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The Takeaway

Policy Briefs from the Mosbacher Institute for Trade, Economics, and Public Policy

Financial Implications of Coal-to-Gas Fuel Switching

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Low natural gas prices and environmental regulations have led to a significant shift in the United States' power infrastructure. Utilities continue to retire coal-fired power plants and build new natural gas generators. This not only generates environmental benefits but also appears to reduce price risk by lowering the volatility of wholesale power prices.

Extreme weather events of the past decade have intensified concern about climate change and its negative effects. Climate change is now a topic that frequently "trends" in the media and high-profile new activist movements—including Extinction Rebellion, the Youth Climate Movement, and Greta Thunberg's Fridays for Future—have put climate change on the agenda of many government meetings and international summits. The most recent scientific projections have warned of exceedingly dire outcomes if society sticks to existing targets

WHAT'S THE TAKEAWAY?

Coal-fired power plants in the US are being replaced with natural gas-fired power plants.

Some worry that this will lead to more volatile electricity prices.

In reality, natural gas generators are more flexible and better able to respond to changing market conditions, which helps lower price volatility.

Environmental benefits do not have to come at the expense of greater price risk.

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to limit warming to 2 degrees Celsius. As a result, many governments around the world have been looking for ways to reduce or delay the threat posed by climate change.

One of the most common current policy solutions to climate change is decarbonizing the energy industry. In Europe and some parts of the United States (e.g., California), the focus has been on increasing the share of wind and solar energy used to generate electricity—in some cases to 100 percent. In other parts of the world, including in most US states, the priority has been to reduce greenhouse gas (GHG) emissions generated by power plants. To this end, many coal-fired power plants have been replaced with natural gas-fired generators. More than 550 coal-fired power plants were retired in the United States between 2010 and 2019—nearly 45% of existing coal capacity.[1] In 2016, natural gas generators replaced coal as the primary suppliers of electricity in the United States by total amount of energy generated.[2] As a result, power-sector CO_2 emissions fell 28 percent from 2005 levels and overall net GHG emissions in the United States were down about 16 percent from their 2007 peak.[3,4]

US NATURAL GAS PRICES FELL, BENEFITTING ELECTRICITY MARKETS, BUT REMAINED VOLATILE

The shift toward natural gas in electricity generation has been particularly appealing in the United States, where fracking led to a decline in natural gas prices. But the fast pace of transition toward natural gas generation created some concerns, one of which is what impact this transition will have on electricity prices. The natural gas price reduction did benefit consumers, but as EIA data show, even though the average natural gas price fell after 2008, it remained volatile.[5]

Natural gas prices vary a lot from day to day and even hour to hour. Coal prices, on the other hand, have historically been low and stable. The concern is that switching to a fuel source with a more volatile price will raise the volatility of electricity prices.

The cost of fuel makes up about 70 percent of power plants' generation costs. Coal power plants usually have long-term fuel purchase agreements with coal companies, locking in low prices for many years. Natural gas generators, by contrast, face much more fuel price uncertainty. A recent study found that 85 percent of changes in spot prices of natural gas are reflected in generators' fuel procurement costs within a month.[6] These, in turn, affect generation costs and may lead power plant owners to offer their generation to the wholesale market at higher prices in order to account for future price uncertainty. The question is then: when electricity generators switch from coal to gas, does society achieve better environmental outcomes at the expense of greater financial risk for electricity market participants?

PRICE VOLATILITY CREATES SOCIAL COSTS

This is an important question because rising electricity price volatility creates social costs. Wholesale electricity customers (utility companies and municipalities, for example) face real-time electricity prices, while retail customers (e.g., households) in most US states pay a fixed price for electricity. This means that wholesale price volatility cannot be di-

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rectly passed on to end users and must be absorbed by wholesale buyers and sellers. Hedging is quite common in electricity markets[7] and higher price volatility would likely encourage more market participants to engage in hedging or to hedge a greater share of their load obligation. The downside is that hedging can be costly and will inevitably be priced into fixed-rate retail contracts, raising electricity costs for end users.

Anecdotally, it looks like some markets with a high share of natural gas generation might indeed have more volatile electricity prices. In the northeast, for example, where half of all power plants run on natural gas, real-time wholesale electricity prices closely track the price of natural gas.[8] Similarly, across the Pennsylvania-New Jersey-Maryland (PJM) power grid, volatility of real-time electricity prices appears to be higher when natural gas plants set the price of electricity, and lower when coal plants set the price. But these patterns might be occurring for a variety of reasons unrelated to fuel switching. New England has limited natural gas pipeline capacity and when winter temperatures plummet demand for heating gas spikes, as do natural gas prices. It is pipeline constraints, not fuel switching *per se*, that are driving electricity price volatility.

