aways

- **Magnitude of impacts from §111(d) largely dependent on EPA & state interpretations, technical analysis & decisions, as well as market factors**
- **Significant power sector carbon reduction is already baked into system**
- **Few new coal builds expected, even in the absence of GHG policy**
- **111(d) policy requiring only modest plant upgrades does little to reduce CO_2**
  - Many of the least efficient units are already slated to retire
  - Plant upgrades would likely increase coal generation
- **Potential for natural gas prices to be as influential as GHG policy**
  - Low gas prices have potential to make 111(d) policy non-binding
- **Demand-side energy efficiency may be an instrumental compliance strategy**
  - Highly dependent on price/availability
  - Lack of flexibility to reduce CO_2 with demand side EE significantly increases cost
- **Nuclear plant retirements beyond what is currently projected would raise costs and/or dampen CO_2 reductions achieved by §111(d) regulation**
- **Timing flexibility (e.g., emissions budget with banking) helps lower overall costs**

GHG: Greenhouse Gas
§111(d): Section 111(d) of Clean Air Act
CO_2: Carbon Dioxide
EE: Energy Efficiency

Caveats and Limitations

❖ Intention of scoping runs was bounding analysis

- Policy scenarios designed before EPA proposal and only intended to be rough bounding analysis of §111(d) impacts
- Magnitude of impacts from §111(d) will depend on many yet-to-be-determined factors, including EPA & state interpretations & decisions
- Limited cost/performance data and modeling limitations for HR upgrades
- Modeling does not assume that plant efficiency upgrades trigger NSR

❖ Analysis could underestimate costs

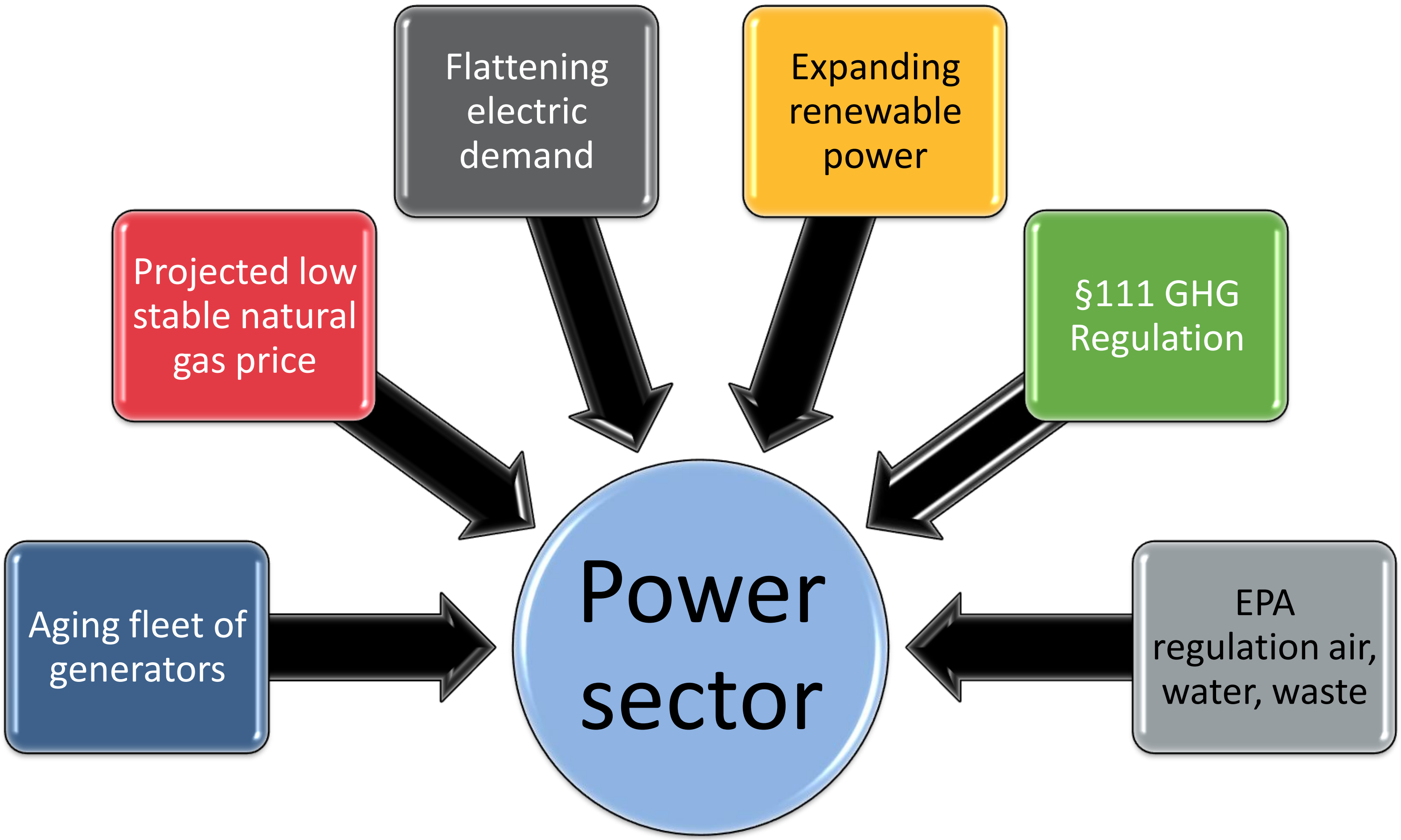
- Most policy runs assume national market-based policy, but a §111(d) approach with state variation would likely be less economically efficient

❖ Analysis could overestimate costs

- Very little innovation assumed in model & could significantly impact results
- Policy is not optimized for lowest cost solution
  - CO_2 price runs don't allow compliance timing flexibility

§111(d): Section 111(d) of Clean Air Act
HR: Heat rate
NSR: New Source Review
CO_2: Carbon Dioxide

Power sector transition driven by many factors



GHG: Greenhouse Gas
§111(d): Section 111(d) of Clean Air Act

Presentation Outline:

I. Reference Case (Slides 7-10)
II. Modeled Policy Scenarios (Slides 11-14)
III. Results of Modeled Policy Scenarios (Slides 15-16)
IV. Scenario 1: Unit Retrofit (Slides 17-18)
V. Scenario 2: $12/ton (Slides 19-20)
VI. Relative Influence of Key Drivers (Slides 21-33)
VII. Scenario 3: $43/ton (Slides 34-35)
VIII. Regional Impacts of Modeled Scenarios (Slides 36-40)

BIPARTISAN POLICY CENTER

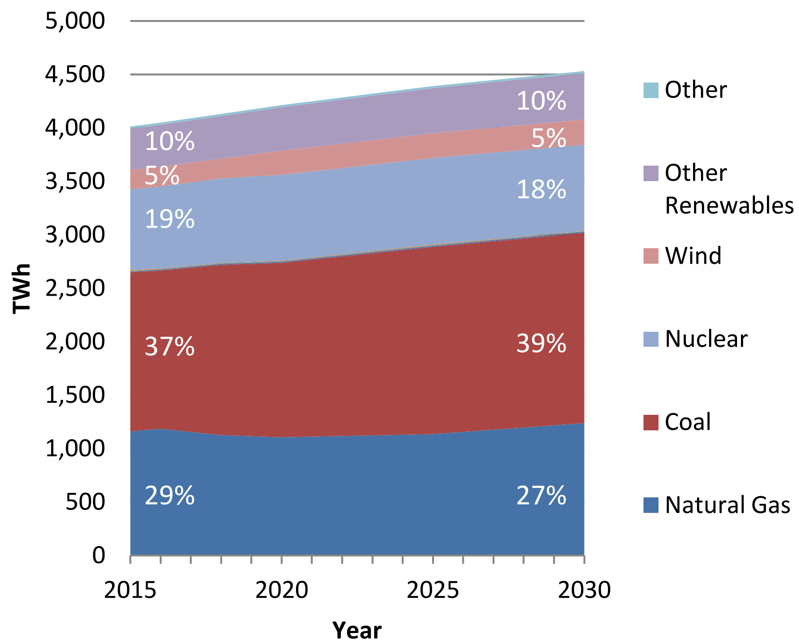
I. Reference Case:

Projected power sector future with market and regulatory factors, but no GHG policy

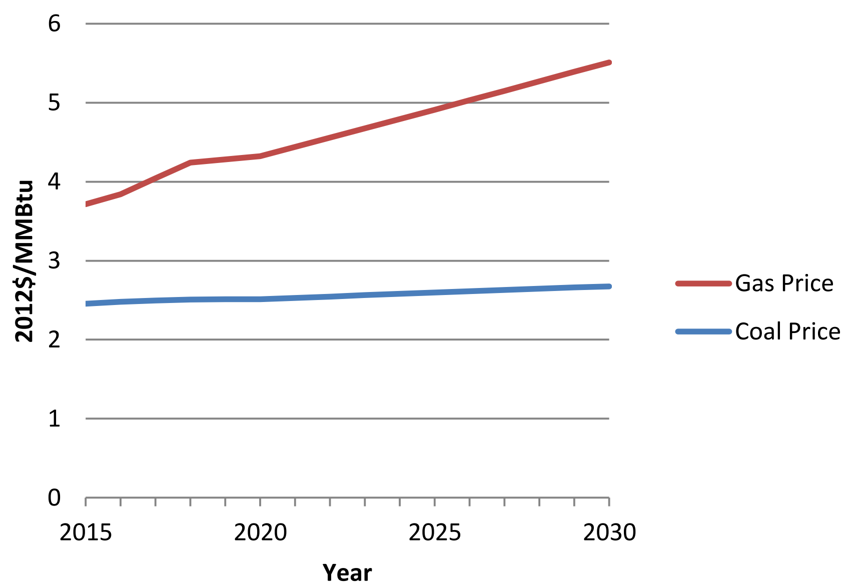
❖ Reference case largely based on EIA Annual Energy Outlook 2013

- No GHG policy assumed
- Percent contribution from each generation type remains fairly consistent
- Modest growth in total generation to accommodate modest load growth
- Coal remains dominant generation fuel

