# Decarbonizing Light-Duty Vehicles

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*Summary*

Reducing the United States' greenhouse gas emissions by at least 80% from 1990 levels by 2050 will require multiple legal pathways for changing its transportation fuel sources. The Deep Decarbonization Pathways Project (DDPP) authors characterize transforming the transportation system as part of a third pillar of fundamental changes required in the U.S. energy system: "fuel switching of end uses to electricity and other low-carbon supplies." The goal is to shift 80%-95% of the miles driven from gasoline to energy sources like electricity and hydrogen. Relying upon the DDPP analysis, this Article, excerpted from Michael B. Gerrard & John C. Dernbach, eds., *Legal Pathways to Deep Decarbonization in the United States* (forthcoming in 2018 from ELI Press), addresses that challenge as applied to light-duty vehicles such as cars and SUVs.

## Introduction

An important component of reducing U.S. greenhouse gas (GHG) emissions by at least 80% from 1990 levels by 2050 involves legal pathways for changing our sources of transportation. Historically, the power sector was the largest source of carbon dioxide emissions. For the first time since carbon emissions were initially tracked in the 1970s, however, the transportation sector is now the leading source of carbon emissions.[1] As of 2015, the transportation sector was responsible for approximately 27% of GHG emissions[2] and 34%[3] of all U.S. carbon emissions.[4] This shift is largely due to accelerated decreases in carbon intensity[5] for the power sector compared to the transportation sector (driven, in large part, by fuel switching from coal to natural gas).[6] Notably, the transportation sector emits more GHG emissions even though the power sector reflects a larger share of energy consumption.[7]

Within the transportation sector, emissions from light-duty vehicles (LDVs)[8] such as cars and sport utility vehicles (SUVs) account for more than one-half of total transpor-

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1. U.S. Energy Information Administration (EIA), *Power Sector Carbon Dioxide Emissions Fall Below Transportation Sector Emissions*, Today in Energy, Jan. 19, 2017 [hereinafter *Power Sector*] ("U.S. carbon dioxide ($CO_2$) emissions from the transportation sector reached 1,893 million metric tons (MMt) from October 2015 through September 2016. . . ."), http://www.eia.gov/todayinenergy/detail.php?id=29612.
2. U.S. Environmental Protection Agency (EPA), *Sources of Greenhouse Gas Emissions* (compared to 25% emissions from the power sector), https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions (last updated Apr. 14, 2017); *Power Sector*, *supra* note 1.
3. The White House, United States Mid-Century Strategy for Deep Decarbonization 41 fig. 4.9 (2016), http://unfccc.int/files/focus/long-term_strategies/application/pdf/us_mid_century_strategy.pdf.
4. U.S. EPA, *Fast Facts on Transportation Greenhouse Gas Emissions*, https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions (last updated Sept. 26, 2017). The latter figure is even higher if one includes oil refineries. *Id*.
5. EIA, *Carbon Intensity of Energy Use Is Lowest in U.S. Industrial and Electric Power Sectors*, https://www.eia.gov/todayinenergy/detail.php?id=31012 ("Carbon intensities reflect the consumption-weighted average of the carbon intensities of the primary fuels consumed in each sector.").
6. EIA, *Natural Gas Expected to Surpass Coal in Mix of Fuel Used for U.S. Power Generation in 2016*, Today in Energy, Mar. 16, 2015, https://www.eia.gov/todayinenergy/detail.php?id=25392.
7. *Power Sector*, *supra* note 1.
8. The EIA defines LDV to

   > include passenger and fleet cars and trucks with a gross vehicle weight rating (GVWR) of 8,500 pounds or less. Light-duty vehicle energy consumption can be influenced by vehicle fuel economy or through passenger behavior and vehicle use. LDV fuel efficiency, the number of vehicles on the road (vehicle stock and new sales each year), and the vehicle mix between cars and light-duty trucks are key factors that determine fuel consumption. Driving behavior, distance traveled, and driver response to fuel price and vehicle price also influence energy consumption by LDVs.

tation GHG emissions.[9] As such, LDVs are an important sector for decarbonization efforts. The Deep Decarbonization Pathways Project (DDPP) authors anticipate two changes required for our LDV fleet by 2050: (1) increased fuel economy standards in excess of 100 miles per gallon (mpg); and (2) deployment of approximately 300 million alternative fuel vehicles (AFVs) to shift 80%-95% of the miles driven from gasoline to low-carbon fuels.[10]

Relying upon the 2015 DDPP analysis and its Mixed Scenario,[11] which assumes an equal blend of electric, hybrids, and hydrogen vehicles, this Article addresses these two specific challenges and develops legal pathways to achieve these goals. It begins with a brief primer on LDV types, their GHG contributions, and the DDPP authors' projections for an LDV future (Part I). Part II then describes the existing legal regime for LDVs and the barriers to achieving more extensive alternative vehicle deployment. Finally, Part III advances legal pathways to achieve the light-duty decarbonization goals by 2050.

## I. The Role of LDVs in Decarbonization

LDVs are the predominant source of GHG and carbon dioxide emissions in the transportation sector.[12] LDVs, as defined by the U.S. Environmental Protection Agency (EPA) for emissions purposes, include passenger vehicles such as cars, minivans, light trucks, and SUVs that have a maximum gross vehicle weight rating of less than 8,500 pounds.[13]

LDVs are heavily dominated by conventional internal combustion engines (ICEs) that emit approximately 20 pounds of carbon dioxide for every gallon of gas burned.[14] Other technologies can be used to power these vehicles, including electric motors and hydrogen fuel cells, but a number of barriers have limited their development (see below in Part II). Of the 230 million LDVs on the road in the United States today, electric and hybrid vehicles represent well under 1%.[15] On an annual sales basis, EV sales still lag far behind ICE sales. For instance, of the 17.55 million passenger vehicles sold in the United States in 2016,[16] less than 160,000 of them were EVs.[17] This part will describe four categories of LDVs and their relative contributions to U.S. GHG emissions.

### A. *LDV Primer*

LDVs can function based on a number of technologies. The majority of LDVs in the United States have ICEs.[18] Alternative types of LDVs include fully battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell vehicles (HFCVs) (collectively referred to as "alternative fuel vehicles," or "AFVs," in this Article).[19] Each of these types will be described below, as well as their relative GHG contributions and their role in the DDPP assessment.

#### 1. ICEs

Vehicles powered by ICEs were first developed for motor transport at the end of the 19th century.[20] Since then, ICE vehicles (ICVs) have dominated the transportation sector.[21] Without significant policy or market changes, their dominance is likely to continue.[22] They are familiar, easy

EIA, *Light-Duty Vehicles' Share of Transportation Energy Use Is Projected to Fall*, Today in Energy, July 18, 2014, http://www.eia.gov/todayinenergy/detail.php?id=17171.

9. The White House, *supra* note 3, at 41 fig. 4.9.
10. James H. Williams et al., Energy and Environmental Economics, Inc. et al., Pathways to Deep Decarbonization in the United States, US 2050 Report, Volume 1: Technical Report xiv (2015) [hereinafter DDPP], http://deepdecarbonization.org/wp-content/uploads/2015/11/US_Deep_Decarbonization_Technical_Report.pdf.
11. The Mixed Scenario also has no deployment of carbon capture and storage (CCS) outside the electricity sector, and a balanced mix of renewable energy, nuclear power, and natural gas with CCS in electricity generation. Non-dispatchable renewables and nuclear power are balanced with electricity storage (pumped hydro), flexible end-use electric loads (electric vehicles and thermal loads like water heating), and electric fuel loads. Hydrogen and synthetic natural gas produced from electricity (referred to as power-to-gas) and biomass are used to decarbonize pipeline gas, which is used in freight transport and industry. DDPP, *supra* note 10, at 17, 27-29.
12. U.S. EPA, Fast Facts on Transportation Greenhouse Gas Emissions, https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions. LDVs emit 60% of total transportation GHG emissions. *Id.*
13. U.S. Department of Energy (DOE), Alternative Fuels Data Center, *Vehicle Weight Classes & Categories*, https://www.afdc.energy.gov/data/widgets/10380 (last visited Feb. 25, 2018).
14. Michael Greenstone, *Overlooked Tool to Fight Climate Change: A Tweak in Fuel Standards*, N.Y. Times, Mar. 28, 2016, https://www.nytimes.com/2016/03/29/upshot/overlooked-tool-to-fight-climate-change-a-tweak-in-fuel-standards.html.
15. DOE, Office of Energy Efficiency and Renewable Energy, *Vehicle Technologies Office: Advanced Combustion Engines*, http://energy.gov/eere/vehicles/vehicle-technologies-office-advanced-combustion-engines (last visited Feb. 25, 2018). In mid-2016, the United States had almost half a million EVs on the road.
16. Bill Vlasic, *Record 2016 for U.S. Auto Industry; Long Road Back May Be at End*, N.Y. Times, Jan. 4, 2017, https://www.nytimes.com/2017/01/04/business/2016-record-united-states-auto-sales.html.
17. Sunny Trochaniak, *Electric Vehicle Sales in the United States: 2016 Final Update*, FleetCarma, Jan. 19, 2017 (stating that 159,333 EVs were sold in the United States in 2016), http://www.fleetcarma.com/ev-sales-usa-2016-final/.
18. *Advancing Clean Transportation and Vehicle Systems and Technologies*, *in* Quadrennial Technology Review 275, 276 (DOE 2015) [hereinafter *Advancing Clean Transportation*], https://www.energy.gov/sites/prod/files/2015/09/f26/QTR2015-08-Transportation.pdf.
19. DDPP, *supra* note 10, at 34. Contrast this with flexible fuel vehicles, which "have an internal combustion engine and are capable of operating on gasoline and any blend of gasoline and ethanol up to E85 (or flex fuel)." DOE, Alternative Fuels Data Center, *Flexible Fuel Vehicles*, https://www.afdc.energy.gov/vehicles/flexible_fuel.html (last updated May 18, 2017).
20. Fred Bosselman et al., Energy, Economics, and the Environment: Cases and Materials 1069 (3d ed. 2010).
21. *Advancing Clean Transportation*, *supra* note 18, at 1.
22. *Id*.

to access, and relatively simple to understand and maintain. But such vehicles also have the poorest fuel economy and highest overall emissions of all vehicle types.[23] Further, ICVs are largely fueled by gasoline and diesel, petroleum products refined from crude oil. In fact, transportation accounts for approximately 71% of overall U.S. petroleum use.[24] Biofuels make up a portion of these fuels, however, and can modify efficiency ratings.[25]

The heavy reliance on petroleum results in significant GHG emissions from the LDV sector. GHG emissions from petroleum-based LDVs account for 60% of total emissions in the U.S. transportation sector, which breaks down to 43.1% for passenger cars and 18.4% for SUVs, light pickups, and minivans.[26] Other transportation sources, like rail, ships and boats, aircraft, and medium- and heavy-duty vehicles, make up the rest of the transportation-sourced emissions.[27] Although the U.S. dependence on petroleum has posed a historic threat to energy security, recent increases in domestic oil production lessen this concern.[28] Nevertheless, increasing concerns about climate change have shaped policies focused on enhancing LDVs fueled by alternatives.[29]

### 2. EVs, Hybrids, and Plug-In Hybrids

Ironically, the first vehicles powered by electric motors were developed in the 1890s in response to an oil shortage.[30] However, as oil prices decreased, the ICVs took center stage,[31] with early versions (perhaps surprisingly) running in whole or in part on biofuels.[32] EVs did not emerge again until the late 20th century.[33] Today's EVs can be categorized into two types: hybrids (HEVs) and fully electric (BEVs). The main difference between the two types is that hybrids combine an ICE and a battery/electric motor system to power the vehicle,[34] while fully electric vehicles are powered entirely by an onboard electric motor.[35] Hybrids are then further divided by the power source.[36] Each of the types and their most popular models are set out below.

*BEV*: Because BEVs are powered entirely by an onboard battery, they require a larger battery that stores more energy than the battery in HEVs and PHEVs.[37] The main battery pack powers the motor and is charged, like PHEVs, by plugging the vehicle into an electrical source.[38] The dominant BEV models are the Tesla Model S and the Nissan Leaf, with the Tesla Model 3 and the Chevy Bolt as the apparent successors.[39]

*HEV*: The battery in HEVs recharges through regenerative braking and the vehicles do not plug into an electrical outlet.[40] The dominant HEV model is the Toyota Prius.

*PHEV*: The larger battery (either nickel-metal hydride or lithium-ion (Li-ion)) in PHEVs recharge predominantly by plugging into an external electrical outlet connected to the grid.[41] The dominant PHEV model is the Chevy Volt.[42]

For simplicity, BEVs, HEVs, and PHEVs are collectively referred to as "EVs" in this Article.

### 3. Hydrogen

HFCVs are powered by electric motors, but they use hydrogen to power a fuel cell inside the vehicle. The polymer electrolyte membrane fuel cell is the most common version of the hydrogen fuel cell for vehicles.[43] Similar to ICVs and HEVs, the amount of energy available for the vehicle is determined by the size of the fuel tank. Like HEVs, HFCVs generate the primary electricity needed to power

23. *See* Fueleconomy.gov, *All-Electric Vehicles*, http://www.fueleconomy.gov/feg/evtech.shtml#data-sources (last visited Feb. 25, 2018); Hongrui Ma et al., *A New Comparison Between Life Cycle Greenhouse Gas Emissions of Battery Electric Vehicles and Internal Combustion Vehicles*, 44 Energy Pol'y 160, 163-64 (2012), http://www.sciencedirect.com/science/article/pii/S0301421512000602.
24. EIA, January 2017: Monthly Energy Review 64 (2017) (DOE/EIA-0035(2017/1), *available at* https://www.eia.gov/totalenergy/data/monthly/archive/00351701.pdf.
25. EIA, *Gasoline Explained: Where Our Gasoline Comes From* [hereinafter *Gasoline Explained*], http://www.eia.gov/energyexplained/index.cfm?page=gasoline_where (last updated Nov. 28, 2017).
26. Nuri Cihat Onat et al., *Conventional, Hybrid, Plug-In Hybrid, or Electric Vehicles? State-Based Comparative Carbon and Energy Footprint Analysis in the United States*, 150 Applied Energy 36, 36 (2015):

    The majority of the energy used in the transportation sector, about 93% of the total energy consumption mix, is provided through petroleum. On the other hand, for the U.S. transportation sector, light duty vehicles comprise 63% of total petroleum use, 59% of total energy use, and 60% of total GHG emissions.
27. U.S. EPA, *supra* note 4.
28. *Gasoline Explained*, *supra* note 25.
29. *See, e.g.*, Andreas Poullikkas, *Sustainable Options for Electric Vehicle Technologies*, 41 Renewable & Sustainable Energy Revs. 1277, 1278 (2015).
30. Joel B. Eisen et al., Energy, Economics, and the Environment 1013 (4th ed. 2015).
31. *Id*.
32. Ethan N. Elkind, Berkeley Law & University of California, Los Angeles School of Law, Planting Fuels: How California Can Boost Local, Low-Carbon Biofuel Production 7 (2015), https://www.law.berkeley.edu/wp-content/uploads/2015/11/Planting-Fuels.pdf.
33. Eisen et al., *supra* note 30, at 1014; Baha M. Al-Alawi & Thomas H. Bradley, *Review of Hybrid, Plug-In Hybrid, and Electric Vehicle Market Modeling Studies*, 21 Renewable & Sustainable Energy Revs. 190, 191 (2013).
34. *See* Poullikkas, *supra* note 29.
35. *Id*. at 1281.
36. When discussing hybrids in this Article, the term means full or strong hybrid vehicles, which have an electric motor in use nearly all the time the car is running and use a large battery for power. John Fuller, *What's a Mild Hybrid System?*, HowStuffWorks, https://auto.howstuffworks.com/fuel-efficiency/hybrid-technology/mild-hybrid1.htm (last visited Feb. 25, 2018). Mild hybrids, vehicles with electric motors to help with efficiency but that cannot move the car on its own, are included with ICEs. *See id*.
37. Poullikkas, *supra* note 29, at 1281.
38. *Id*.
39. *See* Ethan N. Elkind, Berkeley Law & University of California, Los Angeles School of Law, Plugging Away: How to Boost Electric Vehicle Charging Infrastructure 11 (2017) (providing a list of all PHEVs and BEVs available for sale in the United States through January 2017), https://www.law.berkeley.edu/wp-content/uploads/2017/06/Plugging-Away-June-2017.pdf.
40. *See* Poullikkas, *supra* note 29, at 1279 (providing an in-depth explanation of regenerative braking in HEVs).
41. *See id*. at 1280 (providing an in-depth explanation of the modes of operation in PHEVs). Some PHEVs incorporate regenerative braking as well. *Id*. at 1279.
42. Chevrolet, *Volt*, http://www.chevrolet.com/electric/volt-plug-in-hybrid# (last visited Feb. 25, 2018).
43. Oxygen (from the air) and hydrogen are introduced into the fuel cell, which triggers an electrochemical reaction. The hydrogen molecules are broken into protons and electrons in the fuel cell, and the electrons travel through an external circuit providing power to the vehicle's electric motor. DOE, Alternative Fuels Data Center, *Fuel Cell Electric Vehicles*, http://www.afdc.energy.gov/vehicles/fuel_cell.html (last updated Apr. 12, 2017).

the motor onboard the vehicle. There are three hydrogen vehicle models on sale as this Article goes to press: the Hyundai Tucson FC, the Honda Clarity FC, and the Toyota Mirai, with four more models expected to follow.[44]

### *B. LDVs and GHG Emissions*

"[O]il is indeed high-quality energy. It's liquid, which makes it easily moved and stored. It's stable, and it releases a huge amount of energy. It's also much, much cleaner than coal. If it weren't for [carbon dioxide] emissions, oil & gas would be a nearly-perfect energy source."[45] Those troublesome emissions of carbon dioxide, as well as many other pollutants, are part of what is driving the move toward alternative vehicles. Increasing the number of AFVs on the road is an important part of addressing the climate problem. While challenging, the many non-climate co-benefits of such vehicles provide hope.[46]

EVs offer several potential advantages over ICVs, including lower operating costs, lower emissions, less noise, convenient at-home charging, and lower fuel costs.[47] HFCVs also can offer a number of potential advantages over EVs.[48] First, they have a range similar to that of traditional ICVs, as well as a similar refueling time, taking about five minutes to fill the tank. In addition, the HFCV provides stability in cold weather that can be a problem for some pure EVs. It is also easier to scale up an HFCV to a larger vehicle because adding fuel cells is more efficient and space-effective than adding additional batteries. For hydrogen vehicles, unlike the harmful emissions that result from the ICE process, the chemical process associated with the fuel cell produces only water vapor. While this minimizes the traditional pollutants emitted, water vapor is a GHG, resulting in some question about the potential impacts of water vapor on climate change.[49]

With the right combination of electricity generation, manufacture, and disposal practices, however, EVs can be the most promising way to reach GHG emissions reduction goals.[50] Thus, finding the right combination of processes and inputs that will maximize effectiveness of EVs requires a full life-cycle assessment to consider the environmental impact (including GHG emissions impacts) of a vehicle throughout its entire life cycle, "from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end-of-life treatment and final disposal."[51] For EVs, this would include the emissions from driving, the manufacturing and assembly of the batteries, and the energy source of the electric grid.[52] When assessing emissions from driving, for example, ICVs produce more tailpipe emissions and have lower energy efficiency (and convert only 17%-21% of the energy from gasoline to power at the wheels) than EVs (which covert 59%-62% of electricity to power at the wheels).[53] Because BEVs are powered entirely by a battery, for instance, and produce no exhaust or tailpipe emissions, BEVs are considered "zero emission vehicles" (ZEVs).[54] But EVs have GHG impacts that vary based on the extent to which fossil fuels are used to produce electricity.

When assessing the source of electricity for the EVs, in areas where energy for the electric grid is produced from coal, the life cycle of EVs produces more emissions than if the energy for the grid were produced from nuclear, wind, solar, hydro, or other non-emitting sources.[55] This scenario is made all the more likely given that in 2016, 68% of our electricity came from coal or natural gas.[56] For those geographic areas that use relatively low-polluting energy sources for electricity generation, however, PHEVs and EVs "typically" have a well-to-wheel emissions advantage over similar conventional vehicles running on gasoline or diesel.[57]

A 2016 report suggests that if EVs gain more than a 35% market share by 2035, the United States could see a reduction in the amount of oil used per day from nine million to two million barrels, with corresponding carbon reductions.[58] Researchers have noted, however, the increase

44. Fred Lambert, *California Added 1,300 Fuel Cell Hydrogen Vehicles Over the Last Year—Projections Lowered Again*, Electrek, Aug. 21, 2017, https://electrek.co/2017/08/21/california-fuel-cell-hydrogen-vehicles/.
45. Ryan Carlyle, *What Are the Top Five Facts Everyone Should Know About Oil Exploration?*, Forbes, Apr. 3, 2013, http://www.forbes.com/sites/quora/2013/04/03/what-are-the-top-five-facts-everyone-should-know-about-oil-exploration/#76616a50127d; https://www.eia.gov/tools/faqs/faq.php?id=73&t=11.
46. For example, co-benefits of reduced emissions from ZEVs include impacts on ecosystems, health, and resource efficiency, https://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3s3-3-5-6.html.
47. Ghazale Haddadian et al., *Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers*, 28 Electricity J. 53, 54 (2015).
48. HFCVs do have some downsides. These include: (1) there are some questionable sources of energy that might be used to make the hydrogen in the first place; (2) the inefficiency of converting electricity or other energy to hydrogen, which then must be converted back to electricity in the vehicle; (3) the need for a whole new infrastructure build out of hydrogen stations, compared to the ubiquity of electricity; and (4) the high initial costs. As with all new technologies, minimizing challenges and maximizing potential will be critical in establishing a successful path to decarbonization, as will be discussed throughout this Article.
49. National Oceanic and Atmospheric Administration, National Centers for Environmental Information, *Greenhouse Gases* ("Water Vapor is the most abundant greenhouse gas in the atmosphere. . . . The feedback loop in which water is involved is critically important to projecting future climate change, but as yet is still fairly poorly measured and understood."), https://www.ncdc.noaa.gov/monitoring-references/faq/greenhouse-gases.php (last visited Feb. 25, 2018).
50. *See* DDPP, *supra* note 10, at xi (reducing emissions 80% by 2050).
51. *Id*.
52. *Id*. at 163.
53. Fueleconomy.gov, *supra* note 23; Poullikkas, *supra* note 29, at 1281; Ma et al., *supra* note 23, at 165.
54. DOE, Alternative Fuels Data Center, *All-Electric Vehicles* ("Although most U.S. electricity production contributes to air pollution, the U.S. Environmental Protection Agency categorizes all-electric vehicles as zero-emission vehicles because they produce no direct exhaust or emissions."), http://www.afdc.energy.gov/vehicles/electric_basics_ev.html (last updated Nov. 7, 2017).
55. Troy R. Hawkins et al., *Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles*, 17 J. Indus. Ecology 53 (2012).
56. EIA, Electric Power Monthly: With Data for November 2017 tbl. 1.2.A (2018), https://www.eia.gov/electricity/monthly/pdf/epm.pdf.
57. DOE, Alternative Fuels Data Center, *Emissions From Hybrid and Plug-In Electric Vehicles* (noting that wells-to-wheels includes "all emissions related to fuel production, processing, distribution, and use"), http://www.afdc.energy.gov/vehicles/electric_emissions.php (last updated May 18, 2017).
58. Madeline Farber, *This Is What Electric Cars Will do to the U.S. Gas Demand*, Fortune, June 20, 2016 (citing a 2016 Wood Mackenzie report), http://fortune.com/2016/06/20/us-electric-cards-gas-demand/.

in miles traveled each year, and expect this trend to continue into the future.[59] (Strategies to reduce vehicle miles traveled (VMT) are discussed later in Part II.) Dividing the GHG budget allowable in 2050 by the projected miles driven provides a wells-to-wheels GHG emissions target of 48 grams per kilometer (g/km), which translates to the equivalent of a required 114 mpg.[60]

When assessing vehicle manufacture and disposal, however, emissions for that part of the life cycle are higher for EVs because of the GHG emissions associated with battery manufacture.[61] Still, BEVs have significantly lower GHG emissions than comparable ICVs, despite higher emissions in the EV manufacturing process.[62] Although assessments of our current energy system run the risk of putting too much focus on existing infrastructure instead of focusing on the necessary energy system transformation, knowing and understanding the starting point is an important part of planning for deep decarbonization.

