Economics of Power Generation

Prepared by the Legislative Finance Committee
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Understanding Electric Power Generation

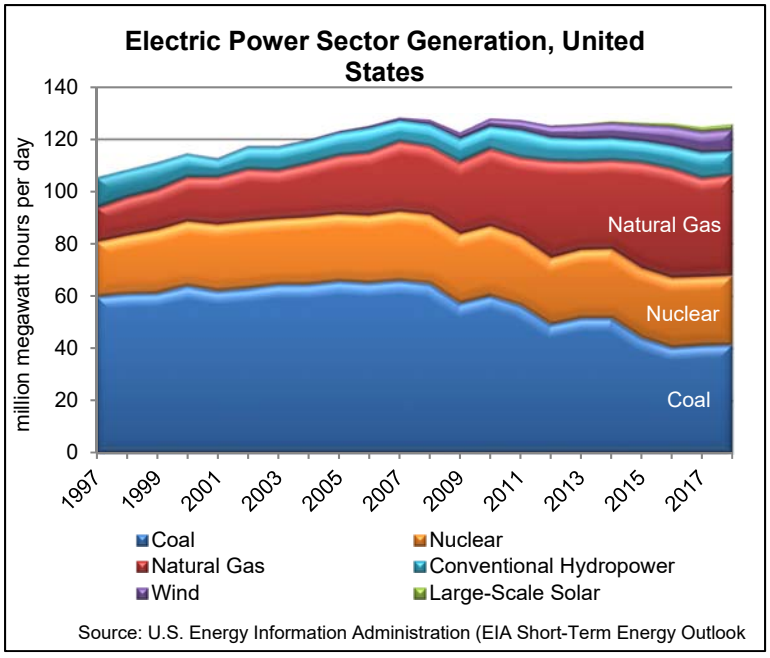
Following the Great Recession, electricity demand in the United States contracted, and energy efficiency improvements in buildings, lighting, and appliances stunted its recovery.

Globally, a slowdown in Chinese coal demand depressed coal prices worldwide and reduced the market for U.S. exports, and coal demand in emerging markets is unlikely to make up for the slowdown in Chinese coal consumption. According to Columbia University's Center on Global Energy Policy (CGEP), over half of the decline in coal company revenue between 2011 and 2015 is due to international factors.[i]

Given current technological constraints, electricity cannot be stored on a large scale at a reasonable cost. Therefore, entities operating the transmission grid must keep supply and demand matched in "real-time" – from minute to minute. Imbalances in supply and demand can destroy machinery, cause power outages, and become very costly over time. The need to continually balance supply and demand plays a key role in how electricity generation sources are dispatched.

In the 1980s, electricity supply was relatively straightforward, with less flexible coal and nuclear plants supplying base load power needs, and more flexible gas turbines and hydroelectric plants supplying peak load power needs. Developments over the last decade challenged this traditional mix of power generation.

Natural gas, wind, and solar now meet 40 percent of U.S. power needs, up from 22 percent a decade ago. Early July 2017, *The Wall Street Journal* reported three of every 10 coal generators has closed permanently in the last five years. Low natural gas prices are a driving factor. Until recently, gas plants only operated about 30 percent of the time, supplying additional power only as needed by the grid. Coal and nuclear plants were relied upon for base-load electricity needs. But with low prices and new technologies, gas plants today run more than half the time with many running virtually nonstop. Thus, natural gas and renewables are taking up more base-load capacity, surplanting coal and nuclear power needs.