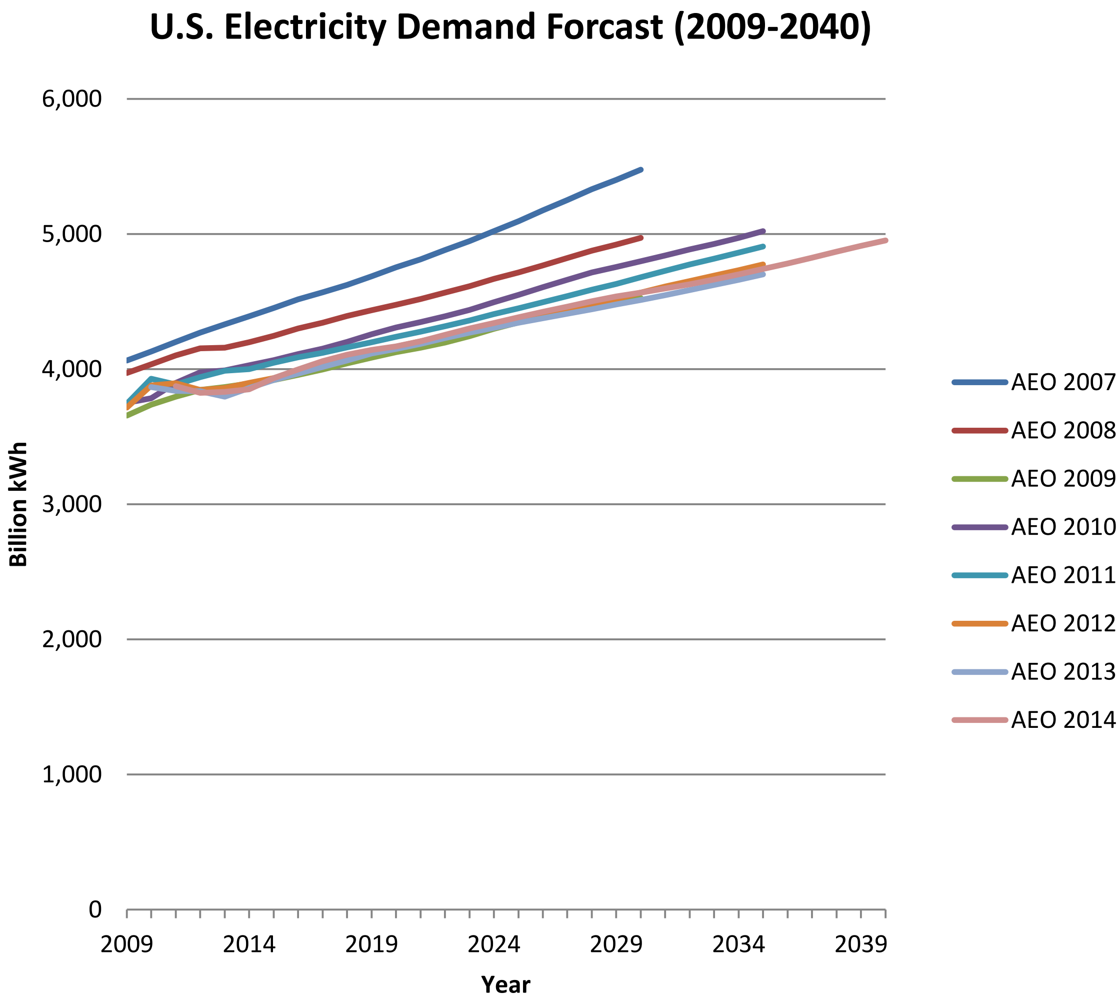
U.S. Generation Mix (Reference)



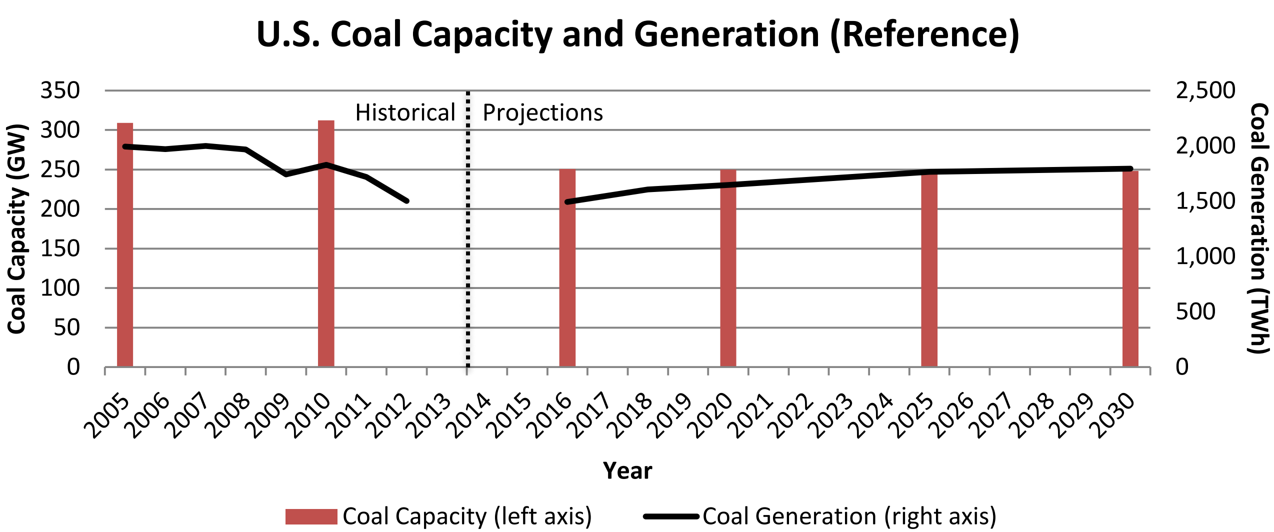
U.S. Average Minemouth Coal Price & Henry Hub Gas Price (Reference)

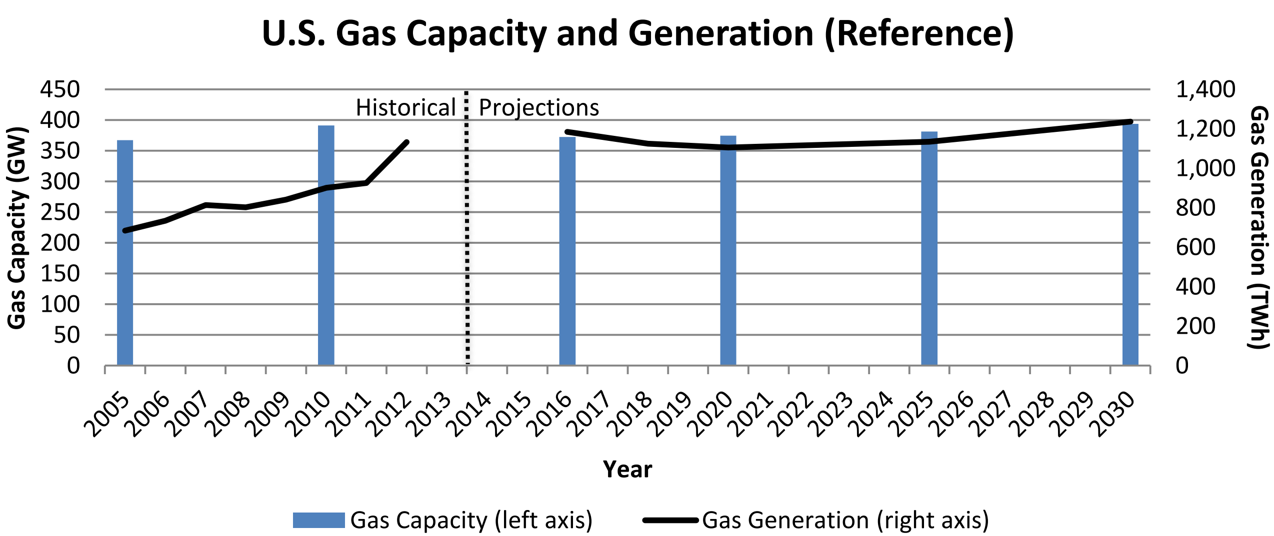


EIA: Energy Information Administration
GHG: Greenhouse Gas



- **Forecasts of the expected demand for electricity have continued to fall over recent years**





Reference (no GHG policy)

- ❖ **Even with significant coal retirements by 2016, coal generation holds steady**
- ❖ **Low electricity demand growth helps to dampens need for new capacity investment, even with significant retirements underway**

GHG: Greenhouse Gas

BIPARTISAN POLICY CENTER

II. Modeled Policy Scenarios:
GHG regulation

No GHG Policy

GHG Policy

Unit Retrofit

Reference

$12/ton

$43/ton

Unit Retrofit: On-Site Modest Unit Retrofits

- **Policy: requires coal plants to invest in on-site reductions by 2020**
  - On-site efficiency (heat rate) retrofits and/or co-fire natural gas/biomass
  - Unit-specific heat rate improvement & cost based on analysis of available data
  - Coal units with on-site gas or nearby pipeline can co-fire 15% natural gas
  - Coal units can co-fire up to 15% biomass (EIA biomass supply and cost)

$12/ton: System-Wide Reductions up to $12/ton

- **Policy: requires electric sector CO_2 reductions up to $12/ton in 2020**
  - Modeled as a national tax that rises at the rate of the social cost of carbon
  - Representative of program with national trading

$43/ton: System-Wide Reductions up to $43/ton

- **Policy: requires electric sector CO_2 reductions up to $43/ton in 2020**
  - Same as $12/ton scenario, except at $43/ton

➢ **All policy scenarios require §111(b) CCS for new coal capacity**

CO_2: Carbon Dioxide
§111(b): Section 111(b) of Clean Air Act
CCS: Carbon Capture and Storage
EIA: Energy Information Administration

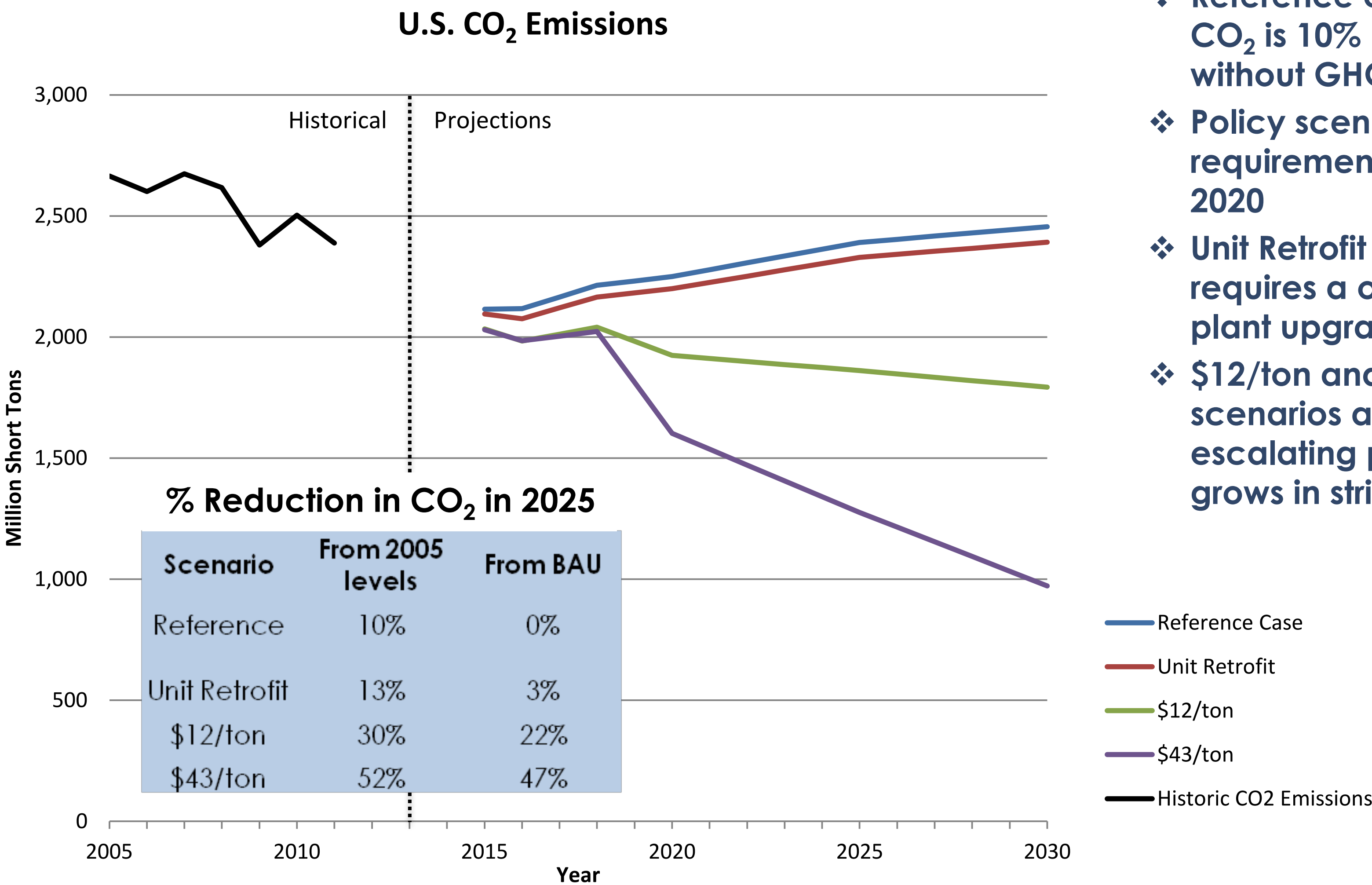
Matrix of Policy Scenario Features

	111(b) Policy	111(d) Compliance Options				Basis for CO_2 Limit
		Heat Rate Upgrades	Co-Fire Gas or Biomass	Shift to Cleaner Generation	Demand-Side Energy Efficiency	
Reference						None
Unit Retrofit	X	X	X			Modest Plant Upgrade
\$12/ton	X	X	X	X	X	Price on CO_2 Emissions
\$43/ton	X	X	X	X	X	Price on CO_2 Emissions

