U.S. Gas Turbine Regulatory Drivers

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Overview

Regulations are forcing changes in how power is generated in the U.S.

- Coal and nuclear plants are being retired
- No new coal or nuclear plants are expected
- Gas and renewable generation sources will have to fill the gap, although renewable energy (wind and solar) is intermittent and will require gas-fired units for backup power

Bottom line:
Demand for gas turbine power generation will experience strong growth through at least 2030

Outline of Presentation

- Retirement projections
- Forecast of new generation
- Specific regulations having an impact on those trends

Power Plant Retirements

Coal Fired Capacity: 40-50 GW will be retired from 2012-2017 due to advanced age of plants and profitability concerns

- Compliance with new environmental regulations will require large capital expenditures and additional O&M costs
- Dispatch changes prompted by GHG regulations will limit operating hours, limiting revenues
- Low natural gas prices are pushing wholesale electricity costs down, further reducing potential revenues

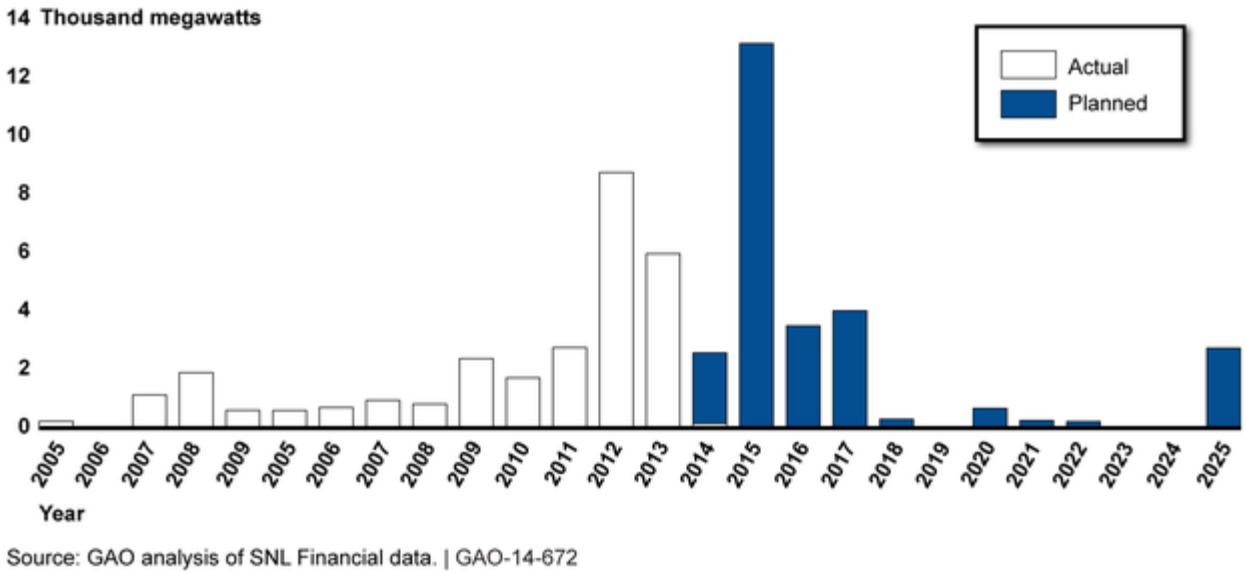
Coal Plant Retirement Projections

Date	Source	Projected Retirements (GW)
March 2011	EPA	10
March 2011	McIlvaine	31-68
April 2011	EIA	45-73
July 2012	GAO	10-38
August 2014	GAO (revised)	42

Nuclear Capacity: Over 10 GW will be retired from 2012-2020 due to age of plants and concerns about safety and profitability

- 4.2 GW at five plants being retired 2012-2015
- EIA projects an additional 6 GW of capacity will be retired by 2020

Coal Plant Retirements



Source: GAO analysis of SNL Financial data. | GAO-14-672

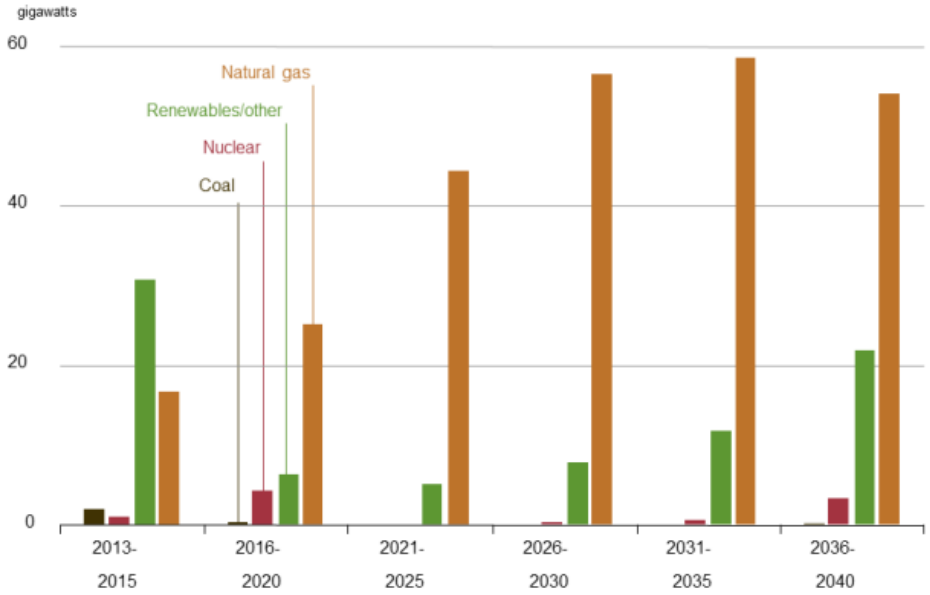
Actual and Planned Retirements of Coal-Fueled Electricity Generating Units
GAO August 2014

