C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Hearings before the Subcommittee on Clean Air and Nuclear Safety of the Senate Committee on Environment and Public Works

Testimony of

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Background

Good morning, I am Bob Perciasepe, the president of the Center for Climate and Energy Solutions (C2ES). Before joining C2ES, I was most recently the Deputy Administrator of the U.S. Environmental Protection Agency (EPA) from 2009 through 2014. Before that, I was the chief operating officer for the National Audubon Society and also the Secretary of Maryland's Department of Environment. A full biography is attached and submitted for the record.

The organization I now lead, C2ES, is the successor to the Pew Center on Global Climate Change, which was founded in 1998 and is widely recognized as an influential and pragmatic voice on climate issues. Our mission is to advance strong policy and action to reduce greenhouse gas emissions, promote clean energy, and strengthen resilience to climate impacts. A key objective is a national market-based program to reduce emissions cost-effectively. We believe a sound climate strategy is essential to ensure a strong, sustainable economy.

Our view is that in the long-term, a national market-based program to encourage a lower-carbon economy is the best approach to achieve the needed reductions in emissions. In the near-term, state leadership is essential to maintaining our existing nuclear fleet as we make this transition to a cleaner energy future. We view nuclear power as a vital element in a low carbon economy. In short, I and my organization have come to the unescapable conclusion that preserving the existing U.S. nuclear reactor fleet for as long as possible is a critical element in the transition to a low-carbon future. These units are just too big and too clean to replace quickly. States with the advantage of existing nuclear capacity should take reasonable steps to prevent the premature retirement of these essential clean energy sources while federal, regional and additional state policies are being developed to facilitate clean energy technologies like renewables, energy efficiency, energy storage, advanced nuclear, and fossil fuel-fired electricity using carbon capture and storage.

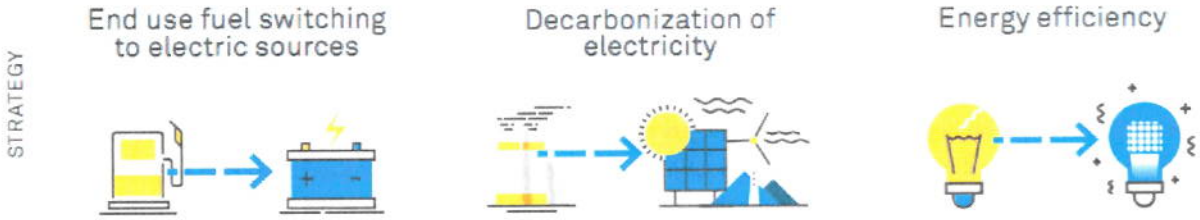
Nuclear power has been providing a significant environmental benefit for decades; society and markets, in most instances, are not valuing that. We know that we need to deeply decarbonize global energy production. In the U.S., we need to reduce emissions across the entire economy (not just in the power sector) by at least 80 percent by 2050, to help stave off the worst effects of climate change. And, just about all of the modeling that has been done to date shows that we need nuclear power, renewables and carbon capture and sequestration to achieve that kind of massive, economy-wide emission reduction.

Nuclear's Role in the Energy Transition Challenge

Decarbonizing the United States' energy system is a monumental task. It will require reducing our greenhouse gas emissions 80 percent or more by mid-century to avoid the worst impacts of climate change. To date, the U.S. has only managed to reduce its net emissions a little more than 13 percent below 2005 levels. That leaves a significant margin yet to account for.

In order to meet the 2-degree Celsius (3.8-degree Fahrenheit) target agreed to by the international community and avoid the worst effects of climate change, global net greenhouse gas emissions must be approaching zero by the second half of this century.[1] Pathways to deep decarbonization generally focus on three, equally important activities: (1) end-use fuel switching, primarily to electric sources (e.g., switching from gasoline- and diesel-powered to electric vehicles), (2) decarbonization of the electric power sector, and (3) increasing deployment of energy efficiency.[2] There are many possible ways to decarbonize the power sector. However, most studies indicate that a diverse mix of renewables, nuclear power, and fossil fuel with carbon capture utilization and storage is the least cost and least technically challenging path to achieve the mid-century goal.[3]

Figure 1: Three Pillars of a Clean Energy Economy



Source: Risky Business Project, From Risk to Return: Investing in a Clean Energy Economy.

