

**EXAMINING HOW FEDERAL INFRASTRUCTURE POL-
ICY COULD HELP MITIGATE AND ADAPT TO
CLIMATE CHANGE**

(116-3)

HEARING
BEFORE THE
COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES
ONE HUNDRED SIXTEENTH CONGRESS
FIRST SESSION

FEBRUARY 26, 2019

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¹ Hon. Carbajal delivered the prepared statement of Hon. DeFazio, who was unable to attend the hearing due to a snowstorm in Oregon.

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Committee on Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

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FEBRUARY 22, 2019

SUMMARY OF SUBJECT MATTER

TO: Members, Committee on Transportation and Infrastructure
FROM: Staff, Committee on Transportation and Infrastructure
RE: Full Committee Hearing on “Examining How Federal Infrastructure Policy Could Help Mitigate and Adapt to Climate Change”

PURPOSE

The Committee on Transportation and Infrastructure (Committee) will meet on Tuesday, February 26, 2019, at 10 a.m. in HVC-210, the Capitol Visitors Center, to receive testimony related to “Examining How Federal Infrastructure Policy Could Help Mitigate and Adapt to Climate Change.” The purpose of this hearing is to examine the role the transportation sector plays in global warming, understand the dual track approach of mitigation and resiliency, and learn from individuals in the public and private sectors whom have demonstrated pragmatic solutions for reducing carbon emissions and building resilient infrastructure.

The first panel will focus on ways to mitigate the effects of climate change, by reducing carbon emissions to reduce the accumulation of greenhouse gases in the atmosphere. The Committee will hear from representatives of the California Air Resources Board, Georgetown Climate Center, Stephen M. Ross School of Business at the University of Michigan, Electrification Coalition, and Airlines for America. The second panel will address how to make infrastructure more resilient and protect people, infrastructure, and ecosystems from the impacts of climate change. The Committee will hear from representatives of the Center for American Progress, McWane Inc., Center for Strategic and International Studies, and The Nature Conservancy.

BACKGROUND

The United Nations Intergovernmental Panel on Climate Change (IPCC) estimates that human activities have caused approximately 1.0°C of global warming above pre-industrial levels, and are likely to cause a 1.5°C increase between 2030 and 2052 if warming continues at the current rate.¹ Impacts from global warming are already apparent.² Unless we take action to quickly reverse course, these trends will persist for centuries and will continue to cause further long-term changes to the environment, such as sea level rise, changing precipitation patterns, more acidic oceans, and increasing frequency and intensity of extreme weather events.³

MITIGATION

The U.S. Transportation Sector’s Contribution to Global Warming

In 2017, the emissions from transportation accounted for about 28.7 percent of total U.S. greenhouse gas emissions, making it the largest contributor of U.S. greenhouse gas emissions.⁴ Historically, electricity generation has been the largest contributor to greenhouse gas emissions, but the replacement of many coal plants with

¹ Global warming of 1.5°C: Summary for Policymakers. Intergovernmental Panel on Climate Change. October 2018.

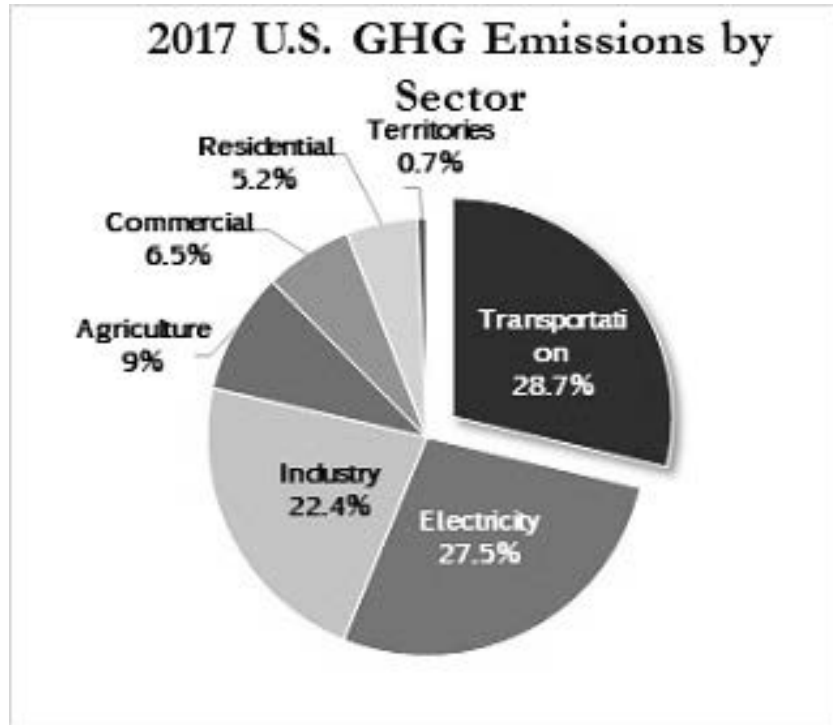
² Ibid.

³ Ibid.

⁴ Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017. Environmental Protection Agency. February 2019. Table 2–10.

cheaper natural gas and rising vehicle miles traveled (VMT) has recently pushed transportation into the forefront as the largest contributor.

Within the U.S. transportation sector, passenger vehicles and freight trucks added together account for 83 percent of greenhouse gas emissions. Aviation contributes only 10 percent of emissions. Other modes such as rail and shipping play a minor role.⁵



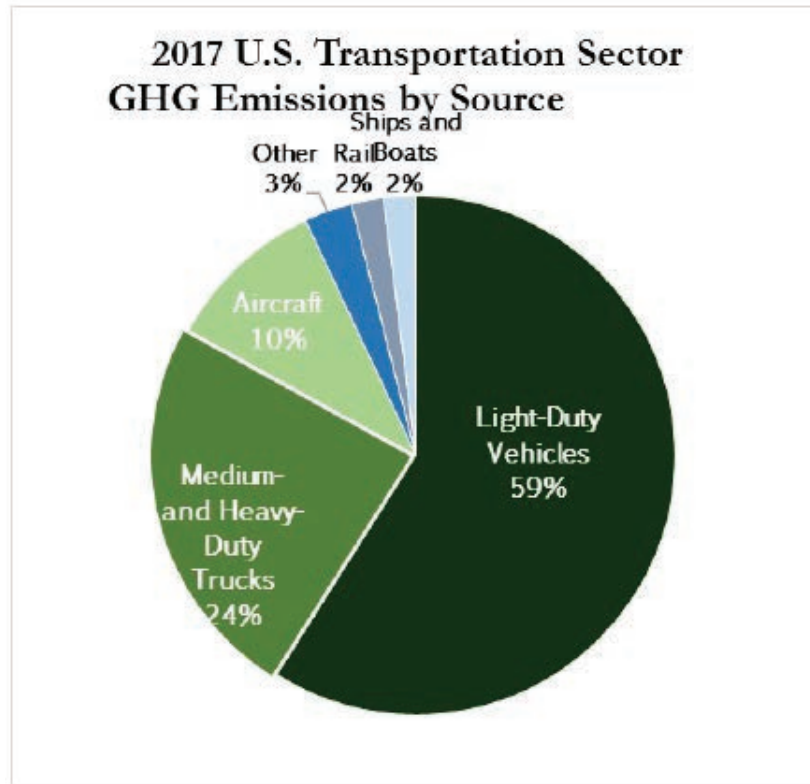
Passenger Vehicles, Light-duty Vehicles, and Freight Truck Mitigation

There are three methods to reduce emissions from passenger vehicles and trucks, which combined account for 83 percent of greenhouse gas emissions, and a robust decline in emissions will require all three methods.

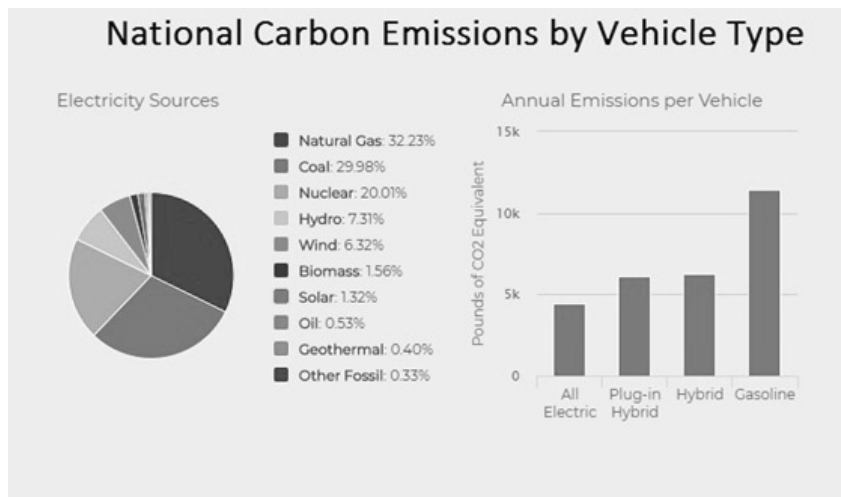
1. *Improved Vehicle Efficiency*—Reducing the amount of fuel necessary to move a vehicle will reduce greenhouse gas emissions. Traditionally, Congress has used CAFE standards to reduce fuel consumption and related carbon emissions, although the current Administration is considering changes to these standards with a final rule pending.⁶ CAFE standards are within the jurisdiction of the Energy and Commerce Committee.

⁵ Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017. Environmental Protection Agency. February 2019. Table 2–13.

⁶ <https://www.nhtsa.gov/corporate-average-fuel-economy/safe>



2. *Switch to Fuel with Less Carbon:* Shifting away from fossil fuels and toward electricity, fuel cells, biodiesel, and fossil fuels with less carbon content than gasoline or diesel can reduce emissions. In the current market place, electrification is viewed as the most plausible replacement for fossil fuel and has the lowest carbon profile.



To find the impact of carbon reduction from switching to a hybrid or electric car in your State see this link: https://afdc.energy.gov/vehicles/electric_emissions.html

3. *Reduce Vehicle Miles Traveled.* Reducing the number of miles driven will reduce carbon emissions. Providing incentives for more efficient travel planning, eliminating the need for some trips, and shifting to more efficient modes will reduce vehicle miles traveled.

Aviation Mitigation

Aviation emissions come largely from commercial carrier jet fuel. According to the IPCC, aviation represents approximately 2 to 3 percent of the total annual global CO₂ emissions from human activities.⁷ While the United States does not currently have standards for aircraft emissions (generally or carbon dioxide specifically), the Federal Aviation Administration (FAA) supports several emission-reduction programs and the industry has taken on initiatives to reduce emissions.

The International Civil Aviation Organization (ICAO), a specialized UN agency made up of 192 member states, is the primary international body for regulating global aviation standards. In 2016, ICAO reached an agreement on the (1) first international carbon dioxide standards for newly built aircraft and (2) first-of-its-kind carbon offsetting scheme known as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).⁸ CORSIA is an emissions offsetting program aimed at achieving carbon neutral growth after 2020 for operators that fly internationally and produce more than 10,000 metric tons of annual carbon dioxide emissions. CORSIA has the support of the United States, U.S. airline industry, and 73 other ICAO member nations representing 75.96 percent of the international aviation industry.⁹

⁷European Union Aviation Safety Agency, *European Aviation Environmental Report 2019*, available at https://www.easa.europa.eu/eaer/system/files/usr_uploaded/219473_EASA_EAER_2019_WEB_HI-RES.pdf; see also EPA's most recent final GHG inventory report, issued in April 2018, US commercial aviation is only 2 percent of the nation's domestic GHG emissions inventory. *EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016*, available at: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016>

⁸International Civil Agency Organization, *ICAO Council Reaches Landmark Decision on Aviation Emissions Offsetting* (June 27, 2018), available at <https://www.icao.int/Newsroom/Pages/ICAO-Council-reaches-landmark-decision-on-aviation-emissions-offsetting.aspx>

⁹National Business Aviation Association, *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA): Introduction & Expectations on the Submission of Emissions Monitoring Plan* (Oct. 16, 2018), available at https://nbaa.org/wp-content/uploads/events/20181011_Overview-of-CORSIA-EMP_NBAA-BACE-2018.pdf

FAA Emission Reduction Programs and Initiatives

1. **CORSIA Implementation**—To comply with the recent ICAO agreements, the FAA and the Environmental Protection Agency (EPA) are required to develop regulations regarding aircraft design standards, emissions data collection, and monitoring. In addition, the agencies are tasked with implementing the new carbon offsetting system for U.S. aircraft operators. Unlike how the Clean Air Act sets standards for other modes, here, the EPA must consult with the FAA on developing any emissions standards for aircraft, giving the FAA a central role in creating and enforcing the new ICAO environmental standards.¹⁰
2. **Continuous Lower Energy, Emissions and Noise (CLEEN) Program**—The CLEEN program is a collaboration between the FAA and industry to drive the development of new aircraft and engine technologies that increase fuel efficiency, reduce emissions, decrease noise, and advance sustainable aviation fuels. During the first iteration of CLEEN, the FAA partnered with five companies and had a total investment value of more than \$250 million by end of the original agreement in 2015.¹¹ Through cost-sharing partnerships with industry, CLEEN projects developed technologies that reduce noise, emissions, and fuel burn. The second iteration, CLEEN II, currently has the FAA partnered with eight companies and is scheduled to continue through 2020.
3. **Voluntary Airport Low Emissions (VALE) Program**—Through participation in the Voluntary Airport Low Emissions (VALE) Program, airports can use Airport Improvement Program (AIP) funds and Passenger Facility Charge (PFC) revenue to finance low-emission vehicles, refueling and recharging stations, gate electrification, and other airport air quality improvements. Through September 2018, this program funded 105 projects at 51 airports and is expected to reduce ozone emissions by 1,192 tons per year over the next five years.¹²
4. **NextGen Implementation**—The FAA continues to develop and implement NextGen technologies and procedures to modernize the air traffic control system. NextGen programs include Performance-Based Navigation procedures (GPS-satellite based flight paths) and Terminal Flight Data Manager (TFDM) deployment (a surface management solution), which will reduce aircraft fuel burn and create a more predictable and efficient flight and ground transportation system at airports.¹³ The TFDM system alone is expected to create 313 million gallons of fuel savings and reduce more than three million metric tons of carbon emissions over the life of the system.¹⁴
5. **Commercial Aviation Alternative Fuels Initiative (CAAFI)**—CAAFI is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants, and U.S. government agencies working to promote alternative jet fuels for commercial aviation. CAAFI has led efforts in research and development, environmental assessment, fuel testing, and demonstration and commercialization of alternative aviation fuels. CAAFI efforts contributed to the creation of testing protocols and new alternative fuel specifications that have enabled approvals for aviation to use new fuels in commercial service. According to the FAA, this is helping to pave the way to large-scale production and use of these fuels. This leadership has also helped make aviation a major target market for the alternative fuels sector.¹⁵

Commercial Aviation

U.S. airlines have increased fuel efficiency by more than 125 percent between 1978 and 2017, and they have moved 28 percent more passengers and cargo in 2016 than 2000, using 3 percent less fuel.¹⁶ This reflects the industry's interest in maxi-

¹⁰ See ICAO, *supra* note 10.

¹¹ Federal Aviation Administration, *Continuous Lower Energy, Emissions and Noise (CLEEN) Program* (2018), available at https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/

¹² Federal Aviation Administration, *Voluntary Aviation Lower Emissions Program (VALE)* (2018), available at <https://www.faa.gov/airports/environmental/vale/>

¹³ United States. Cong. House. Committee on Transportation and Infrastructure. Subcommittee on Aviation. Hearing on *Putting U.S. Aviation At Risk: The Impact of the Shutdown* Feb. 13, 2019. 116th Congress 1st sess. p. 12 (Statement of Paul Rinaldi, President, National Air Traffic Controllers Association).

¹⁴ Id.

¹⁵ United States Aviation Greenhouse Gas Emissions Reduction Plan, submitted to ICAO, June 2015. Available at: https://www.icao.int/environmental-protection/Lists/ActionPlan/Attachments/30/UnitedStates_Action_Plan-2015.pdf

¹⁶ Airlines for America, *Policy Priority: Energy and the Environment* (2018), available at <http://airlines.org/policy-priorities-learn-more/#energy>

mizing fuel efficiency, largely attributed to the fact that fuel consistently ranks as their largest or second largest expense.¹⁷ Furthermore, the U.S. airline industry has committed to ICAO goals to increase fuel efficiency and reduce its environmental footprint. These goals include (1) achieving annual fuel efficiency improvement of 1.5 percent starting in 2010, (2) achieving carbon neutral growth starting in 2020, and (3) reducing net carbon dioxide emissions by 50 percent over 2005 levels by 2050.¹⁸

To achieve these goals, airlines are investing in fleet design standards with greater fuel efficiency, prioritizing the adoption of NextGen technologies, and developing industry coalitions such as the CAAFI to promote and deploy sustainable aviation fuels within the commercial aviation industry.¹⁹

Maritime Mitigation

The maritime industry is taking steps to mitigate its environmental impacts. Overall, the maritime industry is responsible for approximately 2.6 percent of global CO₂ emissions from fossil fuel uses.²⁰ However, the industry is working to reduce those emissions through several means, including slow steaming, conversion to low sulfur fuels, and the implementation of mandatory emission reductions in 2020. There has been worldwide cooperation across the maritime industry to pursue that goal.

RESILIENCY

The impacts of climate change such as rising sea levels and extreme weather events can have a serious impact on our ports, airports, rail lines, roads, bridges, tunnels, locks, canals/channels, waste water systems, transit systems, pipelines, public buildings, and other critical infrastructure. Climate trends affect the design of transportation infrastructure, which is expensive and designed for long life (typically 50 to 100 years). As climatic conditions shift, portions of this infrastructure will increasingly be subject to climatic stresses that will reduce the reliability and capacity of transportation systems and other infrastructure.

Highways

Climate resiliency activities are eligible for Federal Highway Administration (FHWA) funding, including vulnerability assessments and design and construction of projects or features to protect assets from damage associated with climate change. The Moving Ahead for Progress in the 21st Century (MAP-21) Act (P.L. 112-141) required states to develop risk-based asset management plans for the National Highway System and to consider alternatives for facilities repeatedly needing repair or replacement with federal funding. The Fixing America's Surface Transportation (FAST) Act (P.L. 114-94) added a new requirement for states and metropolitan planning organizations consider projects and strategies to "improve the resiliency and reliability of the transportation system and reduce or mitigate stormwater impacts of surface transportation" as part of their planning process.

Water Resources

The United States has over 95,000 miles of coastline and approximately 3.4 million square miles of ocean within its territorial sea. Some 53 percent of the total U.S. population lives on the 17 percent of the land in the coastal zone, and these areas become more crowded every year. Demands on coasts are increasing, and as coastal areas become more developed, these communities are vulnerable to hurricanes, storm surges, and flooding events.

Similarly, inland communities are vulnerable to a changing climate, especially communities that rely on rivers and streams, and associated water resources infrastructure, for transportation, water supply, power, and flood protection. For example, in 2017, the U.S. Army Corps of Engineers Institute for Water Resources released a report on the impacts of climate change to the Ohio River Valley—home

¹⁷ See Victoria Bryan, *Higher Wages, Fuel Prices Turn Up Cost Pressure on Airlines*, Reuters, Feb. 14, 2018, available at <https://www.reuters.com/article/us-airlines-wages-inflation-analysis/higher-wages-fuel-prices-turn-up-cost-pressure-on-airlines-idUSKCN1FY292>

¹⁸ Airlines for America, *A4A's Climate Change Commitment*, available at <http://airlines.org/a4as-climate-change-commitment/>

¹⁹ CAAFI is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants and U.S. Government agencies working to promote alternative jet fuels for commercial aviation.

²⁰ The International Council on Clean Transportation, *Greenhouse Gas Emissions From Global Shipping, 2013–2015* (October 2017).

to more than 27 million people who live within this 204,000 square mile area.²¹ This report modeled how increasingly potent storms could cause increased river levels and the likelihood of flooding in low-lying areas; how more frequent and heavy droughts could reduce river volumes in localized areas, adversely impacting navigation and power generation that all rely on river flows; and the possible economic losses from the potential events.

Water Resiliency Accomplishments

Through the biennial Water Resources Development Acts, the Committee has taken initial steps to ensure that the impacts of climate change are taken into account in the planning, design, and construction of water resources development projects, such as flood risk reduction projects and hurricane and storm damage reduction projects, as well as to promote greater use of natural and nature-based infrastructure systems that seek to mimic nature's resiliency and reduce the effects of extreme weather events, and seek to develop integrated water resources projects that address multiple project purposes. Similarly, the Committee amended the Clean Water Act in the *Water Resources Reform and Development Act of 2014* (P.L. 113–121) to make projects increase the resiliency of water-related infrastructure from the impacts of natural and man-made disasters, including extreme weather events and sea-level rise.

FEMA Resiliency Accomplishments

In 2017, Executive Order 13690—the Federal Flood Risk Management Standard (FFRMS), which amended the longstanding floodplain management Executive Order 11988, was repealed. In 2018, Congress enacted language in the John S. McCain National Defense Authorization Act (NDAA) for Fiscal Year 2019 (P.L. 115–232) to establish minimum flood mitigation requirements for all military construction within the 100-year floodplain.

The FFRMS was developed with significant interagency coordination during the Obama Administration. It was intended to assist in reducing the risk and cost of future flood disasters by ensuring that Federal investments in and affecting floodplains were constructed to better withstand the impacts of flooding. The FY19 NDAA language (Sec. 2805(a)(4)) is a similar step toward resiliency—albeit limited to the Department of Defense—requiring construction of non-mission critical buildings to two feet above the base flood elevation (BFE) and construction of mission-critical buildings to three feet above the BFE.

Congress advanced two additional provisions to incentivize greater resiliency for future projects receiving Federal funding via the Federal Emergency Management Agency (FEMA).

First, in the Disaster Recovery Reform Act (DRRA) of 2018 (P.L. 115–254), the Committee authorized the National Public Infrastructure Pre-Disaster Mitigation (PDM) fund which will be funded as a six percent set aside from disaster expenses. This will be a more consistent stream of funding for PDM, allowing for greater investment in public infrastructure mitigation before a disaster. Additionally, DRRA clarifies what may be eligible for mitigation funding, ensuring Federal investments are cost effective and reduce risk. Until enactment of DRRA, PDM grants were inadequately and inconsistently funded by annual and supplemental appropriations.

Second, in the Bipartisan Budget Act (BBA) of 2018 (P.L. 115–123), Congress authorized the President to adjust the Federal cost share for FEMA Public Assistance grants on a sliding scale for States and Tribes that have invested in measures that increase readiness for, and resilience from, a major disaster (Sec. 20606).

Maritime Resiliency

The U.S. Arctic, as defined in statute²², encompasses U.S. territory north of the Arctic Circle and along the Alaskan coast, including the Aleutian Islands. Three Arctic seas—the Bering, the Chukchi, and the Beaufort—border Alaska, and these seas have historically been frozen for more than half the year. The U.S. Arctic Exclusive Economic Zone contains 568,000 square nautical miles (SNM), of which less than half is considered by NOAA to be “navigationally significant.” The National Oceanic and Atmospheric Administration (NOAA) has designated 38,000 SNM of the navigationally significant areas as survey priority locations in the Arctic and es-

²¹ U.S. Army Corps of Engineers and Ohio River Basin Alliance, *Ohio River Basin—Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance* (May 2017), available at https://www.lrh.usace.army.mil/Portals/38/docs/orba/USACE%20Ohio%20River%20Basin%20CC%20Report_MAY%202017.pdf.

²² The Arctic Research and Policy Act of 1984, as amended (Public Law 98–373).

timates that it could take up to 25 years to conduct modern hydrographic surveys in the priority locations, if resources remain at their current level.²³

Currently, most cargo ship traffic is not trans-Arctic; rather it is regional, focusing on the transport of natural resources and general cargo to and from widely dispersed communities. While there has been a recent increase in shipping activity, that increase is more related to a rise in commodity prices than with the melting of Arctic ice.²⁴ However, the January 2019 Arctic sea ice extent was the sixth smallest in the 41-year record, six percent below the 1981–2010 average.²⁵ While all areas of the Arctic are seeing increased vessel activity, the Northern Sea Route along the Eurasian Arctic coast continues to account for the bulk of Arctic shipping activity.²⁶

Numerous governmental and academic reports have identified infrastructure and operational challenges to maritime transportation in the U.S. Arctic, including limited satellite coverage and architecture to support voice and data communications, the lack of a deep-draft port (accommodating ships with a draft of up to 35 feet), hazardous weather and ice conditions, and the lack of channel marking buoys and other floating visual aids to navigation, which are not possible due to continuously moving ice sheets.²⁷ In order to ensure safe and efficient maritime transportation in the region, it is necessary to conduct surveys to improve nautical charts, improve communications capabilities, improve weather forecasting and modeling, construct a deep-draft U.S. Arctic port, and develop community and regional emergency response networks in preparation for vessel and aircraft accidents and environmental damage related to increased ship traffic and industry.

While climate change is causing the Arctic to become an emergent area, it will not solely affect the polar regions. Rising sea level projections mean that port infrastructure at all latitudes could be at risk of inundation, higher storm surge, and loss of economic function costing hundreds of millions if not billions of dollars to mitigate threats or rebuild/relocate existing infrastructure.

WITNESS LIST

Panel I

- Dr. Daniel Sperling, Board Member, California Air Resources Board
- Ms. Vicki Arroyo, Executive Director, Georgetown Climate Center
- Professor Thomas P. Lyon, Stephen M. Ross School of Business, University of Michigan
- Mr. Ben Prochazka, Vice President, Electrification Coalition
- Ms. Nancy Young, Vice President, Environmental Affairs, Airlines for America

Panel II

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- Ms. Lynn Scarlett, Vice President, Policy and Government Affairs, The Nature Conservancy

²³ NOAA National Ocean Service, <https://oceanservice.noaa.gov/economy/arctic/>, accessed February 19, 2019.

²⁴ Ronald O'Rourke, Congressional Research Service. *Changes in the Arctic: Background and Issues for Congress*. February 7, 2019.

²⁵ National Snow & Ice Data Center, <https://nsidc.org/arcticseaicenews/>, accessed February 19, 2019.

²⁶ O'Rourke.

²⁷ Arctic Council (2009) *Arctic Marine Shipping Assessment*; U.S. White House (2013) *National Strategy for the Arctic Region*; U.S. Government Accountability Office (2014) *Maritime Infrastructure: Key Issues Related to Commercial Activity in the U.S. Arctic over the Next Decade*; Alaska Arctic Policy Commission (2015) *Final Report*; U.S. Committee on the Marine Transportation System (2016) *A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic*; Council on Foreign Relations (2017) *Arctic Imperatives, Reinforcing U.S. Strategy on America's Fourth Coast*; Center for Strategic and International Studies (2017) *Maritime Futures, the Arctic and the Bering Strait Region*; Homeland Security Operational Analysis Center (2018) *Identifying Potential Gaps in the U.S. Coast Guard Arctic Capabilities*; U.S. Committee on the Marine Transportation System (2019) *Revisiting Near-Term Recommendations to Prioritize Infrastructure Needs in the U.S. Arctic*.

EXAMINING HOW FEDERAL INFRASTRUCTURE POLICY COULD HELP MITIGATE AND ADAPT TO CLIMATE CHANGE

TUESDAY, FEBRUARY 26, 2019

HOUSE OF REPRESENTATIVES,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
WASHINGTON, DC.

The committee met, pursuant to notice, at 10:03 a.m., in room HVC-210, Capitol Visitor Center, Hon. Salud O. Carbajal (Vice Chairman of the committee) presiding.

Mr. CARBAJAL. The committee will come to order. I ask unanimous consent that the Chair be authorized to declare recess during today's hearing.

Without objection, so ordered.

Welcome, everyone. Unfortunately, due to an unusually heavy snow storm in Oregon, the chairman remains stuck and is unable to attend today's hearing.

This is the latest evidence, many will say, that climate change increases extreme weather events, and those events negatively affect our transportation system. Today I will deliver the following remarks on behalf of Chairman DeFazio.

Today we bring the full committee together for our second hearing of the year, to examine how Federal infrastructure policy could help mitigate and adapt to climate change. The Transportation and Infrastructure Committee has traditionally worked in a bipartisan manner. We don't always agree, but we do always strive to find common ground.

Today we tackle a topic that has divided Congress for a long time. I urge every member of this committee to approach today's hearing with an open mind and a willingness to listen and learn, and to respectfully engage with each other and today's panel.

The transportation sector is now the largest contributor to global warming. Within the transportation sector, passengers and freight vehicles contribute 83 percent of the global warming emissions. I intend to respond appropriately to this challenge as we move legislation and direct investment to transportation activities this Congress.

I suspect many on both sides of the aisle will want to spar over the Green New Deal. While proponents tout it as critical to avoiding a climate crisis, others have called it a plan that will undermine our economy and way of life. It is difficult to reconcile these two portrayals, but it is not what we are here to do today. If you want to debate the underlying arguments or ideas of the Green New Deal, this is not the venue.

The authors of the Green New Deal set an ambitious goal, one which I support, but their plan encompasses issues far beyond the jurisdiction of this committee. In fact, it was referred to 11 committees, and the resolution provides no details. Rather than debate this resolution, our job is to find pragmatic approaches to address the challenges of our changing climate.

I believe our best chance of mitigating further damage and creating sustainable, resilient infrastructure is to look for areas of common ground.

Many would be surprised to learn that my district is not so different from our ranking member's district. His district is the 40th largest district in the Nation at 18,198 square miles. My district is the 41st largest district in the Nation at 17,274 square miles. We both have population areas. The ranking member has the northern suburbs of Kansas City, while I have two university towns. Moreover, we both have large rural constituencies who make an honest living in agriculture, in Mr. Graves's district, and in timber, fishing, and agriculture in my district.

Ranking Member Graves and I represent similar people, facing similar struggles, and worrying about similar things, some in the rural areas and some in more urban areas. We owe it to our constituents to be pragmatic, thoughtful, and deliberate.

Also on this committee are members with vastly different districts. Mr. Espaillat's district, parts of Manhattan and the Bronx, is so small and dense that one can stroll from one side of the district to the other with a leisurely walk. On the other side of the spectrum, it takes a lengthy plane ride to get across Mr. Young's vast district.

Today I want the witnesses to offer pragmatic, yet effective, solutions to climate change that reflect these differences and that will inform the committee's efforts to mitigate carbon emissions and provide for resilient infrastructure in different disparate districts.

Despite the differences among Member districts, our constituents rely on airports, bridges, drinking water, highways, ports, public buildings, rail, transit, tunnels, and wastewater systems. Protecting critical infrastructure unites us, and firmly within this committee's jurisdiction. I want to be proactive, working with all Members to address this challenge.

I would also ask that Members give thoughtful consideration to the options presented today, and look for areas of future opportunity. For example, many of today's witnesses will support electrification of passenger and freight vehicles because of the overwhelming contribution to global warming emissions by today's fleet.

Some Members may be tempted to blast away at this idea, raising concerns about the economic consequences. Before they do, they should know that over four-fifths of battery electric vehicles and nearly two-thirds of plug-in hybrid electric vehicles are assembled in the United States. I think we can all agree we should support more domestic manufacturing.

So let's get down to business. If you want to do the hard, messy work of legislating to reduce carbon emissions from transportation, and build resilient infrastructure in an effort to tackle global warming, I look forward to working with you. I welcome our wit-

nesses who are here to inform us of pragmatic, but effective, strategic strategies this committee can take.

[Mr. DeFazio's prepared statement follows:]

Statement of Hon. Peter A. DeFazio, a Representative in Congress from the State of Oregon, and Chair, Committee on Transportation and Infrastructure

The following are opening remarks as prepared for delivery by committee Vice Chair Salud O. Carbajal, on behalf of Chair Peter A. DeFazio, who was unable to attend today's hearing due to a snowstorm in Oregon.

Welcome. Unfortunately, due to an unusually heavy snowstorm in Oregon, the chairman remains stuck there and is unable attend today's hearing. This is the latest evidence that climate change increases extreme weather events and those events negatively affect our transportation system. I will deliver the following remarks on behalf of the chairman.

Today we bring the full committee together for our second hearing of the year, to examine how Federal infrastructure policy could help mitigate and adapt to climate change. The Transportation and Infrastructure Committee has traditionally worked in a bipartisan manner—we don't always agree, but we do always strive to find a common ground. Today, we tackle a topic that has divided Congress for a long time. I urge every member of this committee to approach today's hearing with an open mind and a willingness to listen and learn, and to respectfully engage with each other and today's panel.

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I believe our best chance of mitigating further damage and creating sustainable, resilient infrastructure is to look for areas of common ground. Many would be surprised to learn that my district is not so different from the ranking member's district. His district is the 40th largest district in the nation at 18,198 square miles. My district is the 41st largest district in the nation at 17,274 square miles.

We both have populous areas, the ranking member has the northern suburbs of Kansas City, while I have two university towns. Moreover, we both have large rural constituencies who make an honest living—in agriculture in Mr. Graves's district—and timber, fishing, and agriculture in my district.

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So let's get down to business. If you want to do the hard, messy work of legislating to reduce carbon emissions from transportation and build resilient infrastructure in an effort to tackle global warming, I look forward to working with you. I welcome our witnesses who are here to inform us of pragmatic, but effective, strategies this committee can take.

Mr. CARBAJAL. I will now turn it over to Ranking Member Graves.

Mr. GRAVES OF MISSOURI. Thank you, Mr. Chairman. I think we can all agree that we want clean air and clean water for our communities, and we have to be prepared for the challenges that are posed by a sometimes harsh environment.

And as a farmer myself, I know that the environment is important for both quality of life, and it is obviously important for the economy. And I also know we need to work together to find solutions that actually work.

We don't have to live in a fairy tale. And that is where ideas like the Green New Deal come from. There is no other way to describe this idea to completely make over our transportation network.

Who actually believes that we can make aviation unnecessary by building some vast high-speed rail system? Because right here in the real world, the poster child, obviously, for high-speed rail in California has simply run off the tracks right before our eyes. And by the way, this massive shift would put 11 million people in the aviation sector out of jobs, or out of work.

There are some real consequences of pursuing the goals of this fantasy proposal. And that is just one example of the Green New Deal goals and the trillions of dollars it would likely cost.

Infrastructure is an issue that we can find common ground and bipartisan agreement on, with real-world solutions. In recent years, we have passed some really good bipartisan infrastructure legislation that has addressed environmental issues.

For instance, the FAA reauthorization, among other things, established the FAA industry partnership for developing low-energy and low-emission technologies. The Disaster Recovery Act focused on making our communities more resilient to disasters. And we passed three Water Resources Development Acts that address ecosystem restoration, flood risk reduction, and storm risk reduction projects.

Instead of taking the Government-knows-all or one-size-fits-all approach, these laws provide the State, local, and private-sector partners with the tools and flexibility to address their needs and to innovate.

In fact, it is the private sector that is responding to industry-driven and consumer-driven market demands for cleaner energy and cleaner technology. As a result, we continue to have more fuel-efficient cars, trains, trucks, aircraft, and to develop cleaner alternative fuels.

The airline industry, represented here today, is making considerable progress in reducing emissions, and I look forward to hearing more about their efforts.

The freight rail industry is making progress, implementing technologies to limit greenhouse gases, increase fuel efficiency, and reduce their carbon footprint.

At the Federal level we need to ensure that our partners have the ability to keep innovating. We don't need sweeping mandates that ignore economic reality and differing needs within our communities. And that heavy-handed approach, which is envisioned in the Green New Deal, just simply doesn't work, and it just drives entire industries and communities right into the very earth that we are trying to protect.

Today I hope our panelists are going to talk about real, practical, and bipartisan solutions within this committee's jurisdiction which will build the infrastructure, and improve and respond to our environment.

[Mr. Graves's prepared statement follows:]

Statement of Hon. Sam Graves, a Representative in Congress from the State of Missouri, and Ranking Member, Committee on Transportation and Infrastructure

We can all agree that we want clean air and clean water for our communities, and that we have to be prepared for the challenges posed by a sometimes harsh environment.

As a farmer, I know that the environment is important to both quality of life and the economy.

I also know that we need to work together to find solutions that actually work.

We don't live in a fairy tale. That's where ideas like the Green New Deal come from. There's no other way to describe this idea to completely make over our transportation network.

Who actually believes that we can make aviation "unnecessary" by building some vast high-speed rail system? Because here in the real world, the poster child for high-speed rail in California has run off the rails right before our eyes. And by the way, this massive shift would put 11 million people with aviation-related jobs out of work. Those are some of the real consequences of pursuing the goals of this fantasy proposal.

That's just one example of the Green New Deal's goals and the trillions of dollars it would likely cost.

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Instead of taking the "government-knows-best," "one-size-fits-all" approach, these laws provide our State, local, and private sector partners with the tools and flexibility to address their needs and to innovate.

The fact is that the private sector is responding to industry-driven and consumer-driven market demands for cleaner energy and cleaner technology. As a result, we continue to have more fuel-efficient car, truck, train, and aircraft engines, and to develop cleaner alternative fuels.

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At the Federal level, we need to ensure that our partners have the ability to keep innovating.

We don't need sweeping mandates that ignore economic reality and the differing needs of our communities.

That heavy-handed approach, envisioned by the Green New Deal, doesn't work. It just drives entire industries and communities right into the very earth we're all trying to protect.

Today, I hope our panels can talk about real, practical, and bipartisan solutions—within the Committee's jurisdiction—for building infrastructure, and improving and responding to our environment.

Mr. GRAVES OF MISSOURI. And with that, I look forward to hearing from all of our witnesses, and I would yield back.

Mr. CARBAJAL. Thank you, Representative Graves. I would like now to welcome the witnesses on our first panel. We first have Dr. Daniel Sperling, board member, California Air Resources Board; Ms. Vicki Arroyo, executive director, Georgetown Climate Center; Professor Thomas P. Lyon, with the Stephen M. Ross School of Business, University of Michigan; Mr. Ben Prochazka, vice president, Electrification Coalition; and Ms. Nancy Young, vice president, environmental affairs, Airlines for America.

Thank you to each of you for being here today, and I look forward to your testimony.

Without objection, our witnesses' full statements will be included in the record.

Since your written testimony has been made part of the record, the committee would request that you limit your oral testimony to 5 minutes each.

With that, Dr. Sperling, you may proceed.

TESTIMONY OF DANIEL SPERLING, BOARD MEMBER, CALIFORNIA AIR RESOURCES BOARD; VICKI ARROYO, EXECUTIVE DIRECTOR, GEORGETOWN CLIMATE CENTER; THOMAS P. LYON, PROFESSOR, STEPHEN M. ROSS SCHOOL OF BUSINESS, UNIVERSITY OF MICHIGAN; BEN PROCHAZKA, VICE PRESIDENT, ELECTRIFICATION COALITION; AND NANCY N. YOUNG, VICE PRESIDENT, ENVIRONMENTAL AFFAIRS, AIRLINES FOR AMERICA

Mr. SPERLING. Good morning, distinguished members of the committee. Thank you for the opportunity to speak today. My name is Dan Sperling. I am a professor of engineering and environmental science and policy and founding director of the Institute of Transportation Studies at the University of California, Davis. I am also a board member for the California Air Resources Board, holding the transportation seat for the past 12 years, first appointed by Governor Schwarzenegger.

I am here to share experiences from California, and my insights from over 30 years studying the transportation system of this country. Let me frame the challenges before us.

The number-one priority for California, like the rest of America, is to maintain and repair our deteriorating road infrastructure. That is widely accepted. The point of my testimony, however, is to address the additional goal of aligning transportation spending with environmental goals, as well as with social goals.

First, we need to acknowledge that our transportation system is failing. Not only are our roads deteriorating, but congestion, traffic deaths, transit ridership, and greenhouse gases are all worsening. And many people are marginalized with poor access to jobs, health,

and education. We can fix this. We have a once-in-a-lifetime opportunity to do so, thanks to the waves of transformational innovations starting to sweep through transportation.

I refer to these innovations as the three transportation revolutions: electrification, shared mobility, and automation. The challenge is to refocus and restructure how we fund and manage our transportation system, such that we direct these many innovations toward the public interest.

The State and Federal DOTs were called upon in the 20th century to build and operate a massive new highway and rail transit system. They were amazingly successful with this engineering mission. But the organizational culture that was created, and the set of rules and formulas that were put in place are now outdated and, frankly, have been for some time.

As we approach reauthorization of the FAST Act, we need a paradigm shift in how we address transportation. It means focusing on new formulas and performance standards to stimulate innovation, expand the mission of our transportation institutions, and knock down silos within transportation.

Back to California. We have made extraordinary progress in some ways. We instituted the most successful cap and trade program in the world, an effective low-carbon fuel standard, and a variety of requirements for electrification of cars and buses. Together these initiatives continue to fund many billions of dollars in electric cars, trucks, buses, as well as charging stations and hydrogen stations, and much more. I provide a description of these many programs in my written testimony.

We have been less successful in addressing vehicle use, both passenger and freight. We are now shifting our programs and incentives in California to fix this shortcoming. I would characterize California's evolving strategy on vehicle use as fourfold.

One, encourage more mobility and accessibility. That means more passenger miles traveled, but at the same time reducing vehicle use, vehicle miles traveled.

Number two is create more choice for travelers, and that means electric scooters, bikes, pooled services by Lyft, Uber, Via, and others, car sharing, and much more.

Number three is increase investment in protected lanes in infrastructure for these scooters and bikes.

And number four is to electrify all passenger vehicles and passenger services, as well as most of the freight vehicles, as well.

In conclusion, transportation is in desperate need of a fix. Fortunately, innovation is sprouting everywhere in transportation. In a major way, for the first time in half a century, California is pioneering some initiatives, but so are many others. Much more can be done, especially in urban areas, but also in rural areas, as well. Our top priority should be to reform Federal and State policies to incentivize change to encourage innovation to flourish.

Thank you very much.

[Mr. Sperling's prepared statement follows:]

Prepared Statement of Daniel Sperling, Board Member, California Air Resources Board

Good morning Mr. Chairman and distinguished members of the committee. Thank you for the opportunity to testify today.

My name is Daniel Sperling. I hold two different positions: (1) Distinguished Professor of engineering and environmental science and policy and founding Director of the Institute of Transportation Studies at the University of California, Davis; and (2) Board member for the California Air Resources Board, holding the transportation seat (first appointed by Governor Arnold Schwarzenegger in February 2007). CARB, as we call it, is the agency in California principally responsible for administering its climate policies.

I am here to share thoughts on what California is doing to reduce greenhouse gas emissions from transportation, what we have learned, and what the Federal Government might do, with a focus on new approaches to funding and incentives. The opportunity exists for the first time in half a century to create a truly sustainable transportation—economically, environmentally and socially.

California has been a pioneer in reducing greenhouse gas emissions while improving the economy and the mobility and accessibility of its residents . . .

California is home to some of the world's strongest environmental protections, while growing to become the fifth largest economy in the world. California policies have created markets for energy efficiency, energy storage, low carbon fuels, renewable power and zero-emission vehicles. California is home to nearly half of the zero-emission vehicles in the U.S., 40 percent of North American clean fuels investments, the world's best known electric car manufacturer, and the world's leading ride-sharing services.

California has demonstrated that one can invest in clean energy, efficient buildings and sustainable transportation, to gain a healthy environment while also growing the economy. Since 2010, California's economy, per-capita income and the size of the private workforce have all grown significantly faster than the national average, while at the same time reducing its carbon emissions back to the level they were at in 1990.

California is not an island—an especially important understanding in crafting solutions to climate change, a global problem. With ports, industries, water supplies, wild fires, and many communities all vulnerable to climate change, California aims to be a leader and model.

California's strategy is to employ a suite of policy approaches, combining carbon pricing with other complementary programs, including market-based compliance mechanisms, performance standards, technology requirements, and incentives.

A large variety of approaches are needed to grow the economy, solve environmental problems, and adapt to climate change. We have learned over the past decade that climate change is happening more quickly and with greater impact than we imagined, and that we need to pay special attention to transportation. What we see in California is that, despite the rapidly growing number of low and zero emissions vehicles, emissions are stubbornly rising.

The important role of transportation and its link to land use. . . .

California's transportation system underpins its economy. The extensive freight system moves trillions of dollars of goods each year and supports nearly one-third of the State economy and more than 5 million jobs.

Transportation is also the largest source of GHG, criteria, and toxic diesel particulate matter emissions in the State (mobile sources account for almost 50 percent of greenhouse gas emissions in California, 85 percent of nitrogen oxides, and 90 percent of diesel particulate matter). This is not unique to California.

Where and how population grows will also have implications for traffic congestion, demand for new infrastructure (including roads, transit, and active transportation infrastructure), and demand for maintenance and upkeep of existing infrastructure. Historic patterns of growth continue to shape the country. While California has grown to be the fifth largest economy in the world, with world-class cities and thriving communities, many residents have no choice but to spend significant time and money driving from place to place.

The way we grow imposes and often reinforces long-standing racial and economic injustices by placing a disproportionate burden on low-income residents, who end up paying the highest proportion of their wages for housing and commuting. These residents also often live in communities with the most health impacts from lack of active transportation infrastructure and transportation pollution. Communities are at the heart of California's efforts to address climate change: urban and rural ones,

and big and small ones. We cannot meet our goals without re-envisioning the way we plan and build them.

Innovative California initiatives in place . . .

I'd like to present a sampling of major California initiatives to reduce transportation greenhouse gas emissions, which also bolster the economy, enhance public health, revitalize disadvantaged communities, improve mobility, and strengthen resilience to disasters and changing climate, are often the same strategies that reduce transportation sector GHG emissions.

- California's Sustainable Communities Program, SB 375, is a law that sets targets for metropolitan areas to reduce greenhouse gas emissions from passenger transportation. The law has been highly successful at motivating leaders and community groups to reframe how to align transportation and environmental strategies and investments—truly a paradigm shift for the transportation community. What we learned, though, is that strong carrots and perhaps some sticks are needed to go the next step of accomplishing actual change at the local level.
- One example of going the next step: a variety of policy and funding processes are being explored to infuse environmental criteria more deeply into transportation funding decisions.
- As we continue to develop new approaches to transportation planning, it is important that we continue to measure and assess what we have. The transportation system is rapidly changing, so it's important that we have up-to-date data to inform our decisions
- California is investing in infrastructure that supports a suite of low-carbon transportation choices.
 - The Low Carbon Fuel Standard is structured to incentivize the supply of transportation fuels that are lower emitting and supports zero-emissions technology. For example, zero emissions technology use is credited to the low carbon fuel supplier, such as the electric utility or transit agency. Those credits are valued at over \$0.10 per kWh; they are used to fund electric vehicle charging and hydrogen fuel stations, and are expected to be converted into rebates to electric vehicle buyers (estimated to be about \$2000 per vehicle).
 - The California Energy Commission has committed \$276 million for charging infrastructure and \$141 million for hydrogen stations, to be fully spent within about 3 years.
 - Funding from the Volkswagen settlement, \$1.2 billion, is being made available in California over 10 years mostly for electric vehicle charging stations, electric transit and school buses, electric trucks, electric forklifts and other equipment at ports, electric airport ground support equipment, electric ferries and tug boats, and low NOx combustion engine trucks, locomotives, and ships.
- Proceeds from California's Carbon Cap and Trade program are used for investments and incentives to reduce emissions from transportation. Of \$9.4 billion available for public spending since 2012, more than \$7 billion is being used to reduce GHG emissions from transportation, through a variety of programs. These include incentives and funding for clean cars, buses, and trucks, and off-road vehicles, high speed rail, active transportation, and more. Innovative efforts include linking affordable housing, transit, bike paths, car sharing, and urban greenery.
- Recent increases in California's gasoline/diesel tax (SB1) provides billions of transportation dollars to support California's air pollution, climate and public health priorities.
 - Over \$800 million is allocated to active transportation, Sustainable Communities planning grants, transit and rail investments, and a new Congested Corridors program.
 - "The Solutions for Congested Corridors" program provides competitive funding based on performance measures tied to funding. The program requires that regions have an adopted Sustainable Communities Strategy (based on SB375) as part of their Regional Transportation Plan (RTP). Project applications are scored and selected based on metrics for accessibility, economic development, job creation and retention, air pollution and greenhouse gas emission reductions; and efficient land use.

Looking to the future, we need to rethink how transportation dollars are spent . . .

- In California alone over \$1.1 trillion will be spent on transportation infrastructure over the life of current transportation plans—yet these spending plans

often do not reflect key sustainability goals. Federal and State governments, including California, need to update transportation funding to better align projects with health, equity, economic, and environmental priorities.

- In California 24 counties have passed local transportation sales tax measures, which comprise a significant portion of many regions' transportation funds. These measure often list specific projects, locking them in for years or decades. Often, these measure do not fully fund their listed projects, with the result that they go on to capture a region's otherwise-flexible State and Federal funds. While some of these projects or measures have been remarkably supportive of sustainability goals, others are not.
- Fiscally sustainable and equitable methods for funding the transportation system are needed; they should be designed and adopted in a manner that aligns transportation goals with environmental and health goals. This alignment can be achieved through project performance criteria, funding formulas that account for environmental outcomes, and road user charges that account for congestion and environmental externalities.
- Funding programs could be created to fund pilot tests of strategies for improving transportation efficiency, such as shuttles, enhanced transit service, pooling facilitated by ride-hailing, protected bike lanes, and bike- and scooter-sharing, possibly to make travel easier in key zones that are currently highly congested, such as urban downtowns.

Looking to the future, we also need to use policy to direct new mobility services toward the public interest . . .

New mobility options offer an extraordinary opportunity to improve accessibility to jobs, school, health and more. Outside dense core cities, public transit is not efficient and does not serve many people well. An important goal is to improve mobility and accessibility for everyone—but to do so in a way that reduces vehicle miles traveled. It is possible and desirable—but only if the right policies are put in place. If we don't intervene, the likely outcome is higher costs for travelers and infrastructure, greater environmental impacts, and reduced accessibility and mobility by the most disadvantaged segments of our population. California is just beginning to pursue policies that direct these many new services, technologies, and business models (including demand-responsive ride-hailing companies, micro-transit vans and small buses, and micro-mobility options such as dockless scooters and bikes) toward the public interest. These initiatives include:

- Regulations to accelerate the use of electric vehicles and passenger “pooling” by Lyft, Uber, and other “transportation network companies” are being adopted in response to a new law, SB 1014 (2018)—the Clean Miles Standard and Incentive Program—which calls for innovative ways to curb greenhouse gas emissions. This new program will be aligned with future changes to the Advanced Clean Cars automaker regulations, as well as the SB 375 program—the Sustainable Communities and Climate Protection Act (which requires regional GHG reductions from passenger transportation).
- Pilot testing of innovative ideas and services to speed the adoption of clean, efficient transportation solutions. Promote the use of pilot projects that bring together innovators, technical experts, community members, and decisionmaking partners to find creative solutions for accelerating a change in travel choices away from single-occupancy vehicles while improving accessibility and access to opportunity, particularly for low-income communities.
- In our capital city of Sacramento, the regional metropolitan planning organization, SACOG, is developing a “Green Means Go” pilot program that incentivizes and accelerates infill development, reduces vehicle miles traveled, and increases electric vehicle use within designated “Green Zones” or opportunity areas. Green Zones complement SACOG's Civic Lab pilot program, which focuses on targeted innovative transportation solutions and new ideas that can be scaled up throughout the region.
- Emerging public private partnerships are also helping to pave the way, and incentive funding to explore innovative solutions are key,
- For example, the Car-Free Living Program is a first-of-its-kind partnership that encourages residents to use public transportation and ride share, providing a more affordable alternative to car ownership. The real estate developer is enthusiastic because they do not provide as much (expensive) parking garage spaces. New residents who participate in the Car-Free Living Program receive a \$100 monthly transportation credit per apartment to use with Getaround, Clipper card (transit fare card in the San Francisco Bay Area), and Uber. Any resident can also catch a ride in an UberPool from Parkmerced to nearby public transit stations for a flat rate of \$5.

In conclusion . . .

Transportation is in need of a fix, not just because of greenhouse gas emissions, but also because of degrading road infrastructure, worsening traffic congestion, declining transit ridership, and large numbers of people with poor access to jobs, health, and education.

Transportation is also an opportunity. Innovation is everywhere. California is pioneering some initiatives, as are others. But much more can be done. Reforming Federal and State policies to encourage innovation and incentivize change should be a top priority. Funding should be used to support initiatives that promote environmental, social, and economic goals.

Thank you and I look forward to answering any questions you might have.

Mr. CARBAJAL. Thank you, Dr. Sperling.

Ms. Arroyo, you may proceed.

Ms. ARROYO. Good morning, Mr. Chairman, Ranking Member, and committee members. Thank you for the opportunity to share what States and cities are doing to promote clean and resilient transportation. I am Vicki Arroyo, executive director of the Georgetown Climate Center, and professor from practice at Georgetown Law.

I also currently chair the Executive Committee of the Transportation Research Board of the National Academies, and recently chaired TRB's Task Force on Resilience and Sustainability. My comments are my own.

As the Fourth National Climate Assessment makes clear, the U.S. is experiencing serious impacts of climate change. There is an urgent need to transition to a low-carbon transportation system, not only to fight climate change, but to protect public health, provide mobility options, and catalyze economic growth and investment.

States and cities are working to make this transition happen by promoting adoption of cleaner vehicles and fuels, improving public transportation, and enacting pathways to fund clean transportation innovation: just a few examples.

California is investing in transit electric vehicles and clean buses, and requiring investment in disadvantaged and underserved communities using funds from their State cap and trade program that covers transportation fuels. Oregon law makers are working to adopt a similar program.

Twelve States from New England through the mid-Atlantic plus DC participate in the Transportation and Climate Initiative, or TCI, which our center facilitates. Ten TCI jurisdictions recently announced a bipartisan agreement to design a regional low-carbon transportation policy proposal that would cap and reduce carbon emissions from transportation, allowing participating States to invest proceeds in low-carbon and more resilient transportation options.

Due to policies and market shifts, the electricity sector is decarbonizing, leaving the transportation sector the largest source of emissions. A key strategy for reducing these emissions is to switch to zero-emission vehicles. TCI States collaborate on regional, interstate corridor planning, with over 2,500 miles of EV corridors designated by FHWA. Federal funding to support implementation would be helpful.

Beyond funding, Federal action could allow EV charging icons at highway logo signs, and exempt EV charging stations from current

restrictions on commercial activity along the interstate right-of-way.

Zero-emission buses provide opportunities to expand benefits of clean transportation. Last year FTA provided over \$80 million for 52 electric bus transit projects in 41 States. States are also exploring opportunities for zero-emission ships and trucks. Washington State plans to use 45 percent of its VW settlement funds to electrify public vessels, including ferries which are responsible for significant air pollution. Hydrogen fuel cells provide another option for zero-emission green transport.

Beyond clean fuels, States and cities are also working to reduce vehicle miles traveled by promoting more compact, livable communities, and providing options such as transit, biking, and walking. For example, the Dallas Area Rapid Transit system's GoPass allows easy payment for different transit services, even integrating microtransit and scooters.

Arlington, Virginia, where I lived, has enjoyed tremendous economic growth, while holding emissions down by implementing transit-oriented development, including bike paths and more, taking roughly 50,000 vehicle trips off the road each work day. Increasing the Federal match for public transit operating expenses from current levels of 50 percent would help in these efforts, which provide multiple benefits.

In addition to being the largest source of emissions, transportation is quite vulnerable to climate impacts. Since 1980 the U.S. has experienced 241 extreme weather events, costing \$1.6 trillion.

There is a tremendous human toll, as well. My mother and other family members lost their homes in Katrina. Our work on Katrina, Irene, and Sandy identified opportunities to improve how communities can rebuild.

Vermont faced challenges with Federal reimbursement in building back culverts and bridges to withstand future storms after Irene. Incorporating lessons from this and other recent disasters, some Federal funds are now flowing to more resilient investments.

LA SAFE, Louisiana's program initially funded through disaster recovery dollars, works with parishes to design customized projects that improve community resilience, like "complete streets" and nature-based flood mitigation.

Building on reforms in MAP-21, the FAST Act, and the Disaster Recovery Reform Act, funding recipients should be required to consider how climate change will affect infrastructure, making investments designed to withstand future conditions.

Beyond infrastructure, improving operations and evacuation protocols can save lives. In 2004, my father's, Sidney Arroyo's, heart failed during a stressful evacuation from New Orleans in anticipation of Hurricane Ivan, which struck Alabama instead. The next year many people chose not to leave New Orleans before Katrina, some recalling the evacuation challenges the year before, others without access to transportation or not willing to leave behind beloved pets.

Congress swiftly acted to pass the Pet Evacuation and Transportation Standards Act—yes, it spells PETS—and it saved lives in subsequent storms. Congress should again act more comprehensively, joining States and communities in addressing climate

change, while preparing communities for the disruptive challenges to come. Thank you.

[Ms. Arroyo's prepared statement follows:]

Prepared Statement of Vicki Arroyo, Executive Director, Georgetown Climate Center

Good morning, Chairman DeFazio, Ranking Member Graves, and members of the Committee. Thank you for the opportunity to testify today about the steps that states and cities are taking to reduce greenhouse gas pollution from transportation and to make our communities more resilient to the serious consequences of climate change.

Many states and cities are taking bold action to reduce emissions and improve resilience, offering both substantial progress in the fight against climate change and examples of successful action that others could emulate and that the federal government could be helpful in scaling up. However, more action is needed.

I'm Vicki Arroyo and I serve as Executive Director of Georgetown Climate Center, which is based at Georgetown University Law Center. I am also a member of the full-time faculty, serving as a Professor from Practice and as Assistant Dean for Centers and Institutes.

The nonpartisan Georgetown Climate Center was established over ten years ago to serve as a resource to states on issues relating to climate change policy and clean energy and to inform the federal dialogue with the lessons of the states.¹ We work with state and city officials on a bipartisan basis at their request to support their transition to cleaner energy sources in important sectors, including the power sector and transportation, and to prepare for the impacts of a changing climate.

I am also currently Chair of the Executive Committee of the Transportation Research Board of the National Academies of Sciences, and recently chaired TRB's Task Force on Resilience and Sustainability² which made recommendations regarding how TRB might incorporate considerations of a changing climate and the role of transportation—and impacts to transportation infrastructure—into its important work.

While I am proud of these roles and affiliations, my comments today are my own. Given the urgent need to address climate change, it's my privilege to be with you today to share examples of what states and cities are doing to promote cleaner transportation options and to prepare for climate impacts. I hope these examples will help inform your own work.

As the Fourth National Climate Assessment, released in November, describes, the United States is already experiencing serious impacts of climate change—and the risks to communities all across the country are growing rapidly.³

These findings, along with those in the 2018 Intergovernmental Panel on Climate Change (IPCC) report, are clear and should be a call to immediate action. Even if we manage to limit planetary warming to just 2 degrees C, the world will still face increased chances of economic and social upheaval from more severe flooding, droughts, heatwaves, and other climate impacts as well as devastating environmental consequences, the IPCC report warns.⁴

The scientific consensus as described in the IPCC Special Report is that countries around the world must rapidly decarbonize their economies, cutting greenhouse gas emissions in half by 2030 and to near zero by 2050.⁵

Yet the current trends are going in the wrong direction. Despite our increasing understanding of the narrowing window to act, U.S. GHG emissions increased by 3.4 percent in 2018, according to a January report from the Rhodium Group. Clearly more action is needed.⁶

The encouraging news is that many states and cities have committed to taking action. They are taking steps to reduce emissions through legislation, executive or-

¹*About Us*, Georgetown Climate Center, <https://www.georgetownclimate.org/about-us/index.html> (last visited Feb. 19, 2019).

²*TRB Executive Committee*, National Academies of Sciences Engineering Medicine (2019), <http://www.trb.org/CommitteeandPanels/ExecutiveCommitteeOverview.aspx>.

³*Climate Assessment, Volume II: Impacts, Risks, and Adaptation in the United States—Summary Findings*, National Climate Assessment (2018), <https://nca2018.globalchange.gov/>

⁴*Global Warming of 1.5°C*, IPCC (2018), <https://www.ipcc.ch/sr15/>

⁵*Id.*; *Climate Assessment, Volume II*, *supra* note 3.

⁶*Energy & Climate Staff, Preliminary U.S. Emissions Estimates for 2018*, Rhodium Group (Jan. 8, 2019), <https://rhg.com/research/preliminary-us-emissions-estimates-for-2018/>

ders, and pledges made in collaborations such as the US Climate Alliance—now covering roughly half the US population and GDP.⁷

In my testimony, I will be focusing on the transportation sector, which is the largest contributor of GHG emissions in the United States,⁸ and is already facing significant impacts from climate change.

Federal standards have been important in increasing efficiency and reducing emissions, yet transportation-sector emissions are increasing as more vehicle miles are driven, more freight is transported in trucks, and airline travel continues to grow. Transportation is becoming an increasingly large share of U.S. economy-wide emissions as the power sector decarbonizes as a result of market shifts and policy.⁹

There is an urgent need, therefore, to transition to a low-carbon transportation system. Such a transition would not only reduce emissions and fight climate change, it also would bring additional important benefits, including protecting public health by reducing conventional air pollution, providing more mobility options, and driving innovation and economic growth through policy action and through public and private investment.

STATE LEADERSHIP REDUCING EMISSIONS FROM TRANSPORTATION:

Fortunately, states and cities in the US are already investing in low-carbon transportation solutions, and innovation by governments and the private sector has created opportunities to enable low-carbon economic growth.

States are enabling the transition to zero-emission, electric transportation—promoting adoption of cleaner vehicles and fuels; developing strategies to improve public transportation while reducing vehicle miles traveled and congestion; and enacting pathways to fund this clean transportation innovation—including by pricing the emissions that cause climate change.¹⁰ Cities across the country are also reducing air pollution and GHGs through land use policies; by increasing transportation options through investments in public transit, bike and pedestrian facilities, and new mobility solutions; and by switching to alternative fuels such as electricity, hydrogen, and natural gas. Many cities are committing to deep decarbonization by transitioning to zero-emission public fleets,¹¹ including replacing 100 percent of their fossil-fueled buses with electric transit buses.¹²

STATE FUNDING FOR LOW-CARBON TRANSPORTATION INVESTMENTS

Here are some specific examples:

California’s economy-wide cap-and-trade program covers transportation fuels and uses the proceeds generated from selling allowances to invest in transit, electric vehicles, and clean transit buses. It also requires investment in projects serving disadvantaged and underserved communities to ensure that the benefits of this new, low-carbon transportation system are more equitably shared.¹³

Oregon lawmakers are considering adopting an economy-wide cap-and-trade program that could be linked to California’s program.¹⁴

In the Northeast, the Transportation and Climate Initiative of 12 northeast and mid-Atlantic states and the District of Columbia (“TCI”) was launched in 2010. Facilitated by our Georgetown Climate Center, TCI has worked to develop the clean energy economy in the region, improve transportation, and reduce carbon emissions in the transportation sector.

Projects over the years have included eliminating barriers to the use of cleaner transportation fuels and technologies; sharing best practices in promoting smart growth; understanding freight flows into and through the region to consider ways to enhance efficiency and reduce congestion and air pollution; and even working to defeat a patent troll who tried to inhibit sharing of platforms that provide for real-time information on arrivals of subways and buses.

⁷U.S. Climate Alliance Fact Sheet, United States Climate Alliance, <https://www.usclimatealliance.org/us-climate-alliance-fact-sheet> (last visited Feb. 19, 2019).

⁸Sources of Greenhouse Gas Emissions, EPA, <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions> (last visited Feb. 19, 2019).

⁹Transportation Sector Emissions, EPA, <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#transportation> (last visited Feb. 19, 2019).

¹⁰Cal. Health & Safety Code § 38566 (West 2017).

¹¹Climate Mayors Electric Vehicle Purchasing Collaborative, Climate Mayors (2018), <https://driveefleets.org/>.

¹²Zero Emissions Vehicles, C40 Cities, <https://www.c40.org/networks/zero-emission-vehicles> (last visited Feb. 19, 2019).

¹³CCI Funded Programs, California Air Resources Board (Aug. 31, 2018), <https://ww2.arb.ca.gov/our-work/programs/california-climate-investments/cci-funded-programs>.

¹⁴H.B. 2020, 80th Leg. Assemb., Reg. Sess. (Or. 2019).

Since 2012, TCI jurisdictions have explored potential regional policy solutions with analysis that demonstrated the economic benefits of moving to cleaner transportation alternatives. In 2015, the TCI jurisdictions announced plans¹⁵ to work together on potential market-based policies and in 2017¹⁶ began to conduct extensive public outreach.

In 2018, TCI regional outreach engaged 500 diverse stakeholders—including from businesses, local governments, community groups, and NGOs—and over 100 state officials in a series of regional listening sessions, with further outreach through statewide efforts in Massachusetts, New York, and Rhode Island.¹⁷

Those efforts led to a landmark announcement on December 18th, 2018 by nine states plus DC to work together on a bipartisan basis to design a regional low-carbon transportation policy proposal. The proposed plan would cap and reduce carbon emissions from the combustion of transportation fuels and allow each TCI jurisdiction to invest the proceeds in low-carbon and more resilient transportation infrastructure.¹⁸ This approach is modeled on the successful Regional Greenhouse Gas Initiative (RGGI), which has reduced emissions and generated substantial economic benefits in the region. Analysis of the first ten years of the RGGI program estimates that the program has created a net economic benefit of \$4 billion dollars for the participating states, while reducing carbon emissions from the power sector by nearly 50 percent.¹⁹

We believe that the TCI effort can offer similar large benefits and are proud to support this bipartisan group of states in this important initiative.

TCI states are not alone in working to cut transportation emissions—or in recognizing the importance of sustainable funding sources to support needed investments in low-carbon and more resilient transportation infrastructure.

Other states are exploring mileage-based user fees. The state of Oregon conducted two pilots and has now expanded to launch a permanent voluntary program to charge drivers for road usage.²⁰ Several other states, including California and Hawaii, are conducting research or pilot programs to assess the feasibility of mileage-based user fees as an alternative or complement to motor fuel taxes.²¹

STATE ACTION TO SUPPORT ELECTRIC AND ZERO-EMISSION VEHICLES:

For many years now, states have been leaders in supporting a transition to zero-emission vehicles that reduce air pollution, improve public health, and cut greenhouse gas emissions. Today this committee is hearing from California, given its leadership. But critical investments and policy support for zero-emission vehicles are underway in states and cities across the country. Indeed, it is becoming more widely recognized that moving from a transportation system entirely dominated by petroleum-fueled vehicles to electric and other zero-emission transportation options can provide significant benefits for both the environment and the economy.

It is important to understand that switching to electric vehicles significantly reduces GHG emissions even when emissions from power plants that generate the electricity for the electric vehicles are included. For example, in Oregon, a recent analysis showed that an electric vehicle in 2018 would be the equivalent of a gas

¹⁵ *Five Northeast States and DC Announce They Will Work Together to Develop Potential Market-Based Policies to Cut Carbon Emissions from Transportation*, Transportation & Climate Initiative (Nov. 24, 2015), <https://www.transportationandclimate.org/main-menu/five-northeast-states-and-dc-announce-they-will-work-together-develop-potential-market>.

¹⁶ *Northeast and Mid-Atlantic States Seek Public Input As They Move Toward a Cleaner Transportation Future*, Transportation & Climate Initiative (Nov. 13, 2017), <https://www.transportationandclimate.org/northeast-and-mid-atlantic-states-seek-public-input-they-move-toward-cleaner-transportation-future>.

¹⁷ *Listening Session Summary Report*, Transportation & Climate Initiative (Nov. 13, 2018), <https://www.transportationandclimate.org/tci-news-and-updates>.

¹⁸ *Nine States and D.C. to Design Regional Approach to Cap Greenhouse Gas Pollution from Transportation*, Transportation & Climate Initiative (Dec. 18, 2018), <https://www.transportationandclimate.org/nine-states-and-dc-design-regional-approach-cap-greenhouse-gas-pollution-transportation>.

¹⁹ *The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Atlantic States*, Analysis Group: Economic, Financial And Strategy Consultants (Apr. 17, 2018), https://www.analysisgroup.com/globalassets/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_april_2018.pdf.

²⁰ *About, OReGO*, <http://www.myorego.org/about/> (Feb. 19, 2019).

²¹ Susan Handy & Marlon Boarnet, *A Framework for Projecting the Potential Statewide Vehicle Miles Traveled (VMT) Reduction from State-Level Strategies in California*, National Center For Sustainable Transportation (Mar. 2017), https://ncst.ucdavis.edu/wp-content/uploads/2017/03/State-Level-VMT-Strategies-White-Paper_FINAL-03.2017.pdf.

car with 94 MPG rating.²² Even in Missouri, where (as of 2015 data) coal power makes up more than 75 percent of electricity generation,²³ an electric vehicle would be equivalent to a 35 miles per gallon gas vehicle.²⁴ And of course, the opportunities for emissions reductions from adopting electric vehicles will improve throughout the country as the electricity grid decarbonizes (due to fuel switching and the falling prices of wind and solar power for baseload and peak power generation).²⁵ As the grid becomes cleaner, an electric vehicle sold this year will effectively become lower- and lower-emitting throughout its life.

Electric vehicles thus present a very important opportunity for reducing emissions and helping states and cities—along with the United States—reach GHG emission reduction commitments. Eventually—and perhaps within the next decade—electric vehicles will be cheaper to buy and to drive than gas vehicles. However, as is the case with many new technologies, public sector support through research, early deployment, and infrastructure installation will be vital to enabling this market to grow. Continued federal support will be critical in this regard to complement, expand upon, and scale the efforts underway in states throughout the country.

INCENTIVES FOR ZERO-EMISSION VEHICLES:

States across the country are providing incentives to drivers to lower the upfront cost of zero- emission vehicles, including battery electric and hydrogen fuel cell vehicles. Fourteen states currently offer a financial incentive, such as a tax credit, and many electric utilities and local or regional governments offer additional financial or non-monetary incentives to drivers.

Some jurisdictions are exploring “fee-bate” structures—a revenue-neutral incentive mechanism where more polluting vehicles pay a fee inversely proportional to vehicle emissions and lower polluting or zero-emission vehicles receive an incentive or rebate.²⁶ The District of Columbia will be implementing a version of a fee-bate starting in 2020, at which time the District of Columbia Department of Motor Vehicles will assess vehicle title excise tax based on the fuel efficiency of the vehicle, with vehicles that are more fuel efficient than a benchmark level receiving a discount and vehicles that are less fuel efficient paying an additional amount.²⁷

One challenge with reducing emissions from the United States fleet of 250 million passenger vehicles is the long lifecycle of vehicles.²⁸ The average age of passenger vehicles in operation (as of 2017) was 11.6 years, with many vehicles kept in operation for two decades or more.²⁹ One way to incentivize the retirement of low-efficiency older vehicles would be for the federal government to develop a scrappage and replacement program designed to reduce vehicle emissions. Such a program could learn valuable lessons from the Car Allowance Rebate System or “Cash for Clunkers” program of 2009, which was primarily designed as an economic stimulus, but still resulted in improved fuel economy of the vehicle fleet. A federal program could also learn from the scrap and replace programs implemented by two Air Quality Management Districts in California, which provide significant financial incentives to low-income residents who trade in an inefficient vehicle for zero- or near-zero emission replacement.³⁰

²² David Reichmuth, *New Data Show Electric Vehicles Continue to Get Cleaner*, Union of Concerned Scientists (2018), https://blog.ucsusa.org/dave-reichmuth/new-data-show-electric-vehicles-continue-to-get-cleaner?_ga=2.65610987.430581647.1520949632-566757794.1516988670.

²³ *State Energy Analysis Tool*, Georgetown Climate Center, <https://www.georgetownclimate.org/clean-energy/sea.html> (last visited Feb. 19, 2019).

²⁴ Reichmuth, *supra* note 22.

²⁵ See, e.g., Robert Walton, Utility Dive, Xcel solicitation returns ‘incredible’ renewable energy, storage bids (January 8, 2018) <https://www.utilitydive.com/news/xcel-solicitation-returns-incredible-renewable-energy-storage-bids/514287/>; Hawaiian Electric Company Press Release: “New solar-plus-storage projects set low-price benchmark for renewable energy in Hawaii” (January 3, 2019) <https://www.hawaiianelectric.com/new-solar-plus-storage-projects-set-low-price-benchmark-for-renewable-energy-in-hawaii>

²⁶ Natalie Mims & Heidi Hauenstein, *Feebates: A Legislative Option to Encourage Continuous Improvements to Automobile Efficiency*, Rocky Mountain Institute (Feb. 2008), https://www.rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprrts_Feebate_final.pdf.

²⁷ District of Columbia Code 50-2201.03(j)(1A)).

²⁸ *Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances*, Bureau of Transportation Statistics, <https://www.bts.gov/content/number-us-aircraft-vehicles-vessels-and-other-conveyances> (last visited Feb. 20, 2019).

²⁹ *Average Age of Automobiles and Trucks in Operation in the United States*, Bureau of Transportation Statistics, <https://www.bts.gov/content/average-age-automobiles-and-trucks-operation-united-states> (last visited Feb. 20, 2019).

³⁰ *Clean Cars 4 All*, California Air Resources Board (Feb. 5, 2019), <https://www.arb.ca.gov/msprog/cc4a/cc4a.htm>.

ELECTRIC VEHICLES CHARGING ALONG INTERSTATE CORRIDORS:

One area where states are working together is the deployment of fast charging stations along highway corridors. Given “range anxiety” concerns, corridor fast charging is critical to grow the market for electric vehicles. People need to know that they can charge their vehicles, such as my 2018 Chevy Bolt, Bluebell, before they will use the vehicles for long distance trips.

The Pacific Coast states have collaborated since 2011 to develop the West Coast Electric Highway, a network of DC fast charging stations along Interstate 5 and other major roadways.³¹ This project was first funded as part of the American Recovery and Reinvestment Act. Since the initial wave of funding, Washington, Oregon, and California have used public-private partnerships and state grant funding to build out EV charging infrastructure along corridors. The West Coast Electric Highway effort is notable for its focus on expanding consumer awareness of EV charging through outreach and branding. The states have shared their lessons with other regions, including states participating in the Transportation and Climate Initiative in this region.

TCI states have worked to develop EV charging infrastructure since the start of the regional partnership, and have collaborated since 2016 on regional interstate corridor planning. The focused effort on corridor planning has included engagement with the Federal Alternative Fuel Corridors Program, including a regional nomination resulting in over 2,500 miles of EV corridors designated by U.S. Federal Highway Administration (FHWA) in the first round of designations.³²

The Transportation and Climate Initiative has been a valuable forum for electric vehicle corridor planning, due to the leadership of state departments of transportation and given the inherent need to collaborate across state lines to allow residents to travel seamlessly and conveniently between cities, for work, and to tourism destinations. The TCI states have worked together to share best practices, engage with EV charging business and electric utilities, and apply together for grant funding programs.

The TCI states have also worked together to conduct a regional analysis to identify priority locations for additional EV charging infrastructure investment. The technical analysis—launched in 2018—includes an Excel-based tool that can be used to identify which highway exits may be good candidates for additional charging infrastructure investment, as well as an interactive GIS map that displays fast charging infrastructure along corridors in the region and priority investment locations.³³ This corridor analysis was developed by the Georgetown Climate Center and M.J. Bradley & Associates to support the TCI states and was expanded to include Virginia, which joined TCI in September 2018.

In the inter-mountain west states, another bipartisan coalition of governors from eight states launched the Regional Electric Vehicle Plan for the West, or “REV West,” with governors signing an MOU with the goal to promote a network of EV corridors.³⁴

Opportunity for Federal Leadership and Support

While state and regional initiatives such as these are important in their own right and as models, the federal government can play a critical role in providing funding to stimulate greater investment in EV fast charging along highway corridors. The FAST Act instructed the U.S. Federal Highway Administration to designate corridors for alternative fuels (including electric vehicles), but did not provide any direct funding for infrastructure investment to support the build-out of designated or pending corridors.³⁵ Given that electric vehicles are a new technology with limited penetration in the vehicle market, there are very few viable business cases for investment in DC fast charging—particularly along highway corridors—in the absence of some public sector funding to support investment. Nevertheless, significant additional investment in EV fast charging will be needed to provide the minimum level

³¹ *West Coast Electric Highway*, Idaho National Laboratory: Advanced Vehicles, <https://avt.inl.gov/project-type/west-coast-electric-highway> (last visited Feb. 19, 2019).

³² U.S. Department of Transportation Designates Electric Vehicles Corridors in the Transportation and Climate Initiative Region, Transportation & Climate Initiative (Nov. 3, 2016), <https://www.transportationandclimate.org/us-department-transportation-designates-electric-vehicles-corridors-transportation-and-climate>.

³³ The regional EV corridor analysis is publicly available at no cost from Georgetown Climate Center. *EV Corridor Analysis Tool for Northeast and Mid-Atlantic States*, Georgetown Climate Center (July 26, 2018), <https://www.georgetownclimate.org/articles/ev-corridor-analysis-tool-for-northeast-and-mid-atlantic-states.html>.

³⁴ Regional Electric Vehicle (REV) West Program, U.S. Department of Energy: Energy Efficiency & Renewable Energy, <https://afdc.energy.gov/laws/11874> (last visited Feb. 29, 2019).

³⁵ 23 U.S.C. §151 (2015).

of coverage necessary for the market to mature.³⁶ Once a minimum level of EV fast charging coverage is in place and EV sales increase, consumer demand for charging will drive private investments. In order to jump-start this critical transition to transportation electrification, targeted public funding is needed.

Potential federal investment could expand on strategic planning efforts underway in states and regional partnerships to ensure that federal funding is strategically invested to grow the market for EVs while spurring economic development and improving transportation. For example, several states, including California, Washington, and New York, have undertaken modeling and analysis to better understand which highway corridors have been developed by the private market and which are the highest priorities for public funding to support a comprehensive network of EV charging.³⁷ One strategy that this committee might consider is targeting investment in EV charging in rural and remote corridor locations which are currently underserved by the private market, as a business and economic development opportunity for those locations that would also provide access to EVs to a wider range of communities.

In addition to strategically targeting geographic locations, a federal funding program could also provide additional public benefits by including requirements or incentives that ensure driver convenience and a robust private market for charging stations. There is an opportunity for such a federal program to incorporate lessons learned and policies from ongoing state efforts. States participating in the multi-state ZEV Task Force have worked to identify policy outcomes that can be achieved through requirements for EV charging stations installed with public funding. For example, states are exploring open payment requirements, to ensure that drivers know how much they will pay for a charge, can easily use a credit card to pay for charging, and are not required to have a charging station network membership. We've all gotten used to driving up to a gas station and knowing that we can pay with a credit card (for example), without the requirement of becoming a member of a fuel provider like Exxon or Shell. But that is not always the case with EV charging, which can create inconvenience and confusion. Similarly, requirements that charging station hardware, software, and network services be inter-operable could create a more flexible business market that allows for innovation and avoids stranded assets. I would encourage Congress to engage with states and U.S. national laboratories considering these issues when developing potential infrastructure funding programs.

Federal Support for Technical Analysis

Federal technical and financial support could also help states and metropolitan planning organizations better identify gaps in EV charging infrastructure. This could include expansion of existing tools, for example the corridor analysis tool built to inform northeast and mid-Atlantic states³⁸ or the Electric Vehicle Infrastructure Projection (EVI-Pro) tool built by the California Energy Commission and National Renewable Energy Laboratory to assess charging infrastructure needs.³⁹ The federal government could support a study (using EVI-Pro or other methodology) of specific charging infrastructure needs to support long-distance trips on a national level. This analysis has already been conducted for California, Colorado, and Columbus, Ohio, through existing programs or partnerships.⁴⁰

Non-financial Policy Opportunities:

Currently the federal Manual on Uniform Traffic Control Devices does not allow state DOTs to easily add an EV charging station logo to specific service (food/fuel/lodging) signs. The current manual is somewhat unclear on this subject, which has been vexing to many state agencies looking to develop EV charging signage guidance.⁴¹ One potential solution would be to create a new category of highway logo

³⁶Eric Wood, *New EVSE Analytical Tools/Models: Electric Vehicle Infrastructure Projection Tool (EVI-Pro)*, National Renewable Energy Laboratory (Jan. 24, 2018), <https://www.nrel.gov/docs/fy18osti/70831.pdf>.

³⁷*Electric Vehicle Charging Infrastructure*, Washington State Department of Transportation (2019), <http://www.wsdot.wa.gov/funding/partners/evib>.

³⁸*EV Corridor Analysis Tool for Northeast and Mid-Atlantic States*, supra note 33.

³⁹*CEC EV Infrastructure Projection (California)*, National Renewable Energy Laboratory, <https://maps.nrel.gov/cec/?aL=0&bL=cdark&cE=0&lR=0&mC=36.8708321556463%2C-116.34521484375001&zL=6> (last visited Feb. 19, 2019).

⁴⁰Eric Wood, supra note 36.

⁴¹"To qualify for a GAS logo sign panel, a business should have: (1) Vehicle services including gas and/or alternative fuels, oil, and water; (2) Continuous operation at least 16 hours per day, 7 days per week for freeways and expressways, and continuous operation at least 12 hours per day, 7 days per week for conventional roads; (3) Modern sanitary facilities and drinking water;

(specific service) signs for EV charging. This would improve EV driver convenience and provide a significant consumer awareness benefit. California has already taken this approach, modifying its state manual to create a new category for EV charging station logos, and other states are interested in this issue as well. It is important at a minimum that the federal manual maintain flexibility for states to experiment with the best ways to provide logo signs for electric vehicles as we develop an appropriate federal standard.⁴²

Congress might also consider the feasibility and potential benefits and costs of exempting EV charging stations and renewable power installations from federal restrictions on commercial activity in the interstate right-of-way. These restrictions have been identified as a barrier in reports, including the recent Transportation Research Board Report to Congress on the Future of the Interstate Highway report.⁴³

Opportunities for Research and Development:

While there are many exciting developments underway that are helping to expand the uses of EVs and other low-carbon transportation options, there are still technical and logistical barriers where federal support of pilot programs, research, or public-private partnerships might be helpful.

