Testimony for the Record

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Introduction

Chairman Manchin and Ranking Member Barrasso, thank you for the opportunity to testify before the committee today. As the Acting Assistant Secretary of the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE), I oversee a broad portfolio of renewable energy, energy efficiency, and sustainable transportation programs.

Our program's primary focus is on funding technology research, development, demonstration and deployment (RDD&D) through competitive solicitations open to the public and through support for the National Laboratories, which play a central role in advancing America's leadership in science and technology and developing innovative solutions for the future. Additionally, academic institutions, such as universities and colleges, are a resource for innovation, R&D, and training sponsored by EERE. The knowledge generated by EERE research, development, demonstration, and deployment drives down the costs of new technologies, supporting the efforts of U.S. industries, businesses, and entrepreneurs in growing and commercializing innovative energy technologies. These technologies also reduce harmful emissions that disproportionately affect lower income and minority populations. The demonstrations and deployments show how we can use new technologies to expand access to transportation for underserved communities.

Climate change is one of the greatest challenges facing our nation and our planet today. DOE stands ready to work to address the climate emergency and lead through the power of example, by doing its part to ensure that the U.S. builds a 100% clean energy economy and reaches net-zero emissions no later than 2050. We must also ensure that the benefits from a clean energy future are equitably shared by all Americans, from clean air to good-paying jobs, from farmers to factory workers and from cities to the rural economy.

Transportation is the largest source of greenhouse gas emissions in the United States, surpassing the power sector in 2017[1]. It is also central to the economy, supports millions of U.S. jobs and is part of everyday life for all Americans. We are committed to developing the technologies needed to decarbonize transportation and to do so in a way that is affordable, provides improved mobility options for underserved communities, keeps us globally competitive and our nation secure, and grows good paying, middle-class American jobs. This includes opportunities to sustainably grow the role of biomass, address vulnerabilities with respect to critical material supply chains, and create jobs in the rural economy.

DOE's sustainable transportation strategy to decarbonize transportation includes all modes: air, sea, rail, and road. It encompasses activities in the fuel streams of electrification, hydrogen and fuel cells, and biofuels. We will need to deploy solutions from all three of these technologies to be successful in our efforts. In addition, we need to recognize the dramatic changes that are occurring in mobility itself, how people are accessing transportation and how e-commerce and the shipments of goods are changing. Our work includes understanding the transportation system as a whole and how promising mobility options like automation, connectivity and last-mile service – which is the last leg of a journey from a transportation hub to a final destination –

[1] https://usafacts.org/articles/transportation-now-largest-source-greenhouse-gas-emissions/

can help achieve both GHG reductions while also providing more and better mobility choices for underserved communities.

We are working closely with other agencies to achieve our goals, including the U.S. Department of Transportation, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture. I appreciate the opportunity today to share a bit on our work on electric vehicles (EVs), biofuels, and hydrogen fuel cell technologies.

Electric Vehicles

Electrifying transportation is one of the most effective ways we can combat climate change. Our success with electric vehicles is largely dependent on advancements in battery technologies.

At DOE, through our Vehicle Technologies Office (VTO) our research and development investments throughout the past decade have yielded breakthroughs in battery cost and performance; reducing lithium ion EV battery pack costs by about 85% from approximately $1000/kWh in 2008 to $144/kWh in 2020; and driving down weight and enhancing manufacturability. DOE's goal is to lower the battery pack cost to below $80/kWh from the $144/kWh level today, and cell cost to $60/kWh, allowing EVs to reach cost competitiveness with future internal combustion engine vehicles. It's important that EVs are not a luxury, but the most affordable and accessible choice for all Americans.

Although initial costs of EVs are currently more expensive than internal combustion engine vehicles, they offer savings over the life of the car in fuel, maintenance and repair costs. Today, the average EV driver saves approximately $600 in fuel costs each year, and about $6000 in maintenance costs over the average 13,500 miles per year life of the car. By bringing down the upfront cost of EVs through our battery cell and battery pack research and development, EVs will be the clear choice for Americans in the coming years. The total fuel and maintenance cost savings are even greater for work trucks that often have higher mileage per year.

We are also working to improve convenience for EV owners, by decreasing recharge time to less than 15 minutes for a 300-mile range vehicle. Further, we are exploring new battery chemistries with less reliance on rare, critical minerals such as cobalt, to minimize the environmental impacts of production. Our most recent batteries have already reduced cobalt by 60% (vs 2010) and our goal is a 95% reduction.

In addition to light-duty cars and trucks, there has been tremendous progress made on electrifying medium and heavy-duty trucks and buses. This includes both battery electric and hydrogen fuel cell vehicles. Just in the last year, manufacturers have started to make medium and heavy duty electric trucks and electric school buses available for general sales and have demonstrated hydrogen fuel cell long-haul tractor trailer trucks. Demand for electric transit buses has also grown. There is growing consensus that these technologies will play a major role in the future of transportation.

