Existing U.S. Coal Fleet

What the Future May Hold

PRESENTED TO

Council of Industrial Boiler Owners

PRESENTED BY

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THE Brattle GROUP

Agenda

Recent Trends for the Coal Fleet

Environmental Regulations

Future Developments

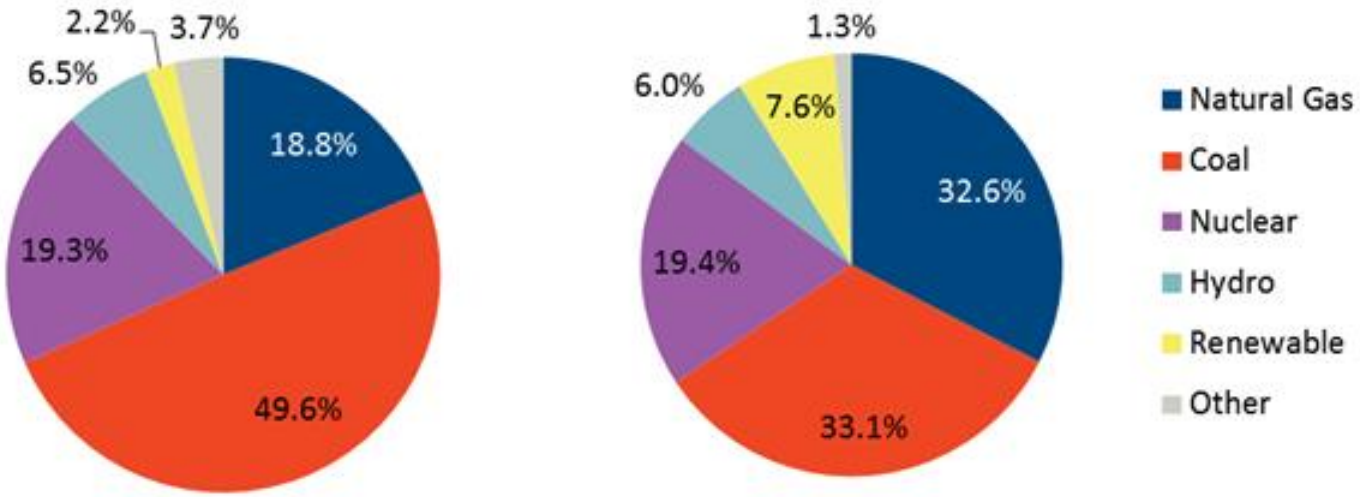
Summary of Present Conditions

Environmental Regulation and Falling Natural Gas Prices Have Driven Down Coal Generation Over the Last Decade

- Gas and renewables have supplanted coal as the capacity of choice
- Total installed coal capacity in the U.S. has fallen sharply
- Unsurprisingly, primarily older, smaller coal units have retired
  - The remaining capacity tends to be more efficient
  - Absent drastic drops in gas prices, load, or significant new regulation, much of this capacity will remain online for some time (and generate)
- However, a return to historical fleet generation levels would require a fundamental shift in gas prices – likely coupled with regulatory developments allowing new coal without CCS

Coal Generation Has Fallen Sharply As A Share of Total U.S. Electrical Output

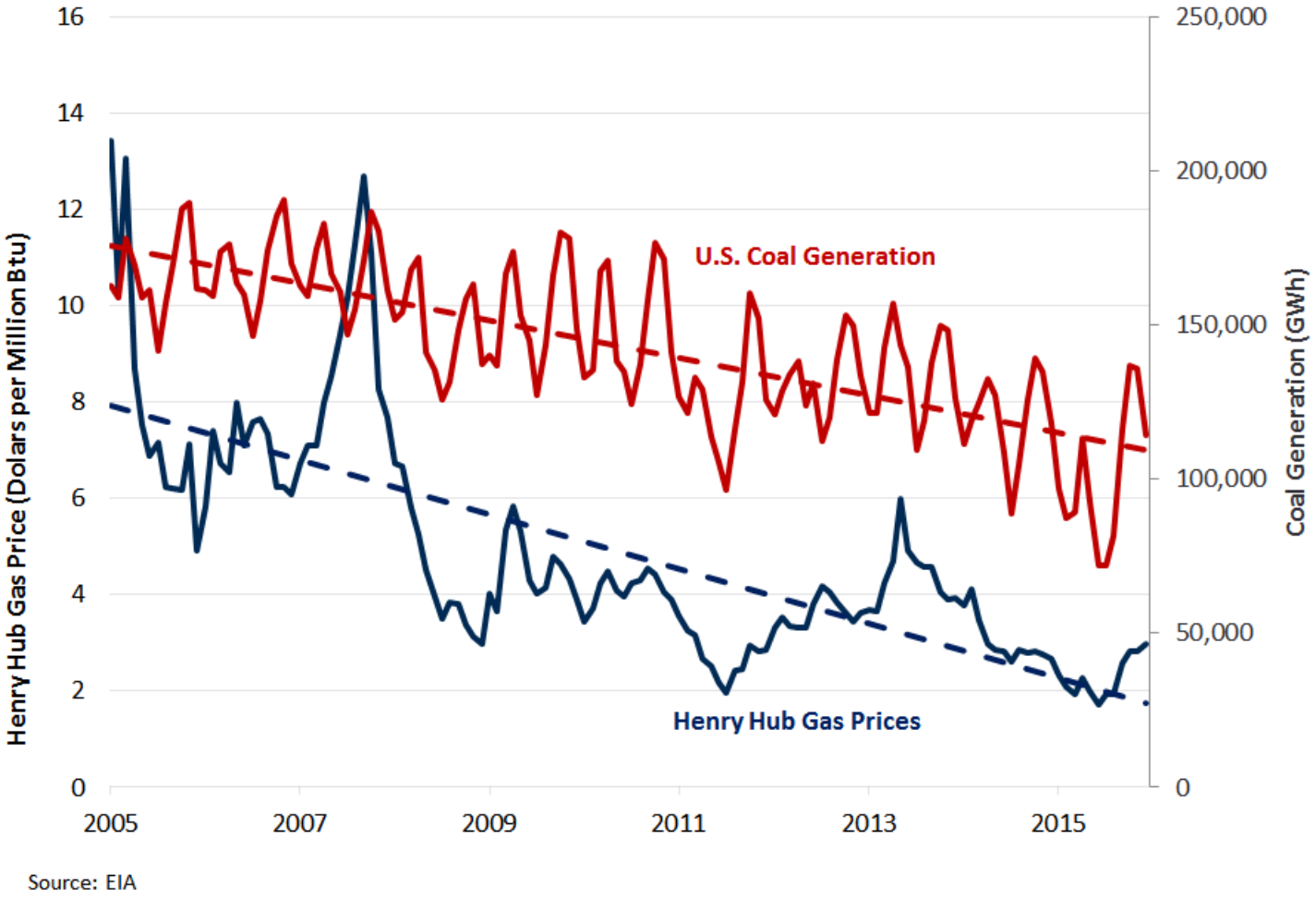
U.S. Electric Generation by Source, 2005 vs. 2015



