Testimony of
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Committee on Science, Space, and Technology
Subcommittee on Energy

Field Hearing on
How the Domestic Nuclear Industry Boosts Local Economies, Curbs Emissions, and Strengthens National Security

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Shippingport, Pennsylvania

Chairman Lamb, Ranking Member Weber, and members of this subcommittee, thank you for giving me the opportunity to testify.

At Carnegie Mellon University, I am a professor in the Tepper School of Business and in the Engineering College. CMU professor Granger Morgan and I co-direct the Carnegie Mellon Electricity Industry Center. The opinions here are mine and do not necessarily reflect the views of Carnegie Mellon University, or those of any other institution.

I commend you for examining domestic nuclear power's effects on local economies, air emissions, and national security. I've spent over a decade studying our electric power industry, including low-pollution sources of electric power such as wind, solar, hydroelectric, and nuclear.

Federal and state policies have made a large difference in reducing the adverse human health effects of electric power generation, by limiting the emissions of particulate matter, sulfur dioxide, oxides of nitrogen, and mercury; by funding the initial development of techniques to recover natural gas from shale formations; by providing federal tax credits and state quotas for renewable electricity sources; and by investing in the development of nuclear power to generate electricity.

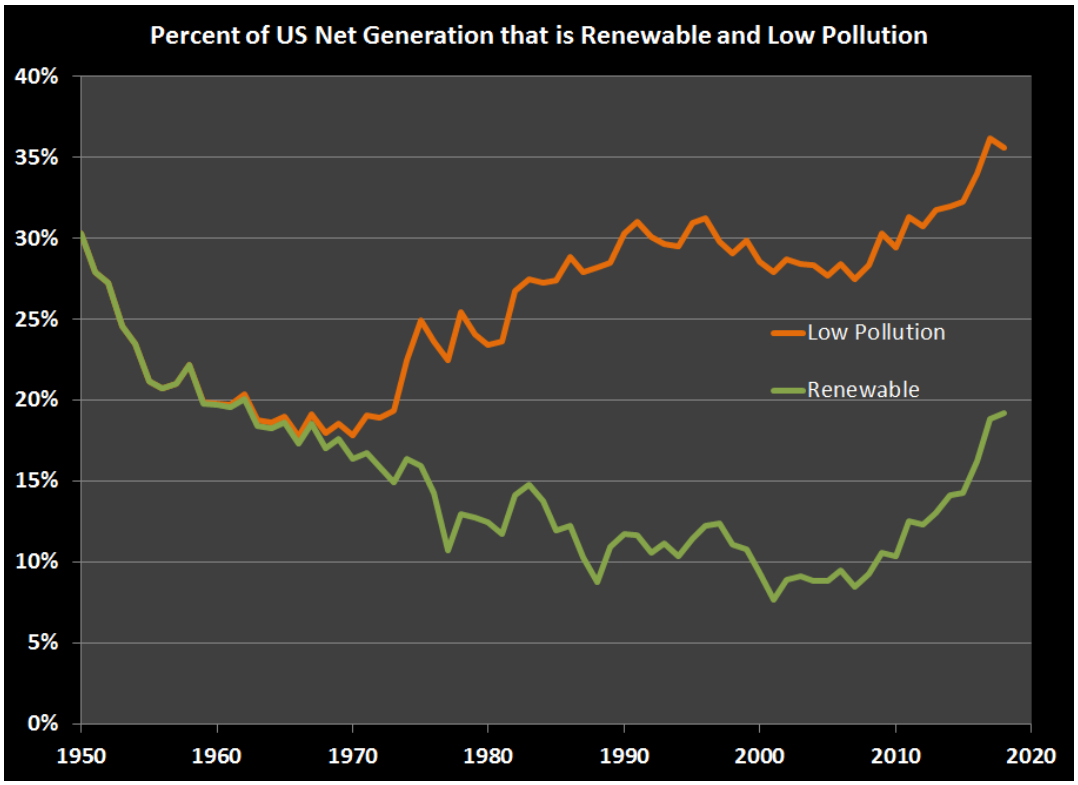
These policies have reduced the number of annual premature deaths due to air pollution from power plants in the USA from well over 40,000 per year when I was growing up to about 10,000 per year now. While particulate matter emissions are still responsible for decreasing Americans' life expectancy by roughly 6 months[1], that reduction in life expectancy is considerably smaller than it used to be.

While much of the public discourse about low-pollution power has focused on renewable generation, "renewable" and "low-pollution" are not synonyms.

