THE CLEAN FUTURE ACT: DRIVING DECARBONIZATION OF THE TRANSPORTATION SECTOR

A Hearing of the Subcommittee on Energy

Committee on Energy and Commerce

United States House of Representatives

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Introduction

Chairman Rush, Ranking Member Upton and distinguished members of the committee, thank you for holding this important hearing and for inviting me to testify.

I am Amol Phadke, and I am a Staff Scientist and Deputy Department Head in the International Energy Analysis Department at Lawrence Berkeley National Laboratory (Berkeley Lab). I am also an Affiliate and Senior Scientist at the Goldman School of Public Policy at the University of California (UC), Berkeley. My research is focused on electrification of heavy duty vehicles, grid scale storage, and deep decarbonization of the power and transport sectors. I have published over 30 peer reviewed journal articles and over 35 scientific reports. I have a Bachelor of Engineering degree from the Government College of Engineering, Pune, India, and a M.S. and Ph.D. from the Energy and Resources Group, from UC Berkeley. I am the lead author of the recently released 2035 Transport Report and 2035 Power Report by UC Berkeley which assess rapid electrification and deep decarbonization of the US transport and power sectors respectively.

My testimony represents my views only and does not necessarily represent the views of Berkeley Lab or of the Department of Energy.

My own research and the research of several other scientists shows that plummeting battery costs, breakthroughs in battery technology, and dramatic declines in clean energy costs have created new opportunities for an accelerated decarbonization of the transport sector via electrification. Significant barriers remain, but the total consumer cost savings and societal benefits of accelerated vehicle electrification are staggering. In this testimony, I will discuss the key findings of our related research.

I will specifically discuss the findings of our recent report: *2035 Report 2.0: Plummeting Costs And Dramatic Improvements In Batteries Can Accelerate Our Clean Transportation Future (**2035 Transport Report**)*.[1]

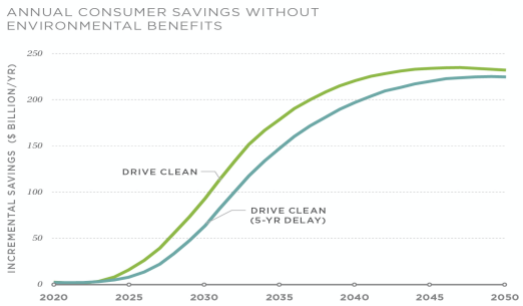

Figure 1: Annual consumer savings in the DRIVE Clean scenario (cumulative savings of $2.7 trillion through 2050) and a delayed-electrification scenario (cumulative savings of $2.2 trillion through 2050).

[1] Phadke, A, N Abhyankar, J Kirsey, T McNair, U Paliwal et al., 2021. 2035 Report 2.0: Plummeting Costs and Dramatic Improvements in Batteries Can Accelerate Our Clean Transportation Future. University of California, Berkeley. Available at www.2035report.com. **[A Phadke and N Abhyankar are co-lead authors]**

We analyze the economic, human health, environmental, and electric grid impacts using a future scenario in which electric vehicles (EVs) constitute 100% of new U.S. light duty vehicle (LDV) sales by 2030 as well as 100% of medium-duty vehicle (MDV) and heavy-duty truck (HDT) sales by 2035. We find that such a scenario is technically feasible and leads to

- Saving consumers $2.7 trillion in vehicle spending (Figure 1). This translates to approximately $1,000 in average household savings each year, over the next 30 years
- 150,000 avoided premature deaths, and nearly $1.3 trillion in avoided health and environmental costs through 2050;
- Over 2 million new jobs in 2035, with opportunities to bolster job growth and global competitiveness through sound industrial policies to support manufacturing.

Several hurdles, including high upfront vehicle costs and inadequate charging infrastructure, rather than technical or economic feasibility, are the largest barriers to EV sales growth and accelerated decarbonization to align with global climate targets.

