ELECTRIC VEHICLES AND INFRASTRUCTURE FUNDING

TECHNICAL MEMORANDUM

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Jeffrey Short
Vice President
American Transportation Research Institute
Atlanta, GA

Danielle Crownover
Research Analyst
American Transportation Research Institute
Atlanta, GA

950 N. Glebe Road, Suite 210
Arlington, Virginia 22203
TruckingResearch.org

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ACRONYMS

AFV	Alternatively Fueled Vehicle
ATRI	American Transportation Research Institute
BEV	Battery Electric Vehicle
EV	Electric Vehicle
EVSE	Electric Vehicle Service Equipment
ExSTARS	Excise Summary Terminal Activity Reporting Systems
FET	Federal Excise Tax
FHWA	Federal Highway Administration
HEV	Hybrid Electric Vehicle
HTF	Highway Trust Fund
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
IEA	Internal Energy Agency
IRS	Internal Revenue Service
kWh	Kilowatt-Hours
MPG	Miles per Gallon
MPGe	Miles per Gallon Equivalent
PHEV	Plug-in Hybrid Electric Vehicle
RAC	Research Advisory Committee
TOU	Time-of-Use
U.S. DOT	United States Department of Transportation
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled

TABLE OF CONTENTS

FIGURES AND TABLES

INTRODUCTION

The federal Highway Trust Fund (HTF) is the primary source of federal funding used by state governments to maintain and improve U.S. surface transportation infrastructure. The majority of HTF revenues (which typically total nearly $40 billion annually) are derived from fuel taxes. These fuel taxes operate as a road user fee, with larger vehicles (e.g. Class 8 tractor-trailers with low miles per gallon [MPG]) paying substantially more per mile for road use than smaller vehicles (e.g. compact cars with very high MPG).

There are several headwinds facing the HTF. First, the per-gallon federal fuel tax rates were last increased in 1993, which has led to inflation-related roadway investment shortfalls. This underfunding occurred even while fuel consumption has increased substantially over the past 30 years.[1] A second issue is the improving fuel efficiency of the U.S. car and truck fleet. A vehicle built today can travel much farther on a gallon of fuel than vehicles from the early 1990s, and as a result the typical driver contributes less per mile to highway tax revenue than that same driver did decades ago.[2] Finally, across the past ten years, the electric vehicle share of the U.S. fleet has grown, and such vehicles by their very nature do not pay any federal motor fuels taxes.[3]

Previous Research

One option that has been widely discussed as a means to overcome the aforementioned fuel tax issues is a national vehicle miles travelled (VMT) tax. A VMT tax in theory would maintain the user-pays approach to transportation funding, while at the same time charging vehicles based on roadway use instead of motor fuel consumption. This VMT concept has been central to highway funding discussions, and as a result the American Transportation Research Institute (ATRI) Research Advisory Committee (RAC)[4] selected a report studying the potential impacts of a VMT tax as a top priority.

The report *A Practical Analysis of a National VMT Tax System* was published in March 2021, and found that a national VMT tax program would cost many billions of dollars in overhead annually, and would have extensive expenses and uncertainties related to compliance and enforcement.[5] Identifying promising approaches to tying electric vehicle use into federal and state transportation tax revenue streams is the focus of this follow-on report.

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[1] U.S. Bureau of Labor Statistics. Databases, Tables & Calculators by Subject. Available Online: https://www.bls.gov/data/

[2] United States Environmental Protection Agency. (January 26, 2021). "Automotive Trends Report." https://www.epa.gov/automotive-trends/highlights-automotive-trends-report#main-content

[3] Rudman, Kristin. (November 30, 2018). "EEI Celebrates 1 Million Electric Vehicles on U.S. Roads." Edison Electric Institute. https://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20Celebrates%201%20Million%20Electric%20Vehicles%20on%20U-S-%20Roads.aspx.

[4] ATRI's Research Advisory Committee (RAC) is comprised of industry stakeholders representing motor carriers, trucking industry suppliers, federal government agencies, labor and driver groups, law enforcement, and academia. The RAC is charged with annually recommending a research agenda for the Institute.

[5] Short, Jeffrey and Dan Murray. "A Practical Analysis of a National VMT Tax System." American Transportation Research Institute. Arlington, VA. March 2021.

Research Approach and Goals

While it is clear through ATRI's 2021 research that a VMT tax is not a financially feasible solution in the short-term due to extensive overhead costs, it is also apparent that the largest threat to HTF solvency is the expected proliferation of electric vehicles in the coming years.

Since 2010, more than 1 million battery electric vehicles (BEVs) have been sold in the U.S.[6] While this represents just a fraction of the country's 276 million registered vehicles, there are many indications that BEV use will grow significantly in the coming decades. These projections will be discussed in detail in the next section.

With this backdrop of a changing vehicle fleet, the goal of this research is to explore options for taxing electric vehicle users for their use of public roadways. In doing so, this research attempts to identify a feasible approach for ensuring that electric vehicle users pay a similar use tax to those who drive traditional vehicles. With such measures in place, threats to the HTF and the roadways it funds could be lessened or eliminated as these new electric vehicles enter the U.S. vehicle fleet.