As we scale up the use of new transportation fuels and technologies over time, research and pilot deployments can help ensure that federal funds are invested efficiently in projects and technologies that reduce emissions, provide energy security, and stimulate economic growth. Additionally, research programs can effectively identify issues that might arise in the future. For example, the federal government could support additional research into questions on how the different zero-emission or alternative fueling and charging infrastructures complement or interact with one another at individual sites or throughout the transportation system. There is significant investment in hydrogen fueling infrastructure in California and other states, due to the significant opportunity for hydrogen to serve as an energy-dense zero-tailpipe emission fuel source for vehicles.⁴⁴

For electric vehicle charging, key questions include the opportunities for managed EV fast charging (e.g., providing options for drivers where the cost and speed of charging vary based on electric grid capacity). A related topic for additional research is the interaction of EV charging with on-site storage to minimize distribution grid impacts. Electrify America and Tesla are making major investments in on-site storage co-located with DC fast charging facilities. This is an area where transportation system research—in conjunction with battery storage research underway at the U.S. Department of Energy and U.S. national laboratories—could prove valuable.

ZERO-EMISSION ELECTRIC TRANSIT BUSES

Moving beyond passenger vehicles, zero-emission transit buses provide opportunities to expand access to cleaner electric transportation, cutting GHG emissions in addition to the smelly and dangerous fumes that affect riders and communities, including those that have been disproportionately harmed by air pollution.

Cities across the country have added electric buses to transit fleets and made commitments for additional procurements. Electric bus pilots are underway everywhere from Anchorage, Alaska,⁴⁵ to Honolulu, Hawaii.⁴⁶ Here in the District of Columbia, the District Department of Transportation has added 14 electric buses to its Circulator service, which serves commonly traveled routes in the District and costs only \$1 to ride.⁴⁷ In Texas, the Dallas Area Rapid Transit is piloting electric

and (4) Public telephone.” U.S. Dep’t of Transp., Manual on Uniform Traffic Control Devices § 2J.01.10 (Dec. 2009).

⁴² Cal. Dep’t of Transp., Manual on Uniform Traffic Control Devices § 2J.01 (Nov. 2014).

⁴³ *Renewing the National Commitment to the Interstate Highway System: A Foundation for the Future*, Transportation Research Board (Feb. 6, 2019), <http://www.trb.org/Main/Blurbs/178485.aspx>.

⁴⁴ California Air Resources Board, California’s Hydrogen Transportation Initiatives, <https://www.arb.ca.gov/msprog/zevprog/hydrogen/hydrogen.htm> (last visited Feb. 20, 2019).

⁴⁵ Casey Grove, *Alaska’s First Electric Bus for Public Transit Read for Anchorage Streets*, Alaska Public Media (Jan. 15, 2018), <https://www.alaskapublic.org/2018/01/15/alaskas-first-electric-bus-for-public-transit-ready-for-anchorage-streets/>.

⁴⁶ Press Release, *Electric Bus Demonstration Showcases Sustainable Ground Transportation Future for Hawaii*, Hawaii.gov (Apr. 11, 2018), <http://hidot.hawaii.gov/highways/electric-bus-demonstration-showcases-sustainable-ground-transportation-future-for-hawaii/>.

⁴⁷ *New DC Circulator Electric Buses*, Circulator, <https://www.dccirculator.com/new-electric-buses/> (last visited Feb. 20, 2019).

buses on its free downtown D-Link route.⁴⁸ These cities, and many others, are using phased pilots and early deployment to test this new technology and address any concerns related to bus performance, charging reliability, and operating costs.

Many cities have set ambitious economy-wide GHG emission reduction goals and are increasingly making commitments to fully electrify their transit fleets as a strategy to reduce transportation emissions. For example, Los Angeles, California, has committed to fully electrify its fleet by 2030;⁴⁹ the Minneapolis and Saint Paul transit agency in Minnesota has announced a 2040 full electrification goal;⁵⁰ and the New York Metropolitan Transit Agency—the largest transit fleet in the United States with more than 5,500 buses—has announced a target of transitioning to a zero-emission fleet by 2040.⁵¹

While electric transit buses provide significant air quality and GHG reduction benefits, along with lower operating and maintenance costs, transit bus electrification is impeded by the higher upfront purchase cost of electric buses and charging infrastructure, a limited economy of scale in manufacturing, and additional routing and charging requirements for fleet managers and operators.

To offset the higher upfront costs, many states are providing funding to transit agencies to support bus electrification. States such as Colorado, Massachusetts, and Virginia have identified transit bus electrification as a priority for investment with the funding received from the Volkswagen diesel emissions settlement. Rhode Island has already launched early deployments of electric transit buses purchased with VW settlement funding⁵² and has prioritized routes that travel through neighborhoods that currently suffer from higher levels of air pollution.⁵³ While these state investments will help to grow the number of zero-emission buses on the road, the scale of funding distributed to states from the VW settlement—\$2.9 billion over ten years, distributed across the 50 states and U.S. territories—will not be sufficient to meet states' clean energy and climate goals.

The U.S. Department of Transportation Federal Transit Administration's Low- or No-Emission ("Low-No") Grant program has been instrumental in providing the funding needed by transit agencies to add zero-emission buses to their fleets. In the 2018 funding period alone, over \$80 million in funding was awarded to support 52 electric transit bus projects in 41 states. The projects supported with this funding include electric bus deployment across a range of geographies, from the Philadelphia metro area—where the Southeastern Pennsylvania Transportation Authority (SEPTA) is adding electric buses—to rural Wisconsin, where the Wisconsin Department of Transportation will add electric buses to rural fleets statewide.

The funding also allows transit agencies to innovative and explore different methods of recharging buses—whether at a central depot or in-route—as well as opportunities to power buses with renewable energy. For example, the 2018 FTA funding for Broward County Transit will not only replace aging buses with battery electric buses models, but will also include solar power installation.

Due to the significant interest from cities and transit agencies, demand for electric bus funding from the "Low-No" Grant program far exceeds available funding levels. For fiscal year 2018, Congress appropriated an additional \$29.45 million in funding—bringing the total to \$84.45 million, but applications from transit agencies still exceeded 6 times the available funds.⁵⁴

Opportunity for Federal Leadership and Support

Electric transit buses are already competitive with diesel buses on a total cost of ownership basis (when including fuel and maintenance costs), and will reach cost

⁴⁸ Dana Branham, Dart's *Fleet of Electric Buses Roll Out in Downtown Dallas*, Dallas News (July 10, 2018), <https://www.dallasnews.com/news/transportation/2018/07/10/darts-fleet-electric-buses-roll-downtown-dallas>.

⁴⁹ *Council File: 17-0739*, LA City Clerk Connect (Nov. 9, 2017), <https://cityclerk.lacity.org/lacityclerkconnect/index.cfm?fa=ccfi.viewrecord&cfnumber=17-0739>.

⁵⁰ *Metro Transit's 100% Electric Bus Fleet Target Is a Big Step*, Fresh Energy (Dec. 10, 2018), <https://fresh-energy.org/metro-transit-100-percent/>.

⁵¹ Phil McKenna, *New York City Aims for All-Electric Bus Fleet by 2040*, Inside Climate News (Apr. 26, 2018), <https://insideclimatenews.org/news/26042018/nyc-air-pollution-electric-bus-public-transportation-mta-clean-technology>.

⁵² State of Rhode Island Press Release, Raimondo, Congressional Delegation Unveil RIPTA's First Electric Buses (October 22, 2018) <https://www.ri.gov/press/view/34479>.

⁵³ State of Rhode Island, *supra* note 52.

⁵⁴ "FTA received 149 eligible proposals from 42 states requesting \$557 million in Federal funds." U.S. Department of Transportation, Federal Transit Administration, *Fiscal Year 2018 Low or No Emission Grant Program Project Selections*, (October 12, 2018) <https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/funding/grants/grant-programs/118881/fy18-low-no-project-selections-and-guidance.pdf>

parity over the coming years.⁵⁵ However, funding support and technical assistance are critical in the near term to offset the higher upfront costs and additional logistical challenges. As the cost of lithium ion battery packs continues to fall, and bus manufacturers increase the scale of production of electric transit buses, costs of buses will continue to decline, and electric transit buses may ultimately provide a lower cost alternative. In the near term, however, additional federal funding for converting combustion engine fleets to zero-emission electric propulsion would provide valuable support to local and state governments.

ZERO EMISSION FERRIES AND MARINE TRANSPORT

In addition to electrifying passenger vehicles and transit fleets, states are exploring opportunities for zero-emission marine transport. Washington Governor Jay Inslee announced his Washington Maritime Blue 2050 Initiative in 2017 to create and expand a sustainable ocean industry through the combined use of electric ferries and ships and zero-carbon-emissions port terminals.⁵⁶ Washington State plans to use around 45 percent of its VW settlement money to fund the electrification of public vessels, with a particular focus on ferries, recognizing that in Washington State, “ferries account for more than half of the air pollution generated by harbor vessels.”⁵⁷

Hydrogen fuel cells may provide another viable option for zero-emission marine transport. A study undertaken by Sandia National Laboratories concluded in July 2018 that it is both technologically and economically feasible to build research vessels powered by hydrogen fuel cells.⁵⁸ The first commercial ship running on hydrogen and producing zero pollution was built in 2017.⁵⁹

The United States could explore additional international partnerships for research and development and implementation. For example, Norway and Finland have deployed battery-electric ferries, and Norway is currently piloting hydrogen ferries.⁶⁰ Norway has passed legislation to make its fjords zero emissions zones by 2026, only allowing electric ships into its waters.⁶¹

DECARBONIZING MEDIUM- AND HEAVY-DUTY TRUCKS

As the movement of goods on our country’s highway corridors continues to increase with the growth of e-commerce, decarbonizing truck transport will be critical to meeting state and national climate commitments. For both long-haul and local delivery by heavy-duty and medium-duty vehicles, a number of low- or zero-emission vehicle and fuel types may serve different use cases.

For reducing emissions of criteria pollutants, natural gas- and propane-fueled vehicles offer a promising and potentially low-cost alternative. For reducing GHG emissions, the federal government could play a key role in enabling the deployment of battery electric and hydrogen fuel cell vehicles.

Many vehicle and engine manufacturers have announced plans to release battery electric trucks over the coming years, and hydrogen truck pilots offer a promising alternative. The U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, has supported significant research and development efforts for hydrogen and fuel cell technologies, including through partnerships with U.S. national laboratories and private sector businesses, and has set ambitious goals for reducing

⁵⁵ *Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO₂*, C40 (Mar. 29, 2018), https://c40-production-images.s3.amazonaws.com/other_uploads/images/1726_BNEF_C40_Electric_buses_in_cities_FINAL_APPROVED_%282%29.original.pdf?1523363881

⁵⁶ Tara Lee, *Leading in the Maritime Sector: Washington Launches Maritime Blue 2050 Initiative*, Washington Governor Jay Inslee (Dec. 12, 2017), <https://www.governor.wa.gov/news-media/leading-maritime-sector-washington-launches-maritime-blue-2050-initiative>.

⁵⁷ The Washington State Plan notes that Converting diesel to all-battery electric ferries will significantly reduce diesel and carbon emissions, improve fleet reliability, virtually eliminate engine noise that can harm marine animals, and reduce ferry operating costs by up to 20 percent. Brett Rude & Mike Boyer, *State of Washington Volkswagen Beneficiary Mitigation Plan*, Department of Ecology: State of Washington (Nov. 2018), <https://fortress.wa.gov/ecy/publications/documents/1802023.pdf>.

⁵⁸ Sandia National Laboratories, *Diesel Doesn’t Float This Boat—Team Designs Zero-Emission Research Vehicle*, Phys.org (July 2, 2018), <https://phys.org/news/2018-07-diesel-doesnt-boatteam-zero-emissions-marine.html>.

⁵⁹ Anna Hirtenstein, *There’s Now Vessel That Produces Zero Pollution*, Bloomberg (Nov. 29, 2017), <https://www.bloomberg.com/news/articles/2017-11-29/oceans-get-zero-emission-ship-in-step-toward-cleaner-cargo>.

⁶⁰ Tjälve Magnusson Svedndsen, *The First Hydrogen Ferry in Norway*, Christian Michelsen Research, <https://www.cmr.no/projects/10568/hydrogen-ferry/> (last visited Feb. 20, 2019).

⁶¹ Fred Lambert, *Norway Is Making Its Fjords The World’s First Zero Emission Zone at Sea*, Electrek (May 4, 2018), <https://electrek.co/2018/05/04/electric-ferries-norway-fjords-worlds-first-zero-emission-zone/>.

the price of hydrogen fuel cells.⁶² This investment in hydrogen as a transportation fuel is as part of a broader opportunity role for hydrogen fuel in a decarbonized United State energy system.

One critical challenge for both of these zero-emission technology types is the development of sufficient charging or fueling infrastructure along highway corridors. Similar to passenger vehicles, a minimum level of infrastructure coverage needs to be in place in order for the market to grow to the scale necessary to support private investment and unsubsidized growth.

Heavy duty battery-electric trucks provide unique charging infrastructure and electric grid challenges. For example, the electric semi-truck specifications suggested by Tesla might require over 1 MW capacity charging per plug—equivalent to a Walmart SuperCenter. A truck stop depot with 10 of these chargers could have a peak electrical load similar to an industrial facility, but will often be located in a rural area far from available electrical power capacity.

The federal government could play a critical role expanding research and pilot programs to determine the most cost effective and efficient means of providing this type of vehicle charging, including the role of stationary storage batteries and co-location of renewable power generation. This work could incorporate the freight corridor planning underway in many states through the FHWA Alternative Fuel Corridor program, and could engage key stakeholders, including electric utilities, the National Association of Truck Stop Operators, and vehicle manufacturers.

REDUCING EMISSIONS BY PROVIDING GREATER MODE CHOICES

In addition to supporting infrastructure to enable a transition to zero- and low-emission vehicles, the federal government can play a key role in reducing the number of vehicle miles traveled by improving transportation efficiency; by promoting more compact, livable communities; and by providing more transportation choices, including public transit, biking and walking. While states generally control land use planning decisions, the federal government has a critical role to play through its administration of transportation funding and infrastructure investment.

Many states are confronting the challenge of reducing air pollution and emissions while experiencing increases in vehicle miles traveled. The Minnesota Pollution Control Agency recently released a report on the state's emissions over the last 25 years and strategies needed to meet the state's greenhouse gas emission reduction targets. The report found that while Minnesota has successfully reduced its overall emissions while growing its economy, the state missed its 2015 emission reduction target; and transportation is now the largest source of emissions in the state. The report suggests that the trends of residents driving more miles and preferring larger vehicles are preventing a greater reduction of emissions, and suggests that additional transportation mode choices can be an effective strategy for the state moving forward.⁶³

STATE SUPPORT FOR BICYCLE AND PEDESTRIAN TRANSPORTATION

There are many examples of state leadership in developing “complete streets” that allow for safe and efficient movement of pedestrians and bicyclists, in addition to vehicles. New Jersey has a nationally recognized complete streets policy that includes significant engagement with counties and municipalities. New Jersey Department of Transportation provides training to its own engineers and planners, along with those from local agencies, on complete streets policies. New Jersey Department of Transportation also provides incentives through its Local Aid and Economic Development grant program to municipalities that meet Complete Streets policy objectives.⁶⁴

Many states' active transit projects are funded through federal programs, including the Capital Investment Grant program, Transportation Alternatives Program, and Surface Transportation Block Grant.

⁶² U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Fuel Cell Technologies Office Accomplishments and Progress, <https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-accomplishments-and-progress>

⁶³ Anne Clafin & Fawkes Steinwand, Greenhouse Gas Emissions in Minnesota: 1990-2016 7, Minnesota Pollution Control Agency: Department of Commerce (Jan. 2019), <https://www.pca.state.mn.us/sites/default/files/lraq-2sy19.pdf>.

⁶⁴ *Complete Streets: Workshop and Training*, Department of Transportation, <https://www.state.nj.us/transportation/eng/completestreets/training.shtm> (last visited Feb. 20, 2019).

PUBLIC TRANSPORTATION AND TRANSIT ORIENTED DEVELOPMENT

Investment in public transit, including light rail systems, bus rapid transit, traditional bus routes, and new mobility applications such as dynamic-routing micro-transit provide additional transportation choices and can stimulate economic development while reducing emissions. Cities and states throughout the U.S. are pioneering innovative ways of making transit more convenient and accessible, while harnessing the benefits of transit for community development and economic growth.

In Dallas, the Dallas Area Rapid Transit (DART) system has introduced the “GoPass,” a simple system that allows easy payment for different transit services while allowing frequent users to automatically take advantage of monthly or daily ride discounts when available.⁶⁵ The GoPass was originally introduced nearly five years ago. DART introduced both the “cash to mobile” option and fare capping last year. These two items especially help low income populations. Last month, DART introduced GoPass 3.0 which begins to fully integrate other modes into the app, such as micro-transit services and scooters. The entire trip can be paid for on the app rather than bouncing back and forth between apps. This month DART is introducing Uber Pool as backup to the micro-transit services already offered, to make sure that the response times are maintained.

Arlington, Virginia, where I live has seen significant economic development and population increases over recent decades, but has successfully decoupled this growth from greenhouse gas emissions by implementing transit-oriented development, in which mixed use developments are clustered near Metro stations.⁶⁶

To encourage more cities and regional governments to invest in critical public transit infrastructure, the federal government might consider increasing the federal match for public transit projects, from current levels of 50 percent (compared to 80 percent for road projects funded by the Highway Trust Fund).

TRANSPORTATION SYSTEM RESILIENCE

Despite innovation in the transportation sector and a shift to cleaner sources of electricity, including improved vehicles and fuels as a result of federal and state policy, we are already seeing the effects of climate change. Extreme weather events are becoming more frequent and intense, creating new challenges for infrastructure agencies that must consider how to prepare assets for these changing conditions and to do so on very limited budgets.

Since 1980, the U.S. has experienced 241 extreme weather-related events with costs of more than \$1 billion. The total estimated cost of these events adds up to more than \$1.6 trillion. And the frequency and scale of these major disasters is increasing. Nearly one-third of total costs have come from events in just the past 5 years.⁶⁷ In 2017 alone, extreme weather events cost the U.S. over \$300 billion, in large part due to Hurricanes Harvey, Irma, and Maria.⁶⁸ These disasters have caused significant damages to infrastructure, which in some cases has led to years-long recovery efforts.⁶⁹

⁶⁵ When using a GoPass, transit riders “never pay more than the price of a day pass in one day, or the price of a monthly pass in one month” through an automated payment system. Dallas Area Rapid Transit, *GoPass Frequently Asked Questions*. <https://www.gopass.org/customer-service/questions-answers>

⁶⁶ *Billion Dollar Weather and Climate Disasters: Overview*, NOAA: National Center For Environmental Information (2019), <https://www.ncdc.noaa.gov/billions/>.

⁶⁷ NOAA, Billion-Dollar Weather and Climate Disasters.

⁶⁸ Chris Mooney & Brady Dennis, *Extreme Hurricanes and Wildfires Made 2017 the Most Costly U.S. Disaster Year on Record*, Washington Post (Jan. 8, 2018) <https://www.washingtonpost.com/news/energy-environment/wp/2018/01/08/hurricanes-wildfires-made-2017-the-most-costly-u-s-disaster-year-on-record/>.

⁶⁹ For example, Vermont experienced an estimated \$250-300 million in infrastructure damage resulting from Tropical Storm Irene. Vermont’s challenges of rebuilding culverts more resiliently during the recovery period, due to barriers at the time in federal law and disaster recovery programs, is explored in the report. Lessons Learned from Irene: Climate Change, Federal Disaster Relief, and Barriers to Adaptive Reconstruction, Georgetown Climate Center (Dec. 20, 2013), <https://www.georgetownclimate.org/reports/lessons-learned-from-irene-climate-change-federal-disaster-relief-and-barriers-to-adaptive-reconstruction.html>. In New York, the many transportation-related impacts resulting from Hurricane Sandy in 2012, summarized in the report Transportation During and After Sandy, have led to numerous efforts to improve resilience in transportation infrastructure. Sarah Kaufman, et al., *Transportation During and After Hurricane Sandy*, Rudin Center For Transportation: NYU Wagner Graduate School of Public Service (Nov. 2012), <https://wagner.nyu.edu/files/faculty/publications/sandytransportation.pdf>. See, e.g., Post Hurricane Sandy Transportation Resilience Study in New York, New Jersey, and Connecticut, U.S. Department of Transportation (Oct. 2017), <https://www.fhwa.dot.gov/environment/>

As many of you know from the communities you represent, the human toll from these events is huge. In 2005, many members of my family, including my mother, sister and brother-in-law, aunt and uncle, lost homes in Katrina. The year before, my father Sidney Arroyo died during a stressful evacuation from Hurricane Ivan. The human and economic toll of these events is staggering. It is vital that we capture lessons on how to improve infrastructure and operations to get people out of harm's way in advance of storms and to build back differently as these events become more common and more severe.

Our work in communities after Hurricanes Katrina, Irene and Sandy demonstrate opportunities to improve how communities rebuild after storms.

WHAT STATES ARE DOING

Many states and local governments are learning from recent extreme events and are working to prepare their infrastructure systems for additional impacts of climate change. We are seeing more dedicated funding for resilient investments. Innovative steps include nature-based resilience strategies to help mitigate impacts of flooding and heat, new committees and task forces to examine climate change impacts and to design infrastructure to be more resilient, and new requirements to account for climate change in state or local planning and investments. For example, legislation and voter initiatives in Massachusetts, California, and Miami have committed funding for programs and projects that will build resilience in communities and infrastructure systems. In Massachusetts, state legislation authorized hundreds of millions of dollars for critical infrastructure protection and adaptation, implementation of the state's integrated hazard mitigation and climate adaptation plan, and other state and local resilience measures as part of a \$2.4 billion package.⁷⁰ Legislation in California (and subsequent voter approval) authorized over \$4 billion in bonds for conservation and resilience, parks and recreation, and water projects, including \$443 million specifically for climate change preparedness and habitat resiliency, and \$550 million for flood protection.⁷¹ And in Miami, voters approved a bond package with nearly \$200 million for projects to mitigate impacts of sea-level rise and flooding.⁷²

States and local governments are also showing commitment to resilience through planning and programs, task forces and studies, and new design requirements and development and zoning regulations. The Louisiana's Strategic Adaptations for Future Environments (LA SAFE) Program, initially funded through disaster recovery dollars in 2012, works with parishes to co-design customized projects and programs that will improve community resilience like "complete streets" and nature-based flood mitigation projects.⁷³ California's Climate-Safe Infrastructure Working Group, established pursuant to legislation passed in 2016,⁷⁴ completed its recommendations in 2018 for how the state can better integrate climate science into engineering and design.⁷⁵ New York State established formal statewide sea-level rise projections by regulation in early 2018,⁷⁶ implementing an important aspect of the state's Community Risk and Resiliency Act (2014), which is designed to integrate considerations of climate change impacts to proposed projects in certain funding and permitting

sustainability/resilience/publications/hurricane_sandy/fhwahep17097.pdf; *Port Authority of New York and New Jersey—PATH System Resiliency and Recovery Improvements*, Georgetown Climate Center: Adaptation Clearinghouse (Jan. 16, 2015), <https://www.adaptationclearinghouse.org/resources/port-authority-of-new-york-and-new-jersey-path-system-resiliency-and-recovery-improvements.html>. In Colorado, severe rains and flooding in September 2013 caused major road damage and wash-outs along US 34, which provides sole access to some areas. Recovery and reconstruction efforts extended into 2018, but resulted in a more resilient design of the highway. See *US 34 Big Thompson Canyon*, Colorado Department of Transportation, <https://www.codot.gov/projects/floodrelatedprojects/us-34-big-thompson-canyon-1> (last visited Feb. 20, 2019).

⁷⁰ An act promoting climate change adaptation, environmental and natural resource protection, and investment in recreational assets and opportunity, ch. 209, 2018 Mass. Sess. Laws.

⁷¹ California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018, Ch. 852, 2017–2018 Cal. Sess. Laws (subsequently approved by voters in June 2018 as Prop. 68).

⁷² Adam Aton, Climate funding passes; vulnerable cities get new mayors, E&E News (Nov. 8, 2017), <https://www.eenews.net/climatewire/2017/11/08/stories/1060065971>.

⁷³ *Louisiana's Strategic Adaptations for Future Environments*, LA Safe, <https://lasafe.la.gov/> (last visited Feb. 20, 2019).

⁷⁴ Climate change: infrastructure planning, ch. 580, 2015–2016 Cal. Sess. Laws.

⁷⁵ *Paying It Forward: The Path Toward Climate-Safe Infrastructure in California*, California Natural Resources Agency (Sept. 2018), <http://resources.ca.gov/climate/climate-safe-infrastructure-working-group/>.

⁷⁶ NY Env'tl. Conserv. Law § 490 (2018).

processes overseen by state agencies.⁷⁷ Maryland expanded its “Coast Smart” program in 2018, now requiring that state-funded local projects (in addition to state capital projects) be sited and designed according to the state’s “Coast Smart” criteria, which were also updated in 2018 pursuant to the legislation.⁷⁸ And a range of local governments in places like Houston, Broward County, and New York City are implementing new floodplain and zoning regulations and design requirements to ensure that infrastructure investments and other development either avoid high-risk areas or are built to withstand future storms and conditions.⁷⁹

WHAT CAN CONGRESS DO?

In its recent report, the Committee for the Study of the Future Interstate Highway System highlighted the importance of preparing the Interstate Highway System and other roads and bridges for the impacts of climate change and more intense weather events.⁸⁰ Congress should act on these recommendations to ensure that major federal infrastructure investments, including but not limited to the Interstate Highway System, are built to withstand flooding, increased heat, and other climate change impacts. Congress can build on steps already taken in MAP-21 and the FAST Act (integrating resilience and risk considerations in transportation planning processes), and in the Disaster Recovery Reform Act (authorizing a set-aside funding source from disaster expenses for pre-disaster mitigation grants for public infrastructure projects that will improve resilience, among other provisions designed to foster long-term resilience as part of disaster recovery).⁸¹ To ensure fiscal responsibility, recipients of federal funding should be required to consider how climate change will impact their infrastructure systems and assets in the future, and ensure that their investments are designed accordingly to withstand future conditions. States should be provided with the tools and information they need to adequately integrate these considerations into capital decision-making processes, and with strong incentives to engage in resilience planning and to modify codes and standards ahead of disasters to facilitate resilient rebuilding when funds are available.⁸² It is more important than ever to ensure that federal dollars are spent wisely and not wasted on investments that will not be built to last under future climate conditions and a “new normal” that includes increasingly severe weather events.

In addition to infrastructure, we should understand that resilience to impacts depends on people as well and developing strategies to evacuate safely.

In Katrina, more than 1800 people who stayed behind died. Some didn’t leave because of the difficulty in evacuating the year before during Ivan. Others didn’t have

⁷⁷ *New York Community Risk and Resiliency Act (S06617B)*, Georgetown Climate Center: Adaptation Clearinghouse (Sept. 22, 2014), <https://www.adaptationclearinghouse.org/resources/new-york-community-risk-and-resiliency-act-s06617b.html>.

⁷⁸ For more information, see Georgetown Climate Center, Maryland HB 1350/ SB 1006—Sea Level Rise Inundation and Coastal Flooding—Construction, Adaptation, and Mitigation.

⁷⁹ Houston voted to update its Floodplain Management Ordinance, now regulating new development in the 500-year floodplain instead of just the 100-year. City of Houston, Ord. No. 2018–258 (Apr. 4, 2018). Broward County is now using “future conditions” maps that account for the impacts of sea-level rise on groundwater levels when approving drainage and other water management infrastructure, which will help ensure that infrastructure lasts in the future. Broward Cty., Fla., Ordinance No. 2017–16 (May 23, 2017). In New York City, the Mayor’s Office of Recovery and Resiliency developed new Climate Resiliency Design Guidelines to be used in the planning and design of city capital projects.

⁸⁰ National Academies of Sciences, Engineering, and Medicine, *Renewing the National Commitment to the Interstate Highway System: A Foundation for the Future* (2018).

⁸¹ Federal Aviation Administration Reauthorization Act of 2018, H.R. 302, Div. D, 115th Cong. (2018). For example, the DRRRA also clarifies that predisaster hazard mitigation funds may be used to establish and implement the latest hazard-resistant designs and criteria (modifying 42 USC 5133(e)), and it adds new evaluation criteria for predisaster hazard mitigation assistance awards, including the extent to which potential grantees have adopted the latest hazard-resistant designs and codes, and “the extent to which the assistance will fund activities that increase the level of resiliency” (modifying 42 USC 5133(g)). It also clarifies that Public Assistance funds can reimburse costs of rebuilding facilities according to “the latest published editions of relevant consensus-based codes, specifications, and standards...” or “in a manner that allows the facility to meet the definition of resilient” (which is to be developed by FEMA rulemaking) (modifying 42 USC 5172(e)).

⁸² Standards-setting organizations like the American Society of Civil Engineers have been engaging for several years in discussions about how to modify infrastructure design to account for changing risk profiles as a result of climate change. ASCE’s Committee on Adaptation to a Changing Climate recently published a new Manual of Practice with guidance for engineers and others involved in infrastructure decisionmaking to assist with integrating adaptive design and minimizing lifecycle costs given a changing climate. *Climate-Resilient Infrastructure: Adaptive Design and Risk Management*, Committee on Adaptation to a Changing Climate, ASCE; Edited by Bilal M. Ayyub, Ph.D., P.E. 2018.

affordable options for transportation or shelter, and still others didn't want to leave their pets behind after discovering that public transport and shelter options prohibited animals. Because of those hard lessons, Congress passed the Pet Evacuation and Transportation Standards Act—yes, “PETS”—which no doubt has saved lives of countless pets and people in more recent storms.

New programs like “Evacuteers” in New Orleans have sprung up to make sure people (and pets) can get out of harm's way, and portions of the I-10 twin spans, after sections were knocked out in Katrina, have been elevated.

There is more to be done to prepare our communities for the changes we're experiencing now that will accelerate and worsen over time, even while states and cities work to do their share to tackle the emissions contributing to a changing climate.

Thank you for considering how Congress might support them in these efforts.

Mr. CARBAJAL. Thank you, Ms. Arroyo.

Professor Lyon, you may proceed.

Mr. LYON. I wish to thank the chairman, ranking member, and other members of the committee for inviting me to today's hearing. My name is Tom Lyon, and I am a professor of economics at University of Michigan, with appointments in both the Ross School of Business and the School of Environment and Sustainability. The views I am presenting today are my own personal views and do not represent those of the university or any funders of my research.

There is no question that U.S. infrastructure is in bad shape. The American Society of Civil Engineers gives U.S. infrastructure an overall grade of D-plus, with roads receiving a D. The time is ripe to come together to improve the situation.

And it is wise to consider how infrastructure funding might affect greenhouse gas emissions. Total carbon emissions from the U.S. transportation sector rose 22 percent between 1990 and 2017. And in 2017 transportation surpassed electricity as our largest emitter.

My remarks today make two main points: first, market-oriented solutions offer incentives for innovation and cost reduction that can help to contain the social costs of addressing climate change; second, the history of U.S. Government policy for alternative fuels displays an inconsistency that illustrates why it is wise to be cautious about picking particular technology solutions.

Economists have long advocated market-based solutions to environmental problems. This approach minimizes the total cost of achieving a given level of environmental protection, and provides dynamic incentives for innovation in pollution control.

A famous example of a market-oriented policy is congestion pricing, used in London since 2003. A related example comes from Los Angeles, where single-occupancy vehicles can use the high-occupancy vehicle lane by paying a toll that depends on the level of highway congestion. These programs use market mechanisms to reduce congestion at a much lower cost than building more highways.

Another market-based policy is funding roads through a tax on vehicle miles traveled, as has been supported by Chairman DeFazio and Ranking Member Graves. Economic research suggests that if the current schedule of increases in fuel economy standards is maintained, and if the VMT, vehicle miles traveled tax, is differentiated for urban and rural driving, then the VMT tax is likely to outperform a gasoline tax.

Market-based instruments allow for innovation and flexibility on the part of the private sector. This is especially important in the heavy truck market, which relies primarily on diesel fuel.

Cummins and Tesla are producing electric heavy trucks. Toyota is testing heavy trucks powered by hydrogen fuel cells. Natural gas trucks are also being developed. It is too early to tell which of these fuels will be best, so it is important for policy to allow for flexibility. Mandating a specific technology could lock the industry into an inferior option.

This brings me to my second point. U.S. policy towards alternative fuels has vacillated over time, as favored technologies rose and fell. Policy support has switched from methanol to natural gas to battery electric vehicles to hydrogen to hybrid electric vehicles to biofuels, and now back to battery electrics. This has sent confusing signals, making it hard for the auto industry to make long-term investment plans for alternative fuel vehicles.

A market-oriented approach would take a modest view of Government's ability to lead the deployment of any particular technology. Mandating technology choices in downstream markets risks creating cycles of hype and disappointment, or creating lock-in to an inferior technology.

When it comes to encouraging the adoption of electric vehicles, research suggests that financing electric charging stations is more effective than subsidizing vehicle purchases directly. However, there are many possible sources of funding for charging stations, and a thoughtful approach to creating public-private partnerships seems warranted.

It may also be useful to require compatibility in charging standards across manufacturers, which would decrease duplicative investments and expand the size of the electric vehicle market.

In summary, economic analysis cautions against picking technological winners, and supports the use of market-based instruments that allow flexibility and encourage innovation. This is especially important for medium and heavy-duty trucks, where multiple technologies all offer promise, and for the deployment of fueling infrastructure for alternative fuels such as electricity.

Thank you again for allowing me to share my views, and I look forward to your questions.

[Mr. Lyon's prepared statement follows:]

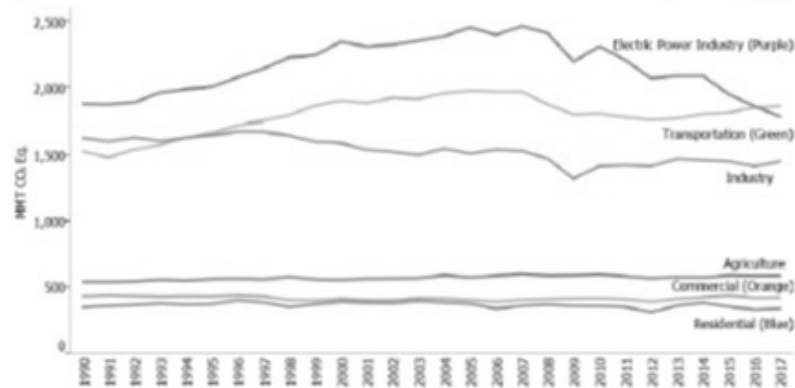
Prepared Statement of Testimony of Thomas P. Lyon, Dow Chemical Professor of Sustainable Science, Technology and Commerce, University of Michigan

I wish to thank the chairmen, ranking members and other members of the Subcommittees and full Committee for inviting me to today's hearing. My name is Thomas Peyton Lyon and I hold the Dow Chemical Chair of Sustainable Science, Technology and Commerce at the University of Michigan, with appointments in both the Ross School of Business and the School of Environment and Sustainability. I am an economist by training, and at the Ross School my home department is Business Economics and Public Policy. At Michigan I teach an MBA-level graduate course entitled "Energy Markets and Energy Politics." I have served as Director of the Erb Institute for Global Sustainable Enterprise and as Associate Director for Policy and Social Science at the UM Energy Institute. In the latter capacity I helped to launch the Transportation, Economics, Energy and Environment (TE3) conference, which for the last 5 years has brought together top academic researchers with leaders from industry and government to discuss these important issues. I have received research grants on transportation from the Sloan Foundation and the U.S. Environmental Protection Agency. I am currently the President of the Alliance for Research on Corporate Sustainability (ARCS), an international alliance of top business schools that have a commitment to understanding the links between business and sustainability.

There is little question that U.S. infrastructure is in bad shape. The American Society of Civil Engineers (ASCE)'s 2017 Infrastructure Report Card gave U.S. infrastructure an overall grade of D+. Transit received a D-, Roads a D, and Bridges a C+; Rail topped the list at a grade of B. The relatively good performance of rail is largely due to private industry investment by the rail freight industry, although Federal funding also contributes. Passenger rail, in contrast, exhibits a "large and growing backlog of capital needs." (ASCE, p. 75). "More than two out of every five miles of America's urban interstates are congested and traffic delays cost the country \$160 billion in wasted time and fuel in 2014. One out of every five miles of highway pavement is in poor condition." (ASCE, p. 77) "The U.S. has been underfunding its highway system for years, resulting in a \$836 billion backlog of highway and bridge capital needs . . . The Federal Highway Administration estimates that each dollar spent on road, highway, and bridge improvements returns \$5.20 in the form of lower vehicle maintenance costs, decreased delays, reduced fuel consumption, improved safety, lower road and bridge maintenance costs, and reduced emissions as a result of improved traffic flow." (ASCE, p. 78) Similarly, "Despite increasing demand, the nation's transit systems have been chronically underfunded, resulting in aging infrastructure and a \$90 billion rehabilitation backlog." (ASCE, p. 89)

Total greenhouse gas emissions from the U.S. transportation sector rose from 1,469.1 million tons of CO₂-equivalent (MMT CO₂E) in 1990 to 1,794.2 (MMT CO₂E) in 2017 (USEPA, 2019, p. 2–3), an increase of 22 percent. Although emissions dropped sharply in 2008 and 2009 as a result of the Great Recession, they have been rising again since 2013. In fact, as of 2017, the transportation sector in the U.S. has surpassed the electricity sector as the largest emitter of greenhouse gases, as shown in the figure below (from USEPA, p. ES-24). Light-duty vehicles account for 60 percent of transportation emissions, with medium- and heavy-duty vehicles accounting for 23 percent of the total.¹

Figure ES-14: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO₂ Eq.)



There are many opportunities to reduce transportation sector emissions, including reducing travel demand, making greater use of public transit, switching to more fuel-efficient vehicles, and adopting a wide range of alternative fuels such as electricity, hydrogen, biodiesel, and compressed natural gas. Emerging connected and automated vehicles (CAVs) offer opportunities to improve highway safety and fuel efficiency, although they may ultimately increase overall fuel consumption (Stephens et al., 2016).

My remarks today will make two main points. First, market-oriented solutions offer incentives for innovation and cost-reduction that can help to contain the social costs of addressing climate change. Second, the history of U.S. government policy for alternative fuels displays an inconsistency that illustrates why it is wise for government policy to be cautious about picking particular technology solutions.

¹ <https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions>

Economists have long argued for market-based instruments for the solution of environmental problems, such as emissions fees (Pigou, 1920) or systems of tradable permits (Montgomery, 1972). The advantages of this approach are that it minimizes the aggregate cost of achieving a given level of environmental protection (Baumol and Oates, 1988), and provides dynamic incentives for the adoption and diffusion of cheaper and better pollution control technologies (Milliman and Prince, 1989). One of the most prominent applications of the approach was the U.S. sulfur dioxide (SO₂) trading program, which is credited with reducing acid rain in the Northeastern U.S. at a cost lower than initially projected (Schmalensee and Stavins, 2013).

In the transportation sector, a prominent example of a market-oriented policy is the use of congestion pricing, as was famously done in London beginning in 2003 (Leape, 2006) and more recently in Gothenburg, Sweden (Hysing et al., 2015). Because London exempted hybrid electric vehicles (HEVs), the congestion tax has also increased their use (Morton et al., 2017).

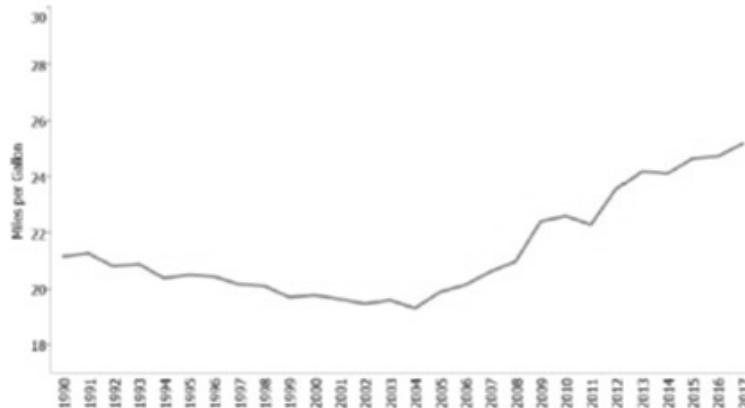
A less familiar example comes from Los Angeles, where beginning in 2013 the High-Occupancy Vehicle (HOV) lane on Interstate I-10 has been converted to a High-Occupancy Toll (HOT) facility, under the city's ExpressLanes program (Bento et al., 2017). The program allows Single-Occupancy Vehicles (SOVs) to travel in the HOV lane by paying a toll that ranges from \$0.10 to \$15.00 depending on the level of congestion on the highway. The toll is adjusted dynamically to keep travel speeds in the HOV lane at roughly 45 miles per hour. The program uses market mechanisms to reduce congestion at a much lower cost than highway expansion.

Another market-based policy is funding roads through a tax on vehicle miles traveled (VMT), as has been supported by Chairman DeFazio and ranking member Graves.² Oregon has experimented with such a policy, California has initiated a pilot project, and other States have shown interest as well (Langer et al., 2017). Economic research suggests that a VMT tax can have substantial benefits. Parry and Small (2005) calculate that the optimal VMT tax would be more economically efficient than the optimal gasoline tax, would raise more revenue, and would be better at reducing congestion and accidents than a gasoline tax. However, a gasoline tax would more directly target the environmental performance of vehicles, as well as the increased accident hazards created by driving heavier and less fuel-efficient vehicles (Anderson and Aufhammer, 2013). Langer et al. (2017) use a unique dataset on individual driver behavior to estimate the effects of a VMT, and conclude that its performance is likely to be very similar to that of a gasoline tax in terms of overall social welfare. However, if the Obama-era increases in Corporate Average Fuel Economy (CAFE) standards are maintained, and if the VMT is differentiated for urban and rural driving, then the VMT outperforms a gasoline tax.

A crucial advantage of market-based instruments is that they allow for innovation and flexibility on the part of the private sector. This is of particular importance with regard to the heavy truck market, which currently relies primarily on diesel fuel. As mentioned above, medium-and heavy-duty trucks only produced 23 percent of the emissions from the transportation sector in 2016, but the relative impact of trucks is likely to increase over time as the efficiency of light-duty vehicles continues to improve (see the figure below, which is from USEPA 2019, p. 3–23).

² <https://www.ttnews.com/articles/missouri-rep-sam-graves-consistent-support-vmt-funding-approach>

Figure 3-13: Sales-Weighted Fuel Economy of New Passenger Cars and Light-Duty Trucks, 1990–2017 (miles/gallon)



Different companies are pursuing different technological solutions for reducing carbon emissions from trucks. Cummins and Tesla are producing electric heavy trucks.³ Toyota is testing heavy trucks powered by hydrogen fuel cells.⁴ Natural gas trucks could also offer climate advantages, but these are dependent on reduced leakage of methane across the supply chain and engine efficiency improvements (Camuzeaux et al., 2015). It is too early to tell which of these fuels will prove to be best in particular uses, so it is important for policy to allow for flexibility as innovation advances. Mandating a particular type of technology for these vehicles could lock the industry into an option that ends up being less than optimal.

HISTORY OF ALTERNATIVE FUELS POLICY

U.S. policy toward alternative fuels has vacillated over time as favored technologies become the “fuel du jour” and then lose ground to a new alternative. The pattern is illustrated in the following figure (from Melton et al., 2016, p. 3).

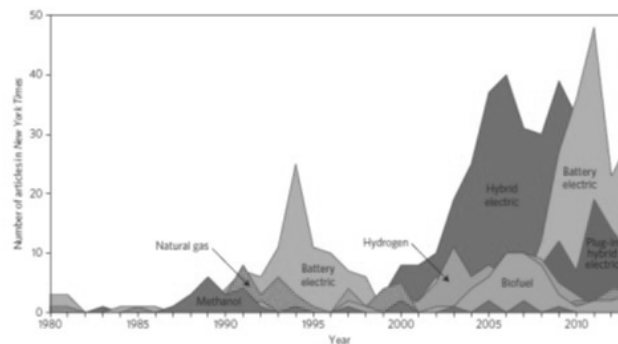


Figure 2 | Media attention for all alternative fuel vehicle technologies for 1980–2013. Media attention skipped among numerous AFV technologies between 1980 and 2013. These waves of attention are indicative of sequential and repeated shifts in society’s focus from one emerging technology to another over time.

President Reagan was a promoter of methanol, a fuel that quickly fell out of favor. A few years later, California imposed a zero-emissions vehicle (ZEV) mandate, with the expectation that this would drive deployment of electric vehicles, but the policy

³ <https://www.forbes.com/sites/joannmuller/2017/08/29/take-that-tesla-diesel-engine-giant-cummins-unveils-heavy-duty-truck-powered-by-electricity/#7dabd12278f1>

⁴ <https://www.trucks.com/2017/10/12/toyota-hydrogen-fuel-cell-electric-truck-hits-road/>

had little impact on actual deployment. Hydrogen fuel cells attracted attention with the passage of the Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Act of 1990, whose purpose was to “accelerate efforts to develop a domestic capability to economically produce hydrogen in quantities that will make a significant contribution toward reducing the Nation’s dependence on conventional fuels.” The Partnership for a New Generation of Vehicles (PNGV) was launched in 1993, with the goal of producing a new set of highly fuel-efficient vehicles, and emphasizing hybrid diesel-electric vehicles. Each of the big domestic manufacturers produced fully operational concept cars that got at least 72 miles per gallon, but a lack of ongoing support meant that none actually made it to market. Government attention shifted back to hydrogen in 2003 with President George W. Bush’s “Hydrogen Fuel Initiative,” which provided \$1.2 billion of funding to develop hydrogen fuel cells. This was bolstered by the FreedomCAR and Vehicle Technologies Partnership between the Department of Energy and the U.S. Council for Automotive Research (consisting of Ford, GM, and Chrysler). At around the same time, however, political attention began to turn to biofuels, and the 2002 Renewable Fuels Standard provided strong policy support for corn-based ethanol, the climate benefits of which have been questioned by numerous authors (DeCicco et al., 2015; Hill et al., 2016). In 2007, California Governor Arnold Schwarzenegger issued an executive order creating a low-carbon fuel standard, and the climate benefits of this policy have also been questioned (Holland et al., 2009).

This history of jumping from one favored technology to another in rapid succession has sent a confusing set of signals to the automobile industry, making it difficult for the auto industry to make long-term investment plans for alternative fuel vehicles. As Melton et al. (2016, p. 8) point out, “goals are often announced . . . without consideration for factors such as supply constraints, rate of innovation adoption, and consumer acceptance.” It is little wonder that these government-led calls to action might be considered non-credible by industry actors and investors.

What lessons are to be drawn from this experience? One response would be to build government capacity in technology assessment and forecasting, hoping to render future government programs more credible (Melton, et al., 2016). A market-oriented approach would take a more modest view of government’s ability to lead the deployment of any particular technology. Of course, it is widely acknowledged that government needs to play a key role in fundamental research and development (Jaffe et al., 2005), and that this may entail funding a wide range of promising early stage technologies. However, attempts to dictate technology choices to downstream markets run the risk of either creating cycles of hype and disappointment (Melton et al., 2016) or creating “lock in” to an inferior technology (Cowan, 1990). An alternative could be to create more research tournaments by offering prizes for technological breakthroughs (Taylor, 1995), such as the Breakthrough Prizes funded by Silicon Valley leaders.⁵

What might these considerations imply for the financing of electric charging stations, a potentially important infrastructure policy? Li et al. (2017) find that funding charging stations instead of subsidizing vehicle purchases would have been twice as effective in encouraging the adoption of electric vehicles. This is promising, but it is not obvious that such funding must be provided by the Federal Government. There are many possible sources of funding for charging stations, including vehicle manufacturers such as Tesla, electric utilities,⁶ employers, retail establishments, and municipalities, as well as State and Federal Governments. In light of this array of options, a thoughtful approach to creating a public/private partnership seems warranted. It is also worth noting that the less costly policy of mandating compatibility in charging standards would decrease duplicative investment in charging stations by car manufacturers and increase the size of the electric vehicle market (Li, 2019).

In summary, economic analysis cautions against picking technological winners and supports the use of market-based instruments that allow flexibility and encourage innovation. This is especially important for medium- and heavy-duty trucks, where multiple technologies all offer promise, and for the deployment of fueling infrastructure for alternative fuels such as electricity.

⁵ <https://www.nationalgeographic.com/science/2018/11/news-breakthrough-prizes-2019-award-winners-biology-physics-math/>

⁶ <https://www.forbes.com/sites/constancedouris/2017/11/08/who-should-pay-for-electric-vehicle-chargers-who-should-profit/#4c8518d34aa5>

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Mr. CARBAJAL. Thank you, Professor Lyon.

Next, Mr. Prochazka, you may proceed. But first, let me just say that I apologize for getting your name placard wrong. We are going to fix that in a minute. Please proceed.

Mr. PROCHAZKA. Thank you, Mr. Chairman, Ranking Member Graves, and distinguished members of the committee. And my last name is often mispronounced, so at least we got that correct today. [Laughter.]

Mr. PROCHAZKA. So I want to thank you all for the opportunity to talk about this important issue. As a son of a dad who spent 25 years working for the FAA, my experience started real young with transportation.

So I am the vice president of the Electrification Coalition, a non-partisan, nonprofit organization that works to accelerate the adoption of plug-in electric vehicles around the country in an effort to reduce the economic and national security threats posed by U.S. oil dependency. We are a sister organization of Securing America's Future Energy, which leads a broader approach with the same core mission, and works for all fuels.

You have a copy of my written testimony, and I am happy to answer questions after. But today's hearing is an opportunity to summarize a few key points: one, the hope that EVs can be a bipartisan issue; two, EVs are going to help diversify our transportation fuels; three, there are successes from around the country to highlight; and four, we hope to share several policy recommendations that could support EV adoption.

Currently 92 percent of the U.S. transportation sector is powered by oil. Supply is determined by a cartel, and traded on an unfair and unfree oil market, meaning disruption anywhere affects prices everywhere. We need aggressive policy interventions that are going to diversify transportation fuels, an issue that should be at the top of every lawmaker's list.

Through transportation electrification, we can power the way we move, while also improving our economic and national security. Electricity is diverse, American-made, low-cost, ubiquitous, and stable. And when used for transportation, it is fundamentally cleaner than internal combustion engines, regardless of the source. And as the grid gets cleaner, so do EVs.

And not only do EVs reduce pollution, oil dependence, and cost, they have incredible acceleration, and are actually fun to drive.

EV adoption is also growing rapidly, last year hitting 1 million sold, and in 2019 will have almost 50 models available. Battery costs are dropping. Charging is getting faster. And now buses, garbage trucks, delivery vehicles, and class 8 vehicles are going electric.

Despite the advantages of electrification, barriers both real and perceived remain. Consumer knowledge is low. Upfront costs can be higher. Local, State, and Federal policies can remain in flux. But the Electrification Coalition and others are working to reduce these barriers at all levels.

In Orlando we worked with area theme parks and Enterprise Rent-a-Car to launch the Nation's first EV rental car program, providing an extended EV test drive. In Fort Collins and Loveland we launched Drive Electric Northern Colorado, our first accelerator

community. By coordinating fleet transition, increased charging, and consumer education in one location, we accelerated adoption to three times the national average.

The Electrification Coalition was also the lead implementation partner for the Smart City Challenge. Seventy-eight cities responded, offering innovative ideas to electrify transportation, showing that communities were hungry for solutions. Seven finalists were selected: Portland, San Francisco, Denver, Austin, Kansas City, Columbus, and Pittsburgh. And now all are leading examples for electrification. The winner, Smart Columbus, and with our partnership, is now a thriving EV ecosystem that is substantially increasing EV adoption.

Our daily commutes are also going electric. Greensboro, North Carolina, has become one of the largest fleets on the east coast, recently launching 16 buses. It is going to eventually eliminate 2 million gallons of diesel.

In Chicago, for every bus they deploy, they expect to save about \$25,000 in annual fuel costs. Imagine extending that to the 70,000 city buses and 400,000 school buses operating nationwide. If just half were to go electric, it would save \$6 billion annually, and cut over 400 billion gallons of lifetime diesel use.

And in partnership with Climate Mayors, a group of 400 mayors, we launched the Climate Mayors EV Purchasing Collaborative, which provides tools to make transition easier. From Cape Canaveral to Houston, L.A., and San Diego, they have committed to purchase over 500 EVs in the next year.

We have several main recommendations. One, we should retain 30D, the Federal tax credit to purchase EVs. With some of the companies already reaching the cap, we support lifting the cap with a stakeholder-negotiated sunset.

Charging infrastructure must meet an electric future. Funding DOT Alternative Fuel Corridors program can improve signage, expand nationwide charging, and show consumers considering an EV that charging is increasing, nationwide. We should also renew and extend the 30C Federal tax credits per additional EV charging.

We also need to expand electric bus adoption. We recommend low- or zero-interest loans that can demonstrate the payback of lower operational costs. Programs like the FTA's Low or No Emission grant program should be continued and expanded, and we must also look for opportunities to create incentives and paths to accelerate medium and heavy-duty vehicle electrification.

Each year the U.S. military spends at least \$81 billion to protect global oil supplies. Roughly—it is roughly 28 cents for every gallon we use. Policies that diversify our transportation fuels are a small price, compared with the opportunity to strengthen our economic and national security, a goal everyone should support.

Thank you for the opportunity to testify. I appreciate and look forward to your questions.

[Mr. Prochazka's prepared statement follows:]

Prepared Statement of Ben Prochazka, Vice President, Electrification Coalition

Chairman DeFazio, Ranking Member Graves, and distinguished members of the Committee,

Thank you for the opportunity to testify on this important issue. My name is Ben Prochazka, and I am the Vice President of the Electrification Coalition, a non-partisan, non-profit group of business leaders committed to promoting policies and actions that facilitate the deployment of electric vehicles on a mass scale in order to combat the economic and national security dangers caused by our nation's dependence on oil. The Electrification Coalition is comprised of leaders representing the entire value chain of the electrified transportation system. These leaders believe federal infrastructure policy can and must do much more to accelerate our economy's transition away from oil as the only transportation fuel which we believe is critical to providing choice to consumers and businesses and strengthening our economy and national security.

The Electrification Coalition is a sister organization of Securing America's Future Energy, or SAFE. For over a decade, SAFE has been committed to strengthening America's national and economic security by reducing U.S. oil dependence. While we are here today to talk about electric vehicles (EVs) and the EC's continued role in their adoption, SAFE supports efforts to bring greater fuel diversity to U.S. consumers and businesses attempting to remain fuel neutral when possible but assist certain fuel types as necessary. In 2006, SAFE formed the Energy Security Leadership Council (ESLC), a nonpartisan group of business and former military leaders in support of long-term policy toward this goal. The ESLC is co-chaired by Frederick W. Smith, Chairman and CEO of FedEx, and General James T. Conway, 34th Commandant of the U.S. Marine Corps (Ret.).

Today's timely hearing provides an opportunity for us to share some examples of early market successes of EVs and challenges to EV adoption, explain why EVs should have strong bipartisan support, and to encourage this committee to help accelerate EV adoption (including transit buses, passenger, and medium- and heavy-duty vehicles) and to increase the number of available charging station locations and signage across the country.

THE CHALLENGE OF U.S. OIL DEPENDENCE AND TRANSPORTATION

The United States is the single-largest oil consumer in the world. We consume, as a nation, approximately one-fifth of daily global supply, 70 percent of which is used to power our transportation system. Since 92 percent of the energy consumed in the U.S. transportation system comes from oil, businesses and consumers have no alternatives available at scale when oil prices spike. With the uniquely global nature of oil pricing, a supply disruption anywhere impacts prices everywhere. This is exacerbated by the opaque and unfree oil market dominated by the OPEC cartel, which controls 83 percent of the world's proven oil reserves.

Such market manipulation often leads to rapid fluctuations in oil prices—both upwards and downwards—and wreaks havoc on our businesses, our cities, and the average American's pocketbook, ultimately straining the entire U.S. economy. Although oil prices were comparatively low in 2018, the volatile nature of the oil markets means American household budgets will almost certainly be pressured by higher prices in the near-to-medium-term future—and likely with little warning—and that the tax cut given by President Trump just as tax cuts by Presidents Bush and Obama will be sent to OPEC members and to purchase higher cost oil than to the pockets of average Americans.

Additionally, higher oil prices significantly added to the U.S. federal debt between 2002 and 2012, and every U.S. recession over the past 40 years has been preceded by, or coincided with, an oil price spike. Despite the recent increase in domestic oil production, the United States sent more than \$133 billion abroad in 2018 to pay for oil, often to countries that neither share American strategic interests nor values. The economic importance of oil also creates adverse national security challenges. Notably, more than 50 percent of daily oil supplies pass through one of seven major chokepoints, many in unstable regions, particularly the Middle East. In addition, the U.S. military spends at least \$81 billion per year to protect global oil supplies—accounting for 16 percent of DoD base budgets. If this cost is spread over the roughly 19.8 million barrels of oil consumed daily in the U.S., the implicit subsidy for petroleum consumers comes out to \$11.25 per barrel of crude oil, or \$0.28 per gallon.

WHY ELECTRIC VEHICLES ARE THE SOLUTION TO OIL DEPENDENCE:

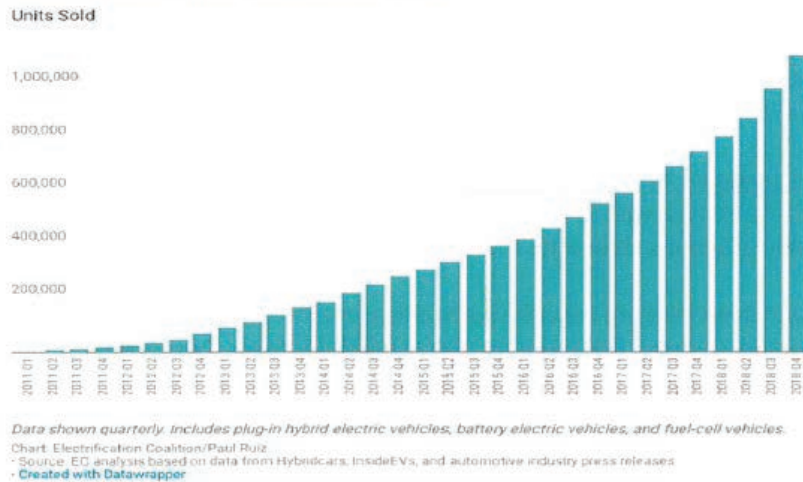
Electric vehicles have the potential to dramatically reduce our nation's oil dependence. By utilizing electricity to charge rapidly improving battery technology, we can power our transportation sector with a diverse, domestic, price stable, and fundamentally scalable energy supply. In addition, this approach is fundamentally cleaner even when the electricity is generated by coal but as we have seen in the last few years the mix of fuels to power electricity continues to get cleaner.

Electric vehicles provide a range of other benefits, which are addressed in detail later in this testimony but can be briefly mentioned here. Fewer moving parts means there are lower maintenance costs for EVs, while also allowing local and state governments to meet air quality challenges like non-attainment zones. Additionally, thanks to the ubiquity of U.S. electricity infrastructure, much of the nationwide fuel delivery network for EVs is already in place.

STATE OF THE ELECTRIC VEHICLE MARKET:

The vehicle manufacturing and charging infrastructure industry have seen important progress in recent years as investments have grown, with several OEMs committing billions more dollars to develop new models. Today, 50 light-duty EV models are already available to American consumers and cumulative light-duty EV sales growing quickly, as we recently surpassed 1 million units in the United States since January 2011. This is also being matched with increased investments from the private sector and utilities to expand the number of charging stations and speed of the chargers, reaching almost 50,000 chargers at the end of 2020.

Cumulative Units Sold Since 2011



Electrified transportation is rapidly expanding in the commercial and transit sectors as well, with plug-in hybrid and battery electric trucks ranging in size from Class 1 to Class 8 already operating on city streets around the country. Today there are electric delivery vehicles carrying packages for FedEx and UPS, plug-in electric garbage trucks operating in Seattle and Sacramento, a Class 8 yard truck in Buffalo, and 16 electric buses bringing commuters to work in Greensboro, NC. Those 16 buses in Greensboro alone are estimated to eliminate nearly 2 million gallons of diesel usage. Considering there are approximately 70,000 city buses and 400,000 school buses in the U.S., the potential for fuel savings and air quality improvements nationwide are tremendous. The commercial and transit sectors are increasingly driving electric—and Americans are increasingly seeing the shift happening on their daily commutes, as more than 13 percent of all transit agencies either have EV buses in service or on order.

We look forward to 2019 as a key transitional year when available light-duty EVs meet more consumer needs while approaching cost parity over the life of the vehicle with petroleum-powered vehicles. Additionally, there are exciting signs from indus-

try of a growing list of vehicle options in almost every segment of the market, providing an electric vehicle solution for almost every lifestyle.

While growth in the EV market is promising, there is still significant work that must happen to ensure EVs can meaningfully improve the economic and national security of the United States by providing the needed fuel diversity in transportation. Transitions like this are difficult, there is no guarantee of success, and there is much to be done to make sure we accelerate these critical changes, but there are tremendous signs of hope and the stakes cannot be higher.

THE ELECTRIFICATION COALITION'S ACCELERATOR PROGRAMS

From coast to coast, the EC has worked with federal, state, and local policy-makers to create scalable and replicable programs across the United States to accelerate the adoption of EVs.

Our work has included deep learning experiences in cities and through public and private sector partnerships in Colorado, Georgia, Ohio, Florida, North Carolina, Texas, Pennsylvania, and New York. Our efforts have expanded access to infrastructure, created an EV rental car program with Enterprise Rent-a-Car, launched regional and national bulk procurement initiatives that can reduce the administration and real costs of vehicle acquisition, and initiated the nation's first full ecosystem efforts that united diverse partners through "EV accelerator" communities that serve as models for successfully driving EV adoption. These initiatives have provided us with the opportunity to develop a growing list of case studies and best practices that will make it easier for the next communities to drive adoption at even greater rates.

To realize these gains, the Electrification Coalition has worked tirelessly at the local and state levels to bolster EV adoption. In 2013, the Electrification Coalition created Drive Electric Northern Colorado, its first accelerator community. Accelerator communities are cities or regions where all of the necessary public and private stakeholder partnerships are combined with the appropriate business environment, regulatory support, and consumer education to achieve substantially higher EV sales. The first accelerator community achieved EV sales three times the national average by implementing this combined approach. The accelerator community model was later replicated in Rochester, NY, and its success has encouraged New York to launch similar communities across the state.

In addition, the Electrification Coalition worked with the Florida Energy Office and major private sector partners in Orlando such as Enterprise Rent-a-Car to create one of the nation's first EV rental programs, called Drive Electric Orlando. This program has already provided thousands of the state's visitors with first-hand experience in driving EVs, thereby building confidence in and comfort with the technology, dispelling myths, and allowing drivers to discover the overall benefits of EVs.

On a larger scale, the Electrification Coalition is acting as a technical and strategic advisor to Smart Columbus, the winner of the U.S. DOT's Smart City Challenge. This \$50 million endeavor—funded through \$40 million from U.S. DOT and \$10 million from the Paul G. Allen Family Foundation—is breaking down the barriers to EV adoption in the Midwest and working to significantly accelerate EV adoption by consumers and fleets. Smart Columbus is simultaneously sharing and implementing national best practices, leveraging over \$510 million in private-sector investment, and developing new innovations to achieve substantially increased EV adoption in the Columbus region.

Further demonstrating the local-level EV programs, the Electrification Coalition is engaged with several initiatives to spur collaboration and information sharing between and among U.S. and international cities. These include the Mobility Innovation Challenge and the Global Pilot EV Cities Initiative. Through these initiatives we have learned that cities are facing immense transportation challenges for which electrification provides an immediate and achievable solution.

The EC is also the technical advisor for the Climate Mayors EV Purchasing Collaborative, a nationwide bipartisan collaboration of mayors who are committing to electrify city fleets. This initiative is designed to reduce the barriers to electrification for our nation's municipal fleets, thereby accelerating the transition. Already, 19 founding cities and two counties have publicly committed to the purchase of 376 EVs, representing more than \$11 million in EV investment.

At the state level, the EC developed the Zero Emissions Vehicle (ZEV) State Scorecard to provide a single, comprehensive, and data-driven ranking of the key policies being implemented in ZEV MOU states to support increased EV adoption. As the ZEV MOU states are among the nation's leaders in policies that accelerate

the adoption of EVs, the scorecard provides the ability to assess the policies and actions that most effectively impact EV adoption at the state level.

This is all necessary because while EV purchases have increased, they are yet to reach a tipping point. Perception issues continue to persist, as high numbers of consumers have neither driven an EV nor know about the lower fuel and maintenance costs they offer. Similarly, auto dealerships often don't prioritize EV sales with strong knowledge about the available EV models, meaning electric cars are not being integrated into showrooms. Attracting consumers to EVs will also help solve current infrastructure issues, as every vehicle sold will contribute to a developing value chain system that feeds into infrastructure investment, creating jobs and boosting local economies in the process.

ELECTRICITY IS DIVERSE IN SOURCE AND DOMESTICALLY PRODUCED:

There could not be a more domestic or bipartisan solution to the issue of oil dependence in our transportation sector than vehicle electrification.

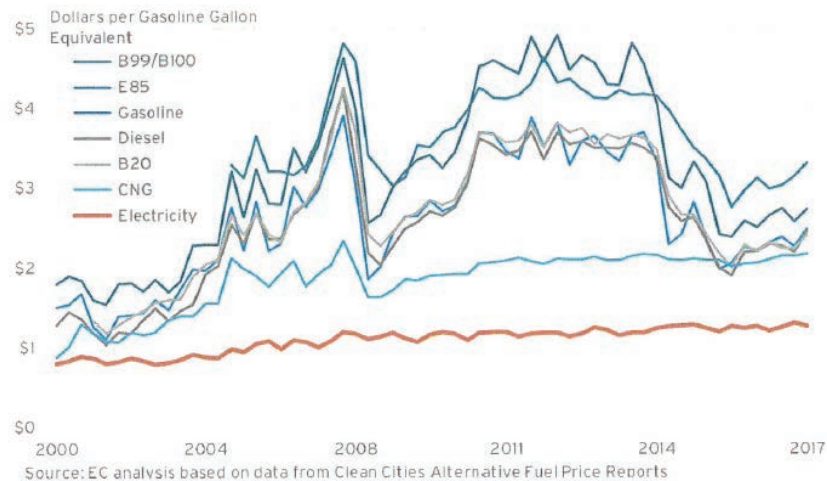
Electricity is generated from a diverse set of largely domestic sources. These sources include nuclear, coal, natural gas, and renewables such as wind, water, and solar. An electrified transportation sector can maximize the electric grid's diverse generation capacity and, when the availability of resources for generating electricity change, electricity generation can shift to power EVs with other alternatives. Moreover, whereas oil supplies are subject to a wide range of geopolitical risks, domestic and localized electricity production unquestionably benefits local economies while creating jobs for American workers.

Operating a vehicle on electricity is considerably less expensive and energy-intensive than operating a conventional internal combustion vehicle. In large part, this is due to the higher efficiency of electric motors. Conventional internal combustion engine (ICE) vehicles convert only approximately 20 percent of the energy stored in gasoline into power for the wheels. In contrast, EVs convert approximately 60 percent of the electrical energy from the grid into power for the wheels. Miles traveled by EVs also emit less CO₂ and other emissions than vehicles powered by petroleum fuels. As noted, this is true even with today's mix of electricity-generating resources in the U.S.—which will only get cleaner as alternative generation options are integrated into the grid.

Additionally, North Carolina is home to one of the world's largest deposits of lithium, a core component of EV battery technology. Millions of dollars have been raised and invested in recent months to further expand production of this strategic mineral in the state, and is an example of how effective policies have the potential to leverage emerging investments from the private sector.

ELECTRICITY PRICES ARE LOW AND STABLE:

Electricity prices are substantially less volatile than gasoline or diesel prices, increasing by an average of less than 2 percent per year in nominal terms since 2000. The electric power system is designed to meet peak demand at any time from existing generation sources—meaning throughout most of the day, and particularly at night, consumers demand significantly less electricity than the system can deliver. Assuming that charging patterns are well-managed, the system has substantial spare capacity to meet new demand from EVs parked at homes and other locations during nighttime hours.



This low cost and price stability, which stands in sharp contrast to the price volatility of oil or gasoline, exists for at least two reasons.

First, the retail price of electricity reflects a wide range of costs, only a small portion of which arise from the underlying cost of the source. The remaining costs are largely fixed. This is significantly different from gasoline, where the cost of crude represents a significant percentage of the cost of retail gasoline.

Second, although real-time electricity prices can be volatile (sometimes highly volatile on an hour-to-hour or day-to-day basis), they are nevertheless relatively stable over the medium and long term. Therefore, in setting retail rates, utilities use formulas that will allow them to recover their costs, including occasionally high peak demand prices for electricity, but which effectively insulate the retail consumer from the hour-to-hour and day-to-day volatility of the real-time power markets.

By isolating the consumer from price volatility, electric utilities are providing EV drivers the very stability that oil companies cannot provide to consumers of gasoline.

THE POWER SECTOR HAS SUBSTANTIAL SPARE CAPACITY:

Because large-scale storage of electricity has historically been impractical, the U.S. electric power sector is effectively designed as an 'on-demand system.' In practical terms, this has meant that the system is constructed to be able to meet peak demand from existing generation sources at any time. However, throughout most of a 24-hour day—particularly at night—consumers require significantly less electricity than the system is capable of delivering. Therefore, assuming charging patterns are appropriately managed, the U.S. electric power sector has substantial spare capacity that could be used to power electric vehicles without constructing additional power generation facilities. In fact, the Department of Energy's Pacific Northwest National Laboratory found that the existing grid has enough capacity to accommodate more than 150 million EVs without significant system upgrades.

Unlike many proposed alternatives to petroleum-based fuels, the nation already has a ubiquitous network of electricity infrastructure. No doubt, electrification will require the expansion of charging infrastructure, additional functionality, and increased investment in grid reliability, but the power sector's infrastructural backbone—generation, transmission, and distribution—is already in place.

CHALLENGES TO ELECTRIC VEHICLE TRANSITION:

We have yet to reach a tipping point in EV adoption due to a number of persisting barriers to widespread consumer uptake. EV adoption rates are influenced by many factors, including the training and enthusiasm of automotive dealers, low vehicle availability in certain markets and vehicle classes, consumer knowledge, and low gasoline prices. Electrifying our transportation sector is an immense and urgent challenge. And while cities and states around the country are intensifying efforts

to rapidly increase EV adoption, there are significant opportunities for federal infrastructure policy make an even greater impact.

This hearing provides a great opportunity to share some policy recommendations that we believe can help accelerate the EV market. Below we have identified the current barriers to adoption and key policy recommendations to address them.

INITIAL PURCHASE PRICE:

The upfront costs of EVs have long acted as a deterrent to EV purchases. Although prices of electric models have traditionally been higher than their ICE counterparts, prices are rapidly dropping as battery technology becomes cheaper. In 2008, battery prices were as high as \$1,000/kWh and there were relatively large production inefficiencies due to lack of scale. Greater battery production is now underway, driving battery prices below \$150/kWh today. Many experts believe that once battery prices reach \$100/kWh, EVs will become completely cost competitive with internal combustion engines.

Incentives like the 30D federal tax credit for purchasing EVs remain critical to fostering greater adoption at this early stage, and improvements to the 30D tax credit can make it even more effective. The current cap of 200,000 vehicles per manufacturer does not align industry incentives with factors such as early adoption or rapid technological advancement—first movers should be rewarded, not penalized. In order to enjoy the significant energy security benefits of widespread transportation electrification, it is vital that we reform 30D by raising the cap—and establish a sunset date—in order to continue incentivizing increased EV production and ultimately widespread EV adoption.

CONSUMER PREFERENCES:

As oil prices fell in 2015, sales of less fuel-efficient light trucks dramatically increased. By the end of 2018, light trucks represented nearly 70 percent of all new vehicles sold in the United States on an annualized basis. In terms of the early EV market, consumer preferences have also largely been ignored, as the vast majority of EVs available have been light-duty sedans. However, a wider range of models is now becoming available, with offerings at all points across the consumer market including SUVs and trucks. As an example, Ford recently announced plans to release an all-electric version of its highly popular F-150 truck.

INFRASTRUCTURE NEEDS:

Similarly, infrastructure needs must be expanded along with the availability of models. Range anxiety is decreasing as battery capacity improves, but this concern must be addressed with incentives, policies, and pilot programs to continue the build-out of EV chargers and, more broadly, charging corridors spanning the United States. To this end, one key policy lever is the 30C federal tax credit, which covers one-third of the cost to purchase and install charging infrastructure (valued up to \$1,000 in homes and up to \$30,000 in commercial applications).

ENCOURAGING FASTER EV BUS ADOPTION:

Beyond the private passenger vehicle market, electric buses are already beginning to meet some of the demands of transit systems in the U.S. However, we believe policymakers have the opportunity to accelerate the adoption of EV buses by addressing some of the barriers that transit agencies currently face. We should encourage the adoption of EV buses through federal financing mechanisms such as low-interest or zero-interest loans to public entities. This will help to address the realities of state and city budgeting, which often prioritize the lowest upfront capital expenditures (e.g., purchasing buses with internal combustion engines) with a tradeoff of higher overall lifetime operational costs versus electric buses. As a result, long-term fuel and maintenance costs are not factored into initial purchasing decisions—which overlooks the key long-term benefits of electric buses.

SUPPORTING COMMUNITY ENGAGEMENT EFFORTS:

Besides federal support, there are a number of impactful policy options at the state and local levels. These include both monetary incentives, most commonly in the form of vehicle purchase incentives, and other non-financial incentives. It is incredibly important to ensure consumers are aware of the programs that are available to them, as they are unlikely to purchase EVs if they are unaware of the technology, how it can fit their lifestyle, and the potential savings.

In order to combat consumer misunderstanding of the technology, industry and advocates such as the EC have used several strategies to raise consumer awareness.

These include campaigns to increase awareness of charging infrastructure (e.g., adequate and highly-visible signage) and to convey to consumers the value benefit of electrification, such as the money that can be saved on fuel over time.

CHANGE AT THE FEDERAL LEVEL

These initiatives described previously have proven to be very effective at the local level, with the promise of further success. However, improvements in infrastructure policy at the federal level can have a multiplier effect on such initiatives, allowing not only the nationwide replication of these projects but also a meaningful expansion in both their scope and scale.

Congress and the Administration should continue to support the 30C and 30D federal tax credits, which support critical R&D efforts and incentivize consumer adoption respectively at this nascent stage of the industry's development. Retention of the \$7,500 federal purchase incentive is vital to continuing to build momentum because some automakers have entered the tax credit's phase-out stage. We support lifting the cap on the total number of vehicles covered by the tax credit, and then a sunset to be negotiated by the stakeholders. Affordability should form a major part of these negotiations.

As mentioned earlier in this testimony, electrifying city and municipal bus fleets would be a vital step forward in reducing oil dependence and enhancing U.S. energy security. To encourage this transition, we recommend prioritizing low-cost loans as an attractive financing solution to EV bus purchases, as city budgets implicitly penalize electric options by prioritizing upfront costs in their purchasing processes. In addition, further expanding the U.S. Department of Transportation's Federal Transit Administration Low or No-Emission Bus Competitive Grant Program, and other related initiatives, would act as a critical deciding factor for municipalities considering the switch to electric buses. Finally, the Federal Highway Administration's continued support of bus programs through the FAST Act must also be maintained. We are encouraged to hear the FAST Act received full funding in recent spending bills.

Very importantly, federal policy is required to expand our nation's network of charging infrastructure, and allay persistent consumer fears over range and charging anxiety. Expanding the FHWA Alternative Fuel Corridors program should be integral to this effort. In addition, greatly improving signage directing drivers to EV chargers would also prove highly beneficial. The presence of such signage would not only be helpful to current EV drivers, but also demonstrate to other drivers considering the switch to an EV that the requisite charging infrastructure is available.

Thank you again for the opportunity to testify before this committee. I look forward to your questions.

Mr. CARBAJAL. Thank you, Mr. Prochazka.

Ms. Young, you may proceed.

Ms. YOUNG. Thanks to Chairman DeFazio for calling this hearing.

Ranking Member Graves, Chairman Carbajal, members of the committee, before we begin I would like to acknowledge that we at A4A join the entire aviation community in expressing our deepest sympathies for the families and loved ones of the crewmembers aboard Atlas Air flight 3591.

We also appreciate the opportunity to testify today on the important role infrastructure management plays in addressing the climate change threat.

The U.S. airlines have a decidedly strong fuel efficiency and greenhouse gas emissions record that is often overlooked or misstated. Although we drive over 10 million U.S. jobs, \$1.5 trillion in economic activity, and 5 percent of the Nation's GDP, we account for only 2 percent of the Nation's greenhouse gas emissions inventory.

While this percentage is far less than most sectors—for example, less than the 17 and 28 percent shares attributed to passenger vehicles and power plants—we take our role in controlling greenhouse gas emissions very seriously. In fact, between 1978 and

2017, the U.S. airlines improved their fuel efficiency by more than 125 percent, saving over 4.6 billion metric tons of carbon dioxide, equivalent to taking more than 25 million cars off the road each of those years.

These numbers are not happenstance; we have achieved this record by developing and deploying technology, operations, and infrastructure advances central to providing safe and vital air transport as efficiently as possible within the constraints of our current air traffic management system.

Indeed, for the past several decades, our airlines have invested billions in fuel-saving aircraft and engines, innovative technologies like winglets, cutting-edge flight management software, improved ground operations, and other measures. And I commend you to my written testimony for detailed descriptions of these initiatives, including deployment examples from A4A members.

But despite our strong record to date, we are not resting on our laurels. Since 2009, A4A and our members have been active participants in a global aviation coalition that committed to 1.5 percent annual average fuel efficiencies through 2020, with a goal to achieve carbon-neutral growth in international aviation, starting in 2021.

Further, we are working towards an additional aspirational goal to achieve a 50-percent net reduction in carbon dioxide emissions in 2050. The initiatives we are taking to meet these goals are designed to responsibly limit our greenhouse gas emissions contribution, while allowing commercial aviation to continue to serve as a key contributor to the U.S. economy.

The efforts of our airlines are vital to these innovations. But so too are the public-private research and development partnerships we have with FAA and NASA.

In addition to driving further fuel efficiency and emissions savings through improved technology operations and infrastructure, we are dedicated to deploying commercially viable, sustainable, alternative jet fuel, which could be a game-changer. We have made huge strides through our Commercial Aviation Alternative Fuels Initiative, farm-to-fly initiative, and other programs, such that United Airlines already is taking commercial supply of such fuel at Los Angeles International Airport. And Alaska, FedEx, Southwest, Jet Blue, and American all have agreements to support their future deployment of such fuel.

Moreover, we support both international aviation greenhouse gas emissions agreements reached in 2016 under the International Civil Aviation Organization. The first of these agreements established a fuel efficiency and carbon dioxide certification standard for future aircraft, while the second represents the first and only market-based measure for greenhouse gas emissions from an individual business sector.

The U.S. Government played a key leadership role in shaping these agreements, consistent with a mandate under Public Law 112–200. While rejecting the unilateral approach the European Union was taking, that law directed U.S. officials to conduct international negotiations to pursue a global approach to addressing aircraft emissions. The two ICAO agreements, which are intended to be in lieu of unilateral measures, are broadly supported by the

aviation industry, and we continue to look forward to working with Congress and the administration on their implementation.

We are confident that the measures we are taking will reduce aviation's emissions footprint even further, while allowing commercial aviation to continue to provide an invaluable service to our Nation and its economy. However, there is a complementary role for the Federal Government to play.

Specifically, we seek support from Congress and the executive branch in three key areas: first, business-case-based implementation of the next generation air transportation system, NextGen, prioritizing existing equipage; second, stable policies to further support making sustainable alternative jet fuel commercially viable; and third, continuation and proper funding of aviation environmental research and development programs.

Again, thank you for the opportunity to testify, and we look forward to working with you on these important issues.

[Ms. Young's prepared statement follows:]

Prepared Statement of Nancy N. Young, Vice President, Environmental Affairs, Airlines for America (A4A)

On behalf of our A4A members, thank you Chairman DeFazio, Chairman Larsen, Ranking Member Graves and Ranking Member Graves for the opportunity to testify today. As you know, the U.S. airlines have a tremendous fuel and greenhouse gas (GHG) emissions record, accounting for 2 percent of the nation's GHG emissions inventory while driving 5 percent of its GDP. In fact, between 1978 and year-end 2017, the U.S. airlines improved their fuel efficiency by more than 125 percent, saving over 4.6 billion metric tons of carbon dioxide (CO₂), equivalent to taking 25 million cars off the road each of those years. And we carried 34 percent more passengers and cargo in 2017 than we did in 2000, while emitting no more CO₂.¹

These numbers are not happenstance. As an industry, we have achieved this record by driving and deploying technology, operations and infrastructure advances to provide safe and vital air transport as efficiently as possible within the constraints of our air traffic management system. Indeed, for the past several decades, airlines have dramatically improved fuel efficiency and reduced CO₂ emissions by investing billions in fuel-saving aircraft and engines, innovative technologies like winglets (which improve aerodynamics), and cutting-edge route-optimization software. But despite our strong record to date, A4A and our member airlines are not stopping there nor are we resting on our laurels.

