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Before the U.S. Senate
Committee on Energy and Natural Resources

Full Committee Hearing to
Examine the Electric Sector in a Changing Climate

March 5, 2019

Testimony

Good morning, Chairman Murkowski, Ranking Member Manchin, and Members of the Committee. My name is Susan Tierney,[1] and I am a Senior Advisor in the Denver office of Analysis Group, an economic consulting firm where I specialize on policy, economics and environmental issues associated with the electric industry.

Thank you for inviting me to testify at this important Senate hearing on conditions in the electric sector in a changing climate. I am testifying on my own behalf at today's hearing.

I understand that the Committee seeks to foster a constructive discussion on the need to address climate change, on its impacts on the electric sector, and on the need for workable solutions and progress toward reducing greenhouse gas ("GHG") emissions related to power production and other energy uses. The electric sector has a critical role to play in those solutions, so this is an important area of inquiry by the Committee and by others in Congress.

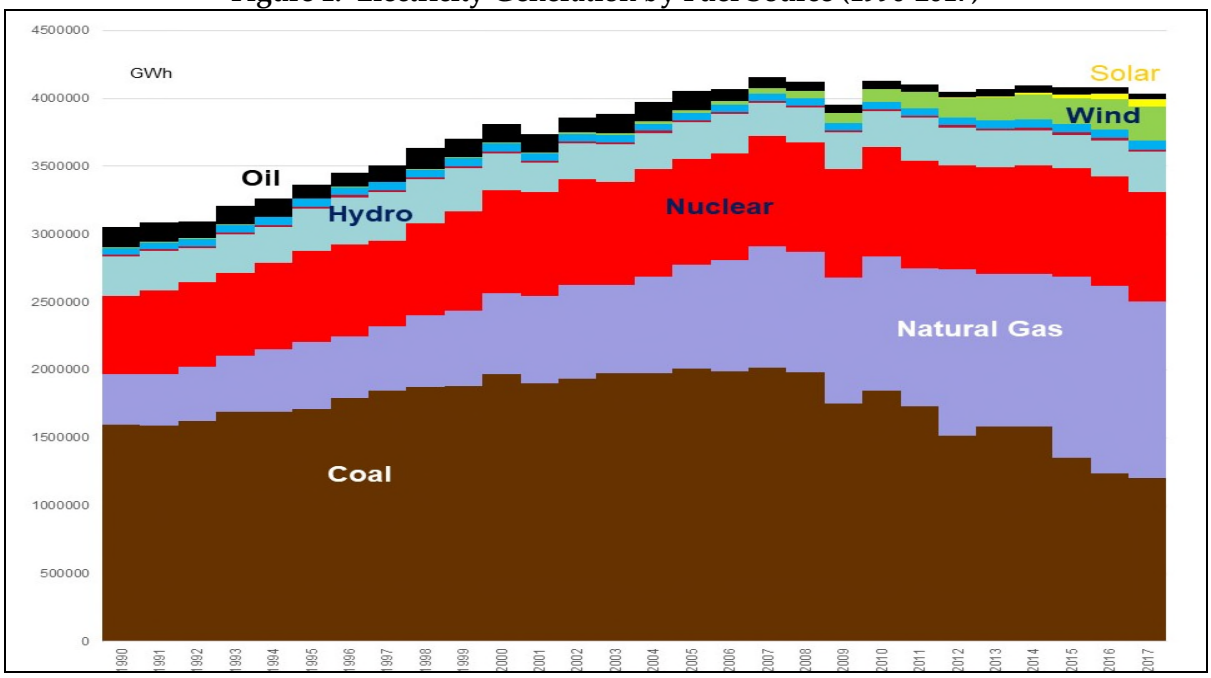
At the hearing, I have been asked to describe trends in the U.S. electric industry that are affecting emissions of greenhouse gases, and I am honored to have this opportunity to help inform the record today.

It is well understood that the U.S. electric power system is undergoing a major transition. Over the past decade, changes have been driven predominantly by low natural gas prices, which have led to increased use of gas for power generation. Declining costs of wind and solar projects, along with flat demand—even as the economy has grown—have also had significant impacts on the changing electricity mix.

Figures 1 and 2 show the changing resource mix in the nation's electricity supply since 1990 (Figure 1) and the more recent trends in each fuel source's role in electricity production between 2005 and 2017 (Figure 2).