A robust policy ecosystem is required to address these barriers which potentially includes strong standards that require all new auto sales to be zero emission by 2035, targeted financial incentives that ramp down over time, equity focused programs, investments in a ubiquitous charging network and a modern grid, strong "Made in America" policies, and smart electric utility regulations. These are described in a Companion Policy Report to the 2035 Transport Report (see Baldwin et al. 2021).[2] Europe and China are implementing several of these policies already and in 2020, EV sales and public EV charge points in Europe and China were more than double of those in the US.

In addition, enhanced investments in RD&D are required to establish US leadership in clean technology and further enable rapid decarbonization of the transport sector. Next, I will elaborate on the findings of our recent research.

2035 Report 2.0: Plummeting Costs And Dramatic Improvements In Batteries Can Accelerate Our Clean Transportation Future

In our recent report, *2035 Report 2.0: Plummeting Costs And Dramatic Improvements In Batteries Can Accelerate Our Clean Transportation Future*, we analyze the economic, human health, environmental, and electric grid impacts of a future in which ground transportation is all-electric. Our main scenario, called the Drive Rapid Innovation in Vehicle Electrification (DRIVE Clean) scenario, represents a future in which EVs constitute 100% of new U.S. light duty vehicle (LDV) sales by 2030, as well as 100% of medium-duty vehicle (MDV) and heavy-duty truck (HDT) sales by 2035. The scenario also assumes that the grid reaches 90% clean electricity by 2035, and

[2] Baldwin, Sara, Amanda Myers, Michael O'Boyle, and David Wooley. 2021. Accelerating Clean, Electrified Transportation by 2035: Policy Priorities (A 2035 2.0 Companion Report). Energy Innovation and University of California, Berkeley.

substantial EV charging infrastructure is deployed. We then compare the DRIVE Clean scenario to a No New Policy scenario, in which EVs constitute 45% of new LDV sales, 38% of MDV sales, and 12% of HDT sales in 2035, and the clean electricity share reaches only 47% by 2035. By demonstrating that the ambitious DRIVE Clean goals are technically feasible and economically beneficial, we aim to inform broader discussions of the U.S. transportation transition. Following are key findings from our analysis.

1. CONSUMER SAVINGS FROM EV OWNERSHIP START SOON AND GROW RAPIDLY

Historically, EV sales have been hindered by two consumer cost disadvantages: the total cost of ownership (TCO) and upfront prices of EVs have both been high in relation to internal combustion engine (ICE) vehicles. Our results show, however, that electric heavy-duty trucks already hold a TCO advantage today, and light-duty EVs will overtake ICE vehicles in TCO terms within 5 years (Figure 1). In addition, light-duty EVs will reach upfront price parity with their ICE counterparts in the mid- to late-2020s, while electric HDTs will approach upfront price parity with diesel trucks in the mid- to late-2030s. However, the persistence of high upfront EV costs is a major barrier to achieving rapid decarbonization of the transportation sector. At a national level, the DRIVE Clean scenario yields cumulative economic savings of approximately $2.7 trillion through 2050 compared to the No New Policy scenario — an average household savings of approximately $1,000 per year over the next 30 years. The DRIVE Clean scenario's electrification of light duty EVs by 2030 is critical to the benefits realized, saving $460 billion more than a scenario in which 100% light-duty EV sales are achieved 5 years later.