111(b): Section 111(b) of the Clean Air Act
111(d): Section 111(d) of the Clean Air Act
CO_2: Carbon Dioxide

BIPARTISAN POLICY CENTER

III. Results of Modeled Policy Scenarios



% Reduction in CO_2 in 2025

Scenario	From 2005 levels	From BAU
Reference	10%	0%
Unit Retrofit	13%	3%
$12/ton	30%	22%
$43/ton	52%	47%

- **Reference case 2025 CO_2 is 10% below 2005 without GHG policy**
- **Policy scenario requirements begin 2020**
- **Unit Retrofit scenario requires a one-time plant upgrade**
- **$12/ton and $43/ton scenarios apply an escalating price that grows in stringency**

CO_2: Carbon Dioxide
GHG: Greenhouse Gas

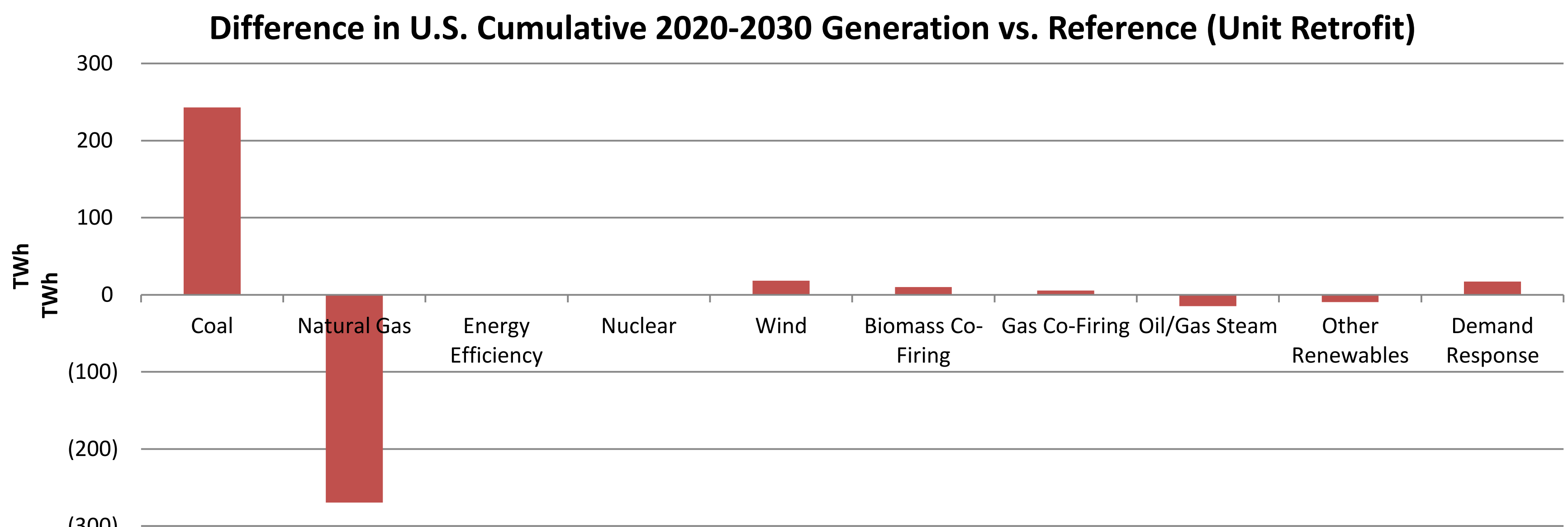
BIPARTISAN POLICY CENTER

IV. Scenario 1: Unit Retrofit

Unit Retrofit scenario: modest changes from Reference case

❖ Between 2020-2030:

- 1% increase in cumulative generation from coal
  - Plant efficiency upgrades = more electricity generated per ton of coal
- 2% decrease in gas generation
  - Plant upgrades at coal units allow them to better compete with gas
- Slightly fewer coal retirements (2 GW fewer 2015-2030)



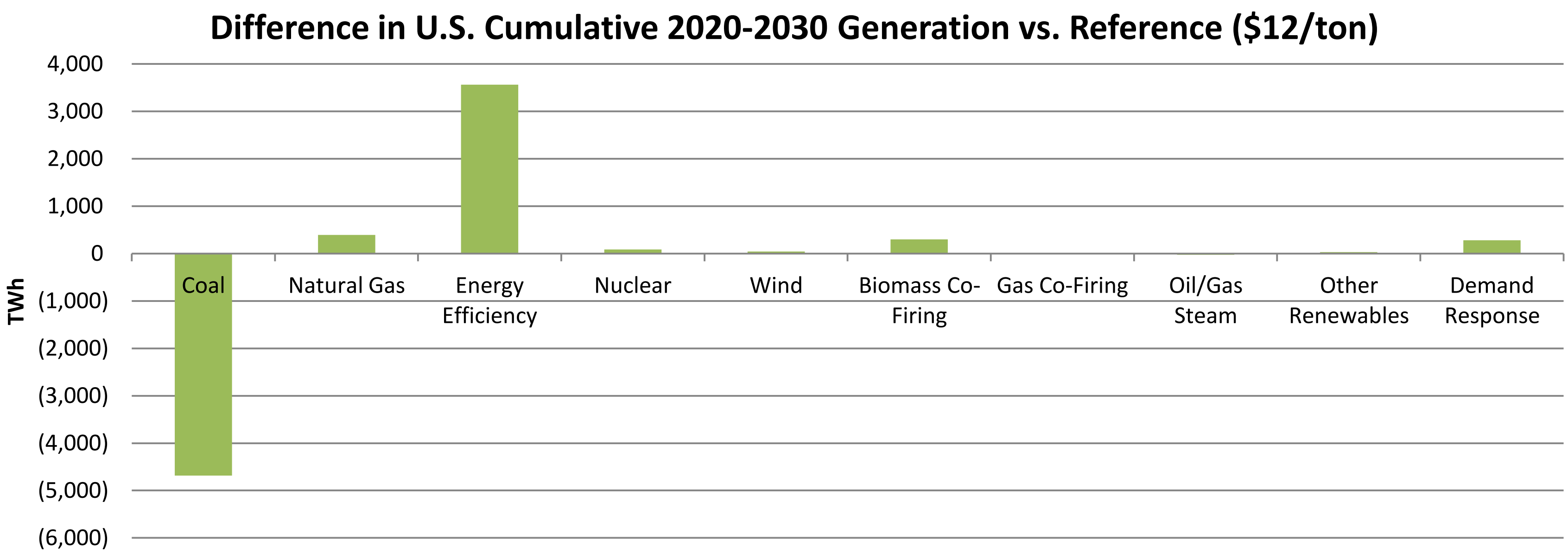
BIPARTISAN POLICY CENTER

V. Scenario 2: $12/ton

$12/ton scenario: significant changes from Reference case

❖ Between 2020-2030:

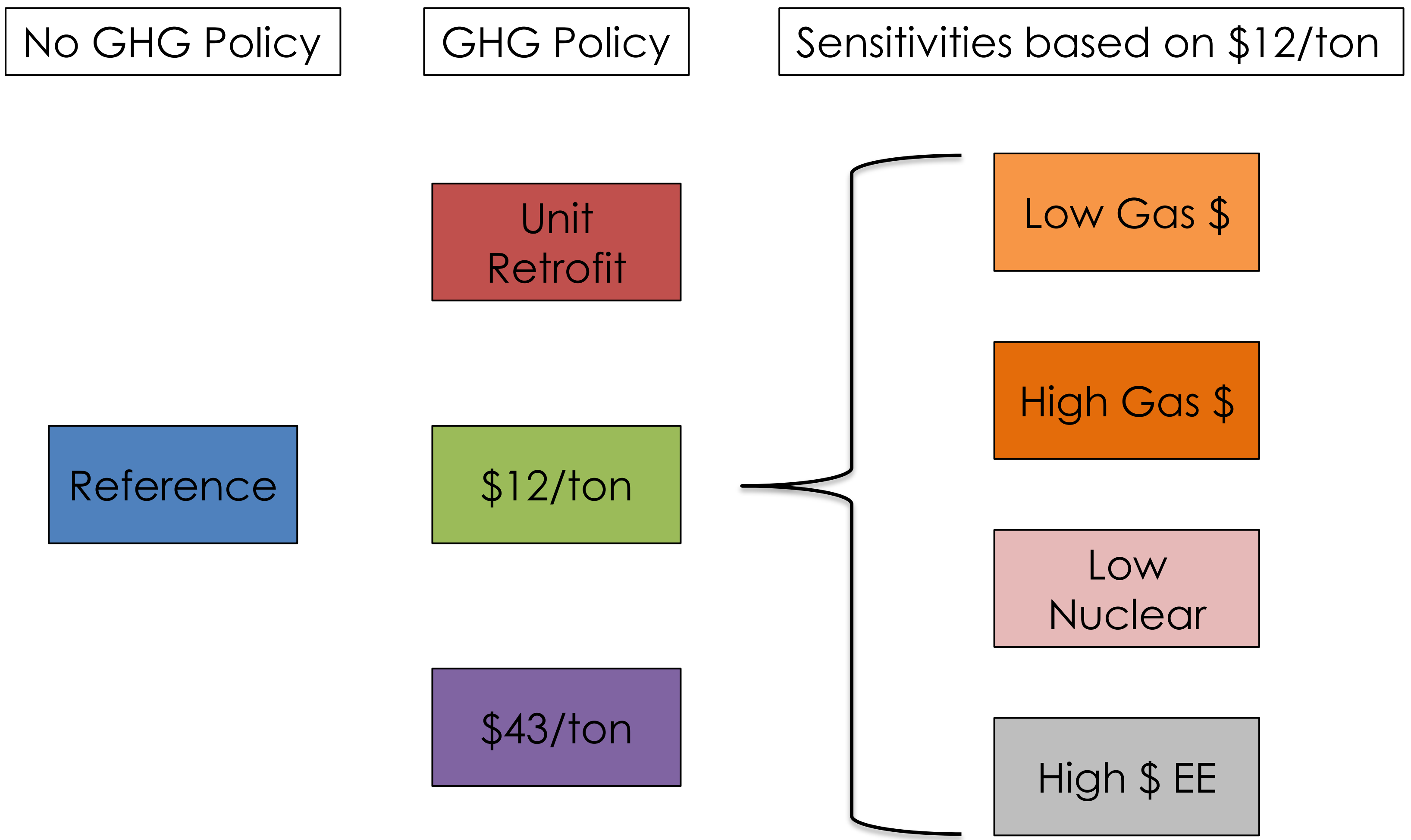
- 25% decrease in cumulative generation from coal
- Demand-side efficiency makes up for >¾ of the coal decrease
- Modest increase in natural gas generation and biomass co-firing
- 69 GW of additional coal retirements in 2015-2030