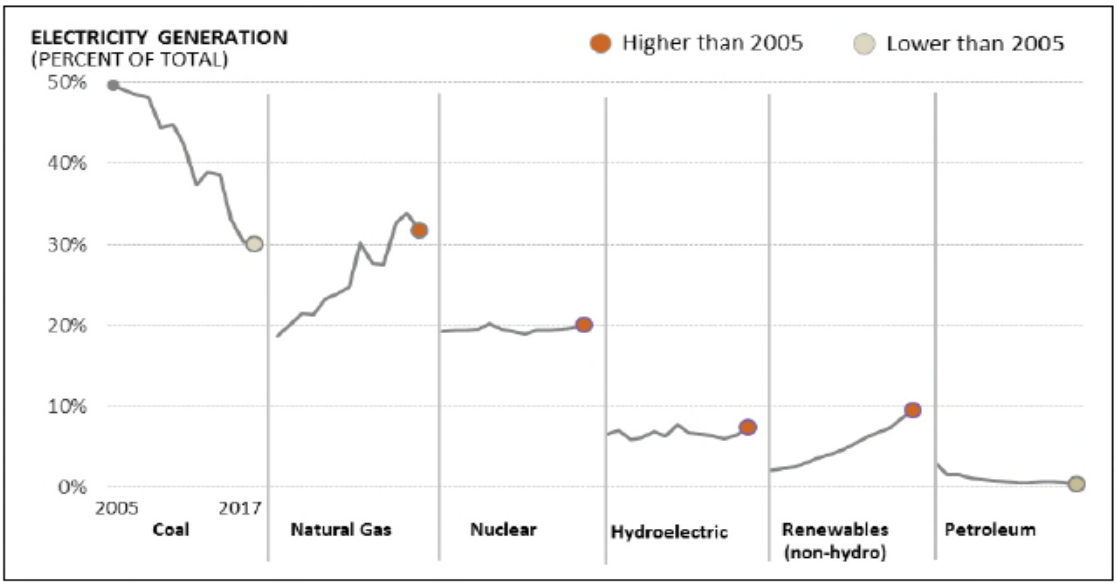
[1] I have provided my bio at the end of this testimony.

Figure 1: Electricity Generation by Fuel Source (1990-2017)



Source: Energy Information Adminstration ("EIA") data on annual electricity generation by fuel.

Figure 2: Percentage of Electricity Generation by Fuel Type (2005-2017)

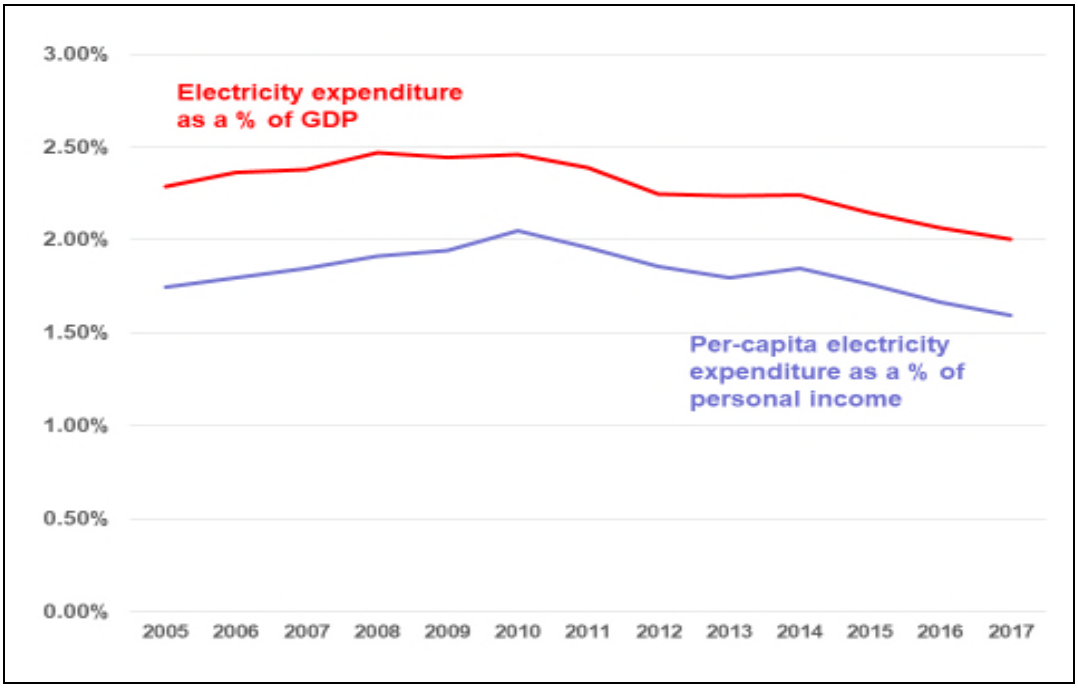


Source: Congressional Research Service ("CRS"), "U.S. Carbon Dioxide Emissions in the Electricity Sector: Factors, Trends, and Projections," January 7, 2019.

There is much good news in these trends: Today's electric system is more diverse than in the past (as shown in Figure 2), continues to provide highly reliable service to consumers, is enabling greater

economic bang per buck[2] spent on electricity (Figure 3), and has contributed positively to lowering consumers' electricity bills in the past decade (Figure 3).

