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U.S. Electricity Prices in the Wake of Growing Natural Gas Production

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The recent boom in domestic energy production has reduced the price consumers pay for electricity in some regions of the United States, but the decline in prices may not persist. Low-priced natural gas has been attractive to power and utility companies as a substitute for other traditional fuels such as coal and nuclear. The relative costs of these fuels, combined with national energy policy, affect the composition of fuels used in generating electricity and ultimately the prices paid by consumers.

Over the last decade, there has been a steady decline in coal-generated electricity. Coal, thanks to its low and stable price relative to petroleum and natural gas, historically has been the No. 1 fuel used to generate electricity in the United States. However, as coal-fired power plants have aged, the rising cost of

maintenance and environmental compliance has made these plants more costly to operate. Natural gas is a cleaner-burning alternative to coal, but natural gas has seen larger price fluctuations relative to coal.

After fluctuating annually in the early 2000s, the price of natural gas has declined since 2008. Higher prices, however, are expected in the future. Analysis of national data from 1970 to 2012 suggests future increases in natural gas prices would lead to a moderate increase in electricity prices. During this low-price period of natural gas, average electricity prices have declined in states where the share of electricity generated from natural gas has significantly increased. In the future, electricity prices will be more sensitive to changes in natural gas prices if the share of electricity generated from natural gas continues to grow.

Trends in Fundamental Drivers of Electricity Prices

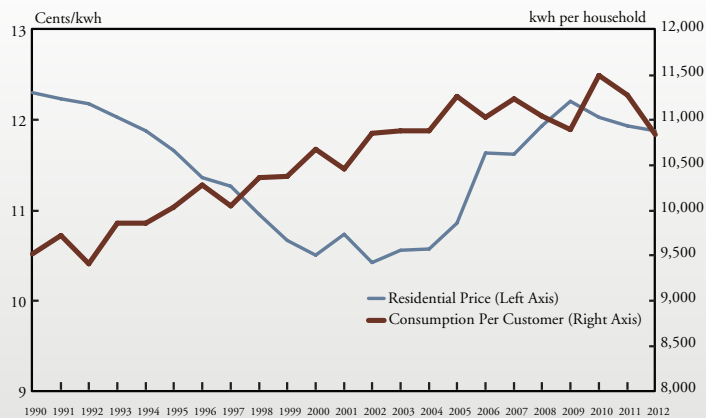
In recent years, consumers have paid slightly lower prices for electricity than a couple of decades ago despite a steady increase in demand for electricity. While fluctuations in demand for goods and services in the broader economy affect demand for electricity and its price, fuel sources play a larger role. Fluctuations in electricity prices are closely linked to the cost and composition of fuels used to generate electricity. Still, decisions about what fuels to use for electricity generation are not solely based on cost. State and local policies that specify environmental standards and generation guidelines also have an effect on fuel selection and that effect may be more significant in the future.

From 1990 to 2012, the price of residential electricity in the United States fluctuated within a



Chart 1

U.S. Average Real Residential Electricity Price and Consumption per Customer, 1990 to 2012



Sources: Energy Information Agency and authors' calculations.

narrow range. After reaching a low of 10.4 cents per kwh (2012 dollars) in 2002, the price increased year-over-year to 12.3 cents per kwh in 2009 (Chart 1).¹ Since then, average electricity prices have decreased slightly, though they remain at levels last seen 20 years ago. The recent decrease may be explained by the lagging effects from lower consumer demand during the recession and changes in the cost and composition of fuel used to generate electricity.

Total U.S. electricity consumption has grown at a slower pace in the last two decades than in the previous four. From 1990 to 2012, average annual consumption grew 1.4 percent. Over that period, there was a shift in the amount of electricity consumed by the three major categories—residential, commercial and industrial—and their

relative sizes.² The residential category became the largest consumer of electricity in 1995—a status it retains today by a wide margin. Residential electricity consumption has also grown at a slightly faster pace than the total.³ Average household consumption in the United States has grown from 9,517 kwh in 1990 to 10,837 kwh in 2012 (Chart 1). Even though the pace of growth in electricity consumption has slowed compared to previous decades, the expectation is that the current level of growth will continue.