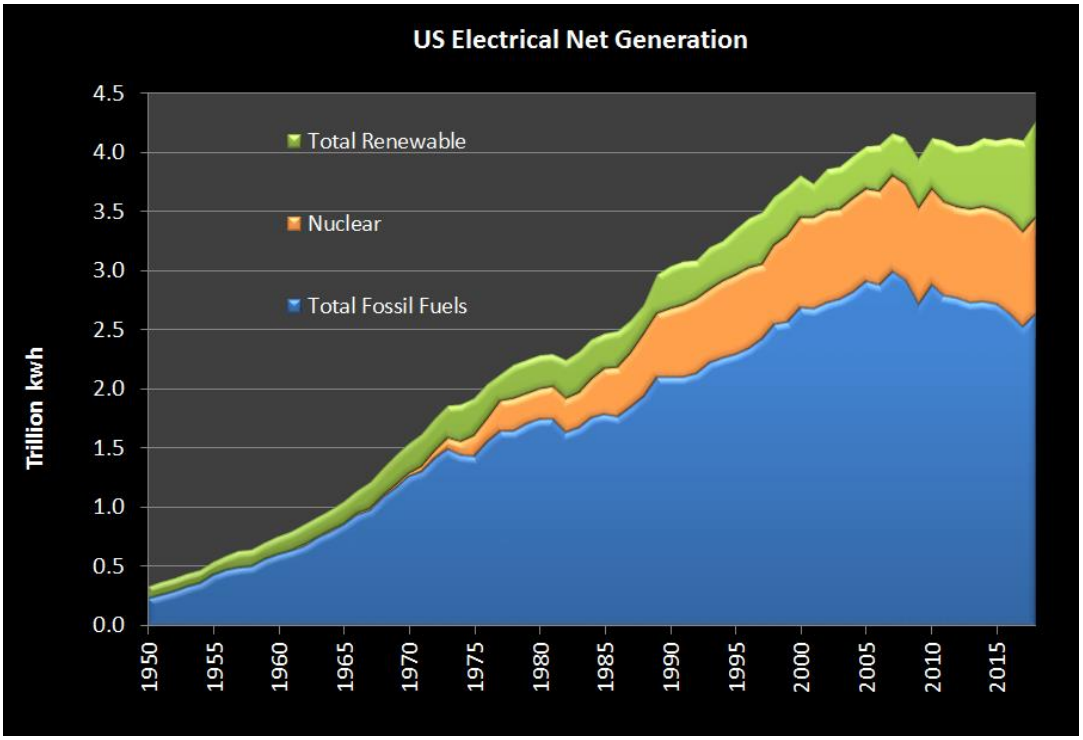
The following graph shows the percentage of the USA's electric power that was generated by renewable sources (water, wind, solar, geothermal) and by low-pollution sources (those plus nuclear power) from 1950 through 2018, according to figures published by the US Energy Information Administration. Renewable energy as a percentage of electricity generation in the United States fell from 30% in 1950 to a low of 8% in 2001, as the market share of hydroelectric power was eroded by fossil fuel generators (largely coal and oil) built to keep up with rapidly increasing demand for electricity. Even though production from the USA's hydroelectric plants tripled from 1950 to 1973, demand for electricity grew nearly six-fold in the same period. It was only in the past decade that wind and later solar added to renewables' market share, bringing the total it up to 17% in 2018.

Nuclear generation today provides half of all low-pollution electric power in the USA.