In order to accelerate the rate of decarbonization, we will need breakthroughs in technology accompanied by strong policy signals for businesses to innovate.

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[1] IPCC, "Summary for Policymakers," in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Cambridge, United Kingdom: Cambridge University Press, Cambridge, 2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf.

[2] Risk Business Project, *From Risk to Return: Investing in a Clean Energy Economy* (Ricky Business Project, 2016), https://riskybusiness.org/fromrisktoreturn.

[3] Jesse Jenkins and Samuel Thernstrom, *Deep Decarbonization of the Electric Power Sector Insights from Recent Literature* (Arlington, VA: Energy Innovation Reform Project, 2017), http://innovationreform.org/wp-content/uploads/2017/03/EIRP-Deep-Decarb-Lit-Review-Jenkins-Thernstrom-March-2017.pdf.

Entrepreneurs, engineers, and investors are working to develop a wide range of advanced nuclear reactor designs. In the United States and Canada, nearly 50 companies backed by more than $1 billion in private capital are working on these plants.[4]

Advanced reactors can dependably generate zero-emission electricity and useful heat, and they are scalable to produce large quantities of energy from a very small footprint. New designs hold the promise of being more affordable, even safer, and are expected to produce less waste than the current generation of reactors.

The recently adopted Nuclear Energy Innovation Capabilities Act (NEICA), which went through the Energy and Natural Resources Committee, directs DOE to prioritize partnerships with private innovators to test and demonstrate advanced nuclear reactor concepts. It authorizes the creation of a National Reactor Innovation Center to combine the technical expertise of the National Labs and DOE to enable the construction of experimental reactors.

Additional support in the area of modernizing the licensing process for advanced reactors from the recently reintroduced Nuclear Energy Innovation Modernization Act (NEIMA) will also be critical to support the timely development of advanced reactor technology, as it will create greater certainty for developers and investors.

Modeling to date clearly shows that we need nuclear power, renewables, carbon capture, and improved energy efficiency to achieve large-scale, economy-wide emission reductions. It is absolutely necessary to pursue all promising zero-emissions technologies with equal vigor.

Importantly, existing nuclear power plants are a critical bridge to our advanced nuclear future. Keeping the U.S. nuclear fleet in place for as long as practical helps avoid backsliding in emissions, helps maintain our domestic nuclear expertise, and buys us the critical time necessary to develop, deploy and commercialize the next generation of nuclear reactors and other zero-emission technologies.

NEICA and policies like it will help to speed the development process and spur the kind of innovation that we will need to provide a cleaner second half of the century.

With thoughtful leadership, this step proves bipartisan backing exists for solutions to support the development of clean technologies like advanced nuclear, carbon capture, energy storage, and others – even in a challenging political environment. To meet our climate and clean energy goals, we must seek stable solutions that endure political transitions and maintain an ambitious pace to reduce emissions – and NEICA is an encouraging sign that there are potential partners for cooperative action.

Value of existing nuclear plants to completely decarbonizing the electric power sector

The existing nuclear fleet provides more than half of the United States' zero-emissions electricity that is simply not replaceable quickly. We have uniformly seen, with premature nuclear retirements, the lost emission-free power was substantially replaced with coal or natural gas. This increased emissions of CO_2 as

[4] Samuel Brinton, *The Advanced Nuclear Industry* (Washington, DC: Third Way, 2015), https://www.thirdway.org/report/the-advanced-nuclear-industry.

well as traditional air pollutants that contribute to smog and other serious public health impacts. Looking at in-state power sector CO_2 emissions in the year before and the year after nuclear power plant closures for these three states:

- Wisconsin saw a 2.6 million metric ton increase,
- Florida saw a 2.7 million metric ton increase, and
- California's saw a 9.6 million metric ton increase.