BIPARTISAN POLICY CENTER

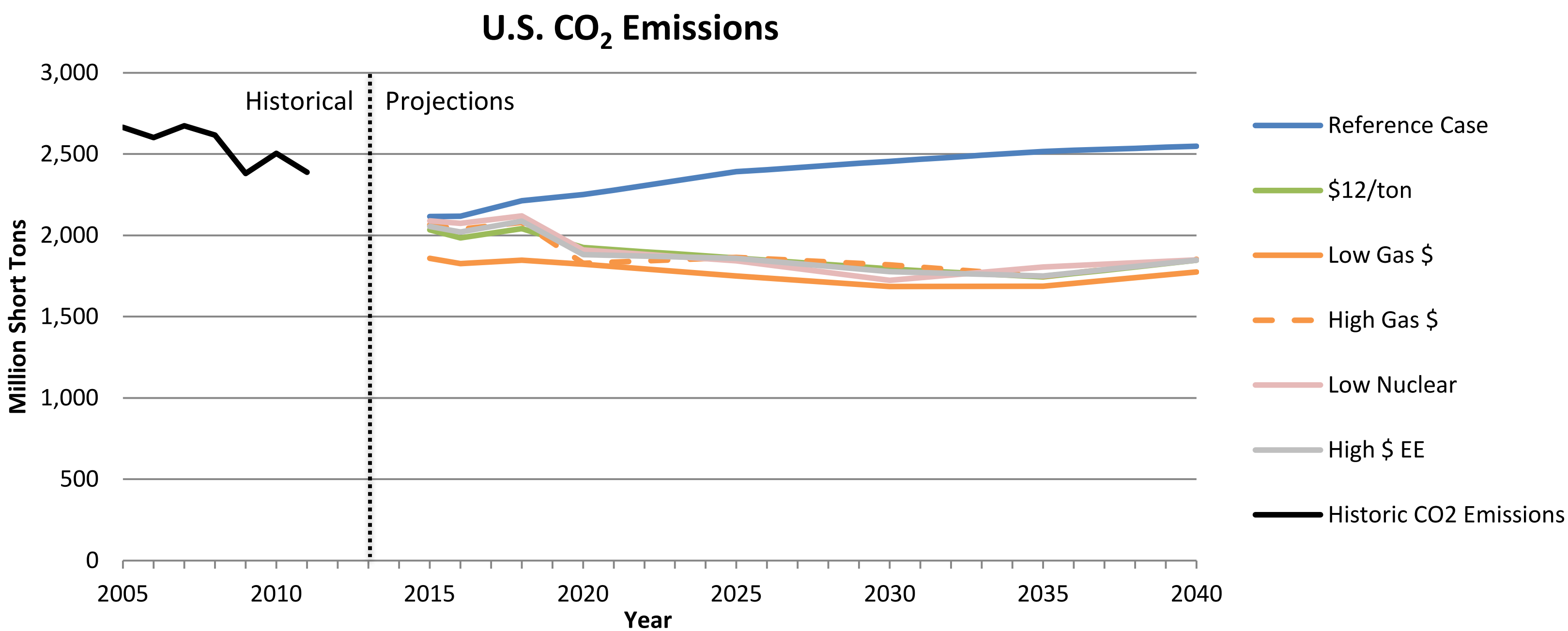
VI. Relative influence of key drivers

Natural gas prices
Cost/availability of demand-side EE
Fate of existing nuclear fleet


No GHG Policy
GHG Policy
Sensitivities based on $12/ton
Unit Retrofit
Low Gas $
High Gas $
Reference
$12/ton
Low Nuclear
$43/ton
High $ EE

Sensitivity runs vary assumptions to understand relative impacts

- Implemented as an emissions cap set at 2020-2040 CO_2 trajectory from $12/ton policy scenario, with national emissions trading & banking
- Four sensitivity cases – high and low natural gas price, high-cost energy efficiency, and additional retirement of existing nuclear plants

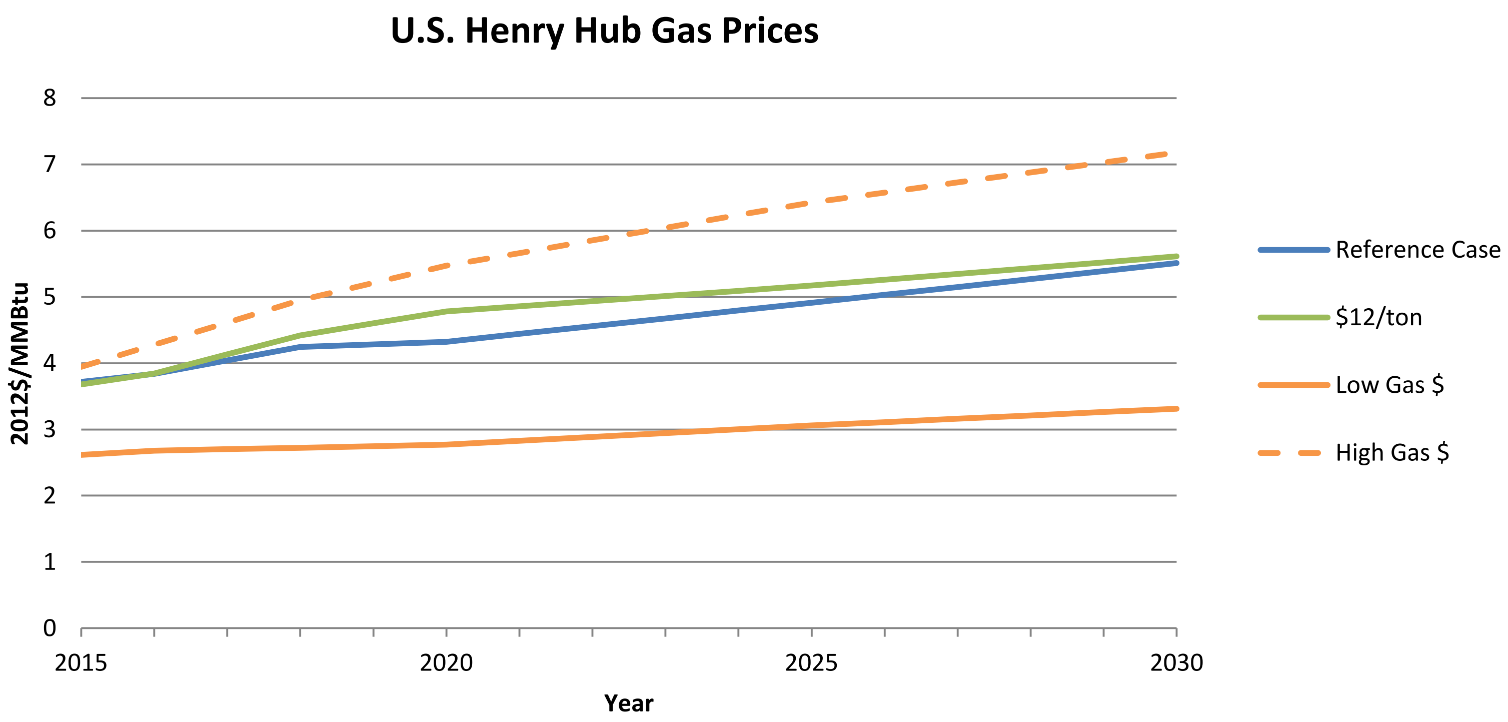


- The cap is not binding in the low gas price case – the low gas price drives CO_2 below the required level

CO_2: Carbon Dioxide

Natural Gas Price

- Natural gas price is a key determinant of the generation mix and wholesale electricity prices
- High and low gas price sensitivities are based on EIA's AEO 2013 gas supply cases



EIA: Energy Information Administration
AEO: Annual Energy Outlook

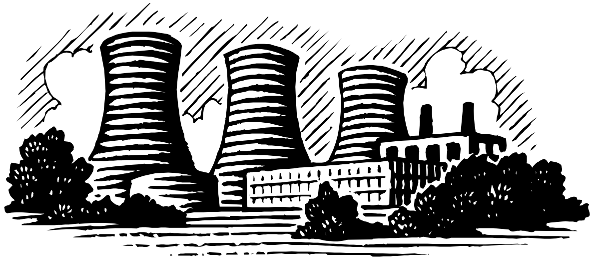
Demand Side Energy Efficiency

- **The cost & availability of demand side energy efficiency are critical in determining its influence as a §111(d) compliance option**
- **Estimates of the cost/availability of demand side energy efficiency vary***
  - LBNL, March 2014: 2.1 cents/KWh (range: <1 – 5 cents/KWh)
  - ACEEE, April 2014: 1.7-3.2 cents/KWh
  - NRDC based on Synapse (2011): 2.3-3.2 cents/KWh
  - ACCCE based on Alcott and Greenstone (2012): 11 cents/KWh
  - Studies vary in methodology. Most estimates include only program costs. Some, such as ACCCE, include total resource costs, which are ≈182% of program cost.
- **To test importance of demand-side EE cost, we varied the assumed cost**
  - $12/ton case: demand side EE is available to utility at 2.3-3.2 cents/KWh
  - High $ EE case: demand side EE is available to utility at 11 cents/KWh
  - If greater supply or lower cost (than 2.3-3.2 cents/KWh) EE is available, EE could play even stronger role in compliance and lower compliance cost

§111(d): Section 111(d) of Clean Air Act
NRDC: Natural Resources Defense Council
LBNL: Lawrence Berkeley National Laboratory
ACEEE: American Council for an Energy-Efficient Economy
ACCCE: American Coalition for Clean Coal Electricity