Source: U.S. Energy Information Administration (EIA Short-Term Energy Outlook

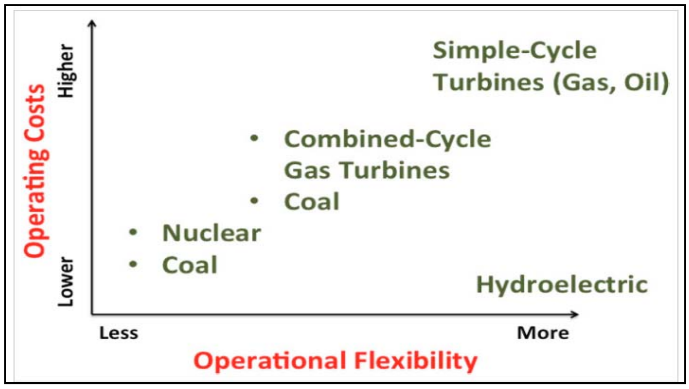
Key Concepts in Power Generation

Electricity demand is commonly viewed in terms of base load vs. peak load

- **Base load** is the minimum level of electricity demand required over a period of 24 hours; it is the load below which the demand never falls and therefore must be supplied 100 percent of the time.
  - **Base load plants** run continuously over extended periods of time, and power from these plants is used to cater the base demand of the grid (e.g. coal power plants, nuclear power plants, hydroelectric plants, geothermal plants, solar thermal with storage, biomass).
- **Peak load** is time of high demand often occurring for shorter durations; it is the difference between base demand and the highest demand.
  - **Peak load plants** generally cater to demand peaks; they are started up whenever there is a spike in demand and stopped when the demand recedes (e.g. gas plants, solar power plants, wind turbines, diesel generators).

Characteristics Influencing Power Plant Operations

- Flexibility of the generation source is determined by the minimum run time and ramp times.
  - **Minimum run time:** the shortest amount of time a plant can operate once it is turned on
  - **Ramp rate:** influences how quickly the plant can increase or decrease power output
  - **Ramp time:** the amount of time it takes from the moment a generator is turned on to the moment it can start providing energy to the grid at its lower operating limit
- Less flexible plants (longer minimum run times and slower ramp times) → generally better suited to provide base load energy
- More flexible plants (shorter minimum run times and quicker ramp times) → generally better suited to fill peak demand
- The recent decline in coal power generation can be explained in part by the inflexible nature of this power source, which affects its competativeness with more flexible sources. Recall, the grid requires demand and supply to always be in balance. Since coal plants cannot be easily started or stopped, it is difficult if not impossible to utilize this power source to meet sudden shifts in demand. Natural gas, on the otherhand, is well suited to meet shifts in demand, and low prices have led to greater utilization of natural gas plant capacity.



Relative comparison of operating cost and operational flexibility for different power plan technologies (this excludes most renewables since their operational flexibility is partially dependent on prevailing weather conditions such as irradiance and wind speed/direction)

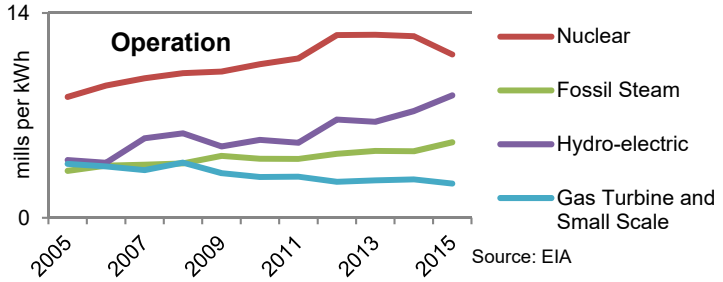
Source & Image by Penn State University

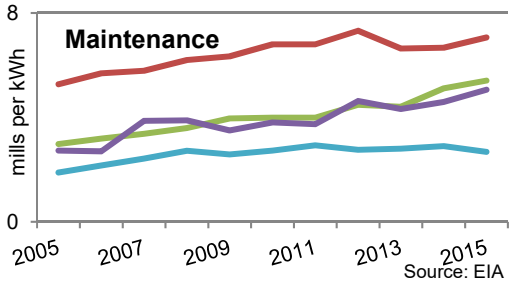
Electric power generation costs play a key role in selecting power sources

- **Capital:** including land, equipment, construction, interest, depreciation, "regulatory costs" (permits, environmental approvals, etc.)
- **Operating and Maintenance (O&M):** includes fixed costs (wages, routine maintenance, some taxes and insurance, other fees) and variable costs (equipment outage maintenance, utilities, and consumables). The operating cost required to produce each megawatt hour (MWh) of electric energy is referred to as the "**marginal cost**".
- **Fuel** costs dominate the total cost of operation for fossil-fired power plants (e.g. price of coal and natural gas). For renewables, fuel is generally free (e.g. no fuel cost for sun or wind) and the fuel for nuclear power plants are very low. For these types of power plants, labor and maintenance costs dominate total operating costs.