In response to the substantial emissions increases that followed the closure of San Onofre, the State of California is in the process of procuring energy efficiency and renewable energy to replace the 2,256 MW Diablo Canyon Nuclear Power Plant, currently scheduled to close over the 2024-25 timeframe.[5] Replacing this zero emitting power will essentially get the State back to where it is today, emissions-wise. This is a key observation: **early nuclear retirements lead to increased emissions and many years of alternative clean energy development, just to get back to where the state started,** and during that time, the atmosphere received many millions of tons of carbon dioxide that will be there for centuries.

Last year, Florida Power & Light became the first operator to apply to the Nuclear Regulatory Commission (NRC) for a second license renewal (SLR) for its Turkey Point plant in South Florida.[6] An SLR will bring the total operational lifetime of a reactor to 80 years. In addition to avoiding carbon dioxide emissions further into the future, extending a nuclear plant's life creates additional opportunities. Plant operators are more likely to consider performing maintenance (e.g., turbine upgrade) activities that would not have otherwise been considered for a plant planning to retire in a few years, which would further improve the efficiency of the nuclear power plant. Thereby avoiding even greater quantities of carbon dioxide emissions.

Renewables and nuclear are needed

Maintaining existing reactors and potentially running them longer (i.e., perhaps up to 80 years) and improving their efficiency avoids backsliding in emissions in the short- and medium-term. In the long run, it also buys time to deploy greater quantities of renewables, energy efficiency, energy storage, advanced nuclear and fossil fuel-fired electricity using carbon capture and storage.

The mid-century decarbonization challenge is daunting. U.S. electricity demand growth has largely flat-lined over the last decade. The drivers of this trend have been upgrading to more efficient equipment, implementing efficiency standards (light bulbs and appliances), slowing population growth and a shift away from energy-intensive industries to a more service-oriented economy.[7] However, in the mid- to long-term, assuming deep decarbonization policies are put in place, electricity generation nationally could increase by

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[5] In 2018, California derived 45 percent of its in-state electricity generation from carbon-emitting sources (i.e., natural gas) and 8 percent from nuclear power, U.S. Energy Information Administration, 2019.

[6] Aaron Martin, "Florida Power & Light applies for second license renewal for Turkey Point nuclear reactors," Daily Energy Insider, February 5, 2018, https://dailyenergyinsider.com/news/10502-florida-power-light-applies-second-license-renewal-turkey-point-nuclear-reactors/.

[7] U.S. Energy Information Administration, *Annual Energy Outlook 2017 with projections to 2050* (Washington, DC: U.S. Energy Information Administration, 2017), https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

more than 75 percent by 2050, as we see greater deployment of electric vehicles, electric heat pumps for home heating and cooling, electric boilers in industry, and many other areas of end-use electrification.[8] Most scenarios show very large increases in renewable generation and that nuclear power has an even larger role to play (to meet this increased level of consumption) in the future electricity generation mix.[9]

We need to ensure that the existing nuclear fleet remains in place for as long as practical to help support a more electrified future. However, six plants have retired since 2013, two plants are scheduled to shut down this year (2019), and an additional six plants will close by 2025. Not all reactors will run for 80 years; some are unlikely to run for 40 years due to short-term economic challenges. However, most profitable facilities are expected to apply for the SLRs. Zero-emission technologies like small and advanced nuclear reactors would have a clear role to play as the size of the power market grows and in replacing retiring plants.