Since 2009, A4A and our members have been active participants in a global aviation coalition that committed to 1.5 percent annual average fuel efficiency improvements through 2020, with a goal to achieve carbon neutral growth in international aviation from 2020, subject to critical aviation infrastructure, technology, operations and sustainable fuels advances by government and industry. Further, we are working toward an additional aspirational goal to achieve a 50 percent net reduction in CO₂ emissions in 2050, relative to 2005 levels.

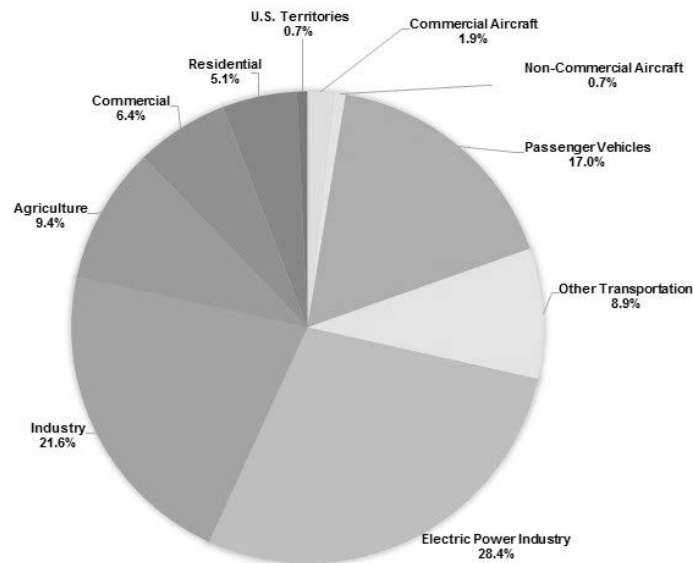
The initiatives we are undertaking to further reduce our GHG emissions are designed to responsibly and effectively limit our fuel consumption, GHG contribution and potential climate change impacts while allowing commercial aviation to continue to serve as a key contributor to the U.S. economy. A4A and our members are keenly focused on these initiatives, both at the national and international levels. We welcome this hearing on Federal infrastructure policy to help address climate change as there is a critical role for the Federal Government to play in advancing aviation infrastructure, technology and energy policy to complement our efforts.

¹Fuel savings facts are from data from the U.S. Department of Transportation Bureau of Transportation Statistics. Carbon dioxide savings and equivalencies were calculated using EPA tools at: www.epa.gov/cleanenergy/energy-resources/calculator.html.

THE U.S. AIRLINES ARE EXTREMELY GHG EFFICIENT AND ARE COMMITTED TO FURTHER
LIMITING THEIR GHG FOOTPRINT

The U.S. airlines have a decidedly strong GHG emissions track record that is often overlooked or misstated. We contribute just under 2 percent of the nation's GHG emissions inventory. To put that into context, as illustrated in Figure 1 below, passenger vehicles (cars and light duty trucks) account for over 17 percent and power plants for 28 percent of the total inventory. The picture is similar when viewed on a global basis with worldwide commercial aviation contributing approximately 2 percent of man-made GHGs.²

FIGURE 1. THE U.S. GHG INVENTORY BY SECTOR³



At the same time, U.S. commercial aviation is vitally important to local, national, and global economies, supporting a large percentage of U.S. economic output. Indeed, in 2014, commercial aviation drove 10.2 million U.S. jobs, \$1.5 trillion in economic activity and 5 percent of our nation's GDP.⁴ And in 2017, U.S. air-travel exports of \$41 billion helped fuel \$211 billion in other U.S. travel and tourism exports.⁵ Comparing the U.S. airline industry's economic output to its GHG output, it is clear that commercial aviation is an extremely GHG-efficient economic engine.

Our global aviation coalition continues to meet our 2009 commitment of a 1.5 percent annual average fuel efficiency improvement, and we are working on our goal to achieve carbon neutral growth in international aviation from 2020, subject to critical aviation infrastructure and technology advances achieved by government and industry. As detailed below, our primary focus is on getting further fuel efficiency and emissions savings through new aircraft technology, operations and infrastructure improvements and sustainable alternative jet fuel (SAJF). In addition, consistent with the mandates in Public Law 112-200, A4A and our member airlines have supported two significant international fuel efficiency and GHG savings agree-

² Air Transport Action Group, *Aviation Benefits Beyond Borders* (2018), available at https://aviationbenefits.org/media/166344/abbb18_full-report_web.pdf (citing the 2017 Global Carbon Project, *Global Carbon Budget*, available at <https://www.icos-cp.eu/GCP/2017>).

³ U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016* (April 2018), Table ES-6: U.S. [GHG] Allocated to Economic Sectors at ES-24; Table A-119: Total U.S. [GHG] Emissions from Transportation and Mobile Sources at A176-77.

⁴ See FAA, *The Economic Impact of Civil Aviation on the U.S. Economy* (Nov. 2016), available at https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf.

⁵ Bureau of Economic Analysis, *International Transactions (ITA) Table 3.1—U.S. International Trade in Services Lines 8, 12 and 1*, available at <http://www.bea.gov/iTable/iTable.cfm?ReqID=62&step=1#reqid=62&step=6&isuri=1&6210=1&6200=51>, and <http://travel.trade.gov/research/reports/recpay/index.html>.

have supported two significant international fuel efficiency and GHG savings agreements adopted in 2016 under the auspices of the United Nations body that sets standards and recommended practices for international aviation, the International Civil Aviation Organization (ICAO). Notably, industry and government collaboration remains critical to our efforts.

EXAMPLES OF TECHNOLOGY, OPERATIONS AND INFRASTRUCTURE INITIATIVES

With fuel being one of the highest and most volatile cost centers for airlines—and every penny of increased fuel price equating to an additional \$200 million fuel bill per year—the U.S. airlines’ environmental and economic interests in saving fuel and reducing emissions align. Accordingly, the U.S. airlines have been able to deliver tremendous economic output while reducing our emissions through reinvestment in technology and more fuel-efficient operations on the ground and in the sky. Indeed, today’s airplanes are more technologically advanced—they are quieter, cleaner and use less fuel than ever before—and airlines are flying them in ways that take maximum advantage of the technology within the constraints of our current air traffic management (ATM) system. This flight optimization reduces fuel burn and environmental impacts. Some examples of the advancements that have resulted in the U.S. airlines’ 125 percent fuel efficiency improvement since 1978 and will continue to support improvements include:

- *Upgrading Fleets.* With recently improved finances, the U.S. airlines and aircraft operators have been able to invest billions of dollars to upgrade their fleets with newer, quieter aircraft that produce less noise and fewer emissions. For example, U.S. airlines purchased more than 480 new aircraft in 2017, with more than 1,550 additional planes expected in the coming years. Our airlines have also made significant investments in winglets, altering fan blades, and other measures that improve aerodynamics. By way of example, in 2017, Alaska Airlines finalized installation of split scimitar winglets on all of its eligible 737 aircraft. With such winglets enabling aircraft to be approximately 4.5 percent more fuel efficient than those without winglets, Alaska improved average fuel efficiency by over 34,000 gallons per aircraft each year. And Alaska’s new 737NG aircraft are modified when they receive them, making the aircraft as fuel efficient as possible upon entry into service.⁶ Accordingly, in 2017, Alaska’s scimitar winglets modification saved an additional 4.5 million gallons of fuel, equating to a reduction of 42,633 metric tons of CO₂.
- *Introduction of Innovative, Cutting-Edge Technologies and Improved In-Flight Operations.* Our airlines also are investing billions of dollars in technologies to enable more efficient flight paths. For example, the airlines have undertaken equipment for Required Navigation Performance (RNP) and Performance-Based Navigation (PBN) procedures, which provide navigation capability to fly a more precise path into and out of airports.⁷ A4A airlines also have deployed increasingly sophisticated software to analyze flight paths and weather conditions, allowing aircraft to fly more direct, efficient routes where the ATM system is able to accommodate them. A4A airlines continue to do all they can within the existing ATM system to utilize programs to optimize speed, flight path and altitude, which not only reduces fuel consumption and emissions in the air but avoids wasting fuel waiting for a gate on the ground. In addition to pursuing the use of RNP approach procedures at additional locations, A4A carriers—such as UPS Airlines at its hub in Louisville—have worked with FAA to pioneer protocols for optimized profile descents (OPDs) (also referred to as “continuous descent arrivals”), which reduce both emissions and noise, and we are doggedly pursuing implementation of OPDs where the existing ATM system allows. Demonstrating that the efforts extend to the smallest details of airline operation, our members also have worked on redistribution of weight in the belly of aircraft to improve aerodynamics and have introduced life vests on certain domestic routes, allowing them to overfly water on a more direct route.
- *Improved Ground Operations.* A4A airlines also are employing single-engine taxiing when conditions permit, redesigning hubs and schedules to alleviate congestion and converting to electric ground support equipment (GSE) when

⁶This and other fuel and emissions savings initiatives are detailed in Alaska’s sustainability report, available at <http://www.flysustainably.com/wp-content/uploads/2018/09/AlaskaAirReport-Final-092418.pdf>.

⁷In fact, Alaska Airlines pioneered the application of RNP technology during the mid-1990s to help aircraft land at some of the world’s most remote and geographically challenging airports in the State of Alaska.

feasible. For example, as part of Southwest Airlines' ongoing program to modernize its GSE fleet, the company invested \$7.9 million in electric vehicles in 2017.⁸ Further, our airlines are improving ground operations by plugging into electric gate power where available to avoid running auxiliary power units (APUs). By way of example, American Airlines' "Fuel Smart" program is securing emissions reductions by such means, as well as washing engine components for maximum efficiency, and other initiatives.⁹ Similarly, while Hawaiian Airlines already provides external gate power to its narrow-body fleet between the Hawaiian Islands, the airline has made significant headway toward its goal of having gate power available to its entire wide-body fleet within 3 minutes of arrival as aircraft fly between Hawaii, 11 U.S. gateway cities and 10 international destinations, with the potential to reduce Hawaiian's APU usage by an estimated 30 minutes per flight, saving some 620,000 gallons of fuel annually and cutting CO₂ emissions by 5,933 metric tons.¹⁰

- *Reducing Onboard Weight.* A4A airlines continue to exhaustively review ways, large and small, to reduce aircraft weight—removing seat-back phones, excess galley equipment and magazines, introducing lighter seats and beverage carts, stripping primer and paint and a myriad of other detailed measures to improve fuel efficiency. For example, by replacing flight bags with flight crew tablets, UPS reduced the weight associated with these critical materials by 70 pounds, with the reduced fuel burn equating to 1,400 metric tons of CO₂ emissions avoided.¹¹

In addition to the above types of measures, A4A and our members continue to partner with FAA, NASA, research entities and other aviation stakeholders to advance research, development and deployment of breakthrough technologies and operational and infrastructure advances. The Continuous Lower Energy, Emissions & Noise or "CLEEN" program is a key initiative in this regard. This FAA-industry public-private partnership is focused on near-to-medium term aircraft engine and technology breakthroughs for lower emissions and noise, enhanced energy efficiency and aviation alternative fuels. The program, which requires a one-to-one match of private dollars, has enabled the development of new technologies such as the Adaptive Trailing Edge (ATE) on the aircraft wing, providing up to a 2 percent reduction in aircraft fuel burn and a 1.7 decibel reduction in aircraft noise; the Twin Annular Premixed Swirler (TAPS) II advanced engine combustor, yielding significant reductions in emissions of oxides of nitrogen (NO_x); and geared turbofan engine technologies, contributing to a 20 decibel aircraft noise reduction and a 20 percent fuel burn reduction.

Another critical program is the FAA Center of Excellence for Alternative Jet Fuels and the Environment (ASCENT), the university-based research vehicle for the FAA to discover, analyze, and develop science- and technology-based solutions to support the growth of the U.S. aviation industry by addressing the energy and environmental challenges the industry faces. This program also requires a one-to-one match of private-to-Federal funding and supports work by 16 university partners across the country. In addition to providing a better understanding of aviation environmental impacts that shape industry and government energy and environmental work, ASCENT's applied research has helped with the development of air traffic procedures and airport infrastructure configuration to enhance the efficiency of U.S. aviation.

And for advanced, future airframe and engine technologies, the aviation industry collaborates with NASA through its Aeronautics Research (ARMD) program, which is considering transformative configurations, including light weight, high aspect ratio wings; unconventional structures; advanced propulsion; and electrified aircraft propulsion, among other radical concepts.

⁸See Southwest Airlines, "One Report" (2017), available at <http://southwestonereport.com/2017/stories/electricity-sparks-fuel-savings/>.

⁹See American Airlines, 2017 Corporate Responsibility Report, available at http://s21.q4cdn.com/616071541/files/doc_downloads/crr/CRR-Report-2017.pdf. In addition to achieving savings in costs and GHG emissions, Fuel Smart translates a portion of its APU fuel savings into a donation to the Gary Sinise Foundation for the purposes of providing travel for active duty military members, veterans, first responders and their family members in need. Since Fuel Smart launched in 2010, American has generated nearly \$4 million in contributions through the program, helping more than 6,800 service members and their families travel to receive the support they need.

¹⁰See Hawaiian Airlines' Airport Operations Lowering Fuel Use, Carbon Emissions, available at <https://newsroom.hawaiianairlines.com/releases/hawaiian-airlines-airport-operations-lowering-fuel-use-carbon-emissions>.

¹¹See UPS 2017 Corporate Sustainability Progress Report available at https://sustainability.ups.com/media/2017_UPS_CSR.pdf.

The Development and Deployment of SAJF

Recognizing that improving fuel efficiency with today's petroleum-based energy supply can only take us so far, A4A and our members are dedicated to developing commercially viable, environmentally friendly alternative jet fuel, which could be a game-changer in terms of aviation's output of GHG emissions while enhancing U.S. energy independence and security.

To be sustainable, alternative jet fuel must meet three core criteria. It must be demonstrated to be (1) as safe as petroleum-based fuels for powering aircraft; (2) more environmentally friendly than petroleum-based fuels; and (3) capable of being produced to provide cost-competitive, reliable supply. A4A and our members have been working with government partners and other stakeholders in a concerted effort to meet these criteria—and we have made tremendous progress, having moved from test flights to commercial and military flights with SAJF. But we must continue to tackle each challenge, using every tool to attain full viability.

As the challenges to standing up a self-sustaining aviation alternative fuels industry cut across multiple disciplines—from aviation, to agriculture, fuel production, investment capital, logistics and beyond—no one initiative or program can do it all. Yet, the U.S. aviation industry determined early on that a coordinating body would be needed to establish a clear vision and leverage the efforts across initiatives. Accordingly, in 2006, A4A, FAA, the Aerospace Industries Association (AIA) and Airports Council International-North America (ACI-NA) co-founded the Commercial Aviation Alternative Fuels Initiative® (CAAFI) to serve as the driving and coordinating force for the industry's efforts. "CAAFI's goal is to promote the development of alternative jet fuel options that offer equivalent levels of safety and compare favorably on cost with petroleum-based jet fuel, while also offering environmental improvement and security of energy supply."¹² Through CAAFI, we have worked to address and overcome the challenges to commercial-scale deployment of SAJF—ensuring safety and environmental benefit while working to achieve supply reliability and cost-competitiveness.

SAJF—Ensuring Safety

No matter what issue or challenge we face, airlines never lose sight of their core mission: safety. Our fuels must meet rigorous specifications that ensure safe operation, whether in the icy cold at 30,000 feet or while filling tanks on the ground at airports crowded with activity. Accordingly, before an alternative fuel can be approved for commercial use, it must meet rigorous safety and performance standards set out in the applicable specification, which is controlled by ASTM International, an organization devoted to the development and management of standards for a wide range of industrial products and processes. This specification, in turn, is included in FAA product approvals and required air-carrier manuals.

One of CAAFI's most significant contributions to date has been the development of the approval process for alternative jet fuels through ASTM. Not surprisingly, the original jet fuel specification, ASTM D1655, titled "Standard Specification for Aviation Turbine Fuels," covered only jet fuels derived from specific fossil-fuel sources. The CAAFI team worked within ASTM to identify means for gaining approval of jet fuels derived from alternative feedstocks provided that those fuels are equally safe and effective.¹³ As a result, in August 2009, after completing its rigorous review process, ASTM approved D7566, "Aviation Turbine Fuel Containing Synthesized Hydrocarbons." This specification allows for alternatives that demonstrate that they are safe, effective and otherwise meet the specification and fit-for-purpose requirements to be deployed as jet fuels, on par with fuels under ASTM D1655. It is structured, via annexes, to accommodate different classes of alternative fuels when they are demonstrated to meet the relevant requirements. As shown in Figure 2, we now have five approved "pathways" for SAJF production, and more are currently undergoing the rigorous review and approval process.

¹² See www.caafi.org.

¹³ CAAFI worked within ASTM to issue a specific standard to facilitate the approval of alternative jet fuel made from varying feedstocks and production processes, ASTM D4054, "Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives."

FIGURE 2. Approved SAJF “Pathways” Under ASTM D7566

Pathways/Process	Feedstock Examples	Date of Approval	Blending Limit
Fischer-Tropsch Synthetic Paraffinic Kerosene (FT-SPK)	Biomass (forestry residues, grasses, municipal solid waste)	2009	Up to 50%
Hydroprocessed Esters and Fatty Acids (HEFA-SPK)	Oil-bearing biomass (e.g., algae, jatropha, camelina, carinata)	2011	Up to 50%
Hydroprocessed Fermented Sugars to Synthetic Isoparaffins (HFS-SIP)	Microbial conversion of sugars to hydrocarbon	2014	Up to 10%
FT-SPK with aromatics (FT-SPK/A)	Renewable biomass such as municipal solid waste, agricultural wastes and forestry residues, wood and energy crops	2015	Up to 50%
Alcohol-to-Jet Synthetic Paraffinic Kerosene (ATJ-SPK)	Agricultural wastes products (stover, grasses, forestry slash, crop straws)	2016 (plus added feedstocks 2018)	Up to 30%

By meeting the rigorous jet fuel specification and fit-for-purpose requirements, sustainable alternative jet fuels are demonstrated to be “drop-in” fuels, completely compatible with existing airport fuel storage and distribution methods and airplane fuel systems. Accordingly, they do not carry added infrastructure costs for airlines, fuel distributors or airport authorities, enhancing prospects for their commercial viability.

Ensuring Environmental Benefit

We also have made tremendous progress on demonstrating whether a particular alternative jet fuel provides environmental benefit relative to petroleum-based fuel. As carbon is fundamental to powering aircraft engines, this and the CO₂ generated upon combustion cannot be eliminated from drop-in jet fuels, but they can be reduced, either through increasing the per-unit energy provided in the fuel, reducing carbon somewhere along the “lifecycle” of the fuel, or some combination of the two. Indeed, there can be emissions all along the “life” of the fuel—from growing or extracting the feedstock, transporting that raw material, refining it, transporting the finished fuel product and using it. By examining the emissions generated at each point in the lifecycle, one can ensure that the emissions benefits that are sought are in fact real and do not create emissions “dis-benefits” along the way.

Ensuring the environmental benefit of alternative aviation fuels is critical to A4A and its member airlines. Accordingly, as far back as 2008, we agreed on a set of alternative fuels principles, which include a commitment that the alternative fuels we accept need to have reduced lifecycle GHG emissions compared to today’s fuels and not compete with food production. In that commitment, we agreed to work through CAAFI to ensure this. Accordingly, CAAFI’s Sustainability Team,¹⁴ which I co-lead along with Dr. James Hileman of the FAA, has developed and supported seminal guidance on the methodologies for lifecycle analysis of alternative aviation fuels¹⁵ and case studies that use these methodologies.¹⁶ SAJF has been demonstrated to achieve up to an 80 percent lifecycle GHG savings relative to petroleum-based fuel.¹⁷ In addition, a comprehensive assessment under the Transportation Research Board’s Airport Cooperative Research Program (ACRP) confirms that the use of SAJF can reduce more than just GHG emissions, including emissions

¹⁴ CAAFI’s Sustainability resources are available at: http://www.caaafi.org/focus_areas/sustainability.html.

¹⁵ See “Framework and Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels (Final Report) (2009, AFRL-WP-TR-2009-2206); see also Young, CAAFI Environment Team: Developing Tools & Means to Address Environmental Issues (April 16, 2013), available at http://www.caaafi.org/files/presentations/Environment_Young_ABLC_Apr17_2013.pdf.

¹⁶ See, e.g., Stratton, Wong & Hileman, Life Cycle Greenhouse Gas Emissions from Alternative Jet Fuels (April 2010).

¹⁷ International Air Transport Association, Sustainable Aviation Fuels: Fact sheet, available at https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-alternative-fuels.pdf.

of sulfur oxides (SO_x), particulate matter (PM), carbon monoxide, unburned hydrocarbon emissions, and NO_x.¹⁸

While seeking emissions benefits from SAJF, A4A and its members also recognize that use of such fuels must not create environmental problems in other areas. SAJF must be produced in a fashion meeting all relevant environmental criteria, including land use, water management and the like. Put another way, the production, transport and use of these fuels generally must be deemed “sustainable.” Accordingly, CAAFI also has provided peer-review guidance on making sure relevant sustainability criteria are met.¹⁹

Fostering Supply Reliability and Commercial Viability

As noted by Bill Harrison, Technical Advisor for Fuels and Energy at the U.S. Air Force Research Laboratory, scaling up supply and making SAJF cost-competitive may well be the most significant challenge to its full-scale commercial deployment.²⁰ A key role that A4A and its member airlines are playing as end-users of such fuels is to send appropriate market signals to would-be producers, the farmers and others who generate energy feedstock, and investors in the alternative fuels industry.²¹ Further, A4A entered into a “Strategic Alliance for Alternative Aviation Fuels” with the U.S. Department of Defense’s Defense Logistics Agency-Energy (DLA-Energy, which previously was known as the Defense Logistics Agency’s Defense Energy Support Center) to further encourage alternative fuel producers to include SAJF in their product slate. Our vigorous pursuit of SAJF has sent an unmistakable signal: U.S. airlines are committed to making SAJF viable and will do their part to overcome the obstacles that may stand in the way. But we recognize that we cannot do it alone. Ongoing commitment in public-private partnerships is needed to get the alternative aviation fuels industry over the cusp, just as was the case when the Federal Government jump-started the Internet, satellite systems and other backbone infrastructure—working with industry to help make these ventures self-sustaining.

While CAAFI has focused on supply reliability and commercial viability, other public-private partnerships and initiatives have been needed to spur investment in this new supply chain. Perhaps most notable in this regard is the Farm to Fly initiative, which A4A, the U.S. Department of Agriculture (USDA) and Boeing created in 2010 to help meet the direction set in the 2008 Farm Bill that U.S. programs aimed at energy crops should be equally available for air transportation fuels as for ground transportation fuels.²² Indeed, the aim of the original Farm to Fly initiative was “to accelerate the availability of a commercially viable sustainable aviation biofuel industry in the United States, increase domestic energy security, establish regional supply chains and support rural development.”

The initial Farm to Fly initiative helped make accessible to farmers, fuel producers, airlines and military aviation a number of the tools and programs that had been available to ground-based alternative fuels for some time. It also resulted in a two-part report in January 2012 which offered a blueprint for continuing to advance opportunities for Rural America and the aviation sector through aviation biofuels.²³ Moreover, the initial Farm to Fly initiative helped spawn two regional initiatives to foster the development and deployment of alternative jet fuels derived from sustainable biomass grown in the United States. The first of these, the Sustainable Aviation Fuels Northwest (SAFN) initiative, led in part by A4A member Alaska Airlines, together with the Port of Seattle, Port of Portland, Spokane International Airport, Boeing and Washington State University, found that an aviation

¹⁸ See Transportation Research Board, ACRP Project 02–80: “State of Industry Report on Air Quality Emissions from Sustainable Alternative Jet Fuels,” at 5 (April 2018) (available at <http://www.trb.org/Aviation1/Blurbs/177509.aspx>).

¹⁹ See CAAFI, *Alternative Jet Fuel Environmental Sustainability Overview* (July 2013), available at http://www.caafi.org/information/pdf/Sustainability_Guidance_Posted_2013_07.pdf. CAAFI also provides a step-by-step overview of sustainability review processes on its webpage at http://www.caafi.org/focus_areas/sustainability.html.

²⁰ Harrison, *Alternative Fuels: How Can Aviation Cross the Valley of Death* (Massachusetts Institute of Technology Master’s Thesis, 2008).

²¹ One of many such signals is a “how to” document on how alternative aviation fuels producers can work with airlines on purchase agreements. This document, “Guidance for Selling Alternative Fuels to Airlines,” is available on the CAAFI website at http://www.caafi.org/files/CAAFI_Business_Team_Guidance_Paper.pdf.

²² Conf. Rpt. 110–627, on H.R. 2419; p. 911, May 13, 2008.

²³ See *Agriculture and Aviation: Partners in Prosperity*, available at <http://www.airlines.org/Documents/usda-farm-to-fly-report-jan-2012.pdf>; see also *Agriculture and Aviation: Partners in Prosperity: Putting Aviation at the Forefront of the President’s Biofuels Targets, Part II. Industry Recommendations*, available at http://www.airlines.org/Documents/Farm_to_Fly_Recommendations-A4A-Boeing-Jan2012.pdf.

biofuels industry can be commercially viable in the Pacific Northwest and identified four, particularly promising feedstocks; oilseeds, forest residues, municipal solid wastes and algae; for generating advanced aviation biofuels.²⁴ The second, the Midwest Sustainable Aviation Biofuels Initiative (MASBI), led in part by A4A member United Airlines, Boeing, Honeywell's UOP, the Chicago Department of Aviation, and the Clean Energy Trust, developed recommendations to help "achieve the potential economic, environmental, and energy security benefits that can be delivered from a robust sustainable aviation biofuels industry in the Midwest."²⁵

In April 2013, we launched Farm to Fly 2.0, bringing in additional stakeholders and expanding the supply chain reach. Although the Farm to Fly initiative has been important for bringing together tools and the various participants in the aviation alternative fuels supply chain, there would be no such initiative without the Energy Title programs under the Farm Bill—the most recent version of which is the Agricultural Improvement Act of 2018. While the 2018 Farm Bill included a number of energy programs, some of which are accessible to those in the supply chain for providing SAJF, we urge Congress to fully fund programs like the Biomass Crop Assistance Program (BCAP) and the Biomass Research and Development Program (BRDI) to leverage the investments that the U.S. Government and the private sector have already made and provide the stability needed for further progress.

While challenges remain, our joint efforts are bearing fruit. For example, United Airlines began using commercial quantities of SAJF at Los Angeles International Airport in 2016 pursuant to an off-take agreement with AltAir Fuels to purchase up to 15 million gallons of SAJF over 3 years. United has also made a \$30 million equity investment in Fulcrum BioEnergy, which includes provisions to co-develop up to five facilities and purchase at least 90 million gallons of SAJF per year over 10 years.²⁶ FedEx and Southwest Airlines have similarly committed to each purchase 3 million gallons per year from Red Rock Biofuels, and JetBlue has signed a 10-year off-take agreement with SG Preston for up to 10 million gallons per year. Further, both Alaska Airlines²⁷ and American Airlines²⁸ have signed Memoranda of Understanding with Neste for coordination and potential future deployment of SAJF. Moreover, while airlines purchase and manage all fuel purchases, they are increasingly partnering with airports and other stakeholders to help assess the potential for deployment of SAJF at particular airports in areas where SAJF production is being considered and may be commercially viable. For example, Alaska Airlines partnered with Boeing and the Port of Seattle on an infrastructure study for potential future deployment of SAJF at Seattle-Tacoma International (Sea-Tac)²⁹ and several airlines have entered into Memoranda of Understanding with Sea-Tac and San Francisco International Airport (SFO) to explore potential SAJF coordination opportunities. In addition, in 2017, United and Atlas Air joined various foreign airlines and Chicago O'Hare International Airport in a special "Fly Green Day" commercial deployment of SAJF.

Although these initial purchase and cooperative agreements for SAJF deployment are promising, two critical observations capture why we cannot be complacent in our efforts. First, these projects would not exist without the public-private partnerships we have engaged in to date. And second, while meaningful to the parties involved, they still are relatively small scale, largely because producing SAJF to meet the rigorous jet fuel specification is a higher hurdle than the equivalent for alternative ground-based fuels. Accordingly, to expand upon these projects and spur more, we must continue to employ all the tools and partnerships we have identified and created to date and take further action to lay the foundation for all supply chain elements to become self-sustaining.

INDUSTRY-SUPPORTED ICAO AGREEMENTS ON FUEL EFFICIENCY AND CO2 EMISSIONS FROM INTERNATIONAL AVIATION

Although the U.S. airlines' financial and environmental objectives have continually prompted fuel and GHG emissions savings, several countries have imposed or

²⁴ See SAFN, Powering the Next Generation of Flight, available at http://www.safn.com/wp-content/uploads/2011/06/SAFN_2011Report.pdf.

²⁵ See MASBI, Fueling a Sustainable Future for Aviation, available at http://www.masbi.org/content/assets/MASBI_Report.pdf.

²⁶ Details on United Airlines' SAJF program are available at <http://crreport.united.com/our-environment/sustainable-fuel-sources>.

²⁷ See Alaska Airlines Press Release, available at <https://newsroom.alaskaair.com/2018-09-10-Alaska-Airlines-and-Neste-grow-innovative-partnership-to-fly-more-sustainably>.

²⁸ See Neste Press Release, available at <https://www.neste.com/neste-and-american-airlines-collaborate-explore-opportunities-renewable-fuel-use>.

²⁹ The infrastructure report is available at https://www.portseattle.org/sites/default/files/2018-03/Aviation_Biofuel_Infrastructure_Report_Condensed.pdf

threatened to impose on international aviation unilateral carbon emissions trading, taxing and charging schemes, which are siphoning away from aviation the very funds the industry needs to purchase new, more fuel efficient aircraft and take other steps to meet our fuel efficiency and emissions savings goals. In fact, as of 2013, the Air Transport Action Group (ATAG) had estimated that \$7 billion in such charges already were being levied on airlines, with more introduced or proposed since.

One of the most onerous of the unilateral measures has been the European Union's imposition of its emissions trading scheme (EU ETS) on international aviation. Despite international opposition from the outset, beginning in 2009, the EU required airlines and aircraft operators (including U.S. airlines and aircraft operators) with flights to European States and territories to monitor and report to the EU their emissions for the entirety of each individual flight to, from and within the EU, as a prelude to the emissions trading obligation that was due to begin in 2012. As a result of the pressure put on the EU from the U.S. and other countries, most significantly from the U.S. adoption of the "European Union Emissions Trading Scheme Prohibition Act" (PL-112-200), the EU "stayed" the extraterritorial application of the EU ETS to international aviation through year-end 2016, to take into account the progress in ICAO on an agreement for handling aviation's CO₂ emissions from international flights. In December 2017, the EU approved legislation to extend the stay until year-end 2024, again making the stay subject to ICAO action, this time with respect to progress on implementation of agreements reached in 2016 on aviation's international CO₂ emissions.

A4A greatly appreciated the leadership of this Committee in approving the "European Union Emissions Trading Scheme Prohibition Act" in 2012. Significantly, in addition to recognizing that the unilateral action of the EU in imposing its ETS on U.S. aircraft operators was unlawful and inappropriate, the statute directed that DOT, FAA and other appropriate U.S. officials "use their authority to conduct international negotiations . . . to pursue a worldwide approach to address aircraft emissions, including the environmental impact of aircraft emissions." Consistent with this directive, the U.S. played a significant role in developing two ICAO agreements to support aviation GHG emissions goals and stave off the proliferation of unilateral emissions taxes, charges and trading schemes—one agreement for a fuel efficiency and CO₂ certification standard for future aircraft and another to establish an international carbon offsetting system to help the industry work toward achieving carbon neutral growth in international aviation from 2020. Both of these agreements, which are supposed to be implemented in lieu of unilateral measures, are broadly supported by A4A, our members and the broader U.S. aviation industry.

The ICAO Fuel Efficiency and CO₂ Emissions Certification Standards for Future Aircraft

ICAO's Committee on Aviation Environmental Protection, which includes representatives from the U.S. EPA, FAA and State Department, the aviation industry, and environmental non-governmental organizations (NGO's), worked to develop, and then in 2016 proposed for adoption, a set of fuel efficiency and CO₂ emissions certification standards for future aircraft. The standards, which were approved by ICAO's governing body (the ICAO Council), confirm an agreed level of fuel efficiency for future aircraft, which equates to CO₂ emissions reductions. The standards applicable to new-type design large aircraft (i.e., aircraft used by airlines) are slated to go into effect in 2020, while the standards for the future manufacture of existing-type large aircraft (also referred to as "in-production aircraft") are slated to go into effect in 2023.³⁰

Although some countries automatically incorporate ICAO standards into their laws, the United States adopts ICAO emissions standards through rulemaking, typically with EPA adopting the underlying standards and FAA adopting rules to certify aircraft to the standards. As aviation is a global industry, with airlines and aircraft operators operating internationally and aircraft manufacturers selling their aircraft in international markets, it is critical that aircraft emissions standards continue to be agreed at the international level and implemented by ICAO Member States.

A4A and our members support having EPA and FAA incorporate the ICAO fuel efficiency and CO₂ certification standards into U.S. law. Indeed, U.S. aircraft manufacturers will not be able to have their aircraft certified to the standards—a prerequisite for the manufacturers to be able to sell their aircraft in the international

³⁰ The standards for smaller aircraft (those with less than 60 tons of maximum takeoff weight) have lower levels of stringency and slightly different effective dates, recognizing that flight physics complicate the adoption of certain of the more effective fuel-efficiency technologies into such aircraft.

market—unless the United States adopts them into U.S. law. Further, if U.S. aircraft manufacturers cannot have their products certified to the internationally agreed standards, U.S. airlines will not be able to purchase these aircraft for international service.

The ICAO Carbon Offsetting and Reduction Scheme for International Aviation

A4A and its members also supported the work that was undertaken in ICAO to develop proposals for a “global market-based measure,” in the form of an international carbon offsetting system, to help work toward the industry’s goal to achieve carbon neutral growth in international aviation from a 2020 baseline. This measure, the “Carbon Offsetting and Reduction Scheme for International Aviation” (CORSIA), has two parts. First, CORSIA requires that all 192 ICAO Member States have their aircraft operators monitor and report to them their international CO₂ emissions under a common set of rules beginning on January 1, 2019. Second, CORSIA includes an offsetting obligation, which is slated to commence on covered international routes beginning in 2021 and continue through 2035.

The emissions target under the CORSIA agreement is to help support carbon neutral growth on the international flights of operators from the countries that are in the system. All are motivated to achieve emissions savings through technology, sustainable alternative jet fuels, operations and infrastructure measures, although the carbon offsetting requirement kicks in to help fill any gap toward meeting the goal.

While all countries were obligated to begin requiring emissions monitoring data from their aircraft operators as of the beginning of 2019, the offsetting system is slated to be implemented in phases, with the first 6 years of the offsetting system, 2021 through year-end 2026, being implemented amongst countries on an “opt-in” basis. After that, the offsetting obligation becomes mandatory for all ICAO Member States except the least developed countries and those with very low levels of international aviation activity. Although countries have until June 2020 to opt into the first phase of the offsetting provisions, as of January 2019, 78 countries, representing seventy-seven percent of international aviation activity, including the United States, had already signed up to participate from the beginning.³¹

Very importantly, only the flights to and from the covered countries will be subject to the offsetting requirement. In other words, there is a mutual exemption from the offsetting requirement on flights to and from countries that either are not in the two 3-year opt-in phases or are exempt for the duration of the system. This is critical to avoid competitive distortion, satisfy the non-discrimination provisions in the international aviation treaty and ensure that U.S. operators are not disadvantaged by the United States’ opting in to the CORSIA offsetting obligation in the non-mandatory phases.

Critically, the agreement states that the CORSIA is to be “the” market-based measure applying to international aviation GHG emissions, precluding countries from imposing unilateral carbon measures on international flights from other countries.

In June 2018, the ICAO Council adopted a package of standards and recommended practices (SARPs) for implementing CORSIA. As with the ICAO CO₂ standard for future aircraft, it is up to the Member States of ICAO to implement these ICAO provisions. FAA and DOT have existing statutory and regulatory authority that allow them to adjust the fuel reporting requirements that currently apply to U.S. aircraft operators through a rulemaking to comport with the expected ICAO emissions monitoring standards. However, given the short time between ICAO adoption of the SARPs and the January 1, 2019 effective date of the emissions monitoring provisions, FAA and DOT were unable to issue a rulemaking before then. Accordingly, A4A has worked with FAA and other aircraft operator associations to commence the monitoring provisions under a voluntary agreement and we await the DOT/FAA announcement of this approach. Additionally, new, appropriately tailored legislative authority will be needed for DOT/FAA to apply the 2021+ CORSIA offsetting obligation to U.S. aircraft operators. We would very much like to work with this Committee on a tailored approach to implement the CORSIA SARPs over the course of the next couple years.

CONGRESS AND THE ADMINISTRATION SHOULD COMPLEMENT THE AIRLINE’S INITIATIVES TO ADVANCE AVIATION INFRASTRUCTURE, TECHNOLOGY AND ENERGY POLICY

We are confident that the measures A4A and our members are taking will continue to limit and reduce aviation’s carbon footprint, while allowing commercial

³¹ICAO keeps a list of the countries that have signed up for the opt-in phase on its website at <https://www.icao.int/environmental-protection/CORSIA/Pages/State-pairs.aspx>.

aviation to continue to provide an invaluable service and be a key contributor to our nation's economy. However, support from Congress and the executive branch is needed in three key areas to complement the airlines' concerted efforts: (1) business-case-based implementation of the Next Generation Air Transportation System (NextGen) prioritizing existing equipage; (2) stable policies to further support making SAJF commercially viable; and (3) continuation of aviation environmental research and development programs.

As recognized by the Future of Aviation Advisory Committee (FAAC) in 2010, "NextGen will enable the [National Airspace System] to safely and efficiently accommodate greater numbers of aircraft, from large commercial airliners to smaller general aviation (GA) aircraft, while reducing the overall environmental impact and energy use of civil aviation."³² Indeed, while A4A member airlines are doing all they can to promote efficiencies within the current ATM system, completing the transition to a satellite-based system will significantly reduce the inefficiencies that are inherent in the outdated, radar-based air traffic control system—saving up to 12 percent of fuel burn and emissions. Not only is an optimally functioning ATM system indispensable to ensure safety and the wellbeing of our industry, our nation's economy, the air traffic control workforce and airline customers, it is also critical to the environment.

As noted, in addition to enhancing U.S. energy independence and security, commercially viable, environmentally friendly SAJF could well be a game changer for the industry's GHG emissions. The aviation industry and would-be alternative jet fuel suppliers are on the cusp of creating a viable alternative jet fuel industry, but government support is needed in the near term to provide financial bridging and other tools necessary to help us get over the cusp. It is critical that Congress and the Administration continue to fund the programs under the Energy Title of the Farm Bill and support public-private initiatives such as CAAFI, the Farm to Fly initiative, and ASCENT.

Further, as recognized by the FAAC, "aviation-related R&D investments are vital for a high technology economy and enable solutions that can decrease emissions, create good jobs, increase U.S. competitiveness, and provide substantial enhancements to mobility that benefit the public."³³ As noted, FAA, NASA and the U.S. aviation industry are already partnering on a wide range of research and development projects through the CLEEN, ASCENT and NASA ARMD programs. These programs, which also include research dollars for FAA to maintain leadership in the ICAO environmental standard-setting process, are critical. While the agencies appear to be committed to continuing them, their funding has been under attack. We urge Congress to continue to fully support and fund the FAA and NASA aviation environmental research programs. This is vital to U.S. aviation competitiveness and the leadership role the U.S. plays in driving appropriate aviation energy and environmental standards.

CONCLUSION

As an industry, aviation is a small part of the nation's GHG footprint, but we have nonetheless strived to reduce our impact through technology, operations, infrastructure and alternative fuel advances to provide safe, vital, efficient, and environmentally sustainable air transport within the constraints of our air traffic management system. We will not rest on our laurels in light of this record but will continue to invest where appropriate to maximize environmental benefits while supporting our nation's economy. We look forward to working with this Committee on policy initiatives to complement our efforts.

Again, thank you for the opportunity to testify, I look forward to your questions.

Mr. CARBAJAL. Thank you, Ms. Young. We will now move on to Member questions. Each Member will be recognized for 5 minutes, and I will start by recognizing myself.

Dr. Sperling, thank you for your testimony and leadership in reducing greenhouse gas emissions. As we both are aware, California has been a leader in the fight against climate change. We have shown that protecting our environment and improving the economy are not mutually exclusive.

³²U.S. DOT, *Future of Aviation Advisory Committee, Final Report*, at 15.

³³Id. at 13.

In your testimony you state that, from California's experience, "we cannot meet our [carbon emission reduction] goals without re-envisioning the way we plan and build [our communities]." Can you expand further on what you meant by that?

What are some of the ways the Federal Government can support efforts to better coordinate transportation policy, housing policy, and job access at the State and local levels?

Mr. SPERLING. Thank you. So there are a couple things. One is, as I said, there is a lot of innovation happening in transportation.

So one of the things that can be done is creating programs to support many of these new initiatives, pilot projects, demonstration projects, because we need experimentation, and we don't really know—as we go all these shared economy ideas, automation, how it—connecting it with transit, with microtransit, with micro-mobility—all of these concepts are brandnew. Ten years ago we weren't doing any of this.

And so how do we do them and merge them with electrification, as well? So that—one program—that is one idea.

The other big idea would be we need a better way of linking transportation funding to reward communities, cities, MPOs, for basically doing the right thing, in terms of investing in these more efficient and low-carbon strategies. And I would note that almost everything we do for greenhouse gas reduction and climate are the same things we would do for an efficient transportation system. And so restructuring some of that funding so that we break down the silos, we help transit link up with these in public-private partnerships, and just rewarding them for making the investments that are necessary to get lower carbon cities.

Mr. CARBAJAL. Thank you, Dr. Sperling.

Ms. Young, thank you for your time here to discuss how our Federal infrastructure policy could help mitigate and adapt to the growing threats of climate change. As many of us are aware, the climate crisis is probably one of the biggest challenges of our lifetime.

U.S. airlines have increased their fuel efficiency by more than 125 percent between 1978 and 2017, and they have moved 28 percent more passengers and cargo in 2016 compared to the year 2000, using 3 percent less fuel.

In your testimony you discussed the economic incentives that airlines have to reduce their carbon emissions and fuel consumption. Can you expand further on the benefits to our environment and economy?

Ms. YOUNG. Oh, well, thank you very much for the question. We are very proud that our economic interests align hand in hand, really, with our environmental interests. Essentially, as you know, jet fuel is the number-one or number-two cost for airlines in any given year, and our airlines compete with each other, head to head. So the better you do with shepherding your fuel to good use, and hence saving greenhouse gas emissions, the more competitive you are.

So that is why, as I testified in my written testimony, our airlines have long been deploying an array of measures without Government mandates, things like, certainly, buying new aircraft, now that our financial situation has turned around after the scourge of

9/11 and SARS and the downturn, but also really focused with our partners—airports, air navigation service providers, manufacturers—in making sure that we drive technology, operations, and infrastructure in all aspects to be fuel efficient.

I think another example that goes beyond fuel efficiency—because there is only so far you can go with that—is sustainable alternative jet fuel. Very quickly, in 2006 we recognized that, really, the focus on alternative fuel was on the ground-based fuels. So we basically helped create, with the airports, the manufacturers, FAA, and others, basically, a market and a way to develop and deploy these fuels. And you are seeing that bear fruit today.

Mr. CARBAJAL. Thank you, Ms. Young. I will now recognize Representative Gibbs for 5 minutes.

Mr. GIBBS. Thank you. Thank you, Mr. Chairman. I just want to make a couple of comments quick before my questions about, you know, the markets are driving the innovation. And some of the witnesses' testimony have said that, where we have seen vast improvements in airlines cutting their CO2 emissions, more fuel efficient. We are seeing manufacture aviation cutting their—80 percent life cycle fossil fuel, more efficient planes, and—as was stated.

Highways, we are seeing more efficient vehicles, more types of vehicles. American Trucking Associations has achieved significant greenhouse gas emissions, about 23 percent. We are seeing a 25-percent improvement in greenhouse gas reductions, fuel efficient gains over 2018 levels. Moving forward, it is improving.

Maritime transportation seeing—they have a goal to reduce their CO2 emissions by 50 percent by the year 2050. So there is a lot of good things done, and the market has been driving it.

My first question to Ms. Young is dealing with the Green New Deal. Talk about how it would affect the U.S. economy by the airlines. And we are seeing the airlines and other modes making these good improvements to efficiency. How would this Government intervention—would that hinder innovation, or —what would you—your viewpoint on that?

Ms. YOUNG. Well, thank you very much for the question. I think it is probably no surprise to you or others on the committee that Airlines for America has a lot of concern about any plan where the rhetoric around it is saying that we are going to eliminate air travel. And we think that that would be a bit concerning to the more than 157 million Americans who flew last year.

But what I can tell you—and I think you picked up on it in your question—is that we already are motivated and are doing a number of the things that are suggested as measures in that Green New Deal, things like ourselves developing and deploying sustainable alternative jet fuel, really innovating in technology and operations and infrastructure. And we are doing that without a Government mandate.

So I think, from our perspective, there are a lot of good ideas that we have been employing, and that is the way to continue to go for—

Mr. GIBBS. Yes. So basically, you are saying the market is driving this, and when you are more fuel efficient it helps your bottom line anyway, so you don't need Government coming and telling you.

Of course, in this case, this proposal is just to eliminate your industry, which is an absolute disaster.

Mr. LYON from Michigan, you talk about it in your testimony, about mandating lock-in—different, inferior technology, and you talk a lot about market-driven initiatives, which I am—of course, I am a strong advocate for. Can you elaborate about how certain technologies may have grown by the market versus where there has been Government mandates and—the comparison between—you talked about it a little bit in your testimony. Can you elaborate?

Mr. LYON. Sure. Thank you for the question. I think it is a very complex and intertwined set of forces, actually. I mean you look at electric vehicle deployment, for example, and markets have played a crucial role in moving that forward. But at the same time, Government has played an absolutely central role, as well, with subsidies for vehicle adoption and R&D funding.

So I think it is hard to disentangle these two and say it is all of one or all of the other.

Mr. GIBBS. OK. I just—you know, I—because you said in your testimony—you talked about when certain things are mandated, you know, it locks in—the possibility of locking in an inferior technology, because technologies change. And I think you agree that Government has got to be careful, how they do that.

Mr. LYON. Absolutely.

Mr. GIBBS. Because, you know, sometimes, when it comes to on the regulatory side of Government, we usually are behind what is actually happening. We are always trying to catch up, and—but I concur with you that when you have the markets driving it—and I think what you are trying to say, where there is some—maybe some Government help, and where it is appropriate, as long as it doesn't create artificial consequences or, you know—that go against what the market is trying to—I think that is what you are trying to say.

Mr. LYON. Yes, I am trying to say we should allow for as much flexibility as possible in technological choices going forward, so that we don't prematurely lock into something and we look back on it and say, oh, gosh, we shouldn't have locked into—I mean the classic example on this is the light-water nuclear reactor, right? There are a lot of other nuclear designs that people now think are much superior, but we locked into that one very early on. And you know, it has kind of stalled out the industry in some ways.

Mr. GIBBS. OK, I appreciate the testimony. The only thing I would just say quickly before my time is up is we got to be careful. We let the market function and when it is appropriate, Mr. Chairman, we can do things. But we shouldn't be trying to address social change on what we are trying to do to build infrastructure. I yield back.

Mr. CARBAJAL. Next we will go to Representative Larsen.

Mr. LARSEN. Thank you, Mr. Chairman.

Ms. Young, in your testimony you talked about NextGen flight procedures and so on. Have the airlines, as an industry, done any estimates on how much fuel has been saved by deploying performance-based navigation or required navigation performance? Or, if not a number, can you speak to it?

Ms. YOUNG. So when we are able to fully deploy RNP performance-based navigation procedures, we can save a considerable amount of fuel and, hence, reduce emissions that way. The numbers are a little bit hard to true-up across the country because, as you know, the next generation air transportation system implementation has been sort of piece by piece.

But as I note in my written testimony, I mean, there is around 12 percent estimated inefficiencies in the system that could be gained by full transition to PBN, NextGen, and we support doing that.

Our members have been innovating in the different airspace areas using these procedures for some time, including Alaska Airlines, that initially developed a number of the procedures way back when to address some of the challenges of flying in Alaska.

So it is certainly something we want to continue to drive forward on, and that is why we are recommending that this committee continue to work closely with FAA to make sure that we modernize our airspace.

Mr. LARSEN. On the fleet updates to improve aircraft efficiency, you've worked with manufacturers to make that happen, and you mentioned a few changes to aircraft design: winglets, there are also new engines coming out.

I have a question for you, because in a couple weeks we will be looking at—on the Aviation Subcommittee we will be looking at the future of aviation, trying to look out 30 years or so. I am not asking you to predict what is going to happen, it is kind of hard to predict. But if you had a wish list, what would be the next thing for airlines and manufacturers to make flying more efficient so there is less fuel used and planes are using less fuel?

Ms. YOUNG. Well, thank you for that question. We do work very closely with the manufacturers, and that is a critical part of our program for achieving our emissions goals.

So through a number of things like moving to composite materials, there is still room there. Moving—our jet turbine engines are extremely fuel efficient, but Pratt & Whitney and GE and others have found ways to continue along those lines.

And you mentioned winglets. Those—you know, it may be surprising to people. Those are on the tips of the wings. What you see tipping up there can bring, you know, 4 percent or more additional fuel efficiency. So we are really taking sort of, in the near term, those kinds of approaches.

But working with the manufacturers and FAA and its CLEEN program, and NASA and its programs, we are looking at things as advanced as hybrid electric aircraft.

Mr. LARSEN. Yes.

Ms. YOUNG. We are looking at other materials. There are discussions—we are not sure that we are going to be able to go there, but in changing the entire way the aircraft is designed to be a different shape and more aerodynamic. But those are really the long-term programs.

And if I could stress, the programs that are funded for FAA to work with us, and public-private programs, are one-to-one dollar matches. They bring a lot of bang for the buck. Those focus on the

nearer term breakthroughs that airlines and airports and manufacturers can make.

NASA has a program with us that is the long-term one, and it is basically, again, a one-to-one match. So it is good bang for leveraging the best in aviation.

Mr. LARSEN. Thank you. The CLEEN program has been mentioned a couple of times, and I just want to thank the Members who were here last year to amend the FAA bill to put that program back in place and encourage others to support it in the future, if we get there.

In my time remaining I just want to know, from Mr. Prochazka and Dr. Lyon if there is a conflict between you all in terms of calling for continuing tax cuts for EV and for EV technology, versus relying on the market to place where those EV charging stations are, much like we rely on the market to place gas stations. Should the market lead or should Federal tax credit policy lead?

And I will yield back.

Mr. PROCHAZKA. Thank you for the question. So, you know, I think at this point we are just scratching the surface, in terms of the opportunity for market impacts on infrastructure across the country. We are seeing huge investment from investor-owned utilities. We are seeing even oil companies that are buying infrastructure companies and starting to invest in them in significant ways. And I think that it is saying a lot about what that future might hold.

At the same time, there are needs for, at this point, incentives to still exist to help encourage the early-stage part of this investment. So, while we might have 50,000 chargers across the country that are deployed, things like the alternative fuels corridor are going to be critical, and the funding for that to expand charging.

We also need to retain the tax credits, so 30C, because that is an important driver for businesses. So it can start the process for their investment. And I think we are going to see the long-term impact in fuel savings over time.

Mr. CARBAJAL. Mr. Lyon, if you could submit your response in writing, that would be great. We are trying to adhere to the time limit we are allocating for everyone.

Mr. LYON. OK, will do.

Mr. CARBAJAL. Mr. Larsen, I hope that is OK. We will move on now to Representative Davis.

Mr. DAVIS. Thank you, Mr. Chairman, and thanks to the panel.

You know, judging by Ms. Young's testimony, it looks like companies and industries are already being environmentally conscious. Ms. Young's comments about how innovation has propelled the airline industry to reduce their carbon footprint is something that I think needs to be looked at and monitored by others. I hope other private companies will continue the progress that your industry has shown us.

Additionally, electric automobile manufacturers are joining new and innovative partnerships, and are changing the way we travel. In fact, just outside my district by about two blocks in Normal, Illinois, the company Rivian is looking to produce electric trucks and SUVs, and they just announced a \$700 million partnership with Amazon.

So my question to those on the panel is why do we need a top-down approach to environmental regulation, when industries are already adapting?

And I would like to start with Ms. Young at A4A because of your testimony and your experience.

Ms. YOUNG. Well, thank you for the question. I mean you have heard a lot about market-based measures today, and the best of those are really the natural ones, where you are already driven by the existing market situations to do drive technology, operations, and infrastructure, as we have to get fuel efficiency.

We have pretty aggressive goals, as well. And one of the international agreements that we are supporting would further back-stop the work that we are doing to make sure that, on an international level, aviation meets those types of aggressive goals.

So I think, you know, you want to use the market the way that it is. And essentially, interfering with that can get negative results.

Mr. DAVIS. Well, thank you, Ms. Young.

Mr. Prochazka, with your coalition, I would like to hear your response. And I am glad they got your name plate right. I have the same problem a lot of times with my last name.

[Laughter.]

Mr. PROCHAZKA. Well, I can tell. Maybe later we can talk about how to pronounce it.

Mr. DAVIS. Absolutely.

Mr. PROCHAZKA. Thank you for the question. Actually, I grew up in Kankakee, Illinois, and so I have driven through Normal and been through the Bloomington area quite a bit.

You know, I think in this case we are responding to the idea that we still have an unfair and unfree oil market. And so that is part of the reason that there needs to be incentives to encourage electric vehicle adoption.

We are in a place where, if national oil companies and cartels are controlling the flow of oil, then it leaves American businesses and consumers with few choices when oil prices spike or when supply is cut off. And so I think, if anything, electrifying our transportation sector has got to be part of the solution. It is not the only solution, but it needs to be part of the solution.

And ultimately, it is going to give us the best choice. When you plug into the grid, it doesn't matter how those electrons are produced. It can be coal, it can be wind, it can be solar, it can be any of those. But ultimately, at this point, it gives us the best opportunity for fuel choice.

Mr. DAVIS. But we need baseload generating facilities to be able to power a new electric vehicle economy. Correct?

Mr. PROCHAZKA. Most definitely.

Mr. DAVIS. OK.

Mr. PROCHAZKA. There is a study from the National Renewable Energy Lab and PacifiCorp that shows, basically, that we could put 150 million vehicles on the road and not have a huge impact to our grid. But there is a large opportunity.

Mr. DAVIS. Well, I have actually been out to the Tesla facility and ridden in one of their test semis. And that is a discussion we have to have in the future. And thank you for your testimony.

I want to address before my time runs out environmental reviews. I am not opposed to environmental reviews. As a matter of fact, it was an environmental review in Springfield, Illinois, that unearthed the site where we found artifacts that were part of the 1908 race riots that was credited as being the birthplace of the NAACP. I want to make that a national historic site.

But with that said, 3 weeks ago we had, sitting at that table right there, the mayor of Los Angeles, Mr. Garcetti, and our former colleague, the Governor of Minnesota, Tim Walz, who both told us that we need to be speeding up the regulatory process so that projects in their communities and their States can actually be ready and shovel-ready quicker.

So to anybody else who wants to pick this question up, you know, what can we do to make sure we do what these two local officials asked us to do?

Mr. Sperling, you are from California. What don't you take a shot?

Mr. SPERLING. OK, I will take a shot. We have even a worse problem. By the way, we have something in common, too: my university and your name, Davis.

Mr. DAVIS. That is right, that is right.

Mr. SPERLING. You know, we have an—on top of the EIS NEPA reviews we have our own State, and it has been misused, really, for NIMBY-ism purposes. And it has been used to block all kinds of projects. I think even the most progressive Democrats, or at least many of them, would acknowledge that. And we do need to fix that.

And there is—it is blocking a lot of progress, a lot of investments that need to be made, including a lot of infrastructure investments.

Mr. DAVIS. Thank you, Mr. Sperling.

Thank you, Mr. Chairman.

Mr. CARBAJAL. I will recognize Representative Brownley.

Ms. BROWNLEY. I thank the panel for being here. I have been looking forward to this hearing.

And Dr. Sperling, I am going to ask you a question because, one, you are—I can pronounce your name; and two, you are from California. And please send my best regards to Mary Nichols when you return home.

You talked in your opening comments about aligning environmental goals with transportation goals, and I know, you know, in California I think we have had a very successful program, the California Sustainable Communities program. And I just—I wanted—if you could, talk a little bit about that particular program.

And I want to drill down a little bit more and talk about where the sort of carrots and sticks are to incentivize.

Mr. SPERLING. I will give you the quick answer, and then you can elaborate. And that is we did pass a law in 2008 known as SB75, Sustainable Communities and Climate Protection Act, and it assigned targets to every metropolitan area to reduce greenhouse gas emissions associated with passenger travel.

And in some ways it was successful, in that it changed the debate. It really got the transportation community, in particular, aware that what we are trying to achieve with climate policies really was very well aligned with what they were trying to achieve, in terms of better investments in infrastructure and better planning.

But what it failed at is it did not have any substantive carrots or sticks. And that is where we are. That has kind of motivated much of my testimony, is we need to create those carrots because we need the communities, if they are going to invest in putting in more chargers, or if they are going to build protected bike paths, or if they are going to invest in transit, that they need to be rewarded. And if they do changes on land use, they need to be rewarded because they don't have the resources.

And so that is kind of my biggest plea, you know. It is both Federal to this committee, as well as to the State, is somehow restructure transportation funding so it acknowledges and rewards these environmental goals, as well as the pure VMT population type goals.

Ms. BROWNLEY. And I certainly understand, and we all like carrots more than we like sticks. But what suggestions do you have around the stick portion?

Mr. SPERLING. Yes, the—you know, I spent a lot of time talking to mayors and city councils about some of these new ideas. And the reality is they have very few resources available.

I guess the good news is they are easy to—and I put this word in quotes—to be “bribed.” They are very easy to bring resources, to—you know, a small amount of resources will motivate changes in behavior. But our cities, they have been strapped, they have been—you know, for so many years they have been—you know, they have had their funding cut back so much they don't have a lot of capacity and resources.

And so, any program that does target—you know, that—like getting rid of some of the silos with transit so that transit money can be used for public-private partnerships, as well as to support the operations of the transit operators, you know, there are so many kinds of ideas. And as I said earlier, programmed to support investments in pilot projects and demonstrations.

Sacramento in particular, but Los—all the major cities have major initiatives. But they don't have any funding stream to support it.

Ms. BROWNLEY. Are there any good examples of experimentation in California that has come from private industry? Or if you are saying there is—the resources aren't there—

Mr. SPERLING. Yes, yes, I would say many companies are experimenting in a very small way, including car companies. Car companies are helping electrify Uber and Lyft cars, and they are doing that mostly on their own, so far.

There are various kinds of programs for van pools, electrifying van pools. Some of it is subsidized, but there are some companies that are taking the initiative. So there are some.

But the problem is—and it is just like—you know, I will go back to this discussion about electric vehicles. Every major car company in the world is fully committed to electrifying. This is not a question any more. They have got the supply chains, they have got the technology. They are just waiting for some—either consumers to switch their behavior, or incentives to be created. And they are going to be moving forward in a major way.

And it is the same thing with all of these kinds of ideas, you know, the change happens slowly. Institutions have been, you

know, unchanging—especially transportation institutions—for so long, that they don't have the capacity and creativity. So the companies come along, they have ideas, but they run into road blocks over and over again about how to get that funding and to get the permits and so on.

Ms. BROWNLEY. Thank you.

Mr. Chairman, I yield back.

Mr. CARBAJAL. Next I recognize Representative Perry.

Mr. PERRY. Thank you, Mr. Chairman, and thanks to the panel for your presence today. All of us in the position of policymaking are searching for the best relevant data to use to make the policies, and we are all interested in a better, cleaner environment, whether it is the water, the air, or the climate, in general.

My questions go to Ms. Arroyo.

In your written testimony you make the claim the Fourth National Climate Assessment's findings, along with those in 2018 Intergovernmental Panel on Climate Change, or the IPCC report, are clear and should be a call to immediate action. While the claims are very clearly stated in these reports, the underlying data, to me, is a bit murkier, and I want to explore that a little bit.

These claims are based on the theory that global average surface temperature or gas has increased with greenhouse gas emissions. Validating this theory requires both a valid global average surface temperature record and the use of the proper mathematical methods typically called structural analysis. I think you would agree with that.

My concern is whether either of these necessary conditions has been met.

An August 1981 article in the journal *Science*, authored by Dr. James Hansen et al. calls into question both of these points.

And, Mr. Chairman, I would like to submit the article for the record.

Mr. CARBAJAL. Without objection.

[The article is on pages 159–169.]

Mr. PERRY. In this article, Hansen et al. states, "Problems in obtaining a global temperature history are due to the uneven station distribution, with the Southern Hemisphere and ocean areas poorly represented, and the smaller number of stations for earlier times."

They go on to state the time history of warming obviously does not follow the course of the CO₂ increase, indicating that other factors must affect global mean temperature. In other words, the correlation was not present.

The fact is that over the period of 1900 to date, the year 1900 to date, for very significant portions of the globe, there was really no surface temperature data at all. And yet in 2019 we have a global average surface temperature record going back to the 1880s. It seems obvious that the IPCC and NCA4 would have to overcome these obstacles in order to provide such clear findings that are viewed to be a call for immediate action.

My question in particular, and specifically to you, is the following: If you were to become convinced that the published official gassed data were not, in fact, a reliable depiction of the circumstance, would we then have to conclude that the climate models that are now tuned to replicate the fabricated global average

surface temperature pattern are not able to provide reliable projections of the future state of the climate?

Ms. ARROYO. So, Congressman, I have worked on climate change for 20 years, exclusively. And my first introduction to climate change was 30 years ago, when I was representing Governor Buddy Roemer on a task force of the National Governors Association that, on a bipartisan basis, already thought that the science was compelling enough to issue a report that said that both States and the Federal Government should be addressing this.

The impacts have only become more severe and more obvious, based on what we are seeing in terms of these extreme events. CO₂ levels are rising. That is documented. We have been having measurements in Mauna Loa for many years, but of course we have the ice core record and other records that go back millennia.

We know that we are at CO₂ levels that have never been experienced since millions of years ago, and that is going to lead to dramatic impacts like sea level rise and more intense and frequent storms, et cetera, et cetera.

So, you know, you can maybe find a study or scientist in a certain area that might quibble with that. There was some issues earlier that got reconciled because of the orbit of the devices, the satellites that take the record—

Mr. PERRY. But I want—the gas temperature readings and the lack of information, especially from the Southern Hemisphere, from the turn of the century to present, what about that?

Ms. ARROYO. I am not familiar—

Mr. PERRY. Why is that not relevant?

Ms. ARROYO [continuing]. With that particular study. But what I am familiar with is the scientific record which is, on a published, peer-reviewed basis, overwhelming. That was what the IPCC scientists from all around the world look at. That was what our own Federal Government scientists used in the national climate assessment. This was the fourth such assessment that has been done.

And so I think you can cherry-pick and find a study that might make an alternative point, but we are living in a world that everybody objectively knows is different from the world that we were born into. And that is because the emissions of climate—polluting gases like CO₂ that are being pulled out of the earth and put into the atmosphere at an unprecedented rate. And we are seeing changes that are much faster and more severe than we even anticipated 30 years ago, when I started looking at this issue.

So I am happy to take a look at that report. But having worked on this for 30 years on a bipartisan basis, I don't see any reason—

Mr. PERRY. But you are happy—

Ms. ARROYO [continuing]. To doubt the science.

Mr. PERRY [continuing]. To look at the report.

Ms. ARROYO. Happy to look at the report—

Mr. PERRY. And if you find, indeed—

Ms. ARROYO [continuing]. But I don't see any reason to doubt the—

Mr. PERRY [continuing]. That the gassed data is insufficient, based on an insufficient number of stations, you would be critical of the gassed findings at that—

Ms. ARROYO. I would be happy to look at the weight of the evidence. But just like when we are looking at our health, if a doctor says that you have a serious disease, and recommends a severe course of action, you might want to look at other experts. And so I would look at it along with the other scientific—

Mr. PERRY. All right, my time has expired. I thank you.

Ms. ARROYO [continuing]. Reports out there. Thank you.

Mr. PERRY. Thanks, Chairman.

Mr. CARBAJAL. Next I would like to recognize Mr. Espaillat.

Mr. ESPAILLAT. Thank you, Mr. Chairman. My first question will be for Professor Lyon.

Clearly, matters like congestion pricing, reducing congestion and emissions is sort of like joined at the hip with our ability to provide reliable public transportation. And all of this is sort of like a very deep pocket problem, right? How do we get the finance to promote public transportation and reduce emissions and congestion?

And you mentioned, for example, congestion pricing, which has been around for some time in London, but there is also the tolling of roads and bridges, and, obviously, increasing the gas tax. Which do you see to be the most effective means of capturing the revenue to finance an important project to reduce congestion and emissions and to create greater and greener and more reliable means of public transportation?

Mr. LYON. Well, thank you for the question. And I would be happy to follow up with some written testimony that gives more details.

But my first thought on this is that a VMT tax is very promising, in terms of its ability to raise revenue. It is probably going to be more successful than a congestion tax, just because congestion is a more localized phenomenon. And there has been some research suggesting that a VMT tax could be very effective in revenue raising. So I would say let's start with that, anyway.

Mr. ESPAILLAT. But how has the congestion pricing program worked in London?

Mr. LYON. I think it has been very effective, in terms of reducing congestion, increasing average speeds. And those things reduce fuel consumption, which reduces pollution, because there is a lot of pollution that occurs from trucks and cars just being stalled in traffic.

Mr. ESPAILLAT. Ms. Arroyo, my next question is to you. You refer to green infrastructure. There are communities across America, particularly urban communities, where you see very high levels, for example, of asthma amongst children, and other respiratory diseases.

Now, if we are going to go ahead with a green infrastructure, the first question is do we have the workforce ready and prepared to take on that job?

And the second question is if we do have the workforce available, are we willing to develop a workforce that would then—in those particular neighborhoods that have been adversely affected by this phenomenon, right, the problem with asthma and other respiratory illnesses, are we willing to provide a level of reparation for those communities that have been adversely affected and create jobs—in many cases, prevailing wage jobs—for young people and other people in those neighborhoods?

Ms. ARROYO. Thank you for the question. So a lot of communities that we work with from around the country are interested in some of the benefits of investing in what is called green infrastructure from both an urban heat, island mitigation standpoint to have, you know, cooler roofs, permeable pavements, more trees, urban canopy, and things like that, but also because they are a place for the water to flow.

So when we do see some of these heavier rain events like we are seeing now in this era of climate change, there is a place. For example, you know, water gardens that are being installed in my mother's old neighborhood of Gentilly, which is a very racially mixed, you know, largely elderly population in that community. So some of the places that have not rebuilt, in terms of homes, they are having places for water to go, but also places where people can recreate and have cobenefits from that, which will also contribute to better local air quality, better resilience from conventional rain events, job opportunities, training opportunities.

This is something that, for example, the DC government has worked on in a partnership with folks that have been underemployed, and trying to train them in a program called DC Water Works—which is sort of like a, you know, like a little play on words—to try to train people to install things like solar panels over reservoirs, and things like that. So it is very much something that is of interest to a lot of the cities that we work with, including my own home town of New Orleans.

Mr. ESPAILLAT. Do we have the workforce right now? Let's say if this is to happen a year from now. Are we ready? Are we ready to take this on?

Ms. ARROYO. I mean I think it would be a wonderful thing for the committee to consider investing in, because this really can create local jobs that cannot be exported. And this can happen in every community.

Where I live now, in Arlington, Virginia, there is a lot to be done in terms of urban forestry to counteract some of the kind of, you know, cutting down of the mature trees to build some of the kind of big houses that tend to be what developers do right now.

And so I think that it is just a wonderful solution, and it can train a workforce for sustainable employment, and something that everybody can be proud of.

Mr. ESPAILLAT. Thank you, Mr. Chairman.

Mr. CARBAJAL. I would like now to recognize Mr. Babin.

Dr. BABIN. Yes, sir. Thank you, Mr. Chairman. And thank you, witnesses, for coming up here, giving us your—what you've found over your careers.

First off, I want to say thank you to Ms. Young. You mentioned the Atlas Air crash of flight 3591. That actually went down in my district. I visited that site yesterday. It was a devastating scene. And I just want to say thank you to all the first responders, Federal and State, folks that are out there trying to piece that back together. It is a terrible, terrible thing to behold.

The first question I would like to ask is to Professor Lyon. Can we actually assume that other countries, many of which are developing countries, would opt out of cheap energy sources for more

and expensive cleaner sources? Is that a realistic expectation for us? Professor?

Mr. LYON. Probably, without some kind of international support, that may be difficult.

I mean you look at what China has done over the last, you know, 20 years. They have built an enormous fleet of giant coal plants which burn fairly dirty, inefficient coal. So it looks like India is on track to build a lot of coal going forward, also. So it seems like, to me, that countries that have advanced further economically, like the United States, and that have contributed more to the global warming gas emissions over time, may have a moral duty to help those countries leapfrog some of that dirty technology.

Dr. BABIN. Well, the—I think one of the things that I have seen and talked about with other folks is that we continue to see companies that sell their brand as renewable, green, and environmentally friendly. But when you look at the fine print, we see that a lot of these products are actually made in China, where greenhouse gas emissions are through the ceiling.

And so it is—I think, unless there is some kind of incentive, it is hard for me to imagine that third-world developing countries would do that. And then, to saddle American taxpayers with that duty, as you said, seems to be a long stretch for the American taxpayers.

OK, my next question for Ms. Arroyo, the United States cut 862 million tons of carbon dioxide emissions from 2005 to 2017, which was a 14-percent decline. Over the same period, global emissions rose 26 percent. India increased its carbon dioxide emissions by 1.3 billion tons, and China increased its emissions by 4 billion tons, a 70-percent increase. The United States could continue cutting carbon dioxide emissions, but clearly the greenhouse gases could and would continue to increase. The United States doesn't seem to be the problem.

And so, is the solution to spend trillions of dollars, increase energy costs here in our country, cut jobs, raise taxes on hard-working American families, and jeopardize our strong economy at this point in time? Ms. Arroyo?

Ms. ARROYO. So the U.S. emissions this last year have actually spiked up 3 percent. And clearly, we can't do it alone.

I will say that the States and the cities that we work with are enjoying multiple benefits from their own investment in a clean energy economy of the future. Those States have put into place things like very popular renewable portfolio standards. Many of those States have met and exceeded those standards, and gone further. So that is what has driven our ability to move to cleaner electricity sources that are generally very popular and reduce conventional air pollution and create local jobs that can't be exported, once again.

So a combination of standards at the State and also the Federal level. In the last administration we saw vehicle standards and we saw, you know—efforts to reduce standards from the power sector through the Clean Power Plan are part of the solution, but there is other reasons that are contributing to that, including private-sector leadership and all of that.

That is not to say that the rest of the world doesn't have to do its job. And clearly, the rest of the world came together in Paris

in 2015, and made commitments, as well as the United States made commitments.

Dr. BABIN. Thank you very much. I just—it seems to me it is hard. Just as I said on my first question, Americans are going to be the ones to suffer, while other countries continue to lower their prices at the cost of the environment and the American family.

Dr. Sperling, I think we can all agree on the need for better infrastructure in the United States, but let's look at the details of how our infrastructure is built. Whether it is dams, bridges, or highways, they all require concrete. Cement or concrete is made by heating limestone, which reduces down to about two-thirds of the original limestone weight. The other third goes up in the atmosphere as carbon dioxide.

In other words, making concrete emits carbon dioxide. Do you propose that we eliminate the production of concrete, therefore eliminating the creation of better and stronger infrastructure, which I think everybody in this room, I think, is in favor of increasing our infrastructure and making us more competitive, globally?

Does getting rid of cement seem productive to you? Is that that important?

Mr. SPERLING. That—

Dr. BABIN. I would like to hear what you have to say.

Mr. SPERLING. That is not what I would—

Dr. BABIN. Dr. Sperling?

Mr. SPERLING. No, that is not what I would suggest. And—

Dr. BABIN. Dr. Sperling—OK.

Mr. CARBAJAL. Could you please submit your response in writing? We are trying to adhere to the time limits, so I really would appreciate it.

Dr. BABIN. Thank you.

Mr. CARBAJAL. Next we will go to Representative Mucarsel-Powell.

Ms. MUCARSEL-POWELL. Thank you, Mr. Chairman, and thank you for the witnesses, for being here this morning.

I represent, I believe, one of the most beautiful districts in the country, Florida 26, which includes the Florida Keys, and parts of Miami-Dade County. We are definitely ground zero for the effects of climate change and sea level rise. And we have seen, year after year, storms strengthening, crumbling infrastructure. Our coastline is eroding, due to these strong storms and also sea level rise.

So I know that we have been speaking this morning that the science is clear, and in order to stave off the worst effects of climate change we need to drastically reduce carbon dioxide emissions, and we need to do it very quickly. And I know that there are many ways that we can do this. One is transitioning over to electric vehicles.

So my question right now is to Mr. Prochazka and Ms. Arroyo. Maybe you can both answer this question.

Right now, in the southern part of my district in Miami-Dade County, we have a huge issue of, you know, transportation, lack of access to transportation for the people living in the district that have to commute to work. It is taking them 2 hours, maybe sometimes even more. We have been trying to get rail in South Dade, and I met just recently last week with the transportation board

that approved a fast rapid bus system. Apparently, it is the first one that is being built in the county. I have seen projects in other countries that seem to have been successful.

So one of my questions, Ms. Arroyo or Mr. Prochazka, if we are going to have—one of the questions that I asked was if they were going to have electric buses. And they responded that electric buses posed two major issues: one, that they were much more expensive than traditional buses; and the second is that they are concerned with their ability to install enough charging stations.

So what can we in Congress do to address this impediment for local communities?

Ms. ARROYO. Thank you for the question. So we mentioned the grants program earlier that the Federal Transit Administration has been using to support investment in electric buses in 41 States. Also, many States and cities are using VW settlement money from the scandal with the VW cheating devices on the cars to invest in electric buses. So that is how they are trying to buy down the cost upfront. Because over the life span of the bus, it is actually more on par with conventional gasoline or diesel.

But obviously, getting into the bus in the first place, Federal incentives can play a role there, just like the VW shot in the arm, or the FTA grant program helped. So pilot programs like that are one part of the solution.

And the charging—certainly, if a number of buses charge in the same place at night, for example, that is something that needs to be worked out. It was worked out here in DC, with the Circulator buses, with Pepco, so you need to work with the utilities on that. But that is something that is already doable.

Mr. PROCHAZKA. I will keep my remarks very brief. And I will say that supporting FTA's efforts to allow for bulk purchasing and joint procurement will go a long way. And so it can reduce the administrative and cost burdens associated with bus acquisition. And so I think there is opportunities for cities to convene and create those moments. And I think bus manufacturers are also really excited about those kinds of opportunities.

Secondly, there is an opportunity to think about low- and zero-cost loans. And so the idea is that buses will pay back over time. So electric buses have significantly lower fuel costs, but oftentimes city budget and transit agency budgets prioritize low cost upfront. And so, if we can provide mechanisms to reduce that incremental cost difference, the buses will pay back over time. And, in fact, I think we will see it—will pay back even more than the upfront costs cost at the beginning.

Ms. MUCARSEL-POWELL. That is exactly what I fear, because they are so much more expensive that they are going to try to just use regular gasoline-charged buses.

And my second question, my followup question, was what would be the ultimate impact if the transportation board in Miami were to just stick with regular gas buses? What—you know, what would be the effects on air quality, the health of our communities down in South Dade?

Mr. PROCHAZKA. I will just briefly mention that it is hard to—you know, I don't know the answer specifically for your community.

I will say that the big challenge is that if you purchase a diesel bus right now it is going to be on the road for 10 or 12 years. And so that is a choice that will have already been made. And that pollution and the impacts and fuel costs at that point are sunk.

And so I think it is really important to make sure that the communities prioritize EV buses now, because it is going to save in the future.

Ms. MUCARSEL-POWELL. Thank you. I yield back my time, Mr. Chairman.

Mr. CARBAJAL. I would like to recognize Mr. Garret Graves.

Mr. GRAVES OF LOUISIANA. Thank you, Mr. Chairman. I want to thank you all for being here. Good morning. I appreciate your testimony this morning.

The title of this hearing is "Examining How Federal Infrastructure Policy Could Help Mitigate and Adapt to Climate Change." I want to make note that last year this committee—well, I guess in 2017, it became law in 2018—this committee passed the Disaster Recovery Reform Act, and that legislation, in my opinion, did move us in a direction of resiliency, of making wise investments, recognizing that the current approach toward disasters, where we spend exponentially more money after a disaster, rather than actually being proactive and making principled investments on the front end, is a flawed policy.

And we made substantial changes to help make our Nation more resilient, preparing for the future. And I think this was one area where we had made incredibly flawed decisions that cost our taxpayers. And I would love to tell you millions or billions, but well in excess of \$1 trillion in disaster recovery costs that could have been saved if we had made the right investments and decisions on the front end.

That being said, Ms. Young, I want to ask a question, just make sure I understand something. In your testimony you made reference—and I remember Mr. Calio in this room recently made a similar statement about a significant reduction in fuel efficiency. Were those required? Those reductions, were they required, the fuel efficiency, or the savings?

Ms. YOUNG. No, Congressman. The significant improvement in fuel efficiency—we have made 125 percent since 1978—has been really driven by our own market interests. We are very, very proud that our environmental and economic interests in saving fuel align. And that has, since 1978, saved 4.6 billion metric tons of carbon dioxide. And we are committed to continuing and improving on that record.

Mr. GRAVES OF LOUISIANA. Thank you.

Mr. Sperling, I was previously the chairman of the Water Resources and Environment Subcommittee, and have done tens of billions of dollars in water resource projects and other infrastructure projects in my home State of Louisiana.

I visited California, had a great time with my friend, Mrs. Napolitano, over there. One of the things that I just found remarkable, both on water resource projects and transportation projects, was, quite frankly, the increased cost of projects in California, in many cases. And it appeared—and I want to be clear—I am not certain, but it appeared in some cases that that was a result of re-

quirements that California imposed on itself in regard to different environmental-type requirements under the—what is it, CEBA? California Environmental Protection Act? CEPA, excuse me.

How does the State of California determine which requirements are cost effective versus those that may not be, that are just providing a universal or systemic requirement? Does that question make sense?

Mr. SPERLING. Yes, it does. But that is not one I could answer. I could try to get an answer for you.

Mr. GRAVES OF LOUISIANA. That would be great. Just two other things.

Mr. Chairman, I recently read an analysis based on some EIA data that found that if we migrate entirely to zero-emissions vehicles, that we will actually see an increase—not a decrease, but an increase—in sulfur dioxide and particulates, in oxides of nitrogen, and other emissions, rather than a reduction. And I found that interesting. I think it is something that we probably ought to dig into a little bit more, to make sure that we truly understand the outcomes.

And I also want to be clear that I have actually purchased an electric vehicle, so I am certainly sensitive to—thank you very much. I appreciate that.

[Laughter.]

Mr. GRAVES OF LOUISIANA. But—so I am certainly sensitive to the technologies, and very interested in what the future holds.

But I found that statistic interesting. It actually looked like it was going to be an increase in certain emissions, rather than what I think folks would believe to be a decrease. And this is comparing zero-emission vehicles to new combustion engines, and I think that, once again, we need to be very careful and deliberate about how we move forward.

Last thing, Mr. Chairman. In looking at an analysis just of subsidies and tax credits in the State of California alone, which—keeping in mind these technologies, solar, zero-emissions vehicles, and others, in many cases they are more expensive than other approaches—it appears, for the State of California alone we are approaching \$100 billion in subsidies and credits. And going back to Professor Lyon's testimony, I think we need to make sure that we are making cost-effective solutions and policies.

I yield back. Thank you.

Mr. CARBAJAL. Thanks. I will recognize Mrs. Fletcher.

Mrs. FLETCHER. Thank you, Mr. Chairman. I would like to thank Chairman DeFazio and Ranking Member Graves for holding this important hearing today. And I would like to thank all the witnesses for being here to testify, and share their thoughts with us.

Climate change, as we all know, is driving extreme weather events across the country. It is a crisis that we are ready and we need to address. Certainly, my district, in Houston, Texas, is no stranger to those weather events. And we are committed to addressing this challenge at home in Houston.

One of the things that we know is that the power sector used to be the largest contributor to greenhouse gases. And, thanks to advances in natural gas and renewables, U.S. emissions from the power sector have been on a downward trend.