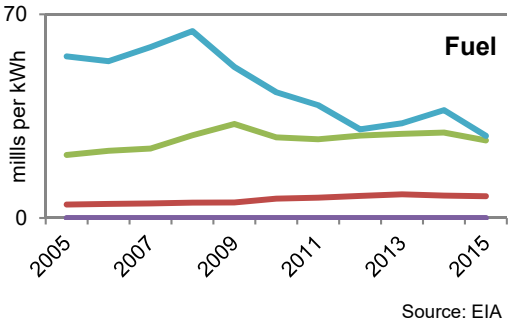
The Trade-Off

- Plants with higher capital costs tend to have lower operating costs. For example, capital investments in wind and solar are relatively high, but fuel costs are virtually zero. Generators that run on fossil fuels tend to have operating costs that are extremely sensitive to changes in the underlying fuel price. Because of the apparent tradeoff between capital and operating cost, comparing the overall costs of different power plant technologies is not always straightforward.





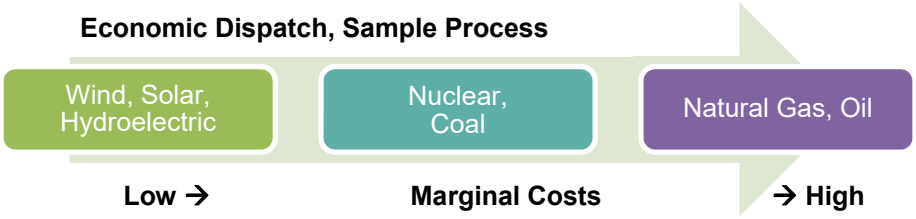
- Fossil steam (e.g. coal) plants have relatively higher operation and maintenance costs than gas turbine and small scale plants (e.g. natural gas, wind, solar).
- Until recently, fuel costs for fossil steam (e.g. coal) plants were much lower than for gas turbine and small scale plants, however with low natural gas prices, fuel costs have been on par for last several years.



- Low fuel costs for gas turbines, wind, and photovoltaic solar, combined with lower operation and maintenance costs, has made these sources more cost-competitive in recent years.
- Nuclear power plants have comparably high operation & maintenance costs, but relatively low fuel costs.
- Hydroelectric plants have moderate operation and maintenance costs, but no fuel costs.

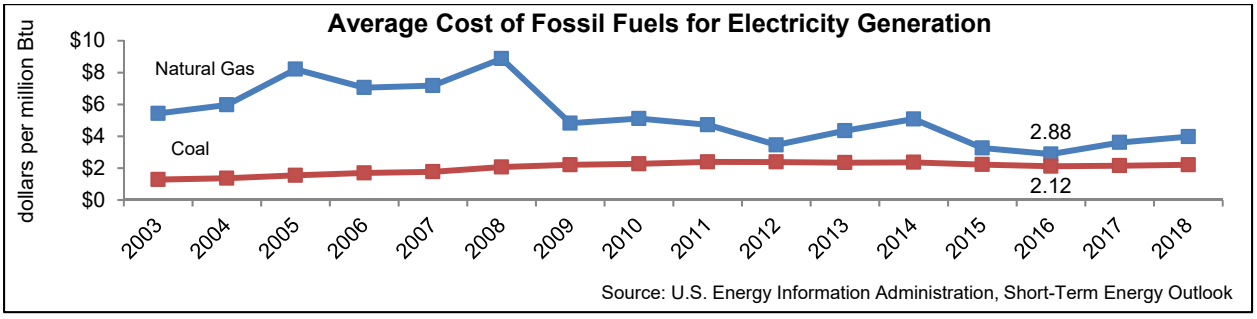
Meeting Consumer Demand

- Resource planning occurs days to years in advance, including construction of new generation plants and supporting transmission lines.
- Utilities must decide in advance their generating plant capacity to produce electricity when the need arises. In other words, consumer demand must be forecasted in advance.
  - Less flexible generators (with large start-up costs or long minimum run times) schedule their operation over a period of days or weeks.
  - Utilities determine the lowest-cost combination of electricity generation to meet forecasted demand.
  - Deviations from the demand forecast are costly – utilities may need to curtail output from some of its generators (if it over-estimated demand) or utilize generators with fast start times but high costs (if it underestimated demand).
- Generation plants are dispatched ("turned on") to meet consumer demand, starting with the generation source with the lowest marginal cost and successively turning on more expensive generation sources as needed until all demand is met.
  - The process of economic dispatch generally does not consider fixed capital costs of power plants, only the costs of operation.