Benefits, Challenges and Opportunities of Nuclear Power

In addition to the climate benefit of avoided carbon dioxide emissions:

- Nuclear is dispatchable and extremely reliable – most plants run 24 x 7 for 18 to 24 months, stopping only for refueling and routine maintenance during the refueling outage.
- They are an important provider of fuel diversity.
- Nuclear power is also extremely energy dense, so it has a very small footprint. For example, three reactors in southern New Jersey (Hope Creek and Salem) provide 40 percent of the state's annual electricity using only a 1.15 square mile footprint.
- Also, they don't contribute to air pollution or acid rain.
- And, they provide good rural jobs.

As for the challenges:

- Many nuclear power plants are reliant on revenue from wholesale power markets.
- Power market prices are at all-time historic lows, primarily due to very low natural gas prices.
- Reactors are not overly expensive to operate, but market revenue (energy and capacity payments) are not sufficient.
- One-third of plants are unprofitable; other estimates say it may be as many as one-half.
- Finding a long-term waste storage solution is also a challenge.

A few opportunities exist:

- Deep decarbonization policies will likely lead to a substantial increase in electric power generation, perhaps a doubling or more by 2050, as we see greater deployment of electric vehicles, electric heat

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[8] White House Council on Environmental Quality, *United States Mid-Century Strategy for Deep Decarbonization* (Washington, DC: White House, 2016), https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf.

[9] Jesse Jenkins and Samuel Thernstrom, *Deep Decarbonization of the Electric Power Sector Insights from Recent Literature.*

pumps for home heating and cooling, electric boilers in industry, and many other areas of end-use electrification.

- And, with greater quantities of variable renewables on the grid, excess generation from nuclear power and/or renewables could produce hydrogen for long-term energy storage – which could be used as fuel for power plants or vehicles.
- Also, new business opportunities exist. Nuclear could provide process heat for creating fresh drinking water, other industrial processes or even district heating.

Key Findings from our May 2018 Report

The key message from our May 2018 report is that targeted state policies, particularly "zero emission credits" or ZEC programs, are the best option right now for existing reactors, as states are able to relatively quickly adopt measures that directly support distressed facilities. For those who are not familiar with ZEC programs, eligible nuclear generation facilities get a credit for each zero-emission MWh of generation they produce. In Illinois and New York that is currently worth around $17/MWh.

From the environmental perspective, these subsidies are defensible. We see a clear failure in power markets. The market was designed for least cost dispatch and reliability. Therefore, generators can currently emit as much carbon dioxide as they'd like, without a cost. The ZEC transparently offsets this market failure and rewards a nuclear generator for its environmental benefit.

ZEC programs have passed in state legislatures with bipartisan support by forming a broad coalition, which has included labor groups, renewable energy interests, and environmental justice groups.

There is a growing appreciation that when a nuclear power plant closes that it is being replaced by fossil fuel-fired generation, which is increasing a state's emission profile. And, recent reports from the Intergovernmental Panel on Climate Change and the Fourth National Climate Assessment demonstrate that we cannot afford emissions backsliding and that climate change is here and now.

As a result of ZEC programs and other targeted policies in New York, Illinois, New Jersey, and Connecticut, those states have, for now, averted the closure of eight plants. Those plants have around 11.8 GW of capacity and help avoid 33 million metric tons of carbon dioxide emissions annually – which is the equivalent of taking 7 million cars off the road every year.

It is encouraging that ZEC policies are up and running and have withstood legal challenges in in New York and Illinois.

Converting a state renewable portfolio standard into a clean energy standard is another state level policy that can help the existing fleet.

Increasingly, states like California, New York, and New Jersey are raising the ambition of their clean energy targets, which leaves the door open for all non-emitting electricity sources.

