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THE STATE OF THE US ENERGY SECTOR

JOSHUA D. RHODES, PhD.

Introduction

The US energy sector is in a state of flux. Deregulated energy markets, steep declines in the costs of renewables, flat electricity demand growth, and steep increases of domestic oil and gas production have resulted in vastly different energy outlooks than in previous decades.

Domestic oil production is at its highest levels since the early 1970s1 and domestic natural gas production is also at all-time record highs2. At the same time, electricity demand has stagnated since 20073 while the makeup of the US electricity generation fleet is in transition from coal to natural gas and renewables. All of these factors intersect in today’s complex energy landscape. This paper provides a short overview of the major trends in today’s oil, natural gas, and electricity sectors.

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Current status of the US energy sector

Oil and gas

One of the largest changes in the US energy sector has resulted from the development of US oil and gas shale resources through expanded use of hydraulic fracturing (fracking) and horizontal drilling. As a result, US crude oil imports are at their lowest level since the early 1990’s and the US is now a net exporter of natural gas for the first time since the 1950’s (Figure 1).

Figure 1: US net imports of crude oil and natural gas.

As the world’s largest consumer and producer of both oil and natural gas, the domestic US energy boom has had profound implications for global energy markets.

Natural gas, already experiencing production increases due to technological advances in fracking and horizontal drilling, is also growing because of rising oil prices. Oil production, particularly shale oil, often produces associated natural gas as a by-product, so as the price of oil rises and production increases, the supply of natural gas increases and thus, the price of natural gas tends to fall\(^8\). Natural gas prices, while volatile in the past, are expected to remain low in the near future, within a range of $3—5/mmbtu\(^9\) according to the US Energy Information Administration.\(^{10}\)

Electricity

The US electricity sector is also undergoing significant changes. Figure 2 shows the breakdown of US electricity generation fleet by fuel type. Today, about 80% of US electricity is generated from natural gas, coal, and nuclear power.\(^{11}\) Figure 3 shows the change in capacities of the major generator types in the US. Since 2008, the US has, on net, retired about 51 GW of coal power plants and, on net, built about 135 GW of natural gas power plants. In the past decade the US has also added about 123 GW of wind and solar power. These changes have triggered significant reductions in the carbon intensity of the US energy sector.

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9. 1 mmbtu = 1 million British Thermal Units
11. See Figure 2 below.
12. See Figure 3 below. This includes behind the meter solar PV.
Figure 2: Total US electricity generation in 2017 by fuel (TWh)

Figure 3: Net change in power plant capacity in the US electricity sector. Other includes oil-based generators, biomass, etc.

Coal

After enjoying dominance throughout most of the 20th century, coal fell to 2nd place behind natural gas in recent years as the preferred fuel for
generating electricity in the US\textsuperscript{13}. Perhaps more telling, as of August, 2017, only one small coal power plant was under construction in the United States\textsuperscript{14}, a combined heat and power plant for the University of Alaska, Fairbanks\textsuperscript{15}. Much of the decline in coal is due to stagnant electricity demand growth, the low price of natural gas, and to a lesser extent, the deployment of renewables. Also, American coal power plants are aging\textsuperscript{16}, and as these units retire, they are being replaced with more efficient and cleaner technologies, often natural gas and renewables that can be built at lower upfront costs and in smaller sizes, both of which decrease investment risk.

Some coal power plants that have already paid off their capital costs can produce electricity competitively with natural gas. However, as the plants age they often require major capital spending, which can trigger the New Source Review provision\textsuperscript{17} of the Clean Power Plan (CPP). The review process of the CPP requires the carbon emissions of the power plant, post investment, to be at levels that necessitate adding costly carbon capture technologies. The current Administration is considering replacing the Clean Power Plan and doing away with the New Source Review provision, but it is not clear that this action would materially change the fate of most coal plants in the US\textsuperscript{18}. For example, Southern Company, a coal-heavy electric

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utility in the Southeast US, has indicated that the change in this rule would not alter the company’s plans to decarbonize its generation fleet\textsuperscript{19}.

\textit{Natural Gas}

Natural gas use has increased in the US electricity sector since the late 1980's when Congress repealed the Fuel Use Act of 1978\textsuperscript{20,21}. Natural gas’ current advantage over coal is two-fold: (1) current and short-term forecasted low prices for natural gas means it is cheaper to generate electricity with natural gas than from coal, and (2) coal power plant retirements are not being replaced by new coal plants, but by a combination of natural gas and renewables. Combined cycle natural gas power plants are about 25\% more efficient than modern coal plants\textsuperscript{22}, and can be built for about one-third the price\textsuperscript{23}. Natural gas plants are also generally more flexible (able to quickly change their output) in their operations and thus are able to respond more quickly to the minute-by-minute changes in electricity market demands\textsuperscript{24}. Moreover, as more variable renewables come online, the value of natural gas’ flexibility will likely increase\textsuperscript{25}.