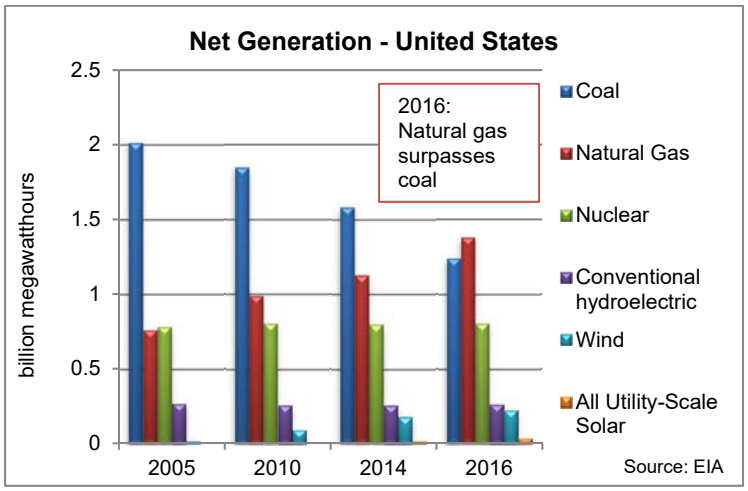


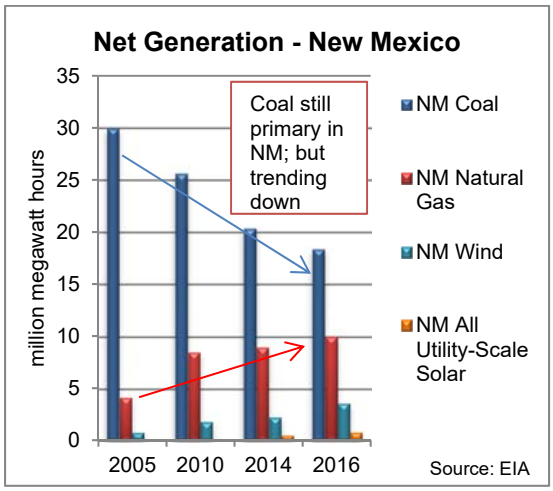
Changes in Electricity Generation (Supply)

- With declines in natural gas prices, marginal costs for natural gas electricity generation have fallen substantially since 2008. As such, net generation from natural gas has increased.
- EIA indicates 2016 was the first year since 1949 that U.S. electricity generation from natural gas surpassed generation from coal-fired plants. Natural gas supplied an estimated 34 percent of total U.S. electricity generation in 2016 compared with 30 percent for coal.



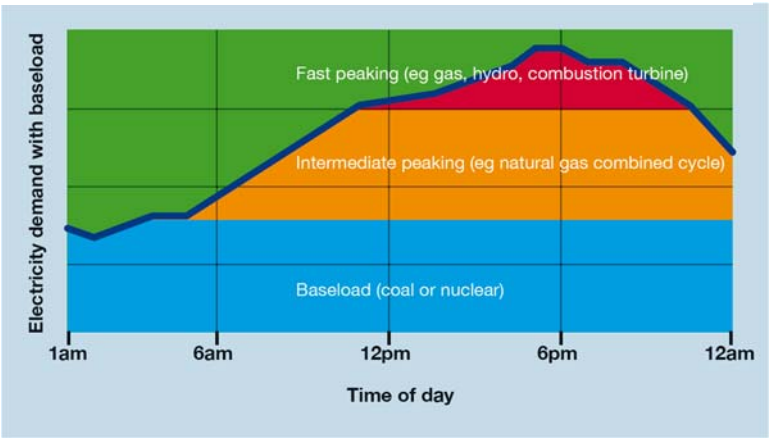
Low prices makes natural gas more competitive for electricity generation