Figure 3: U.S. Electricity Payments Relative to Gross Domestic Product and Personal Income (2005-2017)

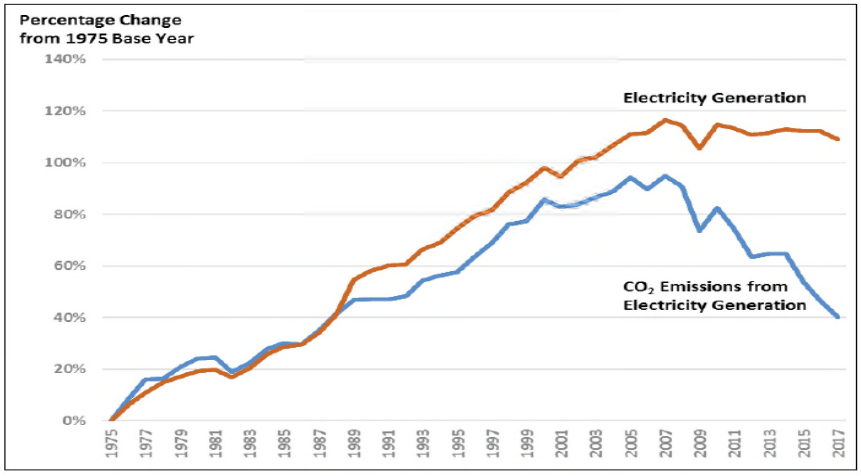


Sources: EIA for electricity revenues; Bureau of Economic Analysis for GDP; Census Bureau for Personal Income.

Another positive consequence of these changes is that carbon emissions from U.S. electricity production have declined substantially over this past decade. Figure 4 shows that even as electricity generation and use have remained relatively flat over the past decade, carbon dioxide (CO_2) emissions from power production declined by approximately 28 percent from 2005 through 2017.[3] So far, these reductions are in line with international commitments that U.S. has made in recent years.[4]

[2] Measured in terms of dollar of Gross Domestic Product ("GDP") per dollar spent on electricity.
[3] EIA, "Carbon dioxide emissions from the U.S. power sector have declined 28% since 2005," *Today in Energy*, December 21, 2018; Congressional Research Service, "U.S. Carbon Dioxide Emissions in the Electricity Sector: Factors, Trends, and Projections," January 7, 2019, page 8 (hereafter "CRS CO_2 Report").
[4] Under the Paris Agreement, "the United States pledged (in 2015) to reduce GHG emissions by 26%-28% by 2025 compared to 2005 levels.7In addition, pursuant to the Copenhagen Accord, the United States pledged (in 2009) to reduce GHG by 17% below 2005 levels by 2020." CRS CO^2 Report, pages 1-2.

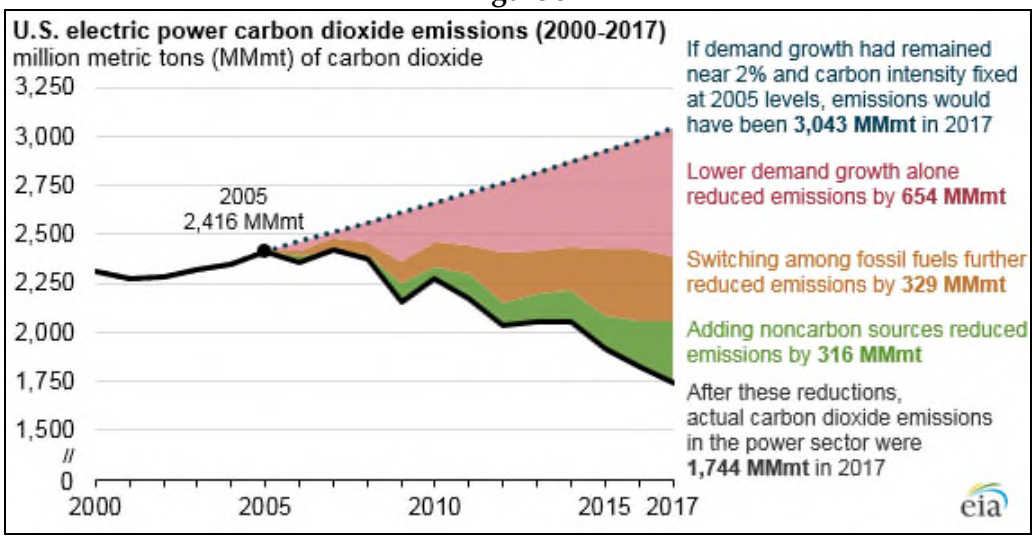
Figure 4: Percentage Change in Electricity Generation and Power-Sector CO_2 Emissions (1975-2017)



Source: CRS CO_2 Report.