This report first analyzes state-level electric vehicle registration fees. While registration fees are promising, these fees have no direct nexus to vehicle use. Next, the report offers a review of the VMT tax concept, highlighting the findings from ATRI's 2021 VMT tax report. Finally, the report explores mechanisms for taxing the energy that is used to propel electric vehicles. Similar to traditional gasoline-powered vehicles, electric vehicles are powered by electricity that can be measured – but in kilowatt-hours (kWh) instead of gallons. Thus, an electricity tax or surcharge that is tied directly to the kWh used by automobiles is the third option explored in this report. In particular, the existing technologies and organizational frameworks that could allow for such charging were analyzed.

It should be noted that much of this paper focuses on the current and future electric automobile population. Data for this type of vehicle is widely available and a measurable number of electric cars are presently operating in the U.S. The population and data for Class 8 electric trucks, on the other hand, is very limited. That said, ultimately this report seeks to identify a path to raise revenue from highway users based on consumption of electricity used for transportation, and those solutions would be applicable to all electric vehicle types.

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[6] USA Facts. (October 22, 2020). "How many electric cars are on the road in the United States?" https://usafacts.org/articles/how-many-electric-cars-in-united-states/

THE CHANGING COMPOSITION OF THE U.S. AUTOMOBILE FLEET

Current Fleet

As stated earlier, there are approximately 276 million vehicles registered in the U.S.[7] The plurality of these vehicles are classified as automobiles (108 million); the overall fleet also includes trucks, buses and other vehicles.[8] While most automobiles in the current U.S. fleet are traditional gasoline-powered vehicles, a growing number use motors powered by electricity.

Definitions of automobile types discussed in this paper are found below.

Traditional Vehicle. The gasoline-powered automobile has an internal combustion engine (ICE), a fuel tank, and does not have an electric motor (formally known as an electric traction motor), nor does it have a traction battery pack which is needed to power an electric motor. A typical gasoline-powered 4-door sedan has an MPG rating of 25.[9]

Hybrid Vehicle. The introduction of the hybrid electric vehicle (HEV), most notably through the popular Toyota Prius (made available in the U.S. market in 2001), was an initial step toward electrifying the U.S. fleet. While HEVs do not run directly on electricity, the vehicles do have an electric motor and a battery alongside an ICE. The traction battery is charged both by the ICE and through a process called regenerative braking. As a result gasoline consumption is decreased greatly, with a 52 MPG rating on average for a four door HEV sedan.[10] Thus, an HEV uses half the fuel of a traditional gasoline-powered car and thus pays half the taxes on a per-mile basis.

Electric Vehicle. The term electric vehicle (EV) has been used to describe several vehicle types. EVs can be propelled by an electric motor and offer at least a partial alternative to the traditional internal combustion engine (ICE). As a result, EVs are able to use less motor fuel, or no motor fuel at all. To better understand the differences among electric vehicle types, below are definitions of the EV categories.

- Plug-In Hybrid Electric Vehicle (PHEV): The PHEV is similar to the HEV, but its battery can be charged by both a gasoline engine and an electric outlet. A PHEV will use electricity and its electric motor before employing the gasoline engine. When operating the gasoline engine, the MPG is similar to an HEV, but this type of vehicle also has a miles per gallon equivalent (MPGe)[11] rating, which averages above 90.[12]

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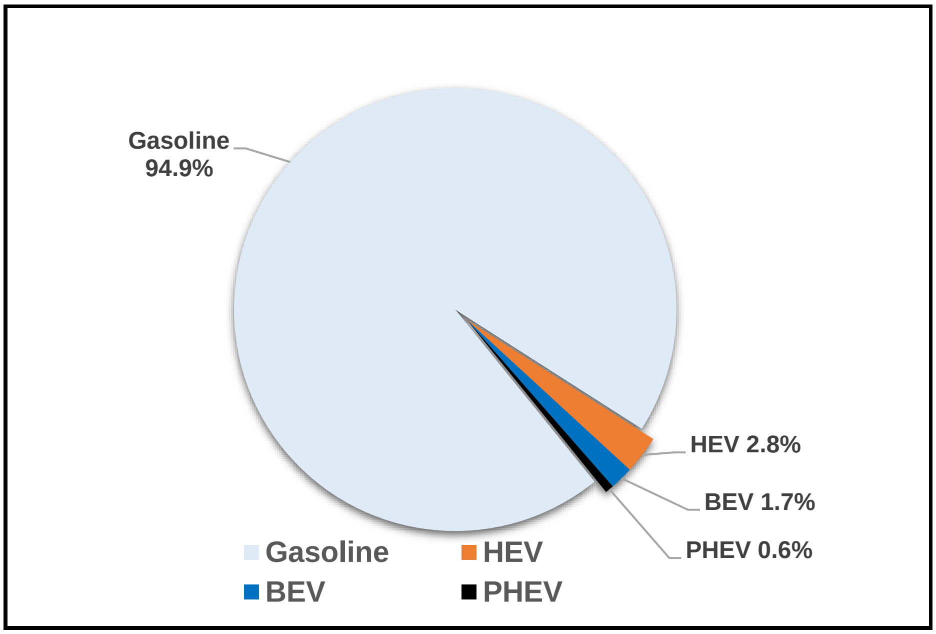
[7] U.S. Department of Transportation Federal Highway Administration. (December 9, 2020). "Highway Statistics Series: State Motor-Vehicle Registrations – 2019." Table MV – 1. https://www.fhwa.dot.gov/policyinformation/statistics/2019/mv1.cfm
[8] Ibid.
[9] U.S. Department of Energy, Vehicle Technologies Office. (March 15, 2021). "FOTW# 1177, March 15, 2021: Preliminary Data Show Average Fuel Economy of New Light-Duty Vehicles Reached a Record High of 25.7 MPG in 2020." https://www.energy.gov/eere/vehicles/articles/fotw-1177-march-15-2021-preliminary-data-show-average-fuel-economy-new-light
[10] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, and U.S. Environmental Protection Agency. (August 24, 2021). "Fuel Economy Guide 2021."
[11] Miles per gallon of gasoline equivalent (MPGe) represents the number of miles the vehicle can travel using the same amount of fuel with the same energy content as a gallon of gasoline.
[12] Ibid.