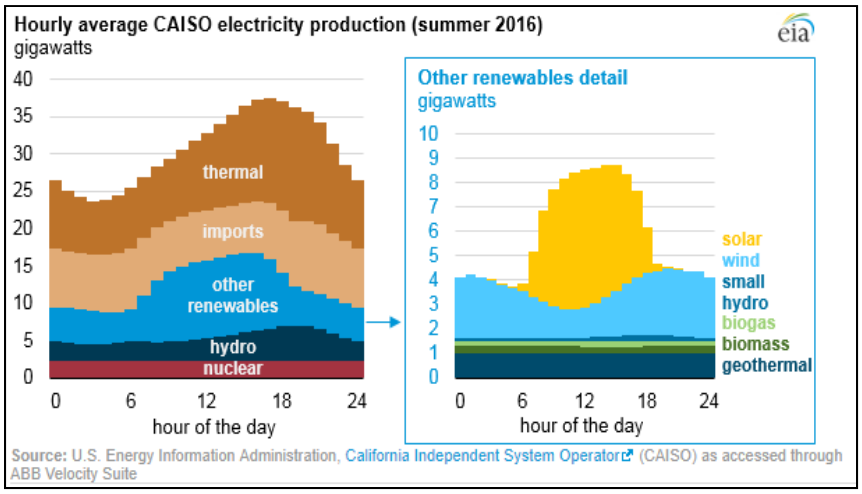


Low marginal costs of renewable challenges traditional methods to meet demand

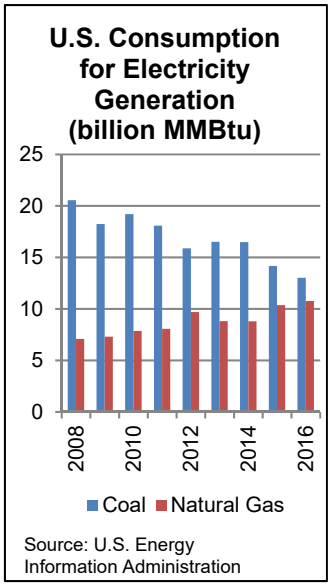
- Solar costs fell 85 percent between 2008 and 2016, and wind costs fell 36 percent.[i]
- Without fuel needs, marginal costs for wind, solar, and hydroelectric are virtually zero, creating an incentive for the grid to take their power first (see discussion on economic dispatch above).
- Renewable energy can be used to meet baseload demand, deviating from the traditional and relatively straight-forward method of meeting baseload with coal and nuclear power.



- As the grid modernizes, flexible power may become valued over baseload generation, particularly with technological advances that increase energy efficiency.
- For example, California uses output from thermal generators (mainly natural gas) and electricity imports from other regions to balance electricity supply and demand in the region with other constant (nuclear) and variable (wind, solar) energy sources.



Future of Coal

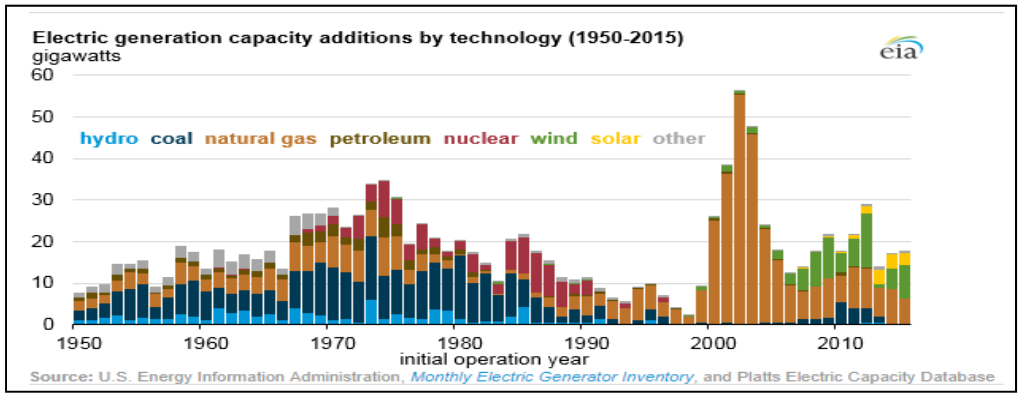


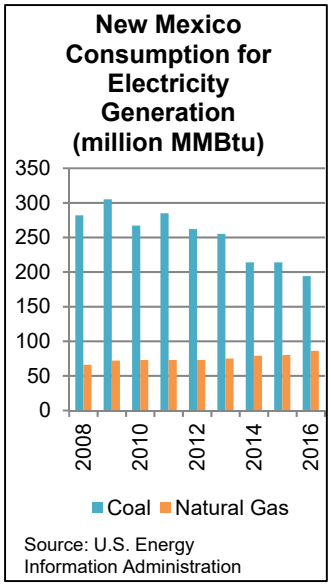
Trends in coal production and consumption