Power-sector CO_2-emission reductions have resulted from multiple factors, as indicated in a recent analysis by the EIA. As shown in Figure 5 (excerpted from EIA's report), emissions reductions since 2005 from power generation stem from flat electricity demand (relative to prior norms of electricity growth that were closer to 2 percent per year), from switching among fossil fuels (including shifts from coal- and oil-fired power plants to output at generating units that use natural gas), and from adding carbon-free electricity sources (like wind, solar, and -nuclear capacity).[5]

Figure 5

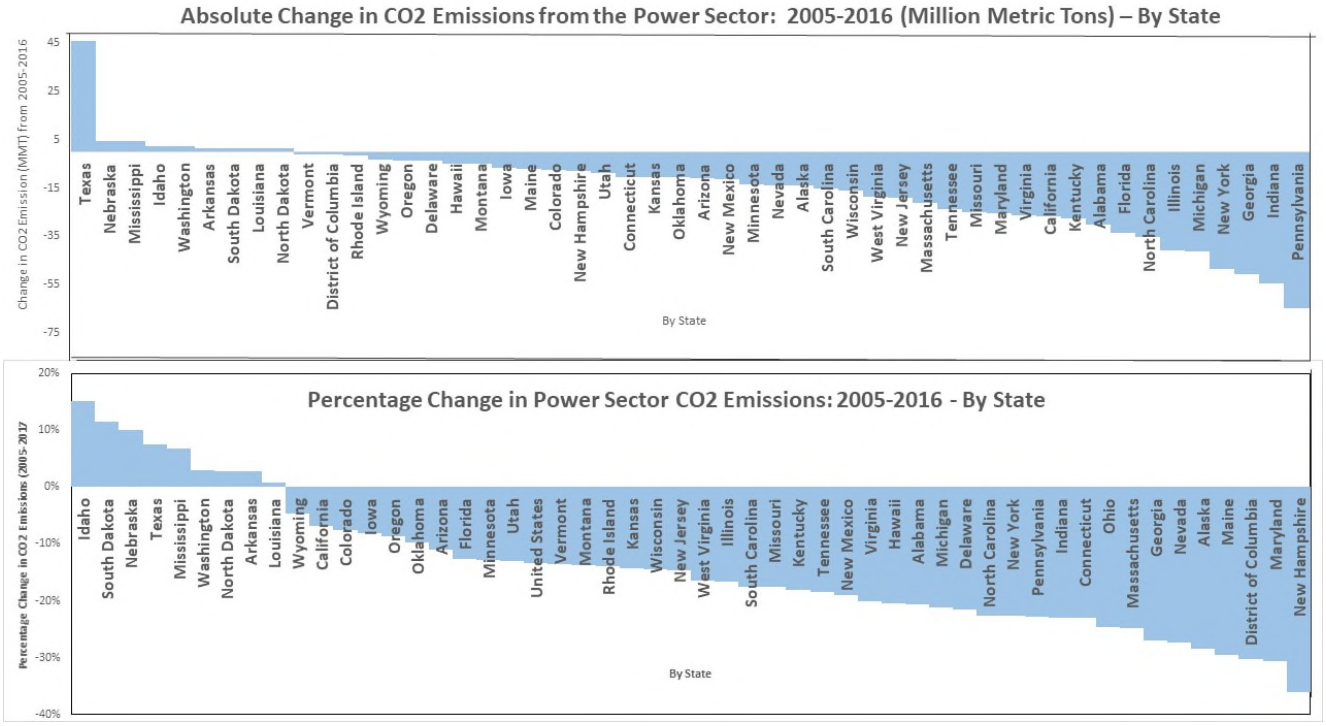


Source: EIA, "Carbon dioxide emissions from the U.S. power sector declined 28% since 2005," October 29, 2018.

[5] I note that had several financially distressed existing nuclear plants (e.g., the Ginna and Fitzpatrick nuclear units in New York, and the Quad Cities and Clinton nuclear stations in Illinois) retired in recent years in the absence of state actions to compensate those plants for their zero-carbon generation, these overall emission reductions would have been much modest.

These power-sector CO_2 emissions reductions have been coming from almost all corners of the United States. As shown in Figure 6, nearly every state experienced a reduction in CO_2 emissions from in-state power plants from 2005 through 2016. (The top section of Figure 6 shows the absolute reduction in CO_2 emissions (in tons), comparing 2016 to 2005 emission levels, while the bottom section of Figure 6 indicates the percentage change in each state's power-sector CO_2 emissions from 2005 to 2016.) Overall, the U.S. improved the carbon footprint of the electricty sector, lowering CO_2 emissions per MWh of electricity by 25 percent from 2005 to 2016; all but two states lowered their carbon intensity.[6]