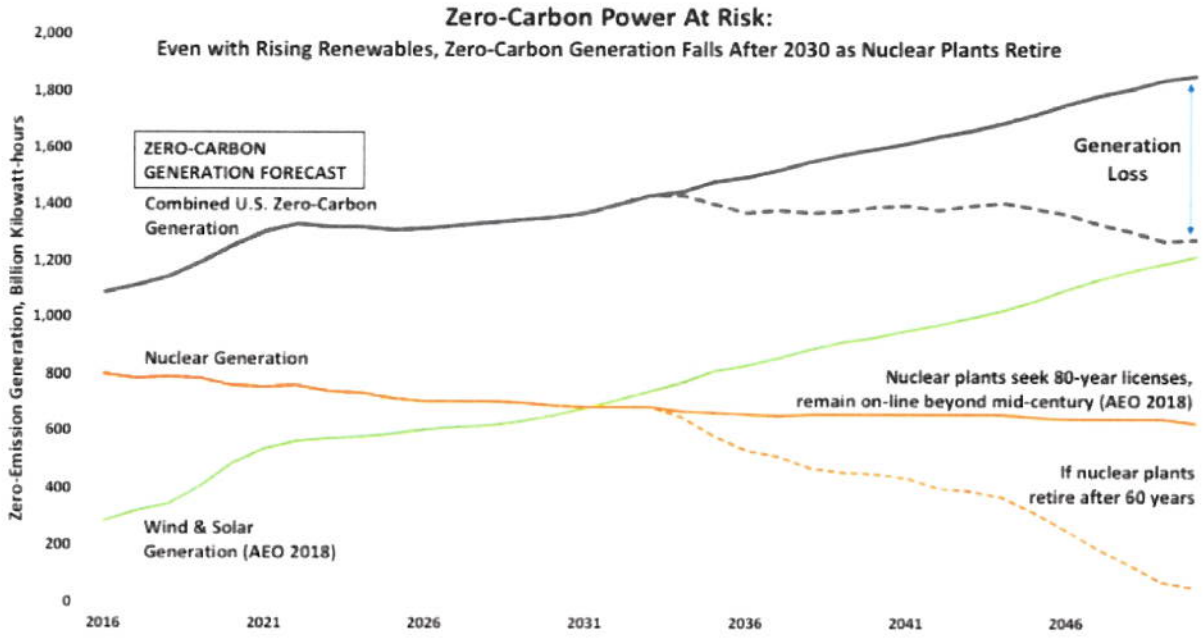
Federal Level Action that Could Help Nuclear Power

Federal-level action from Congress or federal agencies could help nuclear power as well:

- Carbon-pricing (either a tax or a cap-and-trade program) could help nuclear, but the carbon price would have to be significant in order to matter.
- Tax credits for capital expenditures at nuclear plants is another idea that could help.
- Establishing a national clean energy standard, like the one recently proposed by Senator Tina Smith of Minnesota, would also benefit nuclear power.
- Another idea is a federal ZEC program, which could be more far reaching than individual state programs.
- Reforming wholesale power markets (FERC) could also help. For example, in New York state, which have already established a ZEC program, the New York ISO (i.e., the wholesale power market for the state) is looking into adding a carbon price into its market.

Why We Need a Zero-Emission Coalition

Figure 1: Power Generation Trends to 2050



This chart demonstrates why we need a zero-emission coalition – or an all-of-the above approach for zero-emitting technologies.

The chart uses the generation forecast for nuclear power and wind and solar from the U.S. Energy Information Administration's (EIA) "Annual Energy Outlook 2018."

The green line is the forecast for wind and solar generation from 2016 until 2050.

The EIA projects that wind capacity will increase by around 70 percent and solar capacity will be 11 times greater by 2050, producing together around 4 times the amount of electricity or more than 1,200 billion kilowatt-hours.

The solid orange line is the forecast for nuclear generation from 2016 until 2050.

The EIA has included known plant retirements, but it also assumes that the remaining reactors will operate for up to 80 years.

If that holds true, then combined U.S. zero-carbon generation, the solid gray top line, will continue to grow to 2050.

If, however, nuclear plants retire at 60 years, as reflected in the dashed orange line, then the total of U.S. zero-carbon generation will peak around the mid 2030s, flat-line, and potentially even decline into mid-century.