- Increased competition from cheap natural gas is responsible for 49 percent of the decline in U.S. coal consumption, according to Columbia University's Center on Global Economic Policy (CGEP). Lower than expected demand for coal is responsible for 29 percent, and growth in renewable energy consumption is responsible for 18 percent.[i]
- The Energy Information Administration (EIA) projects that trends in coal production in the United States could range from flat to continuing declines through 2040.
  - Electric power generation accounts for more than 92 percent of U.S. coal demand. However, U.S. consumption of coal for electricity generation is trending down.
  - Domestic coal production has declined significantly over the past decade, as natural gas and renewable energy has displaced coal in electric generation.

Electric Generation Capacity

- In the last decade, little coal generation capacity has been added, while capacity for natural gas and renewables are now more common additions.





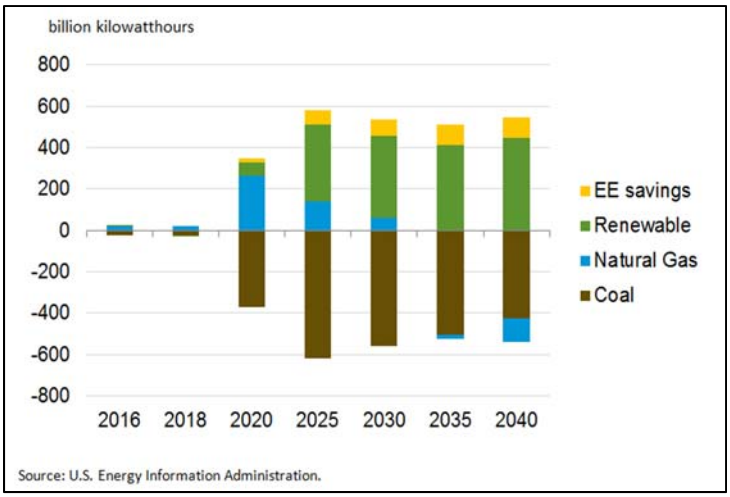
Key Regulation

- In June 2014, the Environmental Protection Agency (EPA) issued its proposed Clean Power Plan to regulate CO2 emissions from existing power plants under the Clean Air Act. The CPP proposes to limit carbon emissions from existing fossil-fuel electric generating units.
  - In February 2016, the U.S. Supreme Court granted a stay on implementing the regulation pending an ongoing lawsuit by several states.
  - In March 2017, President Trump signed an executive order calling for a review of the CPP. Many expect the administration to eliminate the regulation.
- The CPP and state-defined Renewable Portfolio Standards (RPS) increase demand for wind and solar electricity generation. New Mexico requires investor-owned utilities' energy portfolios to be 20 percent renewable by 2020, and for rural electric coopertives, 10 percent.