Source: Energy Information Administration

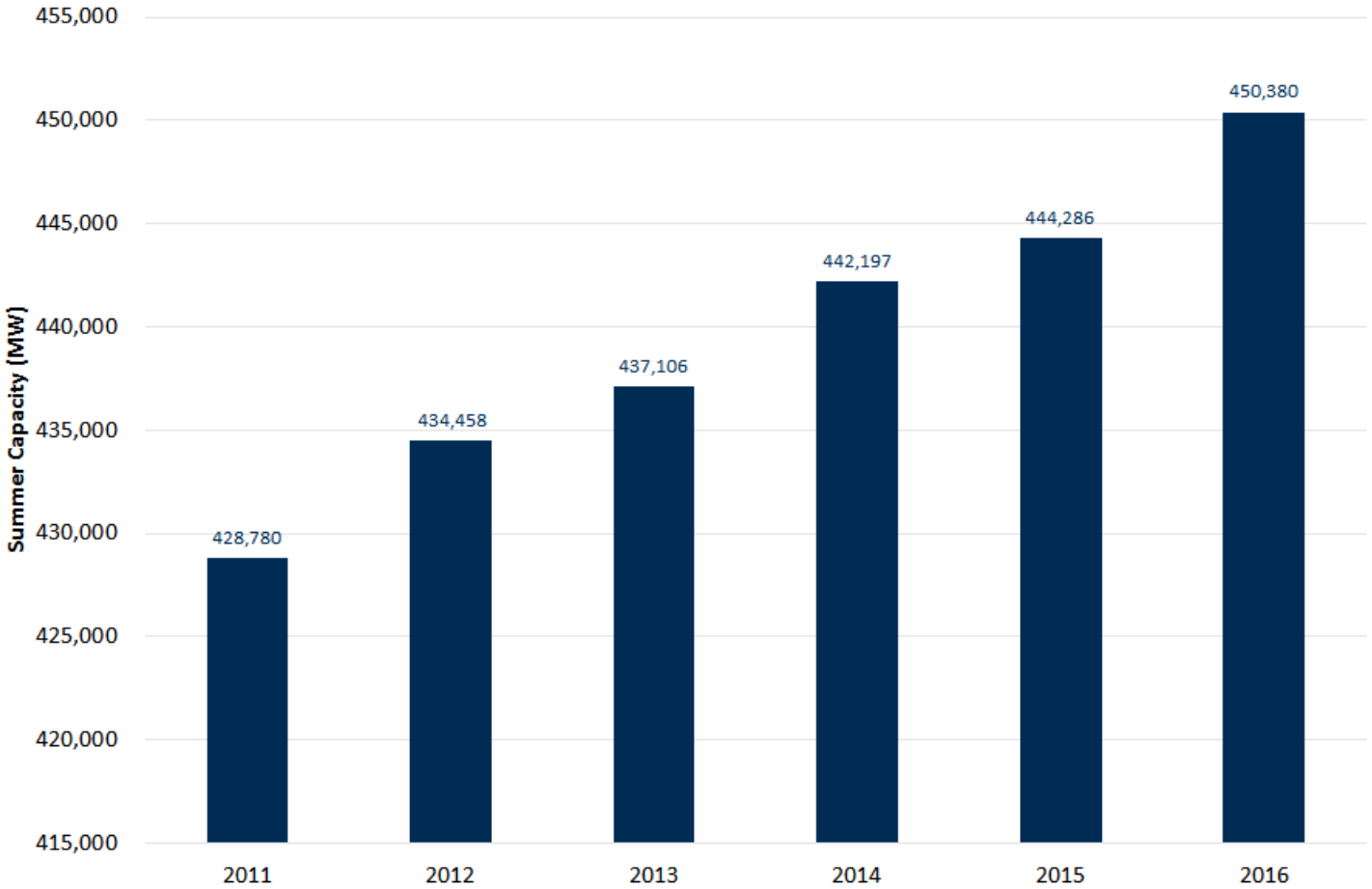
- According to the EIA, electric sector coal consumption fell from 1,037 billion short tons in 2005 to 738 billion short tons in 2015
- In both years, the electric sector accounted for more than 90% of total U.S. coal consumption