So the transportation sector now accounts for just under 30 percent of greenhouse gas emissions, and I have appreciated your testimony on issues relating to transportation this morning.

The first question I have is for Mr. Prochazka. I am so sorry if I mispronounced that.

But one of the things that we have seen is we have seen the effects of low-cost natural gas in the power sector lowering emissions. And I wanted to hear from you. You talked a lot about electrification. But what potential is there for natural gas vehicles, especially as fleet vehicles? What are you seeing in that area?

Mr. PROCHAZKA. Thank you for the question. And I am much more of an expert on electric vehicles than I am on natural gas. However, my sister organization, Securing America's Future Energy, has created a policy paper that focuses on a transportation strategy for the U.S. And so it focuses on all fuels.

And if I may, I would love to submit that as part of the followup testimony, because I think it says a lot of great things about what other fuels might do to—and in this case, mostly to reduce the impacts of oil in terms of our economic and national security. So I would, in this case, defer to that.

[Mr. Prochazka has submitted the following post-hearing supplement to his testimony:]

Per your request, I am submitting with this letter a digital copy of the report I mentioned to you during the hearing, titled "A National Strategy for Energy Security: The Innovation Revolution." This report was published by the Electrification Coalition's sister organization, Securing America's Future Energy (SAFE) in 2016. It examines how the adoption of natural gas and other alternative fuels in the transportation sector would contribute to enhanced economic and national security, and outlines a strategy with actionable steps for enhancing fuel diversity. [The report is retained in committee files and is available at: <http://secureenergy.org/wp-content/uploads/2016/06/SAFE-National-Strategy-for-Energy-Security-2016.pdf>.]

The report contains several policy recommendations for accelerating the adoption of natural gas vehicles and other alternative fuel vehicles that may be of particular interest to you:

Light Duty Vehicles

- *Increase federal research and development investments in automotive-grade batteries and natural gas storage tanks.* Plug-in electric vehicles (PEVs) and natural gas vehicles (NGVs) each have high incremental costs compared to conventional vehicles, due primarily to a single component in each vehicle: batteries in PEVs and storage tanks in NGVs. The government should dedicate additional research and development (R&D) dollars to improving the performance and cost-competitiveness of these two components.
- *Initiate a National Accelerator Community Program.* AFVs [alternative fuel vehicles] require the support of new networks and are only likely to succeed if accompanied by changes throughout multiple products, systems, and industries. SAFE's experience in Northern Colorado demonstrates the success that experiential marketing and community-based programs can have in accelerating AFV adoption. Such communities help spur faster and higher rates of adoption and become models for others to follow. To this end, SAFE recommends establishing a fuel-neutral National Accelerator Community Program for AFVs. The program should develop a process to select 20 communities on a competitive basis, with successful applicants demonstrating the broadest community support and the most promise of deploying AFVs in large numbers as demonstrated by PEV sales.
- *Support creation of non-monetary incentives for advanced fuel vehicles.* Incentives that offer vehicle owners added convenience have proven a major factor influencing vehicle purchasing decisions. These may include free or lower-cost access to high-occupancy vehicle and toll lanes, workplace charging or refueling, the construction of plug-in ready parking garages and lots, vehicle emissions testing exemptions, and free parking.

- *Increase federal deployment of advanced fuel vehicles.* With over 400,000 non-tactical vehicles and over \$1.2 billion dollars in annual fuel costs, the federal government has an enormous opportunity to help promote the use of AFVs and advanced fuels. Such adoption would demonstrate that AFVs can meet a wide range of transportation applications, generating important data and lessons. SAFE recommends the federal government take the following steps to increase federal fleet-wide AFV use: work with states to make bulk vehicle purchases, encourage the General Services Administration (GSA) to join in seeking to lower the cost of AFVs at all levels of government; increase the use of E85 in the federal flexible-fuel vehicle fleet; right-size charging infrastructure; and incorporate AFVs into the next-generation Post Office Fleet.

Long-Haul Trucks

- *Create incentives for medium- and heavy-duty advanced fuel vehicle purchases.* While NGVs, in particular, have seen impressive market share growth in certain applications-transit buses and refuse trucks being prime examples-penetration into freight and delivery markets has been slower. SAFE recommends that Congress pass tax credits for advanced fuel medium- and heavy-duty trucks. Tax credits should be established that offer, at a maximum, \$25,000 for dedicated AFVs weighing between 14,000 pounds and 26,000 pounds, and \$40,000 for dedicated AFVs weighing more than 26,000 pounds. The precise amount should be determined, and recalculated on a quarterly basis, using the price differential (DGE) between diesel and the applicable advanced fuel. The credit should decline by 25 percent for every 50 cents per gallon difference in fuel price.

The credit should be allowed for vehicles placed in service after December 31, 2015, and before January 1, 2021, to promote faster adoption and limit costs. For vehicles placed in service in calendar year 2020, the credit would be limited to 50 percent of the otherwise allowable amount.

- *Congress should establish a grant system for the installation of CNG and LNG fueling stations along high-priority corridors.* The federal government can facilitate the creation of a network of natural gas fueling corridors that will obviate the range concerns of long-haul truck owners and fleet managers. LNG would benefit especially from such a policy; its high energy density makes it attractive to operators traveling long distances carrying heavy cargoes. Without sufficient LNG refueling stations on the National Highway Freight Network, companies without the volume to justify building their own stations have largely refrained from switching from diesel.

SAFE recommends that natural gas refueling infrastructure be prioritized along corridors that are responsible for a large proportion of long-haul medium- and heavy-duty trucking. Through the establishment of a grant system, Congress can ensure that fueling stations exist no more than 200 miles apart alongside the more than 51,000 miles of the National Highway Freight Network.

- *Congress should pass a two-year extension of the Alternative Fuel Excise Tax Credit.* In December 2015, Congress passed legislation that extended the Alternative Fuel Excise Tax Credit through December 31, 2016. This credit provides \$0.50 per gallon for CNG, LNG, and propane autogas, among other advanced transportation fuels. The current extension is short-term and creates tremendous uncertainty for investment in longer-term projects. SAFE urges Congress to pass a two-year extension of the Alternative Fuel Excise Tax Credit so that such uncertainty is eliminated.
- *Establish a diesel gallon equivalent standard in order to create consistency and clarity in the marketing and dispensing of CNG and LNG fuel.* The opportunity to save on fuel costs is a major motivation for car and truck fleet owners to switch from petroleum to natural gas and other alternatives. This shift depends, however, on the fuel cost savings being transparent and easily understood by truck operators and fleet owners. Simplicity and clarity in fuel measurement can do much to aid consumer acceptance of an alternative fuel like natural gas. For this reason, the National Conference of Weights and Measures (NCWM) should approve the creation of a uniform diesel gallon equivalent (DGE) standard as the primary unit for dispensing and pricing LNG. Similarly, the NCWM should vote to allow for CNG to be measured and priced in DGE where sold primarily to medium- and heavy-duty vehicles.
- *States and localities should establish their own incentive programs, particularly around regional and urban goods movement.* Many states and regions have established advanced fuel heavy-duty vehicle incentives. Most are financial incentives for the purchase of vehicles or construction of fueling infrastructure. For example, the New York State Energy Research and Development Authority

(NYSERDA) is providing incentives for alternative fuel trucks and buses. DOT Tiger and DOE Clean Cities grants should be made eligible for these local programs to support state and municipality efforts nationwide.

Localities should also consider non-traditional incentives, such as access to HOV lanes, preferred delivery times for advanced fuel delivery vehicles, preferential treatment in the awarding of local government freight contracts, adjusting urban freight facility zoning rules to reward the use of advanced fuel freight vehicles, allowing access to municipal advanced fuel fueling stations, and assisting freight operators with obtaining federal grants and other incentives for advanced fuel medium- and heavy-duty vehicles.

Mrs. FLETCHER. OK, thank you, I appreciate that. And I would like to see that paper. I believe in my own district there are companies that have transitioned to entirely natural gas fleets, so I think that that is a growing area of opportunity.

And I think, Ms. Arroyo, did you have a followup comment to that, or an answer to the question?

Ms. ARROYO. I was just going to say that they are especially good for reducing emissions of criteria pollutants, natural gas and propane vehicles.

From a greenhouse gas emissions perspective, battery, electric, and hydrogen offer more promise.

Mrs. FLETCHER. OK, thank you. That is helpful. I think, in general, you know, one of the things that we have seen—and we have heard some testimony earlier about some public-private partnerships, or efforts that we are seeing from industry. And so I would like to hear from anyone on the panel who wants to accept about where industry is leading, and how the Government can help amplify those efforts.

I know there were some questions about that earlier, but where can the Government be of assistance in making sure that those efforts are being amplified?

Mr. PROCHAZKA. So I will actually answer this question, if I may. And it is Prochazka, just to demystify.

Mrs. FLETCHER. Thank you.

Mr. PROCHAZKA. Get rid of the C, much easier. So thank you for the question.

Actually, you know, and Houston is a perfect example. It is one of the energy centers of the country. And, in fact, CenterPoint Energy right now is working with great effort to convene a broad community of stakeholders that represents both public and private-sector members of the community, and in partnership with the city of Houston to figure out how to rapidly accelerate the adoption of plug-in electric vehicles.

And I think those kinds of examples are springing up all over the country, where utilities and cities are getting together and recognizing that these are both great economic opportunities, because they can leverage huge investment locally from the private sector, and you can match that with Federal dollars.

And so I think the idea would be for every dollar that can be contributed to that through infrastructure, tax credits, vehicle tax credits, et cetera, that you are going to see the payback from those investments, maybe two or three or fivefold from the investments from the private sector.

Mrs. FLETCHER. Thank you.

Ms. YOUNG. Yes, I would like to add, from our perspective, you have heard a little bit today where we have talked about the CLEEN program. And I want to say what that acronym stands for: The Continuous Lower Energy Emissions and Noise program. And that is an FAA industry public-private partnership to really advance technology operations and infrastructure.

And I wanted to note the acronym, what it means, for—because it focuses on fuel alternatives. It focuses on greenhouse gas emissions, noise, synergistic issues in the way that we fly our aircraft.

Mr. SPERLING. And I will just add one more, and that is with transit operators working with what we call the TNCs, Lyft, Uber, Via, where they are collaborating to provide service in areas that are less dense, and do it much more efficiently than a conventional transit operator can do. And there is many examples of that around the country.

Mrs. FLETCHER. Thank you very much. I yield back my time.

Ms. TITUS [presiding]. The Chair now recognizes Mr. LaMalfa for 5 minutes.

Mr. LAMALFA. Thank you, Madam Chair.

I appreciate the panel coming today. On the aviation sector, thank you for your great information on that, Ms. Young. And indeed, we see more and more greater efficiencies with aircraft and fuel type and everything each year. So I think there is a lot to be proud of in that area, and that is what mystifies me, is that it ever improves, with improving aircraft and the materials they are making them out of, and the winglets you talk about.

I don't see winglets on every plane yet, so I know you get that little plus for making the vortex, however that works. But, you know, that—you are rapidly improving. And so, to hear plans out there to eliminate the airline industry and notwithstanding I will never see high-speed rail go from California to Hawaii—so I don't know how that is going to work—but that said, I commend you in that area.

We haven't heard much about freight rail in this committee today, which indeed, itself, is one of the most efficient ways of moving any kinds of materials across the country, as you get—freight by rail achieves 479 miles on a gallon of fuel per ton. That is pretty amazing. All we hear about in California is we have to keep pursuing this high-speed rail boondoggle, which now has been downsized to the Valley, itself.

So I am sure there is people clamoring out there to get from Merced to Bakersfield 33 minutes faster than Amtrak would accomplish the same thing on a grade A rail at its maximum capacity. So why we are spending billions of dollars on that—and we have given up on the whole concept, the voters passed—when they barely passed the \$10 billion bond about 10 years ago. It mystifies me. So I hope we can have some rethinking on that, because our transportation system really needs to have its emphasis on stuff that people can use: improved highways, et cetera.

So when we talk about moving freight, we also have at the local level a very important need for truck traffic, and the—because, basically, the motto is if you got it, a truck brought it. When, you know, you get to your local level.

So in California we have some very difficult standards on the trucking industry there that CARB has a habit of passing a bill and waiting for the technology to catch up later. It mandated, I think back in 1990, that 10 percent of cars sold would have to be zero emissions by the year 2000. Well, they had to back off from that because battery technology and car technology never caught up to a mandate by whim of a State legislator. So we have that, with the difficulty with diesel trucks in the State, trying to catch up and being retrofitted with these devices that cost tens of thousands of dollars that, in many cases, were catching fire in these retrofits.

So I don't know what the positive is there. I have had anecdotes where people talk to me where they have these devices fitted to some of their hay equipment, and their—up and down the road they have to stop what they are doing every once in a while and run the vehicle from actually working speed up and down the road in order to let the filter burn its way out, and then go back to work.

So this retrofitting doesn't always fit the program. It is when—and Caterpillar actually pulled out of California from supplying diesel engines. Can you imagine? Every guy, every café you go into, somebody is wearing a cap that says Cat Diesel Power, and them being out of the diesel business in California for a time. So this is what happens when you make mandates.

So I would like to hear from Mr. Lyon here. What we are talking about is allowing technology, allowing the market to work. And if we allow that to happen, things like eliminating the excise tax on heavy trucks, allowing more of these newer trucks to be sold instead of trying to retrofit by the force of mandate, what would that look like for the market? What would it look like to improving the fleet?

Mr. LYON. It is a great question. I wish I had the data at my fingertips to give you a really good answer on that. And I would be happy to respond in more detail with a—

Mr. LAMALFA. Well, what we have is the Federal excise tax in relation to the amount of dollars it generates to help infrastructure is pretty small, but you have a pent-up market there, especially driven by mandate—truckers that can afford it that are not just mom-and-pop but, you know, \$120,000, \$130,000 trucks. The FET adds, you know, \$10,000, \$15,000, \$20,000 to the price of that. Do you think that would be a great incentive to move more new vehicles? By eliminating—

Mr. LYON. Like I said, I don't really know the details of the tax structure there in California.

Mr. LAMALFA. Well, it is national FET on that, so—

Mr. LYON. I don't know. I mean it does seem like, to me, that trucks cause a disproportionate amount of wear and tear on roads. And so it may be perfectly reasonable to tax them at a higher VMT rate than light-weight vehicles. But that is not to say that—

Mr. LAMALFA. Well, they are paying a lot more weight fee—

Mr. LYON [continuing]. The current tax rates are—

Mr. LAMALFA [continuing]. Than everybody else, too. So they carry their share on that, and generally end up with more of the bill.

So, well, thank you, Madam Chair. I yield back.

Ms. TITUS. Thank you. We now recognize Mr. Allred for 5 minutes.

Mr. ALLRED. Thank you, Madam Chair. And thank you to the witnesses for being here today and sharing your insights with us on how we can create a more sustainable transportation solution to combat climate change.

I represent parts of Dallas and the suburbs of Dallas to the north, a district that encompasses some thriving job markets, great colleges and universities, bustling arts and cultural scene. And we also are experiencing extremely rapid growth. We have more than 100,000 people a year moving from out of State just to my region. And that growth has led us to have some unique challenges that we need to address as we try to mitigate the congestion on our roads, and combat our greenhouse gas emissions.

In addition to those congestion issues, Texans are also grappling with frequent and intense extreme weather events, as my colleague, Mrs. Fletcher, mentioned, in Houston. But also in north Texas we have experienced record droughts and extremely high temperature patterns. And now, more than ever, I think it is important that we invest in resilient infrastructure that is built to withstand the stresses of uncertain weather conditions. And I look forward to working with the members of this committee to do that.

I also want to just recognize the city of Dallas and our mayor, led by Mayor Mike Rawlings, and their efforts to move Dallas forward to address climate change, and to make Dallas a global leader in that area in a way that also is consistent with meeting our infrastructure needs.

And I want to respectfully disagree with some of the statements that have been made about high-speed rail. There is a very promising high-speed rail project between Dallas and Houston that is largely privately funded that I think will be a model for the rest of the country, and one that I think will be an economic boon for Texas. And, as I said, other areas may try to replicate what we are doing there.

Ms. Arroyo, in your testimony you mention that cities across the country are reducing air pollution by increasing transportation options like investment in public transit, bike, and pedestrian facilities, and new mobility solutions. Do you feel that investments in high-speed intercity passenger rails—rail systems—could contribute to a reduction in CO2 emissions?

Ms. ARROYO. So thanks for that question. And a shout out to Dallas. As you saw, I held up DART as an example, because they are, you know, just doing such innovative work to make it seamless for people to use transit. And if you go around the world on your travels, you see that other countries have managed to find ways to invest in high-speed rail.

I am not an expert on what exactly is happening in a particular place like California or Texas, but I think for certain, you know, metropolitan areas, connecting those routes will be really important to get some of the folks off of the interstates, which are clogged and have some challenges associated with them, in terms of the pollution, both conventional pollution that comes from them for the people who live around them who tend to be disproportion-

ately, you know, poor, minority communities that those interstates cut through.

So I think rail—both conventional rail and high-speed rail—does offer some really exciting alternatives to that.

Mr. ALLRED. Dr. Sperling? Same question to you.

Mr. SPERLING. About high-speed rail?

Mr. ALLRED. Mm-hmm.

Mr. SPERLING. Yes. I mean it definitely would result in a reduction in CO₂, especially—you know, the answer to a lot of these pollution and CO₂ questions is how is the electricity generated.

So, in California, for instance, it was planned that it would be coming totally from renewable energy. And in fact, the law now is to go to completely carbon-free electricity by 2045. So, I mean, that is really the answer, simple answer, to the environmental issues.

Mr. ALLRED. Ms. Arroyo, back to you. In your testimony you state that, since 1980, 241 extreme weather-related events have cost the U.S. an estimated \$1.6 trillion. That is a pretty big number. But then again, infrastructure investments also have a high price tag.

Do you think there would be a net savings for the Federal Government if we were to invest in disaster mitigation and resilient infrastructure, rather than emergency spending once a disaster has occurred?

Ms. ARROYO. So, again, thanks for that question. There is a new study out from the National Institute of Building Sciences that actually increased the number of the rate of return from—for every \$1 that you spend getting a benefit of \$4 to up to \$6 now. That is a new 2018 estimate from things like, you know, elevating buildings in that context, or just—you know, designing things differently, or allowing people to rebuild differently after storms, so you are not basically just putting people back into harm's way and throwing good money after bad.

So it is an excellent question, and it is very true, that resilient infrastructure investment on the front end can save you \$6 for every \$1 that you invest on the back end.

Mr. ALLRED. Thank you.

I yield back, Madam Chair.

Ms. TITUS. Thank you. We have been trying to get high-speed rail between Las Vegas and southern California for a long time.

I now recognize Mr. Palmer for 5 minutes.

Mr. PALMER. Thank you, Madam Chair. I know that we are supposed to reach zero emissions, CO₂ emissions, in 12 years. And we won't be flying airplanes any more. But how are we going to do that, considering the amount of CO₂ that China and other nations that come into the United States—do you have an infrastructure solution for that, Dr. Sperling?

Mr. SPERLING. Well, if we look at China specifically, I know it is easy to, you know, to bang on—

Mr. PALMER. Well, your answer, is it yes or no? Do you have an infrastructure solution for that?

Mr. SPERLING. Yes.

Mr. PALMER. You do? How are you going to block emissions from China?

Mr. SPERLING. They will do it—they are on the path to do it. They have a plan to peak by 2030, and they are making much larger investments in renewable energy on their own than we are in the United States.

Mr. PALMER. Well, here is what we have had, in terms of annual CO2 emissions from 2005 to 2017. The United States has reduced its emissions by 15 percent. That is over 1 billion metric tons. Same period of time, China's is up over 4 billion. That is double, and it is continuing to go up.

So maybe in 2029 they will implement their 2030 plan? It is kind of like what we do on our 10-year budget. You know, we will just—we are always—next year we will be balanced in 10 years. Is that—

Mr. SPERLING. Well—

Mr. PALMER. See, what the Chinese have here is an advantage. As we make these changes to our economy, they will dominate the world economy. You do take the socio—the geopolitics into consideration here, don't you?

Mr. SPERLING. Yes. But if I look at it simply from an environmental perspective, they have a strong incentive there to reduce air pollution, and to—in fact, they are the global leaders on both renewable energy and electric vehicles.

Mr. PALMER. I think they have a stronger incentive to become the dominant power in the world, but we will leave that for another discussion for another time.

I would like to point out one of our colleagues brought up asthma. Asthma rates have skyrocketed.

Ms. ARROYO, do you have any idea of why that is? I will ask for yours.

Ms. ARROYO. I don't. I mean I am not a medical doctor. But, I mean, air pollution is certainly one leading contributor to that, as well as indoor air pollution that can come from, you know, pests, and things like that. But I am not an expert on asthma.

Mr. PALMER. It is interesting, because air quality in the United States has improved dramatically since 1970. You know, our GDP has gone up 262 percent, vehicle miles are up over 189 percent, population is up 59 percent, energy consumption is up 44 percent. Yet emissions are down 73 percent and asthma rates have skyrocketed.

Ms. ARROYO. Well, I mean, one thing I can say, based on my own experience as a regulator, as an environmental regulator in Louisiana, is that, you know, you can look at a mean, like air pollution, nationally or even statewide, and that doesn't necessarily speak to the people who might be the most impacted.

And those again, as I said earlier to Mr. Allred's question, tend to be people who are disproportionately, you know, poor, communities of color, living in places like near ports, near highways, hot spots like in my own home State of Louisiana, around very major industrial facilities—

Mr. PALMER. I am glad you—

Ms. ARROYO [continuing]. That benefit everybody, but only a minority of people live near them.

Mr. PALMER. I am glad you brought up the fact that most of them—it generally impacts poor people. First of all, nobody knows

what causes asthma, so that was—I appreciate you—your response to that. But when you do damage to the economy, you generally have more poor people. And I would just point out that whatever we do in regard to infrastructure, we need to make sure that it benefits all Americans.

And on the electric vehicles, you made the point that we are—you almost made the point that we are dependent on foreign oil and—for our energy. We are not. We are on the path to becoming energy independent. I think electric vehicles have a role to play in that, but I am not sure that we are in a place where the market supports that, given that we put over \$40 billion in subsidies into the electric vehicle industry.

One of my colleagues said he bought an electric vehicle. I think the subsidies that are available to people who buy vehicles, some are approaching \$7,500. When you add the State subsidies, it could be \$13,000. And almost 80 percent of the people who get them are earning over \$100,000, so it is kind of a limited market, wouldn't you say?

Mr. PROCHAZKA. I think that we are on the verge of seeing the market be available to all consumers. And I think that, at this point, you know, the fact that we sent \$133 billion abroad to pay for oil in 2018 alone—

Mr. PALMER. Well, we are about—

Mr. PROCHAZKA [continuing]. Suggests that we still have a challenge.

Mr. PALMER. I can assure you that those days are becoming fewer, when we will be sending money abroad. We will be sending oil abroad, and the money be coming back to us.

Thank you, Madam Chair. I yield back.

Ms. TITUS. Thank you. I now recognize Ms. Davids for 5 minutes.

Ms. DAVIDS. Thank you, Madam Chair. My name is Sharice Davids. I represent the Kansas Third Congressional District. And I appreciate all of you and your time and effort that went into your testimony.

So one of the things that really struck me in listening to the entire panel is that we have a really interesting juxtaposition of things here. The airline industry, or, you know, the idea that it happens to be that your—the market pushes you toward efficiency in a way that benefits our concerns and addresses our concerns about climate change. And a lot of us have concerns about climate change in Kansas.

In the Kansas City metro area we have the Kansas City Climate Change Coalition that includes elected officials, people from various sectors. And even the Kansas City Transportation Authority has started to—they are looking to, hopefully, acquire electric buses. They are operating on hybrids right now.

I think there are a lot of folks, especially in my area, where we have multimodal, a lot of multimodal concerns. There is a lot of rail in the Kansas City metro area. There is a lot of air. There is a lot of highway. We have five highways that intersect.

But one of the things that I have noticed is—Professor Lyon, I would love to hear you kind of talk about the idea of the market deciding—sometimes the market does decide. But at what point do you draw the line around innovation? Because at some point the

Federal Government did decide that passenger vehicles, rail, and car were going to be the thing that we would use. And now, everything that I have heard addresses alternatives to the thing that we decided some number of years ago.

It seems as though we are at a place right now where we need to be thinking in terms of not just the market, dollar-wise, but also what does climate change do to the market.

How are you thinking about innovation, but not just in terms of electric vehicles, innovation of the way that we are viewing the market?

Mr. LYON. Well, let me try to speak to that. Environmental economists normally think there are two big things we need to do regarding climate change.

One is put a price on carbon, and two is fund, with Government funds, early-stage innovation for research and development into technologies that will help reduce carbon emissions. So those are kind of the two big categories, and I think it is pretty widely recognized that Government needs to help with that early-stage R&D investment. And that has driven spin-offs into all kinds of different sectors. I mean the tax sector, for one.

I think the question is where do you stop that and hand things off to the market to actually do the deployment. And my worry is that Government sometimes goes too far into the actual deployment process. So we want to have this kind of smooth, intelligent hand-off from one to the other.

I don't know if that addresses your question exactly.

Ms. DAVIDS. I think I might follow up with a written question for you around that.

Mr. LYON. Sure, sure.

Ms. DAVIDS. So, Mr. Prochazka, can you talk a little bit more about the innovations around the way we are deploying electric vehicles—like, the charging stations and that sort of thing?

And you have talked a little bit already about the impact that subsidies can have. But can you talk a little bit about where the subsidies in other places might be hindering your ability to do this, or the way that we are viewing who is getting what subsidies? Because I feel like you have touched on it a little bit, but I would like to hear a bit more.

Mr. PROCHAZKA. Well, first, let me just mention thank you for the question. I have been to the great city of Kansas City, and KCP&L—

Ms. DAVIDS. Oh, a smart city.

Mr. PROCHAZKA. Yes, a smart city. But in this case, Kansas City Power and Light is a great example of the idea of how you can connect innovation with changes in infrastructure. And in a lot of ways, Kansas City is helping build the 21st-century solution to how city infrastructure—and then I think long-term infrastructure—needs to develop around the country.

And a great example of that is charging infrastructure, we just think of it as a place to charge our cars, but it also can be a great way to help the grid actually respond to demand and pique demand. And so they are installing smart chargers, and also connecting it to information so when people charge you can actually connect the information around that community.

Ms. DAVIDS. Thank you for that. And I am glad—because I was going to have to do it—that you mentioned KCP&L and their work toward providing electric vehicle chargers.

With that I will yield back. Thank you, Madam Chair.

Ms. TITUS. Thank you. We will now recognize Mr. Stauber for 5 minutes.

Mr. STAUBER. Thank you, Madam Chair. I appreciate the witnesses coming forward, and I appreciate your expertise and your knowledge.

I come from northern Minnesota, the northeastern part of Minnesota, where just a few weeks ago it was 71 below zero. And Dr. Sperling, when you talk about using scooters to get to and from work, at 71 below parked outside, it is not going to work in northern Minnesota. And so, I think that we all, I think, want to get there.

Mr. Lyon, you just said something that I really agree with. It is that change—it is that gentle tradeoff with the innovation, research, and development, where the private market will take over. Because right now we are subsidizing a vast majority of our technology to get to zero emissions.

And I think we have to recognize that there are different parts of the country that, because of the weather changes, that we have to look at. And I am just going to give you an example.

In Duluth, Minnesota, it is obviously cold a lot of times of the year. And I will say it is a great part of the country, by the way. So we have the Duluth Transit Authority. They started their electric buses. There was a \$6.3 million Federal grant. They started using those buses on November 19th of this year. And on November 30th they had to pull those buses off because of the problems on—the hills they were starting out, they were going beyond the 6 inches in backing when they started on a hill. The heaters weren't working.

And so the—there was—the innovation started, the temperatures, it didn't work right away in Duluth. They had to actually go to diesel heaters in there. And I think that—so you are looking at a Federal grant that—the buses, I am told, now are working with the additional fixes.

But I really appreciate you talking about that public-private partnership to push the innovation. But at some point I think that we need to let the market, the private industry, take over and reduce the subsidies and move that forward. I am very, you know, concerned about the push on the Federal Government to move forward.

I would say that my question, really, is this. You know, we have the Highway Trust Fund and the Airway Trust Fund. If we remove—you know, go to these innovative green projects, how would—how do you make up—how do we make up the \$35.6 billion shortfall in the Highway Trust Fund and the cut to the public transportation, and almost \$100 million cut to the Inland Waterways Trust Fund with this new technology?

And this goes to anybody, if you would like to answer it.

Mr. SPERLING. There are many ways to raise funding for these kinds of initiatives. So, you know, to use California as an example, we have not only the cap and trade program, which funds probably

\$1 billion a year in clean transportation, but it is used also for affordable housing near transit stations and greening of communities to reduce emissions, as well.

We have a low-carbon fuel standard, so—I should say there is no taxpayer money involved in that. There is, of course, money—you know, eventually comes from individuals. But then we have a low-carbon fuel standard that is a market trading program between the oil companies and other energy suppliers. And that ends up providing large incentives. Part of that will be providing probably about \$2,000 to buyers of electric cars. It provides funding to builders of charging stations and hydrogen stations.

So I am just illustrating that everything doesn't have to come from the trust fund.

Mr. STAUBER. OK—

Ms. ARROYO. I would just add that I participated in the future of the Interstate Highway System report that was requested by Congress. And obviously, the trust fund has already been in dire straits for some time, and part because the gas tax revenues haven't been raised because the gas tax itself hasn't been revisited in so long, and with efficiency improvements, et cetera.

So some States, like Oregon and some of the States on the I-95 corridor, are experimenting with VMT approaches. Some States are adding registration fees to lower carbon fuel vehicles like electric vehicles.

The future of the Interstate Highway System report said that we might consider changes to the Federal system, as well, in terms of allowing tolling, which, of course, they are doing already on the I-66 portion inside the beltway. And, you know, carbon pricing mechanisms like those that are being considered by the States in this region can also provide money for investment and clean and resilient transportation infrastructure.

Mr. STAUBER. Thank you very much.

Madam Chair, I yield back.

Ms. TITUS. Thank you. We will now recognize Ms. Finkenauer for 5 minutes. Your mic is not on.

Ms. FINKENAUER. Is that better? Thank you all so much for being here today. It truly is an honor. And I am just very grateful that Congress is taking climate change seriously, and the impact of severe weather to our infrastructure seriously.

I do really think we have a real opportunity here to rebuild our infrastructure in a way that is more resilient to severe weather, less harmful for our environment, and includes solutions that actually reduce greenhouse gases.

And I got to be honest, I am very, very proud to come from northeast Iowa, and Iowa's First Congressional District, because so many of my towns and cities are taking this seriously, and want to move in this direction, and have been making some very serious progress towards improving the efficiency of our transportation networks.

Waterloo is one city in my district that has done great work, you know, recently launching a mobile app, trying to make transit more accessible, and a more viable option for folks.

You have got Dubuque, where I am from, that has been partnering with IBM, really making great strides, both collecting

data through smart phones, where folks can opt in and make sure that we have the most up-to-date data of where we need some help in our transit system, making streets more accessible, what is in need of repair, a bunch of different issues. So excited to see that partnership developing.

And I will tell you, because of these partnerships and some of the stuff that my district is working towards, it has created a very interesting conversation in Iowa, one, about making sure that we are doing more using technology. And when we are investing infrastructure, making sure we are doing it in a sustainable way.

So I would love to hear from this panel on intelligent transportation systems. And specifically, how can we use new technologies to reduce congestion, and therefore reduce greenhouse gas emissions? What are you guys seeing on the State and local level? What programs are worth expanding? And then what can be scaled up on the Federal level, so that we can make sure every community can benefit?

Mr. SPERLING. Let me start. I have such a long list. But, you know, one thing is, like, for instance, we have in our transportation bill in California that sets aside money for a congested corridor program, green congested corridor program, that is a competitive program that provides funding for local communities that come up with innovative and creative ideas. So there might be something like that that could be scaled up.

I want to note also that, at the end of the day, we have seen a tremendous increase in vehicle miles traveled, and a big part of that is because people are traveling by themselves. I saw a number: 1970, for a car, the average occupancy was 1.9, and now it is 1.4. That, by itself, explains much of the increase in VMT.

Now, the role of these intelligent transportation systems, smart transportation, pooling, is—the idea is that—I think is—really, the key to it is what I call pooling. And that is increasing the utilization of our vehicles.

You know, if we build more infrastructure, they will come. And so, we want to provide it in a way that we do make efficient use of the infrastructure so we don't need more of it. In fact, you know, we will need less parking. And as we move—so one of the ideas is to encourage services like Uber Pool or Lyft Share or Via, and also in connecting them with transit, so that transit does what it does well, where it serves line haul, dense corridors, but we create these services that will provide better mobility and better accessibility, even for relatively low-density areas.

We have the tools now. We didn't have them 5 or 10 years ago. And we are doing a project in the Central Valley in California, which is very rural, where we create these—they start out as car sharing, but people can take the cars and use them to transport other people, and it creates jobs and it improves accessibility for all those people that don't have easy access to high-quality vehicles.

Ms. FINKENAUER. OK, thank you so much.

And Madam Chair, I yield back.

Ms. TITUS. Thank you. Well, now I move to Mr. Balderson for 5 minutes.

Mr. BALDERSON. Thank you, Madam Chair. And I would like to—my questions be directed to Mr. Prochazka. Thank you for taking the time to be here today.

And I know that you have mentioned in your testimony the Electrification Coalition has served as a strategic advisor to Smart Cities Columbus and—thank you very much for your work on that, and you and I are going to discuss that even further. But I am proud of the innovation work that is being done in Columbus, and also in my district.

While Smart Columbus specifically focuses on addressing transportation challenges in an urban environment, how can rural areas learn from such initiatives, so they could address their own distinct transportation challenges and needs?

Mr. PROCHAZKA. Thank you for the question. And, you know, if anyone is looking for an example of how a community can go from zero to now being a leader, Columbus is probably one of the best examples. So I would encourage anyone looking at strategies and techniques to drive adoption of plug-in electric vehicles, Columbus is a great example.

To answer your question, I think, you know, there are key examples of programs that are developing in cities and, I think, rural communities that are great opportunities to drive innovation. One of the key ones that I think is a good opportunity is the idea of joint purchasing. So cities are actually banding together, recognizing that maybe in smaller communities they don't have access to the number of vehicles or the pricing that might exist for larger cities.

And so, by joining together—and that is actually happening in Columbus, where they created a master contract so that any city throughout the State can actually purchase the same EV that Columbus can purchase. Those are great examples of innovations that are reducing costs and creating better access for communities all across the State.

Mr. BALDERSON. Thank you. That leads me into the next question, and you touched on it just a little bit.

Under the leadership of the Columbus partnership, the Smart Columbus Acceleration Fund has already leveraged over \$500 million in private-sector investment, which is a big number. American Electric Power, which is headquartered in Columbus, local car dealerships, and other businesses have worked with the city of Columbus to encourage Smart Columbus and promote the development of electric vehicles within the city.

How can we use Columbus as an example throughout the Nation to encourage the involvement of private-sector businesses to help new technology into our infrastructure?

Mr. PROCHAZKA. And again, thank you for the question. So you know, in Columbus they have a saying that I had to learn, but “the Columbus way.” And I think that, in a lot of ways, they have just electrified the Columbus way. But the idea is that you really can have these burgeoning public-private partnerships that can go much further than cities can do on their own, or than the private sector can do on their own.

And it is this idea of leveraging the investments and the innovation and, frankly, the ingenuity. So they created, as an example,

something called the Mobility Partners, where over 60 businesses that are representing Fortune 100, Fortune 500 companies that exist in Columbus—which many people don't know—and those are banding together and creating amazing programs. They have been able to put 7,000 people behind the wheel through that partnership. They have been working on creating innovation funds that can happen through, as you mentioned, AEP and others to help drive acquisition of vehicles faster and to help create programs that are moving the needle.

And then I think the other part of this is that they are also not recreating the wheel on every example. And so, by working together, they are finding the strategies that might work at Alliance Data and then bringing that over to Cargill Health, and then replicating that at L Brands. And those are perfect examples of the kind of innovation that could happen across the country.

Mr. BALDERSON. I commend you. Thank you very much.

I yield back the remainder of my time, Madam Chair.

Ms. TITUS. Thank you. We will now recognize Mr. Lowenthal for 5 minutes.

Dr. LOWENTHAL. Thank you, Madam Chair. And to all our witnesses, I have listened the entire session and have found it very, very interesting.

You know, I also represent an area that is impacted by climate change very much, southern California—sea level rise. But I am also—what is unique about my district is that I represent the port area of Long Beach and Los Angeles, which over 20 years ago was part of the dirtiest collection of industrial concentration. Forty percent of our Nation's goods come in and out of the port area in my district.

But there have been dramatic changes. And part of that has—and I am going to ask both Ms. Arroyo and also Dr. Sperling—has to do with some of the incentives and some of the money that has been provided for freight.

So I want to focus on freight. Much of our discussion today has been—although it has been mentioned—has been on, really, you know, passenger vehicles and others. But I think that much of what we have done in California, I am wondering how that translates to the rest of the Nation.

I think, Ms. Arroyo, you mentioned in your testimony—I think the written testimony—about how the cap and trade program has helped a lot. I know Dr. Sperling has worked very much on that through CARB, also.

But first, and—I am interested in, you know, how—we have attacked in California, or we have targeted our State's freight sector in a way that we have done—moved towards zero emission, yard equipment, and heavy-duty trucks that—moving toward zero emission and charging outlets, and now talking about tier 3 container ships. And so we are kind of moving in that direction in California.

Interesting, now, that as Dr. Sperling has mentioned, I still—I have circled in his—but emissions are—no matter what—even though what we are doing—emissions are still rising. And even though I have heard all this reduction from other Members, that one sentence has frightened me the most, that all this amount of resources that we are doing—I am just kind of wondering from you,

even though this is not the critical question—when are we going to reach a tipping point, where those emissions start to drop?

You know, is it that we need new kinds of—you mentioned about, you know, sharing and automation and also electrification. But the question I want from Ms. Arroyo is that—how are we going to build upon what you mentioned? Let's say things like the funding cycles, like cap and trade and others, cost of carbon. What do we need to do to move the rest of the Nation towards adopting this?

You know, California has paid—and I am not saying it is just California—has paid a lot of attention towards reducing. But what is the rest of—what do we need to do? What are the major things for freight? Is it the same as passenger vehicles? What are the incentives that we really need to do?

Ms. ARROYO. So there are a lot of different approaches to freight, including trying to shift from the roads to rail, as the—

Dr. LOWENTHAL. That is right.

Ms. ARROYO [continuing]. Gentleman on this side of the aisle mentioned earlier. And also short sea shipping, which is hard to say fast, but I said it slowly—

Dr. LOWENTHAL. And the ports are moving towards rail.

Ms. ARROYO. Right.

Dr. LOWENTHAL. Much more of the—much more because, as was pointed out, we are not going to build more—through urban centers we are not building more highways. And our growth continues, even though they have demonstrated that they can reduce the pollution. But the growth is still there. And I think rail has been certainly one of the answers.

Ms. ARROYO. But I think there is definitely a role for a committee like this one. Because what we found in facilitating the Transportation and Climate Initiative over 8 years now or more has been that there is a great interest in the States in this region, which runs from Virginia now all the way up to Maine, in working together to analyze what the freight flows into and around the region are and to try to move it to more efficient options, which would actually save our roads for passenger vehicles, get it into rail or shipping, et cetera, look at the emissions benefits that come from that. And there really, frankly, has not been a lot of support for that, so that work has not been as sustainable as other work that we have done together. For example, on electric vehicles, where there have been DoD and DOE grants to support corridor planning and things like that.

So one of the things that this group as a region is looking at is a policy proposal that would be under development this year to have a cap and invest program that would generate proceeds that could be invested in cleaner and more resilient transportation infrastructure. And that is to be determined by the States themselves over the course of the year.

Dr. LOWENTHAL. I know I am just about out of time. But Dr. Sperling, any other thoughts about—

Mr. SPERLING. Just quickly, you know, you need to think of it both on the technology side and on the logistics use side. And I think we are making some progress on the technology side. On the logistics side, that is why we are seeing the emissions going up on the passenger side as well as on the freight side.

And part of the challenge is that States do not have much jurisdiction over the rail. Rail is great but, you know, part of it is dealing with that issue because of the interstate commerce. And aviation, the same thing. So we need a renewed focus.

But it is the States and locals that really need to focus on this, what is happening at the local area. And frankly, with the—I call it the Amazon-ization of delivery, we are seeing this proliferation of warehouses all through our communities now. And it is resulting in a lot more truck—local truck VMT, which is—and L.A. is right at the forefront of that.

Dr. LOWENTHAL. Thank you. And I yield back.

Ms. TITUS. Thank you. We will now go to Mr. Westerman for 5 minutes.

Mr. WESTERMAN. Thank you, Madam Chair. Thank you to the witnesses for being here. I just want to say I appreciate the testimonies today and the questions. I think it has been very informative. I want to recap a couple of things.

First, high-speed rail, I have looked at that project in Texas and I think if there is any place that high-speed rail would work in our country, it is probably from Dallas to Houston. So I hope that the private sector will move forward with building that and that we in Congress can help that along, as well.

But I wanted to, and also, when we talk about modes of transportation that are fuel efficient, we talked a lot about rail but we forget oftentimes about our inland waterways and barges that are the most energy efficient means of moving goods that we have. So I hope we keep that in mind as we look at ways of creating more sustainable transportation.

But as we look at kind of the global numbers and where we fit and where U.S. transportation fits in that, the best data I could find says that the U.S. accounts for about 15 percent of global greenhouse gas emissions. And, Ms. Young, in your testimony, you had a chart in there that shows that the U.S. transportation sector is about 28½ percent of U.S. greenhouse gas emissions. So that means that, you know, 28½ percent of 15 percent, means that the U.S. transportation GHG emissions are about 4.3 percent.

So as we look at ways to trim that, we also have to remember that there is a whole other world out there creating greenhouse gas emissions. And that is why I think we need to look at all the different energy sectors as we talk about this. But we can definitely make some impact on U.S. transportation.

Ms. Young, you in your written testimony, you talked a lot about sustainable alternative jet fuels. And I think when we talk about sustainable fuels, we often think that any liquid fuels are not sustainable. But we know that these sustainable alternative jet fuels are made from biomass. And I was just looking at some other data.

In 2015 in California, with all the controls put in place, they were able to offset 1.49 million metric tons of greenhouse gas emissions. Yet the wildfires in California generated 22.8 million metric tons of carbon, which is 15 times more carbon was emitted in those wildfires than what the State of California was able to reduce.

So as we think about liquid fuels and the vast forest resources that we have here, can you elaborate a little bit more about where we are on alternative liquid fuels?

Ms. YOUNG. Yeah, really, thank you for the question. We are very proud of what we have done through the Commercial Aviation Alternative Fuels Initiative to really create the path forward for sustainable alternative jet fuel. And so, you know, beginning in 2006, we started that process. And what we did is we drove the jet fuel specification, which used to only allow petroleum-based fuel, to allow for alternative feedstocks, that also have carbon content, frankly.

So an example, really picking up on your thoughts there, we can take woody waste, so we are not knocking down trees to do this but after a fire or, in the Pacific Northwest where they have, you know, specified amounts of logging, you are able to take out the waste product from that and turn it into jet fuel. In fact, there are two of our members are working with Red Rock Biofuels in Oregon on exactly that type of an approach.

We have United Airlines working with waste residues from cropping. So again, not the food but with AltAir Fuels in California to create sustainable alternative jet fuel.

Mr. WESTERMAN. I am going to have to move along. I have actually got another question I want to submit to you on NextGen, performance-based navigation but I will give that to you in writing if you can reply back to the committee.

Last week in my district, I drove a Tesla. It was an amazing piece of equipment. Being an engineer, I had great appreciation for it. But I know that Tesla requires electricity to operate. And electrical generation and industry make up about 50 percent of the greenhouse gas emissions in our country.

So Dr. Sperling, real quickly, how important is it to develop nuclear, hydro, all the other renewable energies if we move into more of an electric situation?

Mr. SPERLING. This is speaking for myself but, certainly, I believe nuclear is part of it, is part of the solution. Hydro, we have developed most of the big hydro, so probably limited options there. But nuclear, for sure. And wind and solar are the other major ways of reducing emissions in the electricity sector.

Mr. WESTERMAN. Not out of questions but out of time, Madam Chair.

Ms. TITUS. OK. We need to worry about nuclear waste if we go down that path.

I will now recognize Ms. Norton for 5 minutes.

Ms. NORTON. Thank you, Madam Chair. I suppose actually this question is for whoever wants it, perhaps Ms. Arroyo or perhaps others of you, as well.

The Nation's capital, where we are as I speak, sits on the banks of two rivers, the Potomac River and the Anacostia River. It is interesting that the framers built this Capitol on a hill. Maybe they had some understanding of what might be coming a couple of hundred years later.

We have already had to build a levee, the 17th Street levee, because among the low points, perhaps the lowest point is downtown Washington, where the Federal Triangle is. And you will see buildings or agencies there, such as the Justice Department and the IRS—people don't like to see the IRS coming but they certainly

don't want it flooded because we are just going to have to pay for it.

About 10 years ago, there was a serious flood here. Constitution Avenue was under water. I recall distinctly that the National Archives, where some of our most precious documents are housed, was under water. They then had used a self-rising wall for downtown Washington.

So this thing is coming so fast, I am interested in the use of non-polluting vehicles. I drive a hybrid. I am very interested to get to the point where I drive an electric car. But some of them have, for example, we are having in this city, the District of Columbia, we will use the notion of a rebate, where you pay more based on the emissions generated by the automobile that you have and you get a rebate if you do not have as many emissions.

So I would like to know how effective—because these things are beginning to catch on, not only here but around the country. How effective are these rebates or fines, virtually, in encouraging the use of low-emission vehicles? Is it going to be sufficient to have an effect as climate change comes upon places like the Nation's capital so quickly? Are we running out of time or do these really make a difference, particularly when some of these cars cost more than cars that pollute, use gas that pollute?

Ms. ARROYO. So, thank you, Congresswoman. Indeed our center at Georgetown, where you also teach, I know, works with Tommy Wells and his staff here on resilience, the impacts of climate change the District is already seeing, including in ward 7, which is already experiencing flooding from rain events.

But as Tommy Wells believes, I believe in electric vehicles as part of the solution. I drive a Bolt. It has been terrific. It is my first American car that I have ever bought and it was more expensive than cars that I bought in the past. So I do think it is a case where a rebate makes a difference in the upfront cost of it even though, over the course of a lifetime, that cost, you know, is actually less than a gasoline vehicle.

And DC actually gets a shout out in my testimony, in the longer version of it, because you do have what is known as a feebate kind of a program in practice, where people who buy and drive gas guzzlers subsidize the purchase of those more efficient vehicles. And that could be a model for the country, I think.

Mr. SPERLING. And I would like to just add to it because this is one of my favorite policies, this idea of feebates. Because it is—you can make it revenue neutral so there is no burden on taxpayers at all. It is simply a trade from people that are buying the gas guzzlers. And, in fact, we have a gas guzzler and it has been in place since 1975 but it is only on cars and it is only for the most inefficient cars. So this is not a new idea, at least on the fee side of it.

So I think this is an outstanding way of using market forces to accomplish an environmental goal.

Ms. NORTON. Thank you very much. Thank you, Madam Chair.

Ms. TITUS. Thank you. We will now recognize Mr. Lynch for 5 minutes.

Mr. LYNCH. Thank you very much, Madam Chair. And I want to, as well, thank the witnesses who have been terrific with their testi-

mony and I appreciate you helping the committee with its work this morning.

Recently, in the latest worldwide threat assessment of the U.S. intelligence community issued by Director of National Intelligence Dan Coats, he said that climate change poses a serious global threat that could further spark international political instability, adverse health conditions and humanitarian crises. Meanwhile, President Trump says he is not a believer and, what is more, he has established an ad hoc committee to reassess the fact of climate change and the science around it. And in doing so, he has appointed some scientists who, like himself, do not believe in climate change.

And so I want to ask you, considering our efforts here, is that helpful? Does anybody on this panel think that that is helpful? OK, I didn't think so.

I, on the other hand, I hate to be a self-promoter, but I have a bill. I chair—another hat I wear is the chair of the National Security Subcommittee of the Committee on Oversight and Reform and I have got a bill that actually would reinstitute the preexisting initiative which basically asks all of our branches of Government, all of our departments just to look at their own operations and see how we might build resilience and help to prepare for whatever is coming down the pike at us in terms of climate change.

I have a special bone to pick, though, Ms. Young. So I am also on the Subcommittee on Aviation here and I mean this as a friendly exchange. But we talk about RNAV NextGen, this aviation system that is very, very good at conserving jet fuel, because you have got hundreds of thousands, millions of flights that come in over the course of a year across our country and everybody is on this tractor beam, it is really precise, it's laser-like, so that tens or hundreds of thousands of flights per year go over the same home, go over the same child's school.

So while there is a—it is sort of counterintuitive. I know we are trying to save jet fuel. But I worry about—I have one of those districts, I am in a coastal community, I represent the area surrounding or near Logan Airport in Boston. And so I have some towns where it is relentless that this focus, this laser beam has flights coming in. I could stand, I could look out my window, I can tell—I am so close to the airport that I can tell whether people have their tray in the upright position going by, of the plane going by, I swear. So I have two hearing aids, it is over for me.

But the towns I represent, I worry about their health. The emissions coming from those planes, and the noise is driving them nuts. And so these are over schools, these are over small towns. And is there some way, look, now, I understand you want to save jet fuel. And so I am only talking about the end approach of their flight. I am not talking about, you know, redirecting so there is a huge waste of jet fuel. I am just talking about when they get in X number of miles, 8 or 10 miles of the airport and they start to decrease in altitude, could we, could we change the approaches so that same house in Milton, Massachusetts, is not getting, you know, 10,000 flights a month? Or the Cunningham School in Milton, Massachusetts, those kids are not getting that plane flying over their school every single day?

You know, I have a bill that we are hopeful will succeed in terms of having the Academy of Sciences look at the impacts of that. I would really like to have, you know, somebody on the human side, if you will, maybe the Harvard School of Public Health, look at the environment that we are putting my constituents in. You know, these small towns, these neighborhoods of Dorchester and South Boston and Milton and Hull that are sort of on the vector, you would say. Is there any—are we looking at this at all?

Ms. YOUNG. Absolutely, Congressman. So first, you know, anybody who experiences aircraft noise, you know, we appreciate that that is not something that they would like to have. But we also have to keep this in context. I mean, the U.S. airlines reduced the number of people exposed to significant levels of aircraft noise by 94 percent—

Mr. LYNCH. Because you put them all over one house.

Ms. YOUNG. We did that by more than quadrupling enplanements. And you are correct, some of the performance-based procedures under the NextGen program do concentrate or shift the noise. And so people who either did not experience it before are experiencing it or, as you suggest, it does focus it in more precise flight paths.

So there are various ways those things are being addressed. One, we continue our relentless effort to reduce noise overall at the aircraft source, through our own efforts, through working with the manufacturers and programs like CLEEN. But second, as you roll out these new procedures or you revise the procedures, in 2014 and 2016, the NextGen Advisory Committee recommended very specifically to FAA to enhance its community engagement processes to consider exactly the issues that you are talking about. And they have embraced those, maybe not at the time 5 years ago, 7 years ago, but they are undertaking that approach to take into account community involvement and roundtables, including—

Mr. LYNCH. OK, you ate up all my time. We are actually over here. Let me just say, Madam Chair, thank you for your indulgence, I really appreciate that.

Look, it is a coastal community. You can fly over the water. We can solve this thing. Fly over the water rather than over the houses. It is really simple, but I need your cooperation on that. So maybe we can talk later offline.

Madam Chair, I yield back the balance of my time that I don't have and I appreciate your indulgence.

Ms. TITUS. You have no time. Starting to sound like a "Saturday Night Live" skit. I can see the plane tables from my back porch, something like that.

We will now recognize Mrs. Napolitano for 5 minutes.

Mrs. NAPOLITANO. Thank you, Madam Chair. And, Mr. Lynch, I agree with you. My constituency also has complained bitterly over that NextGen situation.

Have any of you considered the education of the public on all of the things that you talk about?

Mr. SPERLING. That is our job as professors.

Mrs. NAPOLITANO. But what means do you use to get the public to know about pollution, about the climate change, about everything you talk about?

Mr. SPERLING. That is one of the key strategies going forward, is for us to understand, you know, what are the impacts and implications and what we, as individuals and as consumers and as taxpayers, can do about that.

Mrs. NAPOLITANO. Anybody else?

Ms. ARROYO. So our center, as I mentioned earlier, facilitates something called the Transportation and Climate Initiative and, last year, the States in this region worked together on a bipartisan basis to hold 6 listening sessions that engaged 500 members of the public—

Mrs. NAPOLITANO. I know but that is members, that is people that are working on it. But you don't disseminate to the general public. They need to hear from you.

Ms. ARROYO. Right. And that is a great point, and we did really try to reach out to diverse constituencies. And we got a lot of really unusual bedfellows in the room. But I know it is just a start.

The other way that we try to have information is up on the website that has the State—

Mrs. NAPOLITANO. Who knows what the website is?

Ms. ARROYO. Right. So, I mean, we try to make our resources available broadly and for free.

Mrs. NAPOLITANO. We need to get more of that out. Anything else? Anybody else?

Ms. YOUNG. I would like to add, I mean, our airlines, the types of measures I talked about in my written and oral testimony, our member airlines share that information in the magazines that they offer on the plane—

Mrs. NAPOLITANO. But it is on the plane. Only the passengers see it. What about general public?

Ms. YOUNG. Well, we meet very frequently with communities and talk about this array of initiatives.

Mr. PROCHAZKA. I will just add that we continue to release reports to document all the different challenges that might exist with our transportation sector and then we use those as mechanisms to communicate with the public. And so those get sent out broadly. We communicate with mass media. We actually work in communities in your district to help make sure that those kinds of resources get folded out, they do get out to communities.

Mrs. NAPOLITANO. I think we need to do a lot more of that. I am sorry to cut you off. But this goes on.

What about the gas tax? Do you think we need to increase the gas tax? Question. Yes or no?

Mr. SPERLING. We need more funding for transportation.

Ms. ARROYO. I do. And many States have actually increased the gas tax.

Mrs. NAPOLITANO. Oh, yes. But I mean Federal. We have not had an increase in decades.

Ms. ARROYO. Yes, yes. I think it is overdue. I think it is overdue. And I think there are other ways that you can increase revenues to invest in cleaner and more resilient transportation as well.

Mr. LYON. I think you need to either increase the gas tax or institute a VMT, vehicle miles traveled tax.

Mrs. NAPOLITANO. True.

Mr. PROCHAZKA. I think we need a comprehensive effort to figure out how we are going to fund the future of transportation. And we would love to work with you and the committee to help figure out the right path.

Ms. YOUNG. Well, I was not really going to speak about the gas tax because we use jet fuel. So we are a very heavily taxed sector and, as you heard in my testimony, we were already very motivated by the fact that fuel is number-one or number-two cost in any given year to do, you know, reduce emissions and fuel burn.

Mrs. NAPOLITANO. Thank you. Ms. Arroyo, our water managers—this is another topic—are seeing firsthand the effects of prolonged drought, less snowpack, more flooding, extreme rain events on our communities and on our infrastructure system. They do not have time to debate climate change and they are dealing with it now. Why is it important to build resiliency?

Ms. ARROYO. Well, because, as you said, people are already experiencing these impacts, whether they are facing drought and fires in the West or flooding in my home State where Congressman Graves has been a leader on trying to build resilience. And one of the things that we do aim to do is to provide tools to translate the science to those policymakers and communities that are on their front lines and figure out how they can build or rebuild differently with the fact that the future is going to look different from the past in mind.

Mrs. NAPOLITANO. Anybody else?

Mr. SPERLING. I would just note that, as we discussed earlier, mitigation is a lot cheaper than adaptation. We need to do both because, as Ms. Arroyo said, it is happening. But at the same time, we need to be putting a lot more effort on the mitigation. In the long run, it will be much cheaper.

Mrs. NAPOLITANO. Well, in the metropolitan area where I come from in Los Angeles, we do not have a good transportation system. But because they passed, as you know, transportation bonds, it is still not enough to handle the mass transit that is necessary. Also, people cannot afford to go on trains, so they use the gas guzzlers. We need to change that.

Mr. SPERLING. I will just very quickly plug the idea, one of the major themes I have been trying to articulate is that we do have the tools and the business models and the technologies to solve much of that, to provide better access to lower income, disadvantaged communities, to increase pooling services. Because now there is information available. We can pool trips, we can provide first/last mile access, we can use these micro—you know, vans that run like Lyft and Uber. There are a lot of tools that we did not have 5 or 10 years ago.

Mrs. NAPOLITANO. I know. But the unfortunate part is that—well, I will submit it to you.

Ms. TITUS. Perhaps you could send that to us in writing if we have that information.

We will now go to Mr. Smucker for 5 minutes. And we apologize that we didn't see you earlier, so maybe you could take a few—a little extra time.

Mr. SMUCKER. Oh, wonderful. I will take that any day. So thank you. So shuttling between this and a markup. But thank you, Madam Chair.

Mr. Prochazka, I am particularly interested in the work that your organization is doing, that you are doing. And I think your goal of less reliance on foreign oil has been shared widely with folks over the last few decades. And I think you will agree with me, we have made tremendous progress in that regard, where we are talking today about being a net exporter of energy. And that would have been unheard of that we would be making those kinds of projections just 20 or 30 years ago.

And I think one of the reasons for that is we have new technologies that have been—we have been able to tap into shale fields and others and extract natural resources, but specifically natural gas, but oil as well from the ground. In Pennsylvania, I represent Pennsylvania, we have the Marcellus shale, which is one of the largest fields in the world, really. And so I think that has been tremendously beneficial. Would you agree with that?

Mr. PROCHAZKA. You know, yes. We have had great steps forward in terms of the ability to domestically produce.

Mr. SMUCKER. And I think you were asked this question before and I may have missed some of it. But I was in the State Legislature of Pennsylvania when we were working on ensuring that that industry could develop and there was, you know, talk and push for natural gas vehicles. And it really came down to one of the same problems we have with electrical, which is fueling stations along the way.

Do you see natural gas vehicles as part of the solution here? Or are you focused entirely on electric vehicles?

Mr. PROCHAZKA. My sister organization, Securing America's Future Energy, really focuses on sort of the full space of alternative fuel options. And so they have come up with a publication called the National Strategy for Transportation that talks a lot about what that full scope ought to look like.

I do think there is a difference around the idea of electric vehicles and, you know, sort of the transition. Electricity is already ubiquitous. We already have the system in place and it is just about tapping into it throughout the places that we drive. And I think that is already showing to be very easy to do at this point and we just need more stations to provide more charging and then we will have more vehicles that will use them along the way.

[Mr. Prochazka has submitted the following post-hearing supplement to his testimony:]

As I mentioned, the Electrification Coalition's sister organization, Securing America's Future Energy (SAFE), published a report in 2016 titled "A National Strategy for Energy Security: The Innovation Revolution." This document provides a strategic blueprint for enhancing our energy security through a series of actionable policy recommendations across four areas:

- Increasing fuel diversity in transportation;
- Advancing the next generation of transportation technology;
- Bolstering American oil production; and
- Combating oil market manipulation.

Strengthening our economic and national security requires a multifaceted approach to diversifying the fuels used in our transportation sector—including natural gas and electricity—and leveraging opportunities for domestic energy production.

For your interest, I have included with this letter a digital copy of the report. [The report is retained in committee files and is available at: <http://secureenergy.org/wp-content/uploads/2016/06/SAFE-National-Strategy-for-Energy-Security-2016.pdf>.]

Mr. SMUCKER. You mentioned in your report cost parity and I just want to hear you talk just a little bit more about it. You think we have reached the point where the cost of buying and maintaining an electric vehicle over its lifetime is now the same as a petroleum or gas vehicle?

Mr. PROCHAZKA. Thank you for the question. And, no, actually I think we have reached the point in large part, depending on the vehicle, but where driving an electric vehicle and taking into account the total cost of operation is cheaper.

Mr. SMUCKER. OK.

Mr. PROCHAZKA. And so it is part of the reason that right now it makes sense to create incentives so that, as the technology is becoming more—

Mr. SMUCKER. I am going to stop you because I want to get to another question.

Mr. PROCHAZKA. Please, go ahead.

Mr. SMUCKER. So wouldn't this be the time to start pulling back some of the Government incentives? You know, I understand the need for incentives. I was involved with the solar industry to some degree, policy with the solar industry. I understand, you know, you have to have a driver that begins to drive down the costs. And in electric vehicles, of course, it is the battery cost and efficiency.

But, you know, we are very close to that tipping point. I think most of the major manufacturers are—they have even set timelines for when their vehicles are going to be entirely electric. So isn't this the time to begin to pull back the subsidies? And wouldn't it be particularly harmful to add an additional layer of Government regulation at this point?

Mr. PROCHAZKA. So, and I can see others want to respond, so I will very quickly say, no, it is quite the opposite. We are actually right at the verge where we need to be, if anything, pushing faster and pushing harder.

Mr. SMUCKER. So at some point, there will be a tipping point where you will not need the Government subsidies?

Mr. PROCHAZKA. Absolutely. Frankly, I believe that we will hit that point at some point and we will need to remove them and EVs are going to be able to compete on the cost.

Mr. SMUCKER. I know I am going to get a little extra time but I do want to get to another question. So we did have a hearing here just a week ago, I think, about a new infrastructure package, how we are going to fund the Highway Trust Fund. One of the ideas—I mean, we know that, you know, the gas tax is a declining source of revenue, particularly if you get your way and vehicles are going to go to entirely electric, which eventually it will, that is going to happen eventually. But one of the thoughts was a Federal registration fee on electric vehicles. I guess my question to you is, from the perspective of an organization pushing for electric vehicles, what do you think makes sense? How do electric vehicles do their part in providing for user fees to pay for our roads and highways?

Mr. PROCHAZKA. I mean, unquestionably, there is going to be a need for EVs to pay their fair share. We are going to need to figure out a solution for how our highway—

Mr. SMUCKER. Are you thinking of any specific proposals?

Mr. PROCHAZKA. I think that there are a lot of things we need to look at, whether it is a user fee, that might be—that is a question, still. I am not sure it is the right solution, exactly. There might be VMT that needs to be considered, so that we are actually thinking about all vehicles paying for use.

I think we have to go and work hard to think about all those solutions and what are going to work the best for what our diverse and future transportation system looks like.

Mr. SMUCKER. Thank you. I know that others wanted to respond. That will be up to the chair as to whether we have time to do that.

Mr. ESPAILLAT [presiding]. They can respond in writing, thank you.

Mr. SMUCKER. Thank you.

Mr. ESPAILLAT. Now we will go to Mr. DeSaulnier.

Mr. DESAULNIER. Thank you, Mr. Chairman. And, like my friend from Pennsylvania, we have been going back and forth from the same committee markup.

Dr. Sperling, it is nice to see you. As a former member of the Air Resources Board, we are probably the only two on the east coast right now.

I wanted to ask the panel, and starting with Dan, having been the author of VMT, the pilot project in California, when I was in the legislature, having spent—I was the coauthor of 375, 65 percent of the U.S. economy now is in these urban areas, super-urban areas. We have spent a lot of money on heavy rail. For those of us who wanted to see urbanization, we thought that was good. But we clearly are not prepared for things like Lyft and Uber.

So, Dan, to your comment earlier about better systems management, as a specific, at SFO in San Francisco, and this is not untypical for airports, we spent a lot of money, billions of dollars, to bring heavy rail into the airport. We are doing it here in DC right now, they are doing it in Los Angeles. But over 50 percent of the trips now in and out of those airports are Lyft and Uber. So how can we incentivize a lot of the good trends that are happening, knowing that electric vehicles are coming, but more the smart technology incorporated in a smart mobility that you alluded to in your earlier answer.

Mr. SPERLING. I would say there are two parts. Thank you. There are two parts to it. One is, how do we use these new innovations in a way that is in the public interest and in the interest of airports, you know, specifically. And that is that, instead of—OK, so this is a simple thing. But airports now, they put a per passenger fee on everyone that comes in. That is crazy. They should be—if a vehicle comes in with 2, 3, 20 people, they should have a zero fee on it and have a large fee if it is a single passenger. Manage the curb space better also, so that the pooled vehicles get preferential space at airports. And these same ideas, of course, translate to cities more broadly, it is not just at airports.

The other part is the electrification and going back to the earlier question on electrification. We do need and want to and plan to

electrify certainly all of the light-duty vehicles. And these Lyft and Uber type cars, they are generating huge amounts of mileage. So those are a prime target to electrify. And Lyft and Uber are interested in doing that. We are creating various incentives. And I think that is a kind of partnership that can happen to create these incentives for them to do it.

But I would note one thing on the electrification part is, we are getting close to cost of ownership being competitive for small cars. And so there are two parts to that. One is, it is small cars. And the other part is, it is total cost of ownership, which is not how people make choices.

So we are going to need incentives for a long time. And especially as we move into the bigger vehicles, as we get into the pickup trucks, SUVs, even small delivery trucks. So this is a long-term commitment and there are ways of doing it that it is not a burden to taxpayers. But there will need to be incentives. And I think we need to apply that, figure out how to do that with Lyft and Uber and Via and those other companies.

Mr. DESAULNIER. On the land-use side, anybody, one of the challenges to VMT in a place like the bay area is we have got working people who are starting families and they are traveling 2 hours, mega commutes, in and out of the region. Have the same problem in the Inland Empire in L.A. It is a real constraint on our economic development. There is a story in the San Jose Mercury News today about how, in spite of creating more jobs than anywhere else in the country and the world, Silicon Valley, we still have people leaving the area. A lot of those people, I assume, are going to the 10 counties that surround the 9 bay area counties.

So this conundrum of VMT and being fair to everybody, but overall systems management, many times, in interregional areas, as defined by the Federal Government. So maybe any kind of insights about how we could put some kind of incentives in that? And I know that the Federal Government and most State government does not like to get involved in local land-use decisions. But our absence is making decisions for people.

Ms. ARROYO. So some of the experience in Arlington that has reduced VMT there while having—or at least held emissions and VMT flat while growing the economy has been to incentivize dense, compact development. So things that used to not be allowed are actually encouraged, building more units closer together. Instead of having a minimum number of parking spaces, having a maximum number of parking spaces. And, of course, coupling that with incentives that drive people to transit and other alternatives, having safer bike paths now, more walking, et cetera, et cetera.

So, I mean, we've learned a lot about transportation demand management. And it would be great to scale that up by, for example, maybe having the Federal Government both continue to offer those employer incentive programs for people who telecommute or take transit, but also sharing best practices would be something that the Federal Government could help do, I think.

Mr. DESAULNIER. I think the Dulles corridor is a real example of what we could do in other places. Thank you, Mr. Chairman.

Mr. ESPAILLAT. We go now to Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman. Before I ask my question, I would like to just sort of preface it with three points. One is, and I think there is a consensus in Congress that would agree that climate change is a national security issue. I think some of you have touched upon that in your written and/or oral testimony today. In 2018, in the Defense Authorization Act, Congress directed the Pentagon to come back with a report on the impact of climate change on military operations, on infrastructure, as well as the efforts by the Pentagon to increase installation resiliency and operational viability, concerns with things like the wildfire in California which closes down the Marine Mountain Warfare Training Center or rising sea levels and the impact at Norfolk. In the 2018 MILCON appropriations bill, we put in language that urged the Secretary of Defense to plan infrastructure and other projects using the best data and science on climate to mitigate the risk to our Armed Forces.

The second point I wanted to make is that I think we all would agree that the DoD is perhaps the largest fossil fuel consumer in the United States. And that is probably why, as early as 2007 in the Defense Authorization Act, which was signed by President Bush, we directed the Pentagon to adopt 25 percent renewable standards by 2025. And as of 2016, they were 50 percent towards that goal. They reduced fuel usage, increased energy efficiency, and it had tremendous benefits to the public utilities in those communities and solar companies in the vicinities of those military installations.

The third point I wanted to make is that, while, you know, the DoD is this large energy consumer, 75 percent of that consumption is on military operations, not necessarily on the installation but the operations in Afghanistan and in Africa, you know, just global operations. And the DoD recognizes that green energy is important. And whether it is motivated by reducing the impact on climate or saving the lives of soldiers and sailors and airmen and Marines, we know that by going to renewable energy sources reduces the burdens on logistic trains and convoys, the number of times that a unit has to stop to refuel, which exposes them to threats and vulnerabilities and things like that. So the DoD, either because of the authorization act in 2007 or a recognition that it saves lives, has been transitioning to renewable energy.

So my question is, and I think that Mr. Prochazka—did I get that right?

Mr. PROCHAZKA. Prochazka.

Mr. BROWN. Prochazka, OK. I know you had mentioned that dependence on foreign oil is a national security concern. So can you or others elaborate on, you know, your thoughts on how moving towards electric vehicles and efficient transportation alternatives, how it can help strengthen national security and also how the work that is being done at the DoD benefits the overall effort in moving to a renewable energy environment?

Mr. PROCHAZKA. Thank you for your question. So two quick things. One is our sister organization, Securing America's Future Energy, actually brought together military leaders to respond to this issue and created something called the Energy Security Leadership Council and it is made up of four-star generals and admirals

and some of the leaders in national security, with the idea that we need to do something to respond to the impacts of our oil dependency. And, as you mentioned, it is both because it is about the economic impacts to our country, in that when oil prices spike, it affects everyone. But it is also because it does affect the lives of young men and women across the country that we send over to protect the flow of oil. And ultimately, the more that we can do to reduce the amount of oil that we need to consume in this country by electrifying our transportation sector, the less likely we are putting our young men and women in the face of threat.

Ms. YOUNG. I would like to add from the aviation sector, in 2010, we entered into a strategic alliance with the Department of Defense through its Defense Logistics Agency, so we could align our drive on the jet fuel specification for sustainable alternative fuel with what the military was doing. And together, we have worked that process very successfully.

Mr. BROWN. I yield back the 1 second time I have remaining, Mr. Chair.

Mr. ESPAILLAT. We will now go to Mr. Johnson.

Mr. JOHNSON OF GEORGIA. Thank you, Mr. Chairman. And I want to thank the panelists for being here today. And let me pull to my questions. You called on me quickly.

Despite the overwhelming scientific consensus that climate change is happening and that humans are the primary driver; this administration is using Government resources to promote fringe science. Mr. Prochazka, President Trump is reportedly forming a panel to question whether the burning of fossil fuels is harming the planet. Allegedly chairing this panel is Professor William Happer, distinguished physics professor with no formal training as a climate scientist, who once argued the dubious proposition that we need to spew more carbon dioxide into our environment, not less. Professor Happer has also argued that the demonization of carbon dioxide is similar to the demonization of Jews in Germany by Hitler.

What are the national security dangers that the White House is risking by challenging the relationship between carbon dioxide and global warming?

Mr. PROCHAZKA. I might defer to other members of the panel. My organization focuses almost primarily on the impacts of oil and gas dependency on economic and national security threats. So we don't really focus as much on climate issues.

Ms. ARROYO. I'm happy to take it.

Mr. JOHNSON OF GEORGIA. Yes, ma'am.

Ms. ARROYO. So not only are the military facilities at risk because, obviously, the Navy has to be at sea level and so their ports are at risk, but their operations are also affected. The freshening of the water from the melting of the huge ice sheets and glaciers actually affects our sonar and so our military readiness. It actually affects the engagements that our troops are being brought into all over the world in more and more contentious conflicts over limited resources, impacted by the lack of food or water that are driven by some of the climate extremes that we are seeing. And not only that, but in our own country, as we have seen in communities like my home town of New Orleans, our military gets deployed to try to

help out in the times of national emergency and we are seeing more and more of those disasters declared on a regular basis every year, you know, with megastorms hitting Puerto Rico and North Carolina and on and on. So they are stretched thin, they are underresourced and climate change is going to make all of these things much more challenging.

Mr. JOHNSON OF GEORGIA. Thank you. Does anyone else want to opine on how this panel that Professor Happer will chair may impede our ability to secure our Nation? Yes?

Mr. LYON. One of the biggest concerns I would have is just that it could help to promote the muzzling of the defense community which, as we've just heard, is highly aware of all of these concerns. And so one of the biggest issues would be censoring the intelligent foresight that the defense community is already engaged in.

And I would just point out that this is a wonderful example of the merchants of doubt strategy that has been written about so eloquently by Naomi Oreskes and I really encourage people to read that book. It turns out that it has been the same group of sort of very old, Cold War physicists who first advocated that smoking didn't cause cancer and now argue that greenhouse gases don't warm the planet.

Mr. JOHNSON OF GEORGIA. It is kind of an unscientific situation led by so-called scientists.

Mr. LYON. They are typically being paid something.

Mr. JOHNSON OF GEORGIA. Yeah, by the interests that they are promoting, no doubt, the coal and fossil fuel industries. Correct?

Mr. LYON. I don't know for sure. The George C. Marshall Institute has been a major player in supporting these Cold War physicists and I don't know for sure where they get all their funding. But it would be very likely that it is fossil fuel-oriented funding.

Mr. JOHNSON OF GEORGIA. Thank you. Perhaps Congress may do well to create some legislation that would require these so-called independent studies by scientists to disclose who is actually funding their work.

A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support. Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle Governors in terms of their interactions with the Federal Government henceforth on infrastructure?

Mr. SPERLING. Probably not California.

Mr. JOHNSON OF GEORGIA. And that's a good thing.

Mr. ESPAILLAT. You can respond, the rest can respond in writing, please. We appreciate it.

Mr. JOHNSON OF GEORGIA. I yield back. Thank you.

Mr. ESPAILLAT. Thank you. We now go to Mr. Rouda, please.

Mr. ROUDA. Thank you, Mr. Chairman. I am Harley Rouda, from Orange County, California. And my wife and I are proud owners of electronic vehicles and a fully solar-powered home. And the question I have for any of you, California has recently passed legislation requiring all homes to have solar panels. And I am curious as to what you think of that being a national standard? And while I recognize that California likely has more days of sunshine than

many other States, I also recognize that North Carolina and New Jersey are leaders in implementation of solar power, solar panels on homes, and that economic incentives can help drive this. So I'll open it up to the panel for your response.

Mr. SPERLING. Thank you. Well, I am not an expert on the solar energy but my colleagues who are, the economists anyway, would argue that the more efficient way of providing solar energy for electricity is through centralized facilities. But I also have solar on my house and I am very proud and happy with it and it works great for me.

So I think it is part of the question of, there is a certain tension there in terms of utility investments versus household investment. Certainly, creating incentives to support those households that do it, I think, is a good idea.

Mr. LYON. If I could just follow up on that, it raises an issue that we really have not talked about, which is the modernization of the electric grid itself. And I think regardless of exactly how you view the importance of rooftop solar versus centralized solar, we really need to modernize our electric grid. There are digital technologies that will allow it to be much more efficient, much more resilient and will allow for net metering and other types of decentralized production.

Mr. ROUDA. I am actually glad you went that direction because that is one of the other topics I would like to expand on, that is the decentralization of the grid and developing microgrids throughout the country. But we have seen some pushback by certain utilities across the U.S. who want to continue to be the primary generator of energy for their region and have not really accepted that paradigm shift that they need to move from a generator to more of the toll roads of electricity to serve the communities that they serve. How would you respond to that?

Mr. LYON. Well, I think you are correct. And State policy has typically been the driver that has led utilities to modernize their grids, open up to net metering. Most States allow net metering now so that has become pretty standard. But I think this is where State policy has probably been more powerful than Federal policy. Just because of the role of the State PSCs.

Mr. ROUDA. And bringing it back to electric vehicles and the continued development and implementation of electric vehicles, one of the challenges that we face are the high-speed recharging stations, access to them, consistency in the standards and, frankly, even signage on the interstates. What would you like to see in those areas to help develop that infrastructure at a faster pace?

Mr. SPERLING. Yeah, you know, I would comment that, indeed, that the growth of electric vehicles is inextricably connected with the grid and it provides a tremendous opportunity as we go to more ephemeral sources of energy, solar and wind, the role of storage becomes hugely important. And electric vehicles can be a very big part of the solution in terms of the vehicle-to-grid type options.

Ms. ARROYO. Having Federal support to fill the gaps, especially in more remote areas that are not as urban and clustered would give people confidence and overcome some of the range anxiety issues, so that would be an early investment. And also maybe tying the use of funds to things like being able to use a charge card to

pay. Because when I tried to take my Bolt up to a wedding in New Jersey, I noticed that different places I stopped had different services. And so it is not like going to an ATM where you can use another bank with your card. We should make it easier for people and these are the kinds of things that Federal funding could be tied to, perhaps.

Mr. ROUDA. And then the last question I have is just on economic incentives in general. Historically, the economic incentives have not favored renewable energies to the same degree as other sources. And if we shift those economic incentives or at least even take into account the long-term implications of the pollution that is created versus renewables, what in those toolboxes of economic incentives would you suggest would help push this forward?

Mr. LYON. Are you thinking electricity now?

Mr. ROUDA. Yes.

Mr. LYON. Well, we are already at a point where wind is cheaper on a per kilowatthour basis than coal or nuclear. And a lot of coal plants are having to shut down because they cannot compete with wind. So we are moving very rapidly toward a world where wind and increasingly solar are going to be highly economic and just continue to take off.

Mr. ROUDA. Well, thank you for your time. I yield back.

Mr. ESPAILLAT. Mr. García.

Mr. GARCÍA. Thank you, Mr. Chairman, and I want to thank the leaders of the committee for organizing this hearing to address one of the greatest challenges this generation is facing and that is climate change. In order to adequately address this crisis, we must aggressively tackle the root causes, the risks, the economic impact and public health hazards that climate change poses. Particularly, I want to emphasize, in underserved working class and minority populations. I support the spirit of the Green New Deal and I cosponsored the nonbinding resolution because we must acknowledge that bold action needs to be taken to address this century-old trend that threatens our world.

The work of this Congress and this committee, however, is to turn that vision into reality. It is time that we put pen to paper, roll up our sleeves and convert bold ideas into actionable policy changes. I am proud that this committee is doing that.

The fact is that climate change will result in more extreme weather events and put more strain on our already crumbling infrastructure. During the last polar vortex in Chicago, two steel beams supporting Lake Shore Drive along the lakefront cracked, as did transit rail in Minneapolis. As demonstrated in our successful reversals of the Chicago River to protect Lake Michigan as a freshwater source, innovative, resilient infrastructure is in Chicago's blood. Much of Chicago's existing infrastructure, however, was built in reaction to environmental challenges that we have faced historically. But decisions made decades ago left communities of color out.

I raise this because, as we consider the long-term infrastructure investment, we must seek more equity in legislation that will have decades-old consequences. Too many communities have been left behind without adequate mobility, are at a higher risk of extreme weather events, and are disproportionately exposed to toxic air and water. Chicago recently received an F for air quality from the

American Lung Association and, according to the EPA, 8 percent of Hispanic children in the U.S. have asthma compared to 6.5 percent nationally. Hispanic children in the U.S. are almost twice as likely to be hospitalized for asthma than white children. Failing to address climate change hurts, but it hurts communities of color more severely.

Looking ahead, the question before us now is what policies do we change and how? According to 2016 data from the EPA, emissions from residential and industrial buildings as well as from transportation emissions account for nearly 40 percent of greenhouse gas emissions. Electricity generation accounts for nearly 30 percent. In short, we need cleaner transit and more energy efficient structures because they have tremendous returns on investment.

In Chicago, we've committed to converting our bus fleet to 100 percent electric by 2040. The city has reduced its overall carbon emissions by 11 percent from 2005 through 2015, while jobs grew 7 percent, dispelling the myth that greening our industry weakens our economy.

Our conversion of over 270,000 streetlights to LEDs in 4 years will yield a savings of \$100 million over a 10-year period. Our comprehensive approach to green infrastructure will make us more resilient.

As a matter of fact, I would like to enter into the record a comprehensive report issued by the city of Chicago, entitled "Resilient Chicago," which details a roadmap forward for our city. And this will be in place as Chicago goes to the polls today to elect a new mayor and a city council. We may have to do a runoff in April, but that will be a fact.

I would like to direct a question to Ms. Arroyo, as I have about 30 seconds left. And that is, in your testimony, you discussed the historical burdens disproportionately shouldered by low-income communities. Can you discuss how climate change heightens those discrepancies for communities of color or low-income individuals and what Federal programs can help to reverse years of inequitable planning and development?

Ms. ARROYO. So thank you for the question. I am happy to follow up in writing at more length. But just quickly, things like urban heat island effect that have a disproportionate effect on places that are really surrounded by concrete and don't have a lot of green space. Flood-prone areas, like the ones that we work with in DC. And I will give a shout out to Chicago for its early leadership on mitigating some of those impacts and being a leader on climate adaptation, as we often call it.

But we do a lot of work with communities also on looking at the impacts of climate change from transportation infrastructure. And one of the things that we learned on the future of the Interstate Highway report is that many cities are interested in trying to reverse those trends about building through cities, that cut through cities without the participation of the communities. And some cities like here in Washington, DC, are actually undergrounding or taking down some of the stretches of the interstate that really carve through some of the neighborhoods and trying to reconnect those neighborhoods. I'm happy to talk to you at more length about other options.

Mr. GARCÍA. Thank you much. I yield back.

Mr. ESPAILLAT. Thank you, Mr. García.

Thank you to the witnesses for your testimony. Your comments have been very, very helpful in this hearing.

