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US HOUSE OF REPRESENTATIVES

ENERGY AND COMMERCE COMMITTEE

ENVIRONMENT AND CLIMATE CHANGE SUBCOMMITTEE

Hearing entitled "Time for Action:

Addressing the Environmental and Economic Effects of Climate Change"

February 6, 2019

Thank you, Chairman Tonko, Ranking Member Shimkus, Vice-Chair Ruiz, and Members of the Subcommittee, for inviting me to testify on the prospects for mitigating greenhouse gas emissions through American leadership on technology, policy, and diplomacy. I am grateful for the opportunity to speak with you today about this crucial challenge and opportunity. I develop strategies to reduce greenhouse gas pollution through my consulting practice, Gigaton Strategies LLC, and it is an honor to share with this committee my *conditional* optimism that we can still contain the most costly and destabilizing climate change impact if we choose to put our nation on a path to *net zero* greenhouse gas pollution by midcentury.

The stakes are high. On current course we face steadily-worsening impacts like sea level rise punctuated by episodic climate-intensified crises including unprecedented floods, heat waves, and cold snaps. If we fail to act, the Fourth National Climate Assessment finalized last year projects annual losses in multiple sectors of the US economy reaching hundreds of billions of dollars by the end of the century, hitting low-income Americans hardest. Just last week the World Threat Assessment from the Director of National Intelligence underscored the role of climate change in fueling global "…competition for resources, economic distress, and social discontent…"[1] Climate change will impose the most acute suffering on the world's poorest and least stable countries, underscoring the moral and national security imperatives to contain this looming crisis.

Climate mitigation is a momentum game—the faster we act, the cheaper pollution-reducing technologies become. When we put in place policies and incentives that deploy emerging solutions like solar and wind power, they become cheaper through economies-of-scale and

[1] https://www.odni.gov/index.php/newsroom/congressional-testimonies/item/1947-statement-for-the-record-worldwide-threat-assessment-of-the-us-intelligence-community

learning-by-doing across the entire value chain. This, in turn, opens up ever-larger markets for clean technologies, catalyzing a virtuous cycle between declining costs and expanding sales (Figure 1).[2] US climate technology leadership also encourages other countries to pick up the pace as they benefit from the low-cost low-carbon solutions we commercialize and export. Finally, moving fast ensures we invest from the start in smarter cities and energy systems rather than stranding investment in polluting infrastructure that we end up having to abandon early.

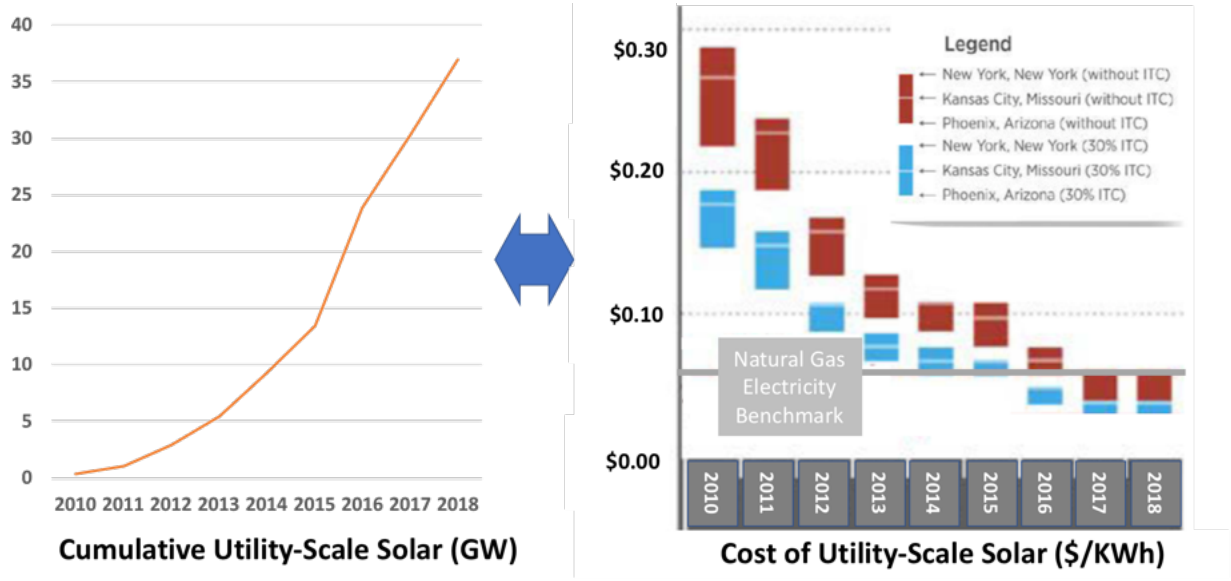

Figure 1. Virtuous cycle between expanding markets and cost reductions achieved through scale and learning-by-doing: the example of utility-scale solar in the U.S.[3]

We should prioritize rapidly reducing greenhouse gas pollution. This requires quickly scaling up zero-carbon electricity sources; broadly electrifying transportation, buildings, and industry; and, driving down major industrial and agricultural sources of methane and nitrous oxide. We know where the pollution comes from and the United States has pioneered key technologies to reduce it, but we need to move much faster to deploy these solutions.