During the Period Natural Gas Prices and Coal Generation Have Fallen Sharply



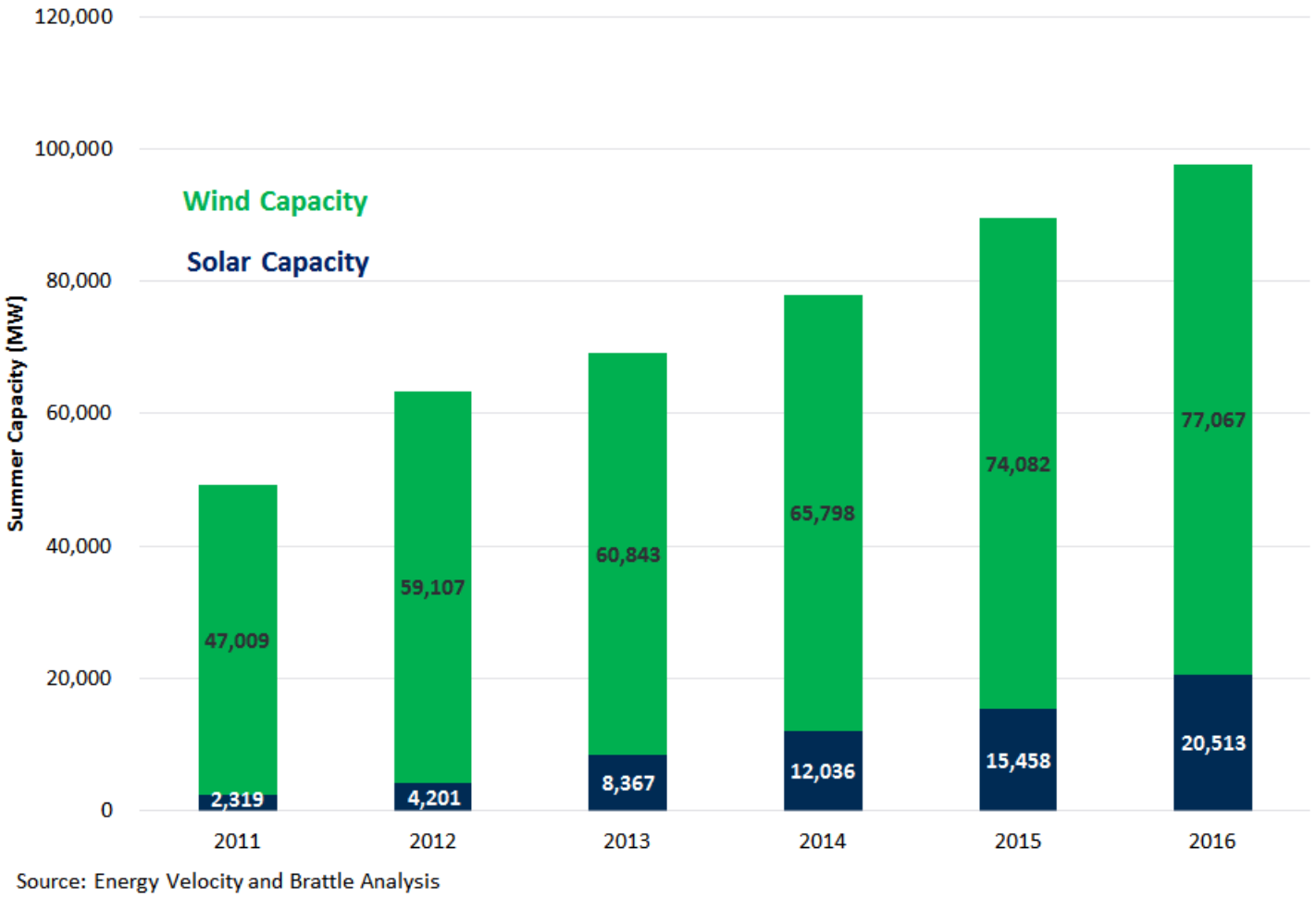
Source: EIA

Since 2011 Installed Natural Gas Capacity Has Risen By Approximately 22 GW