Electrifying vehicles - and especially large trucks - whether powered by batteries or hydrogen fuel cells, can bring significant air quality benefits. These zero-emission vehicles can reduce the pollution in communities near ports, factories, and roadways. In ports for example, as vehicles

and other gas-powered machines idle, air pollutants are being inhaled by the on-site workers. Electric school buses also reduce the exposure to students from harmful emissions and particulates. Electrifying these vehicles and systems can bring important health benefits for many Americans.

We are working with a variety of industry partners and fleets to solve problems and address technology barriers to safely accelerate the development and deployment of electric vehicles and charging infrastructure. Our EV infrastructure work focuses on grid integration and smart charge management, high power charging systems, and cyber-physical security of charging infrastructure.

Battery Technology

As we advance battery technologies, we want to make sure that these batteries are being made domestically, so that we continue to see the growth of battery manufacturing jobs in the U.S. To meet the forecasted demand from light and heavy-duty EVs, the United States will need over one hundred (100) battery cell manufacturing locations in the U.S. by 2035. There is clear consensus that electrification of our economy and specifically in the transportation sector will expand, and other countries and regions such as China, South Korea and Europe are investing to have an economic stake in this industry. The United States currently manufactures only 9% of global battery cells. With the right combination of technological advances and policy signals, we can support U.S. manufacturing and workers.

Growing the domestic EV industry will require a secure and resilient domestic supply chain, "from minerals to markets." DOE is leading the way to reduce U.S. dependence on imported critical materials like lithium, nickel, graphite and cobalt by reducing the amount of these materials needed for battery production, developing substitute materials, improving reuse and recycling, and exploring domestic sources that can be developed in an environmentally responsible manner.

The last critical piece of this supply chain is reusing and recycling the materials. Our research shows that up to 40 percent of the materials for future batteries can come from recycled vehicle batteries and our National Laboratories are conducting research on such efforts, such as the ReCell Center at Argonne National Lab which is also supported by the National Renewable Energy Lab (NREL).

Our commitment aligns with President Biden's recent Executive Order, emphasizing the need to strengthen these supply chains in recognition of their importance to our economy. We want to focus on the entire supply chain, including mining, processing, and manufacturing, which again will translate to a series of good-paying, middle class jobs distributed across the country. At each level of the chain, we want to partner with the private sector.

Biofuels

Biofuels are a crucial part of the Nation's energy system—now and in the future. We see additional and growing opportunities for biomass in a low carbon transportation system. While petroleum currently provides over 90 percent of our transportation energy mix, biofuels provide

almost 10 percent.[2] In 2019, the United States produced over 19 billion gallons of biofuels and supported over 106,000 domestic jobs.[3] The vast majority of these biofuels are ethanol and biodiesel, which are blended into petroleum gasoline and petroleum diesel fuel, respectively. The domestic biofuels industry faced significant challenges over the past year due to reduced demand for transportation fuels as a result of the global pandemic. There are important opportunities to recover from this setback and expand the role of biomass for our rural, farm economies. Supporting these communities and growing job opportunities from bio-refineries of the future is an important part of the President's plan.

The Department of Energy's Bioenergy Technologies Office (BETO) conducts RDD&D activities in support of low-carbon drop-in biofuels that are compatible with existing fuels and infrastructure. These technologies can use traditional feedstocks, such as corn or soy oil, as well as agricultural wastes, forest biomass, algae biomass, municipal solid waste, sludge from farms or wastewater treatment—to make gasoline, diesel, and jet fuel. These technologies will produce direct hydrocarbon replacements for petroleum, which will help the industry overcome the blend limitations on ethanol and biodiesel while also delivering climate benefits. Our bioenergy office funding has helped to lower the cost of these fuels by over 47 percent since 2012 and has strategies in place to continue the pursuit of cost competitiveness with traditional fuels. There are a variety of biofuel production pathways in the BETO portfolio, most delivering 70 percent lower greenhouse gases than petroleum fuels. It will be critical to work closely with the existing bio-fuels industry to leverage their expertise and the lessons learned from the past 20 years to achieve these benefits.

The aviation fuel market is a particularly attractive market for new biofuel solutions. The aviation sector is important to the American economy but is a significant and growing source of greenhouse gas emissions. U.S. commercial aviation consumes approximately 10 percent of transportation energy and is one of the fastest growing uses of transportation energy. Aviation also drives 6 percent of the U.S. gross domestic product and just under 9 percent of national employment. The 106-billion-gallon global commercial jet-fuel market (21-billion-gallon domestic) is projected to grow to over 230 billion gallons by 2050[4].

The aviation sector is difficult to decarbonize because of the need for a high energy density liquid fuel to meet the mission needs for efficiency, long range, safety, and space for passengers and cargo. Current battery technologies do not have the energy density required for a commercial aircraft fully loaded with passengers, fuel, and freight to take off and travel long distances.