Carbon dioxide (CO_2) *sinks* will also play an increasingly important role in compensating for intractable greenhouse gas *sources* as we drive towards *net zero* emissions (Figure 2). There are two complementary types of CO_2 sinks: *natural* and *technological*. Investing in land restoration to create natural carbon sinks in forests, agricultural soils, and coastal ecosystems offers tremendous benefits, ranging from improved land productivity to enhanced resilience to climate impacts, but these opportunities are challenging to scale, involve reversibility risk (including from climate impacts like drought and fire), and are ultimately limited by total

[2] Duke, Richard D. (2002). "Clean Energy Technology Buydowns: Economic Theory, Analytic Tools, and the Photovoltaics Case." Dissertation presented to faculty of Princeton University. Woodrow Wilson School of Public and International Affairs. http://rael.berkeley.edu/old_drupal/sites/default/files/very-old-site/PhD02-Duke.pdf

[3] Solar cost trends from Q2/Q3 2018 NREL Solar Update accessible at https://www.energy.gov/eere/solar/quarterly-solar-industry-update, indicative natural gas electricity costs from bottom-end of range estimated by https://www.greentechmedia.com/articles/read/nevada-beat-arizona-record-low-solar-ppa-price#gs.dPxW6xwJ, and utility-scale solar volumes from https://www.seia.org/solar-industry-research-data.

available land. Carbon dioxide removal technologies, such as direct air capture of CO_2, are not similarly constrained, but they are much more expensive than near-term opportunities to reduce pollution. Thus, even as we prioritize immediate greenhouse gas reductions we must also invest in scaling land restoration and developing negative emissions technologies.

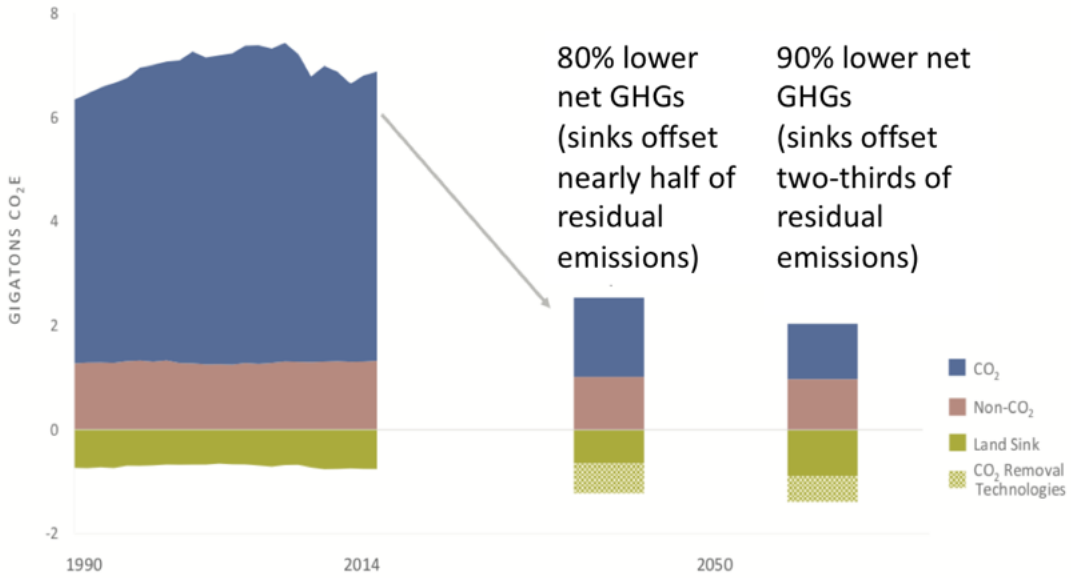

Figure 2. Land sinks and carbon dioxide removal technologies play a crucial role as the US drives toward net zero (United States Midcentury Strategy for Deep Decarbonization, 2016)[4]

We have the private sector dynamism and subnational policy commitment to lead this global economic transformation. But we urgently need federal policy progress to pick up the pace—both new legislation and vigorous implementation of existing legislative obligations and authorities.

I. Large-scale global demand for low-carbon technologies is driving costs down

There is a common, outdated, perception that cutting greenhouse gas pollution is expensive and other countries are therefore doing nothing about their emissions. In fact, every country other than the United States remains committed to the Paris Agreement and all of our major trading partners are taking action (Figure 3).