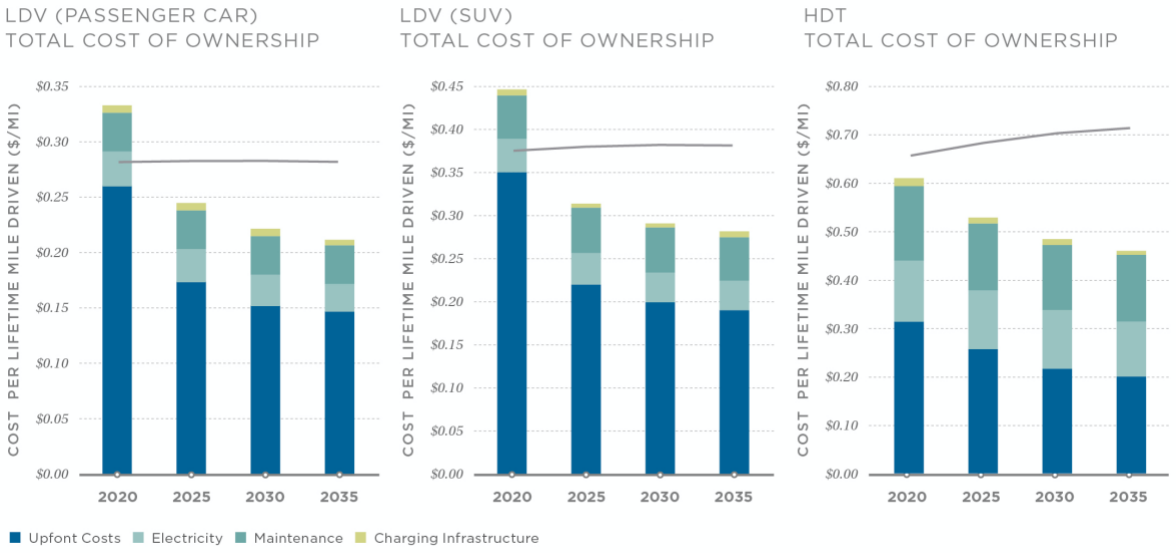

Figure 1: *TCO for EVs (bars) vs. ICE vehicles (lines), showing TCO parity achieved by 2023 for LDVs (left and center) and an existing TCO advantage for HDTs (right). Upfront costs include taxes. Maintenance costs of EVs include battery replacement cost.*

2. ACCELERATING EV ADOPTION SAVES 150,000 LIVES AND AVOIDS $1.3 TRILLION IN HEALTH AND ENVIRONMENTAL DAMAGES THROUGH 2050

Gasoline- and diesel-powered vehicles harm human health and the environment via emissions of pollutants such as fine particulate matter, nitrogen oxides, and sulfur oxides, as well as greenhouse gas emissions that contribute to climate change. These emissions disproportionately impact low-income communities and communities of color, which are often located near major roads, transit centers, or freight hubs. Compared with the No New Policy scenario, the total transportation sector pollutant and carbon dioxide (CO2) emissions reductions in the DRIVE Clean scenario avoid approximately 150,000 premature deaths and equate to nearly $1.3 trillion in health and environmental savings through 2050 (Figure 2). The DRIVE Clean scenario slashes ground transportation sector CO2 emissions by 60% in 2035 and by 93% in 2050, relative to 2020 levels. Total transportation sector emissions fall by 48% in 2035 and by 75% in 2050, relative to 2020 levels (Figure 3).

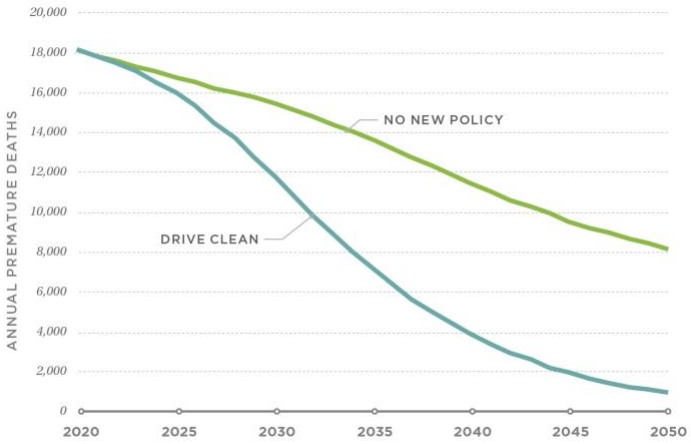

Figure 2: Annual premature deaths in the No New Policy and DRIVE Clean scenarios, 2020–2050. The DRIVE Clean scenario avoids 150,000 premature deaths due to air pollution through 2050.