Existing Nuclear Fleet

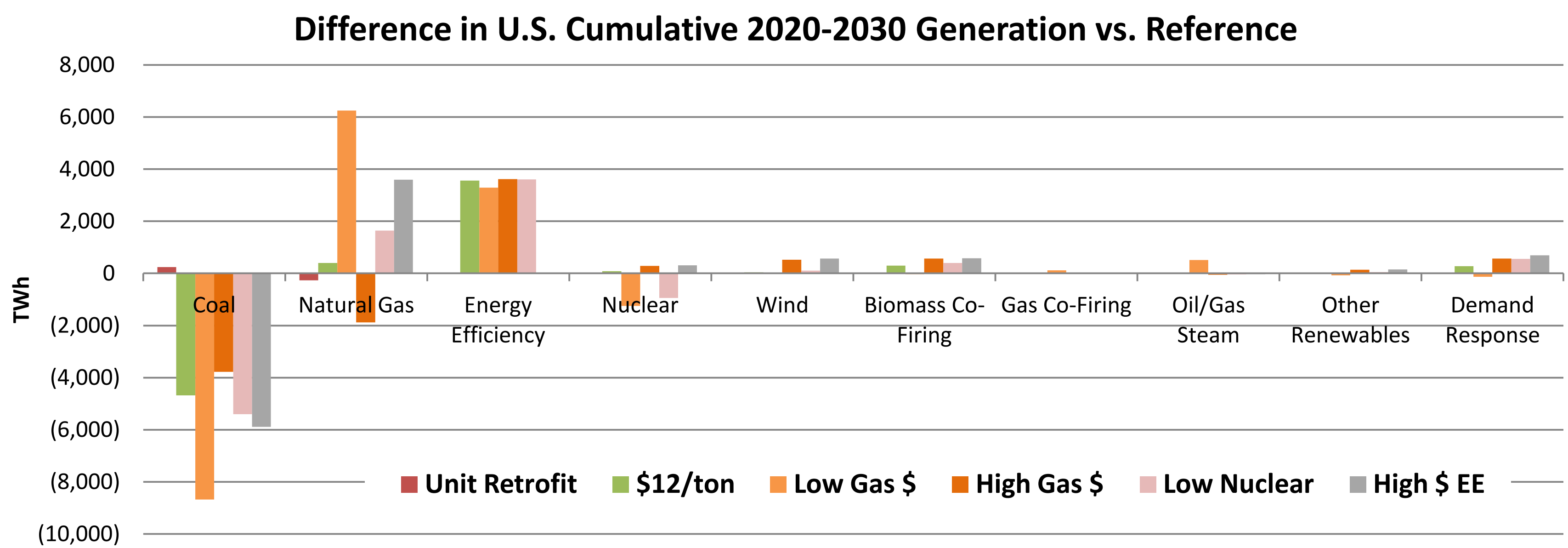
- **Market conditions may threaten the economics of nuclear plants, particularly merchant plants operating in competitive markets**
- **Retirement of existing nuclear facilities implies a loss of zero-carbon baseload power & will increase the cost of compliance for a given CO_2 reduction level**
- **To test the relative influence, the low nuclear sensitivity case assumes:**
  - An additional 7 GW of vulnerable nuclear plants retire in 2015-2016
    - In Reference case, 1 GW retire between 2015-2020
  - No existing nuclear plant is re-licensed at 60 years
    - Between 2015-2040, 51 GW nuclear capacity retires beyond the Reference case



CO_2: Carbon Dioxide

Relative impact of assumptions on generation choices

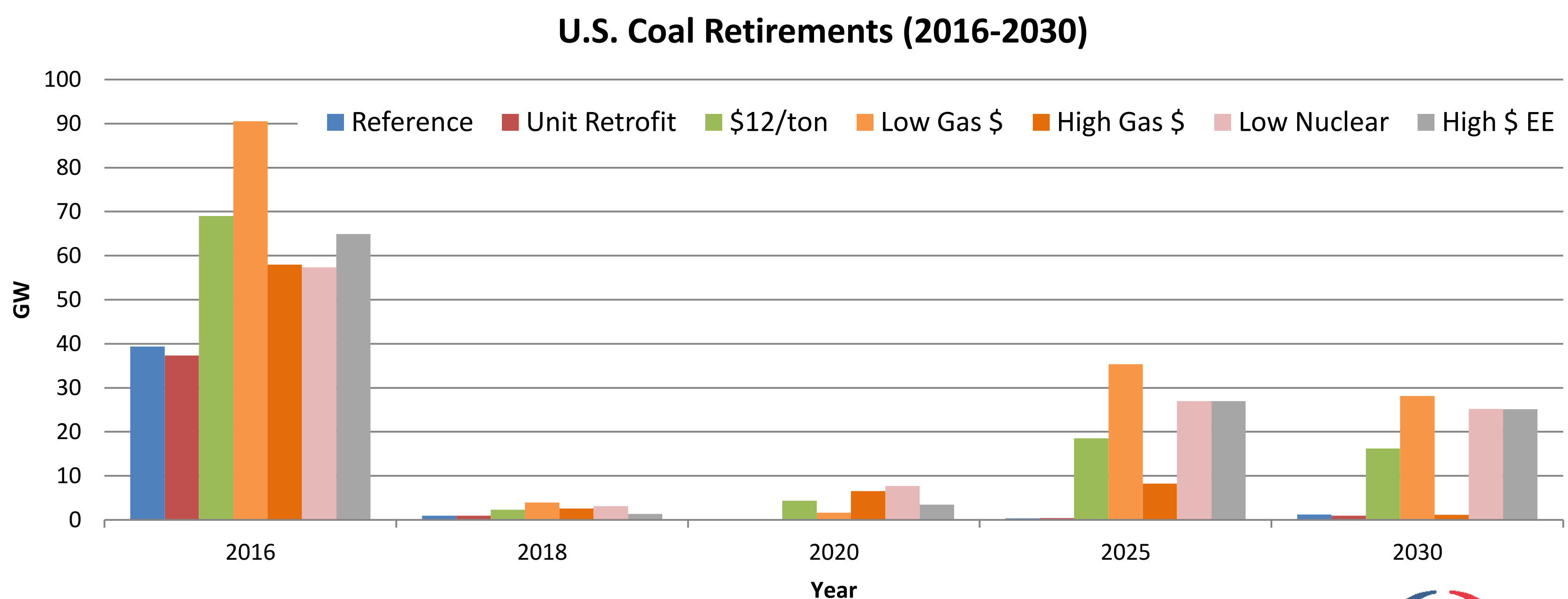
- **Gas price is a key driver of generation mix**
  - Low gas price reduces both coal and nuclear generation
  - High gas price replaces some gas use with coal, nuclear, wind, and biomass
- **At reasonable $, demand-side EE is primary compliance strategy**
  - Use of demand-side EE was consistent across scenarios
  - However, High $ EE (11 cents/KWh) resulted in *no* energy efficiency



GHG: Greenhouse Gas
EE: Energy Efficiency

Relative impact of assumptions on coal retirement

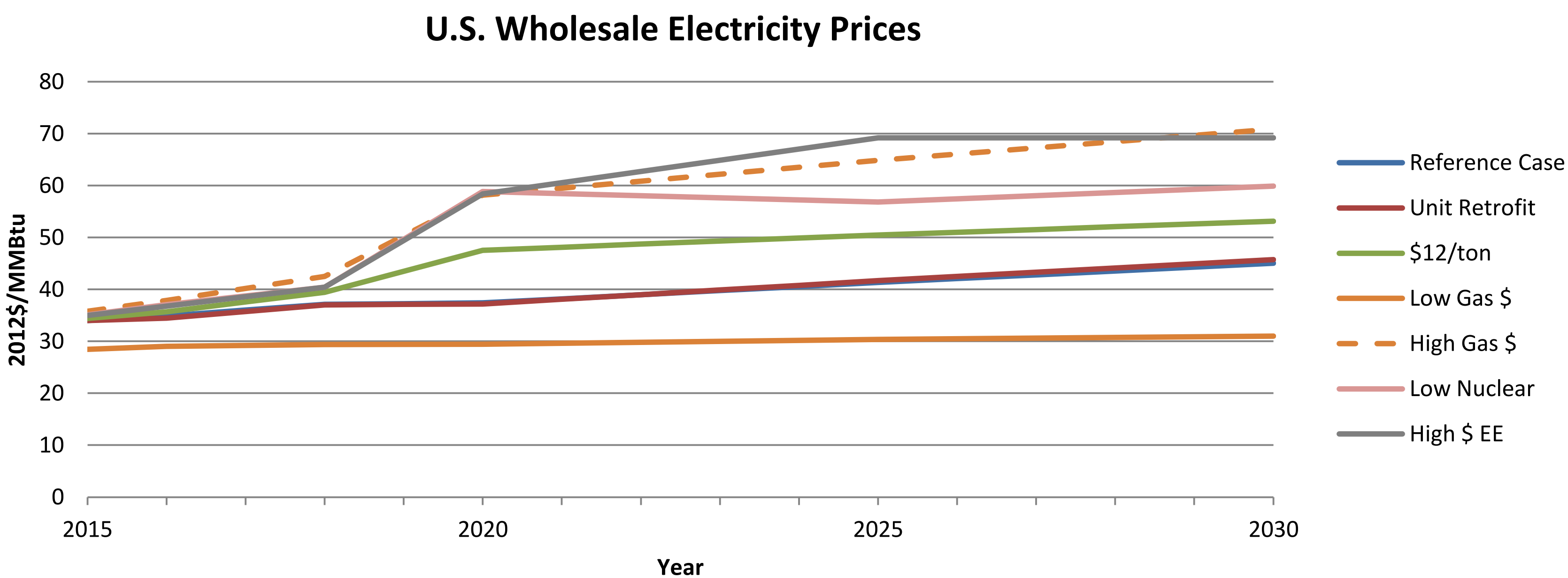
- **Retirements vary significantly depending on gas price**
  - Low gas price results in highest coal retirements in 2016 and later years
  - High gas price retires less coal than $12/ton scenario
- **Lack of demand side EE reductions delays some retirements**
  - Without the demand reductions achieved with demand side EE, the High $ EE case delays some coal retirements to later years



GHG: Greenhouse Gas
EE: Energy Efficiency

Relative impact of assumptions on wholesale electricity prices

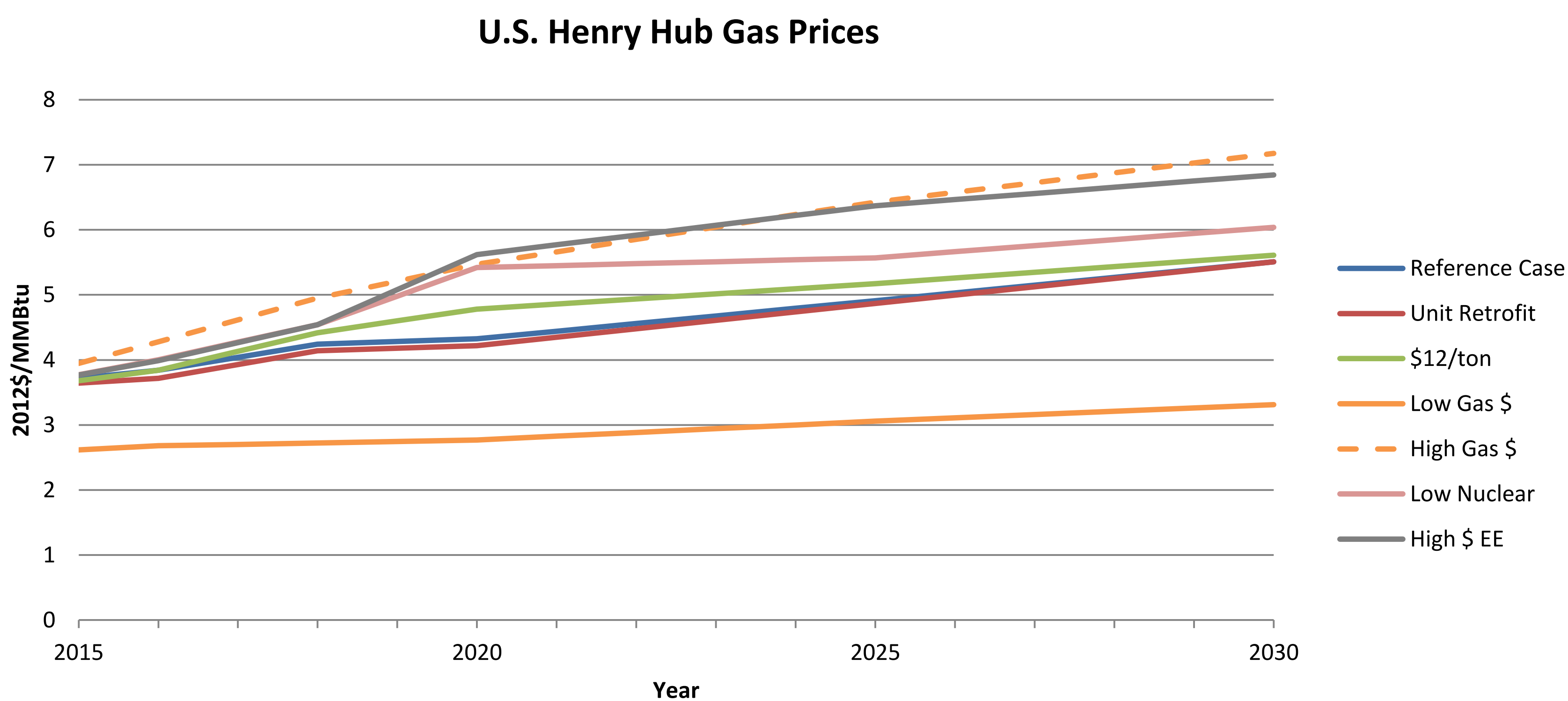
- **Lack of demand side EE results in the highest cost**
  - Because no EE is adopted with the High $ EE assumption, it is representative of a policy without flexibility to chose demand side EE
- **Wholesale price impacts of policy highly dependent on gas prices**
  - Low gas price results in lowest price and lowest CO_2
  - High gas price increases cost twice as much as GHG policy