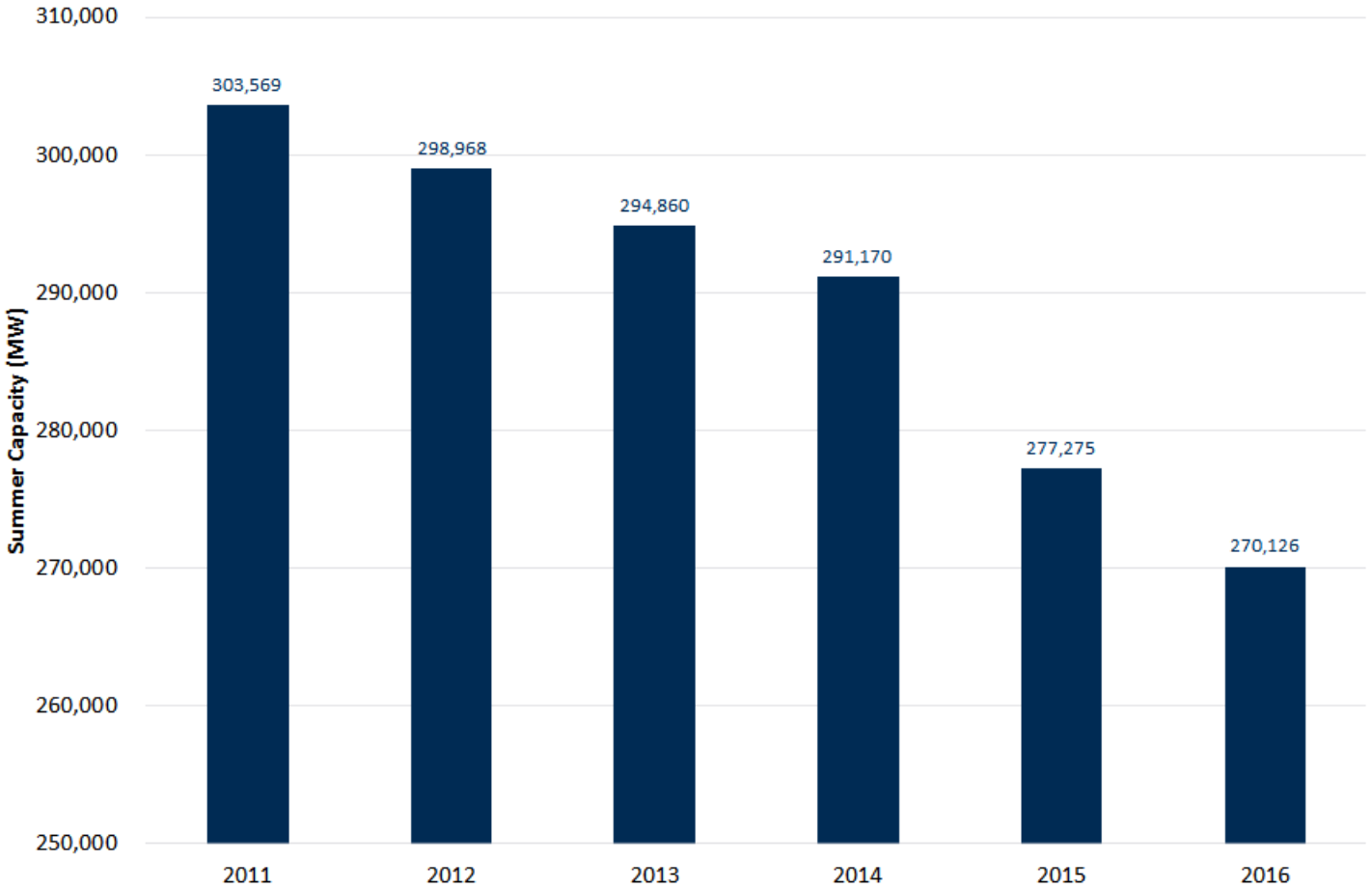
Source: Energy Velocity and Brattle Analysis

Installed Wind and Solar Capacity Has Nearly Doubled



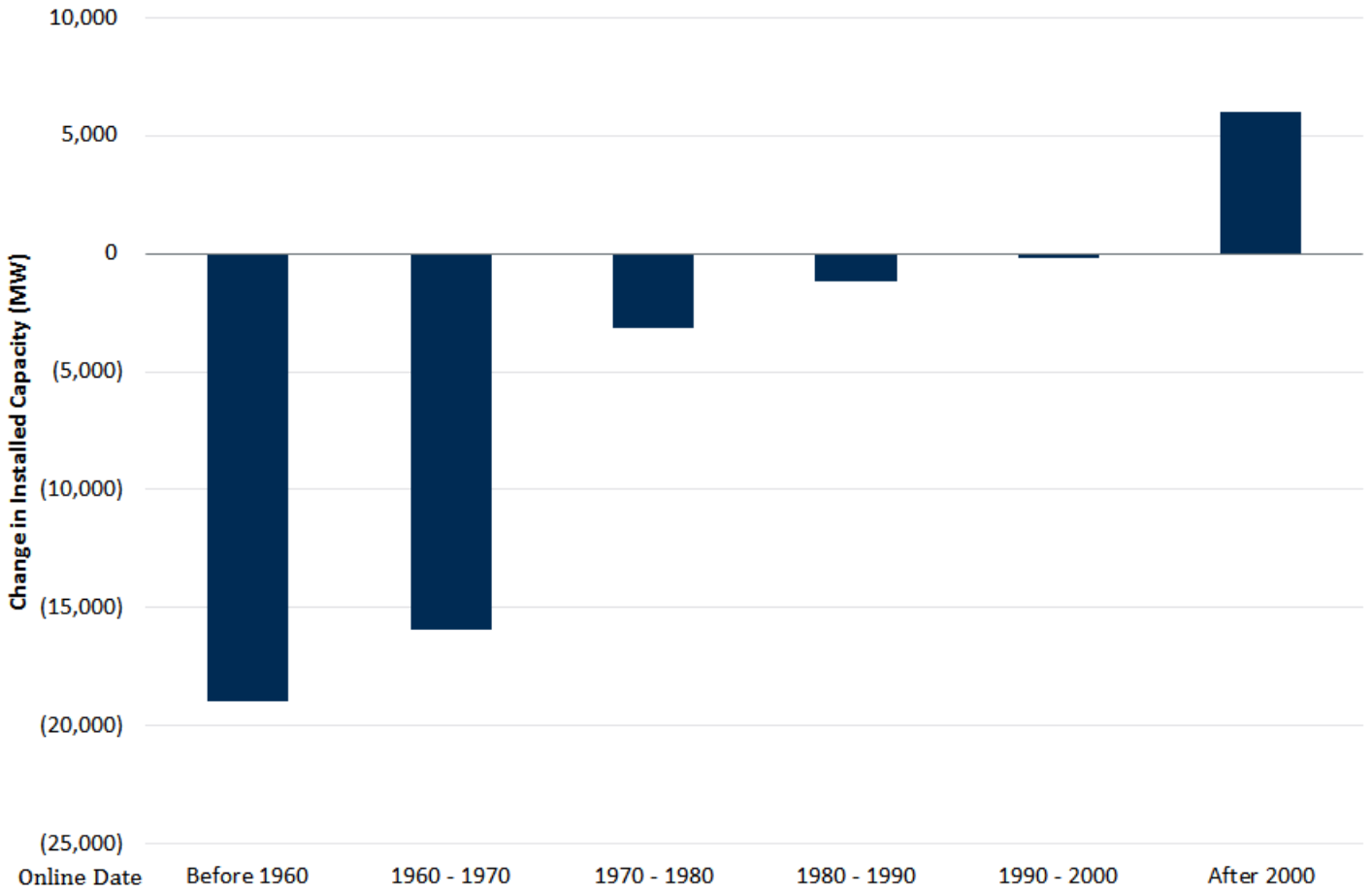
Source: Energy Velocity and Brattle Analysis