## II. Existing Legal Pathways to Achieve LDV Decarbonization

Current laws, policies, and programs to accelerate the transition to a lower carbon LDV fleet primarily focus around three areas: (1) fuel economy standards; (2) emissions standards; and (3) fiscal incentives (including those that support expanded infrastructure to support the transition).[63] Fuel economy standards are controlled by the federal government, emissions standards are controlled by federal and California agencies, and fiscal incentives are provided across all levels of government.

These initiatives have had some success. The White House reported in 2016 that in the prior eight years alone, battery costs had decreased by 70%, there were 40 times more EV charging stations, and 20 times more plug-in hybrid models available.[64] Drastically reduced costs, combined with Tesla's successes with the Model S and Model 3, and public commitments by auto manufacturers to significantly increase their AFV fleets (see Part III below), all suggest trends indicative of a move to alternative vehicles.[65] A 2016 study predicts that existing trends may result in 41 million EV sales in the year 2040, reflecting 35% of LDV sales for that year.[66]

While these are admirable beginnings, these initiatives by themselves will not come close to reaching the DDPP goals of 300 million AFVs on the road by 2050. In comparison to our 1%, Norway is touted as an EV leader, with EVs reflecting 25% of all newly registered cars.[67] This section examines the current legal regimes governing these areas and discusses barriers to the DDPP goals.

### A. *Fuel Economy Standards*

The single most important federal pathway for AFVs uses the Clean Air Act (CAA) and the Energy Policy and Conservation Act (EPCA) to impose fuel economy standards on auto manufacturers.[68] Since 1975, when the EPCA was first enacted in response to the embargo of the Organization of the Petroleum Exporting Countries,[69] the United States, through the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA), has issued corporate average fuel economy (CAFE) standards to increase the fuel economy of U.S. vehicles.[70] For 30 years, these standards remained relatively constant with low penalties and limited enforcement efforts.[71]

In 2011, however, President Barack Obama's Administration significantly ratcheted up the fuel economy standards for both passenger cars and LDVs.[72] This was

59. Chris Gearhart, *Implications of Sustainability for the United States Light-Duty Transportation Sector*, 3 MRS Energy & Sustainability 1, 7 (2016).
60. *Id.*; for a conversion tool, see Unit Juggler, https://www.unitjuggler.com/convert-fuelconsumption-from-gperkmgasoline-to-mpg.html?val=48 (last visited Feb. 25, 2018). This calculation was derived based on the following assumptions: "it is assumed that vehicle-kilometers traveled (VKT) continue to increase [a growth rate of 57 billion kilometers per year] for the decade between 2040 and 2050," which establishes a baseline 2050 VKT estimate of 6.3 trillion kilometers. Gearhart, *supra* note 59, at 2. The GHG budget allowable in 2050 of 303 million metric tons was then divided by the projected VKT, which provides the wells-to-wheels GHG emissions target of 48 g/km. *Id.*
61. Ma et al., *supra* note 23, at 165.
62. Rachael Nealer et al., Union of Concerned Scientists, Cleaner Cars From Cradle to Grave 21 (2015), *available at* http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf.
63. The focus on these three initiatives is not exclusive. For instance, the federal government is also exploring designation of EV corridors, private corporations are investing in research and development, and there are some non-fiscal incentives such as prime parking spots for EVs.
64. Fact Sheet, The White House, Obama Administration Announces Federal and Private Sector Actions to Accelerate Electric Vehicle Adoption in the United States (July 21, 2016) [hereinafter Fact Sheet], https://obama whitehouse.archives.gov/the-press-office/2016/07/21/fact-sheet-obama-administration-announces-federal-and-private-sector.
65. Sean O'Kane, *How the Tesla Model 3 Compares to the Model S and Chevy Bolt*, Verge, July 31, 2017 (stating that Tesla has more than 100,000 Model 3s sold and is working toward 500,000 preorders, while the Chevy Bolt is not likely to sell 200,000 "until 2018 or 2019 at the earliest"), https://www.theverge.com/2017/7/31/16068044/tesla-model-3-vs-model-s-chevy-bolt-electric-car-price-features.
66. Farber, *supra* note 58 (citing a 2016 Wood Mackenzie report); *Electric Vehicles to Be 35% of Global New Car Sales by 2040*, Bloomberg New Energy Fin., Feb. 25, 2016, https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/.
67. Katy Barnato, *This Country Has Hit a Major Milestone for Electric Cars—Here's How*, CNBC, May 24, 2016, http://www.cnbc.com/2016/05/24/this-country-has-hit-a-major-milestone-for-electric-cars-heres-how.html.
68. CAA, 42 U.S.C. §§7401-7671q; EPCA, Pub. L. No. 94-163, 89 Stat. 871 (enacted Dec. 22, 1975). Enhancing the efficiency of the ICE is another important component of a move to decarbonize the LDV fleet. For instance, DOE is working to increase the efficiency of ICEs for passenger vehicles, resulting in fuel economy improvements of 25% for gasoline vehicles and 40% for diesel vehicles, compared to 2010. By 2020, DOE aims to improve the fuel economy of gasoline vehicles by 35% and diesel vehicles by 50%, compared to 2010 gasoline vehicles. DOE, Office of Energy Efficiency and Renewable Energy, *Advanced Combustion Engines*, https://energy.gov/eere/vehicles/vehicle-technologies-office-advanced-combustion-engines (last visited Feb. 25, 2018).
69. 49 U.S.C. §32902(a).
70. 49 C.F.R. §1.50(f) (2000). Authority is delegated to the NHTSA to "[c]arry out the functions vested in the Secretary by the Motor Vehicle Information and Cost Savings Act of 1972." *Id.; see also* 49 U.S.C. §32902(a) ("[T]he Secretary of Transportation shall prescribe by regulation average fuel economy standards for automobiles manufactured by a manufacturer in that model year.").
71. Bosselman et al., *supra* note 20, at 1104-05.
72. NHTSA, *Corporate Average Fuel Economy*, https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy (last visited Feb. 25, 2018).

prompted, in part, by the U.S. Supreme Court's decision in *Massachusetts v. Environmental Protection Agency*, which made clear that EPA had authority under the CAA to regulate GHG emissions from motor vehicles.[73] Section 202(a) of the CAA authorizes standards for emission of pollutants from new motor vehicles that cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare.[74]

NHTSA joined with EPA to issue joint rulemakings that encompass fuel economy standards as well as GHG emissions standards under the CAA, and termed this the "National Program."[75] The first LDV phase, 2012-2016, was designed with an expectation that the corporate fleet average would improve to 35.5 mpg.[76] The second LDV phase, 2017-2025, was designed to achieve the equivalent of a corporate fleet average of 54.5 mpg.[77] (As discussed below, this number is now undergoing a mid-term evaluation and review by the Donald Trump Administration.) Importantly, these reflect a targeted average of the fleet and do not result in each new model meeting these fuel economy standards.

Instead of mandating that manufacturers create a particular type of car, the National Program uses a credit program to provide flexibility.[78] There is a formula that is used to calculate the CAFE standards for each vehicle using that vehicle's "footprint," which is based on size (using wheelbase and track dimensions).[79] As such, each vehicle manufacturing company ends up with a different CAFE target, depending upon the number and size of vehicles the company actually sells. For instance, "manufacturers can average, bank and trade credits earned to meet standards, and can apply for credits for off-cycle technologies, those that achieve [carbon dioxide] reductions but are not reflected in the current plan."[80] Importantly, EPA included an incentive multiplier in the second phase, allowing additional credits for manufacturers that produce EVs (2:1), PHEVs, (1.6:1) HFCVs (2:1), and compressed natural gas vehicles sold in model years (MYs) 2017-2021.[81] The multipliers phase down gradually in MY 2021 and are eventually eliminated for MYs 2022-2025.[82]

### B. *Emissions Standards*

Federal emissions standards for non-carbon pollutants may also play a role in shifting the type of LDV transportation used. In 2000, EPA issued a final rule that reduced emissions, starting in 2004, through a phase-in that "for the first time [applied] the same set of emission standards covering passenger cars, light trucks, and large SUVs and passenger vehicles."[83] This rule created Tier 2 standards, and "[t]he program is designed to focus on reducing the emissions most responsible for the ozone and particulate matter (PM) impact from these vehicles—nitrogen oxides ($NO_x$) and non-methane organic gases (NMOG), consisting primarily of hydrocarbons (HC) and contributing to ambient volatile organic compounds (VOC)."[84] This rule also sought to reduce the sulfur content of gasoline.[85]

In 2014, EPA finalized a stricter set of standards for these pollutants—the Tier 3 standards—which were effective as of 2017. EPA found that "[t]ogether, the Tier 3, light-duty GHG, and [California's Low Emission Vehicle III] standards will maximize reductions in GHGs, criteria pollutants and air toxics from motor vehicles while streamlining programs and providing regulatory certainty and compliance efficiency."[86] Notably, there are no Tier 3 emissions

73. 549 U.S. 497, 532, 37 ELR 20075 (2007) ("Because greenhouse gases fit well within the [Clean Air] Act's capacious definition of 'air pollutant,' we hold that EPA has the statutory authority to regulate the emission of such gases from new motor vehicles.").
74. 42 U.S.C. §7521(a).
75. These standards were challenged, but ultimately upheld. Coalition for Responsible Regulation, Inc. v. Environmental Prot. Agency, 684 F.3d 102, 149, 42 ELR 20141 (D.C. Cir. 2012), *aff'd in part, rev'd in part sub nom*. Utility Air Regulatory Group v. Environmental Prot. Agency, 134 S. Ct. 2427, 44 ELR 20132 (2014), *and amended sub nom*. Coalition for Responsible Regulation, Inc. v. Environmental Prot. Agency, 606 Fed. Appx. 6, 45 ELR 20072 (D.C. Cir. 2015) (unpublished). The carbon reductions in this program rest on assumptions about the number of miles driven, however, and may not fully take into account the rebound effect, where some customers may drive more than they did before they owned an alternative vehicle, thinking that their increased mileage will be offset by the reduced emissions or need to fill up at a gas station. Steve Sorrell & John Dimitropoulos, UK Energy Research Centre, Working Paper No. UKERC/WP/TPA/2007/010, UKERC Review of Evidence for the Rebound Effect 26-27 (2007).
76. Fact Sheet, NHTSA, NHTSA and EPA Establish New National Program to Improve Fuel Economy and Reduce Greenhouse Gas Emissions for Passenger Cars and Light Trucks (Aug. 2012), http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/CAFE-GHG_Fact_Sheet.pdf.
77. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule, 77 Fed. Reg. 62624, 62627 (Oct. 15, 2012), *available at* https://www.gpo.gov/fdsys/pkg/FR-2012-10-15/pdf/2012-21972.pdf.
78. U.S. EPA, *Building Flexibility With Accountability Into Clean Air Programs* (stating that manufacturers can build any size and type car they choose with the standard applying to the fleet as a whole, rather than requiring each and every car to meet a certain emissions standard), https://www.epa.gov/clean-air-act-overview/building-flexibility-accountability-clean-air-programs (last updated Feb. 16, 2017).
79. Justin Berkowitz & Csaba Csere, *The CAFE Numbers Game: Making Sense of the New Fuel-Economy Regulations*, Car & Driver, Nov. 2011, https://www.caranddriver.com/features/the-cafe-numbers-game-making-sense-of-the-new-fuel-economy-regulations-feature.
80. *Id*. (stating that incentive multipliers for EVs, PHEVs, HFCVs, and compressed natural gas (CNG) vehicles sold in model years 2017 through 2021 allow a manufacturer to get more than one credit for each of these vehicles to use toward its compliance calculation. EVs and HFCVs get a value between 1.5 and 2. PHEVs and CNGs get credit values between 1.6 and 1.3.).
81. Regulatory Announcement, U.S. EPA, EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks 8 (Aug. 2012) (EPA-420-F-12-051), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EZ7C.PDF?Dockey=P100EZ7C.PDF. Note that incentive multipliers do not apply to HEVs. *See id*.
82. *Id*.
83. Control of Air Pollution From New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements, 65 Fed. Reg. 6698, 6698 (Feb. 10, 2000) (codified at 40 C.F.R. §§80, 85, 86).
84. *Id*. at 6702.
85. *Id*.
86. Regulatory Announcement, U.S. EPA, EPA Proposes Tier 3 Motor Vehicle Emission and Fuel Standards (2013) (EPA-420-F-13-016a), *available at* https://bit.ly/2tislGy. The Tier 3 standards are the most recent standards for light-duty vehicle and fuel standards adopted by EPA in 2014, which replaced earlier Tier 2, Tier 1, and pre-Tier 1 standards.

standards for carbon—only for the conventional CAA pollutants.[87] In 2012, however, California moved beyond the federal emissions standards by adopting amendments to the state's low emission vehicle (LEV) regulations that included more stringent emissions standards for both criteria pollutants and GHGs for new passenger vehicles.[88]

Although §209 of the CAA preempts all state and local governments from adopting emissions standards for new motor vehicles, §209(b) requires EPA to waive preemption for the state of California to implement its emissions standards, which are as protective as the applicable federal standards in the aggregate and consistent with the applicable federal standards.[89] For the California program as a whole, there is a need based on the compelling and extraordinary circumstances in the state. (For example, the climate and topography in California result in exceptional ozone compliance challenges.) If EPA grants a preemption waiver for a California standard, other states may then elect to adopt standards identical to California's standards. Relying on this preemption waiver provision, the California Air Resources Board (CARB) has embarked on a ZEV standards initiative, which mandates the production of EVs as a certain share of the vehicle fleet. A ZEV is more than a vehicle that emits no GHGs; it also emits no PM, $NO_x$, HCs, or other pollutants. This initiative made California the first in the nation to mandate a particular technology, the ZEV, as opposed to an emissions standard.

The ZEV program includes a requirement that automakers hold a certain number of EV credits each year by producing a certain number of EVs (including HFCVs and PHEVs). This creates a ZEV market that allows manufacturers to purchase excess credits from other manufacturers if they cannot build the number of EVs required. This ZEV mandate requires automakers to sell 15.4% ZEVs of their 2025 new vehicles sales fleet.[90] The plan calls for consumer incentives to promote ZEVs such as high-occupancy vehicle (HOV) lane access and additional charging stations.[91] The plan also requires establishing rates for charging vehicles that are competitive with gasoline and supporting the adoption of public and private ZEV fleets. Mary Nichols, chair of CARB, explains, "If we're going to get our transportation system off petroleum, we've got to get people used to a zero-emissions world, not just a little-bit-better version of the world they have now."[92] Nichols wants 100% of the new vehicles sold to be zero or almost zero emissions by 2030, an important step in meeting the governor's goals of an 80% reduction in GHG emissions by 2050.[93]

California's program has resulted in an excess of ZEV credits, prompting regulators to reassess the stringency of the standards and automakers to object to moving targets.[94] Nevertheless, nine states plus the District of Columbia have followed California's lead, opted into the ZEV initiative, and agreed to put 3.3 million ZEVs on the road by 2025.[95] (Currently, California provides that each state's share of the ZEV targets can be sold in California. If this option were removed, automakers might be forced to add to their distribution network in each participating state.) The 2018-2025 ZEV mandate is the sixth iteration of rules that began in 1990.[96]

### C. *Fiscal Incentives*

The third major category of legal initiatives to achieve LDV decarbonization involves fiscal incentives. These are categorized into three areas: (1) tax benefits; (2) subsidies; and (3) loans. The first way that financial carrots have been used to incentivize alternative vehicles is with tax breaks. The U.S. government provides a federal tax credit of up to $7,500 for those who purchase electric or hybrid vehicles,[97] and a tax credit for the qualifying costs of the purchase and installation of EV charging stations of up to $1,000 on personal property and up to $30,000 on commercial property.[98] Several states offer taxpayers who purchase EVs tax credits up to $6,000 (Colorado) and rebates up to 80% of the cost (Illinois).[99]

The second way the government is trying to encourage more alternative vehicles with fiscal incentives is by providing various subsidies. Subsidies come in many forms, including HOV benefits, parking and registration

87. The CAA identifies six criteria air pollutants: sulfur dioxide, nitrogen dioxide, ozone, particulate matter, lead, and carbon monoxide.
88. California Air Resources Board (CARB), *Low-Emission Vehicle Program*, https://www.arb.ca.gov/msprog/levprog/levprog.htm (last reviewed Jan. 25, 2017).
89. 42 U.S.C. §7543.
90. Auto Alliance, *State Electric Vehicle Mandate*, https://autoalliance.org/energy-environment/state-electric-vehicle-mandate/ (last visited Feb. 25, 2018).
91. Virginia McConnell & Joshua Linn, *Consumer Subsidies Are Not the Only Subsidies for EVs*, Resources for Future, July 17, 2013, http://www.rff.org/blog/2013/consumer-subsidies-are-not-only-subsidies-evs.
92. John Lippert, *California Has a Plan to End the Auto Industry as We Know It*, Bloomberg, Aug. 3, 2015, https://www.bloomberg.com/news/articles/2015-08-03/california-regulator-mary-nichols-may-transform-the-auto-industry.
93. *California's Pursuit of Zero-Emission-Vehicle Quotas Tightens Squeeze on Automakers*, Bloomberg, Aug. 20, 2015 (reporting that eight states released an action plan in May 2014 detailing an agreement originally announced in 2013 to put 3.3 million ZEVs on the road by 2025); Lippert, *supra* note 92.
94. John Lippert, *California Ponders Changes to Fuel Rules as Tesla Cries Foul*, Bloomberg, July 7, 2016, https://www.bloomberg.com/news/articles/2016-07-07/california-considers-change-to-fuel-rules-as-tesla-cries-foul.
95. ZEV Program Implementation Task Force, Multi-State ZEV Action Plan 2 (2014), http://www.nescaum.org/topics/zero-emission-vehicles/multi-state-zev-action-plan.
96. Cal. Code Regs. tit. 13, §1962.2 (2017); CARB, *Zero-Emission Vehicle Legal and Regulatory Activities and Background*, https://www.arb.ca.gov/msprog/zevprog/zevregs/zevregs.htm (last reviewed Oct. 27, 2014).
97. Fueleconomy.gov, *Federal Tax Credits for All-Electric and Plug-In Hybrid Vehicles*, https://www.fueleconomy.gov/feg/taxevb.shtml (last visited Feb. 25, 2018). This tax credit will expire when 200,000 qualified plug-in electric vehicles (PEVs) have been sold by each automotive manufacturer. *Id*.
98. U.S. Department of Transportation, Federal Highway Administration, *Fixing America's Surface Transportation Act or "FAST" Act* [hereinafter *Fixing America's Surface Transportation Act*], https://www.fhwa.dot.gov/fastact/summary.cfm (last modified Feb. 8, 2017); Fact Sheet, Connecticut, Electric Vehicle Charging Stations Tax Credit (Jan. 8, 2016) (the credit applied until Dec. 31, 2016), http://www.ct.gov/deep/lib/deep/air/electric_vehicle/evse_fact_sheet.pdf; DOE, Alternative Fuels Data Center, *Federal Laws and Incentives for Electricity* [hereinafter *Federal Laws and Incentives for Electricity*], http://www.afdc.energy.gov/fuels/laws/ELEC/US (last updated Apr. 21, 2017).
99. Plug in America, *State & Federal Incentives*, https://pluginamerica.org/why-go-plug-in/state-federal-incentives/ (last visited Feb. 25, 2018).

benefits, utility rate reductions, and free charging.[100] Federal incentives include research project grants, alternative fuel technology loans, and requirements for federal fleets (including requirements for a fleet management plan, low GHG emissions vehicle acquisitions, and renewable fuel infrastructure installation).[101] On a state level, at least 37 states and the District of Columbia have current incentives that would provide HOV lane exemptions, financial incentives, vehicle inspections or emissions test exemptions, parking incentives, or utility rate reductions.[102] Several major cities have experimented with subsidies, including cities across California that offer rebates for public agencies wanting to add ZEVs and LEVs to fleets, and financial incentives[103] allowing low-income individuals to replace high-polluting vehicles.[104]

A third way the government is encouraging the proliferation of alternative vehicles is with loans. For instance, the U.S. Department of Energy (DOE) has provided a number of loans to manufacturers of alternative vehicles through the Advanced Technology Vehicles Manufacturing (ATVM) program (funded as a result of the Energy Independence and Security Act of 2007[105]).[106] Four automakers received initial funding from the ATVM program in the first go-round: Nissan ($1.4 billion), Tesla ($465 million), Fisker ($192 million), and Ford ($5.9 million).[107] In addition, the ATVM Loan Program allows ATV manufacturers and ATV components manufacturers to qualify for loans for up to 30% of the cost of the building or revamping of facilities in the United States to produce qualified ATV products.[108]

DOE's Vehicle Technologies Office develops and deploys innovative vehicle technologies that prioritize and bolster our clean energy economy and encourage a transition from imported to domestic alternative fuels, efforts that reduce overall petroleum use and make the technologies in use much more efficient and cost effective.[109] In 2014, former Energy Secretary Ernest Moniz clarified the eligibility requirements for component suppliers that manufacture fuel-efficient technologies and announced steps to be more responsive to loan applicants.[110] A bipartisan group in the U.S. Senate proposed the Vehicle Innovation Act of 2017, which would continue and strengthen the program by authorizing additional Vehicle Technologies Office resources to encourage research and development (R&D), including $313.6 million in funding for fiscal year 2018 with a 4% increase each year through 2022.[111]

Some economists criticize these financial inducements as an inefficient means of achieving fleet electrification and fear that the potential benefits of AFVs are minimized because public and private funds to support adoption of new technologies tend to focus on purchase rebates instead of infrastructure investment.[112] Although drivers of AFVs are happy to enjoy the variety of subsidies provided to them, it is unclear how many are actually swayed away from an ICV purchase because of the current subsidies.[113]

### *D. Barriers to AFV Development*

Despite these initiatives, AFVs face a number of barriers to reaching the DDPP goals. This section focuses on four of the most significant barriers: (1) cost; (2) infrastructure deficiencies; (3) public perception and preferences; and (4) misaligned financial incentives.

