

Oil and Gas, Natural Resources, and Energy Journal


Volume 4 | Number 4

November 2018

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Recommended Citation

Joshua D. Rhodes, PhD, *The State of the US Energy Sector*, 4 OIL & GAS, NAT. RESOURCES & ENERGY J. 547 (2018), <https://digitalcommons.law.ou.edu/onej/vol4/iss4/4>

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ONE J

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VOLUME 4

NUMBER 4

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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1. U.S. ENERGY INFO. ADMIN., *Petroleum & Other Liquids: U.S. Field Production of Crude Oil*, <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS1&f=A> (last updated Sept. 28, 2018).

2. U.S. ENERGY INFO. ADMIN., *Natural Gas Data: U.S. Natural Gas Gross Withdrawals*, <https://www.eia.gov/dnav/ng/hist/n9010us2a.htm> (last updated Sept. 28, 2018).

3. See U.S. ENERGY INFO. ADMIN., *Annual Energy Report*, <https://www.eia.gov/totalenergy/data/annual/showtext.php?t=ptb0802a> (last updated Sept. 27, 2012).

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's⁴ and the US is now a net exporter of natural gas for the first time since the 1950's⁵ (Figure 1).

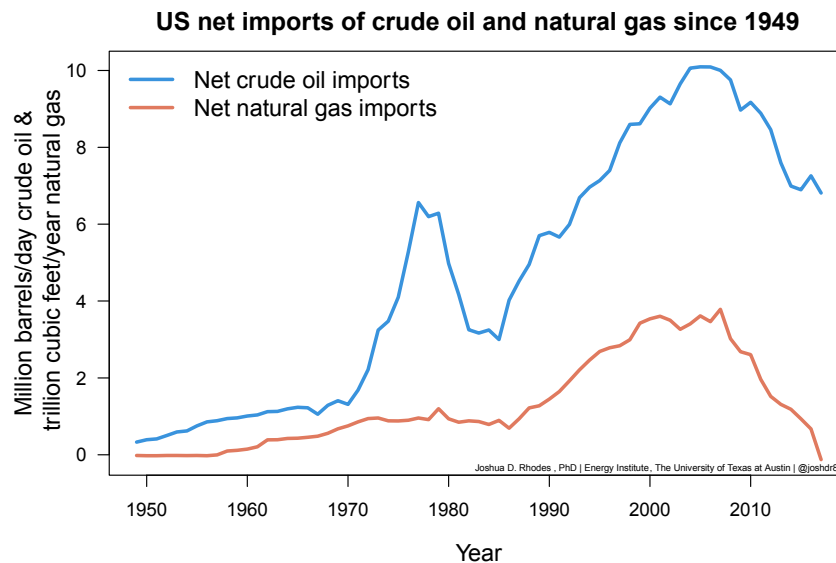


Figure 1: US net imports of crude oil and natural gas.

As the world's largest consumer and producer of both oil⁶ and natural gas⁷, the domestic US energy boom has had profound implications for global energy markets.

4. U.S. ENERGY INFO. ADMIN., *Petroleum & Other Liquids Data: U.S. Net Imports of Crude Oil*, <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRNTUS2&f=A> (last updated Sept. 28, 2018).

5. U.S. ENERGY INFO. ADMIN., *Total Energy Data: Natural Gas Overview Table 4.1*, <https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T04.01#/?f=A&start=1949&end=2017&charted=8>.

6. U.S. ENERGY INFO. ADMIN., *Frequently Asked Questions*, <https://www.eia.gov/tools/faqs/faq.php?id=709&t=6> (last updated Apr. 9, 2018).

7. The Central Intelligence Agency World Factbook, *Country Comparison: Natural Gas – Consumption*, <https://www.cia.gov/library/publications/the-world-factbook/rankorder/>

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 fall⁸. Natural gas prices, while volatile in the past, are expected to remain low in the near future, within a range of \$3—5/mmbtu⁹ 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 solar¹² power. These changes have triggered significant reductions in the carbon intensity of the US energy sector.

2250rank.html (last visited Oct. 30, 2018) (ranking counties by natural gas consumption; current through 2015-16); *see also* U.S. ENERGY INFO. ADMIN., *Today in Energy: United States Remains The World's Top Producer Of Petroleum And Natural Gas Hydrocarbons*, <https://www.eia.gov/todayinenergy/detail.php?id=36292> (May 21, 2018).

8. *See* Maya Weber, *Natural Gas Production Records On The Way, Says US EIA, Pointing To Efficiency*, S&P GLOBAL, <https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/071118-natural-gas-production-records-on-the-way-says-us-eia-pointing-to-efficiency> (July 11, 2018) (citations omitted).