This is not a pathway to deeply decarbonize our power sector.

- This is why we are saying that we need nuclear and renewables, not renewables attempting to replace nuclear power for decades.[10]
- Of course, regulators at the NRC can help extend the life of the existing fleet by approving subsequent license renewals, allowing plants to operate for up to 80 years. This process has begun.
- This would buy us valuable time to deploy more renewables, advanced nuclear and carbon capture and storage before mid-Century.

Energy Efficiency

Increasing energy efficiency is a key strategy in achieving deep decarbonization. It is often said that the cheapest kilowatt is the one that is never used. Setting annual energy savings goals will provide numerous benefits over time. Energy efficiency will help to reduce costs for consumers and reduce the total amount of power generation capacity that needs to be built to support a decarbonized economy (saving ratepayers even more money over time).

We believe that a broad-based approach is the best approach. We need energy policies that preserve existing nuclear, expand renewables, and promote other advanced zero-emission technologies, and we need to implement aggressive energy savings targets to put us on the pathway to 100 percent clean energy by mid-century.

Value of Existing Nuclear Generation to Climate and Air Quality

Nuclear power is by far the largest source of zero-emission power in the United States (see Figure 2). The Center for Climate and Energy Solutions was somewhat neutral on the fate of nuclear energy for many years,

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[10] A recent report from the International Energy Agency (IEA) highlights this point on a global scale. See International Energy Agency, *Nuclear Power in a Clean Energy System* (Paris, France: International Energy Agency, 2019), https://webstore.iea.org/nuclear-power-in-a-clean-energy-system.

but in this past decade we have conducted several reviews of pathways to low-carbon electricity. **Our key publications in 2014 and 2018 found that the goals of significant reductions in greenhouse gas emissions over the next three decades would be severely handicapped if the zero-emissions from nuclear power had to also be compensated for rather than built on.**[11] [12] [13] C2ES has revised its view from neutral to seeing the preservation of existing zero emissions resources, including nuclear, as an irreplaceable **foundation**.

The existing nuclear fleet has enhanced its capacity greatly in the last two decades. Since 1990, nuclear has consistently supplied around one-fifth of U.S. electric power generation, even while total generation increased 33 percent, largely through power uprates (plant modifications that increase the electrical output of existing reactors), shorter refueling outages, and other efficiency improvements. Uprates alone have added over 6,000 MW of emission-free generating capacity since 1977.

The 99 currently operational reactors help avoid the emission of 320 million to 578 million metric tons of carbon dioxide each year. These numbers can seem too large to comprehend – for scale, these avoided emissions equal between one-fifth to one-third of the current emissions of the entire fossil-fired portion of the electric generating sector in the U.S.[14] This means that premature retirement of any reactors make it tougher to meet air pollution, emissions and climate goals.