The European Union has far-ranging renewables and efficiency policies embedded in an emissions trading system currently imposing a carbon price of roughly $20-30 per million metric ton (MMT) of CO_2. Canada has started to implement its Pan-Canadian Framework on Clean Growth and Climate Change which includes a backstop carbon price rising to nearly $40 per MMT of CO_2 by 2022 and a range of robust complementary innovation and deployment measures.[5] Under its 2015 Energy Transition Law, Mexico is competitively procuring renewable

[4] https://unfccc.int/files/focus/long-term.../mid_century_strategy_report-final_red.pdf
[5] http://publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf

electricity to reach its goal of 35% clean electricity by 2024 and recently proposed new regulations to control oil and gas methane emissions.[6]

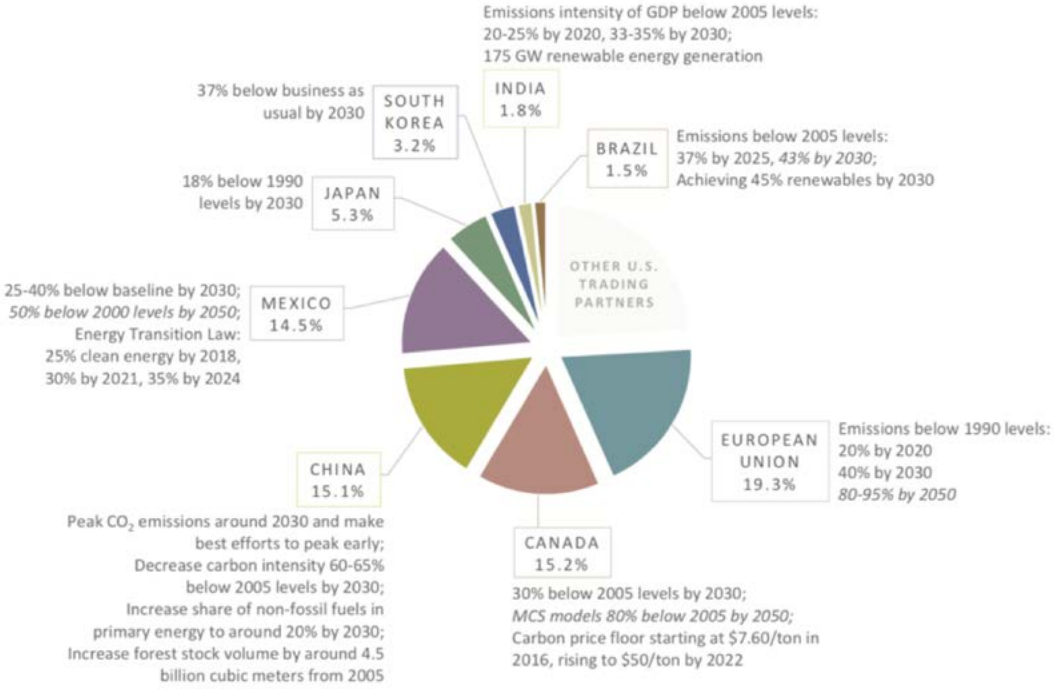

Figure 3. Our major trading partners are taking action
(Segment size represents country's contribution to U.S. total trade volume)[7]

Since 2000, China has issued and implemented 83 major policies to scale up clean technologies, including sustained deployment incentives for renewable energy.[8] By 2017, China was investing $127B in renewable power and fuels, more than triple related US investments that year, and it already had more than twice as much total installed wind and solar capacity as in the U.S.[9] China also sold half a million electric vehicles (EVs) in 2017, half of the global total, and it is launching a "new energy vehicles" tradable credit mandate this year expected to triple EV sales to 1.5 million by 2020.[10] Two of the top three global EV manufacturers are Chinese firms, though Tesla retains the number one slot and General Motors is in the top ten.[11] China is also tracking to deliver on its 2014 pledge, jointly announced with the United States, to more than double the share of its total energy from carbon-free sources and peak its emissions by around 2030.

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[6] http://www.lse.ac.uk/GranthamInstitute/law/energy-transition-law/ and https://www.edf.org/media/mexico-unveils-practical-oil-and-gas-regs-cut-climate-damaging-methane

[7] United States Midcentury Strategy for Deep Decarbonization, 2016 using Census Bureau data. Total trade equals the value of imports from country plus U.S. exports to country. Remainder of circle is comprised of other trading partners, the large majority of which have also developed NDCs.

[8] Kelly Sims Gallagher and Xiaowei Xuan (2019); Titans of the Climate: Explaining Policy Process in the United States and China.