9. 1 mmbtu = 1 million British Thermal Units

10. *See* U.S. ENERGY INFO. ADMIN., *Annual Energy Outlook 2018: with projections to 2050 62 et seq.* (Feb. 6, 2018) (available at <https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf>, Reference case, pg. 29).

11. *See* Figure 2 below.

12. *See* Figure 3 below. This includes behind the meter solar PV.

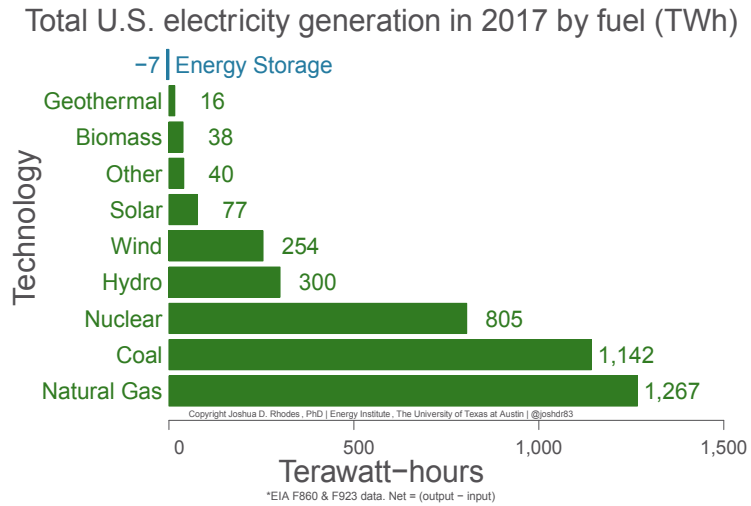


Figure 2: Total US electricity generation in 2017 by fuel.

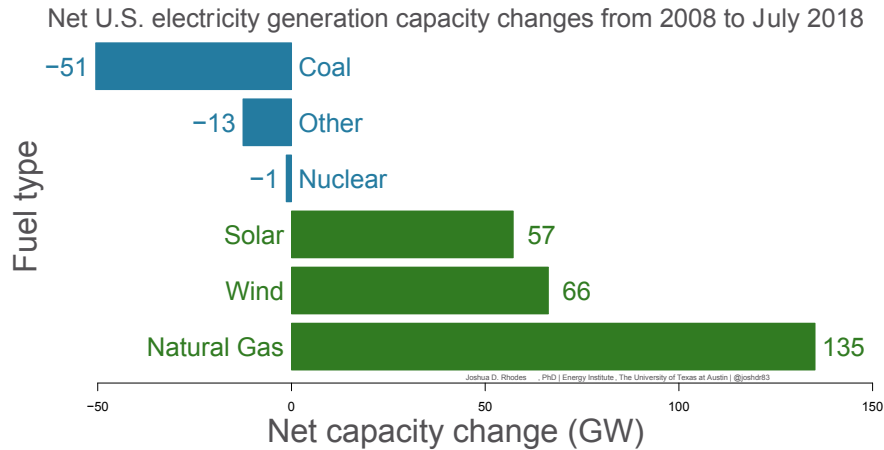


Figure 3: Net change in power plant capacity in the US electricity sector. Other includes oil-based generators, biomass, etc.

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 US¹³. Perhaps more telling, as of August, 2017, only one small coal power plant was under construction in the United States¹⁴, a combined heat and power plant for the University of Alaska, Fairbanks¹⁵. 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 aging¹⁶, 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 provision¹⁷ 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 US¹⁸. For example, Southern Company, a coal-heavy electric

13. U.S. ENERGY INFO. ADMIN., *Today in Energy: EIA Forecasts Natural Gas to Remain Primary Energy Source for Electricity Generation*, <https://www.eia.gov/todayinenergy/detail.php?id=34612> (Jan. 22, 2018).

14. Benjamin Storrow, *Will the U.S. Ever Build Another Big Coal Plant?*, SCIENTIFIC AMERICAN (Aug. 21, 2017) <https://www.scientificamerican.com/article/will-the-u-s-ever-build-another-big-coal-plant/>.

15. Alex DeMarban, *There's only one coal plant being built in the nation, and it's at UAF*, Anchorage Daily News (Sept. 4, 2018) <https://www.adn.com/business-economy/energy/2017/09/04/theres-only-one-coal-plant-being-built-in-the-nation-and-its-at-uaf/>

16. Joshua Rhodes, *The Old, Dirty, Creaky US Electric Grid Would Cost \$5 Trillion To Replace. Where Should Infrastructure Spending Go?*, THE CONVERSATION (March 16, 2017), <https://theconversation.com/the-old-dirty-creaky-us-electric-grid-would-cost-5-trillion-to-replace-where-should-infrastructure-spending-go-68290>

17. Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64510 (proposed October 23, 2015) (to be codified at 40 C.F.R. pts. 60, 70, 71, and 98).