#### 1. Cost

A first obstacle to AFV development, but one that is beginning to fade, is the higher up-front sticker price of AFVs compared to traditional vehicles. The high cost of EVs is impacted both by the expense associated with the new supply chain products required of EVs, as well as the Li-ion

100. *See*, *e.g.*, DOE, Alternative Fuels Data Center, *Recent State Actions* [hereinafter *Recent State Actions*], http://www.afdc.energy.gov/laws/recent (last updated May 21, 2017).
101. *Federal Laws and Incentives for Electricity*, *supra* note 98.
102. *Recent State Actions*, *supra* note 100; Peter W. Davidson, *Electric Vehicle Manufacturing Taking Off in the U.S.*, DOE, May 30, 2014, http://energy.gov/lpo/articles/electric-vehicle-manufacturing-taking-us.
103. News Release, CARB, Making the Cleanest Cars Affordable (June 23, 2015), https://www.arb.ca.gov/newsrel/efmp_plus_up.pdf.
104. Dan Welch, *US Cities Offer Diverse Incentives for Electric Vehicles*, Center for Climate & Energy Solutions, Aug. 7, 2015, http://www.c2es.org/blog/welchd/us-cities-offer-diverse-incentives-electric-vehicles; Plug-In Electric Vehicle Resource Center, *Define Your Incentives Search*, http://driveclean.ca.gov/pev/Incentives.php (last visited Feb. 25, 2018).
105. H.R. 6, 110th Cong. §136 (2007) (enacted), https://www.congress.gov/bill/110th-congress/house-bill/6/text.
106. Danny King, *US Senate Authorizes DOE Green Car Loan Program [UPDATE]*, Autoblog, Apr. 23, 2016, http://www.autoblog.com/2016/04/23/us-senate-doe-loan-program/.
107. *Id.*; American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong.
108. 42 U.S.C. §17013; DOE, Loan Programs Office, *ATVM Loan Program*, http://energy.gov/lpo/services/atvm-loan-program (last visited Feb. 25, 2018).
109. DOE, Office of Energy Efficiency and Renewable Energy, *Vehicle Technologies Office*, https://energy.gov/eere/vehicles/vehicle-technologies-office-0 (last visited Feb. 25, 2018).
110. Press Release, DOE, Sec. Moniz Discusses Advanced Technology Vehicle Manufacturing Loans (Apr. 2, 2014), http://www.energy.gov/articles/sec-moniz-discusses-advanced-technology-vehicle-manufacturing-loans.
111. S. 1225, 115th Cong. (2017), https://www.congress.gov/bill/115th-congress/senate-bill/1225/text.
112. Yu Marco Nie et al., *Optimization of Incentive Policies for Plug-In Electric Vehicles*, 84 Transp. Res. Part B: Methodological 103 (2016) ("A striking example from the case study shows that increasing subsidy to [BEVs] from $4000 to $10,000 achieves virtually nothing at a cost of about $123,000,000 (or more than 35% increase in the total budget)"); James Archsmith et al., Energy Institute at Haas, Working Paper No. 263, From Cradle to Junkyard: Assessing the Life Cycle Greenhouse Gas Benefits of Electric Vehicles 28 (2015), *available at* https://ei.haas.berkeley.edu/research/papers/WP263.pdf; James Bushnell, *Economists Are From Mars, Electric Cars Are From Venus*, Energy Inst. Haas, Dec. 14, 2015, https://energyathaas.wordpress.com/2015/12/14/economists-are-from-mars-electric-cars-are-from-venus/.
113. *See* Matt Richtel, *American Drivers Regain Appetite for Gas Guzzlers*, N.Y. Times, June 24, 2016, http://www.nytimes.com/2016/06/28/science/cars-gas-global-warming.html?_r=0. *But see* Clair Johnson et al., Center for Sustainable Energy, The Clean Vehicle Rebate Project: Summary Documentation of the Electric Vehicle Consumer Survey, 2013-2015 Edition 22 (2017), *available at* https://cleanvehiclerebate.org/sites/default/files/attachments/CVRPConsumerSurvey2013-15Reference.pdf. In addition, some reports find that manufacturers call for more fiscal incentives than other legal tools. Saqib Rahim, *Electric Carmakers Focus on Incentives, Not Carbon Prices*, ClimateWire, July 28, 2010, https://www.scientificamerican.com/article/electric-carmakers-focus/.

batteries, the dominant battery for EVs, which make up approximately one-third of the cost of EVs.[114] Although some of the cost is recovered in fuel savings, federal tax credits, or state incentives, consumers are more likely to shy away from these unfamiliar alternative EVs until they become more affordable.[115] While sales of EVs have increased over the past two decades, deployment of this technology still has a long way to go.[116]

The high cost of EVs is exacerbated by the low initial cost of ICVs. Most consumers still focus on the immediate short-term sticker price comparison as opposed to factoring in longer term benefits, and, on average, ICVs still cost less than their EV counterparts.[117] Although studies demonstrate the lower operating and maintenance costs associated with EVs over time,[118] some studies suggest that EVs depreciate faster than ICVs.[119]

In addition, the consumer impacts of CAFE standards were discussed in some detail as part of EPA's Draft Technical Assessment Report, which identified a number of issues likely to impact consumer car-buying behavior, including manufacturer pricing, payback period, fuel economy, and depreciation—and even this is not an exhaustive list.[120] EPA projections in 2012 estimated that MY 2025 emissions reduction goals of 140 million metric tons GHG savings per year would add an average of $2,000 in incremental first-year costs (including a higher sticker price and higher sales taxes, plus insurance and maintenance).[121]

The overall average lifetime incremental vehicle cost increase was estimated at $2,300 to $2,400, but owners who drive the car for the full vehicle lifetime obtain a savings of $3,400 to $5,000 over the vehicle's lifetime.[122] This is because fuel rate savings are expected to be in the $5,700 to $7,400 range.[123] That puts the projected payback period for higher up-front costs at about 3.2 to 3.4 years.[124] Used vehicle purchasers stand to benefit more, as the payback period on a five-year-old vehicle is 1.1 years, and only six months for a 10-year-old vehicle.[125] As a comparison, one study estimated that, in mass production, the up-front cost of HFCVs would be about $3,600 more than conventional ICVs.[126] Another study determined that HFCVs were significantly more cost effective than EVs that require a 300-mile range, and HFCVs showed notable-but-lesser superiority where the comparable vehicles have a 200-mile range.[127]

### 2. Actual and Perceived Infrastructure Deficiencies

A second challenge is the lack of alternative vehicle fueling stations, and public perception that underestimates existing fueling options. Studies suggest that people generally do not believe there are enough public charging stations for them to seriously consider getting a purely EV.[128] Almost 80% of people surveyed had no knowledge of any public charging station near them.[129] These perceptions are fueled by a lack of knowledge about alternative vehicles, combined with an insufficient track record to provide data to counter these perceptions.

Most, if not all, plug-in electric vehicles (PEVs) come with a Level 1 charger that can be plugged into a standard three-prong 120-volt outlet, so no additional charging equipment is required to charge at home if there is a plug at the needed location.[130] Overnight charging at home is simple, but eight hours of charging on a Level 1 charger may only replenish the vehicle for about 40 miles of driving range.[131] Residential charging would therefore satisfy the daily needs of many homeowner drivers, as studies indicate the average person commutes 26-32 miles per day.[132] But

114. Poullikkas, *supra* note 29, at 1282.
115. Al-Alawi & Bradley, *supra* note 33, at 198, 199.
116. DOE, Alternative Fuels Data Center, *U.S. HEV Sales by Model*, https://www.afdc.energy.gov/data/10301 (last updated May 21, 2017); DOE, Alternative Fuels Data Center, *U.S. Plug-In Electric Vehicle Sales by Model*, https://www.afdc.energy.gov/data/10567 (last updated May 21, 2017).
117. Eric Loveday, *Electric Cars to Cost Same as, or Less Than ICE Within a Decade*, Inside EVs, http://insideevs.com/electric-cars-to-cost-same-as-or-less-than-ice-within-a-decade/ (last visited Feb. 25, 2018); Jens Hagman et al., *Total Cost of Ownership and Its Potential Implications for Battery Electric Vehicle Diffusion*, 18 Res. Transp. Bus. & Mgmt. 11 (2016).
118. *Id.*; Marco Miotti et al., *Personal Vehicles Evaluated Against Climate Change Mitigation Targets*, 50 Envtl. Sci. & Tech. 10795, 10802 (2016) ("We find that the least-emitting cars also tend to be the most affordable ones within and, in many cases, even across different powertrain technologies."); Bernd Propfe et al., Cost Analysis of Plug-In Hybrid Electric Vehicles Including Maintenance & Repair Costs and Resale Values, Presentation at EVS26 International Battery, Hybrid, and Fuel Cell Electric Vehicle Symposium (May 6-9, 2012), at 4, http://elib.dlr.de/75697/1/EVS26_Propfe_final.pdf.
119. Propfe et al., *supra* note 118, at 5; *see also* Chris Woodyard, *Depreciation Hits Electric Cars Hard*, USA Today, Dec. 26, 2013 (stating that a Kelley Blue Book "analysis suggests that most will depreciate more dramatically over five years than their conventional counterparts"), https://www.usatoday.com/story/money/cars/2013/12/26/plug-in-cars-electric-cars-depreciation-resale-residual-value/4194373/.
120. U.S. EPA et al., Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 (2016) (EPA-420-D-16-900), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF.
121. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, *supra* note 77, at 62774-75.
122. *Id.* at 62775.
123. *Id.*
124. *Id.*
125. *Id.*
126. Matthew A. Kromer & John B. Heywood, Massachusetts Institute of Technology, Publication No. LFEE 2007-03 RP, Electric Powertrains: Opportunities and Challenges in the U.S. Light-Duty Vehicle Fleet 118 tbl. 53 (2007), http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.208.4138&rep=rep1&type=pdf.
127. C.E. (Sandy) Thomas, *Fuel Cell and Battery Electric Vehicles Compared*, 34 Int'l J. Hydrogen Energy 6005, 6019 (2009).
128. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, *supra* note 77, at 62775.
129. Mark Singer, National Renewable Energy Laboratory, Consumer Views on Plug-In Electric Vehicles—National Benchmark Report 20 (2016) (NREL/TP-5400-65279), *available at* http://www.afdc.energy.gov/uploads/publication/consumer_views_pev_benchmark.pdf.
130. DOE, Alternative Fuels Data Center, *Developing Infrastructure to Charge Plug-In Electric Vehicles*, http://www.afdc.energy.gov/fuels/electricity_infrastructure.html (last updated Oct. 25, 2017).
131. For example, a Chevy Bolt gets about 4 miles of charge for every hour of Level 1 charge, suggesting a 8pm-6am charge would provide 40 miles. EnergySage, https://www.energysage.com/electric-vehicles/charging-your-ev/charging-chevy-bolt/.
132. AAA, Americans Spend an Average 17,600 Minutes Driving Each Year, https://newsroom.aaa.com/2016/09/americans-spend-average-17600-minutes-driving-year/.

this provides little comfort for the millions of Americans who live in apartments or condominiums without charging access at home.

For this and many other reasons, at-home charging options alone are not enough and the United States does not have enough public chargers to alleviate "range anxiety" for potential EV customers who are concerned about being stranded away from home with no nearby location to "fill up." Unlike in Japan, which now has more EV charging stops than gas stations,[133] the United States only has about 14,000 electric charging stations compared to more than 150,000 gas stations.[134] Public commercial chargers are thus essential to provide availability to recharge outside of the home, as well as faster charging times for EV owners. Level 2 chargers can charge a car in four to six hours, while Level 3 direct current (DC) fast chargers can provide a 50%-80% charge in 20 to 30 minutes depending on the technology, making their development critical to EV deployment.[135] Access to this kind of technology could help facilitate growth of an EV installed base.

Even as public EV chargers develop, other issues must be addressed. For instance, even if owners can locate an EV charger, there is concern that other cars may be monopolizing the spaces. Some chargers provide free electricity or limited enforcement of EV charging parking restrictions that result in cars overstaying their welcome even after they have reached a full charge.[136] In addition, public EV charging stations are still clustered in certain parts of the country, and their limited locations make it more difficult for those who are dependent on only one car to enjoy the same mobility as they do with their ICVs.[137] Even as EV chargers begin to proliferate, it takes more planning to plot a route that brings an EV in proximity to chargers.[138]

Hydrogen vehicles face even greater infrastructure problems, and have even fewer options. For hydrogen vehicles, the main challenge is access to fuel. First, there is no home fueling option for hydrogen vehicles as there is for EVs. Second, public charging is much more limited. California is home to most of the hydrogen fuel stations, but only about 50 public stations were expected to be available by the end of 2017.[139] As of March 2018, there were only 35 retail stations.[140] Outside of California, there are only five hydrogen fuel stations and none are retail stations.[141] Hydrogen fuel stations can follow the model of existing gas stations, and can even be located on existing sites, but developing such an infrastructure has its challenges.

Most importantly, building hydrogen fuel stations is not cheap. More than a decade ago, Shell Oil Company estimated that it would cost about $12 billion to develop an initial nationwide network of 11,000 hydrogen stations in cities and on highways.[142] The total cost to transition primarily to hydrogen vehicles (if that were the plan) could cost hundreds of billions of dollars. The number of hydrogen fueling stations would need to increase dramatically, and those stations would need a way to get the actual hydrogen fuel consumers need to their stations. Economically moving hydrogen could likely require hydrogen-specific steel pipeline infrastructure, which researchers determined could cost as much as 68% more than natural gas pipelines per mile.[143] Some of these costs could be reduced by modifying outdated hydrogen pipeline codes to allow for higher strength, reduced thickness pipe.[144] However, more distributed generation of hydrogen, from energy sources like biomass or electricity, that is closer to the consumption site could allow for manageable delivery via trucks. This lack of fuel availability makes HFCVs limited in flexibility, and can lead to long refueling times. Although filling the tank with hydrogen takes about the same amount of time as gasoline refueling, the limited number of pumps can lead to long waits.

Unless private and public fuel supply stations become more commonplace, EVs will only remain attractive for people who can plug in their cars at home or work and who mainly use them for commuting and for city driving. These vehicles will be less attractive for those who take road trips or travel long distances for their work or social engagements, as well as for the myriad of Americans who do not own homes, stunting the growth of EV chargers across the country.[145] Similarly, hydrogen vehicles may only be seen in California and for larger, heavy-duty vehicles because of their relative ease at scaling up to heavier loads.[146]

133. Justin McCurry, *Japan Now Has More Electric Car Charge Points Than Petrol Stations*, Guardian, May 10, 2016 (reporting on a survey by Nissan, maker of the electric Leaf with its 107-mile charge; this study appears to include personal homes as charging stations whereas the U.S. number does not), https://www.theguardian.com/world/2016/may/10/japan-electric-car-charge-points-petrol-stations.

134. NACS, 2015 Retail Fuels Report 28-29 (2015), http://www.nacsonline.com/YourBusiness/FuelsReports/2015/Documents/2015-NACS-Fuels-Report_full.pdf.

135. EVTown, *Levels of Charging*, http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html (last visited Feb. 25, 2018).

136. *See* Tom Saxton, *Workplace Charging—The Goldilocks Approach*, Plug in Am., Jan. 15, 2015, https://pluginamerica.org/workplace-charging-goldilocks-approach/.

137. *Id*.

138. *But see* DOE, Alternative Fuels Data Center, *Electric Vehicle Charging Station Locations*, http://www.afdc.energy.gov/fuels/electricity_locations.html (last updated Apr. 21, 2017).

139. DOE, Alternative Fuels Data Center, *Hydrogen Fueling Stations*, http://www.afdc.energy.gov/fuels/hydrogen_stations.html (last updated May 18, 2017).

140. DOE, Alternative Fuels Data Center, *Hydrogen Fueling Station Locations*, http://www.afdc.energy.gov/fuels/hydrogen_locations.html (last updated Mar. 16, 2018).

141. *Id.*

142. Joan Ogden, *The Transition to Hydrogen*, Access, Fall 2005, at 10, *available at* http://www.accessmagazine.org/articles/fall-2005/transition-hydrogen/.

143. Jeffrey W. Sowards et al., *Economic Impact of Applying High Strength Steels in Hydrogen Gas Pipelines*, 40 Int'l J. Hydrogen Energy 10547-58 (2015), http://www.sciencedirect.com/science/article/pii/S036031991501575X.

144. *NIST Calculates High Cost of Hydrogen Pipelines, Shows How to Reduce It*, Nat'l Inst. Standards & Tech., July 20, 2015, https://www.nist.gov/news-events/news/2015/07/nist-calculates-high-cost-hydrogen-pipelines-shows-how-reduce-it.

145. *See* Henry A. Bonges III & Anne C. Lusk, *Addressing Electric Vehicle (EV) Sales and Range Anxiety Through Parking Layout, Policy, and Regulation*, 83 Transp. Res. Part A: Pol'y & Prac. 63 (2015).

146. *See* Paul A. Eisenstein, *Hydrogen Could Help Heavy Trucks Clean Up Their Act*, NBC News, Dec. 6, 2016, https://www.nbcnews.com/tech/tech-news/hydrogen-could-help-heavy-trucks-clean-their-act-n692561.

### 3. The Alternative Vehicle Challenge: Public Perception and Preferences

In addition to increased costs and charging infrastructure deficits, a third obstacle is the public perception facing alternative vehicles themselves. One hundred years of gas-guzzling cars breeds a type of familiarity that does not exist with alternative vehicles. Some customers are drawn to what makes them most comfortable, a known quality, an engine they understand, and an extensive selection of models to fit every preference. It would be naïve to ignore the fact that cars are a reflection of one's personality, and a shift to AFVs may require a shift in cultural norms concerning what is acceptable in different communities. These perceptions and preferences manifest themselves in various ways, but this section focuses on people who are hesitant to purchase alternative vehicles due to concerns about performance, safety, limited selection, and a comfort level with ICEs that does not exist for AFVs.[147]

First, some customers are hesitant to purchase AFVs because they are not confident in the performance of these vehicles. This would address issues beyond range anxiety and include concerns about the true environmental comparisons of AFVs and ICVs. For instance, in many parts of the country, fossil fuels like coal and natural gas are still the dominant source of electricity. Although the environmental emissions are less than oil, more customers are likely to move to EVs where the grid that charges them has a larger percentage of renewable energy providing the electricity. Additionally, although the EVs emit less air and GHG pollutants, a full life-cycle analysis indicates that they may emit more toxins over their lifetime because of pollutants associated with lithium mining and disposal.[148] EVs generally rely on lithium batteries to power the electric components of the vehicles, and lithium is found in limited locations around the world.[149]

Second, some customers are reluctant due to safety concerns. As with all new technologies, fear of the unknown trumps fear of the known.[150] Resistance to hydrogen vehicles began due to safety concerns, and some even still think of the Hindenburg explosion when hydrogen is discussed.[151] There are also flammability concerns related to hydrogen, which are similar to other fuel-air mixes. Though it is flammable, hydrogen disperses quickly, thus dissolving quickly into levels that will not combust.[152] In addition, hydrogen is odorless and tasteless, and it is not toxic except in very high concentrations. Risk of electric shock from HFCVs is also a potential concern, as most HFCVs use a much higher voltage to power their electric motors than the current industry norm of 14 volts.[153] The industry is transitioning to a 42-volt standard, in part because shocks from 50 volts or higher can stop a human heart. In contrast, some HFCVs use electric motors requiring 250 volts or more, which can create significant risk. Thus, like all fuels, safe handling is essential, but that is required across fuel sources.[154]

Third, some customers are hesitant due to the limited model selection compared to ICVs. For many years, this was true for EVs. There are approximately a dozen all-EV options,[155] 11 PHEVs and almost 40 hybrids with no plug,[156] and three hydrogen vehicle options[157] compared to the hundreds of ICE options. The number of options is growing, however, and a number of high-end manufacturers like BMW, Volvo, Jaguar, and Audi are providing alternative vehicle options that satisfy the style and drivability desires of many car customers.[158]

Although not as many as for EVs, manufacturers are also entering the HFCV market. Honda offered an early version with its FCX, and began offering its Clarity HFCV for lease in late 2016, at a lower price than originally anticipated.[159] Hyundai has offered a limited number of the Tuc-