[9] Renewable energy excludes large hydro in this report. http://www.ren21.net/status-of-renewables/global-status-report/

[10] http://www.ren21.net/status-of-renewables/global-status-report/ and https://www.bloomberg.com/news/articles/2018-11-14/china-is-about-to-shake-up-the-world-of-electric-cars-quicktake

[11] https://insideevs.com/global-sales-in-december-full-year-2018-2-million-plug-in-cars-sold/amp/

Similarly, India is installing more new wind and solar energy than new fossil-based generation, and independent analysts estimate that this surge of non-hydro renewables will deliver 13 percent of total electricity by 2023.[12] According to Bloomberg New Energy Finance (BNEF), new wind and solar are both about $0.04 per kWh in India—much cheaper than new coal at $0.07/kwh and new combined cycle gas at 0.09/kwh.[13]

All of this investment is driving down the cost of low-carbon technologies through economies of scale and learning-by-doing. For example, global average costs for battery and solar electricity costs are both down about 80 percent since 2010.[14] This translates into affordable mitigation opportunities in the United States as well.

II. It has never been easier to cut greenhouse gas pollution, and all 50 U.S. states have opportunities to lead

In addition to sustained investment in world-leading research, the United States benefits from a rich and diverse resource base, a dynamic private sector, and innovative subnational governments. Building on these strengths and global technology cost reduction trends, cutting emissions in the United States has never been easier, and every state has opportunities to lead the transition to a clean economy.

Figure 4 highlights dramatic reductions in the average cost of solar and wind electricity in the United States such that both now readily compete with new coal and natural gas generation and increasingly compete with existing coal power in certain markets.

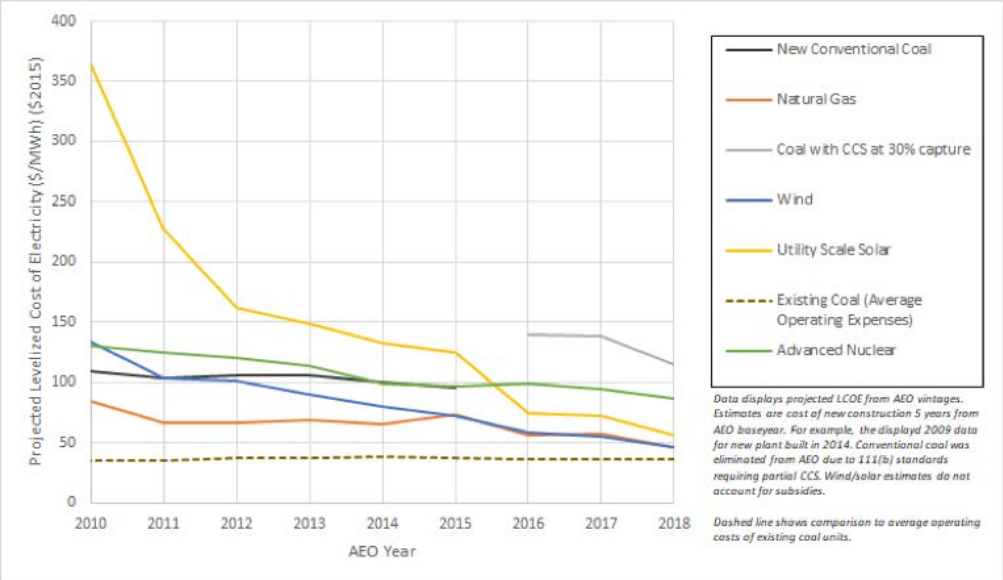

Figure 4. Electricity from low-carbon technology is now competitive with new conventional coal and natural gas derived power in the United States (derived from EIA)

[12] https://www.greentechmedia.com/articles/read/woodmac-expects-india-to-miss-2022-renewables-target#gs.qEite3Nt
[13] https://bnef.turtl.co/story/neo2018?teaser=true
[14] https://bnef.turtl.co/story/neo2018?teaser=true

Consistent with these national trends, renewables are becoming increasingly competitive in all 50 states (Figure 5), with a growing number of states competitively procuring solar at prices in the range of $0.02/KWh, down from over $0.15/KWh a decade ago and well below conventional power.[15] At the same time, over 40 states have installed utility-scale wind power, with contracted prices falling from $0.07/KWh in 2009 to $.02/KWh in 2017.[16] Wind is becoming competitive in ever-broader geographies with advancements like taller turbines and offshore installations opening up less windy regions like the Atlantic Seaboard and Southeast. Nextera, the largest utility in the country with renewable installations spanning dozens of states, predicts that by the 2020s, unsubsidized solar and wind backed with some storage will be cheaper than conventional power, without the emissions or fuel price risk.[17]