- Battery Electric Vehicle (BEV): A BEV operates only on batteries that are charged directly from an external electricity source. A BEV consumes no gasoline and therefore does not pay fuel taxes. The average BEV has an MPGe rating of 123.[13]

Of the 108 million registered automobiles, the vast majority are powered solely by an ICE, use fossil fuels (typically gasoline) and directly emit pollutants including CO_2.

Currently, only a small percentage of the new passenger cars that are added to the U.S. fleet each year (approximately 5.1%) utilize an alternative propulsion system to the ICE such as an electric motor (see Figure 1).[14]

Figure 1: U.S. Passenger Car Sales 2019[15]



It is estimated, based on cumulative sales from 2010 through 2020, that the U.S. automobile fleet at the beginning of 2021 included just over 1 million BEVs.[16] Based on the Federal Highway Administration (FHWA) Highway Statistics vehicle miles traveled data, a typical light-duty vehicle travels 11,599 miles annually.[17] A light-duty vehicle that averages 25 MPG would

[13] Ibid.
[14] Bureau of Transportation Statistics. "Hybrid-Electric, Plug-in Hybrid-Electric and Electric Vehicle Sales." United States Department of Transportation. https://www.bts.gov/content/gasoline-hybrid-and-electric-vehicle-sales; Bureau of Transportation Statistics. "Annual U.S. Motor Vehicle Production and Domestic Sales." United States Department of Transportation. https://www.bts.gov/content/annual-us-motor-vehicle-production-and-factory-wholesale-sales-thousands-units
[15] Ibid.
[16] Davis, Stacy and Robert Boundy. (April 2021). "Transportation Energy Data Book Edition 39." Table 6.2 – Hybrid and Plug-In Vehicle Sales, 1999-2020. https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf#page=182
[17] U.S. Department of Transportation Federal Highway Administration. (November, 2020). "Highway Statistics Series: Annual Vehicle Distance Traveled in Miles and Related Data – 2019 by Highway Category and Vehicle Type – 2019."

require 464 gallons of gasoline to travel that distance. The associated federal fuel tax at 18.4 cents per gallon would generate just over $85 per year.

By applying the $85 tax per vehicle to 1.08 million BEVs, it is estimated that the HTF currently loses $92.2 million in fuel tax revenue annually to BEV usage.

Electric Vehicle Sales Projections

EV sales (including BEVs and PHEVs) in the U.S. are projected to increase rapidly this decade. Consequently, a growing percentage of the U.S. vehicle fleet will pay little or no federal fuel tax. The literature estmates how swiftly the U.S. EV fleet will grow. One projection from the Edison Electric Institute forecasts annual sales of 3.5 million EVs in the U.S. in 2030, bringing the total number of EVs to 18.7 million.[18] Another report by the International Energy Agency (IEA) finds U.S. EV sales to be 14 percent of the global market which, if maintained, would lead to an an estimated 19.6 million EVs in the U.S. vehicle fleet by 2030.[19]

To better understand the impact of EV growth on future HTF revenues, a ten-year period from 2020 to 2029 was analyzed. Since there will be 19 million EVs in the U.S. automobile fleet by the beginning of 2030, and assuming that 80 percent or 15.2 million would fall into the BEV category – consuming no gasoline – these are the figures used in the analysis.[20]

The specific impact of BEVs to the HTF in 2029 was next calculated, assuming that the 15.2 million BEVs would each travel 11,599 miles during that year for a BEV fleet total of 176.3 billion miles. If this population of BEVs had been gasoline-powered with a fuel economy rating of 28 MPG, they would have consumed nearly 6.3 billion gallons of gasoline during the year.[21] However, as fully electric vehicles, this would represent a HTF revenue loss of $1.158 billion.