And Installed Coal Capacity Has Fallen By Approximately 33 GW



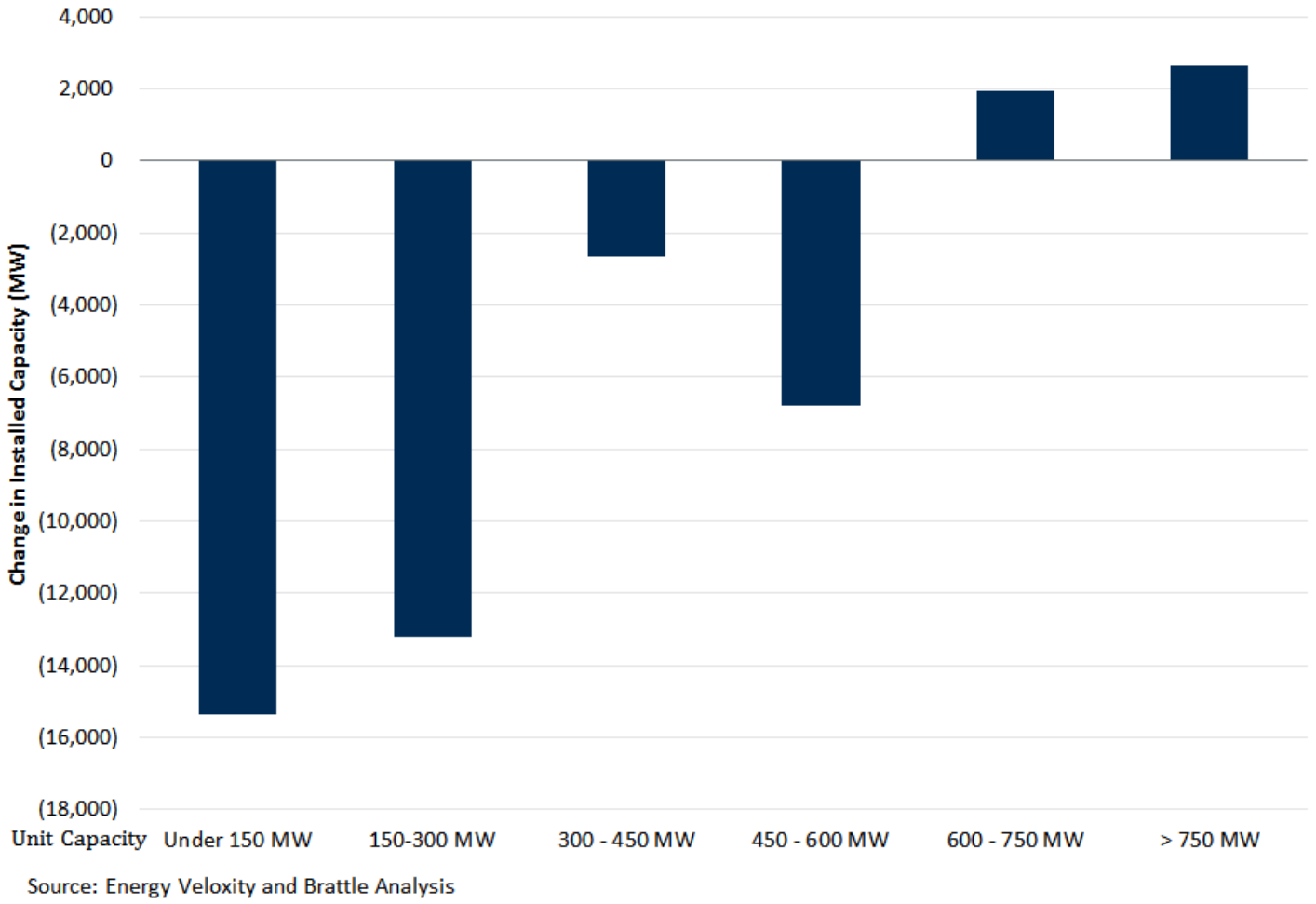
Source: Energy Velocity and Brattle Analysis

Change in Coal Capacity from 2011 to 2016 Driven By Older Units



Source: Energy Velocity and Brattle Analysis

Most Retiring Coal Units Smaller than 300 MW



Source: Energy Velocity and Brattle Analysis

Regulatory History

Over the last several years the EPA has enacted a number of regulations that have negatively impacted existing coal generators