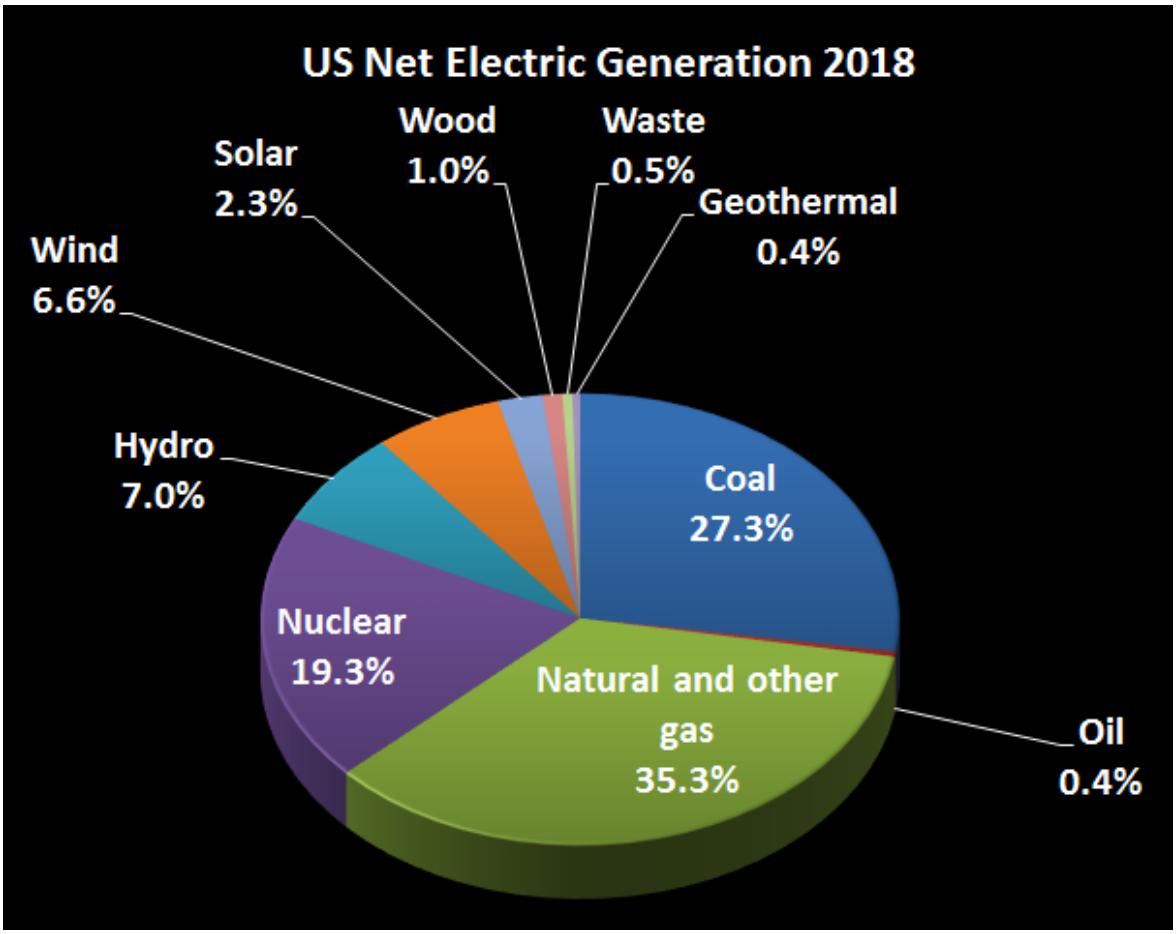
[1] Ambient PM2.5 Reduces Global and Regional Life Expectancy, Joshua S. Apte, Michael Brauer, Aaron J. Cohen, Majid Ezzati, and C. Arden Pope, III, Environmental Science & Technology Letters 2018 5 (9), 546-551, DOI: 10.1021/acs.estlett.8b00360



Coal and oil generation increased by a factor of 5 from 1950 to 1970 to keep up with the demand for electricity. What greatly helped to slow the resulting rapid increase in pollution was the introduction of nuclear power at large scale in the early 1970s.