Based on these findings, the cumulative impact of BEVs on HTF revenue was next calculated for 2020 through 2029. To do this, sales and fleet size for each year were required. Using the 2020 baseline of 1.08 million BEVs, it would require an annual growth rate of 36.85 percent to increase the BEV fleet size to 15.2 million through 2029. This growth rate was applied to sales and total vehicle figures for 2020 in order to estimate vehicle population across the ten-year period (see Table 1). Additionally, it was assumed that fuel economy for ICE vehicles would improve across the ten-year period, and would thus diminish HTF revenues if the vehicles had

Table VM – 1. https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm1.cfm, See Figure 4. EEI/IEI Annual EV Sales Forecast Compared to Selected Forecasts.

[18] Edison Electric Institute. (November 2018). "EV Sales Forecast and the Charging Infrastructure Required through 2030." https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_EEI-EV-Forecast-Report_Nov2018.ashx

[19] Internal Energy Agency. (2021). "Global EV Outlook 2021." https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

[20] Within the EV category, BEVs use no gasoline while PHEVs rely initially on electric power prior to shifting to a gasoline-consuming ICE. Deloitte states that "[BEVs] outperform PHEVs globally" and predicts that "BEVs will likely account for 81 percent of all new EVs sold" globally by the start of 2030. Deloitte. (July 28, 2020). "Electric Vehicles Setting a Course for 2030." https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html

[21] Vehicle Technologies Office. (March 15, 2021). "FOTW #1177, March 15, 2021: Preliminary Data Show Average Fuel Economy of New Light-Duty Vehicles Reached a Record High of 25.7 MPG in 2020." Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/vehicles/articles/fotw-1177-march-15-2021-preliminary-data-show-average-fuel-economy-new-light

been ICE instead of BEVs. To adjust for this, it was assumed that ICE fleet MPG would increase incrementally across the decade from 25 to the 28 MPG figure used previously for 2029. Taking these factors into account, total HTF losses due to BEV adoption for 2020 through 2029 were found to be $4.33 billion.

Table 1: Estimates for BEV Growth in the U.S. and Impact to HTF Revenues through 2029

	2020 Baseline [22]	2021	2022	2023	2024	2025	2026	2027	2028	2029
Annual BEV Sales (millions)	0.24	0.33	0.45	0.62	0.84	1.15	1.58	2.16	2.95	4.04
ICE MPG estimate	25.0	25.3	25.6	26.0	26.3	26.6	27.0	27.3	27.6	28.0
BEV Fleet Size (millions)	1.08	1.41	1.86	2.47	3.32	4.47	6.04	8.20	11.16	15.20
Annual HTF Loss (millions)	$92.2	$118.7	$154.6	$203.3	$269.1	$358.1	$478.5	$641.2	$861.2	$1,158.6

[22] Davis, Stacy and Robert Boundy. (April 2021). "Transportation Energy Data Book Edition 39." Table 6.2 – Hybrid and Plug-In Vehicle Sales, 1999-2020. https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf#page=182

APPROACHES TO TAXING ELECTRIC VEHICLES FOR ROAD USE

States have recognized that electric vehicles are responsible for a growing void in gasoline tax revenues. More than half of states have pursued existing mechanisms, particularly additional registration fees, for capturing this revenue. A few states have looked at a mileage tax as an option through pilot programs. Finally, it may be possible to tax transportation electricity in a similar way to gasoline, though few states have pursued this option.

State-Level Registration Fees

The most widely used method to capture lost fuel tax revenue is through higher vehicle registration fees for alternatively fueled vehicles (AFVs). In addition to charging high registration fees, some states have opted to charge special tag/license plate fees or to charge sales taxes for AFVs. These fees do of course generate revenue, but they are often not aligned well with roadway use. While the gasoline tax has a direct relationship to miles driven for each individual car, and a VMT tax measures precise mileage, a registration fee in theory allows you to drive an unlimited amount in exchange for a static fee.

Georgia charges the highest annual registration fee – $213.88 for non-commercial AFVs vehicles compared to $20 for gasoline vehicles.[23] States such as Alabama and Idaho have designated registration fees for battery-electric vehicles and plug-in electric vehicles. Additionally, states such as Oregon and Utah provide options for EV owners such as paying a high registration fee or opting into paying a VMT tax, which is discussed in the next section. Revenue generated from registration and similar fees is most often directed toward state-run transportation funds.[24] The approaches to EV registrations for most states are listed in Table 2.

Table 2: State EV Fees[25]

Registration	States
States that charge ≥ $100 for EV registration	AL, AR, CA, GA, ID, IL, IN, KS, MI, MS, NC, ND, OH, OR, SC, TN, UT, WA, WI, WV, WY
States that charge additional annual fees for EV owners	AL, AR, CA, CO, GA, HI, ID, IL, IN, IA, MI, MN, MS, MO, NE, NC, ND, OH, OR, SC, TN, UT, VA, WA, WV, WI, WY
States that currently do not designate a registration fee for EVs separate from gasoline-powered vehicles	AK, AZ, CT, DC, DE, FL, KY, LA, MA, MD, ME, MT, NH, NJ, NM, NV, NY, OK, PA, RI, SD, TX, VT

[23] Georgia Department of Revenue. (May 28, 2021). "Motor Vehicle Bulletin Alternative Fuel and Low-Speed Vehicles Annual Licensing Fees Effective July 1, 2021." https://dor.georgia.gov/document/document/2021-alternative-fuel-vehicles-annual-licensing-fees/download
[24] Hartman, Kristy and Laura Shields. (December 12, 2020). "Special Fees on Plug-In Hybrid and Electric Vehicles." National Conference of State Legislatures. https://www.ncsl.org/research/energy/new-fees-on-hybrid-and-electric-vehicles.aspx
[25] Ibid.