18. Joshua Rhodes, *New EPA Rule Unlikely to Stem the Tide Against Coal*, AXIOS (Aug. 23, 2018), <https://www.axios.com/new-epa-rule-unlikely-to-stem-the-tide-against-coal-d51f616b-302d-43e8-b866-62c14c31f21c.html>.

utility in the Southeast US, has indicated that the change in this rule would not alter the company's plans to decarbonize its generation fleet¹⁹.

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 1978²⁰. 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 plants²², and can be built for about one-third the price²³. 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 demands²⁴. Moreover, as more variable renewables come online, the value of natural gas' flexibility will likely increase²⁵.

19. Rod Kuckro & Kristi E. Swartz, *Utilities are Decarbonizing. Will Trump Rule Change That?*, E&E NEWS, <https://www.eenews.net/stories/1060094829>

20. The Fuel Use Act of 1978 restricted the construction of new baseload natural gas power plants.

21. U.S. ENERGY INFOR. ADMIN., *Repeal of the Powerplant and Industrial Fuel Use Act (1987)*, https://www.eia.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/repeal.html

22. U.S. ENERGY INFOR. ADMIN., *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).

23. U.S. ENERGY INFOR. ADMIN., *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).

24. Miguel Angel Gonzales-Salazar, Trevor Kristen, & Lubos Prchlik, *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).

25. F. Teng, D. Pudjianto, G. Strbac, F. Ferretti and R. Bove, "Assessment of the value of plant flexibility in low carbon energy system," *3rd Renewable Power Generation Conference (RPG 2014)*, Naples, 2014, 1-6. (doi available at: 10.1049/cp.2014.0879); See Fei Teng et al., *Assessment of the value of plant flexibility in low carbon energy system*, 3rd Renewable Power Generation Conference (2014) (conference paper).

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 years²⁶.

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% completion³⁰. The only nuclear power plant under active construction in the US is the Georgia Power Vogtle Electric Generating Plant, units #3 and #4³¹, but these units are estimated to have cost overruns of over 100% and final costs are estimated to be about \$27 billion dollars³².

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>).

27. Vaclav Smil, “Too Cheap to Meter” Nuclear Power Revisited, IEE Spectrum (Sep. 26, 2016), <https://spectrum.ieee.org/energy/nuclear/too-cheap-to-meter-nuclear-power-revisited>.

28. TENNESSEE VALLEY AUTHORITY, *Watts Bar Nuclear Plant*, <https://www.tva.gov/Energy/Our-Power-System/Nuclear/Watts-Bar-Nuclear-Plant> (last visited Oct. 30, 2018).

29. See Michael Hiltzik, *America’s first ‘21st century nuclear plant’ already has been shut down for repairs*, LOS ANGELES TIMES, (May 8, 2017), <http://www.latimes.com/business/hiltzik/la-fi-hiltzik-nuclear-shutdown-20170508-story.html>.

30. Brad Plumer, *U.S. Nuclear Comeback Stalls as Two Reactors Are Abandoned*, THE NEW YORK TIMES (July 31, 2017), <https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html>.

31. U.S. ENERGY INFOR. ADMIN., ELECTRICITY ANALYSIS & PREDICTIONS: PRELIMINARY MONTHLY ELECTRIC GENERATOR INVENTORY (BASED ON FORM EIA-860M AS A SUPPLEMENT TO FORM EIA-860) (2018), <https://www.eia.gov/electricity/data/eia860M/> Spreadsheet: August 2018, Tab: Planned

32. Russell Gold, *Southern Co. Earnings Hurt by Cost Overruns at Nuclear-Power Plant*, *Wall Street Journal* (Aug. 8, 2018) <https://www.wsj.com/articles/southern-co-earnings-hurt-by-cost-overruns-at-nuclear-power-plant-1533742372>

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, ID³³.

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 makes it attractive to investors via long-term (10+ year) fixed-price contracts that allow for project risk to be lowered.³⁴ 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.³⁵ 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 US³⁶ and are each expected to grow about 100% over the next decade³⁷.