If there are no further questions, I will now call up panel 2.

Mr. LARSEN [presiding]. All right, we will get started with the second panel. I want to welcome this next panel of witnesses.

We have Mr. Kevin DeGood, the director of infrastructure policy for the Center for American Progress; Mr. James Proctor II, senior vice president and general counsel, McWane, Incorporated; Dr. Whitley Saumweber, the director of the Stephenson Ocean Security Project at the Center for Strategic and International Studies; and Ms. Lynn Scarlett, the vice president of policy and Government affairs at The Nature Conservancy.

I want to thank each of you for being here today. I look forward to hearing your testimony. And without objection, our witnesses' full statements will be included in the record.

As with the previous panel, since your written testimony has been made part of the record already, the committee would request that you limit your oral testimony to 5 minutes. And I know we have an attendance problem right now and I appreciate that now, and I appreciate that and I hope you appreciate Members of Congress, but what you have to say today is important for the record, as this committee continues to move forward in putting together the record on climate change and infrastructure policy.

So I want to thank you very much for being here today and I will turn now to Mr. DeGood for your opening statement.

Thanks.

TESTIMONY OF KEVIN DEGOOD, DIRECTOR, INFRASTRUCTURE POLICY, CENTER FOR AMERICAN PROGRESS; JAMES M. PROCTOR II, SENIOR VICE PRESIDENT AND GENERAL COUNSEL, McWANE, INC.; WHITLEY SAUMWEBER, DIRECTOR, STEPHENSON OCEAN SECURITY PROJECT, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES; AND LYNN SCARLETT, VICE PRESIDENT, PUBLIC POLICY AND GOVERNMENT RELATIONS, THE NATURE CONSERVANCY

Mr. DEGOOD. Thank you, Mr. Chairman, and members of the committee. It is an honor and a privilege to contribute to this committee's work today. For too long, infrastructure and climate policy have been treated as separate issues. Yet what we build deeply influences the production of greenhouse gases, as well as our ability to withstand increasingly extreme weather events. The science demonstrating anthropogenic climate change is settled and, going forward, infrastructure policy should be synonymous with sound climate policy.

The question before this committee is how should we think about resiliency? The answer is that we should think about improving resiliency as both necessary and urgent but ultimately a losing strategy. Hardening facilities can only slow the immense economic, environmental and social damage that climate change will increasingly bring about. No one should operate under the illusion that we can build our way out of the climate crisis. Not every road, rail line, runway and building can be raised, strengthened or relocated.

Instead, public dollars will need to be deployed in a strategic and cost-effective manner to lessen the damage from flooding, fires, extreme heat and storm surges to the greatest extent possible. In short, we should not treat resiliency as a universal backstop, capable of saving us if the United States and other major emitting nations fail to meet their climate commitments. Given the limitations of resiliency, it is critical that the Federal Government invest in projects and adopt policies to dramatically reduce emissions in the near term and eliminate emissions by midcentury at the latest.

The challenges created by climate change are unprecedented. Implementing adaptation and resiliency projects and policies will require a dramatic departure from the status quo. However, many agencies lack the funding, data and technical expertise to accomplish the job. The Federal Government needs to invest not only in assets but people and data as well. If the Federal, State and local officials and administrators are to succeed, they need access to the most accurate and, to the greatest extent possible, localized models for temperature, precipitation, peak storm flows and sea level rise.

Importantly, the adaptation and resiliency decisions the public sector will need to make are both technical and intensely political because infrastructure investments produce benefits as well as burdens. The benefits from investment include access to jobs, markets, improved efficiency and reliability, and reduced costs while the burdens often include geographic isolation and displacement, increased pollution and noise and reduced property values, among many others. History demonstrates that all too often, these burdens are shouldered disproportionately by low-income communities and communities of color. Federal infrastructure and climate policy must advance equity and social justice. This means not only reducing greenhouse gas emissions but also making investments that raise wages and lift up struggling communities facing the greatest needs.

For this reason, it is critical to safeguard the environmental review process. The magnitude of the challenge and the urgent need for action reinforce that infrastructure planning and decision-making must occur in a transparent manner supported by robust public participation. Allowing climate action to serve as a justification for undermining foundational environmental laws such as the Clean Water Act and the Endangered Species Act would be darkly ironic. Environmental review produces better projects. Moreover, by reducing community and environmental impacts on the front end, we can save millions and even billions of dollars on post-construction remediation.

When it comes to both mitigation and adaptation, the Federal Government has not sufficiently exerted its policy prerogatives on grant recipients. In the future, Federal agencies should reduce funding to State and local governments that fail to implement projects and policies that decrease greenhouse gas emissions while also strengthening natural and man-made infrastructure to better withstand extreme weather. Additionally, Congress should recognize the valuable resiliency services that natural systems provide. Focusing Federal resources exclusively on man-made facilities misses the ability of natural systems to reduce storm surge, wildfires, flooding and mudslides. In many cases, investing a Fed-

eral dollar in protecting and maintaining natural habitats will provide larger resiliency dividends than spending that same dollar on hardening man-made infrastructure.

Finally, Federal policy must take a more comprehensive approach to land use, including providing additional funding to States and regions that increase urban density. Low-density exurban expansion cannibalizes natural habitats, reduces water quality, increases mobile-source emissions and expands the volume of linear infrastructure that must be built and made resilient. If we are to make meaningful progress addressing climate change, we must be honest about the underlying drivers of emissions and environmental degradation. The Federal Government cannot remain passive on the issue of land use any longer.

Thank you again for the opportunity to testify. I look forward to your questions and to working with the committee to craft solutions to this pressing challenge going forward.

[Mr. DeGood's prepared statement follows:]

**Prepared Statement of Kevin DeGood, Director of Infrastructure Policy,
Center for American Progress**

Thank you, Chairman DeFazio, Ranking Member Graves, and members of the committee. It's an honor and a privilege to contribute to this committee's work.

For too long, infrastructure and climate policy have been treated as separate issues. Yet, what we build deeply influences the production of greenhouse gases as well as our ability to withstand increasingly extreme weather. The science demonstrating anthropogenic climate change is settled. Going forward, infrastructure policy should be synonymous with sound climate policy.

The question before the committee is: How should we think about resiliency? The answer is that we should think about improving resiliency as necessary and urgent but ultimately a losing strategy. Hardening facilities can only slow the immense economic, environmental, and social damage that climate change will increasingly bring about. No one should operate under the illusion that we can build our way out of the climate crisis. Not every road, rail line, runway, and building can be raised, strengthened, or relocated. Instead, public dollars will need to be deployed in a strategic and cost-effective manner to lessen the damage from flooding, fires, extreme heat, and storm surges to the greatest extent possible.

In short, we should not treat resiliency as a universal backstop capable of saving us if the United States and other major emitting nations fail to meet their climate commitments. Given the limitations of resiliency, it is critical that the federal government invest in projects and adopt policies to dramatically reduce emissions in the near term and eliminate emission by mid-century, at the latest.

The challenges created by climate change are unprecedented. Implementing adaptation and resiliency projects and policies will require a dramatic departure from the status quo. However, many agencies lack the funding, data, and technical expertise to accomplish the job. The federal government needs to invest not only in assets but people and data as well. If federal, state, and local officials and administrators are to succeed, they need access to the most accurate—and to the greatest extent possible localized—models for temperature, precipitation and peak storm flows, and sea level rise.

Importantly, the adaptation and resiliency decisions the public sector will need to make are both technical and intensely political because infrastructure investments produce benefits and burdens. The benefits from investment include access to jobs and markets, improved efficiency and reliability, and reduced costs while the burdens often include geographic isolation and displacement, increased pollution and noise, and reduced property values, among many others. History demonstrates that all too often these burdens are shouldered disproportionately by low-income communities and communities of color. Federal infrastructure and climate policy must advance equity and social justice. This means not only reducing greenhouse gas emissions, but also making investments that raise wages and lift up struggling communities facing the greatest needs.

For this reason, it is critical to safeguard the environmental review process. The magnitude of the challenge and the urgent need for action reinforce that infrastructure planning and decisionmaking must occur in a transparent manner supported by robust public participation. Allowing climate action to serve as a justification for undermining foundational environmental laws such as the Clean Water Act and the Endangered Species Act would be darkly ironic. Environmental review produces better projects. Moreover, by reducing community and environmental impacts on the front end, the environmental review process helps to avoid the need for costly post-construction remediation.

When it comes to both mitigation and adaptation, the federal government has not sufficiently exerted its policy prerogatives on grant recipients. In the future, federal agencies should reduce funding for state and local governments that fail to implement projects and policies that decrease greenhouse gas emissions while also strengthening natural and man-made infrastructure to better withstand extreme weather.

Additionally, Congress should recognize the valuable resiliency services that natural systems provide. Focusing federal resources exclusively on man-made facilities misses the ability of natural systems to reduce storm surge, wildfires, flooding and mudslides. In many cases, investing a federal dollar in protecting and managing natural habitats will provide larger resiliency dividends than spending that same dollar on hardening man-made infrastructure.

Finally, federal infrastructure policy must take a more comprehensive approach to land use, including providing additional funding to states and regions that increase urban density. Low-density, ex-urban expansion cannibalizes natural habitats, reduces water quality, increases mobile-source emissions, and expands the volume of linear infrastructure that must be built and made resilient. If we are to make meaningful progress addressing climate change, we must be honest about the underlying drivers of emissions and environmental degradation. The federal government cannot remain passive on the issue of land use any longer.

Thank you again for the opportunity to testify. I look forward to your questions and to working with the Committee to craft solutions to the pressing challenges created by climate change.

Mr. LARSEN. Thank you, Mr. DeGood.

Mr. PROCTOR, you are recognized for 5 minutes.

Mr. PROCTOR. Mr. Chairman, Ranking Member Graves and members of the committee, thank you for the opportunity to testify today about issues that are vital to our Nation's health, economy and security. During my career, I have been privileged to help promote policies that will make our water infrastructure systems more resilient, secure and efficient, as vice president of McWane and also an affiliation with groups such as the BuildStrong Coalition, the Blue Green Alliance, the Water Infrastructure Leadership Group, EPA's National Drinking Water Advisory Council and the U.S. Chamber of Commerce's Water Policy Task Force. It is an honor to continue that work by appearing here today.

Much of America's drinking water and wastewater infrastructure is nearing the end of its useful life. Tragically, as much as 25 to 30 percent of the treated water that goes into our distribution systems leaks into the ground. Those losses not only squander a vital resource, they result in an enormous waste of energy required to treat and pump that water. That wasted energy also represents unnecessary and avoidable greenhouse gas emissions. As much as 4 percent of our Nation's total energy consumption is water related and accounts for millions of tons of annual greenhouse gas emissions.

Adopting policies that foster more effective utility management, including the reduction of water leaks, would produce a cascade of benefits, reduced operating expenses for cash-strapped utilities, reduced water cost for consumers, the conservation of scarce and vital resources and significant reductions in energy consumption.

and greenhouse gas emissions. Last year's America's Water Infrastructure Act made significant strides toward providing the needed funding, fully authorizing WIFIA, increasing the authorizations for the SRFs and creating new resilience, mitigation and technology programs. We hope that Congress will finish that process by appropriating the authorized funding this year.

In addition, on behalf of the BuildStrong Coalition, I want to congratulate this committee for its work in creating the game changing new predisaster mitigation fund that will provide close to \$1 billion a year for State-based competitive grants to make America more resilient. But that investment must be accompanied by smarter and more effective utility management, such as developing and utilizing emerging technologies that can increase revenue and lower costs through proactive leak detection, water conservation, water quality management and reductions in energy consumption.

Congress should help eliminate barriers to the adoption of these technologies by a number of means by encouraging voluntary cooperative arrangements among utilities and other partners and increasing technical assistance to provide the financial, operational and technical capacity needed to adopt these technologies; by encouraging effective utility management, including water leak audits and full-cost accounting; by establishing a national testbed network to evaluate, demonstrate and approve innovative technologies; by streamlining the regulatory and approval process for proven technologies; and by developing a workforce development program to provide American workers the skills needed to operate the high-tech water and wastewater systems of the future.

In addition, when disaster strikes, water is essential for fire-fighting capabilities and the prevention of disease. Similarly, our vital lifeline systems depend upon access to electric power. Recent hurricanes, floods and wildfires have revealed the vulnerability of our water and power distribution systems to natural disasters. It is my hope that the grant request for the new DRRA and FEMA programs will include projects to increase the resilience of our water and power distribution networks, as few other undertakings will have as broad and significant an impact.

Finally, countries like China and India generate 6 to 33 times more pollutants than production facilities located here in the United States. By making the American iron and steel requirements, the Buy American requirements that are applicable to the drinking water State revolving fund permanent and creating similar requirements for predisaster mitigation infrastructure projects and other water programs, Congress can shift production of the products necessary for the hardening of our infrastructure back to the more efficient and less-polluting factories in the United States, reducing greenhouse gas emissions while preserving and creating American jobs.

The key takeaway is that we can solve a range of problems, economic, environmental and climate related, by tailoring our Federal policies to take advantage of the technologies of the 21st century and the efficiency, productivity and commitment of American workers and industry. We at McWane are glad to have the opportunity to contribute to that process. Thank you for your time and consideration.

[Mr. Proctor's prepared statement follows:]

**Prepared Statement of James M. Proctor II, Senior Vice President and
General Counsel, McWane, Inc.**

Chairman DeFazio, Ranking Member Graves, and members of the Committee:

Thank you for the opportunity to testify about several issues that are vital to our nation's health, economy and security. During my career I have been privileged to help promote policies that will make our water infrastructure systems more resilient, secure, and efficient, working not only in my capacity as vice president of McWane, Inc., but also as a member of the executive committee of the BuildStrong Coalition, the corporate advisory council of the Blue Green Alliance, the Water Infrastructure Leadership Group (the "Ad Hoc Group"), the U.S. Water Partnership, Environmental Protection Agency's National Drinking Water Advisory Council, and co-chair of the U.S. Chamber of Commerce's Business Task Force on Water Policy. It is great honor to have the opportunity to continue that work by appearing here today.

For almost 200 years McWane has proudly provided the building blocks for our nation's water infrastructure, supplying the pipe, valves, fittings and related products that transport clean water to communities and homes across the country and around the world. More recently we have expanded our operations into the fields of infrastructure technology and electric power distribution. We employ more than 6000 team members who work in 25 manufacturing facilities in 14 States and nine other countries.

Water infrastructure remains a core element of our business focus, and we obviously have great interest in ensuring its integrity. Despite its obvious importance, in the past "out of sight, out of mind" best described the nation's attitude toward water infrastructure, and to a large degree that indifference has extended to discussions about climate change as well. But Congress and the public have started to come to grips with the reality that much of America's drinking water, wastewater, and storm water infrastructure, including the more than one million miles of pipes beneath our streets, is nearing the end of its useful life and must be replaced. And a tragic aspect of that reality is that as much as 20–30 percent of the treated water that goes into our distribution systems leaks into the ground as it flows through pipes installed as many as 150 years ago. Those losses not only squander a vital and sometimes scarce resource, they represent an enormous waste of the energy and associated capital required to treat and pump that water. Approximately 4 percent of our nation's total electricity consumption (as much as 19 percent in California) is related to water treatment, pumping, and recovery. Given the fact that much of our nation's energy is still produced by traditional, carbon-based sources, that wasted energy also represents unnecessary and avoidable greenhouse gas emissions. In fact, EPA estimates that treating, pumping and recovering water accounts for more than 45 million tons of greenhouse gas emissions each year. Thus, adopting policies that foster more effective utility management, including the reduction of water leaks, would produce a cascading flow of benefits: reduced operating expenses for cash-strapped utilities, reduced water costs for consumers, the conservation of scarce and vital resources, and significant reductions in energy consumption and greenhouse gas emissions.

In addition, the recent hurricanes, floods and wildfires have revealed the vulnerability of our distribution systems to natural disasters. We must harden our infrastructure before those events occur, taking advantage of mitigation opportunities, especially pre-disaster, that Congress recently created through reforms to the Stafford Act.

The solution to these challenges will of course require funding, and last year's America's Water Infrastructure Act ("AWIA") made significant strides toward addressing that need by fully authorizing long-term, low-cost supplemental loans for regionally and nationally significant projects in the Water Infrastructure Finance and Innovation Act ("WIFIA"), and increasing the authorizations for the State Revolving Funds ("SRFs"). We hope that Congress will finish that process by appropriating funds to those authorized levels this year. Similarly, the Disaster Recovery and Reform Act of 2018 ("DRRA") created significant new funding sources for cost-effective, risk-reducing pre-disaster mitigation projects.

But new funding alone cannot solve a problem of this magnitude. That investment must be deployed wisely and in a manner that realizes its full benefit, by fostering smarter, more efficient and effective utility management. One such avenue is to develop and use emerging technologies that can generate new forms of revenue and

maximize existing sources, while lowering operational costs through proactive leak control, water conservation, better water quality management, reductions in energy consumption and costs, and less wear and tear on assets. Technology can also improve operational efficiencies via data-driven system management. Studies indicate that digital water networks can save utilities up to \$12.5 billion a year. Moreover, the use of more resilient construction techniques can mitigate the impact of storms, earthquakes, wildfires and other disasters.

USING MORE EFFECTIVE WATER UTILITY MANAGEMENT AND DEPLOYING TECHNOLOGY TO REDUCE CLIMATE RISKS

Some examples of specific technologies that are available today, or are on the verge of deployment include:

- *Advanced metering infrastructure (smart meters) that can more accurately record and charge customers based on actual usage.* These systems use low-powered wireless communication devices to transmit water usage information over secure networks, reducing non-revenue water by eliminating unmetered consumption and apparent losses from inaccurate meters, unauthorized consumption, and billing errors. And real time water-usage reports increase conservation which mitigates the effects of water scarcity related to climate shifts while reducing energy consumption and the associated carbon emissions.
- *Remote, real-time leak detection and pressure management systems that identify problems before they become costly main breaks.* Early and accurate leak detection not only prevents wasted water and energy and reduces greenhouse gas emissions, it also reduces repair costs and the risk of contaminants infiltrating into water systems, which could put public health at risk. Such detection systems can also facilitate more effective disaster responses by enabling utilities to identify the location of damage to their systems so that they are able to restore service more quickly. New and effective methods of detection include wireless systems with acoustic sensors and leak-noise correlators, satellite imaging, and sensors that can detect negative pressure waves. Many of these solutions can be simply and inexpensively added to existing and new infrastructure at hydrants and valve boxes.
- *Real time water quality monitoring.* Wireless nodes can accommodate sensors that monitor parameters such as pH and alkalinity and low residual disinfectant, that are markers for the conditions that can predict avoidable situations like Flint, Michigan, and allow utilities to adjust water chemistry before a crisis occurs.
- *The water-energy nexus provides another source of efficiencies and opportunities.* As much as 4 percent of our total annual electricity consumption (20 percent in some States, like California) is related to the treatment and transmission of water, which according to EPA equates to 45 million tons of greenhouse gas emissions each year. Indeed, for most water utilities energy is their second largest cost (35–40 percent of total costs on average), second only to personnel expenses. In addition to reducing consumption of energy as outlined above, new technologies can help utilities become generators of clean energy that can be used to operate systems. Waste sludges can provide a source of renewable fuel for power generation, and the vast expanses of land occupied by treatment plants are sometimes prime locations for solar panels. In addition, inline hydroelectric systems can harness the flow of water through pipelines to generate electricity, particularly in distribution systems based upon gravity flows.

Despite these obvious benefits, utilities face numerous barriers to deploying these and other technologies. First, water utilities are naturally, and appropriately, risk averse. An inadvertent disruption of treatment and distribution capabilities due to a technological failure could cause a catastrophic health crisis, put the environment at risk, or trigger regulatory action. Moreover, a failed deployment could trigger a financial crisis for the utility and perhaps even the community it serves.

Second, the upfront costs of implementing a system-wide technology project can be prohibitive for small utilities, which can preclude adoption even with the opportunity for greater long-term benefits.

The regulatory environment is another, frequently cited barrier. Water quality and environmental regulations play a vital role in protecting public health. However, in many cases redundant, conflicting, or outdated regulations at the State and Federal levels, and among the various States, can create lengthy, complex, and costly approval processes. These regulatory obstacles not only slow the approval of technology directly, but also impede the creation of partnerships that could provide a source of expertise and funding that would accelerate deployment.

Aggravating all of these factors is the diffuse nature of the water sector, which is comprised of more than 55,000 separate utilities, 85 percent of which serve fewer than 10,000 people. Through no fault of their own many small and rural utilities lack the resources and technical expertise required to evaluate the options, design and build the systems, and manage them after construction. Without coordination among neighboring communities, opportunities to overcome these gaps by sharing experience, expertise, best practices, and joint purchasing power are missed. This greatly increases the costs of adoption.

These issues present substantial obstacles, but there are measures that Congress could implement that would eliminate or reduce their adverse impact.

Appropriate Funding for WIFIA, the SRFs, and the New AWIA Programs at Their Authorized Levels.

As noted above, fully appropriating the funding authorized for WIFIA and the SRFs in last year's AWIA bill would provide a significant beginning point. These programs cannot only provide a source of funding for technology projects, they can also provide the technical assistance that small utilities need to evaluate, purchase, and implement projects. Similarly, sections 2005 (Drinking Water Infrastructure Resilience and Sustainability), 2007 (Innovative Water Technology Grant Program), 2012 (Asset Management), 2013 (Community Water System Risk and Resilience) and 2017 (Review of Technologies) of AWIA created several new programs designed to promote resiliency and technology. Fully appropriating those programs and directing that a significant portion of the funding go toward training and technical assistance for small utilities would also make a difference.

Encourage Cooperation Among Utilities and Partnerships.

Congress should also encourage regional cooperation among utilities and remove barriers to the use of private capital as a supplement to public funding. Small systems should be encouraged to consider voluntary cooperative arrangements and partnerships with other entities who can help them develop the necessary financial, operational and technical scale and capacity to adopt the technology that will enable them to reduce their costs and more effectively manage their systems. Such arrangements allow the sharing of best practices, systems and technology and reduce the risk associated with new undertakings in addition to creating economies of scale that increase the availability of funding and reduce costs. There are many paths to such partnering arrangements, including public-to-public, public-to-private, and private-to-private partnerships, cooperatives, concessions, operating agreements, or consolidation or regionalization of assets or services. But let me emphasize that all paths should remain available at the discretion of the local entity.

Specific means by which Congress or EPA might encourage such cooperation include prioritizing regional projects and consolidation costs for SRF and WIFIA funding and providing more technical assistance to small and rural systems, including assistance with the technical and legal aspects of cooperation. Removing the volume cap on private activity bond for water projects would also encourage more private capital to enter the market.

Establish a National Test Bed Network for New Technologies.

A National Water Test Bed Network ("TBN") to evaluate, demonstrate and approve innovative technologies would jump start adoption. Unless utility operators have the confidence that new technologies will work, they are reluctant to adopt or deploy them. But few utilities are willing to serve as the pilot program because of the demands on time and budget, and even pilot programs that do proceed can take years to complete. As a result, the deployment of workable, cost-saving and efficiency-creating technologies is unnecessarily delayed. A National Water Infrastructure TBN to coordinate and accelerate the water industry's deployment of new technologies would bring together the broader water community (i.e., manufacturers, regulators, operators, consulting engineers, etc.), and engage them in demonstration efforts to raise confidence in innovative technologies. The TBN process, including a possible whitelist of proven technologies, would reduce the number of pilot projects otherwise needed and would also shorten the time needed to achieve commercial acceptance.

Streamline the Regulatory and Approval Process for Proven Technologies.

Congress should also direct EPA to conduct a review of existing regulations to identify and address barriers to implementation of smart water solutions. EPA should encourage States to establish consistent and uniform permitting and certification programs and reciprocity, where possible, without compromising protections for public health and respect for State and local autonomy.

Establish a National Program for Collaboration and Sharing of Best Practices.

A national program with a central focus on sharing best practices would help urban and rural utilities, regardless of size, to develop joint partnerships with public and private utilities, engage private sector expertise and technology, and access private capital markets and funding. In addition, this network would help small and distressed water systems find the technical capacity to comply with regulations and to undertake projects to improve or expand their services.

Encourage Effective Utility Management (“EUM”) and Best Practices, Including Water Leak Audits and Full-Cost Accounting.

To succeed, every utility must have an accurate understanding of their financial condition, including the cost of providing water and waste water services. An accurate understanding of costs and their sources is also the essential foundation for conducting the cost-benefit assessments that provide the business case for the adoption of the technologies discussed previously. Yet a recent survey found that fewer than a third of water utilities have an accurate appreciation of their costs of operation, and only a similar percentage operate under rate structures that fully cover their costs. This situation creates severe constraints on the ability of utilities to finance their operations, attract outside investment, or justify technology projects.

One way to close this informational and operational gap is to help utilities identify the extent of water losses in their systems. Water is the “inventory” of a water utility, and an accurate understanding of inventory levels, losses, and production and distribution costs, including associated energy consumption and greenhouse gas emissions, is fundamental to understanding operational costs. An appreciation of those operational costs and their avoidability is, in turn, a vital prerequisite to demonstrating the benefits of deploying technology that would mitigate those losses. Potential partners will also require such information before committing their capital and resources to the rehabilitation of a failing utility.

A number of major water and wastewater associations (AMWA, NAWC, NACWA, AWWA, WEF, WERF, WRF, ASDWA and ACWA) and EPA have endorsed the ten attributes of EUM¹, asset management and financial viability. Asset management includes conducting leak audits to understand the true condition of a utility’s transmission and distribution systems. Financial viability includes an understanding of the full life-cycle cost of utility operations and value of water resources, which is heavily impacted by lost water and its embedded energy. Applicants for Federal support should be encouraged to assess the total costs associated with constructing, operating, and maintaining their water, wastewater and storm water systems, including long-term capital costs. At the same time, EPA should provide more technical assistance to small utilities on how to conduct the audits and assess costs. Moreover, this information must be made more transparent and readily available for public review.

Train a 21st Century Workforce.

The Safe Drinking Water Act includes several set-asides related to operator certification and training for water systems from the funding authorized for the State revolving funds. Congress should buttress that authority by tasking the U.S. Department of Labor with developing a workforce development program that would provide American workers the skills and credentials needed to support the operation, maintenance, and improvement of the hi-tech water and wastewater systems of tomorrow.

INCREASING INFRASTRUCTURE RESILIENCE THROUGH PRE-DISASTER MITIGATION

In 2018, the National Institute of Building Sciences (“NIBS”) released its “Natural Hazard Mitigation Saves: 2018 Interim Report”, concluding that:

- Adopting Model Building Codes Saves \$11 per \$1 Invested
- Federal Mitigation Grants Save \$6 per \$1 Invested
- Exceeding Codes Save \$4 per \$1 Invested
- Mitigating Infrastructure Saves \$4 per \$1 Invested

In recognition of these and other benefits of mitigation, particularly pre-disaster mitigation, this Committee introduced and passed the bipartisan DRRRA and other disaster recovery provisions in the Bipartisan Budget Act of 2018, which support and incentivize States and localities to adopt enhanced mitigation measures to protect lives and taxpayer dollars. On October 5, 2018, President Trump signed the DRRRA into law as part of the Federal Aviation Administration Reauthorization Act

¹Effective Utility Management, A Primer for Water & Wastewater Utilities, <http://dev.watereum.org/wp-content/uploads/2017/04/Effective-Utility-Management-A-Primer-for-Water-and-Wastewater-Utilities.pdf>

of 2018. These reforms amend the Robert T. Stafford Disaster Relief and Emergency Assistance Act and:

- acknowledge the shared responsibility of disaster response and recovery,
- aim to reduce the complexity of the Federal Emergency Management Agency (FEMA), and
- build the nation's capacity for the next catastrophic event.

DRRA also established a new, permanent mechanism to provide substantial funding for cost-effective, risk-reducing pre-disaster mitigation projects. This represents a significant increase in reliable funding for grants for State, local, tribal and territorial governments, and communities that will enable them to better plan and execute cost-effective risk mitigation projects. This nationwide pre-disaster mitigation grant program will impact both public infrastructure and individual preparedness by increasing residential resilience through State-sponsored safe home grants. The competition for these resources will create an incubator for best practices, lessons learned, and great ideas for projects and programs that can be tailored at the State and local level to reduce the risks unique to those communities.

The critical next step for these pre-disaster mitigation programs is building capacity at the State level to identify risks and cost-effective projects, then facilitating the development of effective and efficient grant applications and awards. For its part, the BuildStrong Coalition has partnered with FEMA and the U.S. Chamber of Commerce to host a series of resilience summits across the country to help stakeholders and industry develop the capacity to apply for and implement these grants. The first summit will be May 2, 2019, in Washington, DC. Future meetings will be held in Sacramento, CA, and Houston, TX. Further, through these partnerships we are working to align and leverage other Federal resilience programs, such as Community Development Block Grant-Disaster Recovery (CDBG-DR) funds and resources from the Department of Energy and EPA.

LESSONS LEARNED FROM THE 2017 STORMS—RISK REDUCING PROJECTS

Much of the discussion in congressional hearings and other fora has focused primarily upon above-ground buildings, houses, and other structures. However, the risks to property and human lives and health arising from damage to infrastructure also require attention. For example, water is a critical element of most of our fire-fighting capabilities in the event of a natural disaster and is essential to the prevention of disease and other public health threats. However, earthquakes can rupture water distribution lines unless properly constructed, wildfires can destroy these vital lifelines and contaminate water supplies, and floods can jeopardize underground infrastructure in a manner similar to earthquakes as the ground becomes saturated and more fluid.

The damage to infrastructure during the major hurricanes of 2017 and the recent wildfires highlight the importance of building a resilient power grid. Most hospitals, water treatment plants, food services, communications, search and rescue operations, reconstruction, and other critical lifeline services depend upon access to electric power. However, power is almost always interrupted by such storm events; indeed, there are parts of Puerto Rico that remain without reliable electricity almost 2 years after Hurricanes Irma and Maria. Increasing the resilience of our power grids in these areas would significantly reduce the costs of post-disaster reconstruction and avoiding life-threatening power interruptions.

To address these issues, the BuildStrong Coalition has proposed several possible solutions that should be encouraged in soliciting and reviewing applications for pre-disaster mitigation funding, each of which would be implemented at the State and local levels and would reduce the risk of loss in a disaster event.

One example is focusing standards that could improve the resilience of our electric power distribution systems in disaster prone areas. The National Electric Safety Code establishes standards for the construction of transmission and distribution utility poles. Section 25 defines the strength standards required for different areas of the country, based upon, among other things, loading maps from the American Society of Civil Engineers—*ASCE 74-2010*. ASCE wind maps have been widely adopted by the International Building Code (IBC), International Residential Code (IRC), and International Existing Building Code (IEBC).

The ASCE 74 maps show values for wind speed and ice thickness that are expected to be exceeded every 50 years², identify the weather risks associated with those areas, and specify the wind speeds that the poles must withstand. Puerto Rico, the Virgin Islands, Florida, and certain other island and mainland coastal areas are designated as extreme wind areas, and other areas in the U.S. are consid-

²2017 NESC Handbook Premier Edition.

ered “high risk” for wind and ice accumulation. Section 250C sets the strength standards for extreme wind, and 250D for extreme wind and ice. However, both standards exempt poles of under 60’ in height from compliance with the extreme wind performance criteria, even though the wind measurements used to designate the wind loads are taken at 33 feet. As an additional point of reference, an estimated 90 percent of all poles in use in the U.S. are under 60’ in height.

This 60’ exemption results in a significant reduction in the size and strength of poles for many vulnerable and heavily populated coastal areas. Indeed, even though ASCE 74 would require a wind tolerance of 145 mph in these areas under the exemption the southern U.S. and the Caribbean territories need only design their systems to withstand a Category 2 hurricane (114 MPH), and the Mid-Atlantic and Northeast to withstand a tropical storm (75 MPH). Nine hurricanes above Category 2 have hit the U.S. since 2000³, including Hurricanes Irma and Maria, with winds measured at over 200 MPH and 145 MPH, respectively.

Thus, although Puerto Rico and other southeastern coastal areas have the highest wind loading in the United States, 90 percent of the utility poles in those areas are exempt from compliance with the extreme wind standard in Section 25 of the NESC. The impacts of Hurricanes Irma and Maria vividly demonstrated the consequences of this exemption. According to news reports, more than 50,000 utility poles were destroyed in Puerto Rico during those storms, and another 120,000 were lost in Florida⁴. There was widespread loss of power, which cost an estimated \$5 billion to restore. Had all those poles been installed in accordance with the high wind loading requirements of NESC 250C, including those under 60’, there is a high probability those losses would have been much lower.

There are many options available to utilities to meet the extreme wind loading requirements of section 250C and 250D. Wood poles of a larger size can comply, as can engineered poles made of steel, ductile iron and concrete. Enforcement of these standards without the exemption will not exclude poles made from any particular material.

Florida serves as a good example of the benefits of storm hardening. After the storm seasons of 2004–2005, the Florida Public Service Commission mandated that investor-owned utilities, and recommended that municipalities and cooperative utilities, inspect all poles every 8 years and replace all obsolete poles, including those below 60 feet, with poles that meet the high wind loads in ASCE 74. In 2018, the Florida Public Service Commission declared that the storm hardening programs in Florida are working. Outages from 2017’s Hurricane Irma were much less significant than those in 2004–2005 storm season, and the adoption of more resilient poles reduced the construction man-hours required to restore hardened feeders by 50 percent. At Florida Power and Light, Florida’s largest utility, non-hardened poles were 10 times more likely to fail than hardened poles⁵. As a more specific example, more than 1,000 Section 250C-compliant poles under 60’ in height were in service in the Florida Keys when Irma and Maria made landfall. Not a single such pole was lost, while approximately 1,000 nearby wooden poles that had been installed under the 60’ exemption failed. A video describing that experience can be found at: <https://t.co/YRHdrkVpuD>.

Facilitating applications for upgrading the power distribution system, and eliminating the 60-foot exemption as a prerequisite for approval, would incentivize States to reform this aspect of disaster procurement by requiring that all newly installed or repaired electric distribution poles conform to the requirements of NESC 250C and 250D without regard to height. This approach would not create any preference among available materials—all can bid so long as their products meet the performance standard—but such a measure would greatly reduce the risk and costs to the U.S. taxpayers.

Similar issues arise in wildfire situations. News reports indicate that one of the recent wildfires in California was caused when a transformer exploded on a flammable, wooden pole. In addition, as the fires spread other flammable poles caught fire with resulting damage to the distribution systems. Thus, using pre-mitigation grant funding to encourage the replacement of electrical distribution poles in wildfire-prone areas with poles made of non-flammable materials could reduce damage, interruptions, and reconstruction costs.

Although the upfront costs of more resilient poles might be slightly higher, the long-term savings would be dramatic. For example, there is an approximately \$500 difference between the cost of a wooden pole that does not conform with section

³ <http://www.aoml.noaa.gov/hrd/tcfaq/E23.html>

⁴ <https://www.tdworld.com/overhead-distribution/ground-after-hurricane-harvey>

⁵ Florida Public Service Commission. Docket No. 20170215–EU—Review of electric utility hurricane preparedness and restoration actions, July 24, 2018.

250C extreme wind standard and a wooden pole that does. Similarly, the cost difference between a non-compliant wooden pole and an engineered pole is less than \$2,500. But the typical life expectancy of an engineered pole is three times that of a wooden pole, and a pole replacement under emergency conditions can cost more than \$10,000. Thus, in a single major hurricane like Maria, during which 50,000 poles were destroyed in Puerto Rico, the net savings to communities and the taxpayers could be more than \$500,000,000 from repair costs alone. Those savings would be many times greater if one assumes a larger geographic impact than one State or territory, and that more than one such event will occur over the 30-year lifespan of a typical, non-250C high wind compliant wooden pole.

REDUCING CLIMATE RISKS WHILE PRESERVING AMERICAN JOBS AND COMMUNITIES

In addition to these improvements, Congress can reduce greenhouse gas emissions, while at the same time preserving and creating American jobs, through the maintenance and expansion of domestic preferences for iron and steel products used in infrastructure projects. U.S. producers have invested heavily to modernize their U.S. operations conform to the world's most robust environmental standards. We at McWane are proud to say that our plants are among the safest and most environmentally sound in the world, but every day we must compete against foreign, State-owned or subsidized foundries and mills that regularly flout international trade laws, have no regard for worker safety, the environment, or public health and are not required to operate by standards comparable to those with which U.S. manufacturers must comply.

In fact, the foreign producers with whom U.S. iron and steel producers most often compete are also the most polluting. According to the International Iron and Steel Institute (IISI), Chinese steel producers emit 2.5 tons of CO₂ for each ton of steel manufactured in China. For the global steel industry, IISI reports that average CO₂ emissions were 1.7 tons for each ton of steel produced. The American Iron and Steel Institute (AISI) and the Steel Manufacturing Association (SMA) suggest that the figure of 2.5 tons per ton of steel understates the actual level of Chinese steel CO₂ emissions, and that the true number is closer to four tons of emissions for each ton produced in China, compared to the worldwide average of 1.7 tons per ton of steel. Similarly, a typical plant in China emits more than 20 times the particulate (9.4 lbs. per ton versus 10.4 lbs. per ton) and nearly 35 times the carbon monoxide (149.4 lbs. per ton versus 4.4 lbs. per ton) than are emitted by a typical U.S. plant. As a 2014 report from the National Academy of Sciences, "China's international trade and air pollution in the United States," observed:

As the Chinese economy has grown, the economic structure has also changed, transitioning from a net importer to a large net exporter of energy-intensive industrial products. The energy needed to support this economic growth and transformation has come from combustion of fossil fuels, primarily coal, which has contributed to a global increase in emissions of carbon dioxide (CO₂). At the same time, increased combustion of fossil fuels, relatively low combustion efficiency, and weak emission control measures have also led to drastic increases in air pollutants such as sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), black carbon (BC), and primary organic carbon (OC). Indeed, fossil-fuel-intensive manufacturing, large manufacturing volume, and relatively weak emission controls have meant that China emits far more pollutants per unit of gross domestic product (GDP) than countries with more advanced industrial and emission control technologies. Per unit of GDP in 2006, China emitted 6–33 times as much air pollutants as the United States.

In addition to the harm to the environment, these disparities create significant cost and competitive disadvantages for American producers, that have led to lost sales, closed plants, lost tax revenues, lost jobs, and more carbon emissions. Communities across the country are in decline because the factories that once built our nation's infrastructure have disappeared, depriving them of the vital tax revenues and rate payers needed to operate and maintain their water systems and other public services.

Because carbon emissions impact the global climate system to the same degree regardless of their country of origin, policies that encourage the sourcing of materials from better-performing countries can reduce those emissions. An example of just such a successful policy is the American Iron and Steel ("AIS") preference to the Drinking Water SRF, the Clean Water SRF, and WIFIA. AIS is critical to U.S. iron and steel producers. It has provided producers with important incentives to preserve production capacities in the United States, make significant capital investments to improve manufacturing capabilities, and maintain workforces that sustain

the communities around them. I can say with pride and relief that AIS has saved at least one of our plants from closure, preserving hundreds of jobs in an economically depressed area.

By 2008, our waterworks fittings plant in Anniston, Alabama was the last surviving domestic manufacturer of those products. At one time there were as many as a dozen such plants in the United States, but all, including our other fittings plant in Texas, fell victim to the unfair foreign competition I described previously. Even that lone survivor was at risk of closure when the great recession hit, operating at around 30 percent of its production capacity. But with the application of AIS to the SRF's, first in ARRA and later through WRDA and the annual appropriations process, that plant has increased its capacity utilization to almost 70 percent, added product offerings, and, more importantly, more than doubled the number of jobs. But the benefits of AIS are not limited to our operations. Because of AIS some of the same foreign companies who drove the near destruction of the American fittings industry have now moved their production to the United States, first using existing foundries struggling for work, and more recently purchasing their own production facility. They have done this specifically in response to AIS. It is hard to conceive of a more concrete example of AIS's job-creating impact.

AIS was first enacted for both the DWSRF and the CWSRF in the Consolidated Appropriations Act, 2014. Later in 2014, the Congress enacted permanent AIS statutes applicable to the CWSRF as well as WIFIA as part of the 2014 Water Resources Reform and Development Act. Congress has continued to apply the policy annually through the appropriations process to the DWSRF for Fiscal Years 2015, 2016, 2017, and 2018, and in AWIA Congress extended AIS to the DWSRF for 5 years. While those of us who make products domestically are very grateful for these actions, we urge Congress to enact a statute to permanently apply the AIS procurement preference policy to the DWSRF in any upcoming authorizing legislation, to bring that program into line with the others, to secure the benefits of AIS for future generations, and to eliminate the possibility of a lapse of AIS for the DWSRF, which would burden EPA with administering overlapping programs subject to conflicting standards.

Moreover, many other water-related programs have no domestic content requirement, which not only shifts the production of products for those programs to sources that produce more greenhouse gas emissions and deprives the economy of the benefits of AIS, it also creates administrative inconsistencies and inefficiencies. The programs with no Buy America requirement include the U.S. Department of Agriculture's Rural Utilities Services' Water and Waste Disposal Program, the U.S. Department of Housing and Urban Development's Community Development Block Grant program, the U.S. Bureau of Reclamation's Rural Water Supply program, the Economic Development Administration's Public Works and Economic Development Program, and the Indian Health Services, Facilities and Environmental Health program.

Until Buy America preferences like AIS are made permanent and applied across the spectrum of taxpayer-funded infrastructure programs, the thousands of jobs that have been created and supported by this successful policy are always at risk. It is time to build on what is already a successful program, and to make AIS permanent for the DWSRF and other water and DRRF programs as it is for the CWSRF, WIFIA, and most of the other non-water Federal-aid infrastructure programs. Further, by encouraging production of materials by high-performing American facilities instead of more polluting and energy-intensive facilities in China and elsewhere, application of Buy America policies will ensure that the carbon emissions associated with production for infrastructure projects will be as small as possible.

CONCLUSION

These are only a few of the issues and solutions that merit discussion. The key takeaway, however, is that we can solve a range of problems—economic, environmental, and climate-related—by tailoring our Federal policies to take advantage of the technologies of the 21st century and the efficiency, productivity and commitment of American workers and industry. And when considering Federal resources, we must make resilient, cost-effective investments. We at McWane are glad to have the opportunity to contribute to that process.

Mr. LARSEN. Thank you, Mr. Proctor.

And now I recognize Mr. Saumweber for 5 minutes.

Thank you.

Mr. SAUMWEBER. Thank you, sir. Mr. Chairman and members of the committee, thank you for inviting me here today to discuss the

ways in which Federal infrastructure policy can help mitigate and adapt to climate change. My name is Whitley Saumweber and I currently serve as the director of the Stephenson Ocean Security Project at the Center for Strategic and International Studies. This project is a new effort on behalf of CSIS to examine the links between ocean health, marine resource conflicts and national security challenges.

Prior to joining CSIS, I held appointments as a visiting fellow at Stanford University and as Associate Director for Ocean and Coastal Policy in President Obama's White House Council on Environmental Quality. I have previously worked for the late Senator Inouye and at the National Oceanic and Atmospheric Administration as an advisor to the two previous Administrators. Over the course of my career, I have helped to develop, implement and lead our national ocean, Arctic and fisheries policies and it is this experience that my testimony today draws upon.

The second volume of the Fourth National Climate Assessment issued late last year makes it clear that the impacts of climate change are being felt now and, absent significant changes to the global carbon economy, will be accelerating into the foreseeable future. Climate change therefore serves as both a source of immediate challenge and strategic risk. Managing this risk will require a combination of near-term investments to adapt existing infrastructure and a sustained commitment to developing more resilient systems in the face of continuous change.

The U.S. Marine Transportation System provides for 90 percent of our imported goods, supports \$4.6 trillion in economic activity—roughly one-quarter of our economy—and sustains 23 million jobs. All of these are at risk if we do not provide appropriate investments to ensure resilience in our maritime infrastructure, and to do so in a way that accounts equally for economic, environmental and social values.

The U.S. Committee on the Marine Transportation System has identified three primary risks associated to the MTS associated with climate change: sea level rise, increasing frequency and potency of coastal storms and the opening of the Arctic. They also identify an additional 29 environmental factors that may be exacerbated by climate-related impacts, which would put maritime infrastructure at further risk. These include such diverse threats as invasive species, extreme events and changing migration patterns.

In considering how to respond to such a complicated array of risk factors, we should be clear on how we prioritize the impacts based on likelihood of threat and the value of the infrastructure at risk. But we should also think about how we define resilience and what we wish our goals to be.

The National Academies of Science has defined resilience as the ability to prepare, resist, recover and more successfully adapt to the impacts of adverse events. This is sufficient, so long as we believe that we have a clear sense of what the possible range of those events may be. But the current reality of climate change is that our world is not in steady state. Rather, we exist in a state of continuous change. We should therefore recognize that today's standards will be insufficient to meet tomorrow's needs, just as last year's 100-year flood is this year's hurricane season.

Sea level rise is a great example of this dynamic as it is both accelerating and variable across geographies. But these changes will apply in our communities as well. And when considering investments in port infrastructure, we should understand that the nature of regional maritime industries is likely to change as climate drives changes in regional economies, global shipping patterns and national security challenges.

Among the most clear example of these shifts will be in the Arctic, where we may see an ice-free pole within the next 10 to 20 years. This has tremendous implications for economic development, resource exploitation, shipping routes and strategic challenges. Meeting these needs will require us to consider the level of investment we are currently making and commit to providing the resources needed to support our national security and sustainable economic development in the new ocean.

Moving forward, I commend the committee for considering climate impacts in its deliberations and recommend the following priorities. For general maritime infrastructure needs, the U.S. Coast Guard, U.S. Army Corps of Engineers and NOAA should jointly lead a comprehensive assessment of U.S. port infrastructure and its risk to climate-related hazards. Each of these agencies have a number of programs on which such an effort could build. Individual port needs will vary widely but investments in communication networks for immediate hazard adaptation and contingency planning and land-use planning to optimize use of green infrastructure for long-term resilience should also be priorities. And, finally, investing in Arctic capabilities for the U.S. Coast Guard and related mission capacity should be a priority. This includes fully supporting the Polar Security Cutter program, investing in communication and vessel monitoring networks to support implementation of the Bering Strait Port Access Route Study, supporting implementation of the Alaskan Arctic PARS in the Chukchi and Beaufort Seas and providing for engagement with Alaskan Native communities and governments on the development of a deepwater port facility in the Bering Strait region and moving forward with its development based on this input and the outcomes of the forthcoming U.S. Army Corps of Engineers study.

Thank you. And I look forward to your questions and discussion.
[Mr. Saumweber's prepared statement follows:]

Prepared Statement of Whitley Saumweber, Director, Stephenson Ocean Security Project, Center for Strategic and International Studies (CSIS)

Mr. Chairman and Members of the Committee, thank you for inviting me here today to discuss the ways in which Federal infrastructure policy can help mitigate and adapt to climate change. My name is Whitley Saumweber and I currently serve as the Director of the Stephenson Ocean Security Project at the Center for Strategic and International Studies (CSIS). This project is a new effort on behalf of CSIS to examine the links between ocean health, marine resource conflicts, and national security challenges.

Prior to joining CSIS, I held appointments as a Visiting Fellow at Stanford University and as Associate Director for Ocean and Coastal Policy in President Obama's White House Council on Environmental Quality. I have previously worked in the U.S. Senate for the late Senator Dan Inouye (D-Hawaii) and at the National Oceanic and Atmospheric Administration (NOAA) as an Advisor to the two previous Administrators. I also hold a Ph.D. in Biological Oceanography from the University of Rhode Island. Over the course of my career I have helped to develop, implement,

and lead our National Ocean, Arctic, and Fisheries policies and it is this experience that my testimony today draws upon.

INTRODUCTION

The second volume of the Fourth National Climate Assessment issued last year makes it clear that the impacts of climate change are being felt now and will be accelerating into the foreseeable future without significant changes to the global carbon economy. Climate change therefore serves as both a source of immediate challenge and strategic risk requiring a combination of immediate investment for adaptation and sustained investment to support the long-term resilience of affected systems. From a maritime perspective one of the most important and vital of these is our Marine Transportation System. The U.S. MTS accounts for 90 percent of our imported goods, supports \$4.6 trillion in economic activity, and sustains 23 million jobs. All of these are at risk if we do not provide appropriate investments to ensure resilience in our maritime infrastructure and to do so in a way that accounts for economic, environmental, and social values.

The U.S. Committee on the Marine Transportation System (CMTS) has identified three primary risks to the MTS associated with climate change: (1) Sea Level Rise (SLR); (2) increasing frequency and potency of coastal storms; and (3) the opening of the Arctic. They also identify an additional 29 factors that may be exacerbated by climate related impacts and which would put maritime infrastructure at risk. In responding to these risk factors, we should consider the National Academies of Science definition of resilience as, “the ability to prepare, resist, recover, and more successfully adapt to the impacts of adverse events,” but also recognize that as we do so we must seek to account for continuously shifting baseline. For example, the sea level is rising but the rate at which it is doing so will both increase and be variable across regions. Similarly, in considering investments in port infrastructure to service relevant regional maritime industries, we should consider that the nature of these industries are likely to change as climate drives changes in regional economies. The port side needs of the fishing industry will change, for example as commercial stocks move poleward and the composition of local fleets change.

The most clear example of these shifts is in the Arctic where we may see an ice free pole within the next 10–20 years.

GENERAL RECOMMENDATIONS

Risk Assessment—Invest in programs at the U.S. Coast Guard and NOAA that support a comprehensive risk assessment of major U.S. ports to the primary climate risk factors contained in the CMTS Risk Factors Matrix.

Resiliency Standards—Develop a set of standards for port infrastructure that map to regional predictions of sea level change under each of the Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCP) of green house gas emissions.

Targeted Investment—Consider the use of novel public/private partnerships, including funds such as the Harbor Maintenance Trust Fund, Oil Spill Liability Trust Fund, and National Coastal Resilience Fund to support investment in port adaptation programs that meet revised resiliency standards and are applied based on priority risk assessment needs.

ARCTIC RECOMMENDATIONS

President Obama recognized that the Arctic would become increasingly important from both an economic and strategic perspective as the polar ice cap melts and new shipping lanes and opportunities for resource use and extraction emerged. To grapple with these emerging challenges his Administration developed the first National Strategy for the Arctic Region, and, in partnership with Canada, in 2016, proposed A New Model for Arctic Leadership. Both documents called for building a sustainable Arctic economy, supporting conservation, and supporting Arctic communities including through increased collaboration with indigenous communities and valuation of local and traditional knowledge. Needed investments in Arctic infrastructure should follow a similar model and make sure that local communities are engaged in decisionmaking processes and that impacts on sensitive and changing ecosystems are considered. I list a number of these needs below which also broadly map to the CMTS’ 10-year Arctic infrastructure priorities.

Maritime Domain Awareness and Readiness—

- The USCG’s National Security Cutter program should be fully funded and clearly supported in the developing USCG Arctic Strategy.

- The USCG Alaska Arctic Port Access Route Study (PARS) should be fully funded and completed in a timely manner that allows for appropriate consultation with local communities.
- Support for NOAA's Office of the Coast Survey and National Geodetic Survey should be increased to accelerate Arctic surveying, charting, and National Geodetic Reference Frame updates.
- The U.S. Army Corps of Engineers should complete their feasibility study for a deep water port in Northwest Alaska.
- Development of a deep water port should be pursued based on the recommendations of the USACE study and in consultation with local communities.
- Investment in additional oil spill and incident response infrastructure is critical including pre-positioning and transport planning for events on the North Slope.

Communications—Communication infrastructure to support both ship to ship and ship to shore networks is lacking on the North Slope. Investments are needed to support the expanded use of Automatic Identification Systems (AIS) and broadband communications.

Mr. LARSEN. Thank you for your testimony.

And I want to now turn to Lynn Scarlett.

You are recognized for 5 minutes.

Ms. SCARLETT. Thank you very much. Thank you, members of the committee, for this opportunity to discuss infrastructure resilience. I am Lynn Scarlett, vice president of policy and Government relations at The Nature Conservancy.

As we look to invest in infrastructure in the context of climate change, nature itself can be a solution. Natural infrastructure can be clean, green and dollar smart. It is real and practical. So what is it?

Natural infrastructure refers to investments in natural and bio-engineered systems to contribute to infrastructure needs. It can be deployed alone or in combination with more traditional infrastructure. It includes green spaces that absorb and filter stormwater, reducing flooding and pollution, often at much less cost than refurbishing pipe-and-tunneling systems.

For example, Philadelphia is putting nature back into the city to handle sewerage overflow and stormwater at a fraction of the cost to replace pipes and tunnels. Seattle reduced the volume of runoff in one neighborhood by 98 percent by using natural infrastructure and the price tag was 25 percent less than traditional tools.

Beyond city spaces, natural infrastructure includes the use of living shorelines of sea marshes, oyster reefs and dunes. In Howard Beach, New York, for example, the conservancy evaluated nature-based infrastructure and showed that a combination of nature-based and grade defenses result in avoided losses of \$244 million from extreme storm events.

The potential risk-reducing benefits of nature's assets are not hypothetical. In one study, the conservancy and a global risk modeler for the insurance industry modeled storm surge and damages from Hurricane Sandy. We determined that coastal wetlands prevented more than \$625 million in property damages.

Nature can help with transportation systems, too, especially in culvert design. Most culverts across this country see upsizing as we see more frequent high-intensity storms and the effects of a changing climate. Using culverts with natural bottoms reduces erosion and flooding. In New York, for example, one use of such an approach resulted in a road crossing surviving seven federally declared flood disasters over the past 15 years.

We have engaged across the Nation in natural infrastructure projects. These include one in Hamilton City, California, with the Army Corps of Engineers to reduce flood damage and restore ecosystems through levee setbacks and reconnecting 1,400 acres of flood plain. They include many projects in the Gulf of Mexico and the eastern seaboard on oyster reef restoration. They include efforts in, for example, Coquille Valley, Oregon, to upgrade tide gates and culverts, improve water management at less cost than traditional levees.

But significant opportunities exist to enhance the extent and effectiveness of these efforts. We launched a natural infrastructure initiative with the company Caterpillar as they and other business leaders recognized the potential of natural infrastructure. The initiative includes AECOM, Great Lakes Dredge and Dock, Brown and Root and other partners. The purpose is to accelerate investment in water-based infrastructure and promote the use of natural infrastructure.

The Federal Government is also helping lead the way. The Army Corps has many natural infrastructure projects and recently released a report called Engineering with Nature. But we see more opportunities for Federal leadership. These include consideration of natural infrastructure in Federal agency planning and in community hazard mitigation planning and investments. They include increasing reforestation through the Forest Service Restoration Trust Fund. They include supporting the Federal Highway Administration in infrastructure vulnerability assessments and training around its natural infrastructure guidance for transportation investments.

As we invest in this Nation's infrastructure, let us not build ourselves back into the 20th century. Nature's solutions are part of a better, cheaper, smarter future. Thank you.

[Ms. Scarlett's prepared statement follows:]

Prepared Statement of Lynn Scarlett, Vice President for Public Policy and Government Relations, The Nature Conservancy

Chairman DeFazio, Ranking Member Graves and committee members, thank you for the opportunity to present The Nature Conservancy's views on enhancing resilience of our transportation infrastructure. My name is Lynn Scarlett. I am Vice President for Public Policy and Government Relations at The Nature Conservancy.

The Conservancy is a global conservation organization dedicated to conserving the lands and waters on which all life depends. Guided by science, we create innovative, on-the-ground solutions to the world's toughest challenges so that nature and people can thrive together. We are tackling climate change, conserving lands, waters and oceans at unprecedented scale, providing food and water sustainably and helping make cities more sustainable. Working in all 50 States and 72 countries, we use a collaborative approach that engages local communities, governments, the private sector and other partners, including farmers, ranchers and other landowners.

INFRASTRUCTURE NEEDS AND NATURAL INFRASTRUCTURE

There are tremendous needs for improving and maintaining all kinds of infrastructure throughout the United States. Review of the recent American Society of Civil Engineers' 2017 scorecard giving the state of our nation's infrastructure a D+ summarizes this need. To meet the needs for upgrading our nation's infrastructure requires investing significant resources and finding ways to cost effectively and expeditiously accomplish needed infrastructure investments while sustaining community, environmental, safety and other widely held values. One significant tool in

meeting the infrastructure demands in a cost-effective manner is to consider investments in natural infrastructure.

Natural infrastructure refers to investments in restoration, conservation of nature and nature-based (bioengineered) systems to achieve infrastructure needs. Investments in natural infrastructure often occur combined with investments in more traditional “gray,” or “hard,” infrastructure like levees, roads and seawalls. Investments in natural infrastructure help preserve or reintroduce the basic functions of nature that deliver a suite of benefits in support human well-being; provide clean water and clean air; and sustain lands that provide food and recreation opportunities and reduce greenhouse gas emissions. Many of these solutions provide infrastructure innovations as important for their cost-effective performance as are innovations in high-technology solutions.

INVESTMENTS IN NATURAL INFRASTRUCTURE ENHANCE RESILIENCE TO GROWING IMPACTS

Investments in natural infrastructure can help reduce the impacts of a changing climate. According to the National Oceanic and Atmospheric Administration (NOAA), the U.S. has sustained 241 weather and climate disasters since 1980 where overall damages/costs reached or exceeded \$1 billion. The total cost of these 241 events exceeds \$1.6 trillion. In 2018 across the U.S., 14 weather and climate disaster events resulted in losses exceeding \$1 billion each. These events included one drought, eight severe storms, two tropical cyclones, one wildfire and two winter storms. Overall, these events resulted in the deaths of 247 people and resulted in significant economic impacts.

Weather-related disasters have been escalating, and the trend is expected to continue. Over the last 50 years, Americans have seen a 20 percent increase in high-intensity downpours. In addition, research documents that the proportion of Category 4 and Category 5 hurricanes has doubled from 20 percent to 40 percent in 35 years (Holland and Bruyere, 2012). Coastal storm surge and storm impacts will intensify as sea levels continue to rise the predicted 0.6 feet and 2 feet globally in the next century (Intergovernmental Panel on Climate Change, 2007). Understanding these observed and projected effects are important to advance prudent management and infrastructure investments.

INVESTMENTS IN NATURAL INFRASTRUCTURE ARE A SMART INVESTMENT

Incorporating nature in our infrastructure designs and investments provides opportunities to enhance the resilience of our nation’s infrastructure, delivers a host of benefits and ensures that we are not repeatedly rebuilding infrastructure based on outdated standards and trends. For example, rebuilding culverts without taking into consideration trends of increased rainfall events will result in those culverts being repeatedly blown out, while also damaging roads. We see many examples of this type of repeat damage and Federal funds being wasted rebuilding the same culvert or other types of infrastructure, in the same manner, only to be subsequently destroyed during the next extreme weather event. We should make smarter investments and rebuild larger culvert openings or more resilient infrastructure designs that will accommodate flood waters or withstand other extreme weather impacts. Doing so also helps avoid costly road closures. Larger culvert sizes also enhance the health of rivers, benefiting fish and other wildlife.

WHAT IS NATURAL INFRASTRUCTURE?

Defining the terms natural infrastructure or nature-based solutions can help provide a common understanding of what is meant by these terms. We have received from Members of Congress and congressional staff requests for more information on what is meant by these terms.

The terms have been defined in section 1184 of Water Resources Development Act (WRDA) 2016 legislation:

“The term ‘natural feature’ means a feature that is created through the action of physical, geological, biological and chemical processes over time.”

“The term ‘nature-based feature’ means a feature that is created by human design, engineering and construction to provide risk reduction in coastal areas by acting in concert with natural processes.”

WRDA 2018 amended the definition of nature-based feature to strike the word “coastal,” resulting in the term applying to all areas. We generally agree with this definition.

Natural infrastructure incorporates both the natural environment and engineered systems that mimic natural processes or work in concert with natural systems to

provide flood, fire and drought risk reduction, clean water and clean air benefits. Natural infrastructure delivers economic, societal and environmental benefits.

At its essence, natural infrastructure can protect, restore or mimic the role that nature plays—ecological processes, including, but not limited to, water quality and quantity processes. Natural infrastructure uses vegetation, soil health, land protection, land management and other elements and practices to protect, maintain and restore the natural processes required to manage water and other natural processes, create healthier environments and protect human communities. Natural infrastructure solutions can be applied on different scales: at the city, county or regional scales. By using nature, damages and impacts can be minimized, and communities can recover more quickly from disasters and impacts.

To illustrate varied types of natural infrastructure projects, we include a compilation of natural infrastructure projects from throughout the U.S. in which the Conservancy has been involved. (See Appendix A.) The Naturally Resilient Communities website, which the Conservancy developed along with the National Association of Counties, the Association of State Floodplain Managers, as well as others, provides an overview of natural infrastructure and case studies throughout the U.S. that illustrate varied types of projects.

Benefits of natural infrastructure include the following:

- Reducing risks to people and structures
- Reducing wave heights and storm surge
- Storing and conveying water
- Improving water quality (and reducing costs of water treatment)
- Reducing drought impacts
- Reducing threats of catastrophic fires
- Reducing summer heat and improving air quality
- Reducing erosion and sedimentation
- Providing green spaces, greenways and recreational opportunities
- Providing habitat for fish and wildlife

Types of natural infrastructure include the following:

River work	Coastal work	Urban work
Reconnecting rivers to floodplains Levee setbacks and realignments Flood bypasses Conserving/restoring watershed forests Conserving/restoring river corridors Conserving/restoring wetlands Constructing wetlands Establishing flood water detention areas Fish/flood friendly culverts/bridges Dam removal Establishing filter strips, grassed waterways on farm fields	Conserving/restoring coastal marshes Conserving/restoring oyster and shellfish reefs Conserving/restoring coral reefs Building living shorelines Conserving/restoring intertidal flats Conserving/restoring mangroves	Constructed wetlands Bioretention cells Planting trees Conserving lands in watershed headwaters Sustainable forest management

INVESTING IN NATURAL INFRASTRUCTURE CAN BE ECONOMICALLY PRUDENT

The traditional approach to flood and water quality protection in river-floodplain systems has been to rely on dams and levees to contain flood waters; build treatment plants and lay miles of pipes to treat and transport water and wastewater; and, in coastal areas, build sea walls, bulkheads and other gray infrastructure. While built infrastructure plays an important role in helping to secure and provide essential services to communities, it requires substantial investments for both initial construction and ongoing maintenance. Moreover, extensive reliance on built infrastructure in the United States during the 19th, 20th and early 21st centuries has encouraged land development in areas particularly susceptible to flooding and storm damage and catastrophic flooding when infrastructure fails. And fail it has.

Many disasters during the past decade have involved numerous levee breaches, dam failures and seawall breaches. Failing gray infrastructure has led to extensive property and infrastructure destruction and lives lost.

If left unaddressed, as the nation's water infrastructure and flood protection infrastructure continue to age, we expect economic losses will continue to increase—including the taxpayer's large obligation under the National Flood Insurance Program—along with the risk faced by tens of millions of Americans who live and work behind levees and tens of millions more living along the coast.

Renewing the nation's traditional built flood control and water infrastructure solutions presents a daunting challenge. The American Society for Civil Engineers reports that there are 30,000 documented miles of levees in the U.S. protecting communities, critical infrastructure and valuable property. The levees in the U.S. Army Corps of Engineers' data base protect an estimated \$1.3 trillion in property. Yet development continues to encroach in floodplains along rivers and coastal areas, exacerbating flood risk and putting property at risk. An estimated \$80 billion is needed in the next 10 years to maintain and improve the nation's system of levees. The challenge also exists for coastal infrastructure. In Massachusetts alone, there are about 140 miles of publicly owned sea walls or other structures along the coast designed to protect billions of dollars of property. Most were designed to last a half century but are older than that now. The estimated price tag to repair and fortify all of them against rising seas is more than a billion dollars.

Natural infrastructure or natural infrastructure combined with gray infrastructure is often the most cost-effective and best-performing option for reducing flood risk while delivering a host of other benefits such as improved water quality, enhanced habitat for fish and animals, improved aesthetics and overall contribution to a community's quality of life.

For example, the U.S. Forest Service estimates that 180 million people access their drinking water from national forests. More than 5 million of these people live in communities served by small- and medium-sized utilities that rely on surface water for their drinking water. At a time when climate-driven droughts and megafires are more common, these communities will need support to protect both homes and water supplies. And in urban areas, investments in natural infrastructure—such as parks and green spaces, as well as dunes and wetlands—can help increase cities' resilience to climate change, as well as improve the health, safety and quality of life of urban residents.

GROWING BODY OF EVIDENCE ON EFFECTIVENESS AND COST EFFECTIVENESS OF NATURAL INFRASTRUCTURE

In Coastal Areas

A growing body of knowledge and experience demonstrate the effectiveness and cost effectiveness of coastal natural infrastructure. In the U.S., coastal wetlands act as "horizontal levees" for a value of \$23.2 billion per year in protection from storms (Costanza et al., 2008). Barbier et al. (2013) show that coastal marshes and vegetation have demonstrable effects on reducing storm surge levels, which provides significant value in protecting property in southeast Louisiana. They measured that a mere 1 percent increase in wetland continuity over 6 kilometers would lower residential property flood damages by \$592,000 to \$792,100, and a marginal increase in bottom friction over 6 kilometers would reduce flood damages by \$141,000 to \$258,000.

In a 2016 study, the Conservancy, in partnership with Risk Management Solutions, a global leading risk modeler for the insurance industry, Guy Carpenter & Co. and others showed that marsh wetlands saved more than \$650 million in property damages during Hurricane Sandy and reduced annual property losses by nearly 20 percent in Ocean County, New Jersey (Narayan et al., 2016b).

Oyster reef development and restoration also yield significant economic benefits. A 2012 study by Conservancy economist Timm Kroeger summarized that an investment of \$150 million in oyster reef restoration will achieve the following:

- Build 100 miles of oyster reefs
- Create 380 jobs per year for 10 years, or rather, 3,800 jobs during the decade-long construction phase
- Boost regional household income by \$9.7 million a year during the 10-year construction period
- Increase revenues and sales of crab, fish and oyster harvests by \$7.87 million yearly
- Save property owners up to \$150 million on the construction of bulkheads
- Enhance yearly saltwater angler spending by \$4.9 million in Alabama alone
- Increase annual sales by \$7.3 million in the commercial seafood supply chain

In Freshwater Areas

There are also examples of investing in natural infrastructure in freshwater systems. The best known example is New York City's effort to protect its water supply. In the late 1990's, New York City initiated a plan to protect its source water and avoid the cost of a filtration plant by investing in its 2,000-square-mile watershed. A filtration plant would have cost the city \$8 billion to \$10 billion in current dollars—roughly \$6 billion to build and \$250 million annually to maintain. In contrast,

the cost of securing natural infrastructure in the watershed was estimated at \$1.5 billion. The watershed program has staved off the need to build a filtration plant and provided an annual \$100 million injection to the rural economy in the upper reaches of the watershed by providing supplemental income to farmers and forestland owners, paying local contractors to install septic systems and set up stormwater protection measures and promoting ecotourism (Kenny, 2006.)

Another example is from the city of Medford, Oregon. Its wastewater facility discharges into the Rogue River but exceeds maximum temperature load requirements as allowed by its total maximum daily load (TMDL). To meet its temperature TMDL requirements, Medford evaluated three alternatives: lagoon storage for discharge later in the year, mechanical chillers and riparian restoration and shading. An economic analysis showed that riparian restoration was three times more cost effective than mechanical chillers for reducing thermal loads into the river and would provide additional benefits such as wildlife habitat and water filtration.

It is often more cost effective to invest in reduction of risks of catastrophic wildland fire than to pay for impacts of damaging fires. For example, thinning 1 acre of dense forest in the critical Rio Grande and San Juan-Chama headwaters area costs \$700 on average, whereas the economic impact of 1 acre affected by damaging wildfire can be up to \$2,150 per acre. Even if just one large fire burns, the upfront investment in forest health saves money: Forest thinning to boost fire resilience is estimated to cost \$73 million to \$174 million, with damage estimates between \$104 million and \$1.3 billion. This approach makes economic sense over the long term. A recent study estimated the cost of damages from wildfires from 2009 to 2012 in New Mexico was \$1.5 billion. In contrast, the Rio Grande Water Fund estimates a total cost of \$420 million over 20 years to accelerate the pace and scale of forest treatments and restoration. Preserving and restoring these forests will help ensure the sustainability of New Mexico's water supply and increase social and economic benefits for local communities.

Nationally, a rough estimate is that 67 percent of culverts are not designed to allow for a 1 percent flood (100-year flood) and need upsizing. Assuming a quarter of those need immediate replacement, the savings over the life of the new culverts would be \$8 trillion. The savings increase with increased flood risk and grow exponentially when emergency management is required due to road or bridge washout—none of the calculations account for the dramatic costs of catastrophic failure and emergency replacement. When aggregated to a Federal level, culvert upgrades could represent significant savings to public transportation budgets.

In Hancock, New York, three flood events between 1996 and 2005 damaged an undersized culvert on Big Hollow Creek. In those 9 years, Delaware County spent more than \$70,000 to repair damages to the culvert, as well as the road and adjacent ditches. In addition, the detour length associated with closure of the road for repairs was 18 miles. Late in 2005, with hazard mitigation funding assistance from the Federal Emergency Management Agency (FEMA), the county installed a three-sided concrete box culvert with a natural bottom, designed to convey a 100-year storm and provided at a cost of \$143,000. The improved crossing has survived seven federally declared flood disasters, including Hurricane Irene, without significant damage since its replacement in 2005 (W. Reynolds, Delaware County Department of Public Works, pers. comm.).

In Urban Areas

Natural infrastructure in cities is most often called green infrastructure. Green infrastructure has a proven track record of being more cost effective, in many cases, than traditional gray infrastructure solutions in achieving surface water management goals. For instance, the American Society of Landscape Architects studied 479 green stormwater infrastructure projects, of which 44 percent were lower than and 31 percent were equivalent to the costs of gray infrastructure alternatives.

In one example at Episcopal High School in Baton Rouge, the cost of bioswales and rain gardens constructed in lieu of replacing stormwater pipes with larger-sized pipes saved the school \$390,000, a cost savings of 78 percent over the original project budget of \$500,000.

Green infrastructure projects, beyond level of service and environmental benefits, have compounding economic benefits. In its study of the green infrastructure alternative for the city of Lancaster, Penn., the Environmental Protection Agency demonstrated that the added-value benefits amounted to nearly \$5 million per year.

CONGRESSIONAL ACTIONS BY THIS COMMITTEE AND OTHERS HAVE ENABLED INCREASED INVESTMENTS IN NATURAL INFRASTRUCTURE

Congress has taken some important steps toward recognizing, enabling and funding investment in natural infrastructure. An important milestone occurred in the

special disaster appropriations that Congress passed in response to Superstorm Sandy. Congress appropriated funding for several agencies and programs that provided important investments in natural and nature-based project work resulting in reducing future flood risk. U.S. Fish and Wildlife Service received \$360 million for coastal resilience projects. This funding spurred important investments in natural infrastructure. With this funding, the Conservancy led work in New York to mitigate flooding and improve fish passage in the Ausable watershed and invested in green infrastructure in Accomack and Northampton counties in Virginia. The Conservancy also contributed to work in Delaware restoring Delaware Bay's wetlands and beaches in Mispillion Harbor Reserve and Milford Neck Conservation area, and in Massachusetts removed 10 fish barriers in nine communities resulting in lowering flood risk and improving fish habitat and overall quality of the streams.

Other sources of funding in the Sandy bill also contributed to enhanced resilience by helping invest in natural infrastructure. NOAA was awarded a small amount of funding that it invested in funding networks of State, academic, local and non-governmental organizations to build a learning network to spur planning and implementation of actions to enhance community resilience. This was an important capacity-building investment helping grow and disseminate and build the body of knowledge and capacity to implement future coastal resilience work. One such investment in New Jersey continues to enable ongoing coastal resilience work in that State. Natural Resource Conservation Service was awarded funds through its Emergency Watershed Protection program, which invests in easement purchases in floodplains to restore floodplain areas and allow them to function as areas to absorb and slow floodwaters.

Sandy disaster funding also included \$1 billion in disaster funds for the Housing and Urban Development (HUD) National Resilience Competition. The competition encouraged communities to develop disaster recovery plans from past disasters and make investments to lower risk to future disasters while advancing broader community development goals. The competition encouraged participants to think expansively when developing projects that would enable community development goals and ensure public engagement. As part of the effort, the Rockefeller Foundation collaborated with HUD and provided workshops and expert input to applicants to help build capacity and enhance application quality. Most of the applications in response to this competition included elements of investment in natural infrastructure. The Conservancy would like to see this program replicated.

In addition to funding bills, other legislation has advanced the concept of and enabling conditions for investing in nature as a tool for reducing risk from a range of impacts such as flooding, drought and wildfires.

As noted previously, WRDA 2016 provided the most comprehensive definition of natural and nature-based infrastructure to date. The 2018 WRDA bill builds on this definition to further require the Army Corps to consider natural and nature-based infrastructure when carrying out studies of projects.

As evidence of the Army Corps' own work to support investments in natural infrastructure, the Army Corps held an event at the National Building Museum in Washington, DC, to launch its new publication, "Engineering With Nature: An Atlas." The book is filled with global examples of natural and nature-based project work.

FURTHER WORK TO BE DONE TO ENABLE NATURAL INFRASTRUCTURE INVESTMENTS

Many other statutes have included the need to protect and restore ecosystems and watersheds to protect the myriad of important services intact and healthy natural systems provide to people. There are many more opportunities to continue to include this intent in other legislation dealing with infrastructure investments and disaster, wildfire and drought risk reduction. The Conservancy will continue to advocate for consideration of and investments in natural infrastructure as the Congress works on developing a bill to invest in infrastructure, as well as in other appropriate legislative vehicles.

Congress must also ensure that infrastructure is built to enhance resilience in the context of a changing climate and increasingly frequent extreme weather and wildfire events. Congress can improve planning, training and direct investments in nature-based and gray infrastructure by doing the following:

- Requiring resilience and flood and wildfire risk analysis in federally funded work, and upgrading flood maps and wildfire risk maps
- Bolstering interagency coordination to enhance resilience
- Incentivizing enhanced community hazard mitigation planning and investments
- Enhancing consideration of and investments in natural infrastructure alone or in combination with gray infrastructure to maximize environmental, societal and economic benefits

- Reducing wildfire risk to communities by investing in future risk reductions following disasters and updating Community Wildfire Protection Plans
 - Codifying the Forest Service Legacy Roads and Trails program to prioritize corrections to deferred maintenance
 - Increasing reforestation by investing in the U.S. Forest Service Reforestation Trust Fund to plant an additional 1 million trees in 3 years
- And Federal agencies can play varying roles in advancing investments in natural infrastructure, including the following:
- Army Corps can continue to invest in natural infrastructure by offering training and workshops for its staff throughout the U.S. to help them understand how best to incorporate nature in their project analysis and implementation
 - NOAA can provide data, decision support tools such as online vulnerability assessment and solution analysis tools, technical assistance and training
 - U.S. Geological Survey can make its science more centrally located, accessible and in easy-to-access online GIS-based tools
 - FEMA can make more of its flood data available and accessible to allow better analysis and targeting of risk reduction actions
 - Federal Highway Administration can invest more resources in its infrastructure vulnerability assessment work and dissemination and training around its soon-to-be-released guidance on incorporation of natural infrastructure into transportation investments

GROWING SUPPORT AMONG BUSINESSES AND COMMUNITIES

In addition to growing support in Congress to promote investments in natural infrastructure, the Conservancy has seen encouraging, growing support from businesses who see investments in nature as important business investments.

In 2015, the Conservancy joined with Caterpillar and launched the Natural Infrastructure Initiative (NII). The NII grew out of a gathering of business leaders recognizing the need to work with and invest in nature and understanding this as a business opportunity. Members of the NII in addition to the Conservancy and Caterpillar include AECOM, Great Lakes Dredge and Dock, Ducks Unlimited and Brown and Root. NII members are working collaboratively to accelerate investment in water-based natural infrastructure projects as part of a solution set for infrastructure needs, embed natural infrastructure as part of ongoing discussions about improving investment in water-based infrastructure and promote the use of natural infrastructure in general.

The Conservancy has worked with other companies and organizations to investigate natural infrastructure solutions and invest in projects. Some examples include Dow, Jacobs, Boeing, BSNF and the American Society of Civil Engineers. The Conservancy is committed to working with businesses who understand the value of making these investments.

In addition to corporate support, the Conservancy has seen growing support among elected officials and is working with organizations such as the Mississippi River Cities and Towns Initiative (MRCTI), which represents cities and towns along the main stem of the Mississippi River and advocates on issues facing the communities, such as improving water quality and reducing flood risk. The Conservancy has also worked with the National Association of County Officials (NACO), who has joined with us in support of investments in natural infrastructure. MRCTI and NACO members understand the numerous benefits provided through investments in nature.

CONSERVANCY EXAMPLES OF VARIOUS TYPES OF NATURAL INFRASTRUCTURE WORK

The Conservancy is a leader in executing projects that serve as prime examples of investments in natural infrastructure. I would like to close my testimony by briefly describing a few representative examples of the Conservancy's work taking place throughout the U.S.

Hamilton City, Calif.—Hamilton City is located approximately 90 miles north of Sacramento and is adjacent to the west bank of the Sacramento River. The project is a multipurpose flood damage reduction and ecosystem restoration project consisting of construction of a 6.8-mile setback levee to provide improved flood protection to the community and agricultural areas, and reconnection of approximately 1,400 acres to the Sacramento River floodplain and restoration of that acreage into native riparian habitat. The project was authorized under WRDA 2007, amended in WRDA 2017 and is estimated to cost \$91 million, of which \$31.3 million is the non-Federal contribution. The fact that this project addresses both flood protection and ecosystem restoration required new Army Corps policy guidelines to permit these objectives in a single project. The Conservancy is working with the Army Corps na-

tionally to encourage expanded implementation of multi-benefit projects, which is challenging given the Army Corps' methods for evaluating the cost and benefits of projects. The project will help to lessen historic flooding that has impacted Hamilton City and result in enhanced habitat for fish and wildlife.

Pacific Northwest—Throughout the Pacific Northwest, tide gates and levees are used to control water from rivers and the ocean on low-lying properties. Tidal wetlands—which are critical to the survival of salmon—once covered most of the Coquille Valley. Today, less than 10 percent of these historic wetlands in the Coquille Basin remain. The Conservancy has been working with Federal and State partners in the Coquille watershed in southwestern Oregon to design, upgrade and replace tide gates, which is already proving to provide benefits to the local community and the agricultural grazing lands while at the same time improving water quality, rearing habitat and fish passage.

The Conservancy and partners have work underway replacing old tide gates and culverts with seven new tide gates and five new bridges to dramatically improve fish passage and restore wetland function and tidal flow in the Coquille basin. By working with the Beaver Slough Drainage District, China Creek Gun Club, Coquille Indian Tribe, Federal partners such as NOAA and U.S. Fish and Wildlife Service and other entities, this project is reconnecting 7.8 miles of historic channels to the Coquille River. The new infrastructure requires less maintenance, resulting in cost savings over time. Local landowners have reported their excitement about “raising cattle in the summer and salmon in the winter.”

The construction projects are projected to generate at least \$4.2 million and will support 18 to 25 jobs. Many local businesses will see new demand in specific industries like nurseries, heavy equipment, rock or gravel and local labor.

New Jersey—Since Superstorm Sandy, the Conservancy's New Jersey chapter has been working to demonstrate the success and benefits of projects that help its coastal salt marshes—which helped reduce damages in New Jersey during Sandy by nearly \$500 million—persist in the face of sea level rise. One such project tested an innovative technique in which clean mud and sand from clogged boat channels was sprayed on top of nearby marshes to help boost the elevation of more than 60 acres of marsh. This so-called technique of beneficial reuse of dredged material is aimed at boosting the health of the wetland to help reduce future storm impacts. This project was the result of a successful partnership with the Army Corps, the State of New Jersey and others. The construction on three different marshes was completed about 3 years ago, and the Conservancy is helping to assess the success and impact of the project. The results have been promising. In combination with other nature-based solutions, like oyster reef breakwaters to reduce marsh erosion, the Conservancy is working to expand the consideration and implementation of a variety of natural infrastructure investments to help the Jersey Shore become more resilient to the impacts of climate change.

Washington, DC—To mitigate stormwater runoff, Washington, DC, instituted a first-of-its-kind stormwater retention credit (SRC) market. The market reduces the impact of stormwater runoff—the largest-growing source of pollution to the Chesapeake Bay watershed and the fastest-growing source of urban water pollution globally. It allows land-constrained developers to meet a portion of their stormwater retention requirements by purchasing SRCs. Credits are generated by stormwater retention projects elsewhere in the city, including green infrastructure projects.

Investments in green infrastructure for stormwater retention can bring income to landowners and provide valuable co-benefits, including expanded green space, reduced localized flooding, increased flexibility and onsite revenue options for developers and jobs to build and maintain green infrastructure sites. Offsite credit projects create opportunities for infrastructure investments in underserved communities.

The Conservancy's NatureVest is partnering with Encourage Capital to establish and capitalize District Stormwater, LLC (DS), which will finance and develop SRC-generating projects. DS will work with landowners and community groups to site credit-generating projects in parts of Washington, DC, that would most benefit from green infrastructure while creating liquid, cost-competitive credits for sale in the SRC market. DS anticipates mitigating 500,000 gallons of runoff annually. This will protect fragile ecosystems, such as the Chesapeake Bay, that are too often overrun by polluted stormwater that can contain raw sewage; provide infrastructure services to underserved communities through increased green space and the reduction of localized flooding; and inspire new conservation-minded people as they see the benefits of green infrastructure in their communities.