To prevent higher registration fees or additional taxes from discouraging consumers from buying EVs, many of these states have off-set the EV fees with various incentives such as tax credits and rebates to aid in developing an EV market. Forty-five states and the District of Columbia provide incentives through utilities via Time-of-Use (TOU) rates or through state legislation.

Examples of utility-driven incentives include:

TOU rates. Utilities encourage overnight EV charging at home by measuring and charging customers' energy consumption based on when the electricity is being used. Generally, utilities charge a higher rate for peak-hour electricity and charge lower rates during off-peak hours. TOU rates vary across states and utility companies, and have benefits both to the utility and the customer.

Charging rate discounts. In addition to TOU rates being provided by utilities, there are other rate discounts for charging either in public spaces or at home.[26]

Legislative incentives include tax credits, EV rebates, EVSE (electric vehicle service equipment) rebates, HOV lane exemptions, and EV parking. The most common incentives enacted by states include EV charging equipment installation cost reductions.

Tax credits and rebates. Tax credit is given to EV owners in specific states and varies based on income and EV type. Tax credit type and amount varies by state for vehicle or charging equipment purchased. Rebates are also granted in some states for EV owners for purchasing the EV as well as their own charging equipment.

Emission testing exemption. Many Hybrid Vehicles and EVs (particularly BEVs) do not have state-level emissions testing requirements.

Registration fee reduction. A small number of states offer reduced registration fees for EVs.

Table 3 below shows state alignment with various incentives. Less common incentives not listed in the table include but are not limited to public transit programs, finance incentives, workplace funding, and emission reduction plans.[27]

[26] Hartman, Kristy and Laura Shields. (August 20, 2021). "State Policies Promoting Hybrid and Electric Vehicles." National Conference of State Legislatures. https://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx
[27] Ibid.

Table 3: State EV Incentives[28]

Incentives	States Offering Incentives
States that offer EV rebates	AZ, CA, CO, CT, DE, FL, IA, ME, MD, MA, NE, NH, NJ, NY, OR, PA, VT
States that offer time of use (TOU) rates	AL,CA, GA, IL,IN, MD, MI, MN, NV, NH, NY, NC, OR, TX, UT, VT, VA, WI
States that offer EV tax credit	CO, DC, LA, MT, NY, OK, WA
States that offer EV emission inspection exemptions	CO, MD, MA, MI, MO, NV, NY, NC, OH, RI, UT,VA, WA
States that offer EV charging equipment incentives*	AR, CA, CO, DE, FL, ID, IA, LA, ME, MD, MA, MI, MN, MO, NE, NV, NH, NJ, NY, NC, OH, OK, OR, PA, RI, TN, TX, VT, VA, WA, WI, WY
States that offer registration fee reduction for EVs	CT,DC, IL
States that do not offer incentives for EV purchasing	ND, SD, KS, KY, WV

**Charging equipment incentives include but are not limited to grants, rebates, reduced installation fees, and project funding*

Vehicle Miles Traveled Tax

A second approach to collecting highway taxes from electric vehicles is through a vehicle miles traveled (VMT) tax. The VMT tax is designed to track vehicle mileage and assess a per mile fee on those vehicles. Unlike registration fees, the VMT tax has the ability to collect highway revenues from drivers based on use, thus maintaining the user-pays principle currently found in the motor fuels tax.

While several states have pilot programs for this highway funding approach, the concept is not widely deployed at this time. The OReGO program at the Oregon Department of Transportation is the most established program in the U.S. The program charges automobiles approximately 1.8 cents per mile but not all of that income goes to the state – approximately 40 percent of the revenue is paid to 3rd party technology companies that facilitate the program.[29]

While a VMT tax would capture revenue from electric vehicles, the costs to facilitate such a program at the federal level would be very steep. Tracking a vehicle's mileage and collecting revenue from individual drivers is possible with current technology, but represents substantial

[28] Hartman, Kristy and Laura Shields. (August 20, 2021). "State Policies Promoting Hybrid and Electric Vehicles." National Conference of State Legislatures. https://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx
[29] Whitty, James. (November 2007). "Oregon's Mileage Fee Concept and Road User Fee Pilot Program Final Report." Oregon Department of Transportation. https://www.myorego.org/wp-content/uploads/2017/07/RUFPP_finalreport.pdf

overhead in the form of tracking technology, account management and transaction charges. Beyond operations, ensuring that all registered U.S. vehicles are continually compliant is difficult as well. ATRI found in its 2021 research that a federal VMT program would cost more than $21 billion annually in administrative fees and $7.8 billion in enforcement and compliance costs to collect $35 billion in revenue. This cost is in stark contrast to the federal fuel tax, which is collected from approximately 300 distinct companies and costs less than $70 million to facilitate.[30]