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

33. U.S. ENERGY INFOR. ADMIN., *ELECTRICITY ANALYSIS & PREDICTIONS: PRELIMINARY MONTHLY ELECTRIC GENERATOR INVENTORY* (BASED ON FORM EIA-860M AS A SUPPLEMENT TO FORM EIA-860) (2018), <https://www.eia.gov/electricity/data/eia860M/> (Spreadsheet: August 2018, Tab: Planned).

34. See NATIONAL RENEWABLE ENERGY LAB, *Wind Energy Finance in the United States: Current Practice and Opportunities* at 5 (2017), <https://www.nrel.gov/docs/fy17osti/68227.pdf>.

35. U.S. ENERGY INFOR. ADMIN., *U.S. ELECTRIC GENERATING CAPACITY INCREASE IN 2016 WAS LARGEST NET CHANGE SINCE 2011* (2018) <https://www.eia.gov/todayinenergy/detail.php?id=30112>.

36. U.S. DEPT. OF LABOR BUREAU OF LABOR STATISTICS, *Occupational Outlook Handbook: Fastest Growing Occupation*, <https://www.bls.gov/ooh/fastest-growing.htm> (last modified Apr. 13, 2018).

37. U.S. Dept. of Labor Bureau of Labor Statistics, *Occupational Outlook Handbook: Solar Photovoltaic Installers Summary*, <https://www.bls.gov/ooh/construction-and-extraction/solar-photovoltaic-installers.htm> (last modified Jul. 25, 2018).

project, dollar for dollar, on their taxes.³⁸ This credit can be claimed in full through 2019, after which it steps down to 10% by 2022.³⁹ 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.”⁴⁰ The credit lasts for the first 10 years of electricity production.⁴¹ The current value of the PTC is \$23/MWh⁴² 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 2019.⁴³

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.⁴⁴ 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.⁴⁵ 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.⁴⁶ To compete in

38. DEPT. OF ENERGY, *Business Energy Investment Tax Credit (ITC)*, <https://www.energy.gov/savings/business-energy-investment-tax-credit-itc> (last visited Oct. 30, 2018) (citation omitted).

39. *Id.*

40. DEPT. OF ENERGY, *Renewable Electricity Production Tax Credit (PTC)*, <https://www.energy.gov/savings/renewable-electricity-production-tax-credit-ptc> (last visited Oct. 30, 2018) (citation omitted).

41. *Id.*

42. *Id.*

43. *Id.*

44. FED. ENERGY REG. COMM., OPEN COMMISSION MEETING STAFF PRESENTATION ITEM E-1 (Feb. 15, 2018), (available at <https://www.ferc.gov/industries/electric/indus-act/rto/02-15-18-E-1-presentation.pdf> (last visited Oct. 30, 2018)).

45. Joshua Rhodes, *Energy Storage Is Coming, But Big Price Declines Still Needed*, FORBES (Feb. 18, 2018), <https://www.forbes.com/sites/joshuarhodes/2018/02/18/energy-storage-coming-but-big-price-declines-still-needed/#845c8a55e1d3>.

46. *Id.*

the bulk energy markets, the delivered price of energy from energy storage systems will likely need to fall by about half.⁴⁷

Electric vehicles

Electric vehicles have the potential to disrupt multiple energy markets simultaneously because they substitute one major energy source, oil⁴⁸, for another, electricity. In 2016, U.S. drivers logged over 3 trillion miles⁴⁹ consuming approximately 140 billion gallons of gasoline⁵⁰. High penetrations of electric vehicles have the potential to significantly increase electricity consumption, and some areas of the US electric grid, like California and New England, might be stressed more than others.⁵¹

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.

47. *Id.*

48. Bloomberg New Energy Finance, *Electric Vehicle Outlook 2018*, <https://about.bnef.com/electric-vehicle-outlook/#toc-download> (last visited Nov. 15, 2018).

49. U.S. DEPARTMENT OF TRANSPORTATION: FEDERAL HIGHWAY ADMINISTRATION, *3.2 TRILLION MILES DRIVEN ON U.S. ROADS IN 2016*, (2018) <https://www.fhwa.dot.gov/pressroom/fhwa1704.cfm>.

50. U.S. ENERGY INFOR. ADMIN., *FREQUENTLY ASKED QUESTIONS: HOW MUCH GASOLINE DOES THE UNITED STATES CONSUME?*, <https://www.eia.gov/tools/faqs/faq.php?id=23&t=10> (last updated Aug. 31, 2018).

51. F. Todd Davidson, *Electric Vehicles Are Coming, And New England And California Better Watch Out*, FORBES (Nov. 5, 2018), <https://www.forbes.com/sites/ftodd-davidson/2018/11/05/electric-vehicles-are-coming-and-new-england-and-california-better-watch-out/#31c1a94c2c41>.