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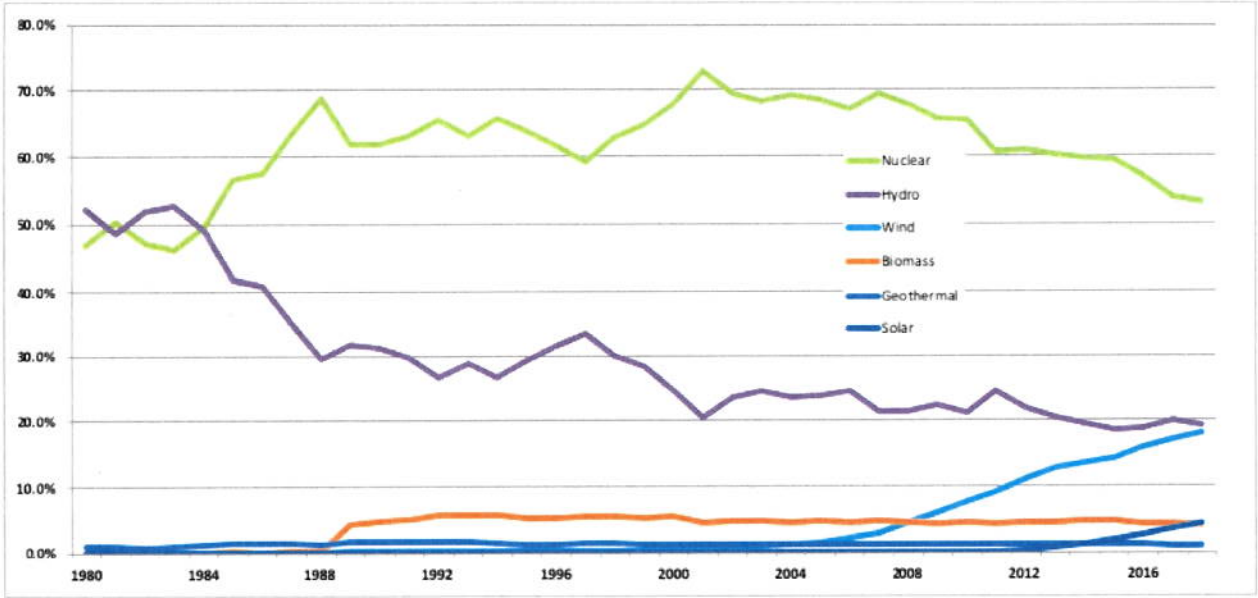
[11] Doug Vine and Timothy Juliani, *Climate Solutions: The Role of Nuclear Power* (Arlington, VA: Center for Climate and Energy Solutions, 2014), https://www.c2es.org/site/assets/uploads/2014/04/climate-solutions-role-nuclear-power.pdf.

[12] Doug Vine, *Solutions for Maintaining the Existing Nuclear Fleet* (Arlington, VA: Center for Climate and Energy Solutions, 2018), https://www.c2es.org/site/assets/uploads/2018/05/solutions-for-maintaining-existing-nuclear-fleet.pdf.

[13] Judi Greenwald and Doug Vine, *Promising Market and Federal Solutions for Existing Nuclear Power* (Arlington, VA: Center for Climate and Energy Solutions, 2018), https://www.c2es.org/site/assets/uploads/2018/10/promising-market-and-federal-solutions-for-existing-nuclear-power.pdf.

[14] "How much of U.S. carbon dioxide emissions are associated with electricity generation?" U.S. Energy Information Administration, last modified May 15, 2019, https://www.eia.gov/tools/faqs/faq.php?id=77&t=11.

Figure 2: Zero-Emission Fuel Sources for Electricity Generation, 1980–2018



Nuclear plants prevent substantial emissions of CO_2, SO_2, NO_X, particulate matter and the formation of ozone, compared to the alternative of natural gas and coal-fired generation that would most likely replace their output.

Nuclear Power and National Security

A recent report issued by the Atlantic Council, to which Senator Sheldon Whitehouse was an honorary co-chair, and where I was a member of the task force, found that the U.S. civilian nuclear power industry is a strategic asset of vital importance to U.S. national security. However, it is facing a serious challenge to its historical leadership in the global civilian nuclear power market, particularly from Russia and China.[15]

To quote the report, "The Task Force found that a flourishing domestic nuclear energy sector is critical to U.S. national security, both in the interconnections between military and civilian uses of nuclear energy, as well as in foreign policy. This report recommends maintaining and expanding the current nuclear fleet; creating a conducive regulatory environment for innovation and new technologies; and encouraging and facilitating nuclear energy exports."

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[15] Atlantic Council Task Force on U.S. Nuclear Energy Leadership, *U.S. Nuclear Energy Leadership: Innovation and the Strategic Global Challenge* (Washington, DC: Atlantic Council, 2019), https://www.atlanticcouncil.org/publications/reports/us-nuclear-energy-leadership-innovation-and-the-strategic-global-challenge.