EE: Energy Efficiency
GHG: Greenhouse Gas
CO_2: Carbon Dioxide

Relative impact of assumptions on natural gas prices

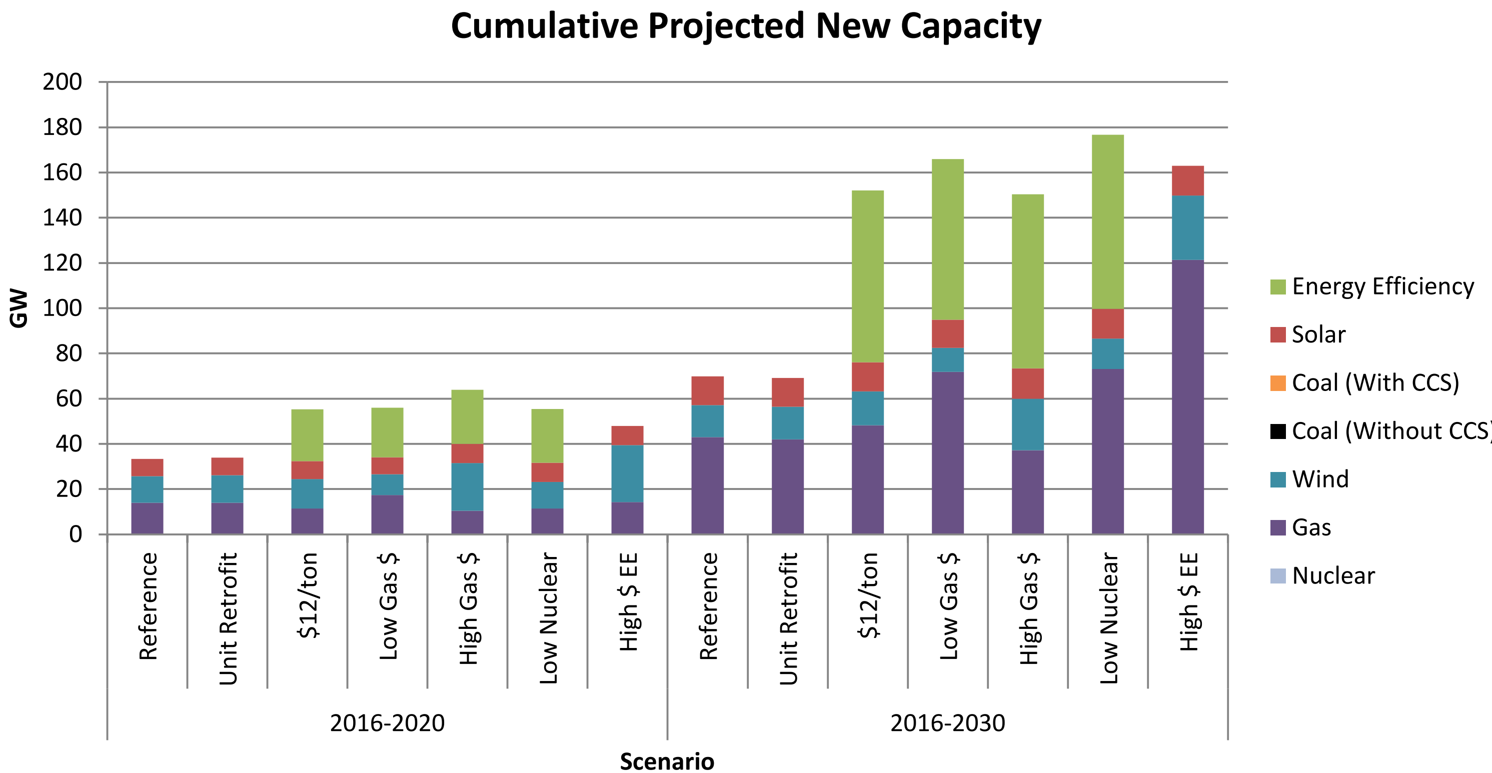
- **Natural gas prices in High Gas $ and Low Gas $ are imposed as an input**
  - In all other runs, gas prices are projected as an output
- **Lack of demand side EE as compliance option leads to highest gas prices**
  - Because, w/out EE, natural gas generation is primary compliance strategy



EE: Energy Efficiency

Relative impact of assumptions on projected new capacity

- **Without demand side EE, more new wind and gas generation gets built**
- **High gas prices limit construction of new gas generation**
  - Instead, rely more on new wind and existing coal

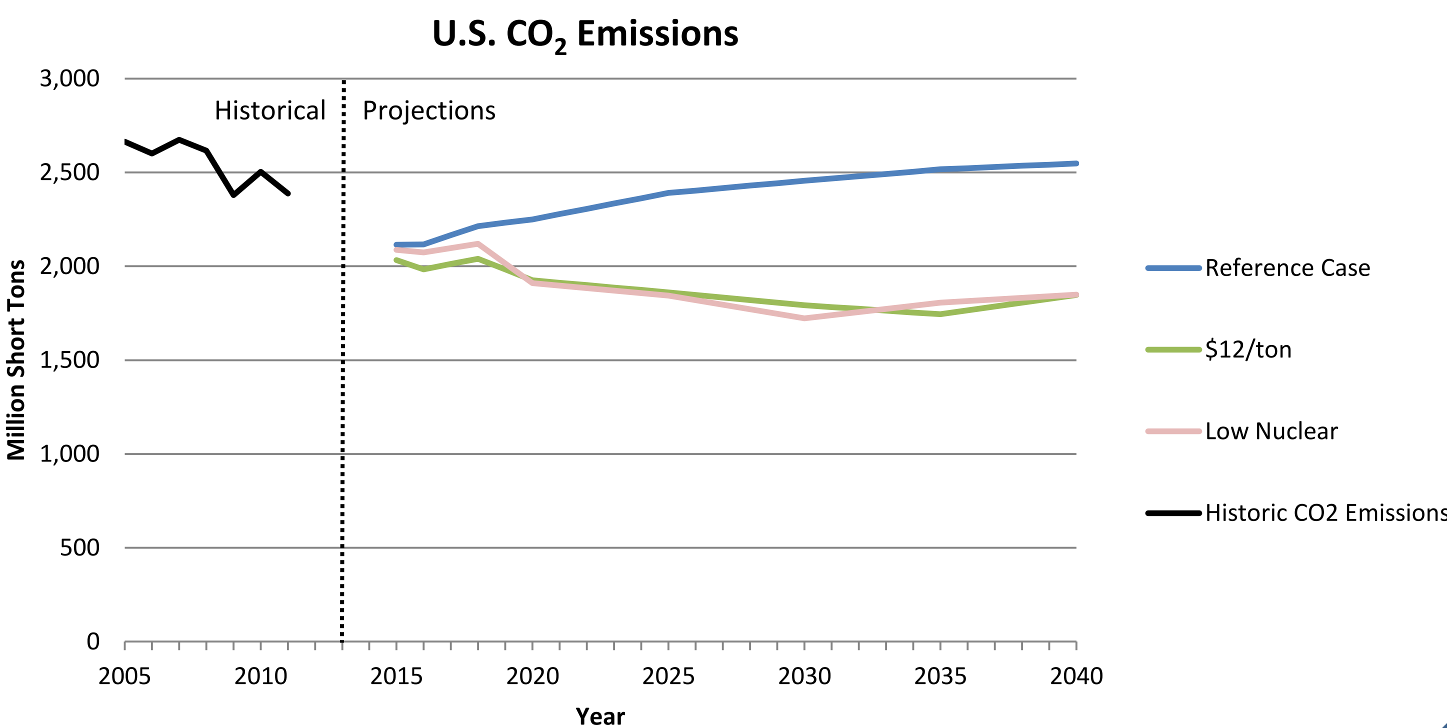


*Firm planned new capacity is included in modeling assumptions and not projected new capacity