Factors other than expected growth in electricity consumption also are likely to place upward pressure on prices consumers pay. The composition and prices of fuels used in generating electricity and a recent shift away from coal as the main fuel are also significant factors. In the early 1990s,

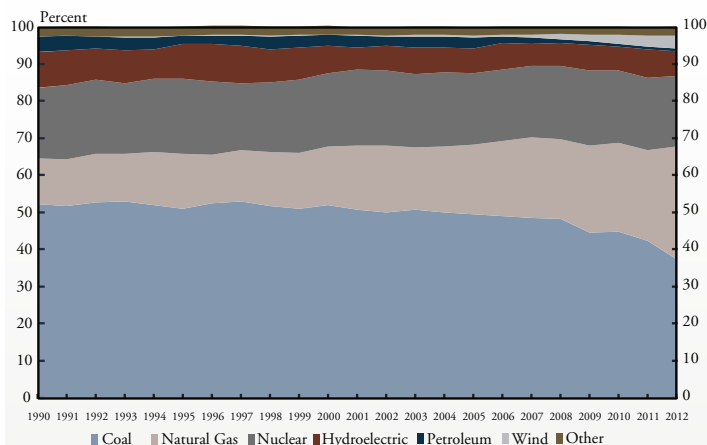
coal was the fuel used most in the United States to generate electricity. In 1990, 52 percent of electricity was produced from coal, followed by nuclear plants and natural gas at 19 percent and 12.3 percent, respectively (Chart 2). Over the next 13 years, coal use relative to other fuels declined. By 2004, less than 50 percent of total electricity was generated from coal. The transition has continued since then, with coal accounting for only 37.3 percent of total electricity by 2012. The main replacement for coal has been natural gas. From 1990 to 2012, the proportion of natural gas used to generate electricity increased 18.1 percent to 30.4 percent. The use of natural gas has accelerated in recent years due to increased production of natural gas at relatively low prices.

The choice of fuel utility companies use in generating electricity is heavily dependent on fuel costs. The sum of fuel, operation and maintenance costs measures the total production costs for electricity plants. Fuel, however, accounts for the vast majority of costs for electricity producers that use fossil fuels. For example, in 2012, fuel was 91 percent of the total production costs for petroleum-burning facilities (Chart 3). For facilities burning natural gas and coal, fuel costs were 86 percent and 76 percent of total costs, respectively.

The reduced cost of natural gas relative to coal has driven the transition

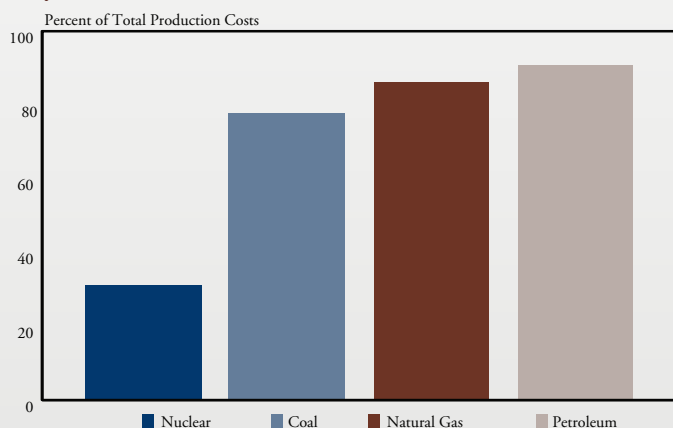


Chart 2
Percentage of Electricity Generation by Source,
1990 to 2012



Sources: Energy Information Agency and authors' calculations.

Chart 3
Fuel as a Percentage of Total Production Cost
by Source, 2012



Sources: Federal Energy Regulatory Commission and authors' calculations.

of utility companies to the use of natural gas. Lower natural gas prices have brought the fuel cost of producing electricity with natural gas in line with the cost of using coal per kwh of generation (Chart 4). The costs of coal and natural gas began converging in 2008 amid a slight increase in coal prices and a significant reduction in the price of natural gas. As of 2012, natural gas and coal costs were similar at 2.63 cents and 2.50 cents per kwh, respectively (in 2012 dollars). However, utility companies also prefer to use fuels with relatively stable prices. Historically, the prices of natural gas and petroleum have been more volatile than coal and nuclear fuel. It is not clear whether the recent increase in domestic natural gas production will stabilize prices, or if increased demand for natural gas from power plants and other end-users will cause future prices to spike.

In addition to fluctuating fuel prices, the costs of adhering to environmental regulations are creating incentives for utility companies to use cleaner fuels in generating electricity. At the state level, renewable portfolio standards have defined the percentage of electricity that must come from renewable sources. Other policies have affected the amount of acceptable pollution from traditional sources. In 2011, the EPA adopted the Mercury and Air Toxics Standards (MATS), which require power plants using coal and petroleum to limit emissions of mercury, arsenic and metals. Many noncompliant power plants have either been retired or converted to use other fuels such as natural gas, biomass and other nonrenewable resources.