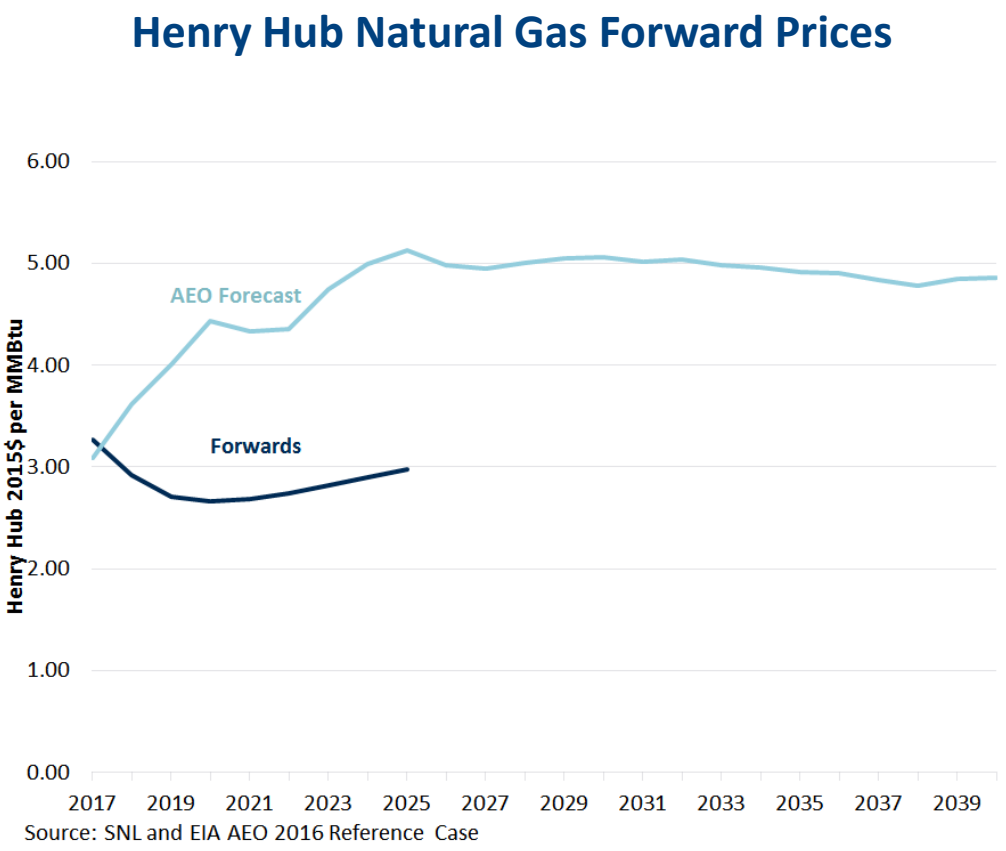
- Mercury Air Toxics Standards (MATS) caps emissions of mercury and other air toxics at coal and oil fired plants
  - Some coal plants required expensive FGDs/scrubbers, baghouses, ACI, or DSI equipment
- The Cross State Air Pollution Rule (CSAPR) placed state level and regional limits on SO_2 and NO_x emissions
  - Applies to both coal and gas generators, but bigger impact on coal
- Regional Haze regulations have particularly impacted plants in the West
- Clean Power Plan (CPP) would impose CO_2 limits on existing power plants
  - CPP could take form of a mass cap or a rate limit; either compliance vehicle would favor natural gas relative to coal generation
  - CPP's future in doubt in light of recent election

Important Federal Regulations

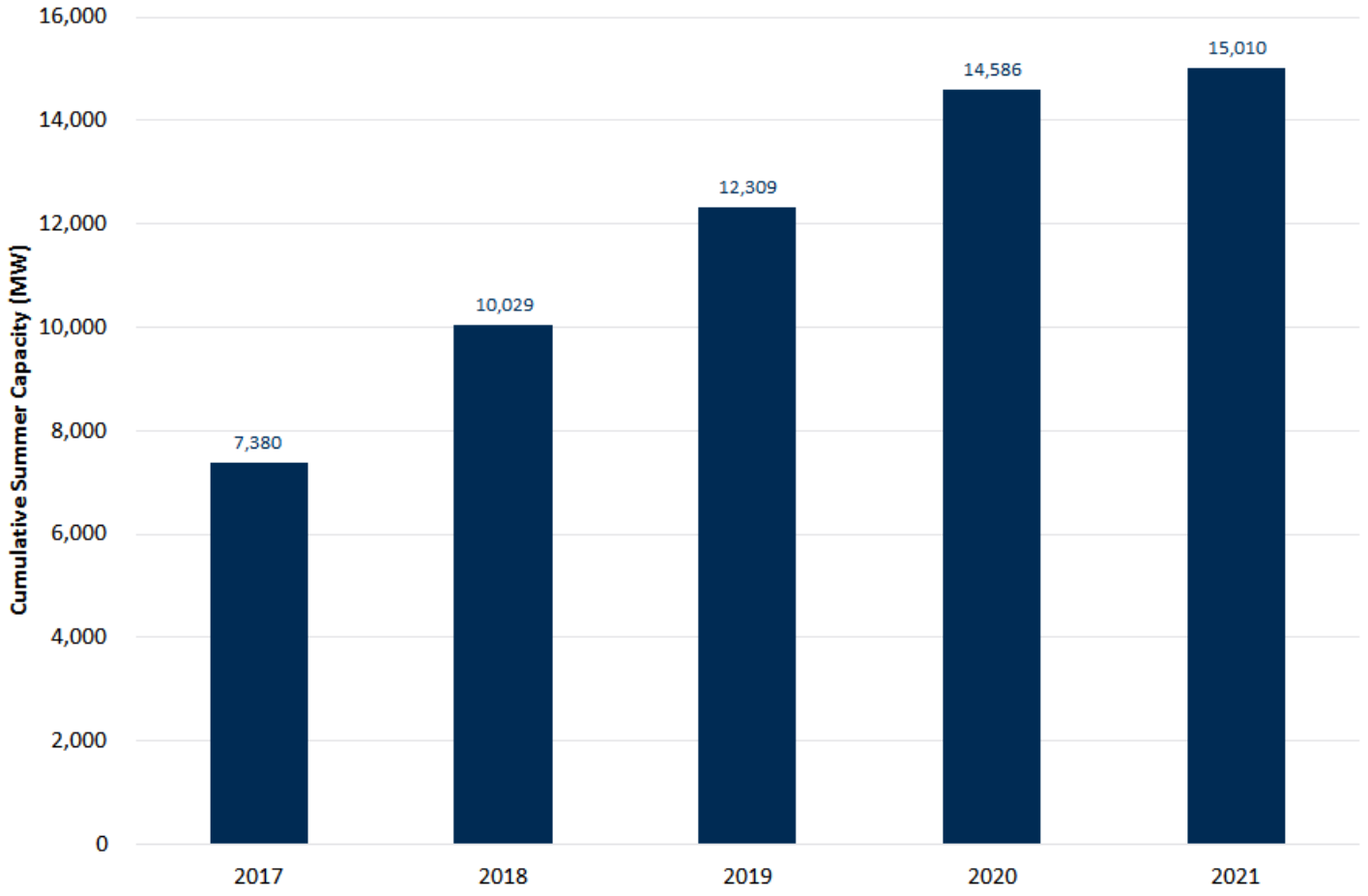
June 2010	EPA Proposes Rules for Coal Combustion Residuals Disposal
March 2011	EPA Proposes MATS
July 2010	EPA Proposes Clean Air Transport Rule (CATR)
April 2011	EPA Proposes Water Intake Rules
June 2011	EPA Finalizes CSAPR (replaces CATR)
December 2011	EPA Finalizes MATS
December 2011	D.C. Circuit Stays CSAPR
March 2012	EPA Proposes Carbon Standards for New Power Plants
April 2014	Supreme Court Upholds CSAPR
June 2014	EPA Proposes Clean Power Plan
August 2014	EPA Finalizes Water Intake Rules
December 2014	EPA Finalizes Rules for Coal Combustion Residuals Disposal
August 2015	EPA Finalizes CPP Rule and Standards for New Plants
April 2015	MATS Initial Compliance Deadline
June 2015	Supreme Court Remands MATS
February 2016	Supreme Court Stays CPP
April 2016	MATS Final Compliance Deadline (with Retrofit Extension)
January 2022	CPP Interim Compliance Period Begins
January 2030	CPP Final Implementation Begins