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147. Joyce McLaren et al., National Renewable Energy Laboratory, Emissions Associated With Electric Vehicle Charging: Impact of Electricity Generation Mix, Charging Infrastructure Availability, and Vehicle Type 16 (2016) (NREL/TP-6A20-64852), *available at* https://www.afdc.energy.gov/uploads/publication/ev_emissions_impact.pdf.
148. John W. Brennan & Timothy E. Barder, Arthur D. Little, Battery Electric Vehicles vs. Internal Combustion Engine Vehicles 36 (2016), http://www.adlittle.de/sites/default/files/viewpoints/ADL_BEVs_vs_ICEVs_FINAL_November_292016.pdf.
149. Henry Sanderson, *Electric Car Demand Sparks Lithium Supply Fears*, Fin. Times, June 8, 2017, https://www.ft.com/content/90d65356-4a9d-11e7-919a-1e14ce4af89b.
150. Press Release, American Automobile Association, Electric Vehicles Continue to Grow in Popularity but Education Still Needed Says AAA (May 9, 2013), http://newsroom.aaa.com/2013/05/electric-vehicles-continue-to-grow-in-popularity-but-education-still-needed-says-aaa/.
151. *See* Joseph J. Romm, The Hype About Hydrogen 104 (2004). "Hydrogen's bad reputation as a transportation fuel in part stems from the Hindenburg disaster.") Ironically, one study concluded that that extremely flammable paint on the skin of the dirigible was the true cause of the disaster. Craig Davis et al., Hydrogen Fuel Cell Vehicle Study, A Report Prepared for the Panel on Public Affairs (POPA), American Physical Society, at 21 (June 12, 2003), *available at* https://www.aps.org/policy/reports/occasional/upload/fuelcell.pdf.
152. Concerns have similarly been raised about CNG vehicles because natural gas is recognized as flammable. Consumers raised concerns about accident risks, thinking that CNG vehicles might be more dangerous than traditional vehicles. However, gasoline pools when it leaks, creating fire and explosion risks. In contrast, like hydrogen, CNG is lighter than air, so it dissipates quickly, and CNG tanks are thick and rigorously tested. Joshua P. Fershee, *Struggling Past Oil: The Infrastructure Impediments to Adopting Next Generation Transportation Fuel Sources*, 40 Cumb. L. Rev. 87, 109 (2009).
153. The International Consortium for Fire Safety, Health, and the Environment, Safety Issues Regarding Fuel Cell Vehicles and Hydrogen Fueled Vehicles, https://dps.mn.gov/divisions/sfm/programs-services/Documents/Responder%20Safety/Alternative%20Fuels/FuelCell-HydrogenFuelVehicleSafety.pdf.
154. *See* $H_2$USA, *FAQ*, http://www.h2usa.org/faq (last visited Feb. 25, 2018).
155. *Electric Cars 101: The Answers to All Your EV Questions*, Consumer Rep., Mar. 29, 2017, http://www.consumerreports.org/cro/2013/03/electric-cars-101/index.htm.
156. Anthony Ingram, *Every 2014 and 2015 Hybrid Car in the U.S.: Ultimate Guide*, Green Car Rep., Aug. 25, 2014, http://www.greencarreports.com/news/1075984_every-2014-and-2015-hybrid-car-in-the-u-s-ultimate-guide/.
157. Liane Yvkoff, *Mainstream Hydrogen Vehicles Are Here—And Expensive*, Forbes, Jan. 31, 2016, http://www.forbes.com/sites/lianeyvkoff/2016/01/31/hydrogen-vehicles-are-here-and-expensive/#2d5e3d9a5612.
158. Danielle Muoio, *Volvo Isn't the Only Company Betting Big on Electric Cars—Here Are 11 SUVs Arriving by 2020*, Bus. Insider Nordic, July 5, 2017, http://nordic.businessinsider.com/2020-electric-suvs-2017-7/; *see also infra* notes 400-05 and accompanying text.
159. *See* Tony Markovich, *Hydro Dip: 2017 Honda Clarity Fuel-Cell Leases Cheaper Than Initially Expected*, Car & Driver, Nov. 18, 2016, http://blog.caranddriver.com/hydro-dip-2017-honda-clarity-fuel-cell-leases-cheaper-than-initially-expected/; Kelly Pleskot, *2017 Honda Clarity Fuel Cell Quick Drive Review: Full Circle*, MotorTrend, Jan. 12, 2017 ("The first new models

son Fuel Cell small crossover,[160] and Lexus and Mercedes Benz have plans to offer HFCVs by 2020. In 2015, the Toyota Mirai became the first mass-produced HFCV to be sold commercially, although the initial run of vehicles was still limited to 700 globally. EPA mileage estimates for the Toyota Mirai are the equivalent of 67 mpg, with a little more than 300 miles of range and a top speed of 108 miles per hour.[161] HFCV efficiency is measured in miles per kilogram of hydrogen fuel, and "the mile per [hydrogen] kilogram measurement is numerically close to a gasoline mile per gallon equivalent [MPGe] (within an MPGe or two)."[162]

Although EVs (some of which are among the safest vehicles on the road)[163] in general seem to generate fewer safety concerns, the same cannot be said for autonomous vehicles, which are poised to be EVs.[164] These concerns about autonomous vehicles may stand in the way of wide-scale adoption. A first concern amongst potential purchasers is that the autonomous modes may fail to recognize and respond to dangers in time.[165] A second concern is that the driver will fail to be as diligent in an autonomous car as in a traditional car. Human nature suggests that as the driver feels less involved in the control of the car, the driver may become less concerned with focusing his or her attention on the task at hand (driving) as opposed to competing lures (texting or calling or playing with the buttons on the autonomous vehicle).

These concerns, though, are waning as more people are starting to believe that the real value of autonomous vehicles is "their potential to improve road safety and reduce fatalities caused by human error."[166] Some states have even removed requirements that a driver be alert (or even present) during operation of an autonomous vehicle. Nevada, for example, adopted legislation providing that "[a] fully autonomous vehicle may be tested or operated on a highway within this State with the automated driving system engaged and without a human operator being present," as long as the vehicle meets certain requirements.[167]

Finally, there are concerns that autonomous vehicles could facilitate more suburban sprawl, add to congestion, increase GHG emissions, negatively impact the job market, create cybersecurity issues, and be more expensive, on average, for households.[168] With proper planning and public policy, however, these concerns need not be a reality.

At the same time that customer preferences indicate some hesitation about alternative vehicles, they also reflect a preference for the status quo of ICEs. Nothing meets our current economic demands like the ICE. Many billions of dollars have been spent on its development, driving down costs of production and maintenance, which created an environment ripe for continued development of manufacturing plants, car designs, and state and federal regulatory regimes.[169] Within this framework, a car culture has developed with more than seven million employees in manufacturing, production, wholesale, and maintenance.[170] For more than 100 years, automotive industry employees have trained and worked in the industry.[171]

Cars with ICEs have been prevalent for so long that the public understands them and knows how to work with them. Customers are unfamiliar with EV technology and some are skeptical that they can learn or find qualified mechanics for this technology.[172] ICEs have also persisted for so long because gas is cheap, relatively safe, and can be stored in a small space.[173] It takes time, money, and patience to change how society thinks about cars. Many believe that the "[c]urrent internal combustion engine technology has many advantages over its potential competitors—lower costs of production and operation, a longer driving range before refueling, and better overall performance—that will ensure its dominance for several decades to come."[174]

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were delivered to customers in December, and it's good timing for Honda."), http://www.motortrend.com/news/2017-honda-clarity-fuel-cell-review/.

160. John Voelcker, *CA Fuel-Cell Car Drivers Say Hydrogen Fuel Unavailable, Stations Don't Work*, Green Car Rep., July 25, 2015, http://www.greencarreports.com/news/1099082_ca-fuel-cell-car-drivers-says-hydrogen-fuel-unavailable-stations-dont-work/.

161. Car & Driver, *Toyota Mirai*, http://www.caranddriver.com/toyota/mirai (last visited Feb. 25, 2018).

162. Antuan Goodwin, *Honda's Second-Gen Clarity Fuel Cell Is So Clean You Could Drink From It*, Road Show by CNET, Nov. 29, 2016 ("Total hydrogen capacity [for a Honda Clarity] is just over 5 kilograms. . . ."), https://www.cnet.com/roadshow/auto/2017-honda-clarity-fuel-cell/preview/.

163. Chris Isidore, *Tesla's Model X Is the Safest SUV Ever Tested*, CNNTech, June 14, 2017, http://money.cnn.com/2017/06/13/technology/tesla-model-x-safety-rating/index.html; *see also* Press Release, Tesla, Tesla Model S Achieves Best Safety Rating of Any Car Ever Tested (Aug. 19, 2013), https://www.tesla.com/blog/tesla-model-s-achieves-best-safety-rating-any-car-ever-tested.

164. *See*, *e.g.*, Cadie Thompson, *GM Will Use Lyft to Launch Its First Self-Driving Car*, Bus. Insider, July 18, 2016, http://www.businessinsider.com/gms-first-autonomous-car-will-be-electric-and-launch-on-lyft-2016-7.

165. *See*, *e.g.*, Troy Griggs & Daisuke Wakabayashi, *How a Self-Driving Uber Killed a Pedestrian in Arizona*, N.Y. Times, Mar. 21, 2018, (reporting on what is "believed to be the first pedestrian death associated with self-driving technology"), https://www.nytimes.com/interactive/2018/03/20/us/self-driving-uber-pedestrian-killed.html; Matt McFarland, *Tesla Driver Killed in Autopilot Crash Said the Technology Was "Great,"* CNNTech, July 1, 2016 (reporting on the death of a Tesla autopilot driver when the car failed to respond when a truck pulled in front of it), http://money.cnn.com/2016/07/01/technology/tesla-driver-death-autopilot/index.html.

166. Ariel Wittenberg, *Autonomous Cars Key to Cutting Oil Imports—Security Panel*, E&E News GreenWire, May 19, 2016, https://www.eenews.net/greenwire/2016/05/19/stories/1060037556.

167. A.B. 69 sec. 8, 79th Sess. (Nev. 2017), https://www.leg.state.nv.us/Session/79th2017/Bills/AB/AB69_EN.pdf; *see also* 2018 Fla. H.B. No. 353, 120th Sess. (proposing legislation providing that human operator is not required to operate fully autonomous vehicle).

168. *See* Paul Lewis et al., Eno Center for Transportation, Beyond Speculation: Automated Vehicles and Public Policy—An Action Plan for Federal, State, and Local Policymakers 1-2 (2017), https://www.enotrans.org/wp-content/uploads/2017/04/AV_FINAL-1.pdf.

169. *See*, *e.g.*, Yuliya Chernova, *Lightweight Engines Still Pack a Punch*, Wall St. J., Sept. 13, 2010, http://www.wsj.com/articles/SB10001424052748703632304575451340914273932.

170. Auto Alliance, *Economy*, http://www.autoalliance.org/auto-jobs-and-economics/2015-jobs-report (last visited Feb. 25, 2018).

171. Wikipedia, *History of the Automobile*, https://en.wikipedia.org/wiki/History_of_the_automobile (last edited Feb. 25, 2018).

172. Jonn Axsen & Kenneth S. Kurani, *Hybrid, Plug-In Hybrid, or Electric—What do Car Buyers Want?*, 61 Energy Pol'y 532-43 (2013).

173. Ralph Kinney Bennett, *Why Gasoline Is Still King*, Am. Enterprise Inst., Dec. 17, 2008, https://www.aei.org/publication/why-gasoline-is-still-king/.

174. Science Clarified, *Will a Viable Alternative to the Internal Combustion Engine Exist Within the Next Decade?*, http://www.scienceclarified.com/dispute/Vol-1/Will-a-viable-alternative-to-the-internal-combustion-engine-exist-within-the-next-decade.html (last visited Feb. 25, 2018).

A number of other behavioral issues must be addressed, including consumer preference for larger LDVs like SUVs[175] and the trending increases in VMT. Because the fuel economy standards are footprint-based,[176] if consumers continue to shift to traditional SUVs and vehicles with larger footprints, then overall fuel economy will rise more slowly even if all models are getting more efficient.[177] Similarly, the number of VMT by light-duty motor vehicles increased 37% from 1990 to 2014, as a result of a confluence of factors, including population growth, economic growth, urban sprawl, and low fuel prices during the beginning of this period.[178] The federal government has even indicated that the greatest impact of autonomous vehicles may be in the miles traveled; autonomous vehicles could lead to either an increase or decrease in VMT.[179] If VMT continues to increase over time, there will be increased pressure on low-carbon energy sources.

### 4. Misalignment Between Financial Motivations and AFV Deployment

A last challenge surrounds the existing business models that revolve around the ICV. First, a number of states have a strong incentive to maintain a core of ICVs due to their heavy reliance on the gasoline tax to fund highway infrastructure in their respective states. The gasoline tax has been in place since 1956 to help pay for construction of the interstate highway system.[180] Since that time, the U.S. Congress has directed the majority of the revenues from this tax to the Highway Trust Fund (HTF).[181] At the federal level, Congress has not increased the tax in more than 20 years, leaving it at 18.4 cents a gallon.[182] As of July 2015, state taxes on gasoline averaged 26.49 cents per gallon, bringing the total tax on gasoline to about 45 cents per gallon.[183] All efforts to reduce reliance on gas-dependent vehicles therefore stand in sharp contrast to efforts to maintain a healthy highway fund. The interplay between fuel economy and the dependence on gasoline tax revenues should not be overlooked, as well as the conflicting demands placed on legislators.

Second, dealers, mechanics, and gas stations have a strong incentive to maintain the dominance of ICVs. Dealers may not be as familiar with AFVs and so are less likely to be able to demonstrate specifics about available incentives, nor be able to exude confidence about charging, range, and battery life-span.[184] More importantly, dealers may also be hesitant to sell AFVs for some of the same reasons that customers may be inclined to purchase them—specifically, the expectation of reduced maintenance costs. These misaligned incentives exist because an essential part of a dealer's business model relies on post-sale revenues related to the sale of used cars, oil changes, and engine maintenance repairs, avoided costs for AFV owners.[185] More car dealers may need to explore options that evolve with the technology, including maintaining and repairing fleets of autonomous vehicles.[186]

In short, although the United States has begun the transition to AFVs, there are a number of obstacles, financial, psychological, and cultural, that stand in the way of a greater shift to AFVs.

## III. Developing Legal Pathways to Achieve LDV Decarbonization

To achieve the DDPP goals in the United States, future law, policies, and programs need to accelerate the transi-

175. Though some models, like the Tesla Model X, are beginning to provide EV alternatives, desire for larger vehicles remains a challenge in the near term for most EVs. *See* John Goreham, *J.D. Power Study Says Electric Cars Too Expensive, Too Small, and Too Unreliable*, Torque News, July 9, 2013, https://www.torquenews.com/1083/jd-power-study-says-evs-too-expensive-too-small-and-too-unreliable-most-consumers.

176. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, *supra* note 77, at 62630 (separate standards were established "for passenger cars and trucks, based on a vehicle's size or 'footprint,' and the actual average achieved fuel economy and GHG emissions levels will be determined by the actual footprints and production volumes of the vehicle models that are produced").

177. Brad Plumer, *How Cheap Oil Is Undermining Obama's Fuel-Economy Rules*, Vox, Mar. 3, 2016, http://www.vox.com/2016/3/3/11155862/crude-oil-prices-fuel-economy.

178. U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014 ES-11 (2016) (EPA 430-R-16-002):

> When electricity-related emissions are distributed to economic end-use sectors, transportation activities accounted for 33.4 percent of U.S. $CO_2$ emissions from fossil fuel combustion in 2014. The largest sources of transportation $CO_2$ emissions in 2014 were passenger cars (42.4 percent), . . . light-duty trucks, which include sport utility vehicles, pickup trucks, and minivans (17.8 percent). . . .

https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf.

179. Gearhart, *supra* note 59, at 12 ("Perhaps the greatest uncertainty associated with connected and autonomous vehicles is the impact these technologies will have on VKT. These technologies may make mobility more effective so that the same societal benefit can be achieved with fewer VKT.").

180. U.S. Department of Transportation, Federal Highway Administration, *Highway History* (Federal-Aid Highway Act of 1956 dedicates the majority of this tax to the federal Highway Trust Fund), http://www.fhwa.dot.gov/infrastructure/gastax.cfm (last updated June 27, 2017).

181. Sean Lowry, Congressional Research Service, The Federal Excise Tax on Motor Fuels and the Highway Trust Fund: Current Law and Legislative History 2 (2015), http://nationalaglawcenter.org/wp-content/uploads/assets/crs/RL30304.pdf; Nie et al., *supra* note 112 (The increased revenue could secure the HTF's financing, promote investments in federal transportation infrastructure, increase values of private property surrounding the improved transportation corridors, and fund low-carbon and renewable energy projects domestically and abroad.).

182. Gilbert E. Metcalf, *Federal Tax Policy Towards Energy*, 21 Tax Pol'y & Econ. 145, 149-50 (2007); Shanjun Li et al., Harvard University, HKS Faculty Research Working Paper Series No. RWP12-006, Gasoline Taxes and Consumer Behavior 2 (2012), https://dash.harvard.edu/bitstream/handle/1/8506866/RWP12-006-Muehlegger.pdf?sequence=1.

183. EIA, *Frequently Asked Questions: How Much Tax do We Pay on a Gallon of Gasoline and Diesel Fuel?* (follow "State-by-state fuel taxes" hyperlink to Excel spreadsheet) (the state taxes usually consist of excise taxes, environmental taxes, sales and/or use taxes, inspection fees, and other miscellaneous charges), http://www.eia.gov/tools/faqs/faq.cfm?id=10&t=10 (last updated Sept. 6, 2017).

184. Eric Evarts, *Dealers Not Always Plugged in About Electric Cars, Consumer Reports' Study Reveals*, Consumer Rep., Apr. 22, 2014, http://www.consumerreports.org/cro/news/2014/04/dealers-not-always-plugged-in-about-electric-cars-secret-shopper-study-reveals/index.htm.

185. Edmunds, *Where Does the Car Dealer Make Money?*, https://www.edmunds.com/car-buying/where-does-the-car-dealer-make-money.html.

186. Joann Muller, *How AutoNation, America's Biggest Car Dealer, Is Future-Proofing Its Business*, Forbes, Jan. 16, 2018, https://www.forbes.com/sites/joannmuller/2018/01/16/how-autonation-americas-biggest-car-dealer-is-future-proofing-its-business/#67cc1dde4120.

tion to a lower carbon LDV fleet with two primary mechanisms: (1) promoting fleet electrification and hydrogen vehicles, and (2) reducing ICVs. These initiatives can take place at all levels of government (federal, state, local, and everything in between) and in concert with private actors (manufacturers and utilities). This part sets forth the legal pathways to overcome the barriers discussed in Part II to achieve essential carbon reductions by 2050.

### A. *Promoting a Reduced-Carbon LDV Fleet*

The first priority is to augment existing legal pathways to continue to develop an LDV fleet of AFVs. Although many point to higher oil prices or a price on carbon as essential to send market signals to both automotive manufacturers and consumers to invest in AFVs,[187] geopolitical factors impact the price of oil more than one country's legal efforts, and carbon prices have repeatedly failed to gain the political traction needed.[188] This section focuses on six of the most critical strategies where public and private laws can help shape a reduced-carbon LDV fleet: (1) develop infrastructure pathways; (2) coordinate the electricity and transportation sectors; (3) reduce AFV costs; (4) tighten fuel economy and emissions standards; (5) integrate autonomous vehicles; and (6) educate drivers.

#### 1. Develop Infrastructure Pathways

One of the most important steps to promote a low-carbon LDV fleet is to develop alternative vehicle infrastructure.[189] A fundamental challenge, however, surrounds the DDPP consideration of roughly equal numbers of HFCVs, EVs, and PHEVs.[190] By moving forward on all three fronts simultaneously, the United States could lose efficiencies that are now in place for ICVs, depending upon variables related to patterns of travel and economies of scale. During the development and deployment of ICVs, every government, oil company, gas station, and consumer was working toward a common goal of developing gas station infrastructure. In contrast, the significant economies of scale of the past may be lost by developing infrastructures in parallel with other chargers that are not compatible with each other unless each fuel supply location becomes an AFV "superstation" that supplies all forms of vehicle fuels. These pathways may be different for electric and hydrogen vehicles, however, and there may be opportunities for different regions to pursue different vehicle options.

□ *EVs*. Charging stations will be essential in residential, commercial, governmental, and industrial locations. The use of charging stations is facilitated by the fact that most vehicles are parked more than 95% of the time, either at home or work.[191] All levels of government can assist with funding of EV infrastructure, and federal, state, and local grants and rebates already apply to a number of areas. For instance, the federal government provides a tax credit worth 30% of the cost of an electric charging station.[192] Such investment can occur at a more local level, too. For example, Salt Lake City, Utah, installed a number of EV charging stations for public use, some of which were initially free, but then transitioned to a modest fee schedule ($2.00 per charging session plus 20 cents per kilowatt hour (kWh)).[193] Congress, state legislatures, and local governments should continue to expand financial and other support infrastructure for expanded use of EVs. In addition, state public utility commissions should support the development of such infrastructure by acting to bolster utility investment in it.