Figure 6: Reduction in CO_2 Emissions from the Power Sector by State: 2005-2016



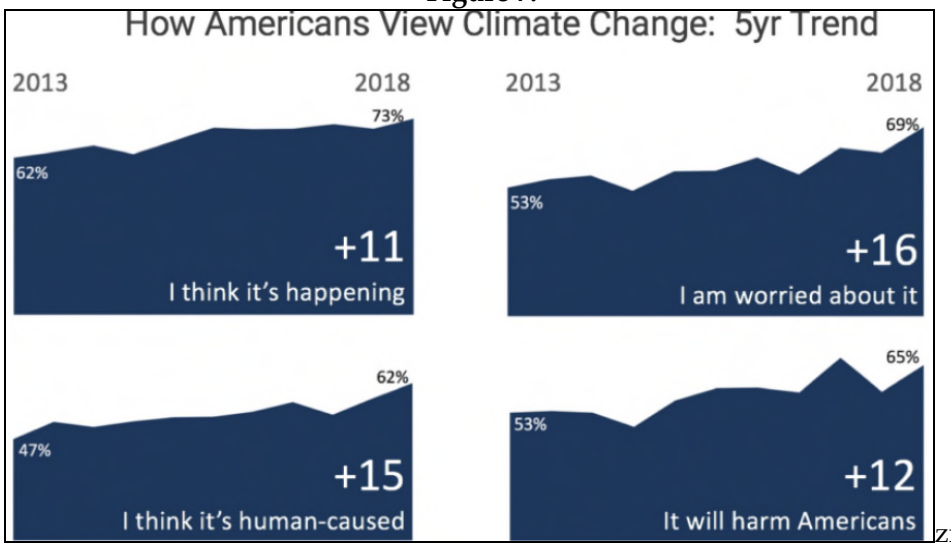
Source: EIA data on emissions by state, https://www.eia.gov/environment/emissions/state/

Many developments are occuring around the country that promise to continue these trends. For example, increasing majorities of Americans now believe that climate change is occuring, that they are worried about it, that it is caused by human activity, and that it will harm Americans.[7] (See Figure 7.)

[6] According to EIA data, all but two states improved (i.e., lowered) their carbon intensity from 2005-2016. North Dakota showed the biggest improvement, with a 43-percent reduction in CO_2 per Mwh. At the other end of all of the states was Louisiana, with a 5-percent increase in carbon intensity. Most states experienced substantial improvement.

[7] "These increases have occurred across the political spectrum….[These trends] have occurred among Democrats and Republicans (although often to different degrees). For example, the 16-point increase in the proportion of Americans who are worried about global warming is largely the result of increased worry among both moderate/conservative Democrats (+19) and conservative Republicans (+18)." Abel Gustafson, Parrish Bergquist, Anthony Leiserowitz, and Edward Malbach, "A Growing Majority of Americans Think Global Warming is Happening and are Worried," Yale Program on Climate Change Communications, February 21, 2019 (hereafter "Yale February 2019 Climate Note"), http://climatecommunication.yale.edu/publications/a-growing-majority-of-americans-think-global-warming-is-happening-and-are-worried/.

Figure 7:



Source: Yale February 2019 Climate Note

Also, many states have elected to adopt policies to introduce increasing amounts of renewable energy and energy efficiency measures: for example, 29 states, Washington, D.C., and 3 territories have adopted renewable portfolio standards, with many of these jurisdictions having recently increased their targets for renewable energy supply in future years.[8] Some states (e.g., New York, Illinois, Connecticut, New Jersey) have adopted policies intended to retain zero-carbon-emitting generation by helping to assure that these existing nuclear plants remain on line as long as they are safely operating.[9] Many states have firm GHG-emission reduction targets. Hundreds of cities and counties around the country have pledged to reduce greenhouse gas emissions from their own energy use and in their communities.[10] Major corporations have entered into long-term contracts to purchase power from renewable energy projects.[11] More and more consumers are installing rooftop solar systems on their

[8] Database of State Incentives for Renewables and Efficiency (DSIRE) website, http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2018/10/Renewable-Portfolio-Standards-2018.pdf.

[9] National Conference of State Legislatures, "State Action in Support of Nuclear Generation," January 26, 2017, http://www.ncsl.org/research/energy/state-action-in-support-of-nuclear-generation.aspx; Doug Vine, "Promising solutions for zero-emission nuclear power," Center for Climate and Energy Solutions (C2ES), October 31, 2018.

[10] According to the C2ES: "More than 350 Climate Mayors in the U.S. have adopted the Paris Agreement goals for their cities. And more than 100 U.S. cities both large and small have pledged to transition their communities to 100% clean energy. About two-thirds or more of mayors who responded to a recent survey by C2ES and the U.S. Conference of Mayors said they generate or buy renewable electricity to power city buildings or operations, buy green vehicles for municipal fleets, and have energy efficiency policies for municipal buildings. And they want to partner with the private sector do more." https://www.c2es.org/content/city-climate-policy/.