Gulf of Mexico—Throughout the Gulf of Mexico and along the eastern seaboard, oysters play a vitally important role in supporting healthy estuaries. Oyster reefs provide multiple benefits, from providing habitat and food for wildlife, to filtering

water, removing nitrogen and stabilizing eroding coastlines. Oysters are also a favorite cuisine for people, and States throughout the southeast once had robust oyster fisheries. A healthy adult oyster can filter up to 50 gallons of water daily, helping to cleanse estuaries and support aquatic grasses and other plants that need light to survive. These plants, in turn, yield benefits like fish production and carbon storage, completing an invaluable cycle. Healthy oyster reefs also serve as natural buffers against rising sea tides and hurricanes by forming breakwaters that help protect shorelines from erosion. Oyster reefs also create economic value, bringing upwards of \$10 million (dockside valuation) into Florida alone. Oyster reefs have severely declined throughout their historical ranges all over the world. Today, oyster reefs are considered one of the planet's most imperiled marine habitats. Over the last two centuries, more than 85 percent of the world's oyster reefs have been lost. The Conservancy is working throughout the Gulf of Mexico, as well as along the eastern seaboard, to restore and build oyster reefs to maximize the services this important species provides to people and nature.

Massachusetts—In September 2016, Gov. Charlie Baker issued an executive order that launched a statewide planning process and a municipal technical assistance program. A priority is placed on investing in nature-based solutions to enhance resilience and actions to mitigate climate change.

Along with the executive order, the State launched a new website, the resilient MA Climate Clearinghouse, to provide communities access to the best science and data on expected climate change impacts, information on planning and actions communities can deploy to build resilience and avoid loss, and links to important grant programs and technical assistance. The State has also stood up the Municipal Vulnerability Preparedness program that provides communities with a planning expert to walk them through a Conservancy-developed community resilience building process. Communities must update their hazard mitigation plans after going through the process and continue to make progress to be eligible for State mitigation grant funds.

This past year, the Massachusetts legislature-enacted climate change bond provided \$2.4 billion in capital funding for the next 5 years. The focus is on investing in nature-based solutions to lessen climate impacts and enhance resilience. In January, Baker filed a bill to increase the real estate transaction fee and use the funds for climate change adaptation and resilience (more than \$1 billion over 10 years).

This program should be replicated at the Federal level. An important role Federal agencies can play is to provide technical and planning assistance, provide the latest science in a user-friendly manner and share best practices to effectively address the challenges of extreme weather and a changing climate that are inflicting significant costs on communities throughout our Nation.

CONCLUSION

Thank you for the opportunity to present The Nature Conservancy's recommendations on the need for the Federal Government to prioritize investment in nature as an important tool for enhancing resilience to the increasing impacts of extreme weather and climate change. The Conservancy will continue to lead the way in contributing to the science and executing projects that demonstrate the important benefits and services that nature provides to people. The Conservancy will continue to work with the Congress to recommend and advance policies to support increased investments in natural infrastructure that help cost effectively address our nation's infrastructure challenges.

APPENDIX A:

NATURAL INFRASTRUCTURE: WHAT DOES IT MEAN?

Natural infrastructure incorporates both the natural environment and engineered systems that mimic natural processes or work in concert with natural systems to provide flood, fire and drought risk reduction, clean water, and clean air benefits. Natural infrastructure delivers economic, societal and environmental benefits.

At its essence, natural infrastructure can protect, restore, or mimic the role that nature plays—the ecological processes—including, but not limited to, water quality and quantity processes. Natural infrastructure uses vegetation, soil health, land protection, land management and other elements and practices to protect, maintain and restore the natural processes required to manage water and other natural processes, create healthier environments, and protect human communities.

Natural infrastructure solutions can be applied on different scales: at the city, county or regional scale. By using nature, damages and impacts can be minimized and communities can recover more quickly from disasters and impacts.

BENEFITS OF NATURAL INFRASTRUCTURE

- Keep people and structures out of harm's way
- Reduce wave heights and storm surge
- Store and convey water
- Improve water quality
- Reduce drought impacts
- Reduce threat of catastrophic fires
- Reduce summer heat and improve air quality
- Reduce erosion and sedimentation
- Provide greenspaces, greenways and recreational opportunities
- Provide habitat for fish and wildlife

TYPES OF INFRASTRUCTURE PROJECTS

River work	Coastal work	Urban work
Reconnecting rivers to floodplains Levee setbacks and realignments Flood bypasses Conserving/restoring watershed forests Conserving/restoring river corridors Conserving/restoring wetlands Constructing wetlands Establishing flood water detention areas Fish/flood friendly culverts/bridges Dam removal Establishing filter strips, grassed waterways on farm fields	Conserving/restoring coastal marshes Conserving/restoring oyster and shellfish reefs Conserving/restoring coral reefs Building living shorelines Conserving/restoring intertidal flats Conserving/restoring mangroves	Constructed wetlands Bioretention cells Planting trees Conserving lands in watershed headwaters Sustainable forest management

MOBILE BAY, ALABAMA

Project Type: Flood and/or Erosion Risk Reduction

Mobile Bay is the fourth largest estuary in the continental United States and plays an important role in nurturing the finfish, shrimp and oysters that are vital to Gulf communities.

Unfortunately, Mobile Bay—like the rest of the Gulf Coast—has lost many of its oyster reefs, seagrass beds and coastal marshes. Losing these reefs has meant increased shoreline erosion and related property damage.

Despite these challenges, Mobile Bay remains one of the largest potential areas for outright restoration, replacement and enhancement of these lost habitats on the Northern Gulf Coast.

The Conservancy is working with partners, including the U.S. Army Corps of Engineers, to build 100 miles of oyster reef and plant 1,000 acres of coastal marsh and seagrass here to help replenish the coastal waters and reduce shoreline flood impacts to local communities.



(c) Beth Maynor Young

HAMILTON CITY, CALIFORNIA

Project Type: Flood and/or Erosion Risk Reduction

In partnership with the U.S. Army Corps of Engineers, the California Department of Water Resources, and Reclamation District 2140, the Conservancy is championing a \$73 million project where, for the first time, the Army Corps designed a multi-benefit project to specifically reduce flood damages and restore critical floodplain habitat on the Sacramento River.

Construction began in spring 2016 building a new 6.8-mile setback levee, along with reconnecting 1,450 acres of floodplain between the new set-back levee and the river.

Approximately 1,361 acres will be restored to native riparian habitat and significantly reduce flood risk to the city of Hamilton, which has frequently evacuated due to flooding.



The Sacramento River supports important agricultural areas and critical wildlife habitat. (c) Jeff Fricker

EMIQUON PRESERVE, ILLINOIS

Project Type: Flood and/or Erosion Risk Reduction

The Nature Conservancy restored 5,900 acres of functional floodplain wetlands and five river miles along the Illinois River in Fulton County, Illinois.

Included in this restoration was, in consultation with the U.S. Army Corps of Engineers, the installation of a state-of-the-art flood control structure.

The final result of this restoration connected floodplain to the 7,000 acres of adjacent Chautauqua National Wildlife Refuge lands, resulting in 14,000 acres of contiguous conservation lands, providing flood control, environmental restoration, and public access to wildlife and waterfowl habitat.



The Nature Conservancy uses its Emiquon Preserve to demonstrate and measure the benefits of restored floodplains and wetlands. (c) Christina Rutter



Water control structure at Emiquon preserve.

SOUTH CAPE MAY MEADOWS PRESERVE, NEW JERSEY

Project Type: Flood and/or Erosion Risk Reduction

In partnership with the U.S. Army Corps of Engineers and the State of New Jersey, the Conservancy undertook a \$15 million restoration project that combined natural features like dunes and wetlands with levees and other engineered structures to control water.

Completed in 2004, the restored preserve has since withstood a series of severe storms, including Irene in 2011 and Sandy in 2012.

Storm waves didn't breach the dunes, wetlands remained intact, and the preserve helped protect neighboring communities, which experienced only minor flooding unlike similar towns up and down the coast.



The Nature Conservancy has helped restore over 630 acres of coastal dunes, which can help protect communities from storms. (c) Harold E. Malde

WHITTENTON DAM, TAUNTON, MASSACHUSETTS

Project Type: Flood and/or Erosion Risk Reduction

In Massachusetts alone, there are close to 3,000 dams; many of them are relics of bygone uses.

The Whittenton Pond Dam was in disrepair, and heavy rains in 2005 brought the threat of a catastrophic breach and flooding of downtown Taunton, which was evacuated for a week as the dam appeared on the verge of failure.

Removing the dam was less expensive than repairing it, with rebuilding cost estimated to be \$1.9 million and removal cost of \$447,000.

The dam's removal in 2013 opened 30 miles of river habitat to vulnerable fish species, avoided \$1.5 million in emergency response cost, increased numbers of two vulnerable species (American eel and river herring), and increased property values due to the lower flooding risk.



Whittenton Mills dam, damaged during 2005 storm. photo credit: MA Division of Ecological Restoration

AUSABLE RIVER WATERSHED, NEW YORK

Project Type: Flood and/or Erosion Risk Reduction

Undersized stream crossings are prone to damage from high flow events and require more frequent maintenance and replacement. During major storms, undersized culverts block water, clog with debris and worsen flood impacts, requiring expensive repairs to the culverts, nearby roads, and private property. When roads shut down due to this damage, it creates lengthy detours, often affecting access to local businesses. Poorly designed and installed culverts also block fish and wildlife movement and impact habitat for economically important fisheries.

In August 2011, Tropical Storm Irene brought significant rainfall to much of New England and eastern New York, resulting in unprecedented flood damage to infrastructure.

The Conservancy secured private and government grant funding to replace and retrofit high ecological priority, flood-vulnerable culverts in New England and in upstate New York. To date, The Conservancy has worked with government and non-profit partners to complete three culvert replacements and two culvert retrofit projects in the Ausable River Watershed in the Adirondacks. These projects connect over 65 miles of previously fragmented fish habitat, mitigate future flood damage, improve safety on vital local road networks, and reduce maintenance costs for communities. The culvert upgrades prevent future road damage that occurs when undersized culverts blow out during floods.



Roaring Brook culvert prior to replacement. At lower flows this culvert outlet was perched above the water surface, creating a barrier to the movement of fish. The stream was constricted by the pipes' combined span of 12 feet, which caused debris buildup and localized flooding.



Roaring Brook culvert replacement: With a width of 35 feet, the new culvert—an open-bottom concrete box with a natural streambed—allows the stream to pass freely underneath, opening six miles of upstream habitat for fish and designed to withstand high water flows.

UPPER MISSISSIPPI RIVER

Project Type: Flood and/or Erosion Risk Reduction

In cooperation with a diverse group of Upper Mississippi River (UMR) stakeholders, The Nature Conservancy is working to garner Federal appropriations for a dual-purpose program called the Navigation and Ecosystem Sustainability Program (NESP). As the name implies, this program is a measured plan to create a sustainable navigation system with strategic improvements at 7 of 37 locks and other small-scale efficiency measures. Safe and efficient movement of traffic would

be renewed on the navigation system, which was constructed almost 80 years ago and is now facing continual rehabilitation to maintain. At the same time, comparable funding for ecosystem restoration on the UMR will afford the opportunity to use additional techniques for river restoration such as reconnecting 35,000 acres of river floodplain; providing native fish passage; regenerating floodplain forests; and managing water levels closer to historic conditions to replicate more natural seasonal conditions.

These new techniques, along with well-established river enhancement measures to revitalize river channels, backwaters and floodplain habitats are estimated to restore 40 percent of degraded UMR ecosystem. A higher-functioning ecosystem provides human and natural services through increased nutrient processing, flood storage capacity, groundwater infiltration, cleaner water, and improved fish and wildlife habitat.



Lock extensions from 600' to 1200' will increase efficiency at the 7 lock improvement sites by eliminating the need double locking (as shown in picture) which is standard practice at all but two locks on the 37 lock system of the UMR. Disintegrating concrete and mechanical systems will be rehabilitated or replaced as the lock is lengthened.

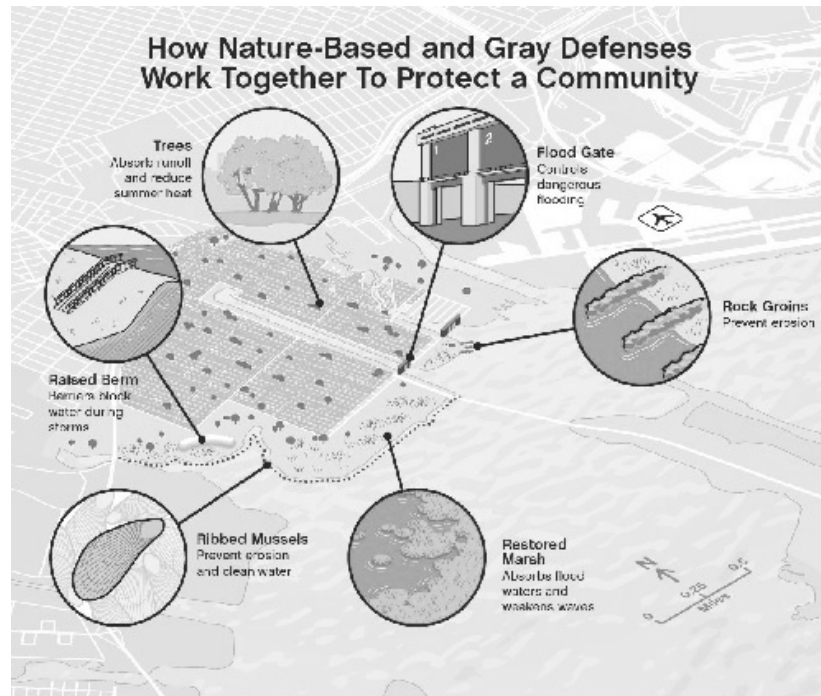
HOWARD BEACH, QUEENS, NEW YORK

Project Type: Flood and/or Erosion Risk Reduction

In the wake of Hurricane Sandy, The Nature Conservancy undertook a project evaluating the role of nature and nature-based infrastructure in protecting communities from some of the impacts of climate change. The community of Howard Beach, Queens, was selected as a case study for the project because this neighborhood, hit hard during Sandy, is low-lying and densely populated. Although Howard Beach was used in the analysis, the study methodology is applicable to coastal communities across New York City and around the globe.

Experts analyzed several infrastructure alternatives, ranging from purely nature-based solutions to one consisting of only gray defenses. The study found that combining natural and gray defenses holds the most benefits. Analysis shows that a hybrid alternative could result in avoided losses in this one neighborhood of up to \$244 million from the current 1-in-100-year storm event.

The best conceptual alternative and most cost-effective, according to the study, utilizes restored marsh habitat on the coast, hard toe mussel beds along the shoreline, floodgates and sea walls to protect against storm surge and rising sea levels and rock groins on the shoreline to help prevent erosion.



Infographic of design alternatives studies.

RIO GRANDE WATER FUND, NEW MEXICO

Project Type: Flood and/or Erosion Risk Reduction

The Rio Grande Water Fund is a ground-breaking project that is engaging private and public partners in proactively protecting vital watersheds in northern New Mexico.

Frequent, high-severity wildfires and subsequent post-fire flooding increasingly threaten the Rio Grande's water security and cause extensive soil erosion that degrade water quality for communities downstream. Restoring overgrown forests is a proven solution to make forests safer and healthier, and such efforts were already underway at a small scale before the devastating Las Conchas fire blazed in 2011. This fire demonstrated that the pace and scale of these treatments was insufficient to guarantee water security for Albuquerque and irrigated agricultural lands. The Rio Grande Water Fund works to generate sustainable funding for a 20-year, large-scale program to restore the health of the forest and watershed with treatments that include thinning overgrown forests, restoring streams and rehabilitating areas that flood after wildfires.

This approach makes good economic sense over the long-term. A recent study estimated the cost of damages from wildfires 2009 to 2012 in New Mexico was \$15 billion. In contrast, the Rio Grande Water Fund estimates a total cost of \$420 million over 20 years to accelerate the pace and scale of forest treatments and restoration. Preserving and restoring these forests will help ensure the sustainability of New Mexico's water supply and increase social and economic benefits for local communities.



Wetlands at Valles Caldera National Preserve. The Rio Grande Water Fund engages private and public partners in protecting vital watersheds in northern New Mexico. Photo credit: (c) Alan W. Eckert for The Nature Conservancy

DETROIT, MICHIGAN

Project Type: Water quality and flood risk reduction with stormwater management

Like many aging cities, Detroit faces water infrastructure challenges. The city's sewer system is combined to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipes. Heavy rain events overwhelm the system's capacity, creating raw sewage overflows that flood basements and overflow into rivers and ultimately the Great Lakes.

Under the Clean Water Act, the city is required to completely eliminate all combined sewer overflow (CSO) discharges, yet the costs of implementing traditional "gray" infrastructure are only increasing, with current estimates at \$1.2 billion. To help reduce or offset these costs, The Nature Conservancy is working with the city to incorporate green infrastructure, a form of natural infrastructure used in cities. The design uses green space and natural plant material to absorb, retain, and slow stormwater runoff, reducing the amount of water entering the storage facility for treatment, reducing CSO's, and decreasing surface flooding. This, in turn, should lead to improved water quality in adjacent rivers and lakes, as well as attractive green spaces that contribute to neighborhood revitalization by offering recreational areas and beautification opportunities.

The Conservancy has also provided technical assistance to develop policies that have helped finance and encourage green infrastructure solutions within Detroit. These policies have enabled economic markets and private investment in support of public amenities in new innovative ways.



Local flooding in Detroit, the result of aging infrastructure and heavy rain. Photo credit: Michael David-Lorne Jordan/David-Lorne Photographic

LOUISVILLE, KENTUCKY

Project Type: Water quality and flood risk reduction with stormwater management

The Nature Conservancy is working with partners to conduct a rigorous evaluation of the link between urban vegetation/greenspace and cardiovascular disease. The goal is to foster the development of public health policy that incentivizes using increased tree canopy and other forms of nature to achieve better health outcomes.

The desire is to quantify avoided healthcare costs as a way to identify and create a funding stream for large-scale and sustained urban tree and other vegetation plantings.

The aim is to create a replicable model for neighborhood greening that other cities and developing countries can adopt. The project hopes to provide more scientific evidence of the value of nature to people.

The Conservancy plans to manage about \$8 million in greening interventions, with planting beginning in 2017 and continuing for a couple of years.



Louisville's heat island has been steadily worsening over the decades, especially in low-income neighborhoods, where temperatures can be 20 degrees higher than surrounding areas.

WASHINGTON, DC

Project Type: Water quality and flood risk reduction with stormwater management

To mitigate stormwater runoff, Washington D.C. instituted a first-of-its-kind Stormwater Retention Credit (SRC) market. The market reduces the impact of stormwater runoff—the largest growing source of pollution to the Chesapeake Bay watershed and the fastest growing source of urban water pollution globally. It allows land-constrained developers to meet a portion of their stormwater retention requirements by purchasing SRCs. Credits are generated by stormwater retention projects elsewhere in the city, including green infrastructure projects. Investments in green infrastructure for stormwater retention can bring income to landowners and provide valuable co-benefits, including expanded green space, reduced localized flooding, increased flexibility and onsite revenue options for developers, and jobs to build and maintain green infrastructure sites. Offsite credit projects create opportunities for infrastructure investments in underserved communities.

The Nature Conservancy's NatureVest is partnering with Encourage Capital to establish and capitalize District Stormwater, LLC. (DS), which will finance and develop SRC-generating projects. DS will work with landowners and community groups to site credit-generating projects in parts of the District that would most benefit from green infrastructure, while creating liquid, cost-competitive credits for sale in the SRC market. DS anticipates mitigating 500,000 gallons of runoff annually. This will protect fragile ecosystems, such as the Chesapeake Bay, that are too often overrun by polluted stormwater that can contain raw sewage; provide infrastructure services to underserved communities through increased green space and the reduction of localized flooding; and inspire new conservation-minded people as they see the benefits of green infrastructure in their communities.



Example of a stormwater retention project

LONG ISLAND, NEW YORK

Project Type: Water quality protection

In what started with the conservation of 11,000 acres of bottomlands in the Great South Bay in 2002, followed by hard clam restoration efforts in collaboration with local, State and Federal resource managers and stakeholders, The Nature Conservancy has embarked on a major campaign to improve water quality on Long Island.

After shellfish restoration efforts did not perform as expected, research was conducted and a group of scientists discovered that nitrogen pollution from wastewater was contaminating Long Island's groundwater and bays at a level high enough that marine life could not thrive. Since that time the situation has worsened and fish kills and toxic algae blooms have become more frequent.

The Nature Conservancy and partners are currently working with local, State and Federal agencies as well as stakeholders to upgrade municipal wastewater infrastructure and onsite wastewater systems from outdated cesspools and septic systems to technology that will remove nitrogen pollution and improve water quality. This will secure the region's fishing and tourism industries into the future, restore tidal marshes that enhance community resilience to storm impacts, and protect public health.



Photo: Kenton Rowe, TNC

Mr. LARSEN. Thank you very much. Thank you. I wanted to yield to myself for 5 minutes and I am going to try to get a question in for each of you. I want to start with Mr. DeGood.

In your testimony, you discuss a dramatic departure from the status quo, and a lot of what we talk about is funding. Are you sug-

gesting that we kind of turn over or start over on the Highway Trust Fund and the Airway Trust Fund and the Inland Waterways Trust Fund in order to create funding mechanisms? What do you mean? What is the departure from the status quo?

Mr. DEGOOD. I think that the basic structure of those programs is OK. I don't think it is really the need for the Federal Government to make a higher percentage of project selection decisions, necessarily. What I do think the Federal Government has to do is set very clear and very aggressive targets and then distribute those greenhouse gas reduction targets to States and metropolitan regions based on the share of VMT or air travel or marine travel that they may be responsible for. And so allowing the sort of strength of federalism to do what it does best, which is have people make decisions that fit their local needs but be very clear on what the responsibilities are moving forward.

Mr. LARSEN. I think I understand your comment about it being a break from the status quo and getting States and localities to go along with that may be difficult. But I appreciate you bringing it up.

Mr. Proctor, I am not going to ask you to go back 200 years in the history of your company to talk about how infrastructure has changed or technology has changed or your workforce has changed. But perhaps in the last 10 to 15 years how it has changed, because you talk about training a 21st-century workforce. What does your workforce—how does it need to be different today than it was even 10 years ago in looking at the future of waterworks?

Mr. PROCTOR. Well, on the manufacturing side, it is dramatically different. The techniques we use to manufacture our products include robotics. Most of the melting systems are computer controlled. Even the finishing systems are 21st-century type equipment. And so a skilled workforce is essential to the success of our manufacturing operations.

But in terms of how people use our products, if you look at water infrastructure, for example, the trillion-dollar number that you hear people knock around about how much we need to invest in water, that is really just to restore our infrastructure back to the condition it was in when it was originally built. But we have opportunities today to make our water infrastructure smarter. Wireless remote sensing, monitoring, leak detection, all those sorts of mechanisms. And to do that, it requires that the utilities that are going to operate these sort of systems have the sort of skills and technological expertise that it takes to run them.

Mr. LARSEN. Thanks. I would love to expand on that but I do want to move on. And I imagine that we will expand on it.

Mr. Saumweber, on resiliency standards for port infrastructure, is there a broad difference from port to port in this country on how they deal with infrastructure and resilience?

Mr. SAUMWEBER. I think a lot of the needs are really determined by the local situation and what the existing networks are for a given port. So it is highly variable from port to port.

Mr. LARSEN. But you note in your testimony, I guess you imply that that is a problem?

Mr. SAUMWEBER. I think the point is that we need to have a national assessment of risk based on the specifics around each port's

location, its physical nature and its value to the broader regional infrastructure.

Mr. LARSEN. OK, all right.

Ms. Scarlett, the issue of natural infrastructure is important in my district and my State. We are doing a lot of restoration, habitat restoration. One of the challenges that we have with habitat restoration, if you just look at Leque Island, L-e-q-u-e for the clerk, Leque Island, the number of different sources of funding in order to do that restoration has made it a longer project than many want. But it is also going to function in terms of resiliency for not just a habitat but for the surrounding area.

Has your organization given thought to funding mechanisms or breaking down stovepipes among funding mechanisms?

Ms. SCARLETT. Yes, we have given a lot of thought to funding mechanisms, both public and public-private. I want to mention one. We have actually been working with the insurance industry to model the effectiveness of natural infrastructure in risk reduction. And not in the U.S. yet but there is potential here. In Mexico, we have actually worked on creation of a bed tax across a tourist district and deploying the bed tax to support reef restoration and reef protection as well as invest in an insurance fund to insure the reef. It is very innovative. It has potential in the U.S.

But we are looking at other things, such as teaming up, for example, with water districts and where nature's solutions can actually better handle wastewater, for example, or water supplies, and use ratepayer fees to invest. So there are a variety of sources, depending on the circumstance.

Mr. LARSEN. Thank you. I yield to Mr. Graves.

Oh, sorry, I yield to Mr. Palmer for 5 minutes.

Mr. PALMER. I thank the chairman.

You mentioned the high-intensity storms, Ms. Scarlett, and I appreciate you being here. How many "Gone with the Wind" jokes do you get with that name? But you mentioned the high-intensity storms. And we have had some. But when you look at the high-intensity storms over the years, particularly the hurricanes, five of them occurred before 1960, one of them was 1961. There have only been two since the 2000s, 2004 and 2005. And I think when you start looking at the flooding issues, it has a lot to do with runoff issues in urban areas, you know, the paved surfaces, the construction in flood zones and the failure to do flood mitigation.

For instance, in the 2016 Louisiana flood, the damages were somewhere between \$10 and \$15 billion, there were a number of lives lost. The Army Corps of Engineers had studied a diversion for years, the Comite River over to the Lilly Bayou, and didn't do it. And as a result, you had a 100-year, 1,000-year flood with catastrophic consequences. And I am happy to report, largely because of the work of my colleague, Garret Graves, that they are now going to do that diversion, so I just want to point that out.

I do appreciate all the witnesses being here, and particularly one of my constituents, Mr. Proctor, I appreciate you being here. I wanted to ask you a question about how does disaster preparedness relate to water infrastructure? As I have just pointed out, there was an opportunity, years in advance of the Louisiana flood, to mitigate that. Can you talk about that a little bit?

Mr. PROCTOR. Yes, sir. Well, water is one of the most essential services that is needed to combat or deal with a disaster. For example, fire losses are the most significant losses that occur. In an earthquake, it is second only to the damage that occurs because the ground is moving, buildings fall, that sort of thing.

If you do not have water service, sprinkler systems do not work, hydrants do not work, the firefighters cannot put those fires out. So it is critical to make sure that you can maintain your water service during an earthquake event or in the aftermath.

Another area where it becomes important is floods. In an earthquake, the soil tends to liquify and that is what puts underground infrastructure at risk. When you have a flood, you can have the same sort of thing happen, where the soils become saturated and the ground starts to move. And it results in telescoping of pipelines and sometimes they pull apart, or actual destruction of the lines if they are put under stress.

And then finally, underground infrastructure can be at risk in a wildfire. Santa Rosa, California, is a good example of what happens when the water infrastructure can melt or otherwise suffer damage because of the intense temperatures that occur during wildfires. So it is important to do things to maintain the resiliency of those systems for those reasons.

Some things that can be done to do that, number one, make certain in the design of the systems you use the most durable materials possible. In the Kobe earthquake, for example, steel and iron pipe failed at a rate of one-third of other materials.

Mr. PALMER. Let me ask you about that. Because in a prior life, I worked for two international engineering companies. We did work all around the world, really, but particularly here in the United States. And when we would do work in California, we had specifications that we had to design to to mitigate against an earthquake.

How do you do that in water systems? Because when the earth is moving, that—obviously, it has an impact on surface structures but subsurface? Can you talk a little bit about the design criteria now and the materials that you are using that would mitigate against the loss of water?

Mr. PROCTOR. Well, two things. Number one, using more durable materials means that your infrastructure is better able to sustain those stresses. But the other thing is there are new earthquake seismic joints that allow pipelines to bend and flex and telescope and contract when the earth is moving around it. And those joints can also be used in flood situations like I talked about a second ago.

A demonstration of the efficacy of those joints is that, again, during the Kobe earthquake, not a single ductile iron pipeline failed that had one of these earthquake joints; whereas, other non-restrained systems that did not have that sort of flexibility, there were very much higher rates of failure.

Mr. PALMER. I thank the gentleman for his answer. My time has expired. Mr. Chairman, I yield back.

Mr. LARSEN. Thank you. The representative from Illinois, Mr. García, for 5 minutes.

Mr. GARCÍA. Thank you, Chairman.

To Mr. DeGood, during the first panel, we heard from more than one witness who mentioned that infrastructure investment and consequently the effects of climate change have historically fallen disproportionately on low-income and minority communities. You raised that point in your testimony.

Why is this? And does solving this issue fall on the Federal, State or local government?

Mr. DEGOOD. I think it is important to recognize that, for the most part, State and local governments are the ones who are making project selection decisions and acting as the project sponsor. So for the most part, the Federal Government acts as a fairly passive funder or cofunder. You know, and I mentioned in my testimony the importance of public participation in the planning process and I cannot stress that enough. You know, there have been calls at times to try to limit the scope of environmental review, to put artificial deadlines on how long it can take for projects to go through that process, and I think that that is the wrong way to go about it.

What we have seen when we have done these lookbacks is that, with a little bit more thought on the front end, we can reduce the level of impact both on natural environments as well as our local communities. And I think the underlying challenge is that when many of these project decisions were made in the 1960s and 1970s, we just had a political system that didn't particularly care so much what communities of color had to say.

And I think it is about empowerment and making sure that people have a seat at the table.

Mr. GARCÍA. And what can we do to make sure that it does not reoccur again if, in fact, we have learned lessons about climate change and begin to change course in how we address it?

Mr. DEGOOD. I think that is a good question. I think it really comes back to making sure that elected officials are held accountable and that planners are held accountable for making sure that people have had a chance to have their voice heard during the project planning phase.

Mr. GARCÍA. Another question on natural infrastructure. Can you provide some examples of how we can save money by utilizing natural infrastructure over investing further in man-made structures?

Mr. DEGOOD. You know, I think the witness down at the end probably has more to say about that. Thank you.

Ms. SCARLETT. Yes, there are all kinds of natural infrastructure. But I will mention one where there are clear cost savings, and that is with stormwater management and addressed combined sewerage overflow problems in cities. And Philadelphia pioneered use of natural infrastructure and at a fraction of the cost of what it would have taken to, for example, dig under the streets, build bigger pipes and tunnels and so forth.

We are seeing that in Detroit. The Nature Conservancy is involved in a partnership there. In Los Angeles, here in Washington, DC. So that is one example where there are very clear cost efficiencies with use of natural infrastructure.

In other cases, on coastal resilience, we have done a look at natural infrastructure, at traditional infrastructure and then at hy-

brids and find sometimes that the hybrid comes in most cost effective.

Mr. GARCÍA. Thank you. And for Mr. Proctor, how do we create a well-coordinated, well-funded effort to educate the public on the importance of investment in our infrastructure? And the second question is, what efforts are we making here at the national level to drive public support to build public support for investments in infrastructure that is needed? And, of course, mindful of the fact that there will be opportunities for public-private collaboration and partnerships, given that you come from the private sector.

Mr. PROCTOR. Well, unfortunately, the water sector traditionally has been sort of out of sight, out of mind. When a constituent hits a pothole in a road, elected officials or operators hear about it. When the water system is deteriorating and water is leaking out into the ground, people don't know about it and so it doesn't get the same degree of attention.

One of the ways that we could educate the public so that the issues become more prominent would be to first of all ensure that all of our utilities know what the full cost of their operations are, including the cost associated with losing 30 percent of the water that goes into our pipelines. Less than one-third of the utilities in the country have that appreciation of their full cost.

Once the utilities know those costs, and one of the ways to do that, as I mentioned earlier in my testimony, is through doing water leak audits. Once we know what those full costs are, then we need to have a level of transparency that ensures that the public is aware of the extent of the loss that is going on and the extent of the true cost of providing the water service that many of us take for granted.

Mr. GARCÍA. Thank you. Thank you, Mr. Chairman. I yield back.

Mr. LARSEN. Thank you, Representative García. Just to note, you don't need to be a big city. The city of Everett has combined 100,000 people and they are doing neighborhood retrofits with natural landscaping as well to deal with the CSO issues. And the conservation district works with Veterans Conservation Corps in the city of Lynnwood to do some things that are very similar, as well. So it can happen locally.

It looks like we have Mr. Rouda for 5 minutes.

Mr. ROUDA. Thank you, Mr. Chairman.

Hi, I'm Harley Rouda from Orange County, California. And last week, I introduced House bill 3317, the Coastal Communities Adaptation Act. We are aimed at helping coastal cities and towns brace themselves for climate change-related events and the bill would make Federal funds available for communities to help address that.

Ms. Scarlett, the question I wanted to ask you in that regard, since you have a focus in this area and I really appreciate the story you shared earlier with Seattle, but my guess is we can talk about hundreds of opportunities, thousands of opportunities, across the U.S. in finding natural ways to address this.

Two questions there. One, how do you drive the narrative, the dialogue, with the decisionmakers to look at alternative options to man-made outcomes? And second, how would some sort of economic incentives from the Federal Government help that process along?

Ms. SCARLETT. First, with respect to motivating decisionmakers to consider these options, we are a significant science-based organization. And one thing we find with decisionmakers is the first question of, well, does it work? And so we have invested a lot of research into the actual functionality, for example, of coastal resilience. In fact, we worked with California to look at coastal resilience across the whole coast of that State. So one issue is providing the information.

But the other is the messenger matters. So we have teamed up with the Association of General Contractors, with stormwater managers, with coastal beach managers, those whose role it is to provide that resilience and risk reduction, schooled them in these opportunities and then they become the voice. And that, we find, is a good pathway to influencing decisionmakers.

Mr. ROUDA. And so the second piece of that, because I think you mentioned in the Seattle example, that you brought that project in at 25 percent less than what traditional problem-solving would have created. That is not always the case. So economic incentives can help bridge the gap for some municipalities to make the right decision or the best decision; is that correct?

Ms. SCARLETT. Yeah, I think there are two ways to look at that. On the one hand, not always cheaper and therefore economic incentives can help and we applaud anything Congress can do to amplify and support investments in natural infrastructure.

The other thing, though, as we've worked with the Army Corps of Engineers, is to actually broaden how we think about benefits. So, for example, coastal resilience infrastructure often not only yields risk reduction but improved fisheries and other economic benefits. If you look at the full picture, often you come out with a very positive economic outcome.

Mr. ROUDA. Thank you. And then, Mr. Proctor, and then for the—for all of you as well, we have a lot of discussion about the public-private partnership opportunities. And I think it is safe to say there are certain infrastructure projects that do not rise to a private-public opportunity, that it is really the Government's job to address that. Can you talk a little bit about where the cutoff point is or where are those opportunities that can be public-private and those that definitely need to be sitting in the public hands?

Mr. PROCTOR. As a member of the private sector, I would like to think that there is nothing the private sector cannot do. But let me say this about P3s. A lot of people, when they think of P3s, they instantly think that you are talking about either consolidation or privatization. That is not necessarily the case. In fact, it is really the exception.

There are opportunities for public-to-public partnerships that can help small utilities, for example, partner with larger utilities to acquire the level of expertise that they need to have to be able to do things like deploy new technology or better operate their systems or comply with regulations or what have you. So there are a lot of partner opportunities out there that do not get a lot of attention but they could be important in helping small utilities meet some of the challenges that they have.

Also, when you talk about partnerships, there is a whole spectrum of different forms that can take. It can be something as sig-

nificant, certainly, as consolidation. But it can also be something that is much less intrusive like, for example, a simple cogeneration contract with a private partner. Or it could just be a concession agreement or maybe a savings agreement where, if a private partner comes in and installs technology that could reduce a utility's cost, then the private partner shares in some of those savings but guarantees a certain level of savings back to those utilities so that they are certain to receive some of the benefits. But there are a lot of options there that are not fully exploited.

Mr. ROUDA. Thank you. Thank you, Mr. Chairman.

Mrs. NAPOLITANO [presiding]. I recognize myself for 5 minutes. I was at the end of the line.

Ms. SCARLETT, I read some of your information and I was looking at your urban work on page 4. It had the planting of the trees. And that was a long time ago, you started going after planting more trees. And yet we don't hear any more about it. What happened?

Ms. SCARLETT. Well, the good news is that we're seeing again a renewed effort to expand tree canopy where you plant trees. But, you know, we have had a—with respect to tree canopy in cities, there have been a view sometimes that maintenance costs and so on and so forth are costly and we began to see, actually, a loss of trees, a significant loss of trees in cities. That is beginning to change course and we are very supportive of that.

Mrs. NAPOLITANO. Great. Now you also mentioned, somebody, that the Army Corps of Engineers has been engineering with nature. I chair the Water Resources and Environment Subcommittee on this committee and I have not heard about it so I have to ask about that. Could you kindly touch on that?

Ms. SCARLETT. Yes, so there are—I do not want to give the impression that the entire Army Corps of Engineers is rabidly focused on natural infrastructure.

Mrs. NAPOLITANO. It takes them a long time to pick up, let me tell you.

Ms. SCARLETT. But there is a growing interest in natural infrastructure because they, too, recognize the benefits and cost effectiveness.

Mrs. NAPOLITANO. Does it have to be a change in language for them to accept it and do the work?

Ms. SCARLETT. The big challenge for them, we got some language in the Water Resources Development Act 2016 and 2018 that stuck in a few little words on natural infrastructure. There is still another issue that would be very helpful for Congress to address and that is, when they do their cost-benefit analysis, they are still required really to look at just one use and one benefit. So, for example, flood risk reduction. If they were able to look at multiple benefits, then the cost-benefit analysis would play out potentially differently and we think that would be helpful.

Mrs. NAPOLITANO. I agree with you.

Today, there was a hearing in the Committee on Natural Resources on climate change. But one of the witnesses was giving misleading information, saying that the drought was over, that the reservoirs and the rivers were full. And I think that is very misleading because no way are they anywhere near full.

Ms. SCARLETT. Maybe our water infrastructure person would speak to that.

When you look at the effects of a changing climate, one of the significant impacts is, in fact, changes in precipitation pattern and the expected length, lengthening of chronic drought. So we do see, depending upon place to place to place, extensive drought. Look at Australia right now, but certainly parts of California, that is correct. There are other places that get heavy rainfall.

Mrs. NAPOLITANO. Thank you. One of the questions I will ask again of this panel, I asked in the last one, public education and public training of the workforce that you need to replace your aging workforce? Anybody?

Mr. DEGOOD. Yes, I completely agree. The Center for American Progress has pushed hard for the notion that we need to twin any conversation about robust national infrastructure investment with a conversation about workforce development. And I think it is long overdue. I am glad you brought it up.

Mrs. NAPOLITANO. But you talk to education institutions about the need of that type of training?

Mr. DEGOOD. Yes, and I think it depends sort of how broadly we want to try to define infrastructure. Obviously, each sector is going to have its own unique needs and its unique challenges. And I think that it is incumbent that we have this workforce conversation in parallel with figuring out what specific facilities we think we need to build.

Mrs. NAPOLITANO. Anybody else?

Mr. SAUMWEBER. I would just add that a slightly related topic is the issue of boundaries between science, communication and policy-makers and enhancing the ability of folks on both sides of that divide to be able to speak to each other. So facilitating better input of science and new science around climate and around resilience issues into policy discussions and vice versa. And that is something that I have worked on in the past quite extensively with a number of boundary organizations and is something that is of great need.

Mrs. NAPOLITANO. But it is also in language that the public can understand, or most.

Mr. SAUMWEBER. Absolutely, 100 percent agree. Yes.

Mrs. NAPOLITANO. All right, sir. I yield myself back. Mr. Stanton.

Mr. STANTON. I am here, thank you very much. I appreciate it. We were at another long hearing so I apologize for being late, but this is critically important work so I appreciate the panelists for being very patient.

Before I was lucky enough be elected to Congress, I served as mayor of Phoenix, Arizona, one of the largest cities in America, and I would politely argue the climate change issues facing our city are as dramatic as anywhere else in the country. So much of the attention is on the coastal communities, and should have a lot of attention on the coastal communities. But extreme heat and drought in Arizona and in Phoenix are incredibly difficult issues that we are dealing with. So I wanted to talk a little bit in that context.

Ms. Scarlett, we are working, in the city of Phoenix, working very closely with The Nature Conservancy on river management in our community. City of Phoenix is investing local tax dollars, not just on infrastructure in our city but actually investing in river

management outside of our city, in some cases hours outside of our city. Because the quality of the rivers and the quality of the water that we receive are one and the same. We are also investing in forest management. The city of Phoenix is working with a lot of non-profit entities to make sure that we have the strongest forest system possible because that also impacts the quality of our water.

And I want to talk a little bit about, as we make important infrastructure decisions here on this committee, and we are going to because it is so critically important that we do an infrastructure bill for America, the movement of water, the efficient movement of water, particularly from sources of water that may be stronger than other areas. In Arizona, obviously, Colorado River is a diminishing resource. Tragically and sadly, we have to deal with it. Moving water from other entities that may be in a stronger water position is a critically important infrastructure item.

And maybe, I do not know if you are in a position to talk a little bit about that as water management, water movement, as a part of any larger infrastructure bill? Or any of the panelists, please.

Ms. SCARLETT. Yes, I can speak to that. Thank you very much, both for the partnership with The Nature Conservancy and your broadening to recognize the connectivity between cities and the surrounding countryside.

You know, The Nature Conservancy has a big emphasis on what we call water funds, which is precisely to work with cities to recognize a lot of their water sourcing comes not from the city itself but from outside. And so in a number of cities, Albuquerque, Santa Fe, elsewhere, we are working with cities to take their water district funding and actually invest in watershed restoration. Two benefits, improved water quality and less sedimentation. But also a lot of that work is fuels treatment; that is, improving forest health to reduce risk of catastrophic wildland fire.

But in places like Phoenix, we are also doing a lot of work on things like groundwater recharge, water banking, so that you have better sort of storage of water in a natural way to then be better positioned to withstand changes in water availability. So there are a lot of different tools. We think you need them all.

Mr. STANTON. I appreciate that very much. Because again, I am going to certainly be an advocate for thinking about water and water planning and movement of water, efficient movement of water as one of the critically important infrastructure investments that we are likely to make.

The other thing I was lucky enough to do as mayor was pass a significant public transportation infrastructure initiative, a 35-year, \$32 billion plan that supported much improved bus transportation, new investments in light rail, 60 miles of light rail, bikeability, walkability, et cetera.

The next question is for Mr. DeGood. I apologize if it has already been asked before. For those of us who have worked so passionately on these issues, it seems obvious. But I want the people watching at home, and I will be able to report back to the people that I represent, why is public transportation infrastructure investment so critically related to the issue of climate change and fighting climate change?

Mr. DEGOOD. Well, first and foremost, too many Americans simply do not have access to other options beyond driving. So whether or not they are trying to go across country or whether or not they are trying to go one-quarter mile away to pick up some groceries for that week, they have to drive. And so part of what you were able to do as mayor was to set that city on a different trajectory to where you can now plan to have growth around those facilities so that people do not always have to drive to satisfy their daily needs.

And we also know, of course, that when you have access to options, your total annual emissions will drop, your total transportation-related emissions will drop. And that is also critical.

Mr. STANTON. Other strategic investments made, obviously solar, moving our entire fleet to alternative fuel vehicles, and changing streetlights to LED. Little things but these are important infrastructure investments where the Federal Government has not been most recently but needs to be a better partner to local government.

Thanks for your testimony. I will yield back the time.

Mrs. NAPOLITANO. Thank you. Ms. Miller, you are next.

Mrs. MILLER. Thank you, Madam Chair.

Thank you all for being here today for a long time. As you all have heard, I understand the importance of being good stewards of our environment. My home State of West Virginia is abundant in natural resources, which provide critical jobs, and is the cornerstone of our State's economy. Furthermore, the companies who mine the land in my State certainly understand the importance of caring for the environment, protecting the delicate ecosystem, providing clean water and improving the infrastructure in the State. Considering these critical aspects in total is absolutely necessary for ensuring the longevity of the land and these precious resources.

That is why I am worried about broad, sweeping and dangerous proposals such as the Green New Deal. Such proposals seek a misguided, one-size-fits-all approach that poses an imminent threat to the economy of my State, critical jobs for my constituents and the lifeblood of West Virginia. The intent of the Green New Deal is to completely halt natural energy production, stop the use of air travel and cars, and end cattle farming. This is just a rebranded war on coal, oil and gas.

Coal, oil and gas production is at its most efficient. In West Virginia, nearly 30,000 people work in the energy industry and 93 percent of our electricity comes from coal. Plans like the Green New Deal would certainly be a death blow to our economy. We can and must do better.

The previous administration took devastating steps that put the coal industry in my State on life support. We need a more common-sense approach to protecting the environment than just eliminating our energy industry altogether. My constituents demand it. I will do everything in my power to make sure that we protect the economy of West Virginia and the jobs of my constituents.

To the whole panel, how can we ensure that we protect and promote existing energy jobs under any new proposed infrastructure plans?

OK, Mr. Proctor, in your testimony, you discuss the importance of keeping good jobs in America. How can Congress be a partner to industry to ensure jobs stay here in the United States?

Mr. PROCTOR. Well, one of the primary mechanisms and one that has been shown to work very well is using domestic preferences when it comes to infrastructure investment. Three of the four major water programs already have a domestic preference, otherwise known as Buy American requirement for iron and steel products that go into our water infrastructure. And it has successfully not only preserved jobs but brought jobs back from overseas into the United States within our industry.

That same sort of program would work well when it comes to disaster mitigation. Now, let me say right upfront that in the event of a natural disaster, our primary and if not only focus needs to be getting relief to the people who are affected by that natural disaster as quickly as possible. But when you are talking about predisaster mitigation, the things that happen before the disasters, when you have time to think about the impacts, that is a perfect opportunity to think not only about the immediate disaster preparedness impacts but also the overall impacts on the economy. And that would be a situation where using a domestic preference for iron and steel products would have not only the benefit of helping to make certain that our infrastructure is hardened, to make certain that the products are produced here in the United States where environmental emissions are a fraction of what they are overseas, but also to get the multiplier effect of infrastructure investment so that we get the full bang for our buck.

I think the statistics that you frequently see are that every dollar of infrastructure that is invested here in the United States produces something like \$1.75 or \$2 of increased GDP. That is even more the case when you invest those dollars in domestically produced iron and steel materials.

Mrs. MILLER. Thank you. And how can Congress help industry maintain a competitive advantage against foreign nations or with foreign nations?

Mr. PROCTOR. Is that to me also?

Mrs. MILLER. Should I just yield back my time or may he answer?

Mr. PROCTOR. Well, one measure that I touched on briefly earlier is to make certain that our workforce has the skills that they need to be able to operate the foundries, the factories and the water systems of today. But the other thing is to make certain that, as we build out our infrastructure, that we do it in a smart way so that we are more efficient. And also, as I mentioned earlier, to level the playing field so that when—we are proud of the safety and environmental performance of our facilities over here. We have invested hundreds of millions of dollars to have the best facilities in the world.

Mrs. NAPOLITANO. Mr. Proctor, I think your time is up.

Mr. PROCTOR. OK, thank you.

Mrs. MILLER. I yield back my time.

Mrs. NAPOLITANO. Ms. Mucarsel-Powell, you're on.

Ms. MUCARSEL-POWELL. Thank you, Madam Chair. And thank you to all of you for coming to such an important hearing this afternoon.

I represent, I mentioned earlier, I believe, one of the most beautiful districts in this country, the southernmost district in Florida. It includes Monroe County, the Florida Keys, and we are ground zero for the effects of climate change. We, along the Florida Keys, as you probably already know, Ms. Scarlett, I did some work with Coral Restoration Foundation as well as some work with The Nature Conservancy at the time. And we have, it is the only living coral reef in the entire United States. It is the third largest coral reefs in the entire planet. It is a very delicate ecosystem.

And I had the opportunity to see firsthand the effects of climate change on our corals. We are right now plagued by not only the ocean acidification which is impacting the corals by causing mass bleaching, but now we have seen a bacterial infection that is now going all the way down to Looe Key, which is a very delicate and lush coral reef. If you have ever been down there, you will know exactly what I mean. But we are extremely concerned because it seems that we do not have the answers as to why this is happening.

I want to ask you, Ms. Scarlett, maybe also you can comment, Mr. Saumweber, but what is it that we can do to protect our coral reefs, since they are part of such an important, not just for a way of life but also for our commercial industries, for our economy in Florida, what can we do in Congress to protect the reefs and to get to the bottom of what is causing this bacterial infection that is killing about 50 percent of the corals that are being infected by this bacteria?

Ms. SCARLETT. Thank you very much. I had the opportunity to be in the Keys just last week. It was lovely.

So a couple of things. First, obviously, we need more science to the degree that we don't wholly understand what is going on with any particular reef. So we know acidification is occurring, we know there is runoff, nutrient runoff from on-land activities. We know those adversely affect reefs. But to find the particular causes in particular reefs requires more science.

But in terms of additionally what we can do, we are very active in something, in a Global Mangrove Alliance. And mangrove restoration plays a very significant role in sort of minimizing coastal erosion, enhancing coastal health in general. We are also very actively involved in coral reef restoration.

A lot of people do not realize that there are tools and ways to actually restore reefs and we are doing that in a number of places actually around the world, not simply on the U.S. coast.

And then finally, you know, reducing those other stressors. There is climate change and the effects on a warming ocean, ocean acidification. But to the degree that that is amplified by nutrient runoff and other factors, it simply puts those corals under more and more stress. So thinking about it in a systems way is part of the solution coupled with the science.

Ms. MUCARSEL-POWELL. Thank you. And you did mention mangroves. And my only concern with using mangroves as natural infrastructure to prevent that runoff and, you know, protect our

coastal communities is that we saw the destruction of the mangroves just last year with Hurricane Irma and it takes years for these mangroves to regrow.

So what can we do, using not only mangroves but maybe other types of natural infrastructure to protect our coastal communities?

Ms. SCARLETT. I think it is—so thank you for that. You know, natural systems cannot do everything everywhere under every circumstance. Certainly, we have found that mangroves and mangrove restoration are an extraordinarily important tool. But when you have extremely high-intensity storms, you are going to get some destruction and it does take a long time to restore them. And so that is why we are also doing things like coral reef restoration. We find that coral reefs themselves, if you restore them, attenuate waves, reduce erosion, reduce risks to communities. So it is a really multipronged approach and it has to be tailored to place.

Ms. MUCARSEL-POWELL. And if I may, Madam Chair, one more question, since I am the last?

You mentioned also, you know, the runoff. And, as you know, we have the Comprehensive Everglades Restoration Plan that we have been trying to complete for the past 18 years. So what is the importance of this type of project to the future resiliency of our community?

Ms. SCARLETT. I cannot stress how important Everglades restoration is and how congressional support for it and funding for it is essential. Everglades restoration does a number of things but, one, as you get the waters flowing across the rivers of grass, it actually pushes freshwater out and prevents saltwater intrusion, an incredibly important issue for Florida, so that is one. Secondly, of course, Everglades restoration, part of the process of having stormwater management areas is to actually reduce the runoff from the agricultural sector that then finds its way out to the ocean, so very important.

Ms. MUCARSEL-POWELL. Very important.

Mrs. NAPOLITANO. Ms. Scarlett, would you mind responding in writing to the lady?

Ms. SCARLETT. I would be happy to do that. I spent 8 years at the Department of the Interior and hundreds of hours on that topic.

Mrs. NAPOLITANO. Well, I thank everybody for being here, the witnesses for testimony. Sorry it was such a long meeting. And your comments were very helpful and enlightening for today's hearing.

But before we close, I want to thank the passenger rail operator in my district, Metrolink, for being in the audience. Their CEO, Stephanie Wiggins—Ms. Wiggins—and board chair, Brian Humphrey. Metrolink is in the process of replacing 40 locomotives with new tier 4 locomotives that reduce NOx and particulate matter by 86 percent. Thank you for being here.

Are there any further questions?

[No response.]

Mrs. NAPOLITANO. I ask unanimous consent that the record of today's hearing remain open until such time as our witnesses have provided answers to any questions that may be submitted to them in writing, and unanimous consent that the record remain open for

15 days for any additional comments and information submitted by Members or witnesses to be included in the record of today's hearing.

Without objection, so ordered.

I would like again to thank the witnesses. Sorry for the long hearing, but your testimony was very important to all of us. And although many were not here, they are listening in their office or in other places.

No other Members have anything to add? No. The committee stands adjourned.

[Whereupon, at 2:30 p.m., the committee was adjourned.]

SUBMISSIONS FOR THE RECORD

Statement of Hon. Rick Larsen, a Representative in Congress from the State of Washington

Thank you, Chairman DeFazio, for calling today's hearing to examine how transportation and infrastructure impact climate change and explore solutions to promote resiliency.

For decades, Washingtonians have seen and felt the harmful impacts of climate change.

As detailed in the fourth National Climate Assessment¹, rising temperatures and greenhouse gas emissions in the Pacific Northwest have resulted in record-breaking wildfires, an acidifying ocean that hurts shellfish hatcheries and declining salmon runs from a lack of suitable habitats.

Washington state's transportation sector is its largest source of greenhouse gas emissions, accounting for nearly 50 percent of all emissions and nearly 64 percent of an average household's energy expenses.²

To respond to the growing challenges resulting from climate change, Congress, the administration, states and industry must join to reduce emissions and foster innovation to encourage sustainability.

Investing in more sustainable transit, maritime transportation, bridge infrastructure and aviation will help maintain the vitality of our wildlife, wilderness areas and green spaces for the use and enjoyment of current and future generations.

As someone who uses public transportation every day, and as cochair of the bipartisan Bus Caucus, I understand how critical reliable bus systems are for commuters.

With the expansion of more efficient transit options, Congress must support states' efforts to meet carbon emission reduction targets. In my home state of Washington, localities are taking significant steps to ensure a cleaner transportation network.

Washington state's electric grid is among the most sustainable and cleanest in the country, making the electrification of transportation a viable option to address the impacts of climate change.

Recently, the state launched several initiatives to electrify transit, including a requirement that 50 percent of all new state-owned and leased passenger vehicles be electric by 2020.³

I have seen firsthand how the transit electrification benefits Washington's Second District. Last September, I attended the ribbon cutting for Everett Transit's first electric bus.

With \$3.4 million in federal funding from the Low or No Emission Bus Program, the City of Everett was able to replace a decades-old diesel fuel bus, serve a high-frequency route and reduce local carbon emissions.

Everett Transit estimates that transitioning four of its diesel buses will lower carbon emissions by nearly 4,000 pounds annually and reduce the amount of particulate matter released into the atmosphere by 500 pounds each year.

In the Pacific Northwest, ferries are critical to keeping the economy moving, carrying commuters and goods around the region.

Ferries help relieve congestion, serve rural communities and can serve as an interim solution when other transportation systems are unavailable.

¹ <https://nca2018.globalchange.gov/chapter/24/>

² <https://www.ofm.wa.gov/sites/default/files/public/budget/statebudget/highlights/budget19/clean-transportation-policy-brief.pdf>

³ Ibid.

However, ferries are among the largest greenhouse gas generators, accounting for 73 percent of Washington state's annual carbon emissions.⁴

To address this issue, Washington State Ferries is working to convert its largest passenger vessels, the Jumbo Mark II, to hybrid-electric propulsion.

The agency estimates this conversion will reduce total carbon emissions by 25 percent. Additionally, the new hybrid-electric ferries will reduce vessel noise, lessening the impact on endangered Southern Resident orcas and other wildlife in the Puget Sound.

Innovative maritime projects, such as the hybrid-electric initiative, promote sustainability, improve the transportation network and generate cost-savings. But these goals cannot be accomplished without federal buy-in.

Congress must provide stable and predictable federal funding for "greening" U.S. maritime to ensure the system remains competitive, encourage new jobs and preserve a healthy environment.

According to the Association of Washington Business, Washington state alone needs over \$190 billion in infrastructure investment, with bridges requiring \$4.3 billion.

Washington state is home to 7,410 bridges. Almost 5,000 have been deemed to need maintenance. Significant funding is needed to ensure the structural integrity and environmental sustainability of bridges and roads.

In 2017, the Washington State Department of Transportation launched a funding initiative to extend the service life of the state's bridges through planned and focused preventative maintenance activities.⁵

To improve the federal government's role in these local projects, I joined Reps. Cicilline, Young and Davis to introduce the IMAGINE Act. This bill would promote the use of innovative materials and advanced technologies to improve safety of the nation's infrastructure, promote resiliency and support jobs and local economies.

As chair of the Aviation Subcommittee, I recognize the role aviation and aerospace can play in efforts to mitigate the effects of climate change.

The subcommittee will focus on fostering innovation in U.S. aviation and aerospace through the advancement of NextGen, as well as the development and deployment of new and greener technologies to bolster U.S. jobs.

Washington state is the aerospace capital of the country, and in the Second District, 23,000 women and men support the aviation economy by making the safest aircrafts and aerospace products in the world.

Several of the 1,450 suppliers in Washington state are working on cutting-edge technologies to make U.S. aviation more efficient and environmentally-sound.

To that end, I am pleased that we have a witness today, Ms. Nancy Young with Airlines for America, to speak to how the U.S. aviation industry continues to make strides to improve fuel efficiency, green ground operations and advance more sustainable propulsion.

The long-term Federal Aviation Administration (FAA) reauthorization bill that Congress passed last year makes progress toward NextGen implementation by including local communities and airports in the process.

NextGen's Performance-Based Navigation procedures and Terminal Flight Data Manager deployment will modernize air traffic control to allow carriers to fly more directly and precisely, reduce aircraft fuel burn and improve the sustainability of the overall aviation system.

For instance, the FAA's Greener Skies initiative improves efficiency of flights landing at Seattle-Tacoma International Airport in Washington state.

It is estimated that Greener Skies will cut fuel consumption by 2.1 million gallons annually and reduce carbon emissions by 22,000 metric tons. In addition, the initiative will reduce aircraft noise exposure for nearly 750,000 people living within the affected flight corridor.⁶

Further, robust funding for the FAA's Continuous Lower Energy, Emissions and Noise (CLEEN) program, supports the development of new aircraft technologies to advance sustainable alternative jet fuels.

Airports across the country are also working to reduce the carbon footprint of their operations, through efforts like electric conversion of their ground service vehicles, use of renewable energy including solar, sustainable fuel initiatives and expanded recycling programs.

⁴ <http://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/125314/WSFHybridElectricPropulsionConversionProject.pdf>

⁵ <https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/2019-WA-Infrastructure-Report-Card.pdf>

⁶ <https://www.faa.gov/nextgen/snapshots/stories/?slide=6>

I have had the chance to visit a few companies in my district at the forefront of innovative, energy efficient aviation technology.

For example, Zunum Aero in Bothell, Washington, is developing hybrid electric aircraft capable of flying up to 12 people between 350 and 500 miles. The company aims to bring the aircraft to market as soon as 2022.

Zunum projects its electric propulsion prototype will cut community and cabin noise by an estimated 75 percent and emissions by 80 percent.⁷

One area where we will continue to see tremendous growth is in unmanned aircraft systems (UAS), or drones.

UAS are flourishing in the skies at a pace we did not imagine ten years ago. There is no denying the extensive societal and commercial benefits of unmanned aircraft and their applications.

Drones are used to perform critical infrastructure inspections of bridges and railroads and assist in recovery efforts following natural disasters and wildfires. In addition, small drone package delivery could produce lower greenhouse gas emissions and consume less energy.

Further, passenger air vehicles (PAVs) are also slated to present a dramatic change in the transportation in and around urban centers in the very near future.

With recent advances in design and technology, PAV concepts in development will have the ability to reduce traffic congestion and the demand on our roads and bridges by carrying every day commuters through the air, at low-altitudes, to work and other nearby destinations.

Of course, before this occurs there are many questions that will need to be answered to safely integrate them into complex airspace. This effort will require the FAA to develop a comprehensive regulatory framework to integrate these operations into U.S. airspace.

Again, Mr. Chairman, thank you for calling this timely hearing.

This committee is uniquely positioned to make considerable progress to address climate change.

I look forward to hearing from today's witnesses on how Congress can be a better partner to advance efforts to green transportation and infrastructure projects across the U.S.

Article Submitted for the Record by Hon. Scott Perry, a Representative in Congress from the State of Pennsylvania

Science, August 28, 1981, Volume 213, Number 4511 "Climate Impact of Increasing Atmospheric Carbon Dioxide", J. Hansen, D. Johnson, A. Lacis, S. Lebedeff, P. Lee, D. Rind, G. Russell.¹

⁷ <https://zunum.aero/our-charge/>

¹ <http://science.sciencemag.org/content/213/4511/957>.

Climate Impact of Increasing Atmospheric Carbon Dioxide

J. Hansen, D. Johnson, A. Lacis, S. Lebedeff
P. Lee, D. Rind, G. Russell

Atmospheric CO₂ increased from 280 to 300 parts per million in 1880 to 335 to 340 ppm in 1980 (*1, 2*), mainly due to burning of fossil fuels. Deforestation and changes in biosphere growth may also

The major difficulty in accepting this theory has been the absence of observed warming coincident with the historic CO₂ increase. In fact, the temperature in the Northern Hemisphere decreased by

Summary. The global temperature rose by 0.2°C between the middle 1960's and 1980, yielding a warming of 0.4°C in the past century. This temperature increase is consistent with the calculated greenhouse effect due to measured increases of atmospheric carbon dioxide. Variations of volcanic aerosols and possibly solar luminosity appear to be primary causes of observed fluctuations about the mean trend of increasing temperature. It is shown that the anthropogenic carbon dioxide warming should emerge from the noise level of natural climate variability by the end of the century, and there is a high probability of warming in the 1980's. Potential effects on climate in the 21st century include the creation of drought-prone regions in North America and central Asia as part of a shifting of climatic zones, erosion of the West Antarctic ice sheet with a consequent worldwide rise in sea level, and opening of the fabled Northwest Passage.

have contributed, but their net effect is probably limited in magnitude (*2, 3*). The CO₂ abundance is expected to reach 600 ppm in the next century, even if growth of fossil fuel use is slow (*4*).

Carbon dioxide absorbs in the atmospheric "window" from 7 to 14 micrometers which transmits thermal radiation emitted by the earth's surface and lower atmosphere. Increased atmospheric CO₂ tends to close this window and cause outgoing radiation to emerge from higher, colder levels, thus warming the surface and lower atmosphere by the so-called greenhouse mechanism (*5*). The most sophisticated models suggest a mean warming of 2° to 3.5°C for doubling of the CO₂ concentration from 300 to 600 ppm (*6-8*).

about 0.5°C between 1940 and 1970 (*9*), a time of rapid CO₂ buildup. In addition, recent claims that climate models overestimate the impact of radiative perturbations by an order of magnitude (*10, 11*) have raised the issue of whether the greenhouse effect is well understood.

We first describe the greenhouse mechanism and use a simple model to compare potential radiative perturbations of climate. We construct the trend of observed global temperature for the past century and compare this with global climate model computations, providing a check on the ability of the model to simulate known climate change. Finally, we compute the CO₂ warming expected in the coming century and discuss its potential implications.

Greenhouse Effect

The effective radiating temperature of the earth, T_e , is determined by the need for infrared emission from the planet to balance absorbed solar radiation:

$$\pi R^2(1 - A)S_0 = 4\pi R^2\sigma T_e^4 \quad (1)$$

or

$$T_e = [S_0(1 - A)/4\sigma]^{1/4} \quad (2)$$

where R is the radius of the earth, A the albedo of the earth, S_0 the flux of solar radiation, and σ the Stefan-Boltzmann constant. For $A \sim 0.3$ and $S_0 = 1367$ watts per square meter, this yields $T_e \sim 255$ K.

The mean surface temperature is $T_s \sim 288$ K. The excess, $T_s - T_e$, is the greenhouse effect of gases and clouds, which cause the mean radiating level to be above the surface. An estimate of the greenhouse warming is

$$T_s \sim T_e + \Gamma H \quad (3)$$

where H is the flux-weighted mean altitude of the emission to space and Γ is the mean temperature gradient (lapse rate) between the surface and H . The earth's troposphere is sufficiently opaque in the infrared that the purely radiative vertical temperature gradient is convectively unstable, giving rise to atmospheric motions that contribute to vertical transport of heat and result in $\Gamma \sim 5^\circ$ to 6° C per kilometer. The mean lapse rate is less than the dry adiabatic value because of latent heat release by condensation as moist air rises and cools and because the atmospheric motions that transport heat vertically include large-scale atmospheric dynamics as well as local convection. The value of H is ~ 5 km at midlatitudes (where $\Gamma \sim 6.5^\circ \text{C km}^{-1}$) and ~ 6 km in the global mean ($\Gamma \sim 5.5^\circ \text{C km}^{-1}$).

The surface temperature resulting from the greenhouse effect is analogous to the depth of water in a leaky bucket with constant inflow rate. If the holes in the bucket are reduced slightly in size, the water depth and water pressure will

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increase until the flow rate out of the holes again equals the inflow rate. Analogously, if the atmospheric infrared opacity increases, the temperature of the surface and atmosphere will increase until the emission of radiation from the planet again equals the absorbed solar energy.

The greenhouse theory can be tested by examination of several planets, which provide an ensemble of experiments over a wide range of conditions. The atmospheric composition of Mars, Earth, and Venus lead to mean radiating levels of about 1, 6, and 70 km, and lapse rates of $\Gamma \sim 5^\circ$, 5.5° , and 7°C km^{-1} , respectively. Observed surface temperatures of these planets confirm the existence and order of magnitude of the predicted greenhouse effect (Eq. 3). Data now being collected by spacecraft at Venus and Mars (12) will permit more precise analyses of radiative and dynamical mechanisms that affect greenhouse warming.

One-Dimensional Model

A one-dimensional radiative-convective (1-D RC) model (5, 13), which computes temperature as a function of altitude, can simulate planetary temperatures more realistically than the zero-dimensional model of Eq. 1. The sensitivity of surface temperature in 1-D RC models to changes in CO_2 is similar to the sensitivity of mean surface temperature in global three-dimensional models (6-8). This agreement does not validate the models; it only suggests that one-dimensional models can simulate the effect of certain basic mechanisms and feedbacks. But the agreement does permit useful studies of global mean temperature change with a simple one-dimensional model.

The 1-D RC model uses a time-marching procedure to compute the vertical temperature profile from the net radiative and convective energy fluxes:

$$T(h, t + \Delta t) = T(h, t) + \frac{\Delta t}{c_p p} \left(\frac{dF_r}{dh} + \frac{dF_c}{dh} \right) \quad (4)$$

where c_p is the heat capacity at constant pressure, p the density of air, h the altitude, and dF_r/dh and dF_c/dh the net radiative and convective flux divergences. To compute dF_r/dh the radiative transfer equation is integrated over all frequencies, using the temperature profile of the previous time step and an assumed atmospheric composition. The

term dF_c/dh is the energy transport needed to prevent the temperature gradient from exceeding a preassigned limit, usually $6.5^\circ \text{C km}^{-1}$. This limit parameterizes effects of vertical mixing and large-scale dynamics.

The radiative calculations are made by a method that groups absorption coefficients by strength for efficiency (14). Pressure- and temperature-dependent absorption coefficients are from line-by-line calculations for H_2O , CO_2 , O_3 , N_2O , and CH_4 (15), including continuum H_2O absorption (16). Climatological cloud cover (50 percent) and aerosol properties (17) are used, with appropriate fractions of low (0.3), middle (0.1), and high (0.1) clouds. Wavelength dependences of cloud and aerosol properties are obtained from Mie scattering theory (14). Multiple scattering and overlap of gaseous absorption bands are included. Our computations include the weak CO_2 bands at 8 to 12 μm , but the strong 15- μm CO_2 band, which closes one side of the 7- to 20- μm H_2O window, causes ≈ 90 percent of the CO_2 warming.

Model Sensitivity

We examine the main processes known to influence climate model sensitivity by inserting them individually into the model, as summarized in Table 1.

Model 1 has fixed absolute humidity, a fixed lapse rate of $6.5^\circ \text{C km}^{-1}$ in the convective region, fixed cloud altitude, and no snow/ice albedo feedback or vegetation albedo feedback. The increase of equilibrium surface temperature for doubled atmospheric CO_2 is $\Delta T_s \sim 1.2^\circ \text{C}$. This case is of special interest because it is the purely radiative-convective result, with no feedback effects.

Model 2 has fixed relative humidity, but is otherwise the same as model 1. The resulting ΔT_s for doubled CO_2 is $\sim 1.9^\circ \text{C}$. Thus the increasing water vapor with higher temperature provides a feedback factor of ~ 1.6 . Fixed relative humidity is clearly more realistic than fixed absolute humidity, as indicated by physical arguments (13) and three-dimensional model results (7, 8). Therefore, we use fixed relative humidity in the succeeding experiments and compare models 3 to 6 with model 2.

Model 3 has a moist adiabatic lapse rate in the convective region rather than a fixed lapse rate. This causes the equilibrium surface temperature to be less sensitive to radiative perturbations, and $\Delta T_s \sim 1.4^\circ \text{C}$ for doubled CO_2 . The reason is that the lapse rate decreases as

moisture is added to the air, reducing the temperature difference between the top of the convective region and the ground (Γh in Eq. 3).

The general circulation of the earth's atmosphere is driven by solar heating of the tropical ocean, and resulting evaporation and vertical transport of energy. The lapse rate is nearly moist adiabatic at low latitudes and should remain so after a climate perturbation. Thus use of a moist adiabatic lapse rate is appropriate for the tropics. But more stable lapse rates at high latitudes make the surface temperature much more sensitive to perturbations of surface heating (7, 8), and hence model 3 would underestimate the sensitivity there.

Model 4 has the clouds at fixed temperature levels, and thus they move to a higher altitude as the temperature increases (18). This yields $\Delta T_s \sim 2.8^\circ \text{C}$ for doubled CO_2 , compared to 1.9°C for fixed cloud altitude. The sensitivity increases because the outgoing thermal radiation from cloudy regions is defined by the fixed cloud temperature, requiring greater adjustment by the ground and lower atmosphere for outgoing radiation to balance absorbed solar radiation.

Study of Venus suggests that some clouds occur at a fixed temperature. The Venus cloud tops, which are the primary radiator to space, are at $H \sim 70$ km, where $T \sim T_s$. Analysis of the processes that determine the location of these clouds and the variety of clouds in the belts, zones, and polar regions on Jupiter should be informative. Available evidence suggests that the level of some terrestrial clouds depends on temperature while others occur at a fixed altitude. For example, tropical cirrus clouds moved to a higher altitude in the experiment of Hansen *et al.* (8) with doubled CO_2 , but low clouds did not noticeably change altitude.

Models 5 and 6 illustrate snow/ice and vegetation albedo feedbacks (19, 20). Both feedbacks increase model sensitivity, since increased temperature decreases ground albedo and increases absorption of solar radiation.

Snow, sea ice, and land ice (ice sheets and glaciers) are all included in snow/ice albedo feedback. Snow and sea ice respond rapidly to temperature change, while continental ice sheets require thousands of years to respond. Thus a partial snow/ice albedo feedback is appropriate for time scales of 10 to 100 years. The vegetation albedo feedback was obtained by comparing today's global vegetation patterns with reconstruction of the Wisconsin ice age (20). Uncertainties in the

reconstruction, the time scale of vegetation response, and man's potential impact on vegetation prevent reliable assessment of this feedback, but its estimated magnitude emphasizes the need to monitor global vegetation and surface albedo.

Model 4 has our estimate of appropriate model sensitivity. The fixed $6.5^\circ\text{C km}^{-1}$ lapse rate is a compromise between expected lower sensitivity at low latitudes and greater sensitivity at high latitudes. Both cloud temperature and snow/ice albedo feedback should be partly effective, so for simplicity one is included.

The sensitivity of the climate model we use is thus $\Delta T_s \sim 2.8^\circ\text{C}$ for doubled CO_2 , similar to the sensitivity of three-dimensional climate models (6-8). The estimated uncertainty is a factor of 2. This sensitivity (i) refers to perturbations about today's climate and (ii) does not include feedback mechanisms effective only on long time scales, such as changes of ice sheets or ocean chemistry.

Model Time Dependence

The time dependence of the earth's surface temperature depends on the heat capacity of the climate system. Heat capacity of land areas can be neglected, since ground is a good insulator. However, the upper 100 m of the ocean is rapidly mixed, so its heat capacity must be accounted for. The ocean beneath the mixed layer may also affect surface temperature, if the thermal response time of the mixed layer is comparable to the time for exchange of heat with deeper layers.

The great heat capacity of the ocean and ready exchange of continental and marine air imply that the global climate response to perturbations is determined by the response of the ocean areas. However, this response is affected by horizontal atmospheric heat fluxes from and to the continents. Ready exchange of energy between the ocean surface and atmosphere "fixes" the air temperature, and the ocean in effect removes from the atmosphere any net heat obtained from the continents. Thus the horizontal flux due to a climate perturbation's heating (or cooling) of the continents adds to the vertical heat flux into (or out of) the ocean surface. The net flux into the ocean surface is therefore larger than it would be for a 100 percent ocean-covered planet by the ratio of global area to ocean area, totaling $\sim 5.7 \text{ W m}^{-2}$ for doubled CO_2 rather than $\sim 4 \text{ W m}^{-2}$. In a climate model that employs only a

Table 1. Equilibrium surface temperature increase due to doubled CO_2 (from 300 to 600 ppm) in 1-D RC models. Model 1 has no feedbacks affecting the atmosphere's radiative properties. Feedback factor f specifies the effect of each added process on model sensitivity to doubled CO_2 ; F is the equilibrium thermal flux into the ground if T_s is held fixed (infinite heat capacity) when CO_2 is doubled. Abbreviations: FRH, fixed relative humidity; FAH, fixed absolute humidity; 6.5LR, $6.5^\circ\text{C km}^{-1}$ limiting lapse rate; MALR, moist adiabatic limiting lapse rate; FCA, fixed cloud altitude; FCT, fixed cloud temperature; SAF, snow/ice albedo feedback; and VAF, vegetation albedo feedback. Models 5 and 6 are based on f values from Wang and Stone (19) and Cess (20), respectively, and ΔT_s of model 2.

Model	Description	ΔT_s ($^\circ\text{C}$)	f	F (W m^{-2})
1	FAH, 6.5LR, FCA	1.22	1	4.0
2	FRH, 6.5LR, FCA	1.94	1.6	3.9
3	Same as 2, except MALR replaces 6.5LR	1.37	0.7	4.0
4	Same as 2, except FCT replaces FCA	2.78	1.4	3.9
5	Same as 2, except SAF included	2.5-2.8	1.3-1.4	
6	Same as 2, except VAF included	~ 3.5	~ 1.8	

mixed-layer ocean, it is equivalent to use the flux $\sim 4 \text{ W m}^{-2}$ with the area-weighted mean land-ocean heat capacity.

The thermal response time of the ocean mixed layer would be ~ 3 years if it were not for feedback effects in the climate system. For example, assume that the solar flux absorbed by a planet changes suddenly from $F_0 = \sigma T_0^4$ to $F_1 = F_0 + \Delta F = \sigma T_1^4$, with $\Delta F \ll F_0$. The rate of change of heat in the climate system is

$$d(cT)/dt = \sigma T_1^4 - \sigma T^4 \quad (5)$$

where c is heat capacity per unit area. Since $T_1 - T_0 \ll T_0$, the solution is

$$T - T_1 = (T_0 - T_1)e^{-t/t_{\text{th}}} \quad (6)$$

where

$$t_{\text{th}} = c/4\sigma T_1^3 \quad (7)$$

Thus the planet approaches a new equilibrium temperature exponentially with e -folding time t_{th} . If the heat capacity is provided by 70 m of water (100 m for ocean areas) and the effective temperature is 255 K, t_{th} is 2.8 years.

This estimate does not account for climate feedback effects, which can be analyzed with the 1-D RC model. Table 1 shows that the initial rate of heat storage in the ocean is independent of feedbacks. Thus the time needed to reach equilibrium for model 4 is larger by the factor $\sim 2.8^\circ\text{C}/1.2^\circ\text{C}$ than for model 1, which excludes feedbacks. The e -folding time for adjustment of mixed-layer temperature is therefore ~ 6 years for our best estimate of model sensitivity to doubled CO_2 . This increase in thermal response time is readily understandable, because feedbacks come into play only gradually after some warming occurs.

It would take ~ 50 years to warm up the thermocline and mixed layer if they were rapidly mixed, or 250 years for the entire ocean. Turnover of the deep

ocean, driven by formation of cold bottom water in the North Atlantic and Antarctic oceans with slow upwelling at low latitudes, is thought to require 500 to 1000 years (21), suggesting that the deep ocean does not greatly influence surface temperature sensitivity. However, there may be sufficient heat exchange between the mixed layer and thermocline to delay full impact of a climate perturbation by a few decades (6, 22, 23). The primary mechanism of exchange is nearly horizontal movement of water along surfaces of constant density (21).

Delay of CO_2 warming by the ocean can be illustrated with a "box diffusion" model (24), in which heat is stirred instantly through the mixed layer and diffused into the thermocline with diffusion coefficient k . Observed oceanic penetration by inert chemical tracers suggests that k is of order 1 square centimeter per second (2, 3, 24).

The warming calculated with the one-dimensional model for the CO_2 increase from 1880 to 1980 (25) is 0.5°C if ocean heat capacity is neglected (Fig. 1). The heat capacity of just the mixed layer reduces this to 0.4°C , a direct effect of the mixed layer's 6-year thermal response time. Diffusion into the thermocline further reduces the warming to 0.25°C for $k = 1 \text{ cm}^2 \text{ sec}^{-1}$, an indirect effect of the mixed layer's 6-year e -folding time, which permits substantial exchange with the thermocline.

The mixed-layer model and thermocline model bracket the likely CO_2 warming. The thermocline model is preferable for small climate perturbations that do not affect ocean mixing. However, one effect of warming the ocean surface will be increased vertical stability, which could reduce ocean warming and make the surface temperature response more like that of the mixed-layer case.

Lack of knowledge of ocean processes

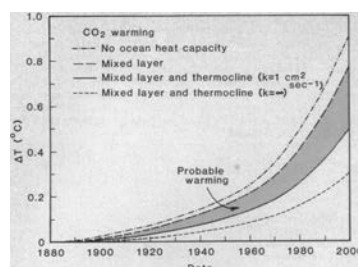


Fig. 1. Dependence of CO_2 warming on ocean heat capacity. Heat is rapidly mixed in the upper 100 m of the ocean and diffused to 1000 m with diffusion coefficient k . The CO_2 abundance, from (25), is 293 ppm in 1880, 335 ppm in 1980, and 373 ppm in 2000. Climate model equilibrium sensitivity is 2.8°C for doubled CO_2 .

primarily introduces uncertainties about the time dependence of the global CO_2 warming. The full impact of the warming may be delayed several decades, but since man-made increases in atmospheric CO_2 are expected to persist for centuries (1, 2, 6), the warming will eventually occur.

Radiative Climate Perturbations

Identification of the CO_2 warming in observed climate depends on the magnitude of climate variability due to other factors. Most suspected causes of global climate change are radiative perturbations, which can be compared to identify those capable of counteracting or reinforcing the CO_2 warming.

A 1 percent increase of solar luminosity would warm the earth 1.6°C at equilibrium (Fig. 2) on the basis of model 4, which we employ for all radiative perturbations to provide a uniform comparison. Since the effect is linear for small changes of solar luminosity, a change of 0.3 percent would modify the equilibrium global mean temperature by 0.5°C , which is as large as the equilibrium warming for the cumulative increase of atmospheric CO_2 from 1880 to 1980. Solar luminosity variations of a few tenths of 1 percent could not be reliably measured with the techniques available during the past century, and thus are a possible cause of part of the climate variability in that period.

Atmospheric aerosol effects depend on aerosol composition, size, altitude,

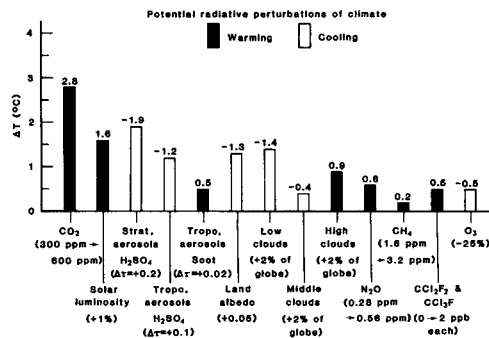


Fig. 2. Surface temperature effect of various global radiative perturbations, based on the 1-D RC model 4 (Table 1). Aerosols have the physical properties specified by (17). Dependence of ΔT on aerosol size, composition, altitude, and optical thickness is illustrated by (26). The $\Delta\tau$ for stratospheric aerosols is representative of a very large volcanic eruption.

and global distribution (26). Based on model calculations, stratospheric aerosols that persist for 1 to 3 years after large volcanic eruptions can cause substantial cooling of surface air (Fig. 2). The cooling depends on the assumption that the particles do not exceed a few tenths of a micrometer in size, so they do not cause greenhouse warming by blocking terrestrial radiation, but this condition is probably ensured by rapid gravitational settling of larger particles. Temporal variability of stratospheric aerosols due to volcanic eruptions appears to have been responsible for a large part of the observed climate change during the past century (27-30), as shown below.