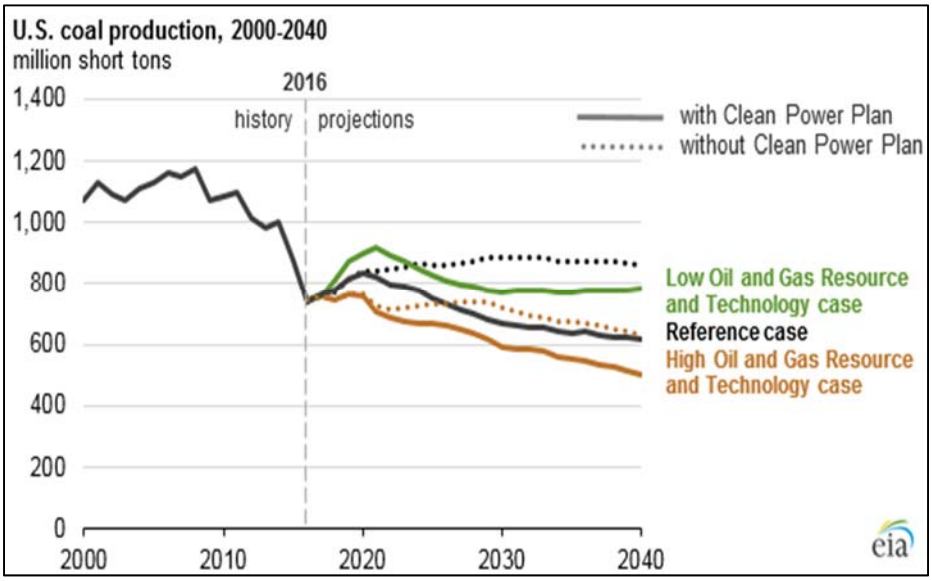
Impacts of the Clean Power Plan

- Using data from its 2015 Annual Energy Outlook (AEO), EIA projects the CPP will lead to declines in coal production through 2040 and increases in production of renewables.
- However, EIA states the future of coal production depends on resources and technology, not just policy choices.
- If the CPP were repealed, EIA's 2017 Annual Energy Outlook (AEO2017) expects coal production to be about 200 million short tons higher than its baseline case, but still lower than 2010 levels.
  - However, under EIA's high resource assumptions (an alternative scenario to the baseline in which natural gas prices remain considerably low or additional technological advances are made) natural gas is likely to displace coal regardless of whether or not the CPP takes effect.
  - In the low oil and gas resource scenario (in which oil and natural gas development is projected to be slower as higher development costs result in higher natural gas prices to the power sector), natural gas generation would be displaced by a combination of increased zero-emission generation from renewables and nuclear as well as coal-fired electricity generation, which remains near or slightly higher than its 2016 level.

Change in Generation and Energy Efficiency Savings Under the Clean Power Plan Base Policy Case Relative to the AEO2015 Reference Case



- In all scenarios of its AEO2017, EIA assumes no new coal generation capacity will be added throughout the forecast period, based on the lack of additional capacity over the last decade.
  - Although declines in coal production are likely to continue, coal still plays a key role in electricity generation throughout EIA's outlook.



- Similarly, analysis by Columbia University's CGEP shows a rollback of envirionmental regulations could mitigate recent declines in coal consumption, but only if natural gas prices increase going forward. If natural gas prices remain low or if renewable energy costs fall quicker than expected, coal declines will continue into the future, regardless of what happens with environmental regulations.[i]

Electricity Pricing

Generally, electricity prices reflect operating and maintenance costs, and most regulatory authorities require utilities to spread the cost of their capital investments (power plants, transmission and distribution lines, equipment, and delivery structures) to customers over the physical life of the investment – sometimes as long as 30 years – under the assumption there will be a stable customer base.

Comparing New Mexico to National Averages and Surrounding States

- Across all sectors, New Mexico retail electricity prices are 9.1 cents per kWh, 1.1 cents below the national average of 10.2 cents per kWh.
- New Mexico's electricity prices in residential, commercial, and industrial sectors tend to fall below Arizona and Colorado rates, but tend to exceed Texas and Oklahoma prices.

Average Retail Price of Electricity in 2016 (cents per kilowatthour)

	New Mexico	Arizona	Colorado	Texas	Oklahoma	U.S. Average
All Sectors	9.1	10.3	9.7	8.2	7.7	10.2
Residential	12.0	12.1	12.0	11.0	10.1	12.5
Commercial	9.8	10.4	9.6	7.7	7.4	10.3
Industrial	5.7	6.1	7.1	5.2	4.8	6.7

Source: U.S. Energy Information Administration

Some Impacts of Electricity Prices on the Economy

- Electricity is vital to economic development. In a high-technology society, electricity is required to power nearly all new products coming into the market. However, while price of energy is one of many factors considered by businesses, other factors such as labor costs, taxes, and access to markets are usually more important than electricity rates.
  - The Institute for Energy Research finds higher electric rates may not incentivize existing business to leave; however, electricity-intensive businesses are less likely to start-up or expand in states with higher-than-average electric rates.
- Electricity pricing affects consumer spending. On average, American consumers spend about 2 percent of their annual income on electricity.
  - Research shows single-family and multifamily low-income households (those with income at or below 80 percent of area median income), households of color, and renting households tend to experience higher energy burdens than the average household in the same metropolitan area.[ii]

[i] Columbia University Center on Global Energy Policy (CGEP), April 2017, *Can Coal Make a Comeback?*
[ii] Energy Efficiency for All (EEA) & American Council for an Energy-Efficient Economy (ACEEE), 2016, *Lifting the High Energy Burden in America's Largest Cities.*