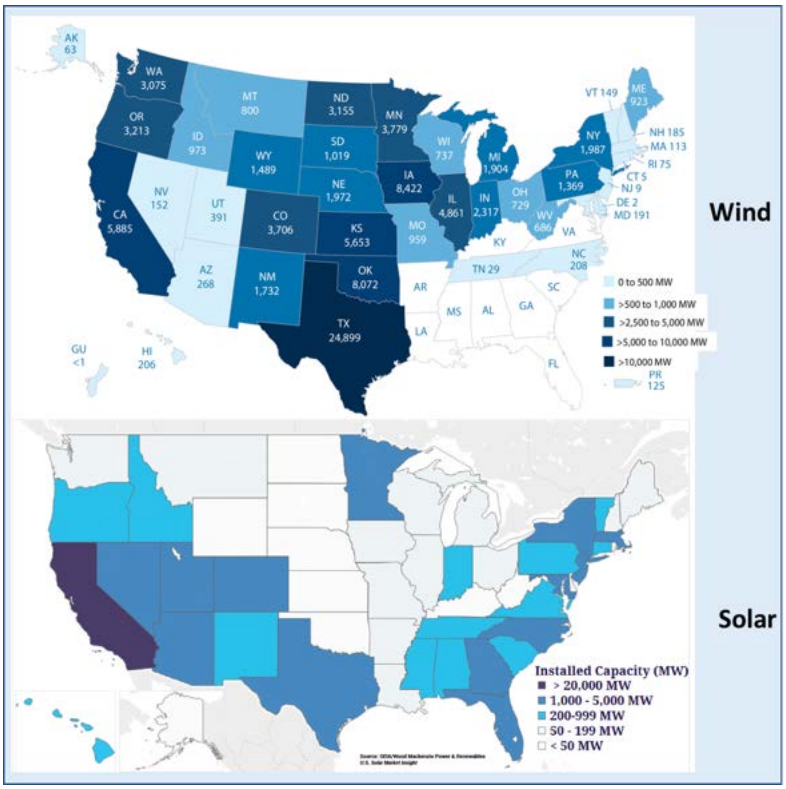

Figure 5. Wind and solar can compete in every state (cumulative installed MW)[18]

Multiple states and industries are also pushing ahead with advanced carbon capture and storage solutions. This key technology is not only useful in the power sector but also essential for cutting industrial pollution and creating options for scaled carbon dioxide removal in coming decades. Netpower is piloting carbon capture and storage technology in Texas with the goal of

[15] https://www.greentechmedia.com/articles/read/nevada-beat-arizona-record-low-solar-ppa-price#gs.wvWKRR3y
[16] https://www.energy.gov/eere/wind/downloads/2017-wind-technologies-market-report
[17] https://www.statista.com/statistics/237773/the-largest-electric-utilities-in-the-us-based-on-market-value, http://www.nexteraenergy.com/company/work.html and http://ieefa.org/nextera-solar-wind-and-storage-will-be-massively-disruptive/
[18] https://www.awea.org/resources/publications-and-reports/market-reports/2018-u-s-wind-industry-market-reports/4q2018_public and https://www.seia.org/solar-industry-research-data

producing carbon-free power from fossil fuels at about the same cost as conventional power.[19] At the same time, ethanol producers in the Midwest are moving to cut their lifecycle carbon emissions in half through carbon capture and storage on their refineries.[20]

Our farmers, including in the Midwest, are leading the world in advanced technologies that boost productivity and drive down greenhouse gas emissions through solutions like optimal fertilizer application and converting methane from waste to energy. And our forests in the Southeast and other forested regions already absorb over 10 percent of our emissions and could cost-effectively offset over half of our residual emissions by midcentury (Figure 1 and Figure 6).