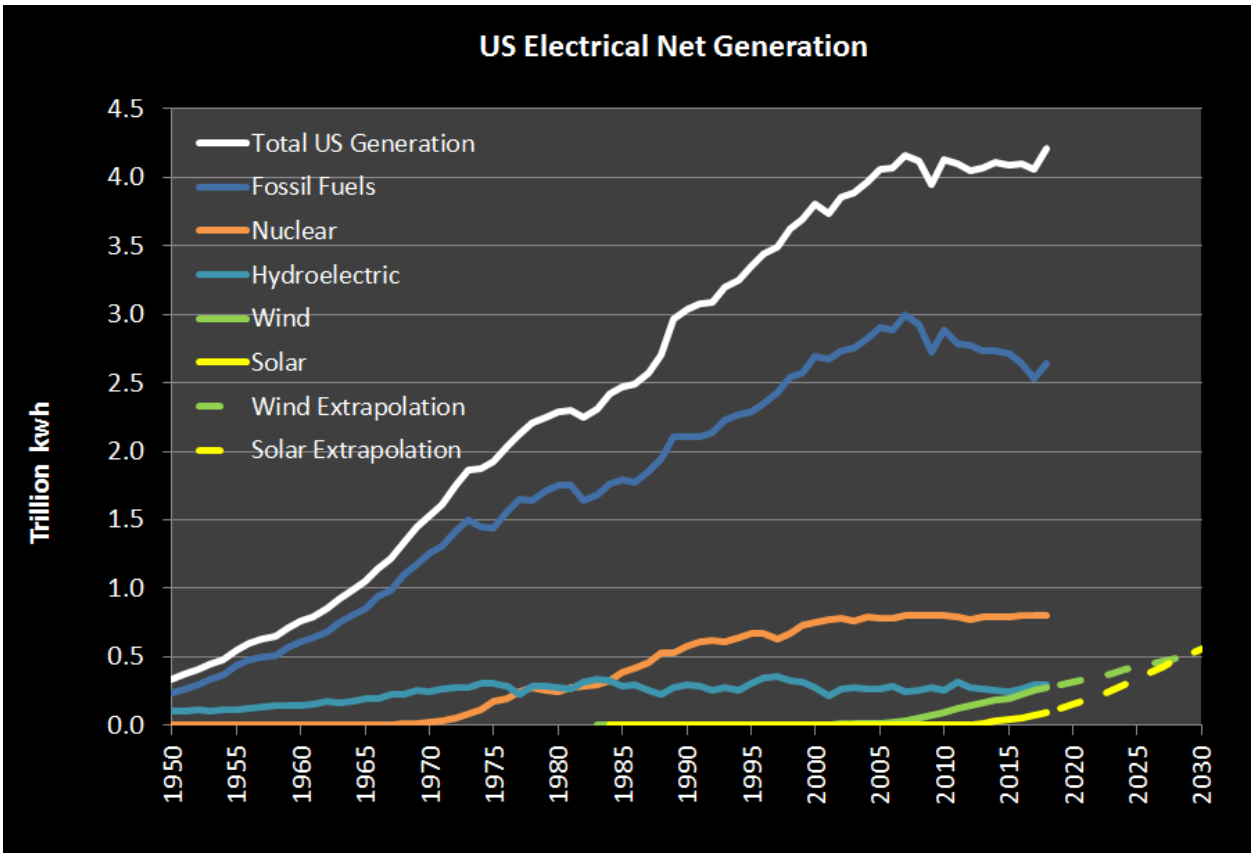


Nuclear power's share of all USA electric power production grew from zero in 1956 to its peak of 21% in 2002. Nuclear power continues to provide 19% of our electricity, while renewables (including hydroelectric) provide 17%.



Renewable energy sources are a key part of the nation's future, but all available low-pollution sources is the best, and most cost effective, way to achieve the goals of reducing air emissions *and* the atmospheric concentration of carbon dioxide.

Wind and solar power have been growing in the past decade. Extrapolating the linear growth of wind and the quadratic growth of solar leads to a significant increase in their generation by 2030, as shown in the figure below.



If demand for electricity stays at the level where it has been since 2007, taken together all renewables—solar, wind, geothermal and hydro—would account for 35% of US electricity generation in 2030 (making the reasonable assumption that hydroelectric power and geothermal won't increase).

That's good, but if the USA's nuclear plants close, by 2030 the net effect would be no increase in low-pollution power. With nuclear, by 2030 we would be at 54% low-pollution electricity. Without nuclear, we would be at only 35%, right where we are today. Clearly, keeping nuclear in the mix is important to a low-pollution future.

Since this hearing is in Pennsylvania, I note that in 2017 39% of Pennsylvania's electricity was produced by nuclear power. The Commonwealth's five nuclear power plants provided 92% of all Pennsylvania's low-pollution power in 2017, the most recent year for which the Energy Information Administration has published state-level data. Because some nuclear plants find they cannot compete against low cost natural gas in today's electricity market, three units, representing 27% of the nuclear generating capacity in the Commonwealth, have announced that they plan to close (the unit at Three Mile Island in 2019 and the two units at Beaver Valley in 2021).

States such as Illinois and New York have recently modified their low-pollution power generation incentive programs to include nuclear plants in the portfolio of low-pollution sources. The US Supreme Court on April 15, 2019 allowed rulings by the 2nd and 7th US Circuit Courts of

Appeals to stand that rejected claims that programs in those two states intrude on the jurisdiction of the Federal Energy Regulatory Commission. Thus, programs such as the Illinois and New York ones appear to be acceptable state prerogatives, and other states currently are deciding what role to play in determining whether low-pollution power incentives should be applied.

At the federal level, there are a number of actions that could be useful if nuclear power is going to continue to supply low-pollution power at scale in the USA.