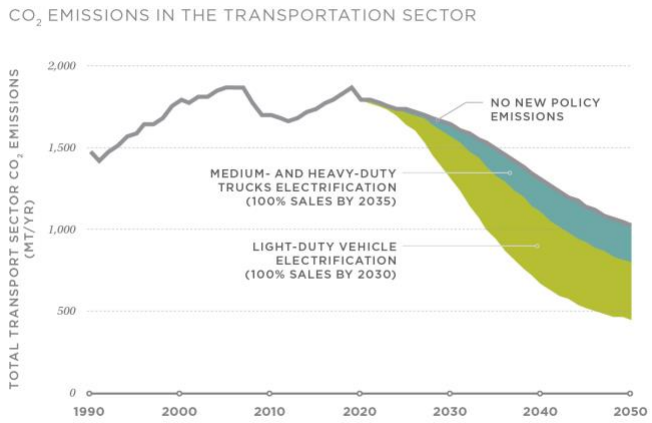

Figure 3: Transportation sector CO_2 emissions in the DRIVE Clean and No New Policy scenarios through 2050.

3. THE ELECTRIC VEHICLE TRANSITION SUPPORTS EMPLOYMENT OPPORTUNITIES ACROSS THE ECONOMY

The DRIVE Clean scenario supports consistent job gains in 2020-2035, peaking at over 2 million jobs in 2035 compared to the No New Policy scenario (Figure 4). Employment gradually ramps up in this timeframe as electric vehicle manufacturing expands and the electric grid adds new renewable energy and battery storage resources to support increased vehicle electrification. Consumer cost savings in the transition to electric vehicles similarly increases induced jobs in the economy. While electric vehicles require less maintenance and have fewer parts, the reduction in auto repair jobs is more than offset by gains in economy-wide induced jobs and increased power sector jobs.

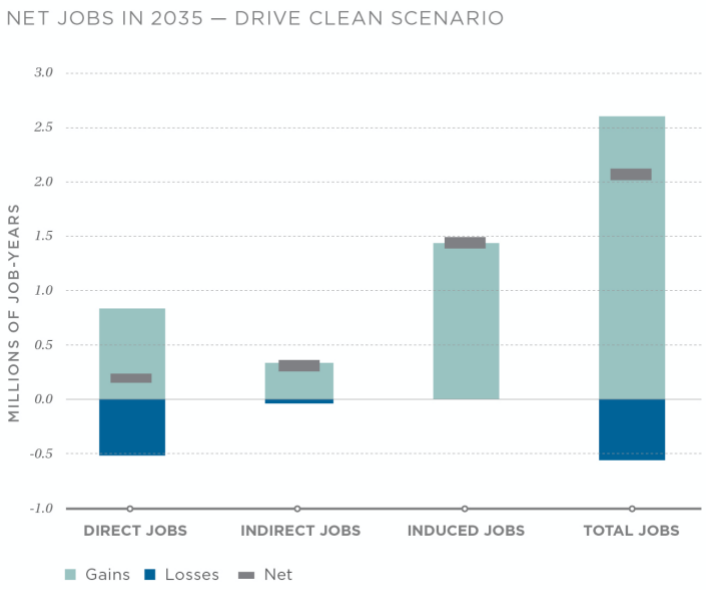

Figure 4: Net jobs in 2035, DRIVE Clean scenario compared to the No New Policy scenario.

4. EV PERFORMANCE AND AVAILABILITY CAN MEET THE NEEDS OF AMERICAN DRIVERS

American drivers have become accustomed to the vehicle performance and availability standards established by gasoline and diesel-powered vehicles for vehicle range (Figure 5), fueling time, diversity of vehicle models, and—for commercial vehicles— weight. EVs have been improving rapidly across all these dimensions, and our analysis suggests they will not present significant barriers to the accelerated EV deployment envisioned in the DRIVE Clean scenario.