New Capacity

In Annual Energy Outlook for 2014 (AEO2014), EIA projects the following new generating capacity for 2013-2040:

- 73% Natural gas
- 24% Renewables
- 3% Nuclear
- 1% Coal

Figure MT-31. Electricity generation capacity additions by fuel type, including combined heat and power, in the Reference case, 2013-40



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Regulatory Overview

EPA has proposed or finalized a number of environmental rules which will have an impact on coal-fired power plants, pushing them towards retirement.

Regulation	Final Rule	Compliance Deadline
Mercury and Air Toxics Standards (MATS)	February 2012	April 2015 Possible extensions of up to two years
Cross State Air Pollution Rule (CSAPR)	August 2011	Group 1 states: 2015 Group 2 states: 2017
New Source Performance Standards for CO_2	Summer 2015	Would apply to any new power plant beginning in 2015
Carbon Pollution Standards for Existing EGUs	Summer 2015	Proposed SIPs due 2016 Compliance period begins 2020
Cooling Water Intake Structure regulation CWA 316(b)	May 2014	Deadlines established through permitting process, generally required by 2019
Disposal of Coal Combustion Residuals (CCR)	December 2014	Self implementing

MATS and CSAPR

Mercury and Air Toxics Standards (MATS)

- Limits emissions of toxic air pollutants from coal and oil fired power plants
- Primary pollutants of concern are mercury, hydrogen chloride (HCl) and fine particulates ($PM_{2.5}$)
- FINAL RULE: Compliance by April 2015 with possible extensions of up to 2 years

Cross State Air Pollution Rule (CSAPR)

- Referred to as the "Good Neighbor" rule
- Regulates emissions from one state that may have a negative impact on air quality in a downwind state
- 28 states in the eastern half of the U.S. must limit state-wide emissions of precursors to ozone formation (NOx, SO_2 and $PM_{2.5}$)
- FINAL RULE issued August 2011 with first phase to begin in 2012
  - But, the rule did not take effect as scheduled due to litigation
  - August 2012: US Court of Appeals vacated the rule and remanded it to EPA
  - April 2014: US Supreme Court reversed Court of Appeals and reinstated CSAPR
  - November 2014: EPA issued new compliance dates of 2015 to 2017

Together, MATS and CSAPR will require coal plants to install:

- FGD or Dry Sorbent Injection (DSI) to control SO_2 and acid gases (HCl)
- SCR or SNCR to control NOx
- Fabric filters or electrostatic precipitators to control particulate matter
- Activated carbon injection units to reduce mercury