Electric Fuel Tax

A third approach to capturing a fuel tax equivalent from electric vehicles is to tax the energy used to propel the EV. The concept of a federal tax on the kWh consumed for transportation purposes is similar to a fuel tax in that charges would be aligned with roadway use. Similarly, more energy efficient and/or lighter vehicles ultimately would pay less in taxes than heavier vehicles, thus tying the impact of vehicle weight to road use.

A kWh tax for electricity used in transportation, which would work in parallel with the motor fuels tax, has not been widely considered at the federal level. There has been little movement at the state level, though Pennsylvania does have an alternative fuel tax for electricity (and other fuels) used to propel vehicles.

In Pennsylvania, "alternative transportation fuels, including electricity, are subject to an Alternative Fuel Tax [that is] intended to tax these fuels at the same rate as gasoline and diesel on a gallon equivalent basis."[31] Certain parties such as alternative fuel dealers of electricity and even drivers who charge an EV at home are required to remit the electricity tax (which is currently $0.0172 per kWh) on a monthly basis to the Department of Revenue.[32] Lawmakers in the state have been pushing to replace this tax with an electric vehicle registration fee.[33] This is in part because the current electricity tax is said to be confusing, cumbersome, difficult to administer, and many EV owners likely do not remit the tax.[34]

There are additional states where the concept of a transportation-related electricity tax is being discussed:

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[30] Short, Jeffrey and Dan Murray. "A Practical Analysis of a National VMT Tax System." American Transportation Research Institute. Arlington, VA. March 2021.
[31] Szybist, Mark, and Kathy Harris. (October 17, 2019). "PA'S Gas Tax and Proposed Electric Vehicle Fees: A Primer." NRDC. https://www.nrdc.org/experts/mark-szybist/electric-vehicle-taxes-pa-what-you-need-know
[32] Pennsylvania Department of Revenue. (2021). "Alternative Fuels Tax Rates." Pennsylvania Government. https://www.revenue.pa.gov/Tax%20Rates/Pages/Alternative%20Fuels%20Tax%20Rates.aspx
[33] Levy, Marc. (November 20, 2020). "Pennsylvania House votes to impose fees on electric cars." AP News. https://apnews.com/article/technology-legislation-pennsylvania-tax-reform-bills-9e46334660df23c617487808a9cb46cb and
Szybist, Mark, and Kathy Harris. (October 17, 2019). "PA'S Gas Tax and Proposed Electric Vehicle Fees: A Primer." NRDC. https://www.nrdc.org/experts/mark-szybist/electric-vehicle-taxes-pa-what-you-need-know
[34] Ibid.

- The states of South Carolina, New York and Arkansas ruled that electricity sold to consumers at charging stations is subject to the state sales tax. [35] [36] [37]

- A bill introduced in the Minnesota legislature in 2021 would replace the flat $75 EV registration fee with a 5.1 cent per kWh "tax on electric fuel distributed by a utility through an electric vehicle charging station at a public or private parking space."[38] Though this bill did not advance, it could be a predecessor to future bills in Minnesota and other states. The bill includes the following noteworthy components:
    - The bill defines electricity used for transportation as "Electric fuel," which is "electrical energy delivered or placed into the battery or other energy storage device of an electric vehicle to be used to power the electric vehicle."
    - The bill defines "person[s] who owns or leases an electric vehicle charging station that dispenses electric fuel, upon which the electric fuel tax has not been previously paid, into the battery or other energy storage device of an electric vehicle in this state at a location other than a residence" as "Electric Fuel Dealers."
    - The bill would require that when electric fuel is consumed at a private residence, the 5.1 cent per kWh tax "must be collected by the utility that provides electric fuel to the electric vehicle charging station and must be collected from the vehicle owner or user by the utility at the time the electric fuel is distributed to the vehicle owner or user at the residence."
    - For public charging, the bill requires that the utility must collect the fee from the vehicle owner or user; when an electric fuel dealer is involved, that entity must pay the utility and has the option to collect from the vehicle owner.

- Iowa's legislature has already passed an electric fuel excise tax. This law will not be implemented until July 1, 2023. At that time electricity sold as fuel at nonresidential locations is subject to a $0.026/kWh excise tax.[39]

To examine the viability of an electric fuel tax, the remainder of this reports addresses the following questions:

1) How much would a kWh tax be for EVs?
2) How would a kWh tax be measured?
3) What is an ideal framework for collecting the tax?