In addition to funding, the Obama White House took the lead in coordinating nationwide EV infrastructure development.[194] To assist in commercial EV infrastructure development, the Obama Administration introduced the EV-Ready building code[195] for adoption in the green building construction code to aid in the commercial EV infrastructure development. The EV-Ready building code was put into effect by Obama's Executive Order No. 13693, but the Council on Environmental Quality has yet to set the required standards.[196]

The Obama Administration also addressed the location of EV chargers, focusing on strategic placement of the scale and location of the chargers, as opposed to the absolute number.[197] Pursuant to the Fixing America's Surface Transportation (FAST) Act, the Federal Highway Administration designated "55 routes that will serve as the basis for a national network of 'alternative fuel' corridors spanning 35 states."[198] By continuing to identify critical corridors, the federal government will be able to prioritize funding and development. To succeed with such corridor planning, regional cooperation will be essential between federal and state officials. For example, seven western states (members of the Western Governors' Association) signed a memorandum of understanding in 2017 to coordinate the

187. *See* Thomas Covert et al., *Will We Ever Stop Using Fossil Fuels?*, 30 J. Econ. Persp. 117, 135-36 (2016).
188. Some modeling during the climate legislation debates even suggested that carbon prices would only add a few cents to the price of gasoline. Rahim, *supra* note 113.
189. Nie et al., *supra* note 112 (finding that "[i]n all tested scenarios, the optimal policy always sets the investment priority to building charging stations").
190. DDPP, *supra* note 10, at 28.
191. David Z. Morris, *Today's Cars Are Parked 95% of the Time*, Fortune, Mar. 13, 2016, http://fortune.com/2016/03/13/cars-parked-95-percent-of-time/; Haddadian et al., *supra* note 47, at 60.
192. *Federal Laws and Incentives for Electricity*, *supra* note 98.
193. Salt Lake City Government, *Transportation—Electric Vehicle Charging Stations*, http://www.slcgov.com/transportation/transportation-electric-vehicle-charging-stations (last visited Feb. 25, 2018).
194. Fact Sheet, *supra* note 64 (see DOE congestion corridors).
195. *Id*.
196. Exec. Order No. 13693, Planning for Federal Sustainability in the Next Decade, secs. 3(h)(ii), 4, 80 Fed. Reg. 15871, 15874, 15876-77 (Mar. 25, 2015), *available at* https://www.gpo.gov/fdsys/pkg/FR-2015-03-25/pdf/2015-07016.pdf.
197. Haddadian et al., *supra* note 47, at 59.
198. Press Release, Federal Highway Administration, Federal Highway Administration Unveils National "Alternative Fuel and Electric Charging" Network (Nov. 3, 2016), https://www.fhwa.dot.gov/pressroom/fhwa1656.cfm.

location of EV infrastructure along major corridors within the states.[199]

The federal and state governments can also play an important coordination function with regards to chargers. They can help standardize the chargers that are being deployed in AFVs and in charging stations via legislation or regulation—by requiring a single standard or by encouraging nongovernmental organizations to work toward a dominant standard.[200] As an example, Tesla chargers are unique and need an adapter to plug into non-Tesla chargers. While there is a single Level 1 and Level 2 charging standard in the United States, there are three competing standards for DC fast-charging Level 3 chargers.[201] Some equipment suppliers have worked to address this by developing multi-standard DC fast-charging stations, but uniformity could help facilitate adoption of EVs.[202]

Public research (funded by and for federal and state governments) and private research (conducted by entities like automakers and utilities) seeking to enhance the speed of these chargers is critical in deciding where to locate EV charging stations. Current EV commercial infrastructure has largely been focused on shopping malls, locations that make sense because drivers can charge their cars when they would otherwise be sitting idle.[203] While it would enhance public perception to see charging stations along highways and public corridors, the more prudent course may be to continue to co-locate them with restaurants or shopping centers so drivers can rationalize the hour-long charge time. Charging an EV takes more time than filling the tank with gasoline, and the chargers need to be installed in places where drivers do not feel like they need to add hours to their journeys to allow time for charging. Although even the fastest chargers require approximately an hour for a full charge, new research suggests that a 10-minute charger may be on the horizon.[204] Alternatively, owners of alternative vehicles may turn to ICE rental cars for longer journeys.[205]

Some states and cities have begun establishing various programs and regulations to facilitate residential charging infrastructure. Other states and cities could do the same. For instance, the Drive Clean Seattle program, which began in 2016, includes support for the installation of EV charging units in homes through a municipal electric company program that pays up-front installation costs and allows repayment through utility bills. It will increase the number of publicly available, fast-charging units for EVs.[206] Similarly, Denver is requiring garages for new homes to have the capacity to fast charge an EV.[207] Hawaii prohibits multiunit dwelling associations from denying EV owners an opportunity to install charging stations.[208]

While these initiatives focus on single-family homes, apartment and condominium parking garages are essential targets in efforts to proliferate residential chargers. Studies show that 40% of the U.S. population lives in apartments or condominiums.[209] State and local governments should consider following the lead of Seattle, Denver, and Hawaii, which began allocating funding and instituting regulations that incentivize EV charging in residential spaces. And again, state and local government incentives to encourage owners of multiunit dwellings to add access to electrical outlets in parking areas would help make such vehicles more appealing. In addition, the New York City Council instituted a pilot program in 2016 to install EV charging stations in "publicly accessible locations" to service existing neighborhoods.[210] Similar local efforts are needed to address the necessary transformations required to supply electricity to parking spaces of this large portion of the population.

Another potential solution for non-homeowners may rest with the proprietary technology of mobile public chargers. FreeWire Technologies' Mobi Chargers are portable, and even towable, refueling machines designed to provide Level 2 and Level 3 charging for the millions of Americans who live in rental units, condominiums, and other multi-dwelling residential spaces.[211] These portable chargers may also be a viable option for tribal lands and rural areas far from the EV charging networks that develop along the more populated corridors. In the same vein as a spare tire, drivers can also carry a spare battery onboard. These "spares" are much more expensive and heavy than traditional spare tires, limiting the feasibility of this as an option for range anxiety. Perhaps, a better

199. Memorandum of Understanding Between Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming Regional Electric Vehicle Plan for the West (Oct. 12, 2017), https://www.colorado.gov/governor/sites/default/files/rev_west_plan_mou_10_12_17_all_states_final_1.pdf.

200. Kyle Field, *EV Charging—The Time for a Single Fast-Charging Standard Is Now!*, CleanTechnica, Jan. 1, 2016, https://cleantechnica.com/2016/01/01/ev-charging-time-single-fast-charging-standard-now/.

201. David Tuttle & Ross Baldick, *Technological, Market, and Policy Drivers of Emerging Trends in the Diffusion of Plug-In Electric Vehicles in the U.S.*, 28 Electricity J. 36 (2015).

202. *See id*.

203. Justin Doom, *Electric Car Owners Face Confusion at the Charging Station*, Bloomberg, May 30, 2013 ("[Ecotality, a] San Francisco company[,] recently signed a deal to put chargers in front of 225 Kroger grocery stores. Customers pay between $1 to $2 per hour to power up."), http://www.bloomberg.com/news/articles/2013-05-30/electric-car-owners-face-confusion-at-the-charging-station.

204. Nie et al., *supra* note 112, at 103.

205. Luke Ottaway, *An Intriguing Cure for Range Anxiety Allows Any EV to Take a Road Trip*, Torque News, Apr. 30, 2014, http://www.torquenews.com/2250/intriguing-cure-range-anxiety-allows-any-ev-take-road-trip.

206. Seattle Office of Sustainability and Environment, Drive Clean Seattle—FAQs, http://www.seattle.gov/Documents/Departments/OSE/DCS_FAQ_Final.pdf.

207. City of Denver, Amendments to the Building and Fire Code for the City and County of Denver 426 (2016), https://www.denvergov.org/content/dam/denvergov/Portals/696/documents/Denver_Building_Code/2016_Denver_Building_andFire_Code_Amendments.pdf.

208. Hawaii State Energy Office, State of Hawaii Department of Business, Economic Development, and Tourism, Report to the Hawaii State Legislature: Act 164: Working Group 4 (2015), http://files.hawaii.gov/dbedt/annuals/2015/2015-act-164-installation-of-ev-charging-stations.pdf.

209. U.S. Census Bureau, *Historical Census of Housing Tables*, https://www.census.gov/hhes/www/housing/census/historic/units.html (last revised Oct. 31, 2011).

210. Angela Matua, *Charging Stations for Electric Cars Will Be Popping Up in NYC Thanks to Astoria Councilman*, QNS, Nov. 21, 2016, http://qns.com/story/2016/11/21/charging-stations-electric-cars-will-popping-nyc-thanks-astoria-councilman/.

211. EVTown, *supra* note 135; FreeWire Technologies, *Mobi Charger Series*, https://freewiretech.com/ev-charging (last visited Feb. 25, 2018).

solution as the market develops may be for public fuel stations to carry spare batteries or fuel cells that can be traded out of the AFVs. With greater access to local EV infrastructure, such initiatives would likely encourage consumers to purchase EVs.

State legislatures could also request assistance from public utility commissions in promoting EV infrastructure. California's Senate Bill 350, for instance, requires the state public utilities commission to elicit utility plans that would increase EV usage.[212] In response, all three California utilities are installing additional chargers and are including the cost of them in consumers' electric bills. Pacific Gas and Electric Co. (PG&E), the largest utility in California, obtained approval from the California Public Utilities Commission to install 7,500 charging stations in its territory,[213] more than double the number that were previously in place.[214] But many state utility commissions have rejected utility requests to include EV charger costs in their rates, concerned about the inequities of socializing costs for chargers across all customers when only a small proportion of its customers rely on EVs.[215]

Private stakeholders, including car dealerships, commercial and residential property owners, employers, entrepreneurs, and AFV manufacturers can also play a critical role in developing away-from-home charging infrastructure.[216] Employers, for example, should work with landlords to add charging facilities. State and local governments can provide more incentives for expanded workplace charging, particularly by making "strategic utility investments in infrastructure" to support the DDPP goals.[217] State and local governments could encourage service providers and workplace site hosts to install charging stations near them.[218]

As more workplaces offer EV chargers, employees can feel confident that they can charge their vehicles while at home and while at work. It will be important for laws to facilitate workplace charging as opposed to hindering it.[219] San Diego's electric utility is taking steps to be a leader in the DOE Workplace Charging Challenge, a program that has partnered with more than 400 employers that have committed to providing employees charging access at work.[220] When employers join the program, DOE works to "respond to their technical and management challenges by providing one-on-one assistance, publishing relevant informational resources, and hosting industry expert webinars."[221] As part of the program, San Diego Gas and Electric (SDG&E) pays to install and operate the chargers and employees pay for charging per session.[222]

Other private charging options were also created as the result of public and private funding. Blink, a membership charging network, is owned by Car Charging Group, and grew out of an EV charging project funded by DOE, via a $114.8 million federal stimulus grant supported under the American Recovery and Reinvestment Act.[223] The stimulus funding was combined with private matching investments to support the nearly $230 million project, which was designed to support EV charging infrastructure sufficient to support 8,300 EVs via the installation of 15,000 commercial and residential charging stations in 16 U.S. cities.[224] Other networks, like EZ-Charge, which provides free charging for two years to Nissan Leaf owners,[225] uses networks like Blink and other companies to expand their reach and create options for EV drivers.[226]

As an example, companies like Tesla have their own supercharging network[227]—a Destination Charging network that provides partners (like hotels, restaurants, and shopping centers) with their first two wall connectors free, as well as added visibility in the Tesla online and in-car

212. S.B. 350, 2015 Leg. (Cal. 2015), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

213. Max Baumhefner, *PG&E to Deploy 7,500 Charging Stations for Electric Cars*, Nat. Resources Def. Council, Dec. 15, 2016, https://www.nrdc.org/experts/max-baumhefner/pge-deploy-7500-charging-stations-electric-cars.

214. Anne C. Mulkern, *California Utility Wants to Install Huge Number of Electric Car Chargers*, ClimateWire, Aug. 26, 2016, https://www.scientificamerican.com/article/california-utility-wants-to-install-huge-number-of-electric-car-chargers/.

215. *Should Utilities Build Charging Stations for Electric Cars?*, Huffington Post, Sept. 11, 2017 ("Missouri, Michigan and Kansas all have slapped down utilities' requests to build charging stations with customers' money."), https://www.huffingtonpost.com/entry/should-utilities-build-charging-stations-for-electric_us_59b696e7e4b0bef3378ce201. For example, the Missouri Public Service Commission determined that it did not have statutory authority to regulate utility-owned and-operated EV charging stations because EV charging stations do not constitute "electric plants." Report and Order in the Matter of the Application of Union Electric Company d/b/a Ameren Missouri for Approval of a Tariff Setting a Rate for Electric Vehicle Charging Stations, File No. ET-2016-0246, Tariff No. YE-2017-0052 (Apr. 19, 2017), https://www.efis.psc.mo.gov/mpsc/commoncomponents/view-document.asp?DocId=936080234.

216. *See* Dana Lowell et al., M.J. Bradley and Associates LLC, Accelerating Investment in Electric Vehicle Charging Infrastructure (2017) ("[P]olicies and programs to support and encourage the deployment of private and public charging infrastructure are critical to foster the development of the electric vehicle market."), https://www.mjbradley.com/sites/default/files/Ceres_PEVinfraAnalysis_120617.pdf.

217. *See* Elkind, *supra* note 39, at 2.

218. Singer, *supra* note 129, at 20.

219. *See*, *e.g.*, Matthew Goetz & Paul Leahy, Georgetown Climate Center, Federal Income Tax Treatment of Workplace Electric Vehicle Charging as a Fringe Benefit (2016) (stating that "employers currently face a federal tax uncertainty regarding whether complimentary or discounted workplace charging constitutes a taxable fringe benefit"), http://www.georgetownclimate.org/files/report/GCC_TaxConsiderationsforWorkplace Charging_June2016_0.pdf.

220. *See* DOE, Workplace Charging Challenge—Progress Update 2016: A New Sustainable Commute 2 (2017) (DOE/GO-102016-4929).

221. *Id*.

222. California Plug-In Vehicle Collaborative, Amping Up California Workplaces: 20 Case Studies on Plug-In Electric Vehicle Charging at Work—SDG&E (stating that the company will also install 350 EV chargers across the city), http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/case-studies/SDGE.pdf.

223. Blink, *Charging Electric Vehicles for Over 20 Years: Our History*, http://prod.blinknetwork.com/blink-history.html (last visited Feb. 25, 2018).

224. Nissan, *Nissan Leaf: No Charge to Charge*, https://www.nissanusa.com/electric-cars/leaf/charging-range/charging/no-charge-to-charge/ (last visited Feb. 25, 2018).

225. *Id*.

226. *See* EZ-Charge, *Participating Networks*, https://www.ez-charge.com/participating-networks/ (last visited Feb. 25, 2018).

227. Tesla, *Supercharger* (stating that their system has the world's fastest charging station, featuring 1,130 Supercharger Stations with 8,496 Superchargers worldwide), https://www.tesla.com/supercharger (last visited Feb. 25, 2018).

networks.[228] A recent pilot program between PG&E and BMW, iChargeForward, "successfully demonstrate[d] PG&E's theory that EVs can be used as a flexible grid resource—which could ultimately lead to cost savings associated with operating and maintaining the grid as well as owning an EV."[229] (See Section 3 below.)

All providers of charging stations (including cities, employers, and multiunit residential property owners) should continue to monitor the efficacy of different rate structures to best incentivize efficient charging. For instance, free charging stations can initially reduce availability because people who do not need to charge their vehicles may do so anyway. This kind of oversubscription could discourage EV adoption by those who would most reap the benefits of workplace charging, or it could require overinvestment in charging infrastructure that would not be needed with proper price incentives. Free workplace charging can also encourage daytime charging, which means EV owners would be charging their vehicles during peak times, rather than overnight, during cheaper, off-peak times, when utilities tend to have excess capacity. As such, charging just higher than local home electric rates, at least in the near term, can help ensure access for those who need daytime charging, while minimizing infrastructure impacts.[230]

The sharing economy, known for companies like Uber, Lyft, and Airbnb, is another private mechanism that could expand charging infrastructure. Apps like PlugShare can connect EV owners with multiple thousands of charging options from private residents.[231] Elbnb, a website and app developed by Renault Group in Sweden, increased by 3.5% the number of charging stations in the country in just two weeks. This expansion can be a good thing, but the speed and quality of the services provided by each individual can vary widely, and that uncertainty can be disconcerting to drivers.

□ *Hydrogen vehicles*. One pathway toward increasing the number of hydrogen vehicles is for an automaker or other private entity to develop technology that can provide cost-effective home hydrogen fueling. Honda announced in 2007 that it was developing a home fueling station.[232] This unit was to be powered by natural gas and provide hydrogen for a vehicle, along with heat and electricity for the home. In 2010, Honda began work on a solar hydrogen station, which would make for a more effective system.[233] As of 2018, however, no version has reached the market yet.

Although such stations assist with reducing local pump congestion and can provide on-site access at home or work, they do not alleviate the lack of infrastructure for out-of-state travel.[234] Home hydrogen fueling stations could help in the transition and might lower the overall cost of this infrastructure, but this decentralization would require significant technological advances to lower costs for individual consumers. The number of HFCVs is so low that they are unlikely to be able to support commercial home fueling station development until their numbers are much greater.

Automakers have recognized these limitations, and have taken steps to address key concerns. Toyota provides three years' worth of hydrogen fuel at the time of purchase for its Toyota Mirai.[235] While this does not expand access to stations, it makes being limited to existing stations more appealing because the fuel is free.[236] In addition, to help address concerns about the lack of fueling stations in some areas, companies like Toyota cover the costs of a rental car for seven days per year to support travel that will extend away from accessible fueling stations.[237]

A more feasible pathway involves increasing the amount of public hydrogen fueling stations. Near the end of 2016, the Obama Administration identified a number of opportunities for continued research, development, demonstration, and deployment investments related to HFCVs.[238] Some of these projects could assist with developing necessary infrastructure to support HFCVs, including improving performance, reducing "the costs of producing hydrogen with clean energy (e.g., advanced electrolysis, thermally assisted electrolysis, thermochemical processes, direct solar water splitting from renewable, nuclear, fossil-CCUS [carbon capture, utilization, and storage] sources)," and improving the "energy efficiency and reliability of hydrogen compression, storage, and dispensing."[239] Still, these are longer-term and unproven advances that will require additional research and investments from public and private sources.

Important questions remain about whether it is inefficient to be developing EV charging stations separately from HFCV fueling stations or whether the path forward may involve a gas station model where vehicles can pull in for a choice of electricity or hydrogen, much like they currently pull in for gasoline or diesel. Recent data and market

228. Tesla, *Destination Charging*, https://www.tesla.com/destination-charging (last visited Feb. 25, 2018).
229. Ari Vanrenen, *PG&E, BMW Pilot Successfully Demonstrates Electric Vehicles as an Effective Grid Resource*, PG&E Currents, June 8, 2017, http://www.pgecurrents.com/2017/06/08/pge-bmw-pilot-successfully-demonstrates-electric-vehicles-as-an-effective-grid-resource/.
230. *Id*.
231. Camille von Kaenel, *Electric Car Charging Could Follow Airbnb Model*, ClimateWire, Aug. 2, 2016, https://www.scientificamerican.com/article/electric-car-charging-could-follow-airbnb-model/.
232. *See* Honda, *Home Energy Station (4th Generation)*, http://world.honda.com/FuelCell/HydrogenStation/HomeEnergyStationIV/index.html (last visited Feb. 25, 2018).
233. Honda, *Solar Hydrogen Station*, http://world.honda.com/FuelCell/HydrogenStation/SolarHydrogenStation/ (last visited Feb. 25, 2018). The science is progressing, but there is still more work to do. *See* William Herkewitz, *We're One Step Closer to Creating Hydrogen Gas From Solar Energy*, Popular Mechanics, Feb. 4, 2016, http://www.popularmechanics.com/science/energy/a19292/were-one-step-close-to-creating-fuel-cells-from-solar-energy/.
234. Fershee, *supra* note 152, at 114-15.
235. Melissa Riofrio, *Here's Everything Toyota Will Give You if You Buy the Hydrogen-Powered Mirai*, PCWorld, Jan. 6, 2015 ("This should make early adopters feel better about finding a hydrogen station, as they're still few and far between."), https://www.pcworld.com/article/2863411/heres-everything-toyota-will-give-you-if-you-buy-the-hydrogen-powered-mirai.html.
236. *See id*.
237. *See id*.
238. The White House, *supra* note 3, at 58-59.
239. *Id*. at 58.

studies indicate that EVs are already the AFV of choice in the United States. A recent study found that there have been more than 540,000 EVs sold in the United States, with more than 130,000 PHEVs or BEVs sold between November 2015 and November 2016.[240]

In contrast, a recent report forecasted global sales of hydrogen-powered vehicles in 2027 to be about 70,000 (or roughly 0.1% of new vehicles sold).[241] Despite DDPP considerations, these recent examples indicate that consumers, as well as manufacturers, already prefer EVs as the primary AFV. Because government resources are limited, it may be appropriate for all levels of government and private sectors to consider prioritizing support for expanding the faster-growing market (EVs), rather than trying to promote a lagging HFCV market, which has similar or greater infrastructure needs and a less clear path to a consumer market.

### 2. Coordinate the Electric Grid With Transportation

A second essential focus for public and private law pathways is on integrating the electric grid with the transportation sector. At present, only 1% of electricity is produced from oil.[242] At the same time, approximately 92% of our transportation sector relies on oil.[243] That results in a natural separation between the two arenas into electricity and transportation fuels, a separation that has spawned separate legal regimes, separate governance institutions, and separate markets for oil and gas,[244] on one hand, and electricity on the other. In 2016, natural gas surpassed coal as the primary source of electricity in the United States, creating a critical link between the transportation and electricity sectors that cannot be ignored.[245]

As a result, it is time for a more realistic and integrated treatment of the electricity and transportation sectors. The electric utilities across the nation are essential partners in this integration. Embracing EVs can offer utilities revenue growth through increased electricity demand and a flexible resource to help with grid management, while providing customers with lower rates because most charging can take place off-peak,.[246] This section explains how such integration can allow both electric utilities and customers to benefit.[247] All of these recommendations will involve the engagement of not only utilities, but state public utility commissions and state legislators as well.

First, EVs can assist utilities as they face stagnant electricity demand.[248] As the DDPP report indicates, a switch from ICVs to EVs will lead to a very large increase in electricity demand nationwide; the grid (and the generation system that feeds it) will need to improve accordingly. By working with EV charging companies to facilitate access and necessary upgrades to accommodate charging needs, the utilities will be able to serve the growing electricity demand and offset some of their losses they are experiencing from solar customers self-supplying.[249] Utilities are rightfully concerned about their profit margins as demand declines, and a surging EV fleet would result in a corresponding surge in electricity demand. Leveraging decreased electricity demand growth with increased electricity demand from EVs makes good business sense for utilities. Utilities can look to EVs to grow load and thus increase profits, depending on regulatory structure, particularly if public charging infrastructure can be put into the rate base. Utilities should also incorporate the demand from EVs in their load forecasts and integrated resource plans and look to EVs to ease the flat and declining demand curve projections for electricity.

Second, utilities and states can help to ensure that EV customers charge at optimal times by experimenting with different incentive structures that encourage off-peak charging.[250] In many regions, there is excess solar energy during daytime hours and excess wind energy at night. Utilities can encourage consumers to charge their vehicles during these off-peak hours when solar or wind is at peak production.[251] Smart grid and smart metering technologies can help facilitate this transition.[252] The California Public Utilities Commission, for instance, approved SDG&E to install 350 EV chargers across the city at a variant rate to encourage owners to charge their vehicles during off-

240. Johana Bhuiyan, *There Have Now Been Over 540,000 Electric Vehicles Sold in the U.S.*, Recode, Dec. 21, 2016, http://www.recode.net/2016/12/21/14041112/electric-vehicles-report-2016.