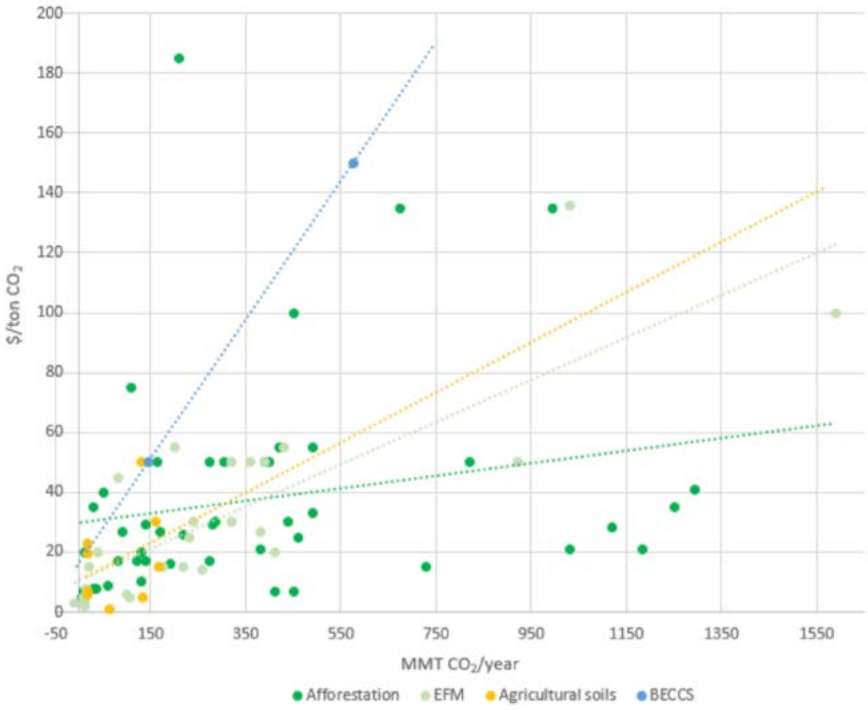

Figure 6. Potential US land sinks by midcentury through afforestation, enhanced forest management (EFM), soil management, and bioenergy carbon capture and storage (BECCS)[21]

States and cities are also driving progress, including through the bipartisan US Climate Alliance that recently added Virginia, New Jersey, Illinois, and New Mexico to include a total of 18 states and Puerto Rico.[22] A dozen states accounting for roughly one-third or new vehicle sales have opted to adopt California's greenhouse gas performance standards for light duty vehicles and plan to proceed despite the current administration's proposed federal rollbacks.[23] At the same time, the Regional Greenhouse Gas Initiative is expanding beyond the power sector to tackle

[19] https://qz.com/1292891/net-powers-has-successfully-fired-up-its-zero-emissions-fossil-fuel-power-plant/
[20] https://www.adm.com/news/news-releases/adm-begins-operations-for-second-carbon-capture-and-storage-project-1
[21] Based on 13 studies (synthesized in Van Winkle et al., 2017; Murray et al., 2005; Chambers et al., 2016) compiled by Emily McGlynn, https://www.rmi.org/hot-property-how-to-manage-valuable-us-landscapes-for-carbon-sequestration/.
[22] https://www.usclimatealliance.org/governors-1/ and https://www.usclimatealliance.org/advanced-transportation/
[23] https://eelp.law.harvard.edu/2018/11/beyond-the-waiver-epas-plan-to-end-state-ghg-vehicle-standards/

transportation and many states are propelling zero emission vehicles through a range of standards and incentives.[24] This subnational policy gives firms like Tesla and General Motors a path to continue scaling up production, hopefully ensuring that the majority of EVs on our roads continue to be made in America.

III. The United States is moving too slowly and risks losing its clean technology edge

Despite this global technology momentum and subnational climate policy, we are not moving fast enough. Energy CO_2 emissions in the US, which accounts for over four-fifths of greenhouse gases, were up 3.4% in 2018 after falling 1.6% per year on average from 2007 to 2016, and only 0.8% in 2017.[25] As shown in Figure 7, the power sector has accounted for most of this downward emissions trend since 2007.

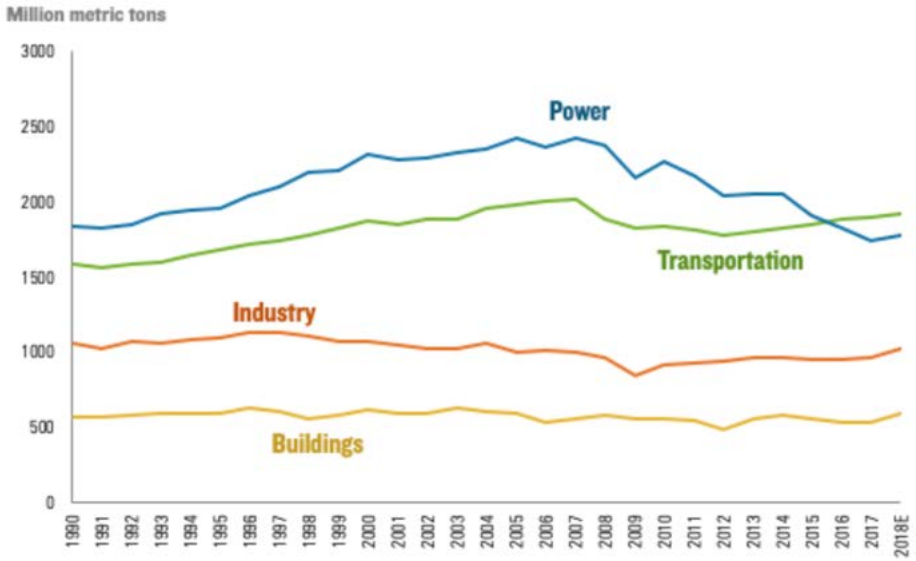

Figure 7. Transportation has overtaken power as the largest source of energy CO_2 (RHG)