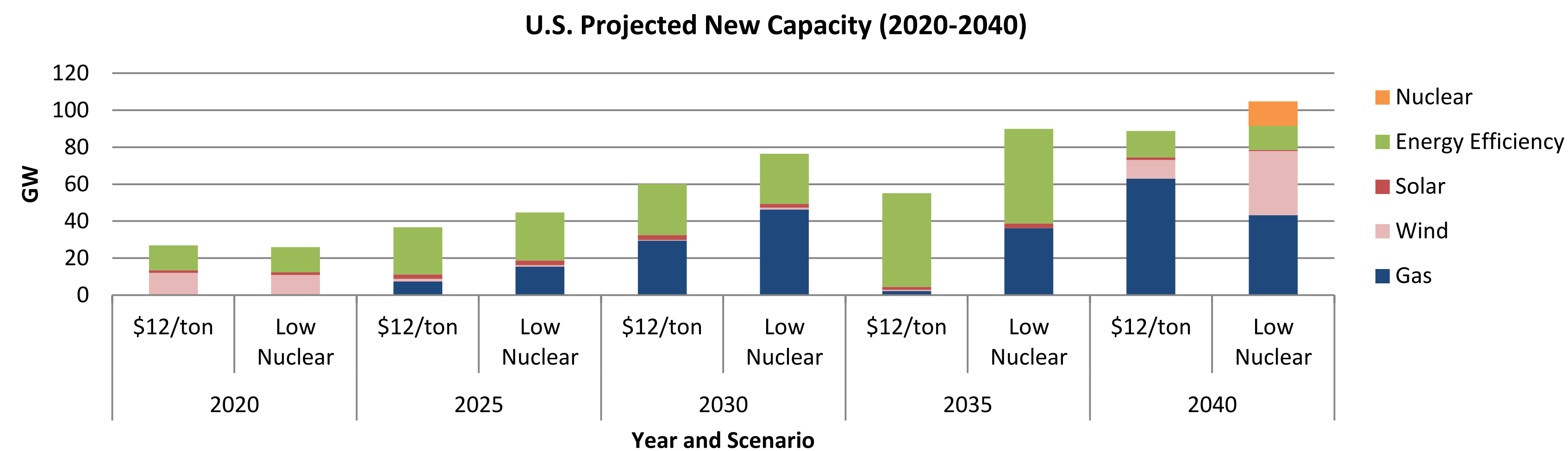
EE: Energy Efficiency

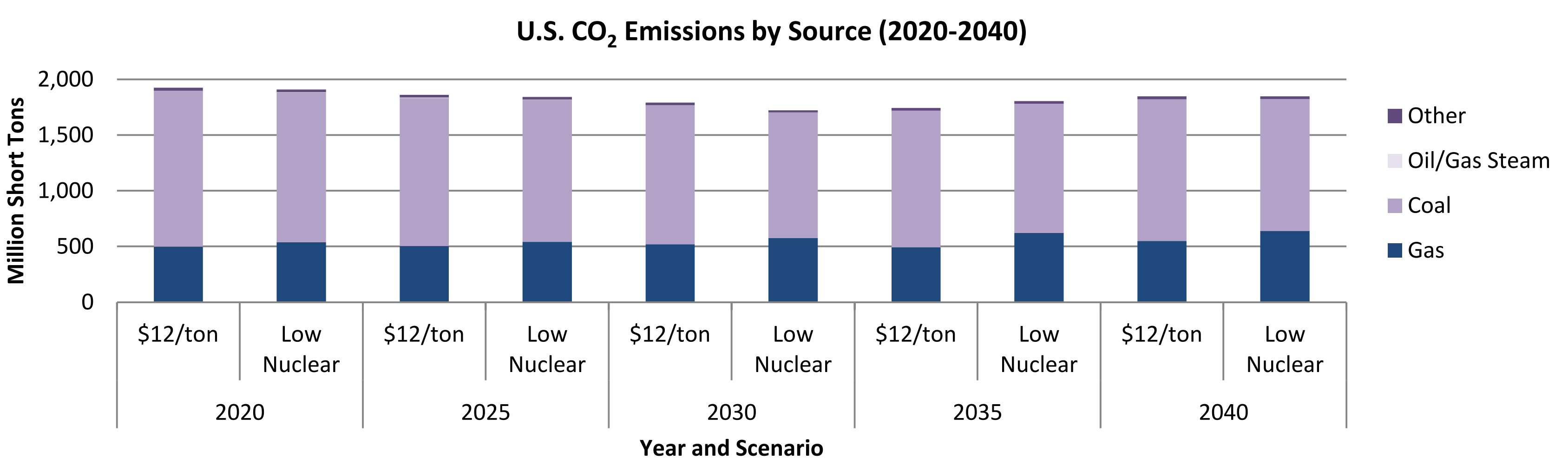
Impact of extra nuclear retirements on emissions and electricity prices

- Assumed 2016 drop in nuclear capacity & retirements at age 60, leads to average 15% increase in wholesale electricity prices between 2020-2030
- The timing flexibility of the emissions budget in the low nuclear case allows extra CO_2 reductions in the beginning to offset higher emissions later, when reductions are more expensive due to nuclear retirements



CO_2: Carbon Dioxide


U.S. Projected New Capacity (2020-2040)
GW
120
100
80
60
40
20
0
$12/ton
Low Nuclear
2020
2025
2030
2035
2040
Year and Scenario
Nuclear
Energy Efficiency
Solar
Wind
Gas


U.S. CO2 Emissions by Source (2020-2040)
Million Short Tons
2,000
1,500
1,000
500
0
$12/ton
Low Nuclear
2020
2025
2030
2035
2040
Year and Scenario
Other
Oil/Gas Steam
Coal
Gas

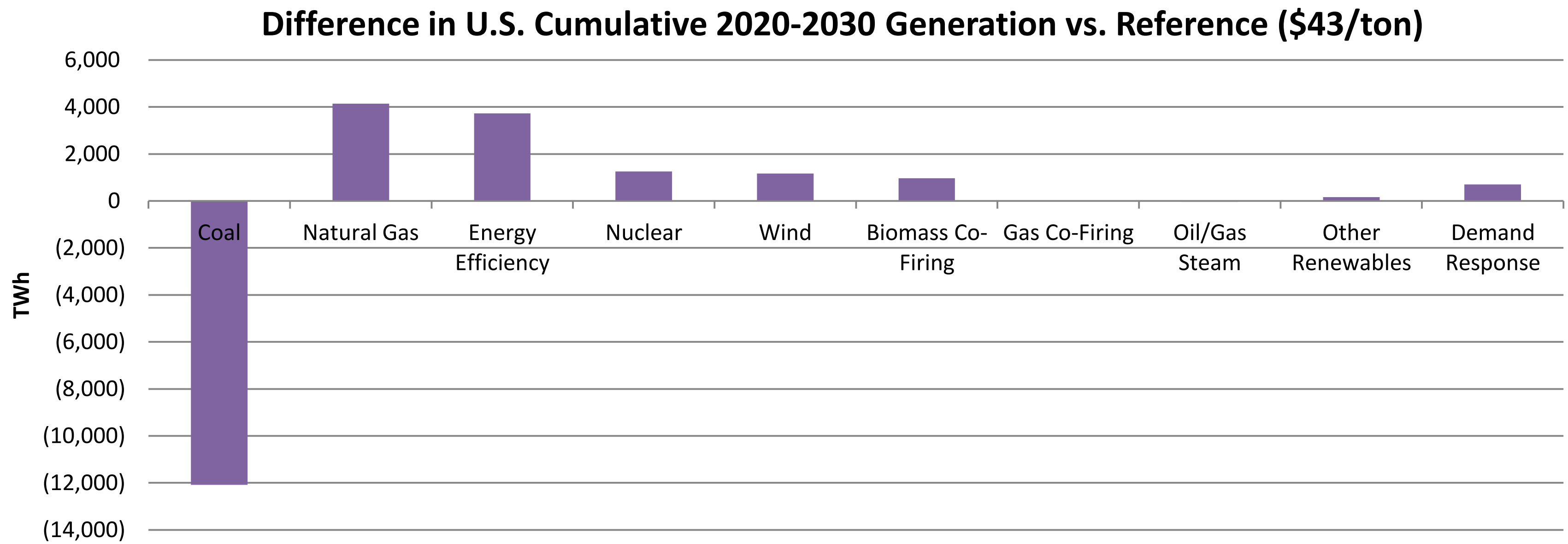
BIPARTISAN POLICY CENTER

VII. Scenario 3: $43/ton

$43/ton scenario: major impacts

❖ Between 2020-2030:

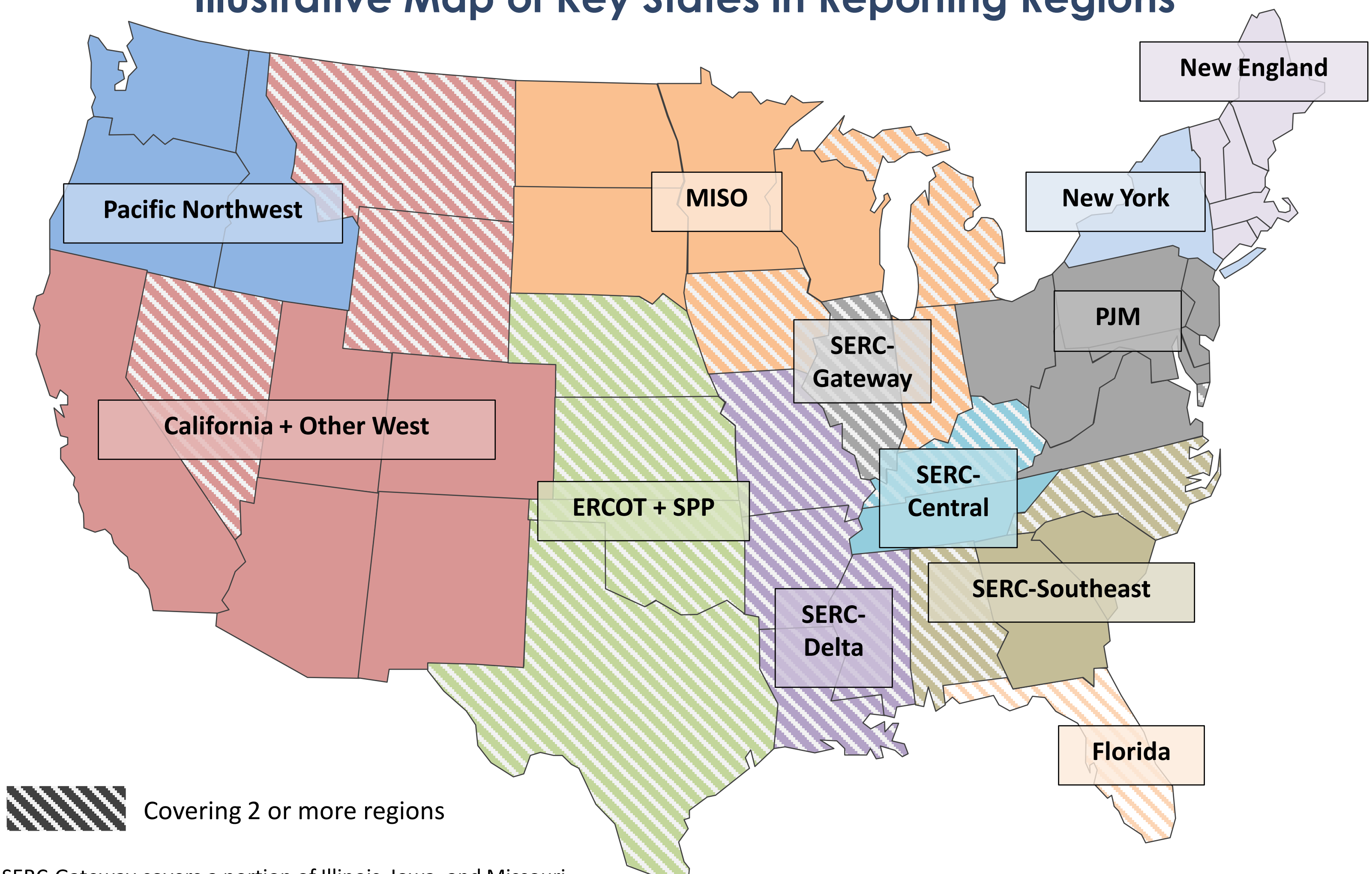
- 64% decrease in cumulative generation from coal
- 33% increase in gas generation
- Significant demand side energy efficiency nearly maxes out the assumed supply
- Some additional demand reduction in response to higher electricity price
- Wholesale electricity price increases by 83% in 2025
- Additional 189 GW of coal retirement through 2015-2030