The focus of state and federal agencies' on more environmentally sustainable electricity production may also affect decisions by electricity producers about the composition of fuels used in the future. It is anticipated that the MATS compliance deadline in 2015 will lead to the retirement of many coal-fired

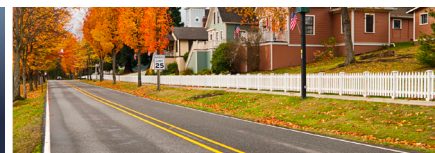
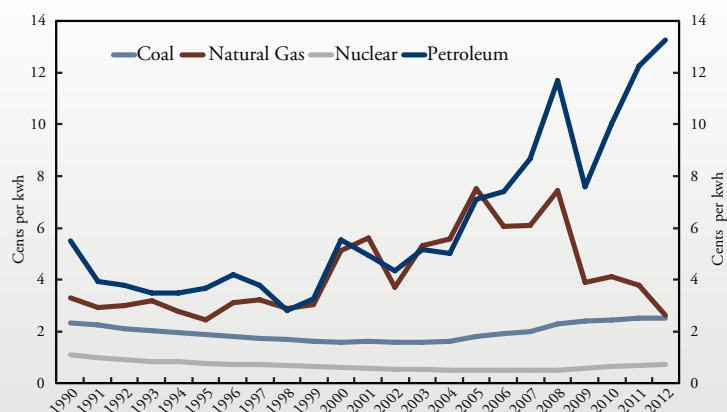


Chart 4
Average Real Cost of Fuels for the Electric Power Industry



Sources: Energy Information Agency and authors' calculations.

plants (Niven and Powell). A more recent proposal by the EPA is the Clean Power Plan, which would reduce carbon pollution from existing power plants. The proposal, still in its public comment period, seeks to reduce carbon emissions 30 percent by 2020 relative to their 2005 levels (EPA). Increasingly stringent environmental regulations may require many coal-fired units to be retired or, alternatively, retrofitted with emissions-control equipment for continued operation on coal (Katusa). These requirements are likely to increase the cost of generating electricity from coal and may encourage utility companies to turn to cleaner sources such as natural gas.

Responses to Commodity Market Developments

The percentage of electricity generated from natural gas has increased in several states alongside

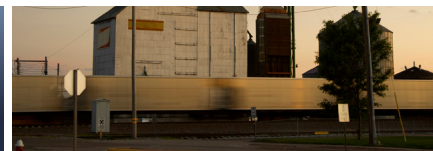
recent developments in natural gas markets. Since the mid-2000s, total natural gas production in the United States has increased substantially. The combination of the Great Recession in 2007-09 and increased domestic production over the past nine years has resulted in a significant decline in natural gas prices. On average since 2007, states with increased production of electricity from natural gas have seen electricity prices decline, while all other states have seen prices rise.

Higher natural gas prices in the mid-2000s, combined with new extraction techniques such as horizontal drilling with hydraulic fracturing, changed the economics of natural gas production. New reserves from unconventional formations of shale and tight gas became profitable to extract. From 2007 to 2012, production and proved reserves in shale gas formations increased more

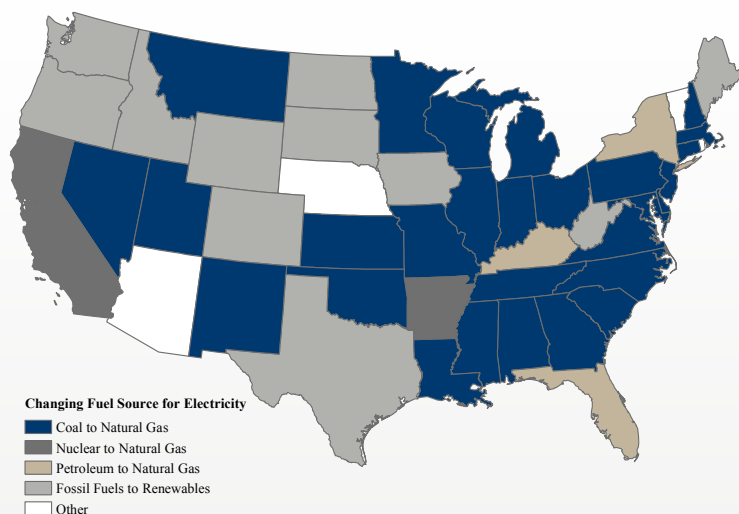
than 400 percent.⁴ In recent years, domestic natural gas prices declined due to increased supply and lack of infrastructure to transport and export natural gas to global markets (Brown).