The aviation industry considers drop-in advanced liquid biofuels, often called Sustainable Aviation Fuel (SAF), to be the only feasible solution to reducing greenhouse gas emissions and decoupling their market growth from carbon emissions. BETO is particularly focused on the

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[2] https://www.eia.gov/todayinenergy/detail.php?id=43096

[3] https://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-energy-efficiency-and-resilience-2019#:~:text=USEER%20reports%20that%20the%20woody,stable%20from%202017%20to%202018

[4] https://www.eia.gov/todayinenergy/detail.php?id=41913#

development of innovative SAF technologies that can address this challenge and position the U.S. as a global leader in the emerging aviation biofuels market.

The "Billion Ton Study," a joint study by DOE and the U.S. Department of Agriculture in 2016, estimates that the United States can grow and harvest about 1 billion dry tons/year of biomass economically and sustainably by 2030, which is sufficient to produce 50-60 billion gallons of advanced biofuels without impacting agriculture, trade, and current uses of biomass. By our analysis, this is sufficient to meet the projected needs of the U.S. aviation industry (35 billion gallons by 2050), produce additional volumes of biofuels and bioproducts for other applications, and reduce CO2 emissions by 450 million metric tons - all while employing over one million people in good-paying jobs.

Hydrogen

Hydrogen is also a key part of our transportation strategy, and a versatile fuel that can play an important role to decarbonize key industrial sectors, provide new energy storage options and support the move to 100% clean electricity production by 2035. Realizing the true potential for hydrogen requires continued research and development, as well as accelerating demonstrations and deployments with the private sector to achieve scale. That is the basis of our 'H2@Scale' efforts to reduce hydrogen production costs to benefit all end-uses, including industrial and transportation applications. The U.S. currently produces 10 million metric ton of hydrogen, mostly in the south-central U.S. As the hydrogen economy grows, we will need to build upon this existing infrastructure and expertise. As renewable energy grows across the U.S., this will also provide new opportunities for green hydrogen production through electrolysis.

In transportation, hydrogen is particularly well-suited for heavy-duty applications that need both the energy density stored hydrogen can provide and centrally located fueling. This includes long-haul heavy-duty trucks, maritime and rail. Last year we launched the Million Mile Fuel Cell Consortium with industry and National Labs to develop fully cost-effective and durable technologies that can demonstrate a class 8 long haul truck by 2025. We are also working to reduce the cost of hydrogen storage on trucks and to develop improved high-pressure fuel stations that can quickly and safely refuel these trucks.

We have also launched the H2NEW consortium to reduce the cost of electrolyzers, which directly ties into the need to achieve low cost, carbon-free hydrogen. Our hydrogen efforts also involve a greater integration of renewable and nuclear energy systems, and it will take an integrated approach from multiple energy sectors to realize the full potential and benefits of hydrogen. We have several projects being conducted jointly with the DOE Office of Nuclear Energy to demonstrate how electrolysis can be coupled with nuclear energy sites to provide benefits both to the nuclear plant and to reduce the cost of hydrogen production. This type of integrated energy systems approach is a key part optimizing resources and achieving large scale, low cost production of clean hydrogen.

Grid Integration

The Energy Act of 2020 (the "Act") directed DOE to establish a research, development, and demonstration program to advance the integration of electric vehicles onto the electric grid. The Act also requires an EV-grid integration assessment report and roadmap of how to best integrate electric vehicles (EVs) for both grid reliability and grid resiliency services. This is an important priority for the Department as we look to the future of the power system. As more and more of electric vehicles come on the road, integrating their charging into the power system becomes an additional consideration in grid planning and operation. Greater vehicle electrification poses both a challenge and an opportunity: a challenge both because it requires more power overall, and because the speed and timing of that additional demand can be difficult to predict; and an opportunity because vehicle charging can provide an additional source of flexibility that can be used to integrate variable generation like wind and solar. DOE is investigating technologies that maximize that flexibility and could effectively allow vehicle chargers to be managed as a grid asset. Vehicles can even be a source of resilience and backup power: for example, during the 2021 Texas ice storms and power outages, previously charged EVs served as a refuge from extreme cold, and, in some cases, provided emergency back-up power to affected households.

The Department is currently conducting a scenario analysis to better understand the national impact of electrifying the transportation sector and understand the impacts this will have on generation. We are also investigating how EVs can provide more system flexibility through managed charging and vehicle-to-grid. Finally, we are investigating the implications of necessary grid upgrades at the distribution level where fleet electrification will be taking place in the near future (e.g. UPS or Amazon).

Conclusion

Thank you for the opportunity to appear before the Committee today. I look forward to working with you to address the climate crisis by providing American families and businesses with a wider range of energy and mobility options that offer more affordability, reliability, and security of our nation's energy.

I look forward to your questions.