241. Chris Woodyard, *Study: Hydrogen Car Sales Will Remain Small Through 2027*, USA Today, May 9, 2016, http://www.usatoday.com/story/money/cars/2016/05/09/study-hydrogen-car-sales-remain-small-through-2027/84157924/.

242. EIA, *Use of Energy in the United States Explained: Energy Use for Transportation*, http://www.eia.gov/energyexplained/?page=us_energy_transportation (last updated May 17, 2017).

243. *Id.*

244. In reality, oil and gas are often found and produced together and by the same entity. Robert Rapier, *The 25 Biggest Oil and Gas Companies in the World*, Forbes, Mar. 30, 2016, http://www.forbes.com/sites/rrapier/2016/03/30/the-worlds-largest-public-oil-and-gas-companies/#7d4769b96cf1.

245. EIA, *Frequently Asked Questions: What Is U.S. Electricity Generation by Energy Source?*, https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3 (last updated Apr. 18, 2017).

246. Michael Shepard, *The $100B Prize: Why EVs Are the Opportunity of the Century for Utilities*, Util. Dive, Apr. 5, 2016, http://www.utilitydive.com/news/the-100b-prize-why-evs-are-the-opportunity-of-the-century-for-utilities/416373/.

247. The majority of utilities are privately owned, with a small number of municipally owned utilities across the country.

248. Mark Chediak, *U.S. Power Demand Flatlined Years Ago, and It's Hurting Utilities*, Bloomberg, Apr. 25, 2017 (citing EIA sources), https://www.bloomberg.com/news/articles/2017-04-25/u-s-power-demand-flatlined-years-ago-and-it-s-hurting-utilities.

249. *Cf.* Herman K. Trabish, *The New EV Playbook: How Utilities Can Gain From the Coming Boom in Electric Vehicles*, Util. Dive, June 27, 2016 (stating that PG&E, a California utility, was seeking "to partner with private providers to install 7,500 level 2 chargers and 100 DC fast chargers"), https://www.utilitydive.com/news/the-new-ev-playbook-how-utilities-can-gain-from-the-coming-boom-in-electri/421559/.

250. *Id. See* Elkind, *supra* note 39, at 5 (utilities can consider a revised rate structure that "encourage[s] experimentation to optimize charging in the right places and times that best meet grid needs").

251. McLaren et al., *supra* note 147, at 1 ("Tulpule (2013) concludes that day charging with solar-powered charging stations in Ohio could realize $CO_2$ emissions reductions of up to 90% versus home charging during evening hours.").

252. *See* Jim Downing, *Future of Electricity*, Sacramento Bee, June 14, 2009, at D1 (stating that a "smart grid" would be better than the current system to handle "the expected flood of plug-in hybrids and electric cars in the next decade").

peak hours when renewable energy resources are at their highest capacity.[253] Utilities may also apply to public utility commissions to implement time-of-use rates to incentivize charging during off-peak periods.[254] Seattle, for example, is taking steps to integrate the electric and transportation sectors by allowing drivers who charge their vehicles at home to take advantage of a Seattle City Light program with lower rates for car electricity use during off-peak hours.[255]

A third option may be for utilities to allow ratepayers' vehicles to charge during low-demand times and discharge the power back to the grid during peak times, serving as forms of grid batteries. A transition to large-scale electric-powered transportation would provide a new storage option.[256] EVs have batteries capable of holding significant charges to provide adequate driving range.[257] As the market for plug-in cars grows, that large number of EVs plugged in and charging, such as overnight or while at work, could be turned into an advantage.[258] Each car would draw electricity up to a full charge, and if the grid needed additional electricity, and generation capacity were not available from renewable sources (e.g., wind or solar), the grid could call small amounts of power from each plugged in EV battery to provide the grid with the needed electricity.[259] Although the transition process could pose challenges, in many cases, the issues could be solved in the near term by using wind or solar resources as parallels to fossil fuel or other baseload sources, with a planned phaseout as EVs increasingly become part of the infrastructure.[260] State utility commissions could allow for incentive rates or provide other encouragement to facilitate such options. Similarly, local governments could support these programs via tax breaks or low- or no-cost property for siting.

One study found that the average U.S. car is parked 95% of the time, so such vehicle-to-grid (V2G) systems would use the car battery to provide energy storage while the vehicle is parked, serving as a reserve for any unforeseen equipment failures or as a reserve during peak demand times.[261] The viability of a V2G system depends on a number of factors, including consumer participation and overall cost of the V2G system, and how it fits in with other parts of a broader vehicle-grid integration plan.[262] Some studies have shown that consumers can earn as much as $4,000 per year by providing V2G services, and organizations with predictable driving patterns may also benefit.[263] Power companies can also benefit because the V2G reserve has a fast response rate,[264] and can help integrate renewables, thus lowering carbon emissions.[265] At least one study evaluated noneconomic costs (e.g., limited freedom in use of the car due to V2G contract terms), as well as economic costs (e.g., the increased battery replacements required if an EV battery provides V2G services with repeated charges and discharges) to assess the feasibility of a near-term market for V2G EVs.[266] While the technology may exist to transform EVs into V2G-capable EVs, there are still associated costs that may hinder such a vehicle's success in the market.[267]

Lastly, as already indicated, it is essential to decarbonize the electricity sector. If our LDV fleet makes the transition from oil to electricity dependence, the source of electricity will become even more critical to decarbonization efforts. A grid that is fueled primarily by fossil fuels generates more carbon than a grid that is fueled primarily by renewable energy. The National Renewable Energy Laboratory has found that "to meet the GHG requirements for light-duty transportation, the grid energy used can have no more than 30% generation from coal."[268] Even without coal in the mix, the percentage of generation from renewables or nuclear must be greater than 36%.[269] In 2016, the U.S. electric grid relied on renewables for only 15%.[270]

The 2015 DDPP technical report makes this point clearly. According to that report, reducing U.S. GHG emissions by 80% by 2050 will require almost complete decarbonization of electricity and, among other things, switching a "large share" of end uses that require gasoline and liquid fuels over to electricity (such as EVs).[271] It would

253. California Public Utilities Commission, Decision Regarding Underlying Vehicle Grid Integration Application and Motion to Adopt Settlement Agreement 2 (Feb. 4, 2016), https://www.sdge.com/sites/default/files/documents/461232896/VGI%20FD.PDF?nid=17366.

254. Nancy Ryan & Luke Lavin, *Engaging Utilities and Regulators on Transportation Electrification*, 28 Electricity J. 78, 88 (2015).

255. Seattle City Light, City Light Rates 101, at 16-17, http://www.seattle.gov/light/rates/docs/citylightrates101_8_8.pdf.

256. James M. Higgins, *It's Closer Than You Thought*, Futurist, May 1, 2009, at 25:

> Electric and electric-hybrid automobiles would have a power source that would not drain the national power grid. Imagine what 200 million electric and electric-hybrid automobiles would do to power-grid demand if they were all plugged in at about 10 p.m. every night. This invention helps solve that problem by taking millions of these autos off the power grid.

257. *See id*.

258. *See id*.

259. *See id*.

260. Fershee, *supra* note 152, at 102.

261. Michael K. Hirdue & George R. Parsons, *Is There a Near-Term Market for Vehicle-to-Grid Electric Vehicles?*, 151 Applied Energy 67, 67 (2015).

262. California ISO, Vehicle-Grid integration (VGI) Roadmap: Enabling Vehicle-Based Grid Services 1 (2014) (providing a VGI plan "to develop solutions that enable electric vehicles (EV) to provide grid services while still meeting consumer driving needs"), http://www.caiso.com/documents/vehicle-gridintegrationroadmap.pdf.

263. Hirdue & Parsons, *supra* note 261, at 67; Willett Kempton & Jasna Tomic, *Vehicle to Grid Fundamentals: Calculating Capacity and Net Revenue*, 144 J. Power Sources 268 (2005) (stating, for example, that school districts may save $6,000 per year by using V2G capable school buses); Corey D. White & K. Max Zhang, *Using Vehicle-to-Grid Technology for Frequency Regulation and Peak-Load Reduction*, 196 J. Power Sources 3972 (2011).

264. *See* Shi Lefeng et al., *The Reserve Trading Model Considering V2G Reverse*, 59 Energy 50 (2013); Henrik Lund & Willett Kempton, *Integration of Renewable Energy Into Transport and Electricity Sector Through V2G*, 36 Energy Pol'y 3578 (2008).

265. Lund & Kempton, *supra* note 264, at 3586.

266. Hirdue & Parsons, *supra* note 261, at 75.

267. *Id*. (reporting on a study that revealed consumers' willingness to pay for V2G-capable EVs is lower than projected costs of such vehicles, the primary reasons being range anxiety, the V2G contract, and high battery costs). The article suggests ways to attract more consumers, including reducing the required number of plug-in hours, paying the consumers in advance for V2G services, and offering more appealing vehicle models. *Id*.

268. Gearhart, *supra* note 59, at 12.

269. *Id*.

270. EIA, Energy Kids, *Electricity in the U.S.*, https://www.eia.gov/KIDS/energy.cfm?page=electricity_in_the_united_states-basics (last visited Feb. 25, 2018).

271. DDPP, *supra* note 10, at xiii.

also be necessary to produce fuel from electricity itself, including, for example, the production of hydrogen from hydrolysis.[272] That would double electricity generation even as carbon intensity is reduced to 3% to 10% of current levels.[273] For this reason, efforts to decarbonize LDVs are heavily intertwined with efforts to decarbonize the electric grid. In the absence of a federal renewable portfolio standard, state and local governments have been the primary drivers of renewable generation. Seattle's municipal utility company, Seattle City Light, for instance, has been carbon-neutral since 2005, with the vast majority of its power coming from hydroelectric generators.[274]

As storage technology continues to develop, renewable sources of EV charging may become more feasible, which can make low- or no-carbon resources more attractive for electricity generation.[275] Private market participants may also be able to capitalize on EVs to make a profit in electricity markets. BMW, General Motors (GM), Nissan, and Toyota are all exploring how to use EV batteries to provide grid services even after they can no longer meet the strict requirements for powering a car.[276] GM, for example, has used batteries from the Chevy Volt to provide energy storage for solar and wind resources at its Warren Enterprise Data Center in Michigan.[277] BMW has been using its used batteries to provide demand response to PG&E in California.[278] These used batteries are approaching as low as $150/kWh, potentially providing one of the most affordable forms of energy storage.[279]

### 3. Lower Costs

A third LDV pathway focuses on reducing the up-front sticker costs so that EVs will be accessible to a greater share of the U.S. population. Some alternative vehicles are comparable in price to some ICVs[280]: Tesla's Model 3 is being offered at $35,000, a move that may encourage even more manufacturers to compete on price,[281] and the market now offers EV models under $30,000.[282] But EV customers often pay a premium of about $10,000 more than ICVs.[283] Analysts have also calculated the total cost of ownership for ICV and EV owners, finding a 44% price differential for compact owners and a 60% price differential for mid-sized vehicles.[284] Studies suggest that the premium will decrease over time, but models disagree on the time period at which EV costs will reach parity with ICV costs.[285] A Bloomberg New Energy Finance report suggests that by the year 2025, EVs will cost the same as their gasoline-driven equivalents,[286] but others indicate it will not occur until 2050.[287]

Reducing AFVs' up-front costs will be crucial to increase market penetration. The DDPP recommends reducing the up-front costs through "timely R&D, market transformation programs, and financial innovation."[288] Specifically, the largest reductions in EV costs are likely to be achieved by reducing battery costs, encouraging the creation of secondary markets for sale of used EVs, and capitalizing on the purchasing power of governments.[289]

□ *Reduce battery costs*. An essential component of this LDV pathway is a drop in battery prices. The price of Li-ion batteries dropped 60% between 2010 and 2015, falling to $350/kWh.[290] Because they make up such a big portion of the price of an EV, however, a further decrease is needed, with some estimates saying a drop in cost by more than one-half is needed for EVs to be competitive with ICVs.[291] Analysts at Bloomberg New Energy Finance believe a drop to $120/kWh by 2030 is possible.[292] All levels of government, as well as private companies, should assist in R&D toward this goal.[293] For instance, in 2017, DOE awarded

272. *Id*.
273. *Id*.
274. Seattle City Light, *The Nation's Greenest Utility: 100 Years of Hydropower. And Counting*, http://www.seattle.gov/light/greenest/cleanhydro.asp (last visited Feb. 25, 2018).
275. *See* Vincent Carroll, *Tilting at Windmills*, Denver Post, Apr. 12, 2009, at D3 ("Now, if utilities ever figure out how to store colossal quantities of energy, then wind and solar (which can be more variable than wind) will no doubt reign supreme. Until then, replacing all coal with wind is a prescription for the middle ages." (quoting Xcel Energy vice president of commercial operations, Thomas Imbler)).
276. Joe Romm, *Why Used Electric Car Batteries Could Be Crucial to a Clean Energy Future*, ThinkProgress, May 9, 2016, https://thinkprogress.org/why-used-electric-car-batteries-could-be-crucial-to-a-clean-energy-future-6ab9a2308cdb/.
277. Diane Cardwell, *G.M. and Nissan Reusing Old Electric Car Batteries*, N.Y. Times, June 16, 2015, http://www.nytimes.com/2015/06/17/business/gm-and-nissan-reusing-old-electric-car-batteries.html?_r=0.
278. Romm, *supra* note 276.
279. *Id*.
280. *The Cost of Car Ownership Over Time*, Consumer Rep., Aug. 1, 2017, http://www.consumerreports.org/cro/2012/12/what-that-car-really-costs-to-own/index.htm. The Toyota Camry has been the best-selling car for 10 years excepting 2001 and costs around $23,000, but the Toyota Prius is the best-selling hybrid since its introduction to the market and costs around $24,000. *See id*.
281. Zachary Shahan, *Tesla Model 3 vs 22 Competitors (The Straight Specs)*, CleanTechnica, Aug. 6, 2017 (discussing the competition Tesla will face from "comparably priced offerings from BMW, Mercedes, Audi, Lexus, Toyota, Acura, and Jaguar"), https://cleantechnica.com/2017/08/06/tesla-model-3-vs-22-competitors-straight-specs/.
282. Laurel Portie, *The 5 Best Electric Cars Under $30K*, List, Oct. 31, 2016 (listing the Nissan Leaf, Ford Focus, Smart Electric Drive, Volkswagen e-Golf, and Mitsubishi i-MiEV), http://www.thelisttv.com/the-list/the-5-best-electric-cars-under-30k.
283. For example, the Ford Fusion ICE sedan's suggested retail price starts at about $23,000. The Ford Fusion Energi, the plug-in hybrid version, starts at $36,000. *See* Ford, *Ford Fusion*, https://www.ford.com/cars/fusion/ (last visited Feb. 25, 2018).
284. Brennan & Barder, *supra* note 148, at 32.
285. *Id*. at 41; Risky Business Project, From Risk to Return: Investing in a Clean Energy Economy 37 (2016), https://riskybusiness.org/site/assets/uploads/sites/5/2016/10/RBP-FromRiskToReturn-WEB.pdf.
286. Prableen Bajpai, *The Rise of Electric Vehicles: By the Numbers*, Nasdaq, Mar. 21, 2016, http://www.nasdaq.com/article/the-rise-of-electric-vehicles-by-the-numbers-cm595564#ixzz4NMHFZgsC.
287. Risky Business Project, *supra* note 285, at 37.
288. DDPP, *supra* note 10, at 72.
289. Costs can also be reduced through the use of more lightweight materials, vehicle connectivity, and other efficiencies. The White House, *supra* note 3, at 58.
290. *Electric Vehicles to Be 35% of Global New Car Sales by 2040*, *supra* note 66.
291. Chisaki Watanabe, *Why Battery Costs Could Put the Brakes on Electric Car Sales*, Bloomberg, Nov. 28, 2017, https://www.bloomberg.com/news/articles/2017-11-28/electric-cars-need-cheaper-batteries-before-taking-over-the-road.
292. *Electric Vehicles to Be 35% of Global New Car Sales by 2040*, *supra* note 66.
293. *See Fact Sheet*, *supra* note 64.

Battery500, a battery consortium, $5.7 million to 15 projects to develop a battery that costs less than $100/kWh.[294]

Many researchers are working to increase the energy density (the amount of energy that can be stored per unit of volume) of Li-ion batteries.[295] According to one observer, researchers find that "lithium-ion technology is not even near its hypothetical boundary for energy density. The near-term R&D efforts should focus on advancing battery energy density, operating temperature range, and developing control systems that facilitate reasonably long mileage range."[296] The Obama White House indicated its goal of developing a 350-kW DC charging system that could charge a 200-mile battery in less than 10 minutes.[297] Some new passenger EVs on the market have ranges of more than 200 miles on a single higher-level charge, "far more than nearly all drivers need in their daily lives."[298] Such advancements would go a long way toward reducing costs, as well as ameliorating range anxiety.

In addition to increasing public and private investment in battery R&D, increasing economies of scale in battery production is crucial. The battery business is increasingly dominated by large Asian companies, and the three largest-selling PEVs are making use of Asian technologies.[299] Domestic companies may need to continue to explore increased battery production capabilities in the United States and at a larger scale, to both lower costs and reduce dependence on foreign components. Tesla may be making moves in this direction with the creation of the Gigafactory in Nevada, expected to produce more Li-ion batteries annually starting in 2018 than were produced worldwide in 2013.[300] Tesla has announced plans to build three more such factories.[301] By manufacturing batteries in such large amounts, Tesla may be able to take advantage of economies of scale not available to small-scale production processes.

□ *Encourage secondary EV markets*. Another development that may assist in forging a path forward for EV proliferation is the creation of an EV secondary market. The historical price of many EVs rendered many of them luxury items, with most first adopters found in wealthy pockets of the country. The current generation of technologically savvy consumers is used to repeatedly upgrading their electronic devices to keep up with the latest and greatest version released. Applying that mindset to vehicles suggests that a large secondary market for EVs may develop as owners trade in their older models for newer ones or that many may switch to short-term leases as opposed to ownership of EV, allowing for more ease in trade-ups.[302]

As used EVs become more accessible to average Americans, EV adoption may be encouraged beyond the wealthy and may spread through more economic strata. Both public and private actors can work to accelerate development of this secondary market by allowing a subsidy for purchasing used AFVs. For example, some states offer income tax credits for purchases of new AFVs or vehicles that are retrofitted or converted into AFVs.[303] Such credits could be allowed, at the state and/or federal level, for used AFV purchases as well. As to private actors, actions taken to benefit any AFVs, such as offering residential charging stations at apartment buildings, will help support deeper market penetration.

□ *Capitalize on purchasing power*. A third pathway involves enhanced investment in AFVs by those with large purchasing power. The federal government, for instance, is the nation's largest vehicle fleet operator, with more than 600,000 vehicles.[304] Federal agencies like the General Services Administration and the U.S. Department of Defense (DOD) are working to implement President Obama's Executive Order No. 13514, which requires a 30% decrease in petroleum consumption.[305] In addition, DOD is subject to a procurement preference for non-tactical electric or hybrid vehicles.[306] Federal funding under the FAST Act may cover up to 80% of costs for government entities at all levels, public transport providers, private and nonprofit organizations, and higher learning institutions for vehicles designated for public transportation that significantly reduce harmful emissions or energy consumption.[307] The federal

294. *See id.*; News Brief, Pacific Northwest National Laboratory, Battery500's First Seedling Projects Awarded Nearly $6 Million (July 19, 2017), https://www.pnnl.gov/news/release.aspx?id=4437.
295. Sung-Jin Cho, *Increasing the Storage Capacity of Lithium Batteries*, AltEnergyMag, Sept. 8, 2016, http://www.altenergymag.com/article/2016/09/increasing-the-storage-capacity-of-lithium-batteries/24525; DOE, Advanced Research Projects Agency-Energy, *Double Energy Density Anodes for Lithium-ion Batteries*, https://arpa-e.energy.gov/?q=slick-sheet-project/double-energy-density-anodes-lithium-ion-batteries (released Apr. 29, 2010). Gasoline still has much greater energy density. Steve Hanley, *EV Battery Energy Density to Be at Parity With Gasoline by 2045, but That Misses the Point*, CleanTechnica, May 13, 2016, https://cleantechnica.com/2016/05/13/ev-battery-energy-density-parity-gasoline-2045/.
296. Haddadian et al., *supra* note 47, at 56. Research to reduce battery costs surrounds not only developing higher energy densities, but enhancing the ability to withstand higher temperatures associated with rapid recharging and using new materials and methods for battery terminals (i.e., anodes and cathodes) for longer lifetimes and higher capacities. *See Fact Sheet*, *supra* note 64.
297. *See Fact Sheet*, *supra* note 64.
298. The White House, *supra* note 3, at 54; *see also infra* Part IV.A.6. (discussing the increased range and lower cost of recent EVs).
299. Sanya Carley et al., Indiana University, Rethinking Auto Fuel Economy Policy: Technical and Policy Suggestions for the 2016-17 Midterm Reviews 19 (2016), *available at* https://spea.indiana.edu/doc/research/working-groups/fuel-economy-policy-022016.pdf.
300. Tesla, *Tesla Gigafactory*, https://www.tesla.com/gigafactory (last visited Feb. 25, 2018).
301. Kirsten Korosec, *Tesla Is About to Massively Expand Its Manufacturing Capacities*, Fortune, Feb. 23, 2017, http://fortune.com/2017/02/23/tesla-is-about-to-massively-expand-its-manufacturing-capabilities/.
302. One study suggests that EVs face greater depreciation than ICVs, suggesting another possible barrier that may encourage more leasing. Bengt Halvorson, *Tesla Aside, Resale Values for Electric Cars Are Still Tanking*, Car & Driver, Aug. 10, 2016, https://blog.caranddriver.com/tesla-aside-resale-values-for-electric-cars-are-still-tanking/.
303. *See, e.g.*, W. Va. Code §11-6D-1 (Alternative-Fuel Motor Vehicles Tax Credit).
304. U.S. General Services Administration, *Electric Vehicle Pilot Program*, http://www.gsa.gov/portal/content/281581 (last reviewed Aug. 13, 2017).
305. *Id.*
306. 10 U.S.C. §2922g.
307. 49 U.S.C. §5312; Fact Sheet, Federal Transit Administration, Public Transportation Innovation, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5312_Public_Transportation_Innovation_(Research)_Fact_Sheet.pdf.

government, at a minimum, should continue implementing these practices.