MORE FLEXIBLE INFRASTRUCTURE REDUCES VOLATILITY

What is not captured by anecdotal evidence is the fact that natural gas generators are in general much more flexible than coal generators and are able to start-up and ramp-up their output quickly. Because of this, regions with more natural gas generators should be able to better respond to changes in market conditions, and this should reduce electricity price volatility. For example, suppose a fire unexpectedly takes a large coal generator offline. In a market with a lot of natural gas generation, the power system operator would dispatch gas generators to make up for the lost coal generation. Because natural gas generators can be turned on and ramped up to full capacity within a matter of minutes, supply would be quickly restored to match demand. By contrast, the same emergency coal outage in a region with little available natural gas generation would require dispatching more coal generation, which can take hours to go from cold start to full capacity. During this time, the shortfall in electricity supply would send prices higher as customers try to outbid each other for available generation. Therefore, because natural gas generators increase the flexibility of generating infrastructure, they should also *reduce* price volatility.

This is indeed what my coauthors and I find when we take a careful look at data from the PJM region.[9] We examine what happens to electricity price volatility when coal generators unexpectedly go offline due to an emergency (most often a fire) and find that, contrary to conventional wisdom, electricity price volatility is lower during hours when natural gas generators spend more time on the margin (i.e., setting the price of electricity). Specifically, in the PJM territory, between 2014 and 2016, placing a natural gas generator on the margin for an extra 30 seconds reduced the intra-hour range of electricity prices by 77 cents (per kilowatt-hour).

The ability to respond more efficiently to variation in market conditions allows regions with a more gas-heavy generation portfolio to

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maintain a better balance between supply and demand. Thus, a growth in natural gas generation capacity is likely to lead to lower, not higher wholesale price risk for electricity market participants.

These results have important policy implications for electricity market planning in general and natural gas integration in particular. Specifically, improved environmental performance from fuel switching does not have to come at the expense of increased price risk. In fact, it is possible that environmental policies that have incentivized the switch from coal to gas generation in the United States created positive spillover effects for financial outcomes in power markets. While we do not know what would happen to price volatility in markets that divest from coal entirely in favor of natural gas and renewables, electricity market planners should consider the possible benefits of fuel switching when making infrastructure planning decisions.

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Notes:

[1] US Energy Information Administration (2019, July 26). *Today in Energy: More US coal-fired power plants are decommissioning as retirements continue*. https://www.eia.gov/todayinenergy/detail.php?id=40212

[2] US Energy Information Administration (updated 2019, April 19). *Electricity explained*. https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

[3] US Energy Information Administration (2018, October 29). *Today in Energy: Carbon dioxide emissions from the US power sector have declined 28% since 2005*. https://www.eia.gov/todayinenergy/detail.php?id=37392

[4] Ramseur, J.L. (2019, January 7). US carbon dioxide emissions in the electricity sector: Factors, trends, and projections. Congressional Research Service whitepaper. https://fas.org/sgp/crs/misc/R45453.pdf

[5] Comparing the Citygate price of natural gas in Pennsylvania (our region of study) for the pre- and post-fracking periods (2000-2007 and 2008-2016, respectively), we observe a decline in the average price of 14% (from $7.71 to $6.63) and a decline in annualized volatility of about nine percentage points (from 48.5% to 39.1%).

[6] Chu, Y., Holladay, J.S., & LaRiviere, J. (2017). Opportunity cost pass-through from fossil fuel market prices to procurement costs of the US power producers. *Journal of Industrial Economics*, 65(4), 842-871. https://doi.org/10.1111/joie.12146

[7] See, for example, Bessembinder, H. & Lemmon, M.L. (2002). Equilibrium pricing and optimal hedging in electricity forward markets. *The Journal of Finance*, LVII(3).

[8] ISO New England (2018). Key grid and market stats, online report. https://www.iso-ne.com/about/key-stats/markets

[9] Saretto, A., Shcherbakova, A. & Lin, J. (2019). What fuels the volatility of electricity prices?, working paper. https://ssrn.com/abstract=3324592

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