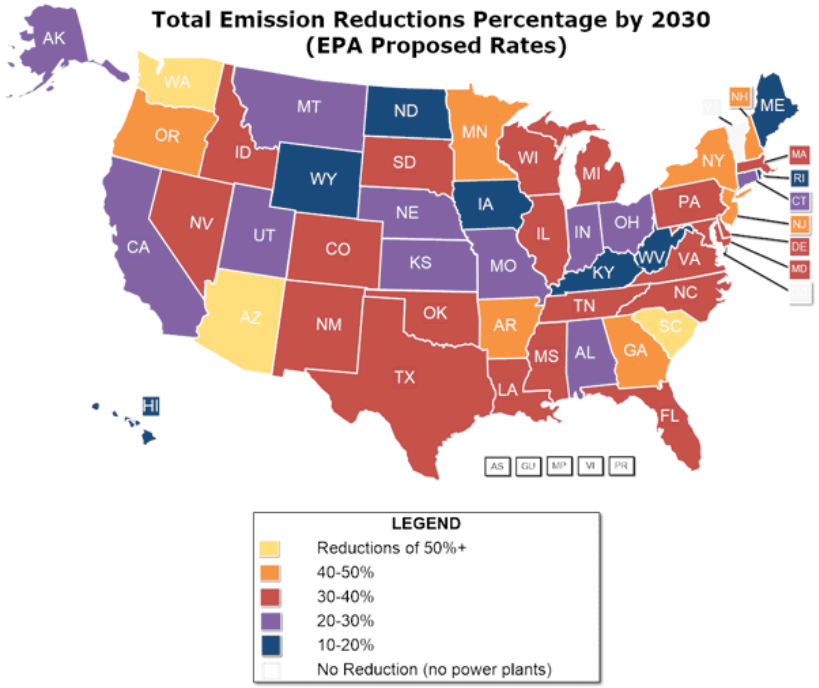
Greenhouse Gas Regulations

New Source Performance Standards (NSPS) for CO_2

- Limits CO_2 emissions from new power plants to:
  - 1100 lb/MWhr for coal fired plants
  - 1000 lb/MWhr for gas fired plants
- Ultra-supercritical boilers can currently achieve an emission rate of around 1700 lb/MWh
- Effectively means that no new coal plants can be built in the U.S. without carbon capture and storage
- STATUS: Proposed in September 2013, Final rule expected Summer 2015

Clean Power Plant Program for Existing Plants

- Sets specific greenhouse gas emission reduction targets for each state
- With the overall goal of reducing nationwide power sector GHG emissions 30% below 2005 levels by 2030
- STATUS:
  - June 2014 proposed rule
  - Summer 2015 expected final rule
  - 2016 proposed SIPs due
  - 2020 compliance period begins



Power Dispatching Rules

EPA used four factors to develop state specific goals for the Clean Power Plant program

- And assumes states will rely on these factors in developing their State Implementation Plans (SIPs)
  1. Heat rate improvements
  2. Dispatch changes
  3. Renewable energy (29 states currently have renewable portfolio standards)
  4. Demand side energy efficiency programs

Dispatch Changes

Electricity from coal fired power plants has typically been dispatched first, because coal plants:

- Take a long time to ramp up, requiring hours or days vs. an hour or less for a gas turbine
- Are generally cheaper to operate than other types of electricity generation

Clean Power Rule sets a goal of shifting dispatching priorities to more efficient NGCC units

- NGCC units had a utilization rate of 46% in 2012
- EPA expects SIPs to raise the utilization rate to 70%, largely at the expense of coal fired units
- For comparison, current utilization rates rante from 1% in South Dakota to 63% in Connecticut

Other Regulations

Cooling Water Intake Structure Regulation - CWA 316(b)

- Power plants often draw large volumes of cooling water from nearby rivers and lakes
- This rule requires modifications to intake structure to prevent impingement and entrainment of aquatic life – by installing traveling screens or reducing intake velocities
- The rule will have a greater impact on coal and nuclear plants, which use 3-5 times as much water as gas-fired power plants

Disposal of Coal Combustion Residuals (CCR)

- Burning coal generates combustion residuals such as coal ash which contain contaminants like mercury, cadmium and arsenic
- Coal ash is disposed of in surface impoundments (wet) or in landfills (dry)
- Disposal has largely been unregulated until the CCR rule was proposed in 2010
- Requires liners for impoundments and landfills, groundwater monitoring and other measures
- Final rule issued December 2014

Conclusion

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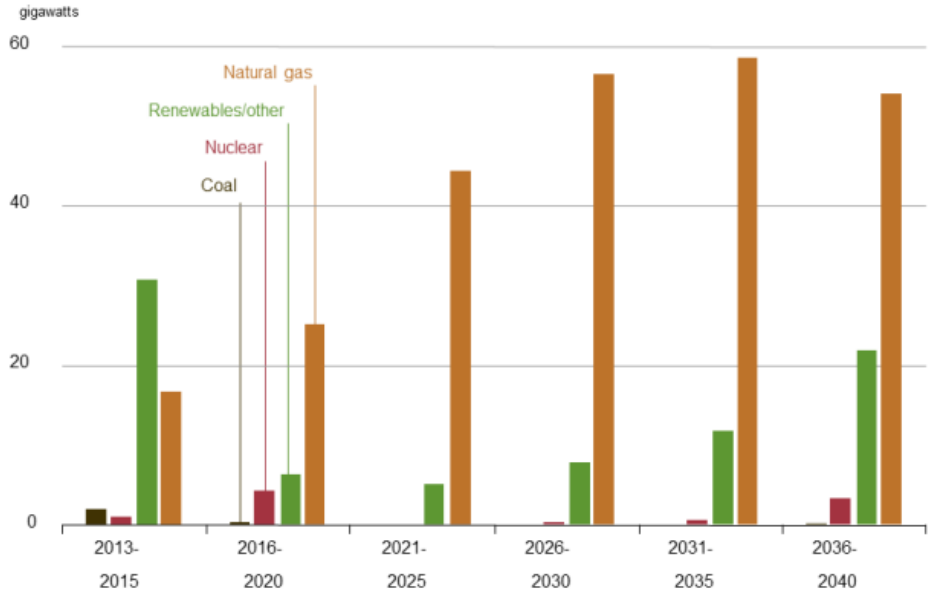

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