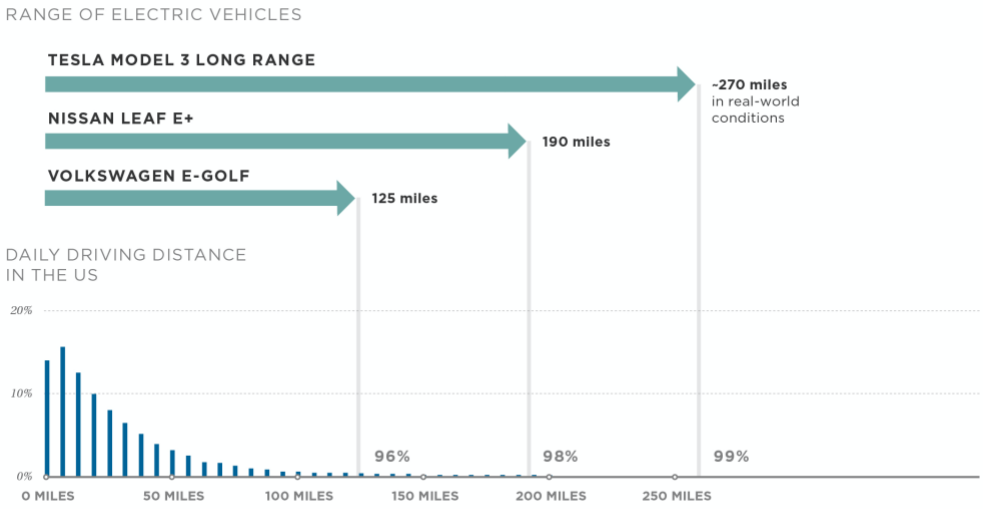

Figure 5: Nearly 96% of U.S. passenger vehicle trips are shorter than 125 miles suggesting many EV models can meet average daily passenger vehicle needs (image recreated from ICCT 2020).

REQUIRED CHARGING INFRASTRUCTURE CAN BE BUILT COST-EFFECTIVELY TO SERVE THE ENVISIONED EV FLEET

To enable the DRIVE Clean scenario, U.S. EV-charging infrastructure must provide drivers with at least as much convenience as provided by existing gasoline and diesel fueling stations. We find that the pace of the required infrastructure scale-up is challenging but achievable, and the costs are modest compared with the benefits of widespread EV deployment.

Each year over the next 30 years, the United States must install an average of approximately 270,000 public chargepoints for LDVs and 35,000 MDV/HDT chargepoints. The cumulative investment in public charging infrastructure ($6.5 billion per year) makes up a small portion of EV TCO in the DRIVE Clean scenario.

5. GLOBAL AND DOMESTIC SUPPLY CHAINS CAN SATISFY ACCELERATED EV AND BATTERY PRODUCTION, LED BY U.S. COMPANIES

With strong policy support, domestic and global EV manufacturing capacity can sufficiently scale to meet the DRIVE Clean goals. In addition, accelerated U.S. EV deployment will present opportunities for U.S. manufacturing leadership in an increasingly competitive global context. The DRIVE Clean scenario requires that annual U.S. electric LDV sales grow from 331,000

to over 15 million by 2030. Domestic manufacturing of these vehicles is beginning to ramp up, with significant investments from manufacturers such as Ford and General Motors. At the same time, more than 125 zero-emission MDVs and HDTs are in production or development in the United States. Similarly, the DRIVE Clean scenario will depend on at least 1,200 GWh

of battery capacity per year by 2035. While current global lithium-ion battery demand is about 300 GWh, global battery manufacturing capacity is expected to exceed 2,000 GWh by 2028. **Strong policies will be necessary to further develop domestic vehicle and battery manufacturing capacity, encourage raw material procurement and cost-competitive battery recycling, and help the U.S. compete globally.**