Responding to lower natural gas prices, the share of electricity generated from natural gas increased in most states and the District of Columbia from 2005 to 2012 (Map 1). Generation from coal declined in most of these states, but the share of nuclear and petroleum used to generate electricity also showed a slight decline. It is notable that the share of electricity generated from renewable sources, mostly from wind power, increased in 11 states during the same period. Installed wind power capacity in recent years has been a fast-growing category for new generation. However, as of 2012, the share of total electricity generated from wind remained small at just 3.5 percent, in contrast to a 30.4 percent share from natural gas.⁵

Electricity prices declined recently in states with the largest increases in the share of electricity generated from natural gas.⁶ Beginning in 2005, residential electricity prices were, on average, higher in states transitioning to natural gas (Chart 5). The real price of electricity (in 2012 dollars) on average increased in all states until 2009, when prices began to fall in states transitioning to natural gas for electricity generation. From 2009 to

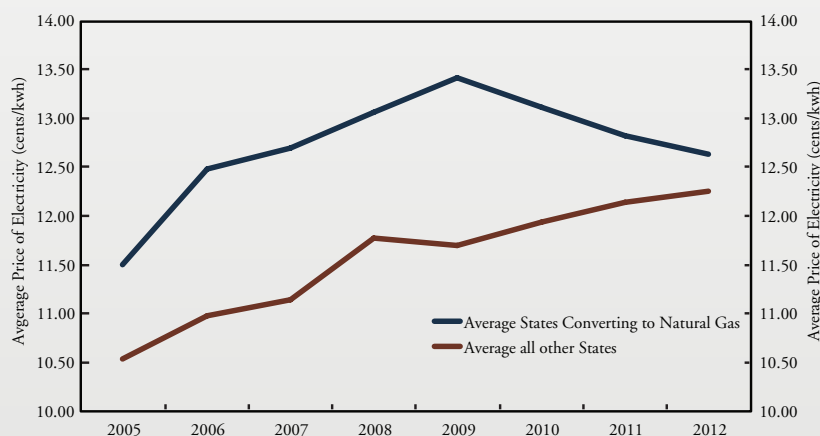


Map 1
States with Increasing Share of Electricity Generated
by Natural Gas, 2005 to 2012



Sources: Energy Information Agency and authors' calculations.

Chart 5
Average Real Residential Electricity Prices for States
Transitioning to Natural Gas



Note: Prices are in 2012 dollars.

Sources: Energy Information Agency and authors' calculations.

2012, residential electricity prices on average declined 6 percent in states transitioning to natural gas versus a 5-percent increase for all other states. These trends suggest a general relationship between natural gas usage and electricity prices.

The Relationship between Natural Gas Used in Generation and Electricity Prices

The implications for electricity prices from increasing generation from natural gas depend upon the relationship between the quantity of natural gas used to generate electricity and the price of natural gas. Increased use of natural gas would be expected to put downward pressure on electricity prices if natural gas is replacing a more costly fuel. Higher natural gas prices would be expected to increase the price of electricity unless natural gas was replacing a more costly fuel, then electricity prices would be expected to decline. The volatility in natural gas prices and increased demand across all end-users pose challenges for continued increases in the transition of natural gas usage in electricity generation. Despite the current low-price environment, some utility companies may be reluctant to switch to natural gas due to fluctuations in price and general concerns of potentially higher fuel costs in the future.

Regression analysis suggests

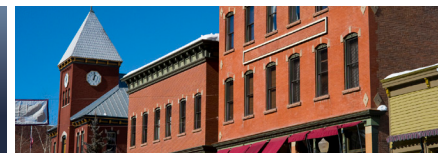


Table 1
Percentage Change in Residential Electricity Prices from
Changes in Natural Gas Prices and Quantities

| | Percent Change in Natural Gas Quantity | | | | | | |
|-----|--|------|------|------|------|------|------|
| | -30 | -20 | -10 | 0 | 10 | 20 | 30 |
| -30 | -3.0 | -4.1 | -5.2 | -6.4 | -7.5 | -8.6 | -9.8 |
| -20 | -0.9 | -2.0 | -3.1 | -4.2 | -5.4 | -6.5 | -7.6 |
| -10 | 1.3 | 0.1 | -1.0 | -2.1 | -3.3 | -4.4 | -5.5 |
| 0 | 3.4 | 2.3 | 1.1 | 0.0 | -1.1 | -2.3 | -3.4 |
| 10 | 5.5 | 4.4 | 3.3 | 2.1 | 1.0 | -0.1 | -1.3 |
| 20 | 7.6 | 6.5 | 5.4 | 4.2 | 3.1 | 2.0 | 0.9 |
| 30 | 9.8 | 8.6 | 7.5 | 6.4 | 5.2 | 4.1 | 3.0 |

Notes: The electricity price effects were determined by multiplying the reported model coefficients by the percentage point increase/decrease in natural gas price/quantity. Moving along/down the zero row/column assumes no change in the price/quantity.