It is worth a closer look at the power sector to unpack three factors that propelled these emission reductions and to consider whether we are on pace even in this best-case sector (Figure 8). First, energy efficiency has held total electric load growth roughly level even as the economy expanded. Federal investment in energy saving technology paired with appliance and equipment standards have combined powerfully with subnational actions, including building codes and demand-side management programs. As one example, DOE has invested about $0.4B to develop American leadership on solid-state lighting such as LEDs, yielding nearly $5B in energy savings already and potentially $50B annually by 2035 as deployment scales.[26] Going forward, the building sector can also become a crucial source of demand flexibility, along with

[24] https://www.utilitydive.com/news/regional-initiative-to-reduce-transportation-emissions-would-mirror-rggi/544738/
[25] https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks and https://rhg.com/research/preliminary-us-emissions-estimates-for-2018/
[26] https://www.energy.gov/eere/ssl/downloads/led-efficacy-what-america-stands-gain

electric vehicles, to ease large-scale integration of large intermittent renewables into our electricity systems.

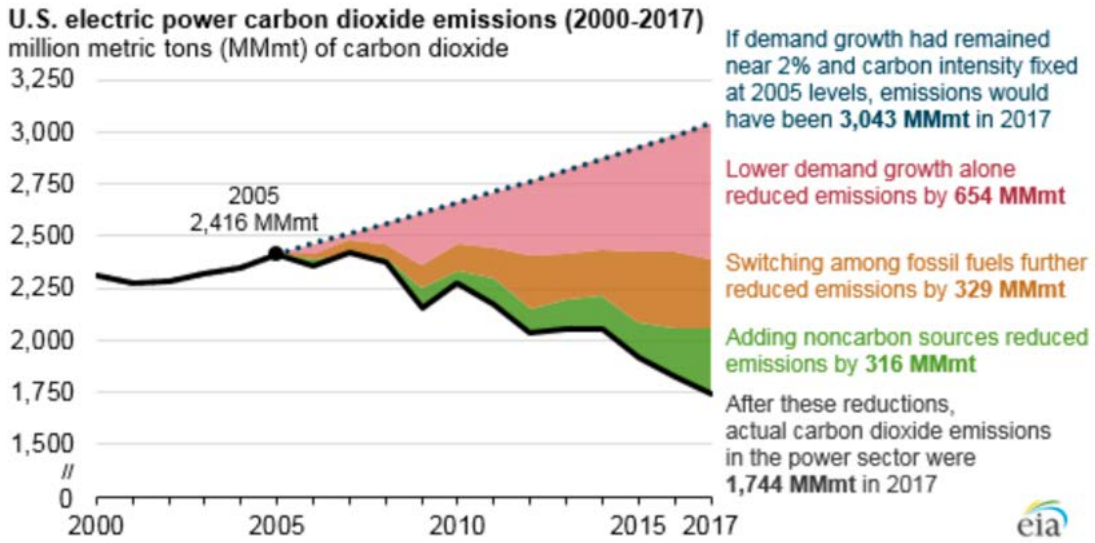

Figure 8. Underlying drivers of recent power sector emissions reductions[27]

Second, coal-to-gas shifts were a driver for power sector emissions reductions over the past decade; however, this dynamic is unlikely to play a major role going forward. Federal investment in hydraulic fracturing helped industry to increase natural gas supply during this period, driving down natural gas prices which, in turn, induced switching from coal to natural gas electricity. Going forward, EIA expects natural gas prices to trend higher, causing capacity utilization rates for coal-fired generators to revert to historical levels of about 70% from the low of 55% reached in 2018.[28] Moreover, improved monitoring indicates that methane emissions from the oil and gas supply-chain may be 60% higher than current official EPA estimates, principally due to leakage during abnormal events.[29] Absent standards that require more leak detection and repair, the near-term warming impact from methane leaks could rival the impact of total U.S. natural gas combustion.

Thus, assuming efficiency continues to largely offset load growth, rapidly expanding renewables will emerge as the dominant driver of durable reductions in power sector emissions. In fact, renewables have been rapidly gaining market share, and EIA projects this will continue through at least 2020 (Figure 9).