6. ELECTRIC GRID IMPACTS OF THE ENVISIONED EV FLEET ARE MANAGEABLE

Even with additional electric loads in the DRIVE Clean scenario, the 90% clean grid is dependable without coal plants or new natural gas plants by 2035. In addition, the resulting wholesale electricity cost is lower than today's costs. Under the DRIVE Clean scenario, all existing coal plants are retired by 2030, no new fossil fuel plants are built, and electricity demand growth from increased electrification averages about 2% per year, a growth rate slower than that achieved in 1975-2005 (Figure 6). To meet this demand, the United States must install on average 105 GW of new wind and solar and 30 GW of new battery storage each year—nearly four times the current deployment rate in the U.S., but lower than that achieved by China in

2020. Although new investments in the distribution system are necessary to support increased load from electric vehicles, the costs are modest. Because electricity sales are increasing due to electrification, the increased distribution costs are spread across more units of electricity, which results in lower costs to consumers on a per kWh basis.

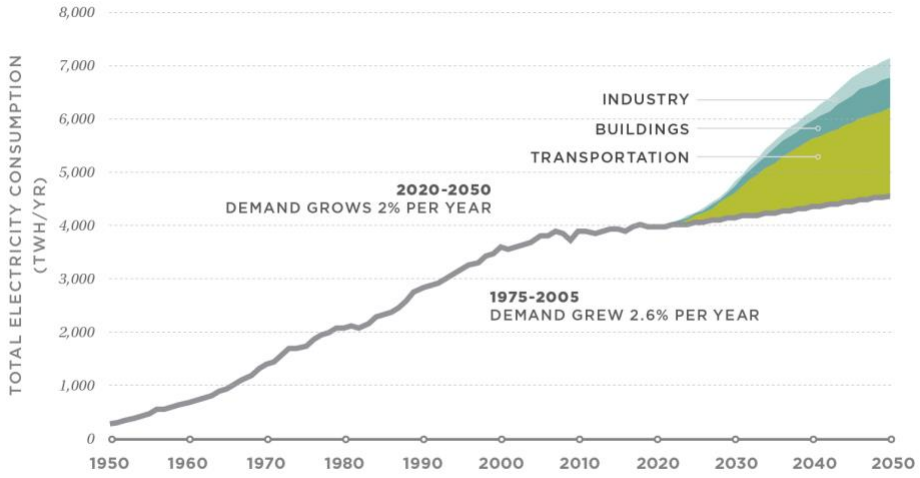

Figure 6: Average annual U.S. electricity demand growth, 2020–2050 (left) and average U.S. renewable energy capacity additions necessary to support the DRIVE Clean scenario, compared to renewable energy capacity additions in China in 2020 (right). The United States must add approximately 105 GW of new wind and solar each year through 2035.

CONCLUSION

Plummeting battery costs, breakthroughs in battery technology, and dramatic declines in clean energy costs have accelerated the timeline for cost-effective transportation decarbonization. Significant barriers remain, but the total consumer cost savings and societal benefits of accelerated vehicle electrification are staggering. Achieving the goal of the DRIVE Clean scenario puts the United States on a 1.5°C pathway for economy-wide decarbonization while yielding substantial human health and environmental benefits and saving consumers $2.7 trillion in vehicle spending—approximately $1,000 in average household savings each year—over the next 30 years. If light-duty vehicle electrification is delayed to 2035 in accordance with many currently proposed transportation electrification goals, we leave significant cost savings on the table. When it comes to electrifying transportation, sooner is definitely better. Europe and China appear to be significantly ahead of the US in terms EV sales and charging infrastructure deployment. For example, in 2020, EV sales and public EV charge points in Europe and China were more than double of those in the US (Figure 6).