[11] As of December 14, 2018, "publicly announced contracted capacity from corporate power purchase agreements (PPAs), green power purchases, green tariffs, and outright project ownership in the United States cumulatively reached an annual high of 6.43 gigawatts (GW). Facebook, AT&T, Walmart, ExxonMobil and Microsoft lead the clean energy acceleration with the top five highest volume in deals. Facebook [has…] several deals totaling 1,849.5 megawatts (MW), while also breaking all buyer cumulative annual procurement records since deals have been tracked." "Corporate Renewable Energy Procurement Continues to Break Records in 2018," Rocky Mountain Institute, December 14, 2018, https://rmi.org/press-release/corporate-renewable-energy-procurement-continues-to-break-records-in-2018/.

buildings.[12] Around the country, the only new generating facilities planned to be added are either gas-fired or wind and solar, in large part because the costs of clean electric technologies continue to drop (and because of the expectation of many investors that there will eventually be controls on power-sector CO_2 emissions).

These trends point strongly suggest that there will be further GHG-emission reductions from the power sector in the future. Further, the trends offer the opportunity for consumers and suppliers to rely on cleaner electricity supply to provide substantial sources of energy for vehicles, industrial operations and building end uses as technologies and costs of doing so improve in the future, and, in so doing, help to further reduce GHG emissions in other parts of the economy beyond the electric sector.

But even with this past decade's substantial success in reducing CO_2 emissions from the power sector without overall adverse economic impacts to the economy or to consumers, the news is far from uniformly positive and not all groups have benefitted from these changes.

First, the effects of climate change are showing up in dramatic and costly ways around the country. The 2018 National Climate Assessment, published by the federal government at the direction of Congress, concluded that the "Nation's energy system is already affected by extreme weather events, and due to climate change, it is projected to be increasingly threatened by more frequent and longer-lasting power outages affecting critical energy infrastructure and creating fuel availability and demand imbalances. The reliability, security, and resilience of the energy system underpin virtually every sector of the U.S. economy. Cascading impacts on other critical sectors could affect economic and national security."[13] Similar conclusions were reached in 2017 by the National Academies of Sciences, Engineering and Medicine's Committee on Enhancing the Resilience of the Nation's Electric Power Transmission and Distribution System (of which I was a member).[14]

In the past few years, climate change has led to droughts, flooding, sea level rise, wildfires, ice storms, and other impacts.[15] Many of these effects have adversely impacted electric-system (and other energy) infrastructure, disrupting service to consumers and leading in many cases to much worse outcomes (such as in the case of the catastrophic 2017 and 2018 wildfires in California that were triggered by electrical equipment and which led to loss of life, homes, other property, and entire communities).

Second, GHG-emission reductions are not happening fast or deeply enough. In fact, U.S. power-sector CO_2 emissions actually increased in 2018 relative to 2017. (See Figure 8.) According to a new study by Rhodium Group of recent emissions trends, several things contributed to these increases: higher overall electricity use in 2018 compared to 2017; output at gas-fired plants making up for most of the incremental demand as well as for most of the continued reduction of output at coal-fired power plants; and continued additions of wind and solar projects.[16] Summing up these effects, Rhodium concluded

[12] "Nearly 60 GW of total solar capacity now installed. Average annual growth rate of 59% over the last 10 years. Generates enough electricity to power more than 11.3 million homes." Solar Energy Industry Association, https://www.seia.org/solar-industry-research-data.

[13] Fourth National Climate Assessment, Chapter 4 (Energy Supply, Delivery and Demand), 2018. https://nca2018.globalchange.gov/chapter/4/.

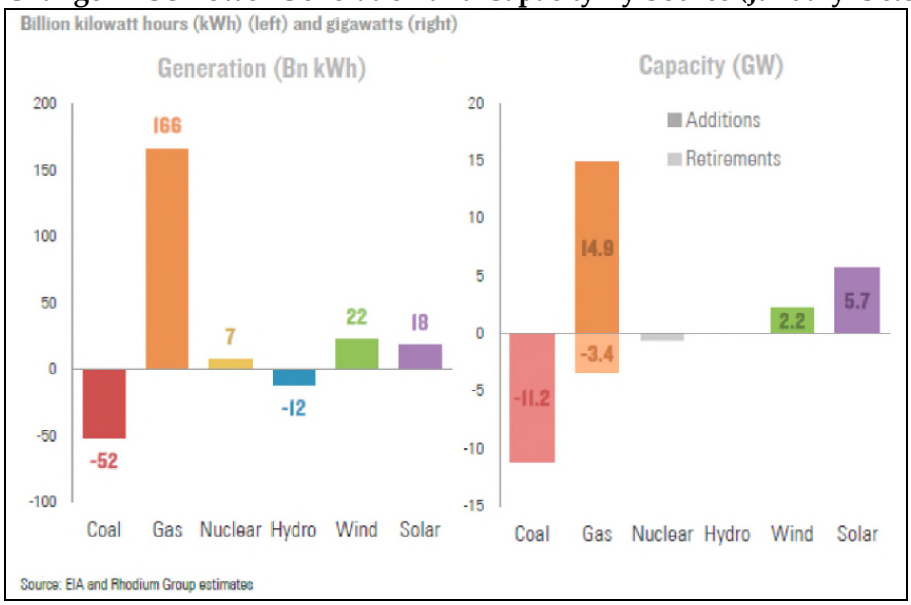
[14] National Academies of Sciences, Engineering, and Medicine, *Enhancing the Resilience of the Nation's Electric System,* The National Academies Press, 2017, https://doi.org/10.17226/24836.