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[35] South Carolina Department of Revenue. (July 7, 2020). "SC Private Ruling." https://dor.sc.gov/resources-site/lawandpolicy/Advisory%20Opinions/PLR20-5.pdf
[36] New York State Department of Taxation and Finance. (July 15, 2013). "Petition No. S121217A." Office of Counsel Advisory Opinion Unit. https://www.tax.ny.gov/pdf/advisory_opinions/sales/a13_18s.pdf
[37] State of Arkansas Department of Finance and Administration. (May 19, 2020). "Gross Receipts Tax – Taxability of Charging Stations for Electric Motor Vehicles Opinion No. 20190622." Revenue Legal Counsel. https://www.ark.org/dfa-act896/index.php/api/document/download/20190622.pdf
[38] Office of the Revisor of Statutes. (March 3, 2021). "SF 1602." Minnesota Legislature. https://www.revisor.mn.gov/bills/text.php?number=SF1602&version=latest&session=ls92&session_year=2021&session_number=0
[39] Iowa House Bill 767, HF 767 88th Congress (2019). https://www.legis.iowa.gov/legislation/BillBook?ga=88&ba=HF767

DEVELOPING A COST PER-KILOWATT-HOUR (kWh)

The research team next identified a tax per kWh for 2021 BEVs that would be equivalent to the gasoline tax. In this analysis the average energy consumption per distance of travel for seven 2021 BEVs (representing 30% of vehicles sold) was compared to the average energy consumption of seven 2021 model year compact and mid-size sedans (representing 39% of vehicles sold) that consume only gasoline (see Table 4).

Table 4: Energy Use Estimates for Traditional and BEV Sedans

	Combined MPGe/MPG (rounded)	Gallons/kWh per 100 miles (rounded)
2021 Gasoline Average	31	3.2
2021 BEV Average	123	28

Next calculations of fuel tax for gasoline vehicles were made. The vehicles on average consume 3.2 gallons of gasoline per 100 miles. Therefore, to drive 100 miles the federal excise tax (FET) on the gasoline would be: $0.184 (per gallon FET) * 3.2 gallons of gasoline = $0.59. To generate the equivalent for the BEV group, 28 kWh per 100 miles is divided by $0.59 (which is equal to the gasoline tax for 100 miles of driving). As shown in Table 5, the equivalent tax for an electric vehicle is $0.021 per kWh.

Table 5: Estimated Tax per Unit of Fuel for Traditional and BEV Sedans

	Gallons/kWh per 100 miles	Tax paid per 100 miles	Tax per gallon or kWh
2021 Gasoline	3.2	$0.59	$0.184
2021 BEV	28	$0.59	$0.021

Finally, the $0.021/kWh tax as a percentage of total energy cost was calculated, and was compared to total gasoline costs, as shown in Table 6. It was determined that, while the federal fuel tax only increased the cost 7.8 percent to drive an ICE vehicle 100 miles, the cost increase for driving a BEV 100 miles was 15.2 percent.

Table 6: Fuel Costs

	National Average Energy Cost (per Gallon or kWh)[40]	Energy Cost per 100 Miles	Energy Cost per 100 Miles Plus Federal Tax	Cost Increase due to Tax
2021 Gasoline	$2.37	$7.57	$8.16	7.8%
2021 BEV	$0.138	$3.86	$4.45	15.2%

[40] U.S. Bureau of Labor Statistics. (2021). "Average energy prices for the United States, regions, census divisions, and selected metropolitan areas." Midwest Information Office. https://www.bls.gov/regions/midwest/data/averageenergyprices_selectedareas_table.htm *Note: Using these data, calculated Average of U.S. Prices for Electricity and Regular Gasoline: August 2020 through July 2021.*

Nevertheless, the cost to operate an ICE vehicle for 100 miles ($8.16) is nearly twice the cost to drive a BEV ($4.45) the same distance – therefore, a tremendous cost incentive exists for BEVs even with the tax. It should be noted that national average energy costs – both for electricity and gasoline – can be volatile. As a result, the overall costs (including tax) of gasoline and electricity could vary greatly from year to year.

MEASURABILITY OF KWH USED IN TRANSPORTATION

For governments seeking to assess a tax on transportation energy, measuring taxable gasoline is much easier than measuring taxable electricity. Most electricity is used for non-transportation purposes, and access to electricity is available at all residential and commercial buildings. Gasoline on the other hand is generally distributed at dedicated retail locations.

Electricity is transferred to an EV using one of three available charging levels. The first (Level 1) uses a standard 120v outlet found in a home or office – this method is the slowest available and may be best for overnight charging at a home, for instance.

Level 2 charging delivers 240v which is substantially higher than Level 1 and delivers more energy in less time. It should also be noted that most public charging stations are Level 2.[41] EV users can install Level 2 charging capabilities for their vehicle, but in some cases that may require special permitting, utility work and a more expensive charger.[42]

Finally, DC fast charging (also referred to as Level 3) offers 480v or more, but is less common due to the energy requirements and equipment costs.[43] It should be noted that levels beyond DC fast charging are being explored. Examples of charge times and ranges for the three common charging options are listed below (Table 7).