Natural Gas Trends

- Both forward markets and EIA project continued low natural gas prices
- Recent forward prices actually suggest some downward price movement (in real terms)
- EIA Reference Case projects Henry Hub prices will rise to around $5/MMBtu in real terms and then remain there
- These price trends promise relatively little future energy market upside for coal



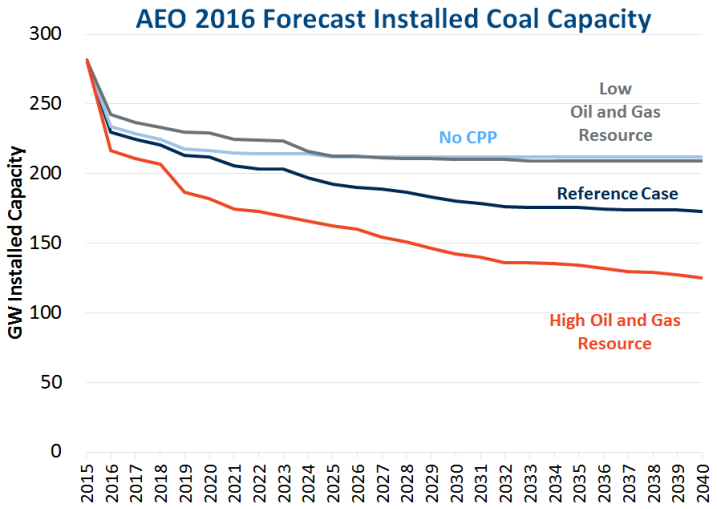
Energy Velocity Reports 15 GW Of Announced Coal Retirements Over The Next 5 Years