[27] https://www.eia.gov/todayinenergy/detail.php?id=37392
[28] https://www.eia.gov/outlooks/aeo/
[29] http://science.sciencemag.org/content/361/6398/186

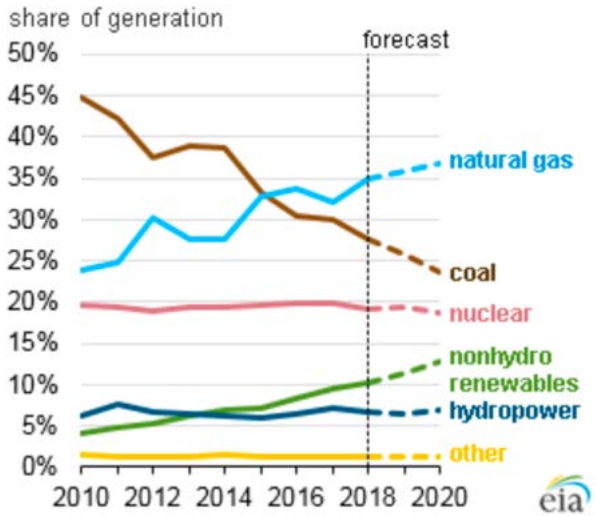

Figure 9. Wind and solar are rapidly gaining market share (EIA)

Even in the power sector, however, we are not moving fast enough. The MCS indicates that we would need to roughly double the pace of renewables installations starting in the 2020s to optimally cut net greenhouse gas emissions by 80 percent below 2005 levels by 2050. The pace would of course need to quicken further to achieve net zero by that year. Unfortunately, after federal renewable energy tax credits phase-out in the early 2020s, industry analysts project a serious downturn, with EIA estimating that new wind installations may even falter entirely in 2022.[30] Meanwhile, emissions are trending higher in the crucial transport sector (Figure 7) and at best level in other sectors, even before federal policy reversals impose new headwinds.

IV. The United States urgently needs federal policy progress to retain its global leadership on climate technology and diplomacy

Even as the falling cost of clean technologies further bolsters the economic case for action, federal climate policy is shifting into reverse. On innovation, the current administration has repeatedly sought to slash investment in advanced clean energy technologies, though Congress has thus far maintained and even increased related investment. Most recently, for FY19 Congress finalized modest increases in DOE research and development investments despite Administration requests for cuts as severe as 70% for key programs.[31]

On deployment, the current administration is aggressively seeking to roll back pollution control standards. Jeopardizing power sector progress, it is seeking to undermine common sense standards seeking to level the playing field between conventional fossil generators and clean power alternatives, including renewables, nuclear, and advanced fossil with carbon capture and storage. These efforts include gutting the Clean Power Plan and repeated efforts to subsidize coal generation under the guise of reliability. Moreover, while states are leading the way in

[30] https://www.eia.gov/outlooks/aeo/ and https://www.greentechmedia.com/articles/read/5-factors-that-will-cushion-the-ptc-phase-us-wind#gs.2sDg96ly

[31] https://www.aaas.org/page/fy-2019-rd-appropriations-dashboard

clean electricity policy, the Federal Energy Regulatory Commission is actively discouraging such policies by raising the costs to consumers with "minimum offer" requirements on sales from clean energy sources.[32]

The current administration is also moving to undermine vehicle standards that would save drivers billions at the pump, empower US automakers to compete with China for the EV future and keep the US roughly on track to deep decarbonization by midcentury.[33] The administration is similarly seeking to weaken common sense standards aimed at reducing leaks of methane from oil and gas production and distribution. It is also seeking to restrict the process for setting future appliance standards that benefit consumers.[34] This is not to mention persistent attempts to erode other critical public health standards such as the Mercury and Air Toxics Rule.

The United States remains uniquely well-positioned to lead the global effort to contain climate change, but we must take decisive steps to give investors the policy clarity needed to scale up solutions. Instead of rolling back standards, we need to ratchet up policy ambition to get the US back in a leadership role, motivating other countries and exporting the climate solutions that allow them to cut emissions faster.

This challenge is too important to leave any tool unused. We need broad, performance-based policies that propel investment to electrify end uses with clean power while catalyzing faster progress in precision agriculture, advanced manufacturing, and improved land management. We also need to invest in coal mining communities and others on the frontlines of this transition to ensure all Americans benefit, including through programs like the Power Plus initiative.[35] This will unleash a wave of reinvestment in American industry, agriculture and forestry that will ensure sustained competitive advantage.

Add it all together and we could cut our net emissions in half by 2035, on track to net zero by midcentury while propelling economic growth and ensuring America retains its leadership in related technologies and international negotiations.

[32] https://www.greentechmedia.com/articles/read/could-ferc-order-put-state-clean-energy-policies-in-danger#gs.8iFTRGmj
[33] From the US Midcentury Strategy (2016), "…if the current expected trajectory of emissions intensity improvements due to fuel economy and GHG emissions standards is sustained through 2050, fleet-wide emissions intensity would decline 76 percent between 2015 and 2050. In the MCS Benchmark scenario, emissions intensity declines 86 percent over the same period. Thus, with only a slight acceleration compared to current trends, fuel economy and GHG emissions standards have the potential to achieve carbon pollution reductions consistent with a deeply decarbonized energy system."
[34] https://www.greenbuildingadvisor.com/article/federal-agencies-begin-efficiency-policy-rollbacks
[35] See, for example, http://www.powerplusplan.org/