Combining federal purchasing power with state and local demand can also help. For example, some cities have committed to alternative vehicle fleets. New York City has implemented the NYC Clean Fleet initiative, which will add 2,000 EVs to the municipal fleet,[308] and Los Angeles has leased hundreds of EVs and PHEVs to make it "the most sustainable city in America."[309] Seattle has taken steps to cut municipal fleet GHG emissions in half by 2025 through the use of cleaner fuels,[310] which indirectly requires the use of alternative vehicles. State and local governments should emulate these examples and consider similar options based on local needs to reduce fleet emissions.

Other governments are engaging in creative community-based group purchase programs to boost EV sales. A consortium of local governments, led by Boulder County, Colorado, issued a request for proposal to automakers asking for their best group EV sales discounts.[311] Boulder Nissan was the only one to respond, and the dealership sold 5% of all Leafs purchased in the entire country, selling four times as many as the dealership had sold in a similar prior period.[312] Similar programs have had "equally impressive results."[313] Such programs provide an opportunity for utilities to become involved, offering "vouchers for a limited amount of free power to EV buyers, assistance getting charging equipment installed, or a small incentive to the dealer for each EV they sell."[314]

Large, private actors can also use their purchasing power to drive demand, and should do so. For instance, the Zero Emissions Airport Vehicle and Infrastructure Pilot Program allows public use airports to use grant funds from the Airport Improvement Program to buy ZEVs and to build and modify infrastructure to support them.[315] Private stakeholders have also committed to transitioning from ICVs to AFVs. Arizona Public Service has committed to going 100% electric, replacing all 2,100 of its vehicles.[316]

### 4. Tighten Fuel Economy and Emissions Standards

Another important legal pathway to the DDPP goals is to continue to ratchet up the fuel economy standards until they reach 100 mpg. Some research indicates that, by 2035, ICVs have the potential to reach 47.5 mpg and that PHEVs have the potential to reach 71.7 mpg.[317] Stakeholders, regulators, and lawmakers can continue to build on such improvements to move the needle over the next 15 years to reach 100 mpg by 2050.

Despite the significant fuel economy improvements made with the 2017-2025 rulemaking, the United States still lags behind other nations.[318] In addition, although the U.S. CAFE standards are 35.5 mpg in 2016 and 54.5 mpg in 2025, the actual fuel economy of new LDVs has often been substantially lower, both because it is a fleetwide average (meaning each car need not meet the standard) and because the testing used to demonstrate fuel economy does not perfectly reflect real-life driving conditions.[319] EPA estimates are getting closer to real mpg experiences in recent years,[320] however, meaning that the 2014 average fuel economy of a new LDV passenger car of 36.4 mpg may be a reasonable estimate.[321]

As part of the 2017-2025 rulemaking, EPA made a regulatory commitment to conduct a mid-term evaluation of longer term standards for MYs 2022-2025 to determine whether they continue to be appropriate based on six more years of information.[322] In a Goldilocks-type assessment, EPA can find that the standards are too lenient, too strict, or just right. This mid-term review is underway, with the final draft report expected in 2018. This review will focus on five factors: (1) consumer demand; (2) manufacturer responses to tighter standards; (3) distributional conse-

308. New York City, NYC Clean Fleet 1-2 (2015) (stating that the total city fleet is 27,152), http://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/NYC%20Clean%20Fleet.pdf.

309. Elizabeth Daigneau, *Is 2015 the Year of the Electric Municipal Fleet?*, Governing, Nov. 2015, http://www.governing.com/topics/transportation-infrastructure/gov-municipal-fleet-electric-vehicles.html.

310. Lynda V. Mapes, *Seattle Mayor Wants to Cut Vehicle Emissions, Add Electric Cars*, Seattle Times, Mar. 10, 2016, http://www.seattletimes.com/seattle-news/environment/seattle-mayor-wants-to-cut-vehicle-emissions-add-electric-cars/.

311. Michael Shepard, *How Group Purchasing Programs Can Supercharge EV Sales*, Util. Dive, May 4, 2016, http://www.utilitydive.com/news/how-group-purchasing-programs-can-supercharge-ev-sales/418532/.

312. *Id*.

313. *Id*. (noting programs in Fort Collins, Colorado, the University of Utah, and Drive Electric Minnesota).

314. *Id*.

315. Federal Aviation Administration, *Airport Zero Emissions Vehicle and Infrastructure Pilot Program Airports*, http://www.faa.gov/airports/environmental/zero_emissions_vehicles/ (last modified Oct. 27, 2017).

316. Tesla, *Forums: Arizona Public Service Fleet to Go All-EV*, https://forums.tesla.com/forum/forums/arizona-public-service-fleet-go-all-ev (submitted Apr. 27, 2016).

317. Gearhart, *supra* note 59, at 7.

318. Japan and the European Union have stricter fuel economy standards, suggesting that further improvements are technologically feasible. Brad Plumer, *Even With Strict New Rules, U.S. Still Lags on Fuel Economy*, Wash. Post, Sept. 12, 2012, https://www.washingtonpost.com/news/wonk/wp/2012/09/12/even-with-stricter-new-rules-u-s-still-lags-in-fuel-economy/; International Council on Clean Transportation, *Chart Library: Passenger Vehicle Fuel Economy*, http://www.theicct.org/global-pv-standards-chart-library (last visited Feb. 25, 2018).

319. Jeff Plungis, *Consumer Reports Analysis Shows EPA Fuel Economy Estimates Are Getting Better*, Consumer Rep., Nov. 14, 2016 (stating that, in 2006, "Consumer Reports tests indicated that the EPA fuel economy estimates on window stickers were off by 10 percent or more"), https://www.consumerreports.org/fuel-economy/cr-analysis-shows-epa-fuel-economy-estimates-getting-better/.

320. *Id*. (stating that between 2009 and 2016, Consumer Reports showed a 3% variation between EPA numbers and their testing).

321. U.S. Department of Transportation, Bureau of Transportation Statistics, *Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles*, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html (last visited Feb. 25, 2018).

322. U.S. EPA, *Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emissions Standards for Model Years 2022-2025*, https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas (last updated Jan. 10, 2018). EPA will examine a wide range of factors, such as developments in powertrain technology, vehicle electrification, lightweighting and vehicle safety impacts, penetration of fuel-efficient technologies in the marketplace, consumer acceptance of fuel-efficient technologies, trends in fuel prices and the vehicle fleet, employment impacts, and many others. *See id*.

quences of tighter standards—social equity; (4) improvements in cost-benefit analysis; and (5) treatment of AFVs.[323]

Preliminary assessments in 2016 by the Obama Administration suggested that EPA was unlikely to reduce the GHG emissions standards.[324] First, EPA has indicated that manufacturers can meet the MYs 2022-2025 standards by utilizing current auto technologies.[325] Automakers are expected to meet the standards by reducing the weight of their vehicles and by employing micro-hybrid technology (stop-start systems) that conserves fuel when the car is idle. AFVs do not even seem to be a required component of achieving the standards. Second, the LDV fleet will continue to consist mainly of ICEs, "with modest levels of strong hybridization and very low levels of full electrification (plug-in vehicles) needed to meet the standards."[326] Third, a consumer's choice to purchase a car or truck depends upon a host of factors, but trends in the car/truck mix are "fully accommodated by the footprint-based standards."[327] Overall, the agencies found that the auto industry has surpassed the standards at this point in time.[328]

At the time of this publication, it is unclear whether the Trump Administration EPA will make similar findings. President Trump's appointment of Scott Pruitt as EPA Administrator has generated speculation that the Trump Administration EPA may roll back the GHG emissions standards, presenting a significant obstacle in the deep decarbonization efforts.[329] The potential for future advances in fuel economy are further hindered by reports that the Trump Administration EPA may even deny California the waiver necessary for California to proceed with stricter GHG emissions standards independent of the federal standards.[330] As of early 2018, top U.S. government officials were in discussions with CARB seeking to maintain one set of national requirements for automakers, which could have a significant impact on the future of U.S. vehicle emissions rules.[331] Several states have indicated that they would file lawsuits to challenge any reductions in vehicle fuel rules should they occur.[332] Revisiting, reinforcing, and tightening GHG emissions standards, though, are necessary if deep decarbonization is to remain a possibility.

The next phase of the federal fuel economy standards (MYs 2026-2034) may be the most critical. This is because, as the DDPP explains, AFVs "must comprise the bulk of new sales" starting in 2030 to achieve the Mixed Scenario.[333] Without higher fuel economy/GHG emissions standards, this may be unlikely to occur, but the federal government should continue the recent trend of tightening emissions standards. The DDPP authors note that transitions for short-lived equipment like LDVs can ramp up slowly, a fact that is consistent with projections that none of the LDV technology stocks achieve significant penetration until the 2030 time frame.[334] The next phase of fuel economy standards may need to both dissuade consumers from purchasing larger LDVs and encourage more AFVs in the auto manufacturer fleets.

In addition to strengthening federal fuel economy standards, the federal government should continue to ratchet up LDV emissions standards and consider federal adoption of California's ZEV mandates. Many of the new ZEV vehicles have been delivered solely to the California market, and are known as "compliance vehicles" because they are only built to "comply" with the CARB mandate.[335] With 10 states currently applying California's ZEV mandates, other states should more seriously consider adopting a ZEV model. Such emissions regulations that encompass a larger part of this country can continue to influence what automakers build. For instance, the world's largest automakers began pursuing hydrogen vehicles in response to the ZEV mandate.[336]

### 5. Integrate Autonomous Vehicles

Another pathway toward fleet electrification is through increased acceptance and use of autonomous vehicles. Since these vehicles are generally fully electric,[337] as EVs emit less GHGs than ICVs, such a shift would generate a reduction in GHG emissions despite regional differences in the source of the electricity.[338] "Companies such as GM and Tesla are currently considering the impact that shared autonomous electric vehicles will have on the transportation sector."[339] Autonomous vehicles are being encour-

323. Alan Krupnick et al., Resources for the Future, Issue Brief No. 14-04, Preparing for the Midterm Review of the Fuel Economy and Greenhouse Gas Emissions Rate Standards for Light-Duty Vehicles: A Summary of Priority Research Questions (2014), http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-IB-14-04.pdf.

324. Letter From Gina McCarthy, Administrator, U.S. EPA, to Stakeholders (Nov. 30, 2016), https://www.epa.gov/sites/production/files/2016-11/documents/ld-pd-stkhldr-ltr-2016-11-30.pdf.

325. U.S. EPA et al., *supra* note 120.

326. *Id*.

327. *Id*.

328. *Id*. According to EPA, more than one-quarter of the 2015 models met the 2018 standards. *Id*.

329. Camille von Kaenel, *Calif., Pruitt Set for Collision Over Vehicle Standards*, E&E News, Jan. 19, 2017 (reporting that "automakers were asking Trump to soften the federal fuel economy rules" and that "Pruitt said yesterday he would review EPA's last-minute decision to lock in the rules through 2025"), http://www.eenews.net/climatewire/stories/1060048609.

330. *Id*. (reporting that California would need a waiver if the federal standards were substantially changed and California wanted to impose stricter standards). *See* CAA §202, 42 U.S.C. §7521.

331. David Shepardson, *U.S. Regulators Meet With California on Fate of Vehicle Fuel Rules*, Reuters, Jan. 8, 2018, https://af.reuters.com/article/africaTech/idAFL1N1P313R.

332. *Id*.

333. DDPP, *supra* note 10, at 71.

334. *Id*. at 27.

335. Jeffrey Wishart, *Report: The Effects of Fuel Economy and Emissions Regulations on the Automotive Sector*, Charged Electric Vehicles, Apr. 29, 2014, https://chargedevs.com/features/report-the-effects-of-fuel-economy-and-emissions-regulations-on-the-automotive-sector/.

336. Fershee, *supra* note 152, at 112.

337. *See, e.g.*, Thompson, *supra* note 164.

338. A related but different benefit is "green routing," taking advantage of the connectivity and autonomous nature of vehicles to optimize traffic flow. Gearhart, *supra* note 59, at 12.

339. Katie Fehrenbacher, *Future Cities Could Run on Shared Fleets of Electric Self-Driving Cars*, Fortune, Oct. 11, 2016, http://fortune.com/2016/10/11/shared-electric-self-driving-cars/.

aged for national security as well as environmental reasons (though safety and mobility remain the primary drivers).[340]

The U.S. Energy Security Council, which "advocates proven transformational policies designed to diminish oil's strategic value by opening the transportation fuel market to competition,"[341] has urged federal regulators to hasten adoption—through legislation or regulatory programs—of fully autonomous vehicles to reduce U.S. reliance on foreign oil.[342] Their goal is to reduce the percentage of the U.S. transportation system that requires oil by 50% by 2040.[343] To meet these goals, the council has asked NHTSA to "preempt state standards for driverless cars" and provide more "flexible federal standards."[344] This is one good option, as early evidence suggests that limited regulation can encourage adoption. Uber has taken advantage of first-mover status by implementing a pilot project of 30 autonomous car service vehicles in Pittsburgh before any regulations have been developed.[345] Lyft and GM have discussed similar plans in an undisclosed city.[346] Still, any preemption plan should include mechanisms to account for local concerns that may not exist in all jurisdictions.

As discussed above, the safety of these vehicles is the potential stumbling block.[347] One pathway for the federal and state governments to increase public confidence may be to phase in fully autonomous vehicles for specific uses before mainstream use on highways and roads. For instance, it may be useful for governmental and private entities to first incorporate them into small-scale tasks in low-traffic areas where they can be tweaked with minimal risk to the public. As one example, Rio Tinto and Volvo are testing self-driving trucks and lorries to save costs and increase efficiency on construction sites.[348] Although these self-driving trucks would still require humans onboard the vehicles, everyone would be going the same direction, at regular speeds, and with minimal pedestrians. Otto, an American startup, has even developed a self-driving kit to retrofit trucks. Current estimates, however, indicate that fully autonomous vehicles that would not require humans onboard will only be feasible around 2030.[349] Lawmakers, particularly at the state and local levels, can also provide more certainty by proactively addressing safety standards and regulations, as well as the liability regime surrounding autonomous vehicles.[350]

### 6. Educate Consumers

A last important component of enabling and enhancing the likelihood of success for the legal pathways discussed above focuses on education. Education can include enhancing the knowledge base for potential consumers, the dealers who are to champion these vehicles, and the work force needed to develop and maintain these vehicles. First, range anxiety can be addressed through a number of ways. Although the first commercially offered EVs could only go between 60 and 120 miles on a full charge,[351] the best-selling EVs now have a range of more than 250 miles.[352] One survey indicated that the majority of drivers want a pure EV to travel 300 miles on a single charge in order "to be willing to consider purchasing one."[353] The projected range for some of the next generation of EVs will satisfy this standard for many consumers.[354]

For those who are still hesitant, hybrid vehicles can also go a long way in helping reluctant buyers overcome their aversion to the fear of being stranded for lack of alternative vehicle infrastructure. This includes vehicles that already offer more than 100 mpg.[355] The technology that automatically converts from electric engines to ICEs provides a continued market for gas stations, and hybrids allow the transportation system more time to transition to more EV chargers. A natural result of the other legal pathways and time is that alternative vehicles may continue to enhance their track record and can provide data and positive feedback loops that can counter negative perceptions about alternative vehicles.

Second, worker skill sets must evolve to keep up with the changing landscape of vehicle production and maintenance. In addition to vehicle repairs, the industry needs workers both to produce Li-ion batteries and to build,

340. At least one study suggests that autonomous vehicles are unlikely to increase productivity. Michael Sivak & Brandon Schoettle, *Would Self-Driving Vehicles Increase Occupant Productivity?* (abstract) (2016), http://www.umich.edu/~umtriswt/PDF/SWT-2016-11_Abstract_English.pdf.
341. U.S. Energy Security Council, Mission Statement, http://usesc.org/energy_security/images/Energy_Security_Council.pdf.
342. Wittenberg, *supra* note 166.
343. *Id*.
344. *Id*.
345. Max Chafkin, *Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month*, Bloomberg, Aug. 18, 2016, http://www.bloomberg.com/news/features/2016-08-18/uber-s-first-self-driving-fleet-arrives-in-pittsburgh-this-month-is06r7on.
346. Maya Kosoff, *Lyft Plans to Put Self-Driving Electric Taxis on the Road by 2017*, Vanity Fair, May 6, 2016, http://www.vanityfair.com/news/2016/05/lyft-plans-to-put-self-driving-electric-taxis-on-the-road-by-2017.
347. *See supra* note 165 and accompanying text; Wittenberg, *supra* note 166 ("When people see and believe that these cars will not crash into each other, the amount of penetration increases very quickly.").
348. *Self-Driving Lorries: A Long Haul*, Economist, Aug. 18, 2016, https://www.economist.com/news/business/21705367-revolution-trucking-industry-distance-down-road-long-haul.
349. *See* Tao Jiang et al., *Self-Driving Cars: Disruptive or Incremental?*, Applied Innovation Rev., June 2015, at 3, *available at* http://cet.berkeley.edu/wp-content/uploads/Self-Driving-Cars.pdf.
350. *See, e.g.*, Mark Geistfeld, *A Roadmap for* Autonomous Vehicles*: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Cal. L. Rev. 1611 (2017) (suggesting a comprehensive regulatory approach to help avoid the high cost of uncertainty related to the emergence of autonomous vehicles), *available at* https://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=4381&context=californialawreview.
351. Fueleconomy.gov, *All-Electric Vehicles*, https://www.fueleconomy.gov/feg/evtech.shtml (last visited Feb. 25, 2018).
352. For example, the Tesla Model S has a 218-335-mile range. Jaclyn Trop, *10 Electric Cars With the Longest Range*, U.S. News & World Rep., Feb. 27, 2017, https://cars.usnews.com/cars-trucks/electric-cars-with-the-longest-range.
353. Singer, *supra* note 129, at iii.
354. *See* Trop, *supra* note 352.
355. For example, cars like the BMW i3 REX and Chevy Volt. Fueleconomy.gov, *Search Results*, https://www.fueleconomy.gov/feg/PowerSearch.do?action=noform&path=1&year1=2011&year2=2017&vtype=Plug-in+Hybrid&pageno=1&sortBy=Comb&tabView=0&tabView=0&rowLimit=200 (last visited Feb. 25, 2018).

operate, and maintain EV charging stations.[356] More technology-related apps need to be developed, programmers need to continue to secure EVs to be resistant to hackers, and software designers are needed to assist with the transition to public chargers. For workers to transition from conventional vehicles to electric, they will need specialized training. The federal and state governments, as well as private stakeholders, should create programs to train employees.

For example, the National Alternative Fuels Training Consortium is a formal training network that facilitates the training of technicians and the dissemination of alternative fuels training materials, involving manufacturers, academic institutions, and governmental organizations. The consortium has training centers in 25 states.[357] The National Automobile Dealers Association hosted an EV workshop at its 2016 convention and released a new publication, *A Dealer Guide to Marketing Electric Vehicles*.[358] Dealers can run test drive events for alternative vehicles, and may even be able to pair EV sales and leases with the sale of charging station installers. The success of the group purchase programs discussed earlier, for instance, hinged on "at least one enthusiastic and informed EV champion at participating dealerships."[359]

Auto manufacturers and governmental entities, particularly state environmental agencies, public utility commissions, and departments of motor vehicles, can also call upon current alternative vehicle owners to educate potential consumers. Electricity prices are more stable than oil prices, so alternative vehicles become more attractive when gasoline prices become more volatile.[360] Campaigns that target a younger generation of first-time car buyers may also help tilt the scales toward alternative vehicles. Studies reflect a generational preference for environmental protection and stewardship that may assist in the fleet transition.[361] Utilities can even help to educate drivers through public awareness campaigns and promotions.

### B. *Reducing the ICV Fleet*

The essential flip side to enhancing the AFV fleet is to reduce the ICV fleet. Therefore, an important component of a U.S. strategy to decarbonize its light-duty fleet is not just to incentivize alternative vehicles, but to provide disincentives for ICEs. As this transition occurs, a number of legal reforms may need to take place in tandem, including a plan for decommissioning underground petroleum storage tanks across the nation as gas stations close,[362] and a plan for safe disposal of the millions of EV batteries that have reached the expiration of their useful life.[363] This section addresses two key policy tools needed to spearhead the transition to a reduced ICV fleet: (1) incentives and (2) bans.

#### 1. Incentives

A first option elicits a carrot instead of a stick approach. A number of governments, including the United States, have offered cash-for-clunker-type programs that provide drivers of older, more polluting vehicles a cash incentive to turn in their old cars. Paris has implemented a cash incentive to scrap their ICVs, encouraging people to take their old cars to the scrapyard by offering a €400 ($444) incentive that can be put toward a travel pass, a bike rental system pass, an EV service rental pass, or the purchase of an electric car or bicycle.[364] Milan offers an incentive up to €5,000 ($5,540) to buyers of EVs who scrap a car that is more than 10 years old.[365] The BC SCRAP-IT Program in British Columbia, Canada, encourages early retirement of less fuel-efficient cars by recycling vehicles and offering a range of incentives that includes cash,

356. James Hamilton, *Electric Vehicle Careers: On the Road to Change*, Occupational Outlook Q., Summer 2012, at 14, 15, *available at* https://www.bls.gov/careeroutlook/2012/summer/art02.pdf.

357. West Virginia University, National Alternative Fuels Training Consortium, *About Us*, http://naftc.wvu.edu/about-us/ (last visited Feb. 25, 2018).

358. *Dealers Urged to Turn to Salespeople to Win New EV Customers*, Nat'l Automobile Dealers Ass'n, Apr. 22, 2016, https://www.nada.org/2016convention/EVPanel/.

359. Shepard, *supra* note 311.

360. *See* DOE, Office of Energy Efficiency and Renewable Energy, *Fact #960: January 16, 2017, Electricity and CNG Fuels Had the Lowest Price Variability Over the Past 16 Years*, https://energy.gov/eere/vehicles/fact-960-january-16-2017-electricity-and-cng-fuels-had-lowest-price-variability-over (last visited Feb. 25, 2018); U.S. Federal Trade Commission, Gasoline Price Changes: The Dynamic of Supply, Demand, and Competition (2005) ("Consumers closely follow gasoline prices, and with good reason. U.S. consumers have experienced dramatic increases and wide fluctuations in gasoline prices over the past several years."), *available at* https://www.ftc.gov/sites/default/files/documents/reports/gasoline-price-changes-dynamic-supply-demand-and-competition-federal-trade-commission-report-2005/050705gaspricesrpt.pdf. "Gasoline prices can change rapidly if something disrupts the supply of crude oil or if problems at refineries or with delivery pipelines occur." EIA, *Gasoline Explained: Gasoline Price Fluctuations*, http://www.eia.gov/energyexplained/index.cfm?page=gasoline_fluctuations (last updated Feb. 6, 2017).