The responsibility for storage of long-lived spent nuclear fuel from civilian and military reactors is a federal responsibility that has not been adequately discharged. While the nation continues to work on permanent solutions for this problem, the situation at civilian power reactors could be improved considerably by developing long-term storage that would allow spent fuel that is now piling up in storage at individual reactor sites to be moved to much safer centrally managed locations.

The US Department of Energy and its national laboratories have a large role to play in understanding how the materials used in nuclear power plants can be monitored as the plants enter middle age. Continuing DOE research into the ways nuclear fuel elements can become more tolerant of transient temperature excursions is one appropriate area of federal action.

In the medium term, as my colleague Professor Granger Morgan and his coauthors have written[2], "To assure that we have safe and affordable advanced reactor designs that can be deployed at scale by midcentury, the United States will need to dramatically increase and refocus the budget of the DOE's NE [office of nuclear energy] toward advanced reactor development. Perceptive and ruthlessly pragmatic program officers will need to be recruited: ones with a sense of the mission's urgency. The government would have to sustain that higher level of support in the face of constant short-term political pressures and, undoubtedly, organized opposition from advocates of other generating sources. Part of that increased budget would have to be dedicated to building new infrastructure, such as fast-flux test facilities and other system test beds. Even with a higher budget, surge funding may be needed in some years to support demonstration reactor development and program leadership would eventually have to focus on moving two or three systematically chosen designs to the point of commercialization."

In summary:

- Nuclear generation today provides half of all low-pollution electric power in the USA.
- The remaining half is provided by hydroelectric, wind, solar, and geothermal power. Wind and solar are growing. However, if the USA's nuclear plants close, by 2030 the net effect would be no increase in low-pollution power. With nuclear, by 2030 we would be at 54% low-pollution electricity. Without nuclear, we would be at only 35%, right where we are today
- The US Supreme Court's decision three weeks ago to allow low-pollution programs in Illinois and New York to go forward is a clear indication that states can choose to support

[2] US nuclear power: The vanishing low-carbon wedge, M. Granger Morgan, Ahmed Abdulla, Michael J. Ford, Michael Rath, Proceedings of the National Academy of Sciences Jul 2018, 115 (28) 7184-7189; DOI: 10.1073/pnas.1804655115

low-pollution power sources in the same way that they can choose to support renewable power sources.

- Spent fuel storage for civilian and military reactors is a federal responsibility. Funds have been collected from each kilowatt-hour produced by our nation's civilian nuclear power generators to pay for a long-term spent fuel storage solution. The federal government should shoulder its responsibility.
- The DOE national laboratories have excellent expertise in the materials science that is relevant to the continued operation of the fleet of nuclear generators. Continuing DOE research into the ways nuclear fuel elements can become more tolerant of transient temperature excursions is one appropriate area of federal action.
- If we are to have safe and affordable advanced reactor designs that can be deployed at scale by midcentury, the United States will need to dramatically increase and refocus the budget of the DOE's office of nuclear energy toward advanced reactor development. Part of that increased budget would have to be dedicated to building new infrastructure, such as fast-flux test facilities and other system test beds. Even with a higher budget, surge funding may be needed in some years to support demonstration reactor development and program leadership would eventually have to focus on moving two or three systematically chosen designs to the point of commercialization.

Thank you for the opportunity to testify on this important matter.

Jay Apt is a Professor at Carnegie Mellon University's Tepper School of Business and in the CMU Department of Engineering and Public Policy. He received an A.B. in physics from Harvard College in 1971 and a Ph.D. in experimental physics from the Massachusetts Institute of Technology in 1976. He is a Fellow of the American Association for the Advancement of Science. He received the NASA Distinguished Service Medal and the Metcalf Lifetime Achievement Award for significant contributions to engineering.

Professor Apt is the director of the RenewElec (renewable electricity) project at Carnegie Mellon University. He and CMU professor M. Granger Morgan co-direct the Carnegie Mellon Electricity Industry Center, one of the world's largest engineering-business centers focused on the electricity industry. The Carnegie Mellon Electricity Industry Center is supported by grants from the Electric Power Research Institute, the Richard King Mellon Foundation, the National Science Foundation, and a number of government agencies, organizations, and companies.

He is the author of more than one hundred peer reviewed scientific publications, and author of several books and book sections. He has published opinion pieces in the Wall Street Journal, the New York Times and the Washington Post.

Professor Apt's web page is https://www.cmu.edu/epp/people/faculty/jay-apt.html.
The publications of the Carnegie Mellon Electricity Industry Center are available at www.cmu.edu/electricity.