[15] Fourth National Climate Assessment, 2018, https://nca2018.globalchange.gov.

[16] Rhodium Group Staff, "Preliminary US Emissions Estimates for 2018," January 8, 2019. https://rhg.com/research/preliminary-us-emissions-estimates-for-2018/.

that between "January and October, US power companies added a greater share of gas capacity than the share of retired coal capacity, and twice as much gas went online as combined wind and solar capacity additions (including distributed solar) during that period. Natural gas-fired generation increased by 166 billion kWh during the first ten months of the year. That's three times the decline in coal generation and four times the combined growth of wind and solar."

Figure 8: Change in US Power Generation and Capacity By Source (January-October 2018)



Source: Rhodium Group Staff, "Preliminary US Emissions Estimates for 2018," January 8, 2019.

Looking ahead, there is significant need for more urgent action to reduce GHG emissions to levels consistent with avoiding the worst effects of climate change. The current progress is important, in part because it demonstrates what it do-able. But recent federal government estimates of future GHG emissions from the U.S. power sector (and other sectors of the economy) do not forecast emissions reductions at rates or levels anywhere near consistent with such levels.

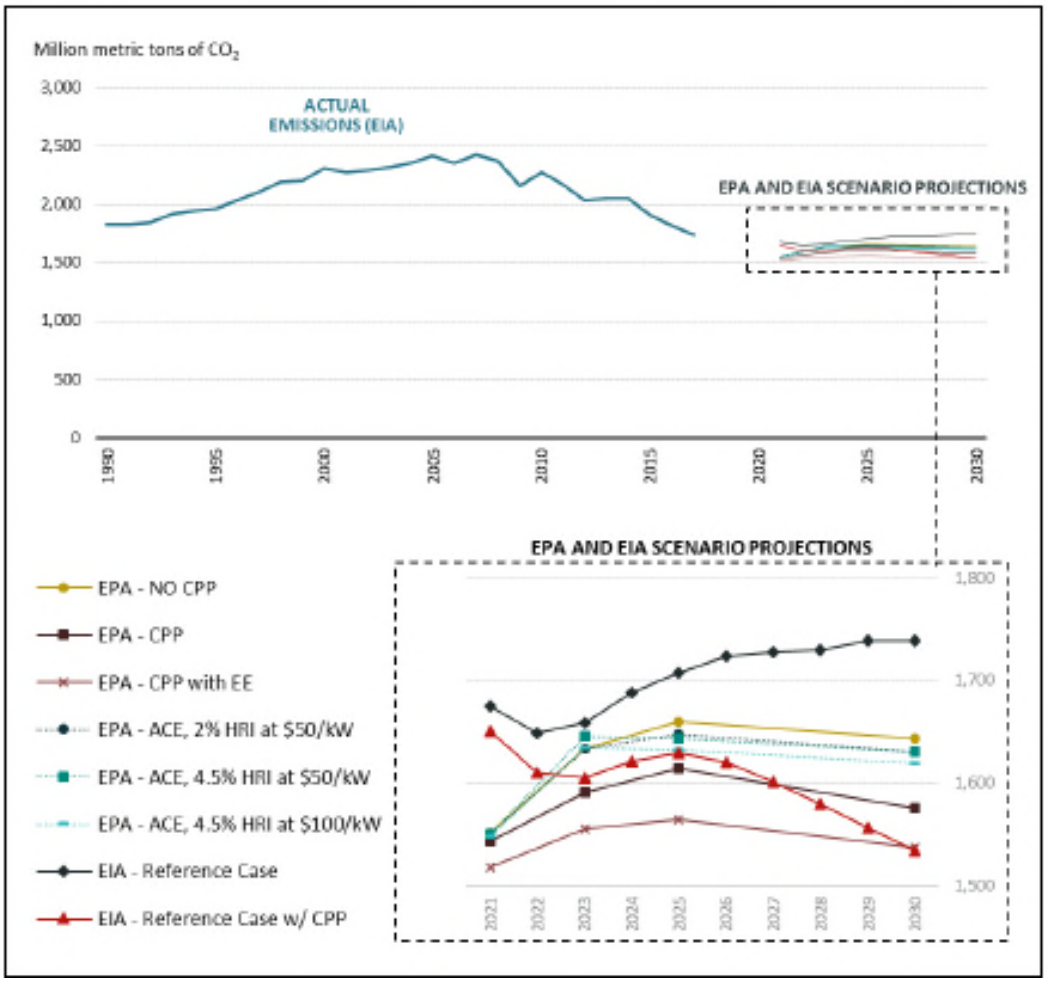
The Congressional Research Service recently summarized various carbon-emission forecasts from a several federal agencies that compare EIA's 2018 reference case (which based on current policy) with other scenario estimates from EIA and from the Environmental Protection Agency ("EPA"). These agency forecasts examine emissions trajectories under alternative assumptions about implementation of the Clean Power Plant ("CPP") versus EPA's proposed Affordable Clean Energy ("ACE") rule. None of these estimtes depict emissions outlooks that are consistent with the need for the U.S. to significantly lower carbon emissions while also increasing vehicles', buildings' and industries' reliance on clean electricity. (See Figure 9.) The recent EIA 2019 Annual Energy Outlook's reference case similarly projects power-sector emissions as being flat, at around 1.5 billion metric tons of CO^2 per year beyond 2020[17]—an outlook that is fundamentally inconsistent with avoiding the worst effects of climate change.