361. Climate CoLab, *Pledge to Drive Electric Vehicles and Install Electric Vehicle Charging Stations*, https://www.climatecolab.org/contests/2014/transportation/phase/1300613/proposal/2406 (last visited Feb. 25, 2018).

362. EPA provides guidance on how to permanently close underground storage tanks. *See* U.S. EPA, Closing Underground Storage Tanks: Brief Facts (1996) (EPA 510-F-96-004), *available at* https://www.epa.gov/sites/production/files/2014-03/documents/clo.pdf. Tank operators must abide by state regulations regarding the closing of underground petroleum storage tanks. For example, see Florida's requirements at Florida Department of Environmental Protection, *Division of Waste Management*, https://floridadep.gov/waste/permitting-compliance-assistance/content/storage-tank-system-rules-forms-and-reference (last visited May 18, 2018).

363. The Commission for Environmental Cooperation estimates that 1.5 million EV batteries are expected to reach the end of their useful life by 2030. Peter Menyasz, *Report: North America Must Plan for Old Electric Car Batteries*, Env't & Energy Rep. (BNA) (Dec. 29, 2015), https://www.bna.com/report-north-america-n57982065571/; Phil Taylor, *When an Electric Car Dies, What Will Happen to the Battery?*, Sci. Am., Sept. 14, 2009, https://www.scientificamerican.com/article/lithium-ion-batteries-hybrid-electric-vehicle-recycling/; DOE, Alternative Fuels Data Center, *Batteries for Hybrid and Plug-In Electric Vehicles*, http://www.afdc.energy.gov/vehicles/electric_batteries.html (last updated Apr. 10, 2017). *But see supra* Part IV.A.2. discussing BMW's use of old batteries to support demand response for a California utility.

364. Oliver Gee, *What Does the Paris Ban on Old Cars Actually Mean?*, Local Fr., July 1, 2016, http://www.thelocal.fr/20160701/what-does-the-paris-ban-on-old-cars-actually-mean.

365. Soot Free for the Climate, *Milan*, http://sootfreecities.eu/city/milan (last visited Feb. 25, 2018).

bicycles, transit sharing, and appealing subsidies for purchasing vehicles with significantly reduced emissions.[366] The United Kingdom ran a scrappage scheme in 2009, primarily to increase new car sales, offering a £2,000 ($2,500) discount on certain new vehicles with a benefit of also shifting people into cars with lower emissions.[367] The United States offered the Cash for Clunkers program in 2009, though it may be time for another round.

The U.S. Cash for Clunkers program provided the short-term stimulus for which it was designed. Between July 1, 2009, and August 24, 2009, the Car Allowance Rebate System (CARS), popularly known as "Cash for Clunkers," resulted in the trade of approximately 700,000 clunkers for vouchers in the amount of $3,500 or $4,500.[368] An October 2013 study conducted by the Brookings Institute summarized the effects of CARS:

> Our evaluation of the evidence suggests that the $2.85 billion in vouchers provided by the program had a small and short-lived impact on gross domestic product, essentially shifting roughly a few billion dollars forward from the subsequent two quarters following the program . . .
>
> On the environmental side, the cost per ton of carbon dioxide reduced due to the program was higher than what would be achieved through a more cost-effective policy such as a carbon tax or cap-and-trade, but was comparable (or indeed lower) than what is achieved through some of the less cost-effective environmental policies, such as the tax subsidy for electric vehicles.[369]

Researchers estimate that the program produced an additional 380,000 vehicle sales and an additional 2,050 job years.[370] However, the program only produced minimal gross domestic product growth and less job growth effects than other stimulus programs, "such as increasing unemployment aid, reducing payroll taxes, providing an additional social security payment, or allowing the expensing of investment costs."[371]

These programs face recurring problems, including a lack of funds to match the demand, short time periods, and differential treatment of the older ICVs that are turned in. If these vehicles are merely sold to other, poorer countries and used there, the global carbon impact has not been reduced. An effective vehicle-swapping program, from an emissions reduction perspective, requires that the program permanently retire the old vehicle. The United States, for example, required scrapping of the older ICVs' engines.[372]

Moving forward, programs targeting the highest emissions vehicles could prove effective in reducing emissions. Such programs could be offered at the local, state, or federal level, and interest in prior programs suggest that consumers will respond. Finding a mechanism to fund such a program, though, may prove challenging. A combination of a carrot and stick, such as a carbon tax of some kind to go along with a cash-for-clunkers program, would be an option. The carbon tax could be used to generate revenues to support the program, leading to reduced emissions while supporting economic activity.

## 2. Bans

A second, but controversial, approach, involves prohibiting the sale or use of ICVs. At first blush, this approach appears to be politically untenable. But a number of countries have indicated plans for a 100% ZEV future. A turning point occurred in 2017 for many countries, with Norway,[373] India,[374] Scotland,[375] France,[376] Britain,[377] and China indicating that they would end the sale of gas and diesel cars by dates ranging from 2025 to 2040.[378] China's statement seems to have sent the most shockwaves through the industry, given that it reflects the world's largest car market (30% of global passenger vehicle sales).[379] In the United States, however, pursuing such a policy at the federal level would likely be a political disaster and more disruptive than productive, given other alternatives.

A few cities have also explored selective bans on ICVs. For example, Paris has implemented a ban on ICVs registered before January 1, 1997, prohibiting them from driving on the city's roads between 8 a.m. and 8 p.m. Monday through Friday.[380] Violators face a fine of €35, which nearly doubled to €68 in 2017.[381] The restrictions may get tighter over the next few years, possibly restricting ICVs altogether by 2020.[382] Not surprisingly, there

366. BC SCRAP-IT Program, *Home Page*, https://scrapit.ca (last visited Feb. 25, 2018).
367. *UK Vehicle Scrappage Scheme Gets Under Way*, Soc'y Motor Manufacturers & Traders, May 18, 2009, http://www.smmt.co.uk/2009/05/uk-vehicle-scrappage-scheme-gets-under-way/.
368. *See* Ted Gayer & Emily Parker, Brookings Institute, Cash for Clunkers: An Evaluation of the Car Allowance Rebate System 1 (2013), https://www.brookings.edu/wp-content/uploads/2016/06/cash_for_clunkers_evaluation_paper_gayer.pdf.
369. *Id*.
370. *See id*. at 8.
371. *See id*.
372. Dan Fletcher, *What Happens to the Clunkers Traded In?*, Time, Aug. 4, 2009, http://content.time.com/time/business/article/0,8599,1914367,00.html.
373. David Roberts, *The World's Largest Car Market Just Announced an Imminent End to Gas and Diesel Cars*, Vox, Sept. 13, 2017 (reporting that by 2025, Norway will end all gas and diesel car sales and that 40% of the nation's cars are already classified as EV, hybrid, or hydrogen in 2017), https://www.vox.com/energy-and-environment/2017/9/13/16293258/ev-revolution.
374. *Id*. (reporting that India plans to end sales of gas and diesel cars by 2030).
375. *Id*. (reporting that Scotland intends to end sales of gas and diesel cars by 2032).
376. *Id*. (reporting that France announced plans to end sales of gas and diesel cars by 2040).
377. *Id*. (reporting that Britain plans to end sales of gas and diesel cars by 2040).
378. *Id*.
379. *Id*.
380. Steve Siler, *Paris Is Smoking: Bans 20-Year-Old Cars, but Collector Cars Can Stay*, Car & Driver, June 1, 2016, http://blog.caranddriver.com/paris-is-smoking-bans-20-year-old-cars-but-collector-cars-can-stay/.
381. *Id*.; Kim Willsher, *Paris Vehicle Pollution Sticker Scheme Comes Into Force*, The Guardian (U.K.), Jan. 16, 2017, https://www.theguardian.com/world/2017/jan/16/paris-vehicle-pollution-sticker-scheme-comes-into-force.
382. *Paris Bans Old Polluting Cars*, Climate Action, July 4, 2016, http://www.climateactionprogramme.org/news/paris_bans_old_polluting_cars.

has been pushback. Drivers want compensation for the inevitable loss in resale value of their vehicles, which may hit hardest on small businesses and the poor, and the group 40 Million Drivers Association has filed a legal action seeking compensation for the loss in vehicle value.[383] The government is offering incentives for drivers to buy EVs and to install EV charging facilities.[384] In addition, to ease the public into the new plan, officers will initially hand out information and explain the new rules, focusing at first on prevention and warning as opposed to immediately issuing fines.[385] The Supreme Court of India sought to address air pollution in the National Capital Region of Delhi through bans of luxury diesel vehicles, which was recently lifted and replaced with a pollution charge,[386] and restrictions limiting entry points for heavy commercial vehicles.[387]

Major U.S. cities may be able to conduct traffic assessments to determine whether it is feasible to follow the Paris approach and ban ICVs registered before a certain date during peak traffic hours. The feasibility of such an approach may depend on factors such as the availability of public transportation, bike lanes, and overall politics. Cities having significant infrastructure of this sort should at least consider the feasibility of such an approach.

Many analysts acknowledge the difficulties of implementing any sort of a policy tool that discourages ICVs due to their relation to highway funding.[388] Historically, the HTF has been dependent on gasoline taxes to support public infrastructure projects. As EVs capture a larger share of the ICV market, this will result in less revenues for the fund. This creates perverse incentives for both federal and state lawmakers that may work against a transition to AFVs.

For instance, some advocate for an increased gasoline tax to incentivize more efficient AFVs.[389] As of September 2017, state taxes on gasoline averaged 27.89 cents a gallon, bringing the total tax on gasoline to about 46 cents per gallon.[390] It is unclear whether an increased gasoline tax would actually decrease carbon emissions or whether it would just generate more revenues.[391] A number of studies demonstrate that drivers' demand for gasoline is quite inelastic.[392] In fact, despite wide fluctuations in gas prices over time, drivers "have not significantly altered their gasoline consumption in response to higher gasoline prices. . . ."[393] This suggests that a gasoline tax may similarly do little to alter gasoline consumption, particularly as the fuel economy of ICVs increases.[394] Indeed, some researchers have conceded that empirical data concerning a gasoline tax's effect on reducing carbon emissions is "virtually nonexistent."[395]

A better approach focuses on ways to offset the lost highway revenue through other means. The National Surface Transportation Infrastructure Financing Commission, for instance, has recommended that the United States transition to a user-charge system in the form of a VMT system, an approach that decouples revenue from gas and may be more amenable to EV owners.[396] Such a move is advisable because those who use the roads the most should be the ones who pay the most for the roads. Furthermore, even without widespread use of EVs, continued funding of the HTF has become a concern. In 2015, to address declining gas tax revenues and the shrinking HTF, President Obama signed the FAST Act, which permitted a host of short-term financial fixes to replenish the HTF's reserves.[397]

383. Alice Wheatley, *All Old Cars Banned From Paris City Centre Under New Law*, Int'l Bus. Times, July 1, 2016, http://www.ibtimes.co.uk/all-cars-over-19-years-old-banned-paris-city-centre-under-new-law-1568501.

384. *Id*.

385. Siler, *supra* note 380.

386. Amy Kazmin, *India Lifts Ban on New Luxury Diesel Vehicles*, Fin. Times, Aug. 12, 2016, https://www.ft.com/content/2bfddfe8-608e-11e6-ae3f-77baadeb1c93.

387. *Supreme Court Bans Heavy Vehicles Into Delhi From 4 More Entry Points*, Press Tr. India, Jan. 6, 2016, https://www.ndtv.com/delhi-news/supreme-court-bans-heavy-vehicles-into-delhi-from-4-more-entry-points-1262550.

388. *See, e.g.*, Alan Jenn et al., *How Will We Fund Our Roads? A Case of Decreasing Revenue From Electric Vehicles*, Transportation Research Part A (2015), at 136 ("Total annual revenue generation decreases by about $200 million by 2025 as a result of EV adoption in our base case, but in projections with larger adoption of alternative vehicles could lead to revenue generation reductions as large as $900 million by 2025."), *available at* https://pdfs.semanticscholar.org/8e39/3f0a61f2924a9b34b13feb55a727d45ad27b.pdf.

389. Lowry, *supra* note 181, at 2; Nie et al., *supra* note 112 (The increased revenue could secure the HTF's financing, promote investments in federal transportation infrastructure, increase values of private property surrounding the improved transportation corridors, and fund low-carbon and renewable energy projects domestically and abroad.).

390. EIA, *supra* note 183 (follow "State-by-state fuel taxes" hyperlink to Excel spreadsheet) (the state taxes usually consist of excise taxes, environmental taxes, sales and/or use taxes, inspection fees, and other miscellaneous charges).

391. *Cf.* Lucas W. Davis & Lutz Kilian, *Estimating the Effect of a Gasoline Tax on Carbon Emissions*, 26 J. Applied Econometrics 1187, 1188, 1211-12 (2011) (arguing that that a 10-cent increase in the gasoline tax would only reduce total carbon emissions by about 0.5% the following year); Jeffrey D. Sachs, *Why It's Time to Raise the Federal Tax on Gasoline*, Politico Mag., Jan. 19, 2015 (arguing for a 35-cent tax increase in January 2015 that would increase government revenue by approximately $50 billion per year over the next decade), http://www.politico.com/magazine/story/2015/01/why-its-time-to-raise-the-federal-tax-on-gasoline-114380.

392. Jonathan E. Hughes et al., *Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand*, 29 Energy J. 113, 130 (2008). But some have suggested that the adoption rate of EVs, especially that of BEVs, is more sensitive to the fuel price than to the vehicle sale prices. Nie et al., *supra* note 112. Other studies, however, indicate that higher gasoline prices do increase the demand for fuel-efficient vehicles.

393. Hughes et al., *supra* note 392, at 132 (finding the short-run price elasticity of gasoline demand was significantly more inelastic from 2001 to 2006 than it was from 1975 to 1980).

394. *Id*. at 131-32 (some hypothesize that an increased dependence on automobiles for transportation, an increase in incomes, and an increase in vehicle fleet fuel economy contribute to the inelasticity of gasoline demand); Lester Picker, *The Effect of a Gasoline Tax on Carbon Emissions*, Nat'l Bureau Econ. Res., http://www.nber.org/digest/may09/w14685.html (last visited Feb. 25, 2018).

395. Davis & Kilian, *supra* note 391, at 1188.

396. National Surface Transportation Infrastructure Financing Commission, Paying Our Way—A New Framework for Transportation Finance 2 (2009), http://www.itif.org/files/NSTIF_Commission_Final_Report.pdf?_ga=2.186724904.1035010385.1512256711-389542463.1512256711.

397. *Fixing America's Surface Transportation Act*, *supra* note 98; Kevin Schleith, Implications of Electric Vehicles on Gasoline Tax Revenues 3, 4 (2015), http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2011-15.pdf. The FAST Act temporarily fixes the federal portion of the HTF with an amalgamation of short-term fixes including investing in services to enable collection of outstanding taxes, facilitating sales of 66 million barrels of oil from the Strategic Petroleum Reserve, cutting annual dividend payments

States have also hatched various ideas to pay for road maintenance and preservation, including fee-based travel, direct taxes on car registration and fuel, increased toll roads, and surcharges on vehicle purchases.[398] Not all of them are providing incentives for AFVs. At least 10 states have adopted one-time fees on hybrids or EVs to assist in transportation infrastructure funding, ranging from $50 to $300.[399] Oregon leads experimentation with a government-mandated program called OReGO in which volunteer drivers pay by mileage instead of paying a fuel tax.[400] The drivers install a device that records miles driven and then pay 1.5 cents per mile rather than a tax per gallon.[401] Ian W.H. Parry of Resources for the Future argues that, if fully implemented, a pay-as-you-drive (PAYD) insurance program, similar to OReGO, would reduce gasoline demand by 9.1% and produce welfare gains of $19.3 billion due to reduced mileage-per-vehicle use.[402] For similar results, the gasoline tax would have to be increased by 27 cents per gallon, or a VMT tax of 3.9 cents per mile.[403]

California, Minnesota, and Nevada joined Oregon in either replacing or adding to the gas tax a VMT tax.[404] The PAYD and VMT options allow for flexibility in that they can adjust rates to account for the type and weight of a vehicle and the location and time of its use. State legislatures should consider this approach, or a one-time fee charged to EV owners at the time of registration, to help ensure that alternative vehicles contribute their share to road construction and maintenance.

In contrast, China and the European Union (EU) both use gasoline taxes as a legal mechanism to increase revenue for environmental and economic purposes. China increased its fuel tax by 0.12 yuan per liter in 2014 and earmarked the additional revenue for addressing climate and environmental concerns as well as sparking investments in "new-energy" industry.[405] The EU levies a minimum fuel tax to control competition and trade within its Single Market and promotes a "competitive, low-carbon and energy efficient economy."[406] EU Member States charge a minimum of €359 (U.S. $398) per 1,000 liters of fuel, and approximately 84% to 87% of Member States' revenues from energy taxes are derived from oil-based products, namely gasoline.[407] Where such policies are enforced with high enough taxes, consumers may move away from ICVs to AFVs. However, when that change happens at scale, tax funds will be reduced and a new mechanism may be needed. As such, China and the EU will likely need another tax model at some point, and thus the United States should be considering a PAYD or VMT system, alongside the possibility of raising gasoline taxes.

Auto companies are also intensifying their efforts to move away from ICV, and should continue to do so. Global competition is providing a boost to EV development. Although Tesla is seen as a leader in the EV markets, BMW, Volkswagen, and Daimler all have announced ambitious EV market goals intended to position themselves as leaders in the EV transformation.[408] Although there is no guarantee that automakers will achieve their EV goals, 2016-2017 also marked a turning point in the direction of their fleets. Specifically, Volkswagen (300 EV models), Daimler (10 EV models by 2022), Volvo (all models by 2019), BMW (15 models by 2025), and Jaguar Land Rover (all models by 2020) all announced plans to significantly increase the number of EV/hybrid models available to consumers.[409]

Of the three U.S. automakers, GM was the first to do the same, indicating an all-electric, zero-emission future that includes 20 EV models by 2023.[410] Ford similarly announced plans for 13 new hybrids or EVs, and plans to build seven of them in the next five years.[411] Ford plans to have 40% of its global nameplates globally electrified by the end of 2020, increasing from the current 13%.[412] Subsidiaries of the "Big Three" U.S. manufacturers were responsible for two-thirds of all AFVs in the market over the past 26 years.[413] In summary, legal pathways exist to accelerate the DDPP goals through promoting fleet AFVs and reducing ICVs, but they will require political will and bipartisan cooperation.

from the Federal Reserve, and using dollars from the Federal Reserve rainy day fund. *See id*.

398. Schleith, *supra* note 397, at 5, 6.

399. DOE, Office of Energy Efficiency and Renewable Energy, *Fact #901: November 30, 2015, States Assessing Fees on Electric Vehicles to Make Up for Lost Fuel Tax Revenue*, http://energy.gov/eere/vehicles/fact-901-november-30-2015-states-assessing-fees-electric-vehicles-make-lost-fuel-tax (last visited Feb. 25, 2018); Kristy Hartman & Emily Dowd, *State Efforts to Promote Hybrid and Electric Vehicles*, Nat'l Conf. St. Legislatures, Sept. 26, 2017, http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.

400. *See* Oregon Department of Transportation, *Getting to OReGO*, http://www.myorego.org/about/ (last visited Feb. 25, 2018).

401. *See* Oregon Department of Transportation, *OReGO Home Page*, http://www.myorego.org (last visited Feb. 25, 2018).

402. Ian W.H. Parry, *Is Pay-as-You-Drive Insurance a Better Way to Reduce Gasoline Than Gasoline Taxes?*, 95 Am. Econ. Rev. 288, 291, 292 (2005).

403. *Id*. at 292.

404. Schleith, *supra* note 397, at 6.

405. *China to Increase Fuel Tax to Curb Pollution, Carbon Emissions*, Bloomberg, Nov. 28, 2014, http://www.bloomberg.com/news/articles/2014-11-28/china-to-increase-fuel-tax-to-curb-pollution-carbon-emissions.

406. European Commission, Taxation and Customs Union, *Excise Duties: Energy*, https://ec.europa.eu/taxation_customs/taxation/excise_duties/energy_products/index_en (last visited Feb. 25, 2018).

407. NERA Economic Consulting, Energy Taxation and Subsidies in Europe: A Report on Government Revenues, Subsidies, and Support Measures for Fossil Fuels and Renewables in the EU and Norway: Report for the International Association of Oil and Gas Producers 85-86 (2014), http://www.nera.com/content/dam/nera/publications/archive2/PUB_OGP_0514.pdf; European Commission, Taxation and Customs Union, *Excise Duties: Energy Tax Rates*, https://ec.europa.eu/taxation_customs/taxation/excise_duties/energy_products/rates/index_en (last updated Feb. 25, 2018).

408. Tim Higgins, *BMW to Expand Electric-Vehicle Offerings*, Wall St. J., Oct. 11, 2016, https://www.wsj.com/articles/bmw-to-expand-electric-vehicle-offerings-1476228762.

409. Roberts, *supra* note 373.

410. Alex Davies, *General Motors Is Going All Electric*, Wired, Oct. 2, 2017, https://www.wired.com/story/general-motors-electric-cars-plan-gm/.

411. Matthew Dolan, *Here Are the Details of Ford's Electric Vehicle Plan*, Detroit Free Press, Jan. 3, 2017.

412. *Id*.

413. DOE, Alternative Fuels Data Center, *AFV and HEV Model Offerings, by Manufacturer*, https://www.afdc.energy.gov/data/10304 (last updated Mar. 2016).

## IV. Conclusion

The legal pathways to 300 million AFVs and 100-mpg fuel economy standards by 2050 are difficult. They require strong support by the executive branch for increased fuel economy standards, state and local governments to remove obstacles in the way of AFV proliferation, public and private actors that are committed to decarbonizing their electricity generation fleets, a host of public-private partnerships with utilities and automakers to assist in the transition with a focus on innovation, and a populace that is willing to learn and change from the only type of LDVs they have known to a new and cleaner generation of LDVs.