The impact of tropospheric aerosols on climate is uncertain in sense and magnitude due to their range of composition, including absorbing material such as carbon and high-albedo material such as sulfuric acid, and their heterogeneous spatial distribution. Although man-made tropospheric aerosols are obvious near their source, aerosol opacity does not appear to have increased much in remote regions (31). Since the climate impact of anthropogenic aerosols is also reduced by the opposing effects of absorbing and high-albedo materials, it is possible that they have not had a primary effect on global temperature. However, global monitoring of aerosol properties is needed for conclusive analysis.

Ground albedo alterations associated with changing patterns of vegetation coverage have been suggested as a cause of global climate variations on time scales of decades to centuries (32). A global surface albedo change of 0.015, equivalent to a change of 0.05 over land areas, would affect global temperature by 1.3°C . Since this is a 25 percent change in mean continental ground albedo, it seems unlikely that ground albedo variations have been the primary cause of recent global temperature trends. However, global monitoring of ground albedo is needed to permit definitive assessment of its role in climate variability.

High and low clouds have opposite effects on surface temperature (Fig. 2), high clouds having a greenhouse effect while low clouds cool the surface (14, 33). However, the nature and causes of variability of cloud cover, optical thickness, and altitude distribution are not well known, nor is it known how to model reliably cloud feedbacks that may occur in response to climate perturbations. Progress may be made after accurate cloud climatology is obtained from global observations, including seasonal and interannual cloud variations. In the

meantime, some limits are implicitly placed on global cloud feedback by empirical tests of the climate system's sensitivity to radiative perturbations, as discussed below.

Trace gases that absorb in the infrared can warm the earth if their abundance increases (5, 34). The abundance of chlorofluorocarbons (Freons) increased from a negligible amount a few decades ago to 0.3 part per billion for CCl_2F_2 and 0.2 ppb for CCl_3F (35), with an equilibrium greenhouse warming of $\sim 0.06^\circ\text{C}$. Recent measurement of a 0.2 percent per year increase of N_2O suggests a cumulative increase to date of 17 ppb (36), with an equilibrium warming of $\sim 0.03^\circ\text{C}$. Tentative indications of a 2 percent per year increase in CH_4 imply an equilibrium warming $< 0.1^\circ\text{C}$ for the CH_4 increase to date (37). No major trend of O_3 abundance has been observed, although it has been argued that continued increase of Freons will reduce O_3 amounts (38). The net impact of measured trace gases has thus been an equilibrium warming of 0.1°C or slightly larger. This does not greatly alter analyses of temperature change over the past century, but trace gases will significantly enhance future greenhouse warming if recent growth rates are maintained.

We conclude that study of global climate change on time scales of decades and centuries must consider variability of stratospheric aerosols and solar luminosity, in addition to CO_2 and trace gases. Tropospheric aerosols and ground albedo are potentially significant, but require better observations. Cloud variability will continue to cause uncertainty until accurate monitoring of global cloud properties provides a basis for realistic modeling of cloud feedback effects; however, global feedback is implicitly checked by comparison of climate model sensitivity to empirical climate variations, as done below.

Observed Temperature Trends

Data archives (39) contain surface air temperatures of several hundred stations for the last century. Problems in obtaining a global temperature history are due to the uneven station distribution (40), with the Southern Hemisphere and ocean areas poorly represented, and the smaller number of stations for earlier times.

We combined these temperature records with a method designed to extract mean temperature trends. The globe was divided by grids with a spacing not larger than the correlation distance for primary

dynamical transports (41), but large enough that most boxes contained one or more stations. The results shown were obtained with 40 equal-area boxes in each hemisphere, but the conclusions are not sensitive to the exact spacing. Temperature trends for stations within a box were combined successively:

$$T_{1,n}(t) = \frac{(n^* - 1)T_{1,n} + T_n - \bar{T}_n + \bar{T}_{1,n}}{n^*} \quad (8)$$

to obtain a single trend for each box, where the bar indicates a mean for the years in which there are records for both T_n and the cumulative $T_{1,n}$ and $n^*(t)$ is the number of stations in $T_{1,n}(t)$. Trends for boxes in a latitude zone were combined with each box weighted equally, and the global trend was obtained by area-weighting the trends for all latitude zones. A meaningful result begins in the 1880's, since thereafter continuous records exist for at least two widely separated longitudes in seven of the eight latitude zones (continuous Antarctic temperatures begin in the 1950's). Results are least reliable for 1880 to 1900; by 1900, continuous records exist for more than half of the 80 boxes.

The temperature trends in Fig. 3 are smoothed with a 5-year running mean to make the trends readily visible. Part of the noise in the unsmoothed data results from unpredictable weather fluctuations, which affect even 1-year means (42).

None of our conclusions depends on the nature of the smoothing.

Northern latitudes warmed $\sim 0.8^\circ\text{C}$ between the 1880's and 1940, then cooled $\sim 0.5^\circ\text{C}$ between 1940 and 1970, in agreement with other analyses (9, 43). Low latitudes warmed $\sim 0.3^\circ\text{C}$ between 1880 and 1930, with little change thereafter. Southern latitudes warmed $\sim 0.4^\circ\text{C}$ in the past century; results agree with a prior analysis for the late 1950's to middle 1970's (44). The global mean temperature increased $\sim 0.5^\circ\text{C}$ between 1885 and 1940, with slight cooling thereafter.

A remarkable conclusion from Fig. 3 is that the global temperature is almost as high today as it was in 1940. The common misconception that the world is cooling is based on Northern Hemisphere experience to 1970.

Another conclusion is that global surface air temperature rose $\sim 0.4^\circ\text{C}$ in the past century, roughly consistent with calculated CO_2 warming. The time history of the warming obviously does not follow the course of the CO_2 increase (Fig. 1), indicating that other factors must affect global mean temperature.

Model Verification

Natural radiative perturbations of the earth's climate, such as those due to aerosols produced by large volcanic

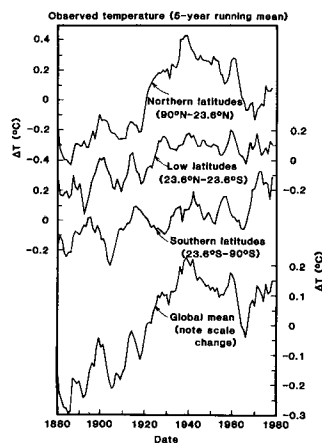


Fig. 3. Observed surface air temperature trends for three latitude bands and the entire globe. Temperature scales for low latitudes and global mean are on the right.

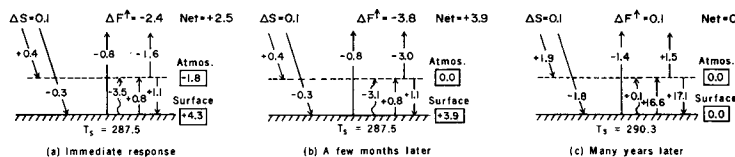


Fig. 4. Change of fluxes (watts per square meter) in the 1-D RC model when atmospheric CO_2 is doubled (from 300 to 600 ppm). Symbols: ΔS , change in solar radiation absorbed by the atmosphere and surface; ΔF^\uparrow , change in outward thermal radiation at top of the atmosphere. The wavy line represents convective flux; other fluxes are radiative.

eruptions, permit a valuable test of model sensitivity. Previous study of the best-documented large volcanic eruption, Mount Agung in 1963, showed that tropical tropospheric and stratospheric temperature changes computed with a one-dimensional climate model were of the same sign and order of magnitude as observed changes (45). It was assumed that horizontal heat exchange with higher latitudes was not altered by the radiative perturbation.

We reexamined the Mount Agung case for comparison with the present global temperature record, using our model with sensitivity $\sim 2.8^\circ\text{C}$. The model, with a maximum global mean aerosol increase in the optical depth $\Delta\tau = 0.12$ (45), yields a maximum global cooling of 0.2°C when only the mixed-layer heat capacity is included and 0.1°C when heat exchange with the deeper ocean is included with $k = 1 \text{ cm}^2 \text{ sec}^{-1}$. Observations suggest a cooling of this magnitude with the expected time lag of 1 to 2 years. Noise or unexplained variability in the observations prevents more definitive conclusions, but similar cooling is indicated by statistical studies of temperature trends following other large volcanic eruptions (46).

A primary lesson from the Mount Agung test is the damping of temperature change by the mixed layer's heat capacity, without which the cooling would have exceeded 1.1°C (Fig. 2). The effect can be understood from the time constant of the perturbation and thermal response time of the mixed layer: $\Delta T \sim \{1 - \exp(-t/\tau)\} \times 1.1^\circ\text{C} \sim 0.17^\circ\text{C}$, for the case $k = 0$. This large reduction of the climate response occurs for a perturbation that (unlike CO_2) is present for a time shorter than the thermal response time of the ocean surface.

Phenomena that alter the regional radiation balance provide another model test. Idso (11) found a consistent "empirical response function" for several such phenomena, which was 0.17°C per

watt per square meter in midcontinent and was half as large on the coast. This response must depend on the rate of mixing of marine and continental air, since the phenomena occur on time scales less than the thermal relaxation time of the ocean surface. Thus, as one test of horizontal atmospheric transports, we read from our three-dimensional climate model (8) the quantities (solar insolation and temperature) that form Idso's empirical response function for seasonal change of insolation. Results ranged from $0.2^\circ\text{C W}^{-1} \text{ m}^2$ in midcontinent, and about half that on the coast, to a value an order of magnitude smaller over the ocean, in agreement with the empirical response (11).

To relate these empirical tests to the CO_2 greenhouse effect, we illustrate the flux changes in the 1-D RC model when CO_2 is doubled. For simplicity we consider an instantaneous doubling of CO_2 , and hence the time dependence of the response does not represent the transient response to a steady change in CO_2 . The immediate response to the doubling includes (Fig. 4a): (i) reduced emission to space (-2.4 W m^{-2}), because added CO_2 absorption raises the mean altitude of emission to a higher, colder level; (ii) increased flux from atmosphere to ground ($+1.1 \text{ W m}^{-2}$); and (iii) increased stratospheric cooling but decreased tropospheric cooling. The radiative warming of the troposphere decreases the "convective" flux (latent and sensible heat) from the ground by 3.5 W m^{-2} as a consequence of the requirement to conserve energy. There is a small increase in absorption of near-infrared radiation, the atmosphere gaining energy ($+0.4 \text{ W m}^{-2}$) and the ground losing energy (-0.3 W m^{-2}). The net effect is thus an energy gain for the planet ($+2.5 \text{ W m}^{-2}$) with heating of the ground ($+4.3 \text{ W m}^{-2}$) and cooling of the (upper) atmosphere (-1.8 W m^{-2}). These flux changes are independent of feedbacks and are not sensitive to the critical lapse rate.

A few months after the CO_2 doubling

(Fig. 4b) the stratospheric temperature has cooled by $\sim 5^\circ\text{C}$. Neither the ocean nor the troposphere, which is convectively coupled to the surface, have responded yet. The planet radiates 3.8 W m^{-2} less energy to space than in the comparison case with 300 ppm CO_2 , because of the cooler stratosphere and greater altitude of emission from the troposphere. The energy gained by the earth at this time is being used to warm the ocean.

Years later (Fig. 4c) the surface temperature has increased 2.8°C . Almost half the increase (1.2°C) is the direct CO_2 greenhouse effect. The remainder is due to feedbacks, of which 1.0°C is the well-established H_2O greenhouse effect.

The greenhouse process represented in Fig. 4 is simply the "leaky bucket" phenomenon. The increased infrared opacity causes an immediate decrease of thermal radiation from the planet, thus forcing the temperature to rise until energy balance is restored. Temporal variations of the fluxes and temperatures are due to the response times of the atmosphere and surface.

Surface warming of $\sim 3^\circ\text{C}$ for doubled CO_2 is the status after energy balance has been restored. This contrasts with the Agung case and the cases considered by Idso (11), which are all nonequilibrium situations.

The test of the greenhouse theory provided by the extremes of equilibrium climates on the planets and short-term radiative perturbations is reassuring, but inadequate. A crucial intermediate test is climate change on time scales from a few years to a century.

Model versus Observations for the Past Century

Simulations of global temperature change should begin with the known forcings: variations of CO_2 and volcanic aerosols. Solar luminosity variations, which constitute another likely mecha-

nism, are unknown, but there are hypotheses consistent with observational constraints that variations not exceed a few tenths of 1 percent.

We developed an empirical equation that fits the heat flux into the earth's surface calculated with the 1-D RC climate model (model 4):

$$F(t) = 0.018\Delta p/(1 + 0.0022\Delta p)^{0.6} - 17\Delta\tau - 1.5(\Delta\tau)^2 + 220\Delta S/S_0 - 1.5\Delta T + 0.033(\Delta T)^2 - 1.04 \times 10^{-4}\Delta p\Delta T + 0.29\Delta T\Delta\tau \quad (9)$$

where $F(t)$ is in watts per square meter, p is the amount of CO_2 in parts per million above an "equilibrium" value (293 ppm), ΔS is the difference between solar luminosity and an equilibrium value S_0 , $\Delta\tau$ is the optical depth of stratospheric aerosols above a background amount, and ΔT is the difference between current surface temperature and the equilibrium value for $\Delta p = \Delta S = \Delta\tau = 0$. Equation 9 fits the one-dimensional model results to better than 1 percent for $0 \leq \Delta p \leq 1200$ ppm, $0.98 \leq \Delta S/S_0 \leq 1.02$, and $\Delta\tau \leq 0.5$. For the mixed-layer ocean model $T_s(t)$ follows from $dT_s/dt = F(t)/c_0$, where c_0 is the heat capacity of the ocean mixed layer per unit area. If the true mixed-layer depth is used to obtain c_0 , $F(t)$ must be multiplied by 1/0.7, the ratio of global area to ocean area. Diffusion of heat into the deeper ocean can then also be included by means of the diffusion equation with T_s as its upper boundary condition.

The CO_2 abundance increased from 293 ppm in 1880 to 335 ppm in 1980 (25), based on recent accurate observations, earlier less accurate observations, and carbon cycle modeling. The error for 1880 probably does not exceed 10 ppm (1, 2).

Volcanic aerosol radiative forcing can be obtained from Lamb's (27) dust veil index (DVI), which is based mainly on atmospheric transmission measurements after 1880. We convert DVI to optical depth by taking Mount Agung (DVI = 800) to have the maximum $\Delta\tau = 0.12$. The aerosol optical depth histories of Mitchell (47) and Pollack *et al.* (29), the latter based solely on transmission measurements, are similar to Lamb's. We use aerosol microphysical properties from (45). The error in volcanic aerosol radiative forcing probably does not exceed a factor of 2.

Solar variability is highly conjectural, so we first study CO_2 and volcanic aerosol forcings and then add solar variations. We examine the hypothesis of Hoyt (48) that the ratio, r , of umbra to penumbra areas in sunspots is pro-

portional to solar luminosity: $\Delta S/S_0 = f(r - r_0)$. Hoyt's rationale is that the penumbra, with a weaker magnetic field than the umbra, is destroyed more readily by an increase of convective flux from below. We take $f = 0.03$, which implies a peak-to-peak amplitude of ~ 0.4 percent for $\Delta S/S_0$ in the past century, or an amplitude of ~ 0.2 percent for the mean trend line. Taking S_0 as the mean for 1880 to 1976 yields $r_0 = 0.2$. The resulting $\Delta S/S_0$ has no observational corroboration, but serves as an example of solar variability of a plausible magnitude.

Radiative forcing by CO_2 plus volcanoes and forcing by CO_2 plus volcanoes plus the sun both yield a temperature trend with a strong similarity to the observed trend of the past century (Fig. 5), which we quantify below. If only the heat capacity of the mixed layer is included, the amplitude of the computed temperature variations is larger than observed. However, mixing of heat into the deeper ocean with $k = 1 \text{ cm}^2 \text{ sec}^{-1}$ brings both calculated trends into rough agreement with observations.

The main uncertainties in the climate model—that is, its "tuning knobs"—are (i) the equilibrium sensitivity and (ii) the rate of heat exchange with the ocean beneath the mixed layer. The general correlation of radiative forcings with

global temperatures suggests that model uncertainties be constrained by requiring agreement with the observed temperature trend.

Therefore, we examined a range of model sensitivities, choosing a diffusion coefficient for each to minimize the residual variance between computed and observed temperature trends. Equilibrium sensitivities of 1.4°, 2.8°, and 5.6°C required $k = 0$, 1.2, and $2.2 \text{ cm}^2 \text{ sec}^{-1}$, respectively. All models with sensitivities of 1.4° to 5.6°C provide a good fit to the observations. The smallest acceptable sensitivity is $\sim 1.4^\circ\text{C}$, because it requires zero heat exchange with the deeper ocean. Sensitivities much higher than 5.6°C would require greater heat exchange with the deep ocean than is believed to be realistic (21, 22).

Radiative forcing by CO_2 plus volcanoes accounts for 75 percent of the variance in the 5-year smoothed global temperature, with correlation coefficient 0.9. The hypothesized solar luminosity variation (48) improves the fit, as a consequence of the luminosity peaking in the 1930's and declining into the 1970's, leaving a residual variance of only 10 percent. The improved fit provided by Hoyt's solar variability represents a posteriori selection, since other hypothesized solar variations that we examined [for instance (49)] degrade the fit. This

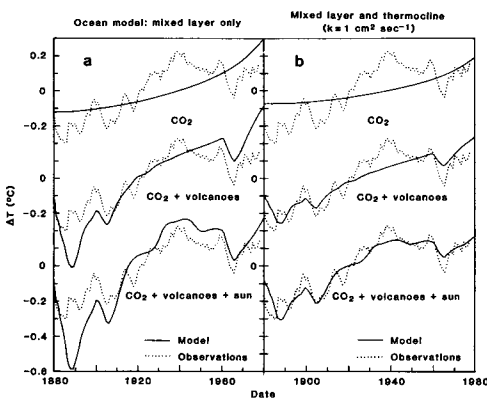


Fig. 5. Global temperature trend obtained from climate model with sensitivity 2.8°C for doubled CO_2 . The results in (a) are based on a 100-m mixed-layer ocean for heat capacity; those in (b) include diffusion of heat into the thermocline to 1000 m. The forcings by CO_2 , volcanoes, and the sun are based on Broecker (25), Lamb (27), and Hoyt (48). Mean ΔT is zero for observations and model.

Table 2. Energy supplied and CO₂ released by fuels.

Fuel	Energy supplied in 1980*		CO ₂ release per unit energy (oil = 1)	Airborne CO ₂ added in 1980*		CO ₂ added through 1980	Potential airborne CO ₂ in virgin reservoirs† (ppm)
	(10 ¹⁹ J)	(%)		(%)	(ppm)	(ppm)	
Oil	12	40	1	50	0.7	11	70
Coal	7	24	5/4	35	0.5	26	1000
Gas	5	16	3/4	15	0.2	5	50
Oil shale, tar sands, heavy oil	0	0	7/4	0	0	0	100
Nuclear, solar, wood, hydroelectric	6	20	0	0	0	0	0
Total	30	100		100	1.4	42	1220

*Based on late 1970's. †Reservoir estimates assume that half the coal above 3000 feet can be recovered and that oil recovery rates will increase from 25 to 30 percent to 40 percent. Estimate for unconventional fossil fuels may be low if techniques are developed for economic extraction of "synthetic oil" from deposits that are deep or of marginal energy content. It is assumed that the airborne fraction of released CO₂ is fixed.

evidence is too weak to support any specific solar variability.

The general agreement between modeled and observed temperature trends strongly suggests that CO₂ and volcanic aerosols are responsible for much of the global temperature variation in the past century. Key consequences are: (i) empirical evidence that much of the global climate variability on time scales of decades to centuries is deterministic and (ii) improved confidence in the ability of models to predict future CO₂ climate effects.

Projections into the 21st Century

Prediction of the climate effect of CO₂ requires projections of the amount of atmospheric CO₂, which we specify by (i) the energy growth rate and (ii) the fossil fuel proportion of energy use. We neglect other possible variables, such as changes in the amount of biomass or the fraction of released CO₂ taken up by the ocean.

Energy growth has been 4 to 5 percent per year in the past century, but increasing costs will constrain future growth (1, 4). Thus we consider fast growth (~3 percent per year, specifically 4 percent per year in 1980 to 2020, 3 percent per year in 2020 to 2060, and 2 percent per year in 2060 to 2100), slow growth (half of fast growth), and no growth as representative energy growth rates.

Fossil fuel use will be limited by available resources (Table 2). Full use of oil and gas will increase CO₂ abundance by < 50 percent of the preindustrial amount. Oil and gas depletion are near the 25 percent level, at which use of a resource normally begins to be limited by supply and demand forces (4). But coal, only 2 to 3 percent depleted, will not be so constrained for several decades.

The key fuel choice is between coal and alternatives that do not increase atmospheric CO₂. We examine a synfuel option in which coal-derived synthetic fuels replace oil and gas as the latter are depleted, and a nuclear/renewable resources option in which the replacement fuels do not increase CO₂. We also examine a coal phaseout scenario: after a specific date coal and synfuel use are held constant for 20 years and then phased out linearly over 20 years.

Projected global warming for fast growth is 3° to 4.5°C at the end of the next century, depending on the proportion of depleted oil and gas replaced by synfuels (Fig. 6). Slow growth, with depleted oil and gas replaced equally by synfuels and nonfossil fuels, reduces the warming to ~2.5°C. The warming is only slightly more than 1°C for either (i) no energy growth, with depleted oil and gas replaced by nonfossil fuels, or (ii) slow energy growth, with coal and synfuels phased out beginning in 2000.

Other climate forcings may counteract or reinforce CO₂ warming. A decrease of solar luminosity from 1980 to 2100 by 0.6 percent per century, large compared to measured variations, would decrease the warming ~0.7°C. Thus CO₂ growth as large as in the slow-growth scenario would overwhelm the effect of likely solar variability. The same is true of other radiative perturbations; for instance, volcanic aerosols may slow the rise in temperature, but even an optical thickness of 0.1 maintained for 120 years would reduce the warming by less than 1.0°C.

When should the CO₂ warming rise out of the noise level of natural climate variability? An estimate can be obtained by comparing the predicted warming to the standard deviation, σ , of the observed global temperature trend of the past century (50). The standard devi-

ation, which increases from 0.1°C for 10-year intervals to 0.2°C for the full century, is the total variability of global temperature; it thus includes variations due to any known radiative forcing, other variations of the true global temperature due to unidentified causes, and noise due to imperfect measurement of the global temperature. Thus if T_0 is the current 5-year smoothed global temperature, the 5-year smoothed global temperature in 10 years should be in the range $T_0 \pm 0.1^\circ\text{C}$ with probability ~70 percent, judging only from variability in the past century.

The predicted CO₂ warming rises out of the 1 σ noise level in the 1980's and the 2 σ level in the 1990's (Fig. 7). This is independent of the climate model's equilibrium sensitivity for the range of likely values, 1.4° to 5.6°C. Furthermore, it does not depend on the scenario for atmospheric CO₂ growth, because the amounts of CO₂ do not differ substantially until after year 2000. Volcanic eruptions of the size of Krakatau or Agung may slow the warming, but barring an unusual coincidence of eruptions, the delay will not exceed several years.

Nominal confidence in the CO₂ theory will reach ~85 percent when the temperature rises through the 1 σ level and ~98 percent when it exceeds 2 σ . However, a portion of σ may be accounted for in the future from accurate knowledge of some radiative forcings and more precise knowledge of global temperature. We conclude that CO₂ warming should rise above the noise level of natural climate variability in this century.

Potential Consequences of Global Warming

Practical implications of CO₂ warming can only be crudely estimated, based on climate models and study of past climate. Models do not yet accurately simulate many parts of the climate system, especially the ocean, clouds, polar sea ice, and ice sheets. Evidence from past climate is also limited, since the few recent warm periods were not as extreme as the warming projected to accompany full use of fossil fuels, and the climate forcings and rate of climate change may have been different. However, if checked against our understanding of the physical processes and used with caution, the models and data on past climate provide useful indications of possible future climate effects (51).

Paleoclimatic evidence suggests that surface warming at high latitudes will be two to five times the global mean warming (52-55). Climate models predict the

larger sensitivity at high latitudes and trace it to snow/ice albedo feedback and greater atmospheric stability, which magnifies the warming of near-surface layers (6-8). Since these mechanisms will operate even with the expected rapidity of CO₂ warming, it can be anticipated that average high-latitude warming will be a few times greater than the global mean effect.

Climate models indicate that large regional climate variations will accompany global warming. Such shifting of climatic patterns has great practical significance, because the precipitation patterns determine the locations of deserts, fertile areas, and marginal lands. A major regional change in the doubled CO₂ experiment with our three-dimensional model (6, 8) was the creation of hot, dry conditions in much of the western two-thirds of the United States and Canada and in large parts of central Asia. The hot, dry summer of 1980 may be typical of the United States in the next century if the model results are correct. However, the model shows that many other places, especially coastal areas, are wetter with doubled CO₂.

Reconstructions of regional climate patterns in the alithermal (53, 54) show some similarity to these model results. The United States was drier than today during that warm period, but most regions were wetter than at present. For example, the climate in much of North Africa and the Middle East was more favorable for agriculture 8000 to 4000 years ago, at the time civilization dawned in that region.

Beneficial effects of CO₂ warming will include increased length of the growing season. It is not obvious whether the world will be more or less able to feed its population. Major modifications of regional climate patterns will require efforts to readjust land use and crop characteristics and may cause large-scale human dislocations. Improved global climate models, reconstructions of past climate, and detailed analyses are needed before one can predict whether the net long-term impact will be beneficial or detrimental.

Melting of the world's ice sheets is another possible effect of CO₂ warming. If they melted entirely, sea level would rise ~ 70 m. However, their natural response time is thousands of years, and it is not certain whether CO₂ warming will cause the ice sheets to shrink or grow. For example, if the ocean warms but the air above the ice sheets remains below freezing, the effect could be increased snowfall, net ice sheet growth, and thus lowering of sea level.

Danger of rapid sea level rise is posed by the West Antarctic ice sheet, which, unlike the land-based Greenland and East Antarctic ice sheets, is grounded below sea level, making it vulnerable to rapid disintegration and melting in case of general warming (55). The summer temperature in its vicinity is about -5°C. If this temperature rises ~ 5°C, deglaciation could be rapid, requiring a century or less and causing a sea level rise of 5 to 6 m (55). If the West Antarctic ice sheet melts on such a time scale, it will temporarily overwhelm any sea level change due to growth or decay of land-based ice

sheets. A sea level rise of 5 m would flood 25 percent of Louisiana and Florida, 10 percent of New Jersey, and many other lowlands throughout the world.

Climate models (7, 8) indicate that ~ 2°C global warming is needed to cause ~ 5°C warming at the West Antarctic ice sheet. A 2°C global warming is exceeded in the 21st century in all the CO₂ scenarios we considered, except no growth and coal phaseout.

Floating polar sea ice responds rapidly to climate change. The 5° to 10°C warming expected at high northern latitudes for doubled CO₂ should open the North-

Fig. 6. Projections of global temperature. The diffusion coefficient beneath the ocean mixed layer is 1.2 cm² sec⁻¹, as required for best fit of the model and observations for the period 1880 to 1978. Estimated global mean warming in earlier warm periods is indicated on the right.

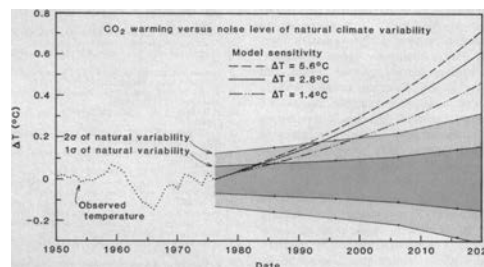
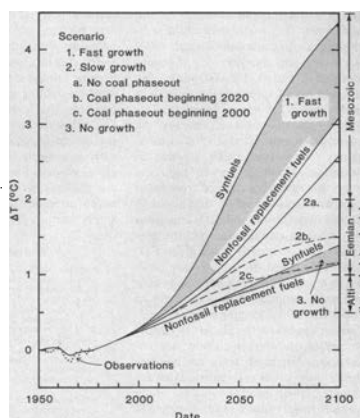


Fig. 7. Comparison of projected CO₂ warming to standard deviation (σ) of observed global temperature and to 2σ . The standard deviation was computed for the observed global temperatures in Fig. 3. Carbon dioxide change is from the slow-growth scenario. The effect of other trace gases is not included.

west and Northeast passages along the borders of the American and Eurasian continents. Preliminary experiments with sea ice models (56) suggest that all the sea ice may melt in summer, but part of it would refreeze in winter. Even a partially ice-free Arctic will modify neighboring continental climates.

Discussion

The global warming projected for the next century is of almost unprecedented magnitude. On the basis of our model calculations, we estimate it to be $\sim 2.5^\circ\text{C}$ for a scenario with slow energy growth and a mixture of nonfossil and fossil fuels. This would exceed the temperature during the alithermal (6000 years ago) and the previous (Eemian) interglacial period 125,000 years ago (53), and would approach the warmth of the Mesozoic, the age of dinosaurs.

Many caveats must accompany the projected climate effects. First, the increase of atmospheric CO_2 depends on the assumed energy growth rate, the proportion of energy derived from fossil fuels, and the assumption that about 50 percent of anthropogenic CO_2 emissions will remain airborne. Second, the predicted global warming for a given CO_2 increase is based on rudimentary abilities to model a complex climate system with many nonlinear processes. Tests of model sensitivity, ranging from the equilibrium climates on the planets to perturbations of the earth's climate, are encouraging, but more tests are needed. Third, only crude estimates exist for regional climate effects.

More observations and theoretical work are needed to permit firm identification of the CO_2 warming and reliable prediction of larger climate effects farther in the future. It is necessary to monitor primary global radiative forcings: solar luminosity, cloud properties, aerosol properties, ground albedo, and trace gases. Exciting capabilities are within reach. For example, the NASA Solar Maximum Mission is monitoring solar output with a relative accuracy of ~ 0.01 percent (57). Studies of certain components of the climate system are needed, especially heat storage and transport by the oceans and ice sheet dynamics. These studies will require global monitoring and local measurements of processes, guided by theoretical studies. Climate models must be developed to reliably simulate regional climate, including the transient response

(58) to gradually increasing CO_2 amount.

Political and economic forces affecting energy use and fuel choice make it unlikely that the CO_2 issue will have a major impact on energy policies until convincing observations of the global warming are in hand. In light of historical evidence that it takes several decades to complete a major change in fuel use, this makes large climate change almost inevitable. However, the degree of warming will depend strongly on the energy growth rate and choice of fuels for the next century. Thus, CO_2 effects on climate may make full exploitation of coal resources undesirable. An appropriate strategy may be to encourage energy conservation and develop alternative energy sources, while using fossil fuels as necessary during the next few decades.

The climate change induced by anthropogenic release of CO_2 is likely to be the most fascinating global geophysical experiment that man will ever conduct. The scientific task is to help determine the nature of future climatic effects as early as possible. The required efforts in global observations and climate analysis are challenging, but the benefits from improved understanding of climate will surely warrant the work invested.

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Statement of the American Short Line and Regional Railroad Association, Submitted for the Record by Hon. Graves of Missouri

Chairman DeFazio and Ranking Member Graves, thank you for holding this hearing addressing the impact that federal infrastructure policy can have on climate change. The American Short Line and Regional Railroad Association (ASLRRRA) is a non-profit trade association representing 603 Class II and Class III railroads in the United States, Canada and Mexico as well as numerous suppliers and contractors to the short line and regional railroad industry. Short lines operate 47,500 route miles of track in 49 states, or approximately 29% of the national railroad network, touching in origination or termination one out of every five cars moving on

the national railroad system, serving customers who otherwise would be cut off from the national railroad network.

While passenger and freight roadway vehicles account for 83% of total greenhouse gas emissions, freight rail accounts for only 2%. As Rep. LaMalfa noted during the hearing, freight rail moves one ton of freight 479 miles on one gallon of diesel fuel. Class II and Class III railroads alone moved 12,074,000 carloads of freight in 2015, equaling 34,778,000 truckloads. According to the Association of American Railroads, if 10% of the freight currently moved by truck was moved to rail, fuel savings would be more than 1.5 billion gallons per year. This is equivalent to removing 3.2 million cars from the highways during the same period.

Transporting goods by rail reduces natural fuel used, and reduces wear and tear, assisting the fuel efficiency of the motoring public.

Congress can facilitate shippers maximizing their use of freight rail in two ways:

- *Supporting the Short Line Tax Credit, also known as 45G.* For 12 years the short line tax credit has proven its worth. It has enhanced capital investment into short line railroads, it has significantly improved competitive rail service for shippers, it has helped improve railroad safety and it has been the difference between piecemeal and corridor improvements. Helping short lines continue to grow freight traffic through infrastructure improvements will deliver long term benefits to the environment.
- *Opposing any increase in truck size or length* is critical to keeping freight on the rails. It has been established both in actual practice, in those states that have allowed bigger trucks on state roads, and in many well-constructed diversion studies, that if truck lengths and weights are increased, freight will be diverted from the rails onto the highways. This modal shift will contribute to climate change by inflicting more damage to pavement, reducing fuel efficiencies for cars and trucks that use the roads. Additional weights and axles needed to support that increased weights contributes to “rolling resistance,” which leads to more fuel consumption.

As Ranking Member Graves noted during the hearing, the freight rail industry is making progress in the area of climate change by implementing technologies to limit greenhouse gases, increase fuel efficiency and reduce its carbon footprint. We believe that policies supporting these efforts by the freight rail industry is one answer to address climate change.

ASLRRA and our member railroads urge the committee to consider the impact that tax and truck size and weight policies can have on climate change and on the efforts that Class II and III railroads are already making to provide safe, reliable, and fuel-efficient transportation.

Statement of Ian J. Jeffries, President and Chief Executive Officer, Association of American Railroads, Submitted for the Record by Hon. Graves of Missouri

On behalf of the members of the Association of American Railroads, thank you for the opportunity to provide a statement for the record. AAR members account for the vast majority of freight railroad mileage, employees, and traffic in Canada, Mexico, and the United States.

Railroads have a strong record of success in meeting our nation’s transportation needs in an environmentally-friendly fashion. They are committed to pursuing further technological and operational advancements that will lead to continued tangible improvements in fuel efficiency, mobility, greenhouse gas emissions, and air quality.

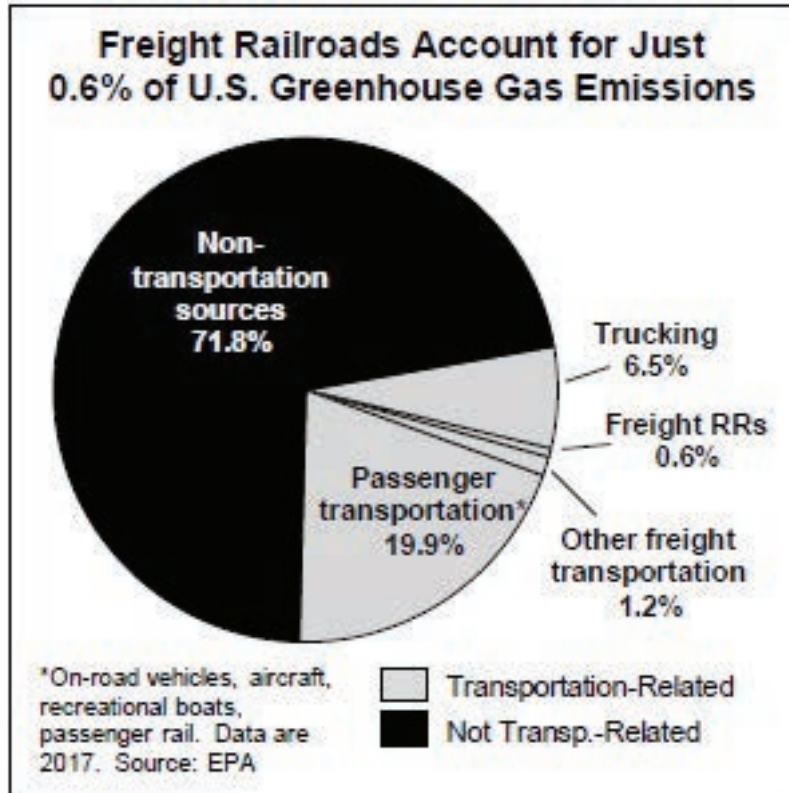
For this reason, I respectfully submit that policymakers should take steps to attract more freight to rail, thereby expanding the substantial greenhouse gas and other public benefits of freight rail transportation. Steps policymakers can take include removing policies that inappropriately tilt the transportation marketplace in favor of other modes; encouraging greater use of rail-related public-private partnerships; and retaining the existing system of balanced regulation that protects rail customers against abusive railroad conduct but also helps ensure railroads are financially able to make the network investments they need to serve their customers safely, reliably, and cost effectively.



RAILROADS ARE THE MOST FUEL-EFFICIENT WAY TO MOVE FREIGHT OVER LAND

According to the EPA, transportation accounted for 28.2 percent of U.S. greenhouse gas emissions in 2017. The vast majority of transportation-related greenhouse gas emissions are directly related to fossil fuel consumption: higher fuel consumption means more emissions. Railroads, though, are the most fuel-efficient way to move freight over land. In 2017, railroads moved one ton of freight an average of 479 miles per gallon of fuel—roughly the distance from Coos Bay, Oregon to San Francisco, or from Hannibal, Missouri to Columbus, Ohio.

Indeed, according to an independent study for the Federal Railroad Administration, freight railroads on average are four times more fuel efficient than trucks. That means, on average, moving freight by rail instead of truck reduces greenhouse gas emissions by 75 percent. The railroad fuel efficiency advantage helps explain why freight railroads account for just 2.0 percent of transportation-related greenhouse gas emissions and just 0.6 percent of total U.S. greenhouse gas emissions, according to the EPA, even though railroads account for well over a third of intercity freight volume.



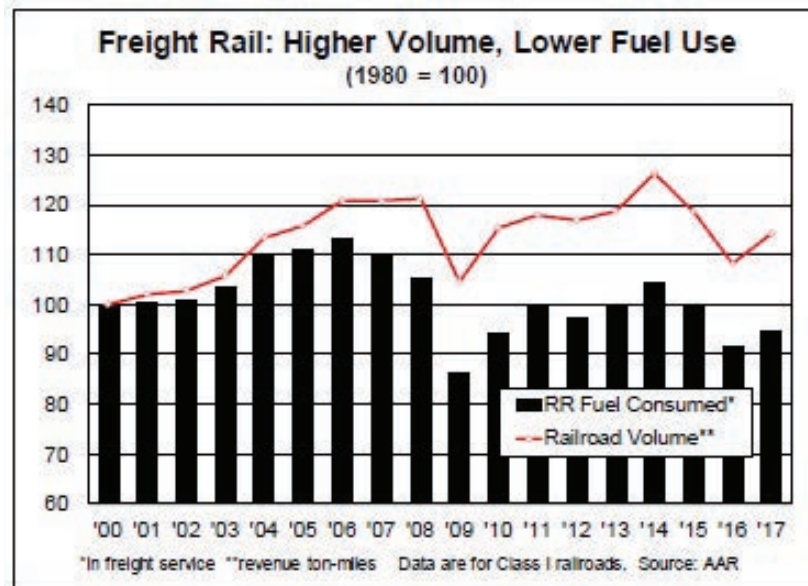
If just 10 percent of the freight that moves by Class 7 or Class 8 (the largest) trucks moved by rail instead, fuel savings would be more than 1.5 billion gallons per year and annual greenhouse gas emissions would fall by more than 17 million tons—equivalent to removing 3.2 million cars from the highways for a year or planting 400 million trees.

RAILROADS ARE CONSTANTLY WORKING TO IMPROVE FUEL EFFICIENCY

Over the years, railroads have worked hard to improve their fuel efficiency—on a ton-miles per gallon basis, rail fuel efficiency in 2017 was up 104 percent over 1980 and up 21 percent over 2000. In 2017 alone, U.S. freight railroads consumed 732 million fewer gallons of fuel and emitted 8.2 million fewer tons of carbon dioxide than they would have if their fuel efficiency had remained constant since 2000. From 2000 through 2017, U.S. freight railroads consumed 8.3 billion fewer gallons of fuel and emitted 92 million fewer tons of carbon dioxide than they would have if their fuel efficiency had not improved.

A single train can carry the freight of several hundred trucks, meaning that moving more freight by rail also reduces highway congestion, which in 2018 cost Americans an average of 97 hours, or \$1,348, per driver just in terms of lost time, according to INRIX (a highway traffic analytics firms). Reducing congestion also reduces wasted fuel (and associated greenhouse gas emissions) by motorists who take longer to get where they want to go. Moving freight by rail instead of trucks has the added bonus of reducing highway wear and tear and the pressure to build costly new highways, freeing up limited funds for other purposes.

U.S. freight railroads are moving more freight than in the past, but using less fuel to do so. How have railroads managed this? Through technological innovations, new investments, improved operating practices, and a lot of hard work.



Steps railroads have taken individually or collectively to reduce fuel consumption include:

- Acquiring thousands of new, more efficient locomotives and removing from service thousands of older, less fuel-efficient locomotives.
- Developing and installing highly advanced fuel management systems that, among other things, calculate the most fuel-efficient speed for a train over a given route; determine the most efficient spacing and timing of trains on a railroad's system; and monitor locomotive functions and performance to ensure peak efficiency.
- Installing idling-reduction technologies, such as stop-start systems that shut down a locomotive when it is not in use and restart it when it is needed, and expanding the use of distributed power (positioning locomotives in the middle of trains) to reduce the total horsepower required for train movements.
- Increasing the amount of freight in rail cars and on trains. Thanks to improved freight car design and other factors, the amount of freight railroads carried in an average train in 2017 was 3,630 tons, up from 2,923 tons in 2000.
- Enhancing operating practices and rail car components to reduce fuel use. For example, advanced lubrication techniques save fuel by reducing friction; improving the aerodynamic profile of trains saves fuel by reducing drag.
- Providing employee training to help locomotive engineers develop and implement best practices and improve awareness of fuel-efficient operations.
- Increasing the use of zero-emission cranes to transfer containers between ships, trucks, and trains at ports and rail facilities.

In recent years, railroads have begun to investigate moving away from diesel locomotives in favor of alternatives—for example, to cleaner burning natural gas, or even potentially to batteries or fuel cells. At this point, it's not at all clear that an alternative will have the combination of affordability, reliability, and capability to be feasible for widespread use, but it does show that railroads are willing to “look outside the box” in terms of enhancing sustainability and environmental preservation.

WHAT POLICYMAKERS CAN DO TO ENCOURAGE MORE FREIGHT TO MOVE BY RAIL

Using freight railroads more means emitting fewer greenhouse gas emissions. Policymakers can help make this happen by removing impediments to moving freight by rail and supporting policies that incentivize shippers to ship by rail.

For example, policymakers can adopt a more equitable system of funding non-rail transportation infrastructure. America's freight railroads, which are almost entirely privately owned, operate overwhelmingly on infrastructure that they own, build,

maintain, and pay for themselves. By contrast, trucks and barges operate on highways and waterways that are largely taxpayer funded.

With respect to federally funded capacity investments in public road and bridge infrastructure, the United States has historically relied upon a “user pays” system. Until relatively recently, that system worked well. Unfortunately, the user-pays model has been eroded as Highway Trust Fund (HTF) revenues have not kept up with HTF investment needs and so have had to be supplemented with general taxpayer dollars. General fund transfers to the HTF since 2008 have totaled almost \$144 billion, according to the Congressional Budget Office, and will require another \$191 billion between 2020 and 2029 to keep the HTF solvent.

Unfortunately, moving away from a user-pays system distorts the competitive environment by making it appear that trucks are less expensive than they really are and puts other modes, especially rail, at a disadvantage. Congress could help ameliorate this modal inequity by reaffirming the “user pays” requirement, preferably through a vehicle miles traveled fee or a weight-distance fee.

On a related note, policymakers should retain existing truck length and weight limits. The taxes and fees heavy trucks pay are already far less than the cost of the damage heavy trucks cause. This huge underpayment would become even greater, and the freight transportation marketplace would become even more distorted, if truck length and weight limits were increased.

A greater use of rail-related public-private partnerships would also lead to more freight moving by rail. Under these arrangements, public entities devote public dollars equivalent to the public benefits that will accrue from a project, while railroads contribute resources commensurate with the private gains expected to accrue. Without a partnership, many projects that promise substantial public benefits (such as reduced highway congestion by taking trucks off highways, or increased rail capacity for use by passenger trains) in addition to private benefits (such as enabling more efficient freight train operations) are likely to be delayed or never started at all because neither side can justify the full investment needed to complete them. Cooperation makes these projects feasible.

Finally, policymakers should keep the existing system of balanced rail rate and service regulation. Today’s balanced rail regulatory system protects rail customers against unreasonable railroad conduct while allowing railroads to largely decide for themselves how to manage their operations. The current system has worked extremely well for railroads and their customers. However, some want to again give government regulators control over crucial areas of rail operations. That would be a profound mistake. It would prevent America’s railroads from making the massive investments a best-in-the-world freight rail system requires and would inexorably lead to less freight moving by environmentally friendly rail.

CONCLUSION

The key to reducing transportation-related greenhouse gas emissions is reducing fuel consumption in transportation. Research and development of new technologies and alternative fuels offers much promise and as previously noted the railroad industry is driving many initiatives in this arena. However, future promise does not help the nation today. Here’s the takeaway that I ask each of you to remember. There is no need to wait for the promises of tomorrow from technologies and new alternative fuels that are not yet ready to be brought to market. America’s freight railroads offer a simple, Cost-effective and meaningful way to help. I urge the Committee to consider the simple infrastructure policy considerations that I outlined on behalf of our member railroads. Thank you again for providing me with the opportunity to provide a written statement.

Comments of the Southern Environmental Law Center, Submitted for the Record by Hon. DeFazio of Oregon

The Southern Environmental Law Center (SELC) thanks the U.S. House Committee on Transportation and Infrastructure for its recent hearing on “Examining How Federal Infrastructure Policy Could Help Mitigate and Adapt to Climate Change.” This critically important subject demands far greater attention than it has received at the federal level in recent years. We offer these comments on key issues and strategies related to transportation and climate change, and provide insight into how these issues are affecting our region.

The connections between our transportation system and climate change are clear and significant. Transportation has surpassed the electricity sector as the nation’s largest contributor of greenhouse gas (GHG) pollution, comprising 28.7% of the na-

tional total in 2017.¹ In addition, the effects of climate change on our transportation infrastructure, including sea level rise and increased flooding from more severe storms, are being felt in both coastal and inland communities across the country. There is a critical need to increase our efforts at the federal, state, and local levels on each of these topics. We must both reduce our transportation system's contribution to global GHG emissions and enhance the resiliency of our transportation systems and our communities to the effects of climate change.

Below we outline a number of approaches and strategies to reduce GHG pollution. Higher fuel efficiency standards and increased adoption of electric and other zero- and low-emission technologies are important components of any transportation-related emission reduction strategy. Achieving meaningful reductions, however, will also require substantial efforts to reduce the number of vehicle miles traveled (VMT) in our transportation system. To accomplish this, we must pay close attention to how our transportation system drives land use patterns, as well as encourage a shift away from motor vehicle use to cleaner transportation modes and reduce single-occupancy travel with a particular emphasis on shared and active transportation. Congestion pricing and similar strategies can also play a role in reducing vehicle emissions. In addition, as important as it is to address passenger vehicle emissions, VMT reductions and shifts to cleaner alternatives are needed in the freight sector as well. It is also imperative that we make consideration of GHG emissions a central factor in our transportation planning processes—either directly, or indirectly via a proxy like VMT.

Enhancing the resiliency of our transportation infrastructure and communities is also essential. Resiliency considerations must be incorporated into the location and planning decisions for new projects, as well as decisions about whether and where to rebuild at-risk infrastructure. Effective maintenance of our existing infrastructure is also increasingly important. In addition, we must protect and augment the many features that provide natural resiliency and serve as effective carbon sinks, such as our forests, wetlands, and marshes.

I. REDUCING GHG EMISSIONS

As others noted during your hearing on this matter and in written testimony, there are many available approaches and opportunities to reduce transportation-related GHG emissions. Efforts to promote cleaner technologies such as electric and other zero- and low-emissions vehicles are an essential piece of this puzzle, and have significant growth potential in the coming years due in part to rapid improvements in electric vehicle (EV) technology and affordability. But to achieve meaningful reductions from our transportation sector, we must also substantially reduce VMT, favor transportation investments that encourage more compact, walkable development, and incorporate GHG emissions considerations in our transportation plans and project-specific environmental reviews.

In addition to achieving GHG reductions, advancements in these areas provide important co-benefits, including more equitable and accessible transportation systems, economic growth and vibrancy, traffic congestion reductions, and improvements to public health—both physical and mental. Such advancements are also necessary to meet the changing needs of America's residents and businesses, which increasingly seek walkable communities with diverse transportation options.

A. Promoting Cleaner Technologies

i.) Fuel Efficiency Standards

Fuel efficiency standards are one area in which the federal government plays a crucial role in promoting a shift toward cleaner transportation technologies. Unfortunately, the current administration has set us down the wrong path. Corporate Average Fuel Economy (CAFE) and carbon dioxide (CO₂) emissions standards adopted by the Obama Administration in 2012 for passenger cars and light duty trucks were estimated to save 4 billion barrels of oil and to reduce GHG emissions by the equivalent of 2 billion metric tons over the lifetime of these light duty vehicles produced in model years 2017 to 2025.²

Last summer, however, the National Highway Traffic Safety Administration and U.S. Environmental Protection Agency (EPA) proposed to roll back these clean car standards and freeze fuel economy and CO₂ emissions standards for light duty vehicles at 2020 levels for five years—a proposal that would result in an increase in petroleum consumption of 0.5 million barrels per day by the early 2030s. This pro-

¹ U.S. Environmental Protection Agency, “Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017” at Table 2–10 (2019).

² 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62624, 62627 (Oct. 15, 2012).

posed rollback is a step in the wrong direction, and would seriously undermine future efforts to reduce GHG emissions across our transportation system. Additionally, as explained in a letter SELC sent to the U.S. Department of Transportation and EPA, the change calls into question the accuracy of many environmental reviews completed for projects in recent years that assumed the Obama-era clean car standards would be in place in their future emissions projections.³

ii.) Electric and Other Zero- and Low-Emissions Vehicle Technologies

This is an important time for the future of zero- and low-emissions technologies, particularly in the case of EVs. In recent years, EV battery prices have dropped dramatically even as vehicle ranges have increased. For instance, the range of the Nissan Leaf has increased from 73 miles in 2011 to 151 miles for the 2018 version. The Southeast is now home to over 65,000 EVs—a five-fold increase since 2013, and the rate of adoption is expected to continue to increase in the coming years with further improvements in technology and as most major auto manufacturers have pledged to significantly increase their EV production.

The significant influx in funding for clean vehicles and electric charging infrastructure resulting from the Volkswagen emissions cheating settlement serves as another key catalyst in the anticipated future growth of EVs. As part of this settlement, \$2 billion was set aside for EV charging infrastructure and education (which has become the “Electrify America” program), as well as \$2.9 billion in additional mitigation funds apportioned to states in which the relevant VW vehicles were sold. States are already taking advantage of this new funding to further promote EVs. Last fall, Virginia awarded a contract to a private entity to install new EV charging stations across the state—devoting the maximum allowable 15% of its mitigation funds toward this effort, and also announced that it will be allocating an additional 15% for electric transit buses. North Carolina has likewise committed to devote the maximum 15% of its mitigation funds toward charging stations.

Foremost among the benefits of EVs is that they are a “zero emissions” technology, producing no tailpipe emissions. Although EVs require electricity to operate, which does not always come from renewable energy sources, the U.S. Department of Energy’s Alternative Fuels Data Center estimates that even in the traditionally fossil fuel-reliant Southeast, EVs are responsible for roughly 75% less GHG emissions than gasoline-powered vehicles.⁴ This benefit will increase over time as these states continue to shift toward cleaner energy sources. Additional public health and environmental benefits flow from a reduction in emissions of nitrogen oxides (NOx) and volatile organic compounds (VOCs), reducing harmful ground-level ozone as well as nitrogen loads to water bodies such as the Chesapeake Bay. EVs are also typically less expensive to maintain and operate than gasoline-powered vehicles, and the purchase price of EVs is predicted to decline to a level on par with gasoline vehicles in the near future.

There are many steps that Congress and federal agencies can take (or continue taking) to support these efforts. Important grants and funding sources that support electric and low-emissions technologies should be continued and expanded, such as federal tax credit programs for EV purchases, the Federal Transit Administration’s “Low or No Emission Vehicle” and EPA’s Diesel Emissions Reduction Act (DERA) grant programs, and Congestion Mitigation and Air Quality (CMAQ) funds administered by the Federal Highway Administration (FHWA). Additional areas where federal support is needed include providing data and technical support to states, localities, and metropolitan planning organizations (MPOs) to identify and plan for EV charging infrastructure needs. Increased federal funding should also be provided to support the installation of charging stations in key areas such as Alternative Fuel Corridors designated by FHWA under the FAST Act.

iii.) Other State and Regional Efforts

It is also important to recognize initiatives being undertaken by regional, state, and local bodies across the country to reduce transportation-related GHG emissions. For example, the Transportation and Climate Initiative (TCI) is a coalition of Northeast and Mid-Atlantic states and the District of Columbia working to reduce carbon emissions and develop clean energy solutions for the transportation sector. Significantly, TCI members announced in December that they will embark on a year-long study to explore the creation of a regional “cap and invest” program that would limit transportation-related emissions and encourage investment in low-carbon tech-

³Letter from Trip Pollard et al., SELC to Elaine Chao, U.S. Department of Transportation et al., “Re-evaluating Completed NEPA Reviews under Proposed Rollback of Clean Car Rules” (Aug. 27, 2018).

⁴See U.S. Department of Energy Alternative Fuels Data Center, <http://afdc.energy.gov/>.

nologies.⁵ Other important regional efforts include the bi-coastal Multi-State ZEV Task Force, comprised of eight states committed to taking action to expand the adoption of zero emissions vehicles and charging infrastructure. Similar initiatives include the West Coast Electric Highway and TCI's Northeast Electric Vehicle Network—both regional programs to create a network of EV charging stations to enable convenient travel both locally and throughout these regions.

There are also a host of individual and collaborative efforts being undertaken by states, localities, MPOs, and non-governmental organizations and businesses to contribute toward reducing our transportation GHG emissions. California is leading the way on a number of these initiatives, including through the adoption of its Sustainable Communities and Climate Protection Law (S.B. 375). S.B. 375 requires GHG reduction targets to be set for light duty vehicles for each MPO area of the state, as well as the development of transportation and/or land use strategies to meet these targets. California, along with New York, Massachusetts, and Oregon (all of which are U.S. Climate Alliance Members), have also established statewide VMT reduction targets.

Congress and federal agencies should encourage these transformative efforts through data sharing and technical support, as well as increased grant and/or direct funding for these activities wherever possible through programs such as those identified in the previous section (Low-No, DERA, CMAQ, etc.). The U.S. Department of Energy's Clean Cities Coalition Network should also be continued and expanded, with an increasing emphasis on zero emissions vehicles. Finally, as discussed further below, we urge you to strengthen (or in some cases, reinstate) nationwide strategies along the lines of a number of these efforts, including transportation GHG performance standards and reduction targets for the National Highway System applicable to all states and MPOs, as well as the potential establishment of related VMT reduction targets.

B. Reducing Vehicle Miles Traveled

Studies are clear that technological improvements alone—such as EVs—will not sufficiently reduce GHG emissions from the transportation sector. Meaningfully reducing GHG emissions from transportation will also require reducing VMT from both passenger and freight vehicles. In order to do so, we must provide greater travel options for both residents and businesses, while also prioritizing transportation investments that encourage more compact and transit-oriented development patterns and enable our communities to reduce their reliance on personal car travel.

i.) Encouraging Cleaner Transportation Modes

An essential component in reducing VMT is to significantly increase our investment in multimodal, shared, and active transportation options. Public transit, passenger rail, bicycle, and pedestrian options can meet people's transportation needs without the high GHG emissions associated with solo private car trips. When bus and ride-sharing fleets are powered with electricity, the GHG emissions reductions are even greater. Increasing investment in freight rail can also provide significant benefits—railroads are on average four times more fuel efficient than trucks, generating 75% fewer GHG emissions.⁶ Congress should explore how best to incentivize, and increase funding for, multimodal transportation projects and services which will help reduce VMT, while also benefitting Americans beyond the direct reduction in GHG emissions.

Reducing VMT through greater mode options creates healthier communities. One study of individuals living near the Charlotte Lynx light rail system showed significant increases in physical health, including that light rail users lost weight and substantially reduced their likelihood of becoming obese.⁷ Public transportation access and walkable communities are also associated with numerous mental health benefits, such as reducing emotional stress and symptoms of depression.⁸ Moreover, public transit use is generally safer, with a much lower fatality rate than private auto-

⁵ See TCI, "Transportation and Climate Initiative Statement" (Dec. 18, 2018), available at http://www.georgetownclimate.org/files/Final_TCI-statement_20181218_formatted.pdf.

⁶ See 2017 Virginia Statewide Rail Plan at 2, available at <http://www.drpt.virginia.gov/rail/reference-materials/virginiastate-rail-plan/>.

⁷ John M. MacDonald, et al., *The Effect of Light Rail Transit on Body Mass Index and Physical Activity*, 39 AM. J. PREVENTIVE MED. 105, 108 (2010). The study concluded that "[t]he findings from the current study suggest that increasing the access to LRT transit for individuals to commute to work may help overcome some of the barriers to engaging in daily utilitarian exercise." Id. at 110.

⁸ TODD LITMAN, VICTORIA TRANSPORT POLICY INSTITUTE, EVALUATING PUBLIC TRANSPORTATION HEALTH BENEFITS 17 (2015), available at http://www.vtpi.org/tran_health.pdf.

mobile travel.⁹ As one researcher has observed, “[p]eople who live or work in transit oriented communities tend to drive fewer annual miles, drive at lower speeds, and have better travel options that allow them to avoid high risk driving, such as after drinking alcohol or when ill.”¹⁰ Mixed-use neighborhoods with public transportation access correspond to lower rates of obesity, while sprawling neighborhoods correspond to higher rates of hypertension, diabetes, asthma, and cancer.¹¹

Expanding public transit and designing for “complete streets” that serve all transportation users, including bicyclists and pedestrians, are also important in creating a more equitable transportation system. Elderly and disabled residents often rely on public transit for their transportation needs. Similarly, ensuring public transit is affordable and connects key employment and education hubs helps provide disenfranchised communities, such as low-income and minority families, with greater access to upward mobility opportunities. In turn, transit stations that can be reached by bicycling or walking are more accessible by a diverse array of passengers.

Further, reducing VMT through shifts to other modes does not come at a cost to economic development. Recent examples have illustrated that businesses are increasingly seeking to locate and invest in communities with good public transit systems, and which are walkable and bikeable. During their respective headquarters searches, both Amazon and Apple identified access to public transit as important to their decisions. Mercedes-Benz relocated to downtown Atlanta,¹² and Kaiser-Permanente decided on Georgia over Colorado because of the public transit options available, specifically the rail system in Atlanta’s Midtown area.¹³ The Charlotte Lynx light rail system has proven to be an enormous economic success for the area with around \$2 billion invested in development along the rail line’s original route, and a slew of new development projects along the line’s extension that opened in 2018.¹⁴

ii.) Prioritizing Investments that Encourage Sustainable Land Use Patterns

In order to make effective reductions in VMT, and in turn GHG emissions, state, local and federal transportation planners need to plan for a future transportation network that is less dependent on single occupancy driving. Simply put, transportation and land use decisions need to be considered together. Much of our current land use patterns have been developed with private car use in mind.¹⁵ In turn, we have a transportation network that facilitates car-centric suburban and exurban sprawl—this both leads to increased VMT and swaths of natural areas being destroyed for large highways and corresponding sprawling neighborhoods. Such destruction of key environmental resources further contributes to climate change by eliminating carbon sinks like forests and wetlands. These pressures are particularly acute in the South, where sprawling suburban development has already led to environmental destruction, and where population numbers are expected to explode in coming years.

Moving away from these land use patterns is both necessary for climate goals and in line with changing preferences of the American public. Suburban living with lengthy commutes is no longer the American dream. Instead, younger generations are increasingly looking to live in communities where they can live, work, and play without getting into a car. More and more people, particularly in the Millennial generation, are consciously driving less and prefer to use alternate modes of transportation.¹⁶ The vast majority of Millennials express a preference for living in more ur-

⁹Id. at 8–9.

¹⁰Id. at 8.

¹¹Id. at 15.

¹²Matt Kempner and J. Scott Trubey, *MARTA A Sudden Factor in Company Moves*, THE ATLANTA JOURNAL-CONSTITUTION, Jan. 16, 2015, <http://www.myajc.com/news/business/marta-a-sudden-factor-in-company-moves/njpnF/>.

¹³Maria Saporta, *Transit and Walkability Key Factors in Kaiser Permanente’s Decision to Put 900 New Jobs in Midtown*, SAPORTAREPORT, Apr. 17, 2015, <http://saportareport.com/transit-and-walkability-key-factors-in-kaiser-permanentes-decision-to-put-900-new-jobs-in-midtown/>.

¹⁴Melissa Oyler, *Charlotte’s Light Rail: A City Changed Forever*, BISNOW, Mar. 12, 2018, <https://www.bisnow.com/charlotte/news/construction-development/development-popping-up-like-weeds-along-charlottes-light-rail-opening-this-week-85974>.

¹⁵DOT, *Transportation’s Role in Reducing U.S. Greenhouse Gas Emissions—Volume 1: Synthesis Report to Congress ES-10* (2010), available at http://ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf. (“[O]ur historic approach to transportation and land use has created an energy-intensive system dependent on carbon-based fuels and automobiles.”).

¹⁶TONY DUTZIK & PHINEAS BAXANDALL, U.S. PIRG FUND & FRONTIER GRP., *A NEW DIRECTION: OUR CHANGING RELATIONSHIP WITH DRIVING AND THE IMPLICATIONS FOR AMERICA’S FUTURE* 21–25 (2013), available at <http://www.uspirg.org/sites/pirg/files/reports/A%20New%20Direction%20vUS.pdf>.

banized, mixed-use, walkable communities with public transportation access.¹⁷ Existing compact, mixed-use development along public transportation routes have shown that such less automobile-dependent communities are a reality with corresponding real benefits: “[r]esidents of communities with high-quality, well integrated public transit ... own half as many vehicles, drive half as many annual miles, walk and bicycle four times more, and use public transit ten times more than residents of more automobile-dependent communities.”¹⁸

These preferences are pertinent to decisions about our future transportation network and climate change. A USDOT report identified changes to land use patterns as one of the transportation-related strategies with the greatest potential to reduce emissions,¹⁹ and it has been estimated that compact development can decrease driving rates by as much as 40% and in turn help reduce GHG emissions.²⁰ These considerations must be a key factor in transportation planning and funding decisions at all levels of government, not only to meet our communities’ evolving transportation needs, but also to ensure that we are capturing the significant GHG reduction potential offered by these changing preferences.

C. Considering GHG Emissions in Planning and Environmental Reviews

Another crucial strategy to reduce GHG emissions from the transportation sector is to ensure that GHG considerations are made a central component of planning and decision-making for our transportation systems. An important action was taken in this area in early 2017 when FHWA published a final rule to incorporate a CO₂-specific performance measure into transportation planning processes.²¹ This measure would have required states and MPOs to track carbon emissions of vehicles traveling on the National Highway System, establish targets for reducing these emissions, and report on progress in meeting their targets. The Trump Administration, however, subsequently delayed and then ultimately repealed the performance measure. This measure would have been a key step toward ensuring that states and MPOs give due consideration to the GHG emissions-related effects of their transportation planning decisions, and should be reinstated.

A similar scenario has played out in the context of environmental reviews under the National Environmental Policy Act (NEPA). In the wake of court decisions finding that NEPA requires consideration of the GHG emissions of proposed actions and in relation to reasonable alternatives, and after years of public input and discussion, the Council on Environmental Quality (CEQ) published guidance in August 2016 outlining how federal agencies should approach climate change analyses in NEPA documents to ensure compliance with the statute.²² Among other things, CEQ provided that NEPA reviews should include analysis of a proposed action’s expected GHG emissions, the relative GHG emissions of the proposal and alternative options, and potential climate-related risks and resiliency considerations related to the action and potential alternatives.²³ In March 2017, President Trump signed an Executive Order directing that this guidance be revoked.²⁴ We understand that new guidance may soon be issued, and we hope that such guidance will be consistent with settled law that requires agencies to consider air quality and climate change im-

¹⁷ Id. at 23; *Millennials Prefer Cities to Suburbs, Subways to Driveways*, NIELSON (Mar. 4, 2014), <http://www.nielsen.com/us/en/insights/news/2014/millennials-prefer-cities-to-suburbs-subways-to-driveways.html>.

¹⁸ LITMAN, *supra* note 8, at 3.

¹⁹ DOT, *Transportation’s Role in Reducing U.S. Greenhouse Gas Emissions—Volume 1: Synthesis Report to Congress* 3–18 (2010), available at http://ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf.

²⁰ Reid Ewing et al., *Urban Land Institute, Growing Cooler: The Evidence on Urban Development and Climate Change* 9, 33, 114 (2008).

²¹ National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program, 82 Fed. Reg. 5970 (Jan. 18, 2017).

²² Christina Goldfuss, CEQ, “Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews” (Aug. 1, 2016); see also Notice of Availability at 81 Fed. Reg. 51866 (Aug. 5, 2016).

²³ In this regard, the guidance stated: “Considering alternatives, including alternatives that mitigate GHG emissions, is fundamental to the NEPA process ... Agency decisions are aided when there are reasonable alternatives that allow for comparing GHG emissions and carbon sequestration potential, trade-offs with other environmental values, and the risk from—and resiliency to—climate change inherent in a proposed action and its design.” Goldfuss, *supra* note 23 at 14–15.

²⁴ Exec. Order No. 13783, 82 Fed. Reg. 16093 (Mar. 28, 2017).

pacts likely to result from a project, including indirect impacts.²⁵ It is also important that this new guidance echo the 2016 version in providing clarity to federal agencies about the proper review of alternatives in relation to climate change, as well as resiliency considerations.

II. ENHANCING RESILIENCY OF INFRASTRUCTURE

Even as we discuss how to reduce GHG emissions, we are experiencing the effects of climate change right now with rising sea levels, increasing frequency and severity of storms, heavier rainfall events and more.²⁶ Southeastern states are being hit particularly hard with many coastal communities regularly suffering from flood and storm events. Indeed, Southern communities such as Hampton Roads and Charleston are among the areas most-threatened by sea level rise in the nation.

On average, Southeastern coastline areas have already experienced one foot of sea level rise in the last century.²⁷ By the end of this century, Southeastern shorelines could see over six feet of sea level rise by intermediate estimates, and the severity of storms and the damages they cause will continue to increase. For example, with Hurricane Matthew in 2016 and Hurricane Florence in 2018, the Carolina coast was dealt two so-called 1,000-year storms in only two years.²⁸ Scientists found that climate change made Florence able to grow larger and drop 50% more rain compared to a world without high greenhouse gas emissions.²⁹ One study found that if there had not been the significant sea level rise seen in the area since 1970, one out of five of the homes impacted by Florence along the Carolina coast would have had far less damage.³⁰

Transportation infrastructure projects must be planned, and maintained, against this backdrop of climate change impacts. While much discussion of adaptation and resiliency focuses on how to effectively rebuild after a flood or storm event, more attention must be paid to how thoughtful planning of transportation projects can prevent some of this damage from happening in the first place.

A. Incorporating Resiliency into Location and Planning Decisions

Large transportation infrastructure projects have a profound impact on the built and natural environments. For example, large highways often require the destruction of significant natural resources in their path such as forests and wetlands, and can cause further indirect harm by inducing growth into previously undisturbed areas. In the context of sea level rise and storm events, this dynamic of induced growth counsels against supporting projects that will bring growth into flood-prone areas. For example, the proposed Mid-Currituck Bridge along the North Carolina Outer Banks would encourage growth in areas that will be underwater from rising seas within a few decades. Similarly problematic are proposals that would encourage growth in flood plains that are becoming increasingly subject to flood events. In essence, such projects invite greater future storm damage. Additionally, as sea level rise brings the coast inland, marshes will similarly migrate inland, which means that transportation proposals must be considered based on both existing wetland areas as well as anticipated future wetland locations. Transportation planners must take a long view when considering whether a project makes sense; just because it can be built now, does not mean it should be.

Such transportation projects also run the risk of replacing natural features that manage flood events and sea level rise—such as forests, wetlands, and marshes—with impervious surfaces, undermining the natural ability of a project area to miti-

²⁵ See, e.g. *Mid States Coal. for Progress v. Surface Transp. Bd.*, 345 F.3d 520, 549-50 (8th Cir. 2003) (holding an Environmental Impact Statement insufficient with regards to climate impacts from increased coal consumption because “when the nature of the effect is reasonably foreseeable but its extent is not,” the agency cannot ignore that effect); *Sierra Club, et al. v. FERC*, 867 F.3d 1357, 1375 (D.C. Cir. 2017) (concluding that FERC should have estimated amount of power-plant carbon emissions that would result from project pipelines).

²⁶ See Trip Pollard, *Damage Control: Adapting Transportation to a Changing Climate*, 39 WM. & MARY ENVTL. L. & POLY REV. 365 (2014).

²⁷ According to gauge observational data not modeling. S. Jevrejeva et al., *Sea Level Projections to AD2500 with a New Generation of Climate Change Scenarios*, 80-81 GLOBAL & PLANETARY CHANGE 14 (2012), doi:10.1016/j.gloplacha.2011.09.006.

²⁸ *Exceedance Probability Analysis for Selected Storm Events*, Nat’l Oceanic & Atmospheric Admin.’s Nat’l Weather Serv.’s Hydrometeorological Design Studies Ctr., http://www.nws.noaa.gov/oh/hdsc/aep_storm_analysis (last modified Apr. 21, 2017).

²⁹ Kevin A. Reed et al., *The Human Influence on Hurricane Florence*, Stoney Brook University (Sept. 12, 2018), https://cpb-use1.wpmucdn.com/you.stonybrook.edu/dist/4/945/files/2018/09/climate-change-Florence_0911201800Z_final-262u19i.pdf.

³⁰ Andrew Freedman, *Study: Sea Level Rise Boosted Hurricane Florence’s Coastal Flooding*, Axios (Sept. 24, 2018), <https://www.axios.com/sea-level-rise-hurricane-florence-coastal-flooding-a32d013f-5b66-470a-9536-7a54c3001d64.html>.

gate these effects and potentially exacerbating flooding issues. Transportation agencies must take a hard look at how proposed projects might harm natural resiliency features in the face of storm, flooding, and sea level projections. Specifically, as discussed above, transportation agencies must take these climate change impacts into account in their environmental reviews under NEPA. This should include reconsidering the regulations that allow agencies to rebuild a road, highway or bridge in its exact same location after being destroyed in a state-declared emergency event, without being subject to NEPA review to consider whether the facility should in fact be rebuilt at all in light of changing storm, flooding, and sea level patterns. See 23 C.F.R. § 771.117(c)(9).

B. Ensuring Proper Maintenance of Existing Facilities

A proactive approach with a long-term view is also needed with existing transportation facilities. Increasingly extreme weather events have meant increasing wear on our transportation infrastructure. Main corridors have been shut down for days at a time in the wake of severe storms, such as I-40 in North Carolina after Hurricane Florence. As these events become increasingly common, transportation agencies need to inventory their existing facilities and determine how best to maintain or upgrade infrastructure to be ready for the next severe weather or flooding event. Adequate and properly maintained stormwater facilities can help to guard against flooding of our roads and bridges and in some cases enable agencies to avoid building costly and unnecessary new infrastructure to address flooding issues. Such a “fix it first” approach is more cost-effective both in terms of dollars and environmental impacts.

CONCLUSION

Thank you for the opportunity to submit these comments. To meaningfully reduce GHG emissions and plan for a resilient future it is imperative that transportation laws, policies, and decision-makers take climate change seriously. We encourage you to continue exploring and to take steps to increase funding opportunities and make policy changes to reduce transportation-related GHG emissions along the lines of the recommendations provided above. We further encourage you to ensure that climate change and its effects, like sea level rise and severe storm events, are being adequately considered during transportation project planning and environmental reviews.

Letter of February 22, 2019, from Matthew J. Strickler, Secretary of Natural Resources, Commonwealth of Virginia, Submitted for the Record by Hon. DeFazio of Oregon

FEBRUARY 22, 2019.

Hon. PETER DEFAZIO
Chair

Hon. SAM GRAVES
Ranking Member

House Committee on Transportation and Infrastructure, 2134 Rayburn Office Building, Washington, DC 20515

DEAR CHAIRMAN DEFAZIO AND RANKING MEMBER GRAVES:

I am writing today to offer the Commonwealth of Virginia’s perspective on ways the federal government can better assist Virginia and other states in mitigating and adapting to the impacts of sea level rise and extreme weather events. Please accept this testimony for the record of the February 27, 2019 Transportation and Infrastructure Committee hearing titled “Examining How Federal Infrastructure Policy Could Help Mitigate and Adapt to Climate Change.”

Virginia has much at stake as Congress considers legislation to address our country’s aging infrastructure. In addition to help repairing and modernizing roads, bridges, and railways, the Commonwealth requires the assistance of the federal government to make coastal communities and critical assets more resilient to climate change and natural hazards.

Sea level rise and more frequent and intense weather events have combined with land subsidence to dramatically increase flooding and storm damage risk to coastal Virginia. We are not unique among coastal states in this regard, but with nearly 10,000 miles of tidal shoreline, the deepest and one of the busiest ports on the east

coast, and numerous military installations including the largest naval base in the world, we are uniquely vulnerable.¹

The recently published, Fourth National Climate Assessment report summary includes the following findings regarding infrastructure:

Climate change and extreme weather events are expected to increasingly disrupt our Nation's energy and transportation systems, threatening more frequent and longer-lasting power outages, fuel shortages, and service disruptions, with cascading impacts on other critical sectors. The continued increase in the frequency and extent of high-tide flooding due to sea level rise threatens America's trillion-dollar coastal property market and public infrastructure, with cascading impacts to the larger economy ... Expected increases in the severity and frequency of heavy precipitation events will affect inland infrastructure in every region, including access to roads, the viability of bridges, and the safety of pipelines. Flooding from heavy rainfall, storm surge, and rising high tides is expected to compound existing issues with aging infrastructure in the Northeast.²

In Virginia, these warnings are already ringing true. According to the National Oceanic and Atmospheric Administration's 2017 Sea Level Trends Map, all eight of the sea level monitoring stations in the Commonwealth show a relative sea level rise of one to two feet per century, among the highest rates of sea level rise on the east or west coasts.³ The Hampton Roads Planning District Commission estimates the negative impacts on private property and public infrastructure from three feet of sea level rise in Southeastern Virginia, in the tens of billions of dollars.⁴ As this trend continues, the costs and profound impacts of natural hazards associated with climate change will only increase the longer we wait to address them. Public health and safety, our environment and natural resources, and the economic wellbeing of the Commonwealth, including our ports, military installations, transportation infrastructure, tourism assets, farms, forests, and fisheries are all at risk.

We must act now to protect lives and property and reduce taxpayer exposure through fiscally responsible planning. It is important to understand that we must not only work to make our existing infrastructure more resilient to sea level rise and other natural hazards, but that we will need to build new infrastructure, both green and grey, for the express purpose of making our coastal communities more resilient.

Virginia is already doing its part. Last November, Governor Northam issued Executive Order (EO) 24: *Increasing Virginia's Resilience to Sea Level Rise and Natural Hazards*. This sweeping directive establishes a roadmap for making Virginia more resilient, including the creation of a Coastal Resilience Master Plan for the Commonwealth. A copy of EO-24 is attached for your reference.

Given the enormous scope of this problem and the significant cost required to better protect people and property from extreme weather and sea level rise, Virginia will require the assistance of the federal government to address this pressing issue and to implement our Master Plan. On behalf of the Commonwealth of Virginia, we respectfully urge the Committee and Congress to consider the following recommendations as you develop infrastructure legislation:

1. Provide robust funding to help states and localities address sea level rise and extreme weather events

As detailed in this letter, the cost of making the United States more resilient to extreme weather and sea level rise is enormous. Without consistent, dedicated funding, coordinated fully across federal agencies, states like Virginia will not be able to adequately protect their citizens and the built and natural infrastructure that underpins their economies. In particular, we urge Congress to make significant investments in pre-disaster mitigation and resilience funding, and U.S. Army Corps of Engineers (Corps) flood protection projects. To meet the challenge before us, we will need unprecedented investment from the federal government to better protect America's coasts. We urge the committee to prioritize flood control projects for those areas most at risk, and to also prioritize projects that are part of comprehensive regional or multi-state plans rather than free-standing projects that may be advanced by a particular locality or interest.

¹ https://www.vims.edu/bayinfo/faqs/shoreline_miles.php

² <https://nca2018.globalchange.gov/>

³ <https://tidesandcurrents.noaa.gov/sltrends/slrmap.html>

⁴ https://www.hrpdcva.gov/uploads/docs/HRPDC_ClimateChangeReport2012_Full_Reduced.pdf

2. Encourage green infrastructure solutions where applicable

Science has shown us that natural defenses against flooding, storm surge, erosion, and other forces are often our most effective—and most cost effective—solutions for protecting vulnerable areas. By reducing storm water runoff and allowing floodplains to function, green infrastructure can help manage both localized and riverine floods. In areas impacted by localized flooding, green infrastructure practices absorb rainfall, preventing water from overwhelming pipe networks and pooling in streets or basements. In coastal areas, natural or nature-based buffers and living shorelines can reduce storm surge and absorb flood waters. In addition, green infrastructure provides an array of co-benefits including improved water quality and productive fish and wildlife habitat. To the maximum extent possible, the Corps should look first toward natural and nature based infrastructure solutions for coastal protection and flood risk reduction, reserving more costly gray infrastructure for situations where it is the only feasible option. In Virginia, we hope to anchor our Coastal Resilience Master Plan with a limited number of structural flood protection projects, while we fill in the gaps with an array of softer solutions including coastal barrier protection, land acquisition, property buyouts, buffers, living shorelines and more.

3. Help states organize and prioritize flood control projects

For years, cities and towns have taken the lead on requesting Army Corps flood control studies and construction projects, which has led to a long list of regional studies that either overlap or leave gaps in coverage along jurisdictional lines. To ensure that studies are providing the maximum benefit, the Corps should assist states in prioritizing and aggregating flood control projects. Furthermore, the Corps should prioritize new studies and new projects according to the greatest flood risk and the greatest economic needs, as well as giving priority to projects that are part of a regional comprehensive plan. In addition, the Corps should provide regional guidance for how to best address sea level rise and pre-disaster hazard mitigation.

4. Deliver timely Army Corps studies and consider third party analysis and study

In recent years, appropriations bills have limited the number of Corps flood control feasibility studies and project starts in any given year. We simply cannot afford the delay. Congress and the Corps must devise a way to expand capacity to complete such studies more quickly and begin detailed planning and project execution to reduce flooding and extreme weather risk.

In an effort to address the critical need for flood control and pre-disaster hazard mitigation, some cities or towns have engaged private engineering companies to undertake studies on how to best reduce flooding. For example, Virginia Beach has spent more than \$4 million studying its vulnerabilities to flooding and sea level rise. Rather than begin a new feasibility study by the Corps, Congress should ensure that the Corps will accept and validate viable commercial and academic study work as the basis for, or in lieu of, a full feasibility study.

5. Ensure strong environmental review

While both the need and desire for coastal protection projects are urgent, we must resist the temptation to circumvent or weaken bedrock environmental laws. This goes for all infrastructure projects. Robust reviews under the National Environmental Policy Act will help ensure that projects with negative unintended consequences are not selected, and that the needs of impacted communities—particularly environmental justice communities—are taken into account. Similarly, thorough and effective consultation under the Endangered Species Act is necessary to protect vulnerable fish, wildlife, and plants that serve as proxies for the health of entire natural systems.

I understand and appreciate the challenging task that lies ahead of you in developing this infrastructure package, and I thank you for your consideration of these requests. Please do not hesitate to contact me if I can be of further assistance.

Sincerely,

MATTHEW J. STRICKLER,
Secretary of Natural Resources, Commonwealth of Virginia

APPENDIX

QUESTIONS FROM HON. HENRY C. “HANK” JOHNSON, JR. FOR DANIEL SPERLING

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration’s unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. I apologize, but I have no expertise in this area.

QUESTIONS FROM HON. MARK DESAULNIER FOR DANIEL SPERLING

Question 2: Your testimony raised the issue of the importance of land use in reducing greenhouse emissions. One problem we face in California is a shortage of housing located at a reasonable distance from job opportunities, with the consequence of more development sprawling out from urban centers and long, “super commutes.”

How do you think federal policy changes can achieve better coordination of land use and housing production with infrastructure investments?

ANSWER. The federal government should review the design of two California laws (Senate Bills 375 and 743), and what we have learned. These two laws, described below, provide a framework for better coordinating land use, housing and transportation.