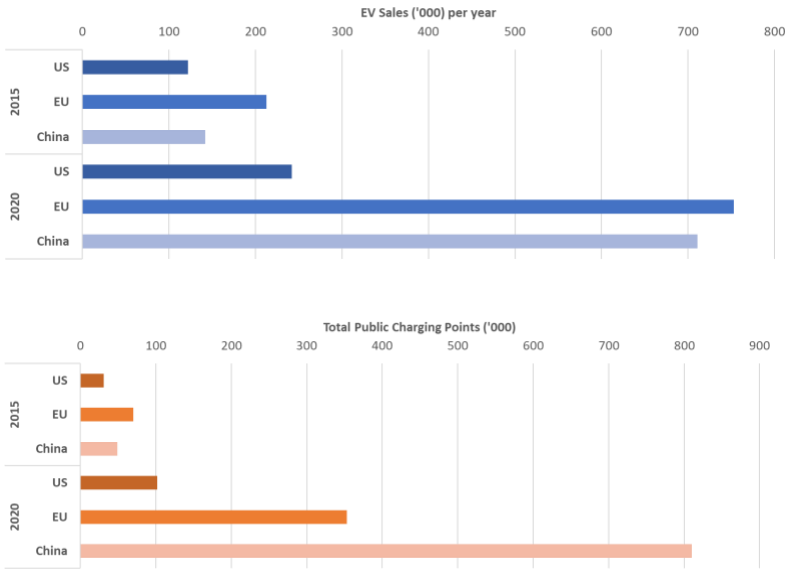

Figure 6: EV sales and pubic charging points in US, EU, and China

New policies and regulations will be needed to achieve the accelerated 100% electric vehicle sales goal. These are described in a Companion Policy Report to the 2035 Transport Report (see Baldwin et al. 2021) which I have summarized below.[3]

Strong national fuel economy and tailpipe emissions standards for all vehicle classes consistent with will pave the road for market transformation, spur technology innovation, reduce local pollution, and lock in consumer savings. Combined with state leadership in ZEV standards, strong national standards will protect consumers, improve public health, and ensure U.S. manufacturers remain globally competitive. America needs strong standards to reduce greenhouse gas emissions in line with a 1.5 degree Celsius global target. These are the highest priority policies in terms of emissions reductions.

Equity-focused policies and programs designed with input from communities most adversely impacted by transportation pollution — namely communities of color in historically redlined neighborhoods, and frontline and underserved communities — will ensure all people, regardless of race or other socio- economic demographics, benefit from cleaner, more efficient transportation solutions.

Targeted incentives that ramp down over time as the market matures will encourage early adoption and drive down costs to benefit all consumers. Means-based incentives will help ensure low- and moderate-income consumers and small businesses also benefit. Consumer education

[3] Baldwin, Sara, Amanda Myers, Michael O'Boyle, and David Wooley. 2021. Accelerating Clean, Electrified Transportation by 2035: Policy Priorities (A 2035 2.0 Companion Report). Energy Innovation and University of California, Berkeley.

programs will increase awareness of expanding EV model availability and suitability. Incentive programs for EV infrastructure are also key to an all-electric future.

Investments in a ubiquitous charging network and a modern grid will address range anxiety and ensure reliability as the EV market grows. Meeting the mobility needs of families and businesses will boost consumer and business confidence in EVs for urban, rural, and long-distance trips.

Strong "Made in America" policies to encourage domestic manufacturing will help retool U.S. industry to manufacture batteries, EVs, energy storage, and other advanced technologies. An early focus on these policies will improve global competitiveness, sustain jobs, and support workers in the transition.

Smart electric utility regulations and local government leadership will reduce permitting and other soft costs and elicit full electrification transportation value for the benefit of EV owners, utility customers, and the grid. Efforts to streamline interconnection and integration of EVs in homes, businesses, and communities will pay dividends as demand grows.

In addition enhanced investments in RD&D are required to establish US leadership in clean technology and further enable rapid decarbonization of the transport sector.

Thank you for the opportunity to share my views with the Committee.