Source: Authors' calculations.

electricity prices tend to decline as more natural gas is used in electricity generation, but tend to increase as the price of natural gas increases. In the present analysis, the price of residential electricity in a given year is assumed to depend on: the quantity of natural gas used to generate electricity in the prior year, the average price of natural gas paid by power generators in the prior year and a time trend.⁷ Regression results indicate a 1 percent increase in natural gas used to generate electricity has reduced the price of electricity by 0.1 percent, while a 1 percent increase in the price of natural gas has increased the price of electricity by 0.2 percent.⁸

Calculating the predicted effects under different scenarios shows what

might happen to electricity prices in the future. The Energy Information Agency (EIA) forecasts the price of natural gas paid by electric power generators will increase nearly 30 percent from 2012 to 2016.⁹ Under this scenario, a 30 percent increase in the price of natural gas would be expected to increase the residential electricity price by 6.4 percent, holding other factors constant (Table 1). The EIA also projects that generation from natural gas will be nearly unchanged by 2016, which, holding the price of natural gas constant, would also leave residential electricity prices unchanged.¹⁰

The volatility in natural gas prices and possible higher prices as a result of increasing demand for natural gas across all end-users may limit a continued shift

toward natural gas use in generating electricity. Although the EIA predicts natural gas will eventually unseat coal as the dominant fuel source by 2035, it likely depends on the relative cost of maintaining and operating coal-fired versus natural gas-fired power plants and overall demand for natural gas. Currently, the United States is only exporting small quantities of natural gas relative to domestic consumption. Higher exports would likely place upward pressure on the price power generators pay for natural gas, and therefore reduce some of its relative advantage over other fuels.

Conclusion

Cheap abundant natural gas has placed downward pressure on electricity prices in the United States. Electricity prices have fallen in states where there was a significant increase in the share of electricity generated from natural gas. Conversely, average electricity prices have increased in all other states. If natural gas prices remain steady, continued increases in natural gas usage in generating electricity would likely accelerate the decline in electricity prices. However, the results in this article show future increases in the price of natural gas, as observed in the past, would lead to moderate increases in residential electricity prices.

Natural gas is expected to continue to replace coal as a fuel source



over the next several years. However, the price of natural gas has historically been more volatile than coal. Despite potentially higher compliance costs for coal-fired plants, which would increase total costs, utility companies

may prefer to purchase electricity derived from sources with more stable prices. Although natural gas prices have fluctuated in the past, a growing domestic supply that keeps pace with growing demand may help limit those

fluctuations. A cleaner fuel source with more stable prices may help anchor electricity prices in the future.

ENDNOTES

¹Energy Information Agency. http://www.eia.gov/electricity/annual/html/epa_02_10.html.

²Energy Information Agency. http://www.eia.gov/state/seds/sep_use/notes/use_print.pdf.

³For our purposes, the term “household” is equivalent to a customer of an electric utility company.

⁴Energy Information Agency. http://www.eia.gov/dnav/ng/ng_prod_sum_dc_u_NUS_a.htm and http://www.eia.gov/dnav/ng/ng_enr_shalegas_a_EPG0_R5301_Bcf_a.htm.

⁵Authors’ calculations using EIA Tables 2.1 and 3.17 at <http://www.eia.gov/electricity/annual/?src=Electricity-f4>.

⁶States were classified as transitioning to natural gas if the difference between their share of electricity generated from natural gas in 2005 and 2012 was above the median (9 percentage points).

⁷National data from the Energy Information Agency from 1970 to 2012 was used in the analysis. All prices were expressed in 2012 dollars.

⁸The coefficients on natural gas quantity and price were statistically significant at the 90 and 99.9 percentiles, respectively.

⁹Energy Information Agency. 2014. *Annual Energy Outlook 2014 with projections to 2040*. Table A.3. <http://www.eia.gov/oiafla/ao/ta/blebrowser/#release=AEO2014&subject=3-AEO2014&table=3-AEO2014®ion=1-0&cases=ref2014-d102413a>.

¹⁰Assuming the quantity of natural gas used to produce a unit of electricity remains constant.



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