The Sustainable Communities and Climate Protection Act of 2008, Senate Bill (SB) 375, (Chapter 728, Statutes of 2008) is intended to encourage regional planning that integrates land use, housing and transportation policy in a way that reduces greenhouse gas (GHG) emissions from driving, and ultimately results in healthier, more efficient, and equitable communities. Under SB 375, metropolitan planning organizations (MPOs) incorporate sustainable transportation strategies (e.g. local, regional and state transportation projects) and land use decisions (e.g. local general plans) in the development of their regional transportation plans to meet greenhouse gas reduction targets.

We have learned two lessons so far from the implementation of this law. First, most of the strategies for achieving GHG emission reductions are the same strategies one would pursue to improve the performance and benefits of transportation investments and decisions. And second, for this type of law to be successful, strong carrots are needed. Carrots are needed to motivate local leaders and community groups to reframe and align transportation and environmental strategies and investments—a paradigm shift for the transportation community.

California’s Senate Bill 743 (Steinberg, Chapter 386, Statutes of 2013), creates a process to change the way transportation impacts are analyzed under the California’s Environmental Quality Act (CEQA). Specifically, it changes the metric of transportation impact in environmental reviews of projects from “level of service” to vehicle miles travelled (VMT). Lead agencies evaluate vehicle travel associated with new development as part of the project’s environmental review and, if the impact is significant, mitigate those impacts by reducing vehicle travel. This new metric is aligned with the achievement of SB 375 and more broadly, sustainable transportation goals.

Question 3: What role do you think metropolitan planning organizations can play in helping to reduce emissions of greenhouse gases? What should the federal government ask MPOs to do differently in the way that they formulate transportation plans and prioritize investments in transportation improvements?

ANSWER. See above No. 2. CARB has compiled a list of best practices for MPOs in the development of regional transportation plans that meet GHG reduction targets under SB 375. They can be found in Appendix C of a legislatively-required re-

view of SB375 at https://ww2.arb.ca.gov/sites/default/files/2018-11/Final2018Report_SB150_112618_05_AppendixC.pdf

Question 4: Should the federal government require states to measure and report on their annual greenhouse gas emissions from mobile sources? What about measuring and reporting on aggregate vehicle miles traveled (VMT)?

ANSWER. Yes. The California Department of Transportation and the California Air Resources Board submitted comments on the Federal Highway Administration (FHWA) MAP-21 Notice of Proposed Rulemaking for the National Performance Management Measures. California strongly urged the FHWA to retain and implement the GHG performance measure established in the third performance measure final rule. As FHWA correctly recognized then, the GHG performance measure is an important mechanism to contribute to states' and U.S.'s efforts to reduce transportation's contribution to climate change by creating transparency and clarity in tracking total emissions from the sector. The comment letter can be found here: http://www.dot.ca.gov/hq/transprog/map21/implementation/ctcarb_110317_jt_cmt_ltr_for_the_fhwa_map-21_pm3_ghg_mea_nprm.pdf

Question 5: Even when transit service options exist, passengers may instead choose to drive or take a taxi, because they perceive that the transit service is unreliable, too slow, or simply too inconvenient.

Besides the obvious need for greater investment in transit and the need for land use planning and housing development coordinated with transit, is there anything the federal government can do to incentivize transit agencies to perform better, spend money more effectively, and do more to innovate to provide better service to passengers?

ANSWER. A wide variety of new technologies and business models have come into existence in the past few years. They present many opportunities to reduce costs to users, transit operators, and infrastructure providers. But they are new and often untested.

- i. The federal government should create a large program to fund pilot projects that bring together innovators, technical experts, community members, and decision-making partners to find creative solutions for accelerating a change in travel choices away from single-occupancy vehicles while improving accessibility and access to opportunity. Pilot projects could test which incentives best motivate travelers to shift to more sustainable travel modes; provide real-time consumer information; develop strategies for making the traveler experience outside of the single-occupancy vehicle more seamless; explore enhancements to transit operations; and/or better integrate walking, cycling, transit, and carpool options via mobility hubs or other approaches.
- ii. Leverage experts to provide insight into the demands on the future transportation system, identify the transformative technologies, solutions, partnerships, and critical steps to meet those demands, in a way that provides clear environmental benefits and fosters greater livability, access to destinations, and compact infill development rather than accelerating sprawl. To highlight a few examples in California that could be done nationally: the State has initiated a Multi-agency Workgroup on Automated Vehicles to address deployment of connected and automated vehicles in California, and Senate Bill 1014 (Skinner, 2018) now directs a number of agencies within the state to foster the use of cleaner cars and more carpooling in ride-hailing trips and directs establishment of goals for reducing the greenhouse gas emissions, including targets for the use of zero emission vehicles.
- iii. Electrification of buses. Electric buses substantially lower operating costs, due to more efficient use of fuel and substantially lower maintenance costs. It is likely that EV transit buses will eventually have a lower total cost of ownership than diesel in most applications.
- iv. New types of buses. DOT and others should start re-evaluating the standard 40 foot bus as the default transit vehicle. Automated and networked technologies may offer the ability to provide high-grade service using minibuses or vans, to areas which are often uneconomical for conventional buses.

Question 6: Between electrification, automation, and so-called "smart cities" we are clearly in the midst of technological innovations in transportation. Some may go so far as to put complete faith in technology's ability to solve many of our urban transportation challenges, believing that advances in technology will make certain forms of public transit obsolete. However, these technological advances will not necessarily, by themselves, address our needs for greater equity in mobility and accessibility, for connecting underserved communities with more opportunities, for

walkable and bike-able urban spaces, for dynamic, diverse, and thriving neighborhoods. And our transit systems are clearly suffering from inadequate investment.

Given our current need for better public transit on one hand, and the many technological innovations that are appearing on the horizon on the other hand, how should the current, changing landscape of technology innovations inform our planning and decision-making around public transportation?

ANSWER. Planning should explore a range of possible futures and identify what policies can be expected to provide win-win solutions. California's MPOs are already exploring the impacts on innovations on their plans and policies.

Also see No. 5 above.

QUESTIONS FROM HON. MARK MEADOWS FOR DANIEL SPERLING

Question 7: You mention in your testimony that California has, in part, addressed energy efficiency through performance standards. In 1993, President Bill Clinton issued Executive Order 12866, "Regulatory Planning and Review", which instructed regulatory agencies to "specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt." This policy was maintained by President George W. Bush and President Barack Obama.

In your experience, do you agree that performance and outcome-based regulations, which provide just as much safety, are more effective than prescriptive procedural regulations in seeing efficiencies made across various industries?

ANSWER. As a generalization, using market-based and performance-based policies are preferable because they do not pick winners and losers and they motivate innovation. Prescriptive regulations are sometimes appropriate, but only if the desired technologies or actions are clear, obvious, and likely to be effective. CARB's success in reducing emissions from mobile sources has relied on a combination of incentives, prescriptive regulations, performance standards, and market instruments. This approach has allowed the state to overcome market and technology barriers for low carbon fuels and low and zero emissions vehicles, and develop pilot programs to support innovation and technology deployment. California has long recognized that there is no single solution for any sector and that working with industry and the broader public through a transparent process can help identify which approach is most cost-effective and feasible while achieving the desired environmental and public health outcomes. California's regulatory process requires that a performance-based regulation be considered when any rule is proposed. As a result, in practice, most of California's regulations are performance based and most major greenhouse gas regulations affecting transportation include a credit-trading market mechanism.

QUESTION FROM HON. JESÚS G. "CHUY" GARCÍA FOR VICKI ARROYO

Question 1: In your testimony, you discussed the historical burdens disproportionately shouldered by low-income communities.

Can you discuss how climate change heightens those discrepancies for communities of color or low-income individuals and what Federal programs can help to reverse years of inequitable planning and development?

ANSWER. The negative impacts of climate change are not experienced equally by all individuals and communities; rather, communities of color, low-income communities, and individuals with disabilities are among those that typically feel the burdens of increased heat and heat waves, flooding, drought, hurricanes and other storms, and other climate stressors disproportionately.¹ These "frontline communities" are more likely to live in areas with higher exposure to pollutants and impacts like extreme heat and flooding that are exacerbated by a changing climate. At the same time they are less likely to have the resources to adapt to the impacts of climate change or to evacuate when faced with a major disaster event like a hurricane, as was clearly demonstrated during Hurricane Katrina.² This unequal distribution of climate and disaster impacts is due in large part to the effects of dec-

¹For more discussion on how frontline communities experience climate change and disaster event impacts disproportionately, see NAACP, *In the Eye of the Storm: A People's Guide to Transforming Crisis and Advancing Equity in the Disaster Continuum*, (2018), available at https://live-naacp-site.pantheonsite.io/wp-content/uploads/2018/09/NAACP_InTheEyeOfTheStorm.pdf; Rejane Frederick, Rebecca Cokley, Hannah Leibson, and Eliza Schultz, Center for American Progress, *Serving the Hardest Hit: Centering People with Disabilities in Emergency Planning and Response Efforts*, Sept. 24, 2018, available at <https://www.americanprogress.org/issues/disability/reports/2018/09/24/458467/serving-hardest-hit/>.

²For a discussion of historical inequality in disaster law and policy, see Daniel A. Farber, *Disaster Law and Inequality*, available at https://ccrm.berkeley.edu/pdfs_papers/Disaster_Law_and_Inequality_Farber.pdf.

ades of systematic oppression through inequitable planning and policymaking at federal, state, and local levels. As a result, individuals in frontline communities may be more vulnerable to health-related effects (e.g., asthma) and infrastructure failures (e.g., due to sub-standard housing and aging infrastructure) resulting from climate change and natural disasters, while receiving less protection from government services and policies.

Furthermore, in addition to the disproportionate effects of environmental disasters on frontline communities, recent research has shown that FEMA disaster aid may also be contributing to an increase in wealth inequality along racial lines.³ While the researchers note that the cause is unclear, it has been shown from past events (e.g., Hurricane Katrina) that FEMA aid is not distributed equitably and the impacts of selective infrastructure redevelopment, while positive for some communities, can be conversely detrimental to others.

Congress should act to ensure that funding through Federal disaster recovery programs (as well as other programs that provide funding to states and local governments for infrastructure or community investments) is distributed equitably to help reverse decades of inequality in Federal investments at state and local levels. Additionally, more could be done to ensure that frontline communities and environmental justice and community-based organizations have a voice in decision making relating to Federal investments and disaster planning and recovery. The Federal government should also be doing more to track these disproportionate impacts of climate change and natural disasters so as to better target future investments and government services (e.g., emergency management and response) to benefit frontline communities.⁴

QUESTION FROM HON. HENRY C. “HANK” JOHNSON, JR. FOR VICKI ARROYO

Question 2: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration’s unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. Governors from both parties are enacting ambitious proposals to invest in transportation infrastructure, reduce greenhouse gas emissions, and make transportation systems more resilient to the impacts of climate change. For example, Massachusetts Governor Baker established the Commission on the Future of Transportation in the Commonwealth to advise his administration on the needs and challenges of the transportation system of the future.⁵ In California, governors from both parties have enacted a cap-and-trade system that includes transportation fuels, and have used the proceeds generated from the program to invest in multi-modal low-carbon transportation solutions.⁶ A federal infrastructure bill would be strengthened and made more effective by building from the successful investments and planning processes underway in states across the country.

QUESTIONS FROM HON. MARK DESAULNIER FOR VICKI ARROYO

Question 3: A Your testimony raised the issue of the importance of land use in reducing greenhouse emissions. One problem we face in California is a shortage of housing located at a reasonable distance from job opportunities, with the consequence of more development sprawling out from urban centers and long, “super commutes.”

How do you think federal policy changes can achieve better coordination of land use and housing production with infrastructure investments?

ANSWER. One important strategy for transportation and housing policy is transit-oriented development. One policy idea to incentivize transit-oriented development would be a federal program to provide low-cost financing for housing investment

³ University of Pittsburgh News Services, “Natural Disasters, FEMA Aid Widen Racial Wealth Gap,” Aug. 27, 2018, <http://www.news.pitt.edu/news/natural-disasters-fema-aid-widen-racial-wealth-gap>.

⁴ For example, in *Disaster Law and Inequality*, Farber notes that FEMA should include demographic information alongside flood hazard maps and consider such information in environmental reviews of major federal projects that impact disaster preparedness (e.g., levees), and demographic statistics should be collected and immediately published following disaster events. Daniel A. Farber, *Disaster Law and Inequality*, 13, available at https://ccrm.berkeley.edu/pdfs_papers/Disaster_Law_and_Inequality_Farber.pdf.

⁵ Commonwealth of Massachusetts, Commission on the Future of Transportation, <https://www.mass.gov/orgs/commission-on-the-future-of-transportation>

⁶ State of California, California Climate Investments, <http://www.caclimateinvestments.ca.gov/>

near transit and rail hubs. This program could be structured similarly to the Federal Highway Administration's Transportation Infrastructure Finance and Innovation Act (TIFIA).⁷

States have explored incentive programs for smart growth and in-fill development, as an effective strategy for creating more affordable housing and reducing greenhouse gas emissions. In Massachusetts, the Smart Growth Zoning Overlay District Act has offered cities and towns a financial incentive to build residential dwellings in designed "smart growth" districts.⁸ A federal program that made community development funding available for smart growth, infill, and transit-oriented development could serve as an effective policy mechanism.

Question 4: What role do you think metropolitan planning organizations can play in helping to reduce emissions of greenhouse gases? What should the federal government ask MPOs to do differently in the way that they formulate transportation plans and prioritize investments in transportation improvements?

ANSWER. Metropolitan Planning Organizations (MPOs) have a critical role in reducing transportation GHG emissions through their roles coordinating active transportation, public transit, and traffic demand management strategies as part of the transportation planning process. The importance of MPOs to transportation and emission reduction planning is increasingly due to demographic trends: suburban counties are the fastest growing area type in the United States, with a 16 percent growth since 2000,⁹ and MPOs can play a critical ensuring that population and economic growth in urban and suburban counties is decoupled from increases in greenhouse gas emissions.

While most land use planning authority is held at the state and local level, the federal government could incentive MPOs and regional planners to consider GHG emissions and develop strategies to reduce emissions through the structure of transportation funding programs. For example, the federal government could require transportation GHG emissions evaluation as part of the longrange transportation plans and three-year statewide transportation improvement programs developed by MPOs.

Several states already require MPOs to set and meet mandatory or voluntary GHG emission reduction goals for transportation. For example, under California's Sustainable Communities and Climate Protection Act of 2008 (S.B. 375), the state sets a GHG target for each MPO and requires each MPO to develop a Sustainable Communities Strategies to meet its GHG target.¹⁰ These Sustainable Communities Strategies are incorporated into each MPO's federally required long-range transportation plan.¹¹ The California requirement does not penalize MPOs that do not achieve the target, but does provide incentives for those that do. Oregon has passed legislation that requires the MPO for Portland (and encourages other MPOs) to conduct scenario planning for meeting transportation-sector GHGs reductions targets set by the state.¹²

Question 5: Should the federal government require states to measure and report on their annual greenhouse gas emissions from mobile sources? What about measuring and reporting on aggregate vehicle miles traveled (VMT)?

ANSWER. In January 2017, the U.S. Federal Highway Administration (FHWA) issued a regulation requiring states to identify a GHG performance measure and report on progress.¹³ The GHG performance measure was repealed in May 2018.¹⁴

When U.S. FHWA issued the draft rule to establish the performance measure (and again during regulatory repeal of the performance measure), several state de-

⁷ Smart Growth America, Legislative Priorities, <https://smartgrowthamerica.org/our-vision/advocacy/legislative-priorities/>

⁸ See: 760 CMR 59, <http://www.mass.gov/hed/community/planning/chapter-40-r.html>

⁹ Pew Research Center, Demographic and economic trends in urban, suburban and rural communities (May 22, 2018), <https://www.pewsocialtrends.org/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and-rural-communities/>

¹⁰ California Air Resources Board, Sustainable Communities, <https://www.arb.ca.gov/cc/sb375/sb375.htm>

¹¹ Cal . Gov't Code § 14522.1

¹² Chapter 865 Oregon Laws 2009 (House Bill 2001); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059). See also Oregon Land Conservation and Development Commission, Metropolitan Greenhouse Gas Reduction Targets, Oregon Administrative Rule (OAR) 660-012, (May 19, 2011).

¹³ National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program, 82 Fed. Reg. 5979, 5993-6003 (Jan. 18, 2017).

¹⁴ National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program, 83 Fed. Reg. 24920, (May 31, 2018).

partments of transportation submitted comments in favor of the GHG performance measure. For example, Minnesota Department of Transportation Commissioner Zelle submitted a comment suggesting that the performance measure was “needed as an authority to track efforts to reduce transportation GHG emissions” and that the rule as originally promulgated would not be an administrative burden; estimating the “burden for analysis and reporting to be less than two hours per year.”¹⁵

For an institution such as Georgetown Climate Center, with a goal of supporting state and local government policymakers, accurate and timely data on vehicle miles traveled and GHG emissions from the transportation sector is important for conducting analysis.

Question 6: Even when transit service options exist, passengers may instead choose to drive or take a taxi, because they perceive that the transit service is unreliable, too slow, or simply too inconvenient.

Besides the obvious need for greater investment in transit and the need for land use planning and housing development coordinated with transit, is there anything the federal government can do to incentivize transit agencies to perform better, spend money more effectively, and do more to innovate to provide better service to passengers?

ANSWER. Electric transit buses offer an enormous opportunity for improved public transit that reduces air pollution and GHG emissions, while providing a better experience for passengers. Federal programs to increase technical support for transit agencies will lead to a more efficient and faster transition to electric fleets. Additionally, federal funding programs could significantly increase their impact by incentivizing private financing of transit buses (monetizing the operational cost savings of electric buses).

Technical Assistance to Support Fleet Transition:

The federal government could provide valuable support for transit fleet electrification by significantly expanding grant funding for both technical analyses and fleet transition planning for transit agencies. This planning assistance could be highly effective at ensuring cost-efficient investments in electric buses and charging infrastructure. Transit agencies with medium-term plans to electrify their entire fleet face significant logistical challenges for operations, routing, and charging buses. While limited-scale pilot deployments of electric transit buses provide valuable experience, many of the challenges of full fleet electrification will not be answered through a pilot deployment. For example, the charging infrastructure considerations for five electric buses will be very different than those for 100 electric buses (for example, depending on electric distribution infrastructure capacity and constraints, a transit agency may favor ‘depot’ charging for a limited pilot deployment, but will require on-route charging for a fully electrified fleet). Federal funding for fleet assessment and transition plans for transit agencies will help to ensure that pilot projects are effectively and efficiently deployed.

Leveraging Public Funds with Electric Transit Bus Financing

Electric transit buses are already nearly competitive with diesel buses on a total cost of ownership basis (when including fuel and maintenance costs), and will reach cost parity over the coming years.¹⁶ One important opportunity is to explore how clean energy financing strategies, such as “Pay As You Save” financing,¹⁷ could to increase the impact of federal funding and help meet the huge demand from transit bus fleets for federal support. Clean energy financing strategies could leverage limited public-sector funding by attracting low-cost private financing that monetizes the operational cost savings of electric transit buses. The U.S. Department of Transportation Federal Transit Administration’s “Low- or No-Emission” (“Low-No”) Grant program has been instrumental in providing the funding needed by transit agencies to add zero-emission buses to their fleets, but this funding is generally not paired with financing—in general, the grant funding pays for the entire upfront cost premium of electric transit buses. Congress could authorize a modified or expanded

¹⁵ Comment from Charles A. Zelle, Commissioner, Minnesota Department of Transportation; Re: Federal Highway Administration’s “National Performance Management Measures; Assessing the Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program,” proposed rule (Docket Number FHWA-2017-0025); <https://www.regulations.gov/document?D=FMHWA-2017-0025-0148>

¹⁶ Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO₂, C40 (Mar. 29, 2018), https://c40-productionimages.s3.amazonaws.com/other_uploads/images/1726_BNEF_C40_Electric_buses_in_cities_FINAL_APPROVED_%282%29.original.pdf?1523363881.

¹⁷ Tariffed On-Bill Finance to Accelerate Clean Transit, CLEAN ENERGY WORKS, <http://www.cleanenergyworks.org/home/clean-transit/>

Low-No grant program that incentivizes transit agency applications that include private financing and investment. As an alternative (to avoid penalizing transit agencies without a willing financing partner) this could be developed as a complementary program in addition to the existing Low-No grant program.

Question 7: Between electrification, automation, and so-called “smart cities” we are clearly in the midst of technological innovations in transportation. Some may go so far as to put complete faith in technology’s ability to solve many of our urban transportation challenges, believing that advances in technology will make certain forms of public transit obsolete. However, these technological advances will not necessarily, by themselves, address our needs for greater equity in mobility and accessibility, for connecting underserved communities with more opportunities, for walkable and bike-able urban spaces, for dynamic, diverse, and thriving neighborhoods. And our transit systems are clearly suffering from inadequate investment.

Given our current need for better public transit on one hand, and the many technological innovations that are appearing on the horizon on the other hand, how should the current, changing landscape of technology innovations inform our planning and decision-making around public transportation?

ANSWER. While automated vehicles have the potential to create significant benefits for public safety and mobility; the energy, emissions, equity, and land use implications are very uncertain, and may depend on the fuel type and public transportation infrastructure used by these vehicles, as well as public policy intervention.¹⁸ Leading transportation researchers and forecasts are showing that the deployment of automated vehicles could lead to a significant increase or decrease in emissions. A recent study conducted by several U.S. national labs concluded that the deployment of highly automated vehicles (in the absence of electrification) could lead to a 200 percent increase or 60 percent decrease in fuel use.¹⁹ Recent analysis has discussed the enormous opportunities from aligning the emerging technology trends of vehicle electrification and automation, along with shared use of vehicles. However, most analyses point to the need for strong public policies to ensure that automated vehicles result in a reduction in vehicle emissions and increase in mobility options, rather than an increase in congestion, vehicle miles traveled, fuel use, and emissions.²⁰

Additionally, the timeline for deployment of fully automated vehicles outside of small geo-fenced areas is highly uncertain. Ford Motor Co. chief executive officer Jim Hackett said at an April 2019 event: “We overestimated the arrival of autonomous vehicles,” and that the near-term applications will be limited.²¹ Policy makers should not wait for the arrival of full vehicle automation to address challenges such as air pollution, GHG emissions, and more inequitable mobility.

At the same time, policymakers can implement programs to improve transportation in the near term while preparing for the ultimate arrival of highly automated vehicles. For example, transitioning to zero-emission transit and for-hire vehicle fleets will establish the charging infrastructure and routing logistics that will enable zero-emission driverless transit (when the technology is mature). Cities across the country are developing strategies and working with businesses to deploy shared electric mobility.²² The federal government could provide additional support to better integrate traditional, fixed-line transit with new on-demand shared-use options. For example, transit agencies across the country are exploring partnerships with transportation networking companies to offer discounts for trips that begin or end at a transit station.²³ Another idea being piloted is transit agencies replacing low-

¹⁸Zia Wadud, Don MacKenzie, and Paul Leiby (2016) <https://www.sciencedirect.com/science/article/pii/S0965856415002694>

¹⁹T.S. Stephens, et. al., National Renewable Energy Laboratory, *Estimated Bounds and Important Factors for Fuel Use and Consumer Costs of Connected and Automated Vehicles* (2016), <https://www.nrel.gov/docs/fy17osti/67216.pdf>

²⁰See generally UC Davis Institute for Transportation Studies, Three Revolutions Policy Initiative, <https://3rev.ucdavis.edu/policybriefs/>

²¹Keith Naughton, Bloomberg News, “Ford CEO Tamps Down Expectations for First Autonomous Vehicles” (April 9, 2019), <https://www.bloomberg.com/news/articles/2019-04-09/ford-ceo-tamps-down-expectations-for-first-autonomous-vehicles>

²²Seattle Department of Transportation, EVSE Roadmap for Shared Mobility Hubs (December 2018), http://evsharedmobility.org/wpcontent/uploads/2018/12/SDOT_EVSE_Roadmap_for_Shared_Mobility_Hubs.pdf

²³See, e.g., City of Charlotte, North Carolina, “CATS Announces First Mile / Last Mile Partnership with Lyft” (April 9, 2018), <https://charlottenc.gov/newsroom/releases/Pages/PR-20180409.aspx>

occupancy transit routes with an on-demand ride-hailing option,²⁴ which can create the opportunity to reinvest cost savings into providing better service along core transit routes. If done effectively and in consultation with affected communities, programs such as these can help to modernize transit services and prepare for upcoming technology deployments. On the other hand, policymakers should be mindful of recent studies finding that transportation networking companies such as Lyft and Uber are increasing vehicle miles traveled and congestion and decreasing transit use.²⁵ Policies to encourage shared trips (such as a per-trip fee, rather than per-bookings fee), connections with transit, and electrification of these vehicles will be critical for this new mobility option to be in the public interest.²⁶

QUESTIONS FROM HON. MARK MEADOWS FOR VICKI ARROYO

Question 8: In your testimony, you talk about how the United States has experienced extreme weather-related events that have cost over \$1 billion (adds up to \$1.6 trillion since 1980). In fiscal year 2018 alone, Congress provided over \$100 billion in assistance for federal disasters, in large part due to hurricanes Harvey, Irma, and Maria—causing damage to infrastructure, communities, and cities. Understanding your testimony focuses on transportation resiliency, clearly there is more that the federal government can do on projects to mitigate and help communities recover from disasters.

Do you think the federal government can be doing more to track how federal money is being spent on disasters, including the nature of specific awards and loans?

ANSWER. Better tracking of federal disaster recovery dollars across the many agencies involved in recovery efforts could significantly improve the efficiency of research efforts relating to disaster recovery, and lead to improved program effectiveness. Organizations that have conducted research in the past on federal disaster recovery programs have overwhelmingly noted the complexity and administrative challenges of these programs, and lack of transparency in assessing how funds are spent and how effective those investments are after the fact. For example, our Center hosted workshops with federal agencies, states, and other stakeholders several years back to discuss opportunities for improving federal programs to better support state and local resilience, including one workshop focused primarily on disaster relief programs. Based on input at those events, we found across the board that beneficiaries of federal program funding could benefit from improved interagency collaboration and alignment of program funding streams, paperwork, and regulatory requirements. Along these lines, stakeholders reported a need for recipients' reporting requirements to be aligned across federal disaster relief programs as well.²⁷ Similarly, by aligning federal agencies' reporting requirements relating to their disaster-related expenditures, overall transparency regarding disaster costs could be improved; this was suggested in a recent CRS report on 2017 disaster supplemental appropriations.²⁸ Improved tracking of federal spending related to disaster events could also help to identify where post-disaster investments are contributing to improved resilience and future hazard mitigation, which ultimately will help translate to cost savings through avoided losses in the future when the next disaster strikes, thereby saving taxpayer dollars.

Question 9: Should the Federal government have a more centralized way to report how Federal money is being spent so that researchers like you can better understand what efforts the federal government is doing to focus and help mitigate disasters?

ANSWER. A centralized reporting system for tracking federal spending relating to disasters would be a vast improvement in terms of government transparency and accountability. With a trend towards increasing extreme weather events and related costs, it is important for the Federal government and researchers to understand where and how recovery dollars are being utilized. This may help identify opportuni-

²⁴ For example, the City of Arlington, Texas, contracts with Via to provide on-demand rides. "Transportation—City of Arlington, TX," www.arlington-tx.gov/residents/transportation

²⁵ See e.g., Schaller Consulting, *The New Automobility: Lyft, Uber and the Future of American Cities* (July 25, 2018), <http://www.schallerconsult.com/rideservices/automobility.pdf>

²⁶ Daniel Sperling, *Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future*, Island Press 2018.

²⁷ See Georgetown Climate Center, *PREPARING OUR COMMUNITIES FOR CLIMATE IMPACTS: RECOMMENDATIONS FOR FEDERAL ACTION*, Chapter 2 (2014), available at <https://www.georgetownclimate.org/files/report/GCC%20-%20Recommendations%20for%20Federal%20Action%20-%20September%202014.pdf>.

²⁸ See Congressional Research Service, *2017 Disaster Supplemental Appropriations: Overview*, 22-23 (March 20, 2018), available at <https://fas.org/sgp/crs/homesec/R45084.pdf>.

ties for cost-effective pre-disaster mitigation, and ensure that post-disaster recovery funds in the future are spent wisely on investments that will withstand extreme storms and other environmental conditions of the future.

Question 10: As a follow-up, my home state of North Carolina has been recovering from Hurricane Matthew for more than two years. Extreme weather conditions like hurricanes and flooding put immense strain on, not only federal resources, but also on state and local resources in responding to these events. We have identified that there are more than 17 federal agencies involved in federal assistance, not to mention countless state, local, tribal, and various non-profit organizations as well. In your research of states and cities and how they respond to natural disasters, surely you must have seen many instances of bureaucratic slow-downs and inefficiencies that should be addressed.

Do you think it would be beneficial to have a lead federal agency in charge of coordinating state, local, and federal response efforts, as well as undertaking efforts to provide assessments related to damage caused by disasters to better streamline the federal response?

ANSWER. If done effectively, having a lead federal agency to coordinate disaster response across federal agencies and with state and local emergency management agencies could prove useful to improve the efficiency and effectiveness of disaster response and recovery. Similarly, it would benefit federal agencies, researchers, and the American public if federal agencies improved in their tracking of disaster spending and efforts, and having a single agency to coordinate the gathering and reporting of these efforts could help to improve government efficiency and accountability.

QUESTION FROM HON. DAVID ROUZER FOR VICKI ARROYO

Question 11: Any discussion of energy infrastructure must include nuclear and natural gas. Nuclear provides 20 percent of our Nation's electricity, creates good paying jobs, and is reliable around the clock, all without producing emissions. My community is lucky to have the Brunswick Nuclear Plant and is also poised to benefit from natural gas pipeline infrastructure, specifically the Atlantic Coast Pipeline (ACP). Energy customers in eastern North Carolina—including homeowners, small businesses, and manufacturers—are depending on the ACP to provide affordable and reliable natural gas.

Shouldn't we keep assets like the Brunswick running while developing new critical infrastructure like the ACP?

ANSWER. States across the country are taking different approaches to existing nuclear power generation assets as part of the transition to lower carbon electricity generation. For example, New York developed a clean energy standard (CES) that includes a renewable energy standard (RES) and the zero-emissions credit (ZEC) requirement.²⁹ The CES was established to “provide[] support for safely-operating up-state nuclear plants” while ensuring that 50 percent of New York State's electricity will be generated by renewables by 2030 (this goal was later increased to 70 percent renewable sources, such as solar and wind, by 2030).³⁰ The New York Clean Energy Standard complements other regulatory programs, such as the Regional Greenhouse Gas Initiative. The New York Public Service Commission order approving the CES cited the example of Germany, where an “abrupt closure of all its nuclear plants resulted in a large increase in the use of coal, causing total carbon emissions to rise despite an aggressive increase in solar generation.”³¹

QUESTIONS FROM HON. SCOTT PERRY FOR VICKI ARROYO

Question 12: Please list all the modes of transportation you used en-route to this hearing (If a vehicle was used for travel, please clarify if it had an internal combustion engine).

ANSWER. I drove from my home in Arlington to the Georgetown Climate Center in the morning in my electric car, a Chevrolet Bolt. For the trip from Georgetown Law to the Capitol Visitor Center, my staff and I traveled in a taxi cab licensed by the District of Columbia Department of For-Hire Vehicles. It had an internal combustion engine, but may have been a hybrid.

²⁹ Order Adopting a Clean Energy Standard, N.Y. Pub. Serv. Comm., Case 15-E-0302 (Aug. 1, 2016).

³⁰ New York State Energy Research and Development Agency, “Renewing the Energy Vision, Clean Energy Standard,” <https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard>

³¹ Order Adopting a Clean Energy Standard, N.Y. Pub. Serv. Comm., Case 15-E-0302 (Aug. 1, 2016).

Questions 13 and 14: During the hearing, I asked about spatial gaps in the global surface temperature station coverage and the impact these unaccounted-for swaths of the globe on the temperature record's validity. Based on your response, it seems like there was some confusion about the study I cited and the temperature record it referred to so I'd like to take this opportunity to clarify a few things and explore this issue further.

First, the global average surface temperature data refers to the input data for the three main global temperature histories—the NOAA Merged Land-Ocean Surface Temperature (MLOST) record, the NASA-GISS (GISTEMP) record, and the Hadley-CRU (HADCRU) record—not the satellite record. The satellite datasets did not begin until 1979 so even if this was the dataset in question, it would do nothing to alleviate the gaps in station coverage in the Southern Hemisphere and the oceans referenced in Hansen et al. (1981). It is incredibly important to understand that the gap in coverage referenced by Hansen et al. (1981) is not for any one of the three temperature records, rather this surface area is not recorded in the data archives used as the land temperature and sea surface temperature (SST) inputs used for all three records. Though they are produced by different entities, these three records are comprised of nearly identical surface temperature input data—the Global Historical Climatology Network (GHCN) for land surface temperature (LST) inputs and the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) for SST inputs—with very little exception; the best available estimate is that 90-95 percent of the raw data is the same in all three records.^{32 33} Given the significant overlap of raw data underlying the three temperature records, it is incredibly important that the data be accurate and its coverage be widespread. As I stated in my line of questioning, Hansen et al. (1981), relaying concerns about the existence of Southern Hemisphere and oceanic data,³⁴ seriously calls into question the extent of the raw data coverage and the validity of the three temperature records relying upon the raw data in the GHCN and ICOADS that now claim to have credible station temperature records going back to 1880.³⁵

It should be noted that Dr. James Hansen is not a scientist who “might quibble with” the theory of global warming; in fact, he was one of the earliest and remains one of the most prominent proponents of the theory of catastrophic anthropomorphic global warming. Dr. Hansen became the Director of NASA Goddard Institute for Space Studies in 1981 and oversaw the creation and development of the GISTEMP temperature analysis; which filled in the gaps by extrapolating the existing southern hemisphere data to fill the entire hemisphere.³⁶ Interestingly, GISTEMP was refined in 1987; providing the scientific basis of his 1988 testimony before the Senate Committee on Energy and Natural Resources where he claimed “it was 99 percent certain that the warming trend was not a natural variation but was caused by a buildup of carbon dioxide and other artificial gases in the atmosphere.”³⁷ This timeline is suspect and his predictions were significantly warmer than what has been observed.

Years later, other leaders in the climate science community privately acknowledged the lack of temperature data and its impact on the warming trend in the data. Dr. Raymond Bradley, Research Director at the Climate System Research Center at UMass-Amherst, responded to an email from Dr. Thomas Crowley, at the University of Edinburgh, stating: “One cautionary note—talking to Phil Jones last week, he mentioned that the recent addition of SH buoy data has added data from areas of the globe hitherto undersampled; it may have ‘suppressed’ the ocean area warming relative to land.”³⁸ In response to this exchange, Dr. Phil Jones, then-Director of the Climatic Research Unit at the University of East Anglia, responded, “in addition to the issue of many more drifters providing measurements over the

³² McKittrick, Ross, A Critical Review of Global Surface Temperature Data Products (August 5, 2010): 4. <https://ssrn.com/abstract=1653928>

³³ Pielke, R. A., Sr. et al., Unresolved issues with the assessment of multidecadal global land surface temperature trends, J. Geophys. Res., 112, (December 29, 2007), D24S08, doi:10.1029/2006JD008229.

³⁴ “Problems in obtaining a global temperature history are due to the uneven station distribution with the Southern Hemisphere and ocean areas poorly represented, and the small number of stations for earlier times.” James Hansen et al., “Climate Impact of Increasing Atmospheric Carbon Dioxide”, Science, Vol. 213, no. 4511 (August 28, 1981): 961. See: http://www.sealevel.info/1981_Hansen_etal_1.pdf.

³⁵ “Source of the temperature data: GHCN-v3 1880-01/2019”, NASA-GISS, S. HEMISPHER. Station Temperature Index in 0.01 degrees Celsius, https://data.giss.nasa.gov/gistemp/taledata_v3/SH.Ts.txt

³⁶ NASA-GISS, “History of GISTEMP”, <https://data.giss.nasa.gov/gistemp/history/>

³⁷ Shabecoff, “Global Warming Has Begun”, NYT (1988).

³⁸ Email from Dr. Raymond Bradley to Drs. Thomas Crowley and Michael Mann. April 13, 2009. <http://di2.nu/foia/foia2011/mail/2729.txt>

last 5-10 years, the measurements are coming in from places where we didn't have much ship data in the past. *For much of the SH between 40 and 60S the normal are mostly made up as there is very little ship data there.* Whatever causes the divergence in your plot is down to the ocean.”³⁹

This is an especially damning admission because it shows that the addition of actual observational data curbed the warming trend in the extrapolated data. Worse, the directors of two of the three main organizations overseeing global temperature histories have admitted that the raw data underlying their histories are incomplete.

Questions 13 and 14 Given this background information, do you believe the data is credible and there is a sufficient enough amount of it to claim that it is a reasonable depiction of the global average surface temperature since the 1880s? If so, please explain how these significant problems with the data were overcome in a manner that allows you to claim this.

ANSWER. It is important to point out that the Hansen paper you cite was from 1981, the year I graduated from high school. This was long before the dramatic increase in computing power that has revolutionized climate science and allowed us to carry phones with as much power as the original supercomputers in our pockets. Since then, scientists have collected 38 years of additional data, both from sensors all over the world and from satellites. They have also made tremendous strides in analyzing the data. All of this scientific work tells the same story: that the planet has warmed at a rapid pace since pre-industrial days.

For example, the Berkeley Earth Surface Temperature (BEST) project aimed to address many of the questions and concerns raised by the congressman. The project used 39,390 unique stations in their analysis, “more than five times the 7,280 stations found in the Global Historical Climatology Network Monthly data set (GHCN-M).” <http://static.berkeleyearth.org/pdf/berkeley-earth-summary.pdf>

Using this vastly larger data set led them to the same conclusions as earlier studies. In fact: “Berkeley Earth also has carefully studied issues raised by skeptics, such as possible biases from urban heating, data selection, poor station quality, and data adjustment. We have demonstrated that these do not unduly bias the results.” <http://berkeleyearth.org/summary-of-findings/>

In addition, four leading scientific institutions, UK's Met Office Hadley Centre, NASA's Goddard Institute for Space Studies, NOAA's National Climatic Data Center, and the Japanese Meteorological Agency have all analyzed the temperature data using different approaches.⁴⁰ Their results are remarkably similar, increasing the level of confidence in the results. There is no question that the planet has warmed significantly (and rapidly) due to human activities.

Finally, even though the planetary warming as seen in actual temperature measurements is both complete and scientifically persuasive, it is also important to add that the detailed record of past climate does not rely on temperature measurements alone. Important data also come from tree rings, coral reefs, sediments, pollen—and especially ice cores. In fact, data from those sources have enabled scientists to put together a remarkably detailed picture of the planet's temperature over thousands and even millions of years. That record shows that the recent planetary warming from human activities is unprecedented in the planet's history, in both the size and speed of the warming.⁴¹

Question 15: In response to my questions regarding the extent of the global temperature observational station coverage, you stated the following: “The impacts have only become more severe and more obvious based on what we are seeing in terms of these extreme events. We know that we are at CO2 levels that have never been experienced since millions of years ago and that's going to lead to dramatic impacts like sea level rise and more intense and frequent storms, etc., etc.” Given the pervasiveness of these claims in the public discourse about climate change and the Committee's jurisdiction over the federal management of emergencies, natural disasters, and flood control, I'd like to explore the link between human greenhouse gas emissions and these extreme weather events.

All the rhetoric around rapid climate change related sea level rise in the 20th century are not in line with the validated tidal gauge data. For example, the Fourth National Climate Assessment (NCA4) claimed “global average sea level has risen by

³⁹ Email from Dr. Phil Jones to Dr. Thomas Crowley April 14, 2009. <http://di2.nu/foia/foia2011/mail/2729.txt> (emphasis added).

⁴⁰ NASA Climate 365 project—a collaboration of the NASA Earth Science News Team, NASA Goddard and Jet Propulsion Laboratory communications teams, and NASA websites Earth Observatory and Global Climate Change. https://climate.nasa.gov/climate_resources/9/graphic-earths-temperature-record/

⁴¹ NASA Goddard Space Flight Center. <https://earthobservatory.nasa.gov/features/GlobalWarming/page3.php>

about 7-8 inches since 1900, with almost half (about 3 inches) of that rise occurring since 1993. Human-caused climate change has made a substantial contribution to this rise since 1900, contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years.”⁴² Dr. Nils-Axel Mörner reviewed the rates of sea level change projected by the Intergovernmental Panel on Climate Change (IPCC) and others with the actual tidal gauge and satellite data. He found, “At most, global average sea level is rising at a rate equivalent to 2-3 inches per century. It is probably not rising at all.”⁴³ Claims that tidal gauges show a significant trend in sea level rise fail to account for non-climate change related factors causing localized rise; this leaves them “bound to exaggerate sea-level rise.”⁴⁴ Removing the gauges that are sited in uplifted and subsiding locations, separates the actual sea level rise from the noise created due to shifts in the gauges physical location. “This leaves 68 [NOAA] sites of reasonable stability. These sites give a present rate of sea level rise of ~ 1.0 (± 1.0) mm/year [$.039$ ($\pm .039$) in/year].”^{45 46} The raw data from “two distinct satellite systems [the TOPEX/POSEIDON sea-level satellites and the GRACE gravitational-anomaly satellites], using very different measurement methods, produced raw data reaching identical conclusions: sea level is barely rising, if at all.”⁴⁷ This shows the NCA4 significantly over-estimated the sea-level rise of the past century.

Given this track record of failure, do you still believe they are correct in claiming: “Global average sea levels are expected to continue to rise—by at least several inches in the next 15 years and by 1-4 feet by 2100. A rise of as much as 8 feet by 2100 cannot be ruled out?”⁴⁸

ANSWER. The “researcher” whom you cite on sea level rise, Dr. Nils-Axel Mörner is a well-known climate “denier”⁴⁹ funded by such climate-denying donors as the Koch brothers and the Mercer Family Foundation.⁵⁰ His interpretation of the sea level rise data has been thoroughly debunked by the scientific community. To quote from one of the rebuttals, “Nils-Axel Mörner’s claims regarding sea level rise are the very definition of denial, involving nothing more than conspiracy theories and unsubstantiated accusations of data falsification which are easily proven untrue. The mainstream media needs to realize that Mörner is simply not a credible source of information about sea level rise or climate science in general.”⁵¹

Dr. Mörner’s assertions have also been considered in the NCA4’s assessment of the data, which has concluded, as your question states, that sea levels “are expected to continue to rise. ... [and] a rise of as much as 8 feet by 2100 cannot be ruled out.” Given the NCA4’s thorough analysis of the data (and the careful debunking of Dr. Mörner’s false claims), there is, in fact, no “track record of failure” (as your question claims) and no reason to doubt the NCA4’s conclusion. If you have further concerns with the NCA4’s conclusions, it would be more appropriate to raise those concerns with the federal agency scientists who conducted the Assessment directly.

It is also important to note that many of the past predictions about the rate of climate change (including sea level rise) have been wrong—because they underestimated the rate of change. As scientists have gathered more empirical data, they have consistently learned that planetary warming is occurring at a faster rate than previously expected.⁵² In two of the many recent examples, research has shown that oceans are warming 40% faster than expected⁵³, and that glaciers are melting fast-

⁴² Wuebbles, D.J., et al., 2017, Executive summary: 10.

⁴³ Nils-Axel Mörner, Sea level is not rising, Centre for Democracy and Independence, Reprinted by Science and Public Policy Institute, December 6, 2012: 4. http://scienceandpublicpolicy.org/wp-content/uploads/2012/12/sea_level_not_rising.pdf

⁴⁴ Ibid.

⁴⁵ Ibid. 11.

⁴⁶ This sample size of 68 sites is still significantly larger than those used by IPCC authors in their “representative” records. Mörner notes that the studies used rely upon 6, 9 and 25 gauges respectively; their rates of rise of higher than the mean of all 159 NOAA sites by a range of 0.8-1.3. Mörner, 10-11.

⁴⁷ Ibid. 4.

⁴⁸ Wuebbles, D.J., et al., 2017, Executive summary: 10.

⁴⁹ <https://www.desmogblog.com/2018/01/18/climate-denial-co2-coalition-trump-morner-funding-sea-level-research-dodgy-journals>

⁵⁰ <https://www.desmogblog.com/co2-coalition>

⁵¹ <https://www.skepticalscience.com/Nils-Axel-Morner-wrong-about-sea-level-rise.html>

⁵² Global warming will happen faster than we think, Nature 564, 30-32 (2018)doi: 10.1038/d41586-018-07586-5

⁵³ How fast are the oceans warming? Science, 11 Jan 2019: Vol. 363, Issue 6423, pp. 128-129, DOI: 10.1126/science.aav7619

er than expected.⁵⁴ Both phenomena are contributing to a faster-than-predicted rate of sea level rise.

Our Center serves states and cities on a bipartisan basis that are already struggling with the impacts of climate change, including increased “sunny day” flooding (not associated with storms) and with saltwater intrusion. To the residents of these communities, this is not an academic question or debate.

Question 16: NCA4 claimed, “A projected increase in the intensity of hurricanes in the North Atlantic (medium confidence) could increase the probability of extreme flooding along most of the U.S. Atlantic and Gulf Coast states beyond what would be projected based solely on relative sea level rise.”⁵⁵ It is important to note that NOAA’s overview of the current research on the topic concluded, “Therefore, we conclude that it is premature to conclude with high confidence that human activity—and particularly greenhouse warming—has already caused a detectable change in Atlantic hurricane activity.”⁵⁶ Additionally, the claim that climate change will contribute to more intense storms is not brought out by the recent past. Despite claims of rapid warming during the past century, the recent past is marked by an overall lack of intense storms. As noted in the Wall Street Journal, there was a 12-year drought in major land-falling US hurricanes prior to Hurricane Harvey in August 2017 and despite the intensity of the 2017 hurricane season it was not the most active, “Last year’s Atlantic hurricane season was particularly hyperactive, ranking as the seventh most intense Atlantic season since records began in 1851.”⁵⁷ They further note, that “cyclones (as hurricanes are known elsewhere) are found in all three tropical oceans, and globally the Accumulated Cyclone Energy index—which measures the combined intensity and duration of these storms—is currently running 20% below its long-term average.”⁵⁸

Given the above information, can you please elaborate on what you meant when you claimed, “the impacts have only become more severe and more obvious based on what we are seeing in terms of these extreme events” and explain the causal link to human-caused greenhouse gas concentrations?

ANSWER. As mentioned above, our Center supports communities and states on the front lines of climate impacts experiencing changes that are not consistent with past norms since recordkeeping began. This question suggests that you may not yet be familiar with a relatively new field of climate science that is known as “climate attribution” science. The idea is to ask the question of whether extreme events like severe rain storms or heat waves have become more intense or common because of climate change caused by human activities. Thanks to recent advances in climate science, the question can now be addressed with a significant amount of certainty and accuracy.^{59 60 61} More than 170 studies have shown that, in case after case, from the European heat wave of 2003⁶² to Hurricane Harvey,⁶³ actual events were more extreme or more likely, or both, because of human-caused climate change. The link between events that are more extreme and/or more frequent can also be predicted from basic physics. Because of planetary warming, the atmosphere contains more energy and more moisture. And because of more complicated atmospheric physics,

⁵⁴ Zemp, M., Huss, M., Thibert, E., Eckert, N., McNabb, R., Huber, J., Barandun, M., Machguth, H., Nussbaumer, S.U., Gärtner-Roer, I., Thomson, L., Paul, F., Maussion, F., Kutuzov, S., and Cogley, J.G. Global glacier mass changes and their contributions to sea-level rise from 1961 to 2016. *Nature*, 2019 DOI: 10.1038/s41586-019-1071-0

⁵⁵ Wuebbles, D.J., et al., 2017, Executive Summary: 27.

⁵⁶ Geophysical Fluid Dynamics Laboratory, NOAA, Global Warming and Hurricanes: An Overview of Current Research Results, (Last Revised: February 8, 2019). <https://www.gfdl.noaa.gov/global-warming-and-hurricanes/>

⁵⁷ Peiser, B. and Ridley M., “Bad Weather is No Reason for Climate Alarm”, Wall Street Journal, January 12, 2018. <https://www.wsj.com/articles/bad-weather-is-no-reason-for-climate-alarm-1515779859>

⁵⁸ Peiser and Ridley, “Bad Weather”

⁵⁹ “Droughts, heatwaves and floods: How to tell when climate change is to blame,” *Nature* 560, 20-22 (2018)

⁶⁰ “Scientists Can Now Blame Individual Natural Disasters on Climate Change,” *Scientific American*, January 2, 2018. <https://www.scientificamerican.com/article/scientists-can-now-blame-individual-natural-disasters-on-climate-change/>

⁶¹ *Attribution of Extreme Weather Events in the Context of Climate Change*, National Academies of Science, 2016. <https://www.nap.edu/read/21852/chapter/1>

⁶² Daniel Mitchell et al 2016 Environ. Res. Lett. 11 074006, <https://doi.org/10.1088/1748-9326/11/7/074006>

⁶³ Trenberth, K. E., Cheng, L., Jacobs, P., Zhang, Y., & Fasullo, J. (2018). Hurricane Harvey links to ocean heat content and climate change adaptation. *Earth’s Future*, 6. <https://doi.org/10.1029/2018EF000825>

that moisture is more likely to be released in more extreme rainfall events.⁶⁴ This has been projected by models for some time but now it is coming to pass.

Question 17: The NCA4 Climate Science Special Report claimed: “Global annually averaged surface air temperature has increased by about 1.8 °F (1.0 °C) over the last 115 years (1901-2016). This period is now the warmest in the history of modern civilization...it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence.”⁶⁵ These claims are contradicted by EPA’s *US Annual Heat Wave Index*,⁶⁶ which clearly shows the 1930s to be the hottest decade on record and Dr. John Christy’s testimony before the House Science, Space, and Technology Committee, “In terms of heat waves, the number of 100 °F days observed in the U.S. from a controlled set of weather stations. It is not only clear that hot days have not increased, but it is interesting that in the most recent years there has been a relative dearth of them.”⁶⁷ The US data record is by far the most complete in the world so using it alleviates the station distribution concerns that exist in the global record. By using a controlled set, Dr. Christy eliminates the potential contamination effects by citing stations in compliance with NOAA standards. Once the data quality concerns are significantly addressed, it becomes clear that temperature doesn’t necessarily rise as greenhouse gas concentrations increase.

Given this information, can you explain why the NCA4 claim provides a reasonable representation of the temperature throughout the 20th century?

ANSWER. The 1930s were indeed a relatively hot period in U.S. history. But that information needs to be put in the proper context—which, if done, actually supports the overwhelming evidence for human-caused planetary warming.

First, the complete temperature record shows that 1934, while warm, was not as hot as temperatures in the U.S. in at least seven other years (all recent)—1998, 2006, 2012, 2015, 2016 (and possibly 2017 & 2018).

Second, and more important, it’s crucial to remember that the U.S. represents only 2% of the total surface area of the planet. When the whole planet is considered, 1934 was not especially hot. In fact, globally, 1934 temperatures were actually cooler than average for the 20th century.⁶⁸

Third, there is some intriguing evidence that suggests that the 1934 heat wave in the U.S. is actually an early example of human-caused climate change. To quote from the paper, “We identify the first record-breaking warm summers and years for which a discernible contribution can be attributed to human influence. We find a significant human contribution to the probability of record-breaking global temperature events as early as the 1930s.”⁶⁹ Since the Industrial Revolution was already well underway, perhaps this finding should not be surprising after all.

QUESTIONS FROM HON. RICK LARSEN FOR THOMAS P. LYON

Question 1: Is there a conflict between calling for continuing tax cuts for EV and for EV technology, versus relying on the market to place where those EV charging stations are, much like we rely on the market to place gas stations? Should the market lead or should Federal tax credit policy lead?

ANSWER. Thank you for this question, which raises some complex issues. As Jaffe et al. (2005) explain, markets—while extremely useful for allocation of most goods and services—may fail us in a variety of ways when it comes to the environment. First, pollution harms innocent third parties and damages the environment, but market prices will not force the polluter to pay for these damages; as a result there tends to be too much pollution and too much damage to human health and to the natural environment. Second, research and development (R&D) generates an accu-

⁶⁴ “Why extreme rains are gaining strength as the climate warms.” *Nature* 563, 458-460 (2018) <https://www.nature.com/articles/d41586-018-07447-1>

⁶⁵ Wuebbles, D.J., et al., 2017: Executive summary. In: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 10, doi: 10.7930/J0DJ5CTG.

⁶⁶ EPA. *US Annual Heat Wave Index*. Updated August, 2016. <https://www.epa.gov/climate-indicators/climate-change-indicators-high-and-low-temperatures>

⁶⁷ Christy, J.R., *Testimony* before the House Science, Space, and Technology Committee, February 2, 2016.

⁶⁸ <https://skepticalscience.com/1934-hottest-year-on-record.htm>

⁶⁹ King, A. D., M. T. Black, S.-K. Min, E. M. Fischer, D. M. Mitchell, L. J. Harrington and S. E. Perkins-Kirkpatrick (2016), Emergence of heat extremes attributable to anthropogenic influences, *Geophys. Res. Lett.*, 43, 3438-3443, doi:10.1002/2015GL067448

mulation of knowledge whose benefits cannot be fully appropriated by the researcher; as a result there tends to be too little R&D. Third, early adopters of a new technology produce benefits for later adopters by testing the product and building a network of users, benefits that are not appropriated by the early adopter; as a result adoption of beneficial new technologies tends to be too slow.

Subsidies for the adoption of new technologies such as electric vehicles (EVs) and EV chargers redress the first and the third of these market failures. With regard to the first failure, subsidies directly induce buyers to switch from internal combustion engines (ICEs) to EVs, which are cleaner in most parts of the U.S. This aspect of the subsidy will remain justifiable as long as the U.S. fails to impose a price on carbon. With regard to the third failure, subsidies accelerate the adoption of the new technology, helping it come down the learning curve faster and thereby lower its production costs and improve its quality. As adoption diffuses throughout society, and the new technology reaches maturity, the need for this aspect of the subsidy will gradually disappear.

It is appropriate to raise the question of how close EV technology is to maturity. There are over a million EVs on the road in the U.S.,¹ out of 276.1 million registered vehicles, roughly 0.3% of the total. This suggests that EV technology has some way to go to reach maturity. Nevertheless, most manufacturers see them becoming a much bigger part of the market over the next decade, suggesting that maturity is within sight.

The placement of charging stations raises a separate issue. There is a chicken-and-egg aspect to the rollout of EVs and fast charging stations. Manufacturers are reluctant to install charging stations until the market for EVs gets large enough to make them profitable. But consumers are reluctant to buy EVs until the network of charging stations is extensive enough to allay range anxiety. To make matters worse, there is currently a range of charging standards used in the market place, which means not all EVs can charge at all charging stations. This further weakens incentives to invest in charging stations, because the competing standards reduce the demand for any one of them. Thus, there is a case to be made for public policy to lead by (1) requiring compatibility between charging standards, and (2) funding the rollout of EV charging stations.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR THOMAS P. LYON

Question 2: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. Thank you for this question. Unfortunately, I am afraid I am not in a good position to answer it. It is of a political nature, and I would defer to members of the Committee on questions like this, as they will likely have more insight into the politics of the situation than I will.

QUESTION FROM HON. DAVID ROUZER FOR THOMAS P. LYON

Question 3: Any discussion of energy infrastructure must include nuclear and natural gas. Nuclear provides 20 percent of our Nation's electricity, creates good paying jobs, and is reliable around the clock, all without producing emissions. My community is lucky to have the Brunswick Nuclear Plant and is also poised to benefit from natural gas pipeline infrastructure, specifically the Atlantic Coast Pipeline (ACP). Energy customers in eastern North Carolina—including homeowners, small businesses, and manufacturers—are depending on the ACP to provide affordable and reliable natural gas.

Shouldn't we keep assets like the Brunswick running while developing new critical infrastructure like the ACP?

ANSWER. Thank you for this question, which raises two different sets of complex issues. Nuclear power in the U.S. has been at a virtual standstill since the incident at Three Mile Island in 1979. No new nuclear plants were begun after the incident until 2013, when construction on the V. C. Summer Generating Station Units 2 and 3 in South Carolina and the Vogtle Generating Station units 3 and 4 in Georgia commenced. The Summer units have subsequently been cancelled, after the company invested roughly \$9 billion in them. South Carolina customers have already

¹ <https://www.scientificamerican.com/article/the-u-s-has-1-million-electric-vehicles-but-does-it-matter/>

paid out \$2 billion to cover the costs of these units that will never produce a single megawatt-hour of energy.² On October 19, 2016, TVA's Unit-2 reactor at the Watts Bar Nuclear Generating Station became the first US reactor to enter commercial operation since 1996—after being under construction for 43 years. Unfortunately, the plant has already suffered an extended, unplanned shutdown for maintenance.³ These plants illustrate the challenging economics of building new nuclear plants in the U.S.

Despite the difficulty of building new nuclear plants, there is a strong case to be made for continuing to operate existing plants, since they produce carbon-free electricity. In fact, one could make a case for providing subsidies for the continued operation of nuclear plants due to their climate benefits.

Natural gas raises a different set of issues. Some argue that it can be used as a “bridge fuel” in the medium-term because it is cleaner than burning coal. Others argue that we should not be investing in long-lived equipment that will lock us into using natural gas for the next 50 years. It is true that when combusted to produce electricity, natural gas is much cleaner than coal—provided methane leakage is controlled. New evidence has emerged in recent years that there is substantial leakage from natural gas pipelines and associated equipment, and this can overwhelm the climate benefits of using natural gas to produce electricity if there is as much as 3% leakage of methane. The most recent estimates put the leakage rate at 2.3%, so the climate benefits of natural gas do appear to exist, but they are considerably smaller than once thought.⁴ Even as a “bridge fuel,” then, natural gas needs to be monitored much more carefully than it has been in the past and leaks must be eliminated.

There remains the question of whether it makes sense to commit to new infrastructure that would lock the U.S. into the use of fossil fuels for 50 years or more, corresponding to the expected lifespan of a new pipeline. Scientific research indicates a need to radically reduce greenhouse gas emissions over the next 20 years,⁵ so investing in new infrastructure that will increase natural gas production and its associated emissions for 50 years is hard to justify. Justification from a social perspective would require that natural gas will displace coal-fired electric generation, that any new pipelines will be monitored intensively for leaks, that there is a credible system for remediation of leaks, and that there is no realistic possibility of using renewable sources instead of natural gas.

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QUESTION FROM HON. HENRY C. “HANK” JOHNSON, JR. FOR BEN PROCHAZKA

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. Historically, there has been a critical need for federal, state, and local governments to cooperate on transportation infrastructure. In general, our hope is that any federal infrastructure bill would help to support the nationwide expansion of charging infrastructure and help to support all sectors of on-road electrified transportation.

While range anxiety is gradually decreasing as battery capacity improves, there is a clear need to expand electric vehicle (EV) charging infrastructure across the country in order to accelerate the transition to EVs and meet the future needs of our transportation system. There are opportunities to simultaneously enhance coordination around signage and wayfinding in order to increase the visibility of EV chargers and bolster consumer and business confidence in their availability.

As I highlighted at the hearing, we can address this challenge through a combination of incentives, sound policies, and pilot programs to spur the installation of more

² <https://www.governing.com/topics/transportation-infrastructure/gov-south-carolina-nuclear-reactors.html>

³ <https://www.latimes.com/business/hiltzik/la-fi-hiltzik-nuclear-shutdown-20170508-story.html>

⁴ <https://theconversation.com/the-us-natural-gas-industry-is-leaking-way-more-methane-than-previously-thought-heres-why-that-matters-98918>

⁵ <https://www.nytimes.com/2018/10/07/climate/ipcc-climate-report-2040.html>

EV chargers—and, more broadly, establish a network of charging corridors spanning the United States.

Some of this work has already begun at the Federal Highway Administration (FHWA) through the Alternative Fuel Corridors program, which was authorized under the FAST Act of 2015. Since enactment, FHWA has already conducted two rounds of designations for sections of the National Highway System that currently have, or are on track to have, sufficient EV charging infrastructure. However, much work remains to be done. Significant gaps remain throughout the National Highway System—and the FAST Act did not authorize funding through this program to support state and local efforts to expand the availability of charging infrastructure in their jurisdictions.

It is our hope that any infrastructure legislation advanced in this Congress will empower the federal government, states, and localities to accelerate the transition to electrified transportation. This is best accomplished through sound, forward-looking policies that promote productive collaboration across all levels of government.

QUESTION FROM HON. LLOYD SMUCKER FOR BEN PROCHAZKA

Question 2: How do electric vehicles do their part in providing for user fees to pay for our roads and highways?

ANSWER. For nearly a century, gasoline taxes have been a primary method for extracting user fees to fund transportation infrastructure. There is not yet a widely agreed-upon solution for charging EV drivers for their use of the road. However, as EVs begin to comprise a larger share of the national fleet, they will need to do their part in contributing to the federal Highway Trust Fund, as well as state and local transportation funds. In the process, and in order to not stifle American innovation, it will be important to make sure we are only asking EV drivers to pay no more than their fair share.

While drivers of battery electric vehicles do not pay gas taxes at the pump, there are other ways that they contribute to transportation funding at the state and local level today. Whenever drivers charge their EVs, there is a tax associated with the electricity usage that goes toward the general fund of their state and/or locality, which has a formula that is used to finance transportation infrastructure. Additionally many states are already working to address a fair and equitable cost solution for all who use our nation's roads.

One proposed solution is the establishment of a vehicle miles traveled (VMT) fee, which can align user fees with the number of miles driven rather than quantity of gas purchased. This would also insulate dedicated transportation funding from further volatility as EVs take a growing share of the U.S. fleet. VMT pilot programs are currently underway in states like Oregon and Washington, which are experimenting with a range of different technologies and reporting methods that would be needed to support the creation of a statewide VMT fee. The findings of these pilots will provide valuable insights for other states and Congress in evaluating how to adequately fund our infrastructure in the future.

Ultimately, providing the necessary funding to support our roads and highways is a challenge that extends far beyond EVs, which still account for a very small portion of road use and road impacts at this stage. Increases in fuel efficiency and the growing hybrid vehicle market have also contributed to reductions in the amount of fuel purchased. This represents an opportunity to reevaluate the concept of anchoring transportation funding to a single commodity, rather than a driver's actual use of the roadways. Moving forward, we must remain open to a range of solutions in order to establish a user fee system wherein everyone pays their fair share.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR NANCY N. YOUNG

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. As noted in A4A's March 26, 2019 Statement for the Record submitted to the House Transportation and Infrastructure Committee and the testimony A4A presented at the February 26, 2019 hearing on the intersection of infrastructure and climate change policy, A4A and our members strongly support necessary investments in aviation infrastructure and airports across the country. The facts clearly show that airport development is blossoming—and it is doing so within a multi-tool financing system that easily allows for investment without adding additional taxes on passengers. Further, the historic five-year FAA reauthorization bill that Con-

gress approved last year provided significant, consistent and stable funding for airports and broadly supported an array of aviation infrastructure programs. That said, there are significant opportunities in Congress' consideration of a broad-based infrastructure bill and other legislation to home in on making aviation investments more business-case-based and efficient. For example, A4A supports the Chairman's proposal to shield FAA programs and personnel from the effects of government shutdowns, which would prevent the delays to infrastructure advancement we saw with the most recent partial government shutdown. Further we urge additional congressional support for smart implementation of NextGen projects prioritizing existing equipment and renew our call for an end to the practice of revenue diversion, which inappropriately siphons away from aviation a significant portion of aviation infrastructure dollars.

A4A looks forward to continuing to constructively engage in these important infrastructure discussions and we welcome such engagement from an array of stakeholders across the country.

QUESTION FROM HON. GARRET GRAVES FOR NANCY N. YOUNG

Question 2: You noted that moving forward with NextGen and performance-based navigation procedures will further enhance airlines' carbon-efficiency and reduce overall greenhouse gas emissions from aviation. Yet many people are objecting to such "NextGen" procedures at their local airports because new flight procedures—even if they reduce aviation emissions—may shift aircraft noise exposures to new communities.

Based on this apparent conflict, how should the government and industry address both climate change and noise?

ANSWER. The U.S. airlines have been simultaneously limiting both greenhouse gas (GHG) emissions associated with climate change and aircraft noise exposures, with a strong record of success. As detailed below, A4A and our members are committed to further progress in both areas, which is best supported by complementary government policies.

As noted in our February 26, 2019 testimony, between 1978 and year-end 2017, the U.S. airlines improved their fuel efficiency by more than 125 percent, saving over 4.6 billion metric tons of carbon dioxide (CO₂), equivalent to taking 25 million cars off the road each of those years. And we carried 34 percent more passengers and cargo in 2017 than we did in 2000, while emitting no more CO₂. Over that same time period, we reduced the number of people exposed to significant aircraft noise by 94 percent, even as the number of people flying quadrupled. And even though enplanements rose 26 percent between 2000 and 2017, significant aircraft noise exposures were decreased by 48 percent.

The U.S. airlines and aviation industry achieved these records through technology, operational and infrastructure advances that have made aircraft and aircraft operation quieter and ever more fuel-efficient, and additional improvements are on the way. For example, with improved finances, U.S. airlines have invested billions of dollars to upgrade their fleets with newer, quieter aircraft that produce less noise and fewer emissions, purchasing more than 480 new aircraft in 2017, and more than 1,550 additional planes are expected in the coming years. Additionally, airlines, airframe and engine manufacturers, business aviation and the FAA continue to break new ground through the public-private research and development programs highlighted in A4A's February 26 testimony. Indeed, although we cited in our testimony the energy efficiency and emissions reduction projects under FAA's Continuous Lower Energy, Emissions and Noise (CLEEN) program, FAA's Center of Excellence for Alternative Jet Fuels and the Environment (ASCENT), and NASA's Aeronautics Research (ARMD) program, all of these initiatives include noise projects and projects that address potential interdependencies between aircraft noise and emissions.

Likewise, more efficient air traffic management, such as that enabled by well-implemented NextGen procedures, can simultaneously reduce both noise and emissions. For example, performance-based navigation can enable Optimized Profile Descents (OPDs), which reduce noise exposure on the ground by holding arriving aircraft at higher altitudes for longer and reduce noise and emissions by supporting reduced thrust as aircraft glide toward landing.

As noted in your question, even though more efficient and precise flight paths can result in fewer people being exposed to aircraft noise, these procedures can shift who is exposed or concentrate noise exposures, raising community concerns. This potential is addressed by the array of statutory and regulatory provisions for aircraft noise assessment and management and community outreach and engagement poli-

cies, which have been greatly enhanced in recent years to further address ATC procedure changes.

Current law requires significant environmental review and outreach, expressly including aircraft noise exposure assessment, when new or revised ATC procedures are considered. Specifically, the National Environmental Policy Act (NEPA) requires environmental assessment of and community outreach regarding procedure changes. Further, Section 4(f) of the U.S. Department of Transportation (DOT) Act and the National Historic Preservation Act (NHPA) require assessment of and notice to the public regarding potential impacts on environmentally sensitive resources, historic properties and communities and include provisions to avoid excessive noise or other impacts to them. Moreover, in response to congressional direction included in Public Law 114-328 and consistent with recommendations from the NextGen Advisory Committee (NAC), FAA has updated and significantly augmented its community outreach policies attendant to consideration of new and revised ATC procedures.

In addition to and separate from the environmental review, mitigation and community engagement provisions directly applying to FAA's consideration and approval of new and revised ATC procedures, FAA regulates aircraft noise and management of community noise exposures. In 2017, FAA codified into U.S. law a new ("Stage 5") aircraft noise standard, which requires future aircraft to be seven decibels quieter than the previous standard, equating to a 35 percent noise reduction at the source. Further, under the Aviation Safety and Noise Abatement Act (ASNA), FAA has the obligation to establish science-based noise exposure metrics and thresholds to assess community noise exposure and received direction from Congress in last-year's FAA reauthorization legislation on timing for the latest assessment. Moreover, ASNA and the regulations thereunder provide for noise assessment and mitigation funding to airports and surrounding communities, noise compatibility planning, sound insulation and other noise abatement programs.

We are confident that the measures A4A and our members are taking will continue to limit and reduce aviation's carbon footprint and limit aircraft noise exposures, while allowing commercial aviation to continue to provide an invaluable service and be a key contributor to our nation's economy. Efficient implementation of NextGen procedures, supported by the web of environmental assessment, community outreach and aircraft noise management provisions, can reduce both noise and emissions impacts while providing means for resolving local concerns. Further, we urge continued congressional support for the public-private CLEEN, ASCENT and NASA ARMD programs, which, as noted in A4A's February 26 testimony, are critical to further breakthroughs.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR KEVIN DEGOOD

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. I cannot speak to the possible future actions of U.S. governors.

QUESTIONS FROM HON. SCOTT PERRY FOR KEVIN DEGOOD

Question 2: In your written testimony, you stated, "If federal, state, and local officials and administrators are to succeed, they need access to the most accurate—and to the greatest extent possible localized—models for temperature, precipitation and peak storm flows, and sea level rise." I could not agree more. If the models aren't correct, then they offer little assistance in projecting future climate trends. This is why I'm extremely concerned about the continued use of the model predictions found in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR-5) for public policy. Dr. John Christy, the head of climate research at the University of Alabama in Huntsville, conducted research on the efficacy of these modeled predictions and his findings were alarming. These models, on average, over-predicted measured temperatures by more than a factor of three. These significantly overheated projections were the basis of the Climate Science Special Report released by the U.S. Global Change Research Program in November 2017.

Given this disparity—modeled projections are warmer observations by a factor of three, on average—do you believe these models produce credible estimates of the impact increased atmospheric CO₂ concentrations on future global average surface temperatures that are valid for policy analysis?

ANSWER. My comments were directed at the need for the production of localized climate impact models by the U.S. government.

Question 3: Is it possible that, over the years, the models have been tuned to data not reflective of the observed state of the climate, leading them to make projections based on a historical climate record that never existed?

ANSWER. I cannot speak to the validity of the modeling methodology of either the IPCC report nor the rebuttal by Dr. Christy.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR JAMES M. PROCTOR II

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. I am not familiar enough with the details of the plan or how governors might react to comment about how the proposal might affect their interactions, but I can offer some thoughts about what an infrastructure bill might include. In addition to the topics discussed in my written testimony, legislation should:

1. Incentivize partnerships among water and wastewater systems and the consolidation of failing water and wastewater systems.
 - a. *Reduce the number of water systems that lack operational, technical and financial capacity to meet federal and state water quality standards.* Many failing systems serve small to midsize communities (less than 100,000 population) and lack the capacity to maintain compliant and resilient water and wastewater systems. Thousands of such systems are in significant non-compliance (SNC) and unable to meet minimal performance and health-based standards. These systems should be incentivized and, in cases where public health is seriously compromised or in long-standing SNC status, compelled, to partner with or seek a new owner/operator that can adequately provide water services. Regionalization should also be encouraged by, among other things, repurposing SRF and other grants for that purpose.
 - b. *Provide more financial incentives and "safe harbor" protections for "Good Neighbors".* To encourage financially sound and well-managed water systems to partner with or take over distressed systems, the government must reduce the significant financial and legal liabilities posed to the acquirer or "Good Neighbor". Provide set asides and expand SRF funding exclusively to fund consolidation. For example, California currently provides up to \$5M for systems that wish to explore and implement consolidation.
2. Encourage more private sector participation and investment by eliminating barriers.
 - a. *Remove debt defeasance penalty.* A simple way to accelerate investment is the elimination of the need to "defease" public bonds alongside an asset purchase. This can be achieved through a simple IRS interpretation change, thereby allowing municipal system acquisitions to improve net proceeds the municipalities receive when their systems are purchased or consolidated at their option. The current rule inadvertently deters beneficial agreements, as its requirements are often cost-prohibitive, adding up to 15-20% of the total value of the transaction. Treasury could make this change through a rule-making.
 - b. *Remove tax-exempt water infrastructure private activity bonds from state volume caps.* In addition to federal dollars, another effective option for the federal government to provide long-term, capital-intensive infrastructure projects is the private activity bond (PAB). These bonds are a form of tax-exempt financing for state and municipal governments that want to collaborate with a private entity to meet a public need. This partnership approach makes infrastructure repair and construction more affordable for municipalities and ultimately for users or customers. This well-established program would provide significant benefit to water-sector investments were the state volume cap to be lifted and defeasance penalty eliminated.
 - c. *Provide all water systems with equal access to SRF loans.* EPA has long interpreted the Clean Water State Revolving Fund (SRF) to apply only to the publicly owned systems due to the statute applying to "publicly owned treatment works" (POTW). Although EPA has long held that private water systems are eligible for Drinking Water SRF funds, numerous states disallow such funds for private entities. This disparity prevents the private sector from leveraging federal investment to benefit the same communities (and rate payers) otherwise eligible for federal funds.
3. Modernize and streamline the SRFs.

- a. *Streamline procedures.* Eliminate federal/state redundancies in cross-cutters and streamline the application process and paperwork to make it easier for smaller systems to seek assistance.

Additional Considerations:

Although Congress should hold communities accountable for results, they should encourage federal agencies to defer to local communities and their engineers of record by the means employed. For too long Washington has imposed unfunded, one-size-fits-all mandates that have increased burdens and costs on local water systems without regard to the diverse water and wastewater infrastructure needs of local communities, who must evaluate numerous factors when considering the proper design and materials for their community and water projects. Encouraging and supporting local governance allows those closest to the problem to determine the best solutions, including the use of green infrastructure and water recovery and recycling solutions, which stimulates innovation and saves money as local communities can hold those in their community more accountable.

The recommendations described above focus on more immediate actions that either Congress or the President could initiate to help improve and rebuild the Nation's water infrastructure. These recommendations are actions that can be taken in addition to supporting certain existing programs and policies. For example, tax-exempt municipal bonds are the principal finance tool that most utilities use to finance large-scale projects. Congress and the Administration need to protect these as tax reform moves forward. Other useful existing tools are in the Rural Utility Services programs at the Department of Agriculture and Community Development Block Grants.

Similarly, there is a type of secondary infrastructure that supports the water sector: the network of research organizations that support and execute research that guides the water sector toward smarter, more efficient water infrastructure. Currently, federal support is virtually absent for water infrastructure-related research.

In addition, while the bulk of infrastructure discussion focuses on capital assets, the people who manage and operate water systems are the sector's most valuable assets. The sector faces the aging workforce issues that many other sectors of American society faces. While there is already a strong cadre of technical training organizations in the water sector, federal funding to facilitate ongoing sector-led training would be beneficial. EPA, through its oversight capabilities, could be a mechanism for facilitating greater coordination and consistency in training across state borders to enable the water workforce to move more easily from one state to another to meet workforce needs.

Lastly, in addition to legislative and administrative options, the President should consider issuing a Presidential Policy Directive outlining a vision for the development of integrated, efficient and effective water infrastructure strategy to (1) elevate water infrastructure modernization, improvement, and security as a national priority; (2) establishing inter-agency coordination and oversight mechanisms, resources, and staffing to align U.S. government agencies' priorities, actions and budgets, and improve collaboration, coordination, and efficiency across federal agencies; (3) encourage local co-finance, full-cost and life-cycle accounting, and information sharing for federal assistance; (5) promoting economic growth, development, and exports of U.S. technologies, products and services; and (6) advance national security and international cooperation over water.

QUESTION FROM HON. DAVID ROUZER FOR JAMES M. PROCTOR II

Question 2: Any discussion of energy infrastructure must include nuclear and natural gas. Nuclear provides 20 percent of our Nation's electricity, creates good paying jobs, and is reliable around the clock, all without producing emissions. My community is lucky to have the Brunswick Nuclear Plant and is also poised to benefit from natural gas pipeline infrastructure, specifically the Atlantic Coast Pipeline (ACP). Energy customers in eastern North Carolina—including homeowners, small businesses, and manufacturers—are depending on the ACP to provide affordable and reliable natural gas.

Shouldn't we keep assets like the Brunswick running while developing new critical infrastructure like the ACP?

ANSWER. Although I am not an expert on power generation issues, I do believe that nuclear power is an undervalued and underutilized alternative for the production of carbon-free electricity.

QUESTIONS FROM HON. RICK LARSEN FOR WHITLEY SAUMWEBER

Importance of Funding the Coast Guard

Question 1: You provided several recommendations in your written statement regarding Arctic maritime infrastructure, most of which highlighted responsibilities of the U.S. Coast Guard. In fact, as our nation's sole military, maritime law enforcement agency, the Coast Guard appears to be a pivotal element to ensure the Federal Government can capably provide an active presence in an open and accessible Arctic region.

Do our future efforts in the Arctic depend on having the Coast Guard present and active in the region?

ANSWER. Response was not received at the time of publication.

Question 2: What are the security implications if the Coast Guard is unable to maintain mission readiness and operational capability in the Arctic?

ANSWER. Response was not received at the time of publication.

Question 3: Considering the importance of the Coast Guard, not only in the Arctic but in the coterminous United States, should Congress pass legislation such as H.R. 367, the Coast Guard Pay Parity Act, to ensure that in any future lapse in appropriations that the Coast Guard gets paid just like the other four military services?

ANSWER. Response was not received at the time of publication.

Arctic Risk Assessment

Question 4: In your testimony, you recommended that Congress invest in Coast Guard programs to support comprehensive risk assessments at major U.S. ports to the primary climate risk factors found in the Committee on the Marine Transportation System's Risk Matrix.

Should the Coast Guard itself conduct a comprehensive assessment of how climate risk factors might affect all Coast Guard facilities and the Service's operational readiness?

ANSWER. Response was not received at the time of publication.

Question 5: Are all of the risk factors in the CMTS Risk Matrix applicable to the Coast Guard?

ANSWER. Response was not received at the time of publication.

Question 6: Should Congress pass H.R. 1322, to direct the Coast Guard to undertake such an assessment and report to Congress?

ANSWER. Response was not received at the time of publication.

Port Infrastructure Resiliency

Question 7: In the recently passed Fiscal Year 2109 Consolidated Appropriations Act, the Congress appropriated \$293 million for a new Port Infrastructure Development Grant program. You recommended in your written statement that resiliency standards should be developed for port infrastructure that map to regional predictions of sea level change under a variety of scenarios projected by the Intergovernmental Panel on Climate Change (IPCC).

To your knowledge, have port infrastructure resiliency standards been developed, either in the U.S. or abroad?

ANSWER. Response was not received at the time of publication.

Question 8: What factors should be included in resiliency standards for port infrastructure?

ANSWER. Response was not received at the time of publication.

Question 9: Regarding the new port infrastructure development grant program, should we prioritize grant applications that design resiliency into the project? Are there other types of incentives you might recommend to encourage applicants to account for resiliency in their grant proposals?

ANSWER. Response was not received at the time of publication.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR WHITLEY SAUMWEBER

Question 10: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. Response was not received at the time of publication.

QUESTION FROM HON. HENRY C. "HANK" JOHNSON, JR. FOR LYNN SCARLETT

Question 1: A few days ago, Vice President Mike Pence promised members of the National Association of Governors that Congress would pass an historic infrastructure bill next year. And of course, that would require bipartisan support.

Do you believe that the administration's unpopular infrastructure proposal with this panel will muzzle governors in terms of their interactions with the Federal Government henceforth on infrastructure?

ANSWER. A backlog of investment needed to upgrade, maintain and make more resilient our nation's infrastructure is widely understood and accepted. Congress has demonstrated bipartisan cooperation on infrastructure related bills in the last couple of years as seen in passage of the Water Resources Development Act and the Federal Aviation Administration reauthorization, among others. Thoughtfully drafted, such bills address significant infrastructure needs facing our nation.

My testimony before the Transportation and Infrastructure Committee focused in large part on the need to consider natural infrastructure when making our nation's infrastructure investments. Infrastructure investments should include nature-based solutions to support robust economic development, improve the quality of life in our communities and sustain America's lands and waters for future generations. When using the term "natural infrastructure," we mean actions like restoring floodplains along rivers to allow better absorption of floodwaters and enlarging and using natural features for culverts to allow for larger flows of water to pass through without blowing out the culverts and the road structures along with them.

Natural infrastructure can be used alone or alongside gray infrastructure (like seawalls, dams, levees and water and wastewater systems) to provide cost-effective and sustainable solutions that bring multiple benefits. In addition to helping reduce risk, natural infrastructure can deliver clean water and air, sustain lands that grow food and provide enhanced recreational opportunities and wildlife habitat—all benefiting local economies.

During the past several years, Congress has included provisions in bills such as the Water Resources Development bill just passed in 2018 that includes increased consideration of using natural infrastructure. These provisions received bipartisan support, and the bill passed with overwhelming bipartisan support.

QUESTION FROM HON. DEBBIE MUCARSEL-POWELL FOR LYNN SCARLETT

Question 2: You discussed runoff in your testimony. As you know, South Florida has been trying to complete the Comprehensive Everglades Restoration Project for the past 18 years.

What is the importance of this type of project to the future resiliency of our community?

ANSWER. The Comprehensive Everglades Restoration Plan (CERP) is a critical resiliency effort benefiting Floridians, U.S. residents and beyond. In addition to the restoration of the Everglades, CERP will help protect the domestic wellfields in south Florida, provide ongoing aquifer recharge through its existence and maximize water management flexibility to serve the areas of six million residents. The work of the CERP also helps preserve a globally important ecosystem, maintaining the important source of tourism for the region as well as natural infrastructure that provides storm risk reduction benefits and critical habitat to important plants and animals.