As part of many efforts around the U.S. to address these challenges facing the electric sector in a changing climate, the Senate Energy and Natural Resources Committee can play a critically important role in the near term to raise national ambition and support solutions related to this important issue.

[17] EIA, Annual Energy Outlook 2019, page 103 of the PPT format, https://www.eia.gov/outlooks/aeo/.

Americans' economic security, physical health, and national security depends upon further action to address climate change, and the Committee's jurisdiction over research and development activities at the Department of Energy positions it to play an important role in helping to solve the climate challenge.

Figure 9: Actual and Various Projected CO_2 Emissions from the U.S. Power Sector



Source: CRS CO^2 Report

I hope that as the Committee undertakes its efforts to shine attention on climate change and the role of the power sector in addressing it, the Committee succeeds in cultivating serious, constructive, and pragmatic discussions about clean-energy, low-carbon solutions. As the Committee focuses its spotlight on climate solutions, it will be important to avoid adopting prematurely narrow technological solution sets (such as hard-and-fast commitments to renewable-only solutions) and to create options for the many different technologies and strategies that will be needed to allow Americans to prosper in a low-carbon economy.

Thank you for affording me this opportunity to present this information to the Committee.

Bio of Susan F. Tierney, Ph.D.

I am a Senior Advisor at Analysis Group, Inc., a 850-person economic consulting firm headquartered in Boston, Massachusetts, with other U.S. offices in California, Colorado, Illinois, New York, Texas, and Washington, D.C.

I have been involved in issues related to public utilities, ratemaking and electric industry regulation, and energy and environmental economics and policy for over 25 years. During this period, I have worked on electric and gas industry issues as a utility regulator and energy/environmental policy maker, consultant, academic, and expert witness. I have been a consultant and advisor to private and publicly owned energy companies, grid operators, government agencies, large and small energy consumers, environmental organizations, foundations, Indian tribes, and other organizations on a variety of economic and policy issues in the energy sector.

Before becoming a consultant, I held several senior governmental policy positions in state and federal government, having been appointed by elected executives from both political parties. I served as the Assistant Secretary for Policy at the U.S. Department of Energy. I held senior positions in the Massachusetts state government as Secretary of Environmental Affairs; Commissioner of the Department of Public Utilities; Executive Director of the Energy Facilities Siting Council; and chair of the Board of the Massachusetts Water Resources Authority.

My Masters degree and Ph.D. in regional planning are from Cornell University. I previously taught at the University of California at Irvine and at MIT. I am a Visiting Fellow in Policy Practice at the University of Chicago's Energy Policy Institute; and a member of the advisory councils at New York University's Institute for Policy Integrity and Duke University's Nicholas School for the Environment.

I currently sit on several non-profit boards and commissions, including as: chair of ClimateWorks Foundation and of Resources for the Future; a trustee of the Barr Foundation; and a director of World Resources Institute, the Energy Foundation, and the Keystone Center. I am a member of the Committee on Modernizing the U.S. Electricity System of the National Academies of Sciences, Engineering, and Medicine; NYISO's Environmental Advisory Council. I recently chaired the U.S. Department of Energy's Electricity Advisory Committee and chaired the National Renewable Energy Laboratory's External Advisory Council, and was a member of the National Academy of Sciences committee on resiliency of the U.S. electric system. I was co-lead convening author of the Energy Supply and Use chapter of the Third National Climate Assessment, served on the Secretary of Energy's Advisory Board, and chaired the Policy Subgroup of the National Petroleum Council's study of the North American natural gas and oil resource base.

After 35 years in Boston, I moved with my husband to his home state of Colorado in 2016.