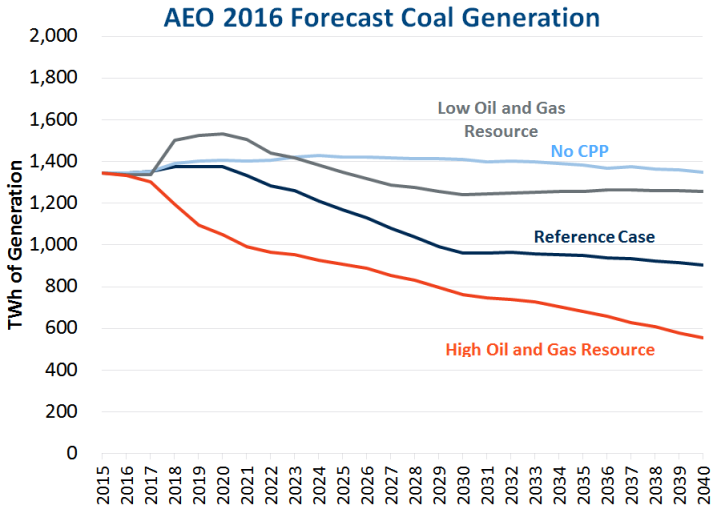


Source: Energy Velocity and Brattle Analysis

EIA Forecasts for Coal Generation and Capacity

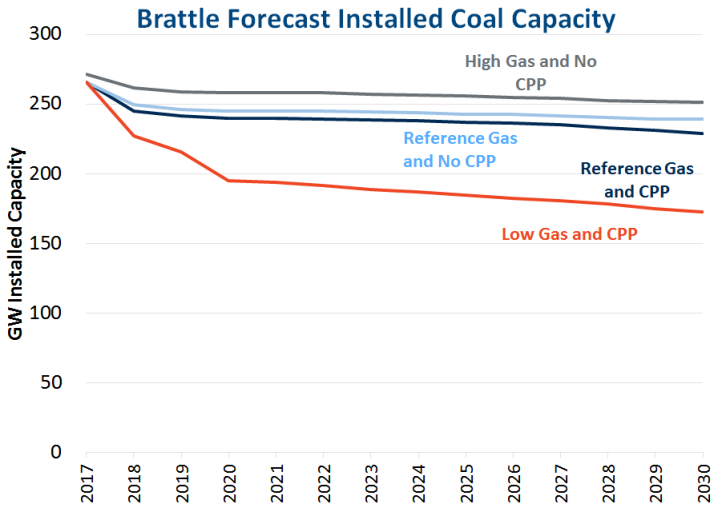
- EIA forecasts project coal capacity declining over time
- CO_2 policy and natural gas assumptions have a major impact on generation
- Under high natural gas price and no CO_2 policy cases, EIA projects remaining coal units will run at higher capacity factors
- EIA does not include a high natural gas price with no carbon policy case
  - Would have potential upside

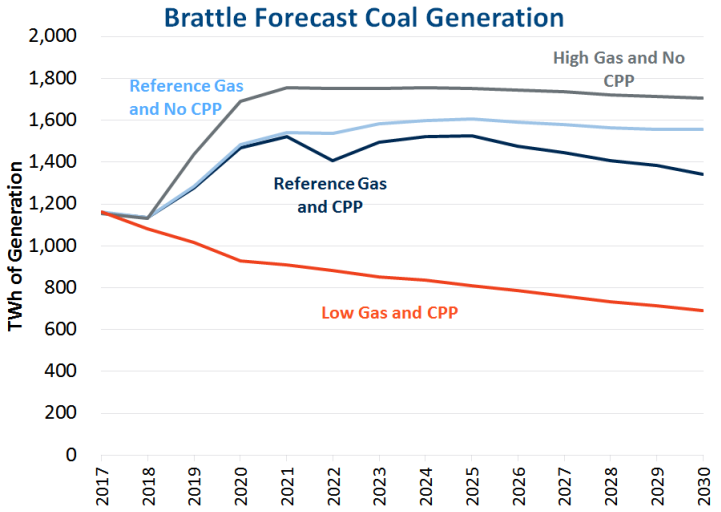




Brattle Analyzed Coal Generation With and Without CPP Under Different Gas Prices

- Brattle forecasts coal generation recovering even with CPP – difference with EIA likely driven by lower early retirements
- Combination of carbon policy and low gas prices result in steady decline in capacity and generation
- With high natural gas prices and no carbon, coal generation substantially recovers
- Even under most "bullish" scenario, coal generation does not reach previous highs (around 2,000 TWh annually in mid-2000s)





Conclusions – Regulation and Gas Prices

Historically the backbone of U.S. power generation, coal's share has fallen over the last decade – prospects for recovery seem fairly dim

- Environmental regulations have played a major role
  - Impact of CSAPR and MATS already largely realized
  - CPP less likely, but future federal, state and regional carbon policies (e.g. RGGI, AB32) may still pose a threat
  - Under current regulation new coal plants require CCS
- Low gas prices, falling capital costs for wind and solar, state RPS policies, and federal renewable tax credits hurt the economics of coal generation
  - Solar costs expected to continue to fall
  - Natural gas prices uncertain, but expected to remain relatively low
- Low load growth exacerbates the effect of competition and regulation

Conclusions – Intermittent Resources Reduce the Value of Inflexible Generators

Although past trends may not continue, increased penetration of intermittent resources (i.e. wind and solar) will hurt the economics of generators that cannot respond to price signals in real time

- Regions with high levels of renewable penetration often see negative prices
- While the eventual sunset of the PTC will mitigate negative prices, price swings will still be correlated with renewable penetration
- CCs, CTs, and RICE units are better able to adapt to rapid price swings throughout the course of the day
- The economics of relatively inflexible coal generators will suffer

Conclusions – Drivers of Decline

Contrary to some political claims, market forces have driven the decline of coal as much or more than regulation

- While regulation certainly played a major role in the decision to retire existing plants, innovation in other sectors has made coal less competitive
- Even without the CCS requirement, coal plants are much more expensive to build than natural gas combined cycles
  - With low natural gas prices, coal plants have lost the fuel cost advantage
  - They also lack the flexibility of gas-fired generators; penetration of renewables has increased the value of operational flexibility
- While past renewable construction was driven by policy, falling costs are likely to make unsubsidized renewables economic in some regions
- A substantial increase in coal generation would require either a technological breakthrough making coal plants much less expensive to construct and operate or a drastic increase in gas prices
  - Any significant carbon policy would prevent a recovery in coal generation

Presenter Information

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Mr. Kline, CFA, a Senior Associate of the Brattle Group, has worked extensively on the modeling of electricity systems. His experience includes assessment of the impact of environmental and regulatory proposals, analysis of the impact of distributed energy resources on utilities and ratepayers, valuation of generating and transmission assets, analysis of the economic substance of structured financial transactions, and damages analyses. He has worked on projects throughout the Eastern Interconnection, the Western Electricity Coordinating Council, and the Electric Reliability Council of Texas.

Mr. Kline is a CFA® charterholder. He earned an MBA from the Wharton School and a BSFS from Georgetown University. Prior to joining the Brattle Group he was a Principal with the Berkeley Research Group.