BIPARTISAN POLICY CENTER

VIII. Regional Impacts of Modeled Scenarios

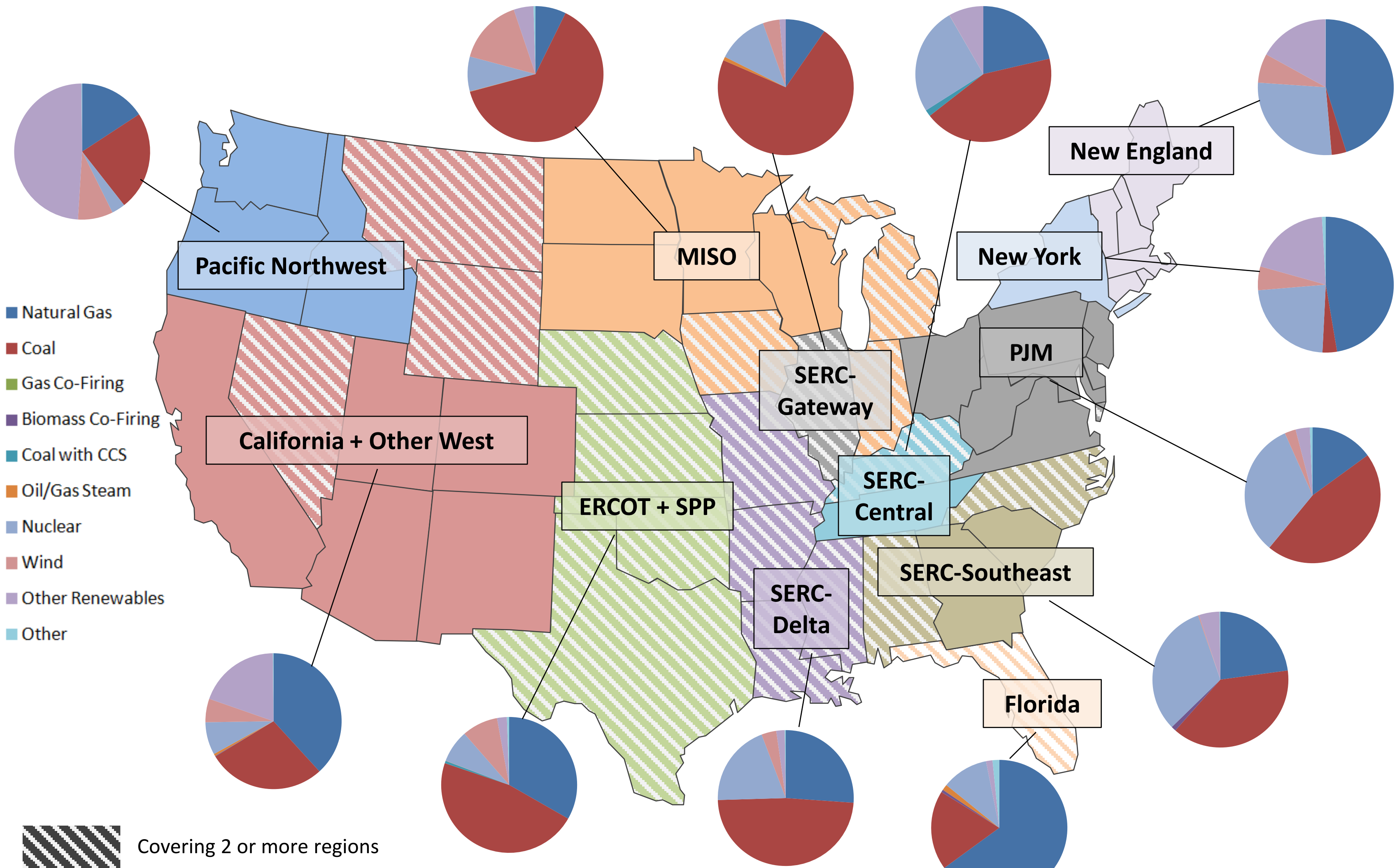
Illustrative Map of Key States in Reporting Regions



*SERC-Gateway covers a portion of Illinois, Iowa, and Missouri.

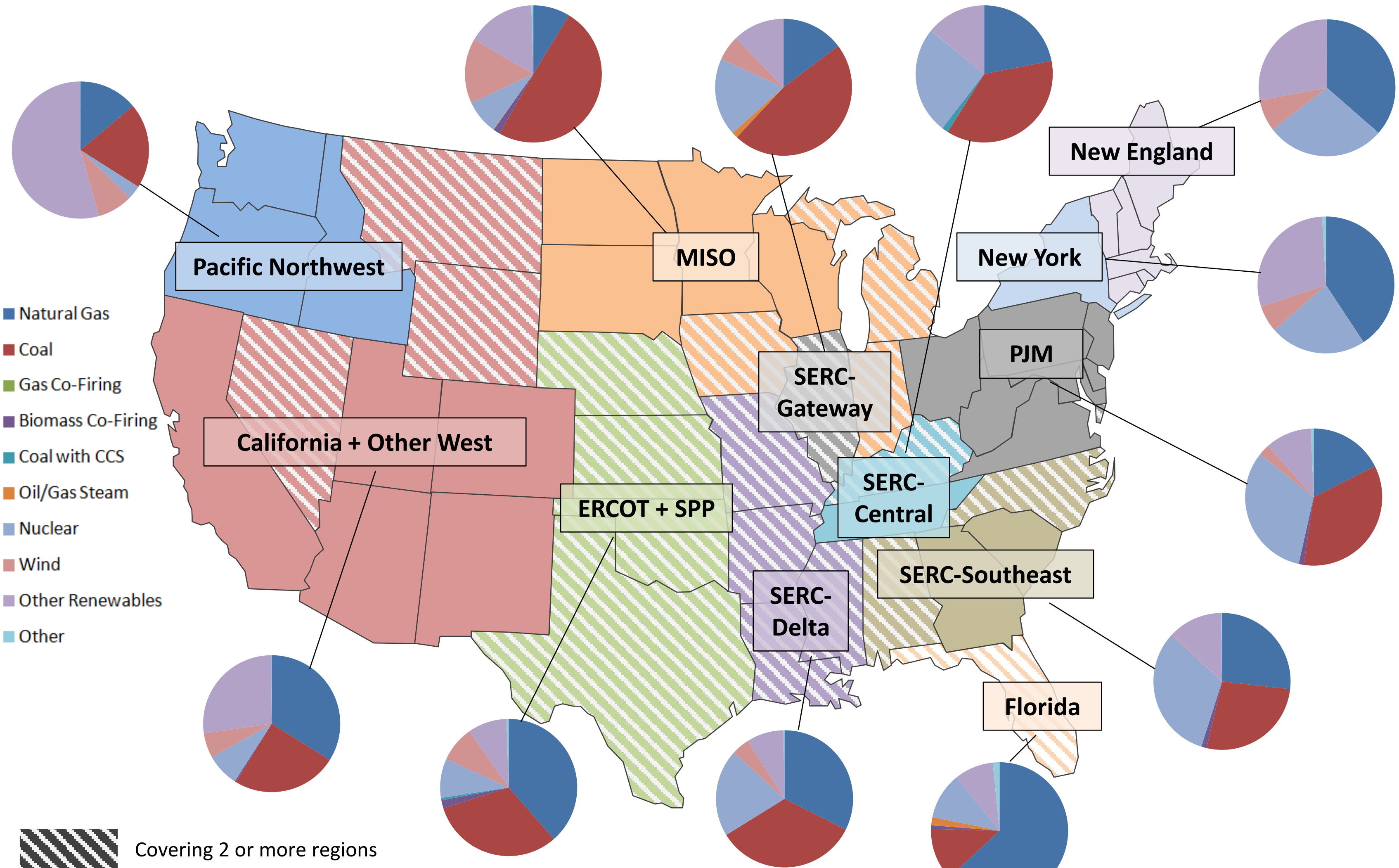
This map is illustrative and representative of the reporting regions as they align with state boundaries.

REGIONAL GENERATION MIX IN 2025 REFERENCE CASE



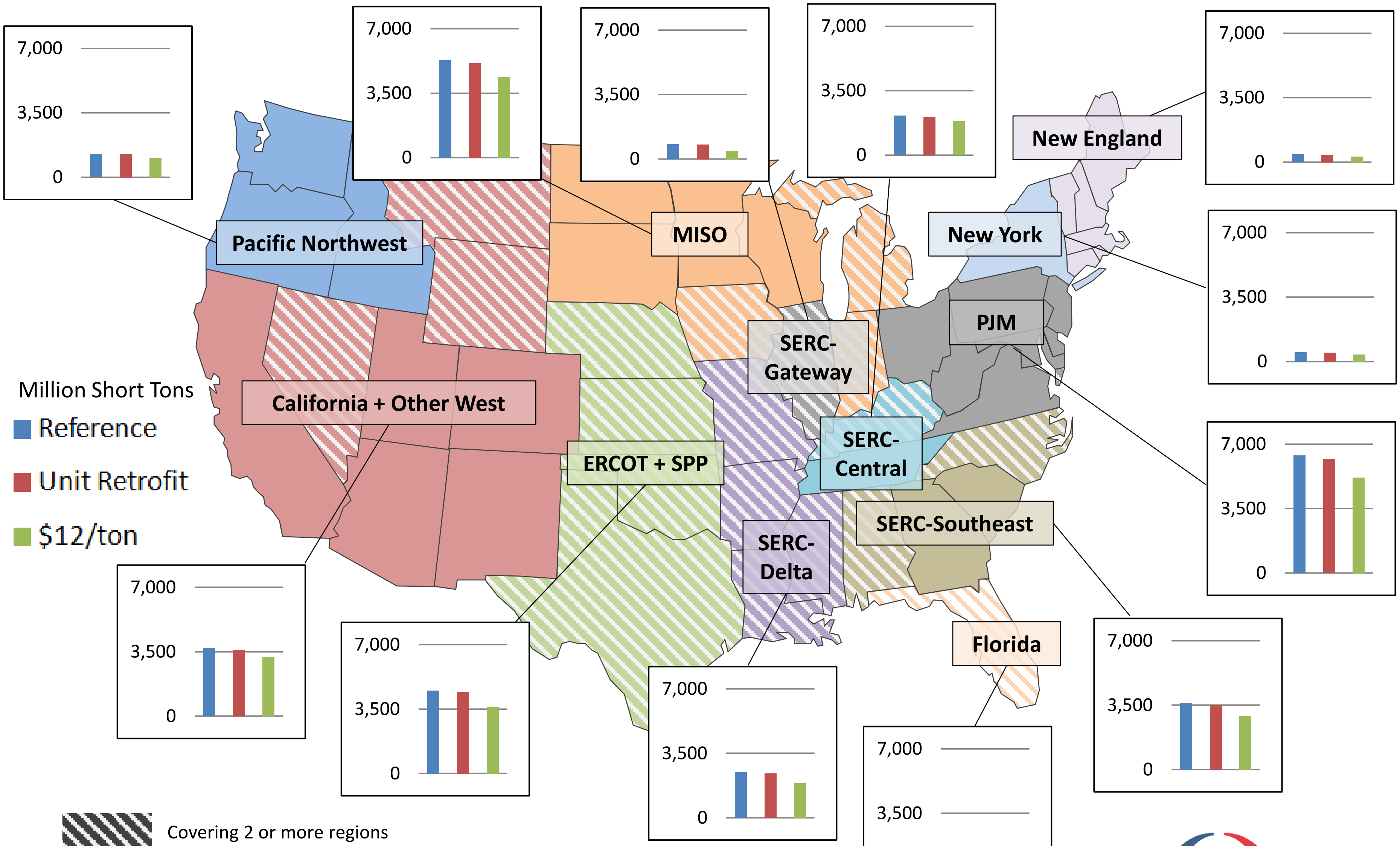
This map is illustrative and representative of the reporting regions as they align with state boundaries. SERC-Gateway covers a portion of Illinois, Iowa, and Missouri.

REGIONAL GENERATION MIX IN 2025 $12/TON POLICY SCENARIO



This map is illustrative and representative of the reporting regions as they align with state boundaries. SERC-Gateway covers a portion of Illinois, Iowa, and Missouri.

CUMULATIVE CO_2 EMISSIONS IN REFERENCE, UNIT RETROFIT, AND $12/TON CASES (2016-2030)



This map is illustrative and representative of the reporting regions as they align with state boundaries. SERC-Gateway covers a portion of Illinois, Iowa, and Missouri.

BIPARTISAN POLICY CENTER

www.BipartisanPolicy.org

For additional detail about modeling assumptions as well as additional results see the Technical Appendix