\begin{itemize}
\item \textsuperscript{19} Rod Kuckro & Kristi E. Swartz, \textit{Utilities are Decarbonizing. Will Trump Rule Change That?}, E&E NEWS, https://www.eenews.net/stories/1060094829
\item \textsuperscript{20} The Fuel Use Act of 1978 restricted the construction of new baseload natural gas power plants.
\item \textsuperscript{22} U.S. ENERGY INFOR. ADMIN., \textit{Analysis & Projections: Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants Table 2}, https://www.eia.gov/analysis/studies/powerplants/capitalcost/ (Nov. 22, 2016) (Table 1 showing heat rates for “Natural Gas Combined Cycle (NGCC)” to be 6,600 BTU/kWh and for “Ultra Supercritical Coal (USC)” to be 8,800 BTU/kWh).
\item \textsuperscript{23} U.S. ENERGY INFOR. ADMIN., \textit{Analysis & Projections: Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants Table 2}, https://www.eia.gov/analysis/studies/powerplants/capitalcost/ (Nov. 22, 2016) (Table 2 showing capital cost for “Advanced CC” to be $1,088/kW and for “Dual Unit Advanced PC” to be $3,124/kW).
\item \textsuperscript{24} Miguel Angel Gonzales-Salazar, Trevor Kristen, & Lubos Prchlik, \textit{Review of the operational flexibility and emissions of gas- and coal-fired power plants in a future with growing renewables}, 82 part 1 Renewable and Sustainable Energy Reviews 1497, 1499 (2018) (Table 1).
\end{itemize}
Nuclear

Nuclear ranks third in US electricity production (at about 20%) and is the largest source of carbon free electricity in the US (Figure 2). That said, nuclear power is also on the decline in the US – of the 98 nuclear power plants currently operating, 12 of them, totaling about 11.7 GW of capacity, have announced plans to retire over the next seven years.26

While it was once said that electricity from nuclear power plants would be “too cheap to meter,”27 recent projects have been plagued by significant cost overruns. Watts Bar Unit 2, brought online in 2016, was the first nuclear power plant to be energized in the US since 1996,28 but was saddled with billions of dollars in cost overruns.29 In 2017, the South Carolina Electric & Gas V.C. Summer Nuclear Station #2 and #3 project was abandoned after an investment of $9 billion only managed to get the plant expansion to 40% completion.30 The only nuclear power plant under active construction in the US is the Georgia Power Vogtle Electric Generating Plant, units #3 and #4,31 but these units are estimated to have cost overruns of over 100% and final costs are estimated to be about $27 billion dollars.32

26. U.S. ENERGY INFOR. ADMIN., TODAY IN ENERGY: AMERICA’S OLDEST OPERATING NUCLEAR POWER PLANT TO RETIRE ON MONDAY (Figure 3) (2018) (available at https://www.eia.gov/todayinenergy/detail.php?id=37055).


Beyond those two units, the only other nuclear plants under consideration are twelve 50 MW small modular reactors, scheduled to be installed between 2025 and 2026 at Idaho National Lab in Idaho Falls, ID.

Wind and solar

Driven by declining capital costs, long-term contracts, and a growing social preference for cleaner energy, wind and solar have enjoyed significant growth in the past decade, and are expected to continue growing. Most of the costs of wind and solar are in the construction phase since their marginal costs are low (i.e., the fuel is free). The low operating costs of wind make it attractive to investors via long-term (10+ year) fixed-price contracts that allow for project risk to be lowered. These technologies continue to be seen as a favorable hedge against future uncertainty with energy prices and climate legislation. As evidence of this fact, wind and solar have consisted of about half of all new electricity generation capacity additions in the past decade. Continued growth is expected and the US Bureau of Labor Statistics has noted that “Solar photovoltaic installers” and “Wind turbine service technicians” are the fastest growing jobs in the US and are each expected to grow about 100% over the next decade.

Wind and solar have enjoyed favorable tax credits and incentives, which arguably have allowed them to grow faster than they otherwise would. Both wind and solar projects can claim the Investment Tax Credit (ITC), which allows the project owner to offset 30% of the installation costs of the

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project, dollar for dollar, on their taxes. This credit can be claimed in full through 2019, after which it steps down to 10% by 2022. Most wind projects claim the Production Tax Credit (PTC) instead of the ITC. The PTC is an “inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year.” The credit lasts for the first 10 years of electricity production. The current value of the PTC is $23/MWh for projects that commenced construction in 2016, but steps down by 20% for projects that commenced construction in 2017, 40% for projects that began construction in 2018, and 60% for projects that started construction in 2019.

Energy storage

Cheap energy storage is often seen as the “missing link” technology that will usher in a future of renewables-based, low-carbon energy. The Federal Energy Regulatory Commission recently passed a rule allowing energy storage systems to participate in wholesale electricity markets as both a buyer and a seller. While this development is important for energy storage systems’ business case, prices still need to decline for this technology to be viable on a large scale. Energy storage systems linked to renewable energy systems, like wind and solar, are starting to displace “peaking” power plants that only operate a fraction of the year when electricity is in great demand and prices are high. However, these peaking power plants only produce about 1% of total delivered US electricity. To compete in

39. Id.
41. Id.
42. Id.
43. Id.
46. Id.
the bulk energy markets, the delivered price of energy from energy storage systems will likely need to fall by about half.\footnote{Id.}

\textit{Electric vehicles}


\textit{Conclusion}

The past decade has seen significant changes in many US energy sectors. Increasing domestic production of oil and gas has changed global energy flows and has directly influenced how the US generates electricity. Cheap natural gas and low-marginal cost renewables are displacing aging coal and nuclear power plants. If these changes persist, future generations might look back on the current decade as being as disruptive and transformative as the energy crises of the 1970’s.

Emerging technologies such as electric vehicles and distributed generation and storage could further exacerbate current trends as the interdependencies of different economic sectors grow. The current pace of change is significant and will likely lead to an energy future that is much different than the not-so-distant past.