Table 7: Sample Charging Level Statistics[44]

	Volts	Range per Hour of Charging
Level 1 Charging	120	3-5 miles
Level 2 Charging	240	12-60 miles
DC Fast Charging (Level 3)	480	60-80 miles (in 20 minutes)

Measurability of Public Charging. Measuring kWh used at public charging stations is likely easier than measuring home charging. Public charging stations are dedicated to charging EVs, and therefore are more likely to have a dedicated meter.[45] Additionally, the charging station provider is measuring how many kWh are transferred to EVs at these locations, and are charging the customer accordingly. Thus, the owner of the device is already measuring the kWh.

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41 U.S. Department of Energy. "Developing Infrastructure to Charge Plug-In Vehicles." Alternative Fuels Data Center. https://afdc.energy.gov/fuels/electricity_infrastructure.html
42 Smart Energy International. (June 26, 2019). "US utilities turning to managed EV charging programmes". https://www.smart-energy.com/industry-sectors/electric-vehicles/us-utilities-turning-to-managed-ev-charging-programmes/ ; see also: City of Atlanta. "Permitting Process for Electrical Vehicle Supply Equipment (EVSE) in a Single Family Residence Setting." "https://www.atlantaga.gov/Home/ShowDocument?id=538
43 California Clean Vehicle Rebate. "Electric Vehicle Charging Overview". https://cleanvehiclerebate.org/eng/ev/technology/fueling/electric
44 Plug-In NC. "Charging Station Levels." Advanced Energy. https://pluginnc.com/charging-levels/
45 Accuenergy. "Energy Metering for Electric Vehicle (EV) Charging Station Consumption." https://www.accuenergy.com/application-solutions/metering-electrical-vehicle-charging-stations/

Measurability of Home Charging. Measuring electricity use for home EV charging may be more challenging. Single family residential properties typically have a meter that measures electricity use as it enters the home. While sub-meters are available for separate units, a traditional electric bill simply indicates how many kWh are used by the home. Smart meters in conjunction with smart chargers, however, may help identify transportation energy consumption at a single family home.

- Smart Meters. Smart meters measure electricity consumption, voltage and other information for electric utilities and their customers. This type of meter is able to communicate information (often wirelessly) to a utility, and the utility can then convey the information to the customer. The deployment of smart meters in the U.S. is advanced, with 99 million meters being installed by the end of 2019 and an estimated 115 million or 75 percent of U.S. households by the end of 2021.[46]

  Since the smart meter collects consumption information in real time, utilities are able to have a variety of rates based on time of day. Such rate structures, known as TOU rates, provide incentives for users to limit or allocate their electric consumption based on current grid demand. For instance, off-peak hours when demand is lowest would have lower-than-average rates, while peak times may have rates that are higher than the average.

  While TOU rate structures require measurement and communication of information from the smart meter to the utility, there is also technology that allows the utility to communicate with appliances within the home. As an example, Dominion Energy has a program where it is able to change the setting remotely on participating customer's HVAC during certain peak times. Similar remote access programs exist for electric vehicle owners as well, including Georgia Power's Plug-In Electric Vehicle plan – but this plan and other similar plans require a smart charger, as discussed below.[47]

- Residential Smart Chargers**.** A smart charger is typically a Level 2 vehicle charging device that can schedule the times of day and duration of charging and can inform drivers remotely on EV charge status. Smart chargers enable communication between utilities, the power grid operators and EV users to measure the draw from the grid to the home to the vehicle. This is critical to off-peak charging and TOU rate plans. Smart chargers should not be confused with the standard Level 1 charging equipment that is similar to an extension cord.

Approximately 80 percent of U.S. electricity is consumed at residential locations.[48] The key to measuring residential use of electric fuel for transportation is communication between the utility (via smart meter) and the customer; this is enhanced further when the vehicle can communicate

[46] Cooper, Adam and Mike Shuster. (April 2021). "Electric Company Smart Meter Deployments: Foundation for a Smart Grid (2021 Update)." The Edison Foundation. https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_Smart_Meter_Report_April_2021.ashx
[47] Georgia Power. "Plug-In Electric Vehicle." https://www.georgiapower.com/residential/billing-and-rate-plans/pricing-and-rate-plans/plug-in-ev.html
[48] Grid Integration Tech Team and Integrated Systems Analysis Tech Team. (November 2019). "Summary Report on Evs at Scale and the U.S. Electric Power System." US Drive. https://www.energy.gov/sites/prod/files/2019/12/f69/GITT%20ISATT%20EVs%20at%20Scale%20Grid%20Summary%20Report%20FINAL%20Nov2019.pdf

with the utility via smart charger.[49] Cheaper charging rates through TOU plans are certainly attractive and only available through smart meters (which are required to measure time of day). If a TOU plan is specific to vehicle use, a smart charger is necessary as well. Additionally, smart chargers help EV owners charge during low-rate time periods automatically (and thus EV owners do not need to plug in at a certain time). This method allows for the measurement of electric fuel used by EVs. Table 8 below shows rate examples from Georgia Power, which can be compared with the earlier national average kWh rate of 13.8 cents.

Table 8: TOU Rate Plan Example, Georgia Power[50]

	Super-Off Peak	**Off-peak***	**On-Peak**
Charging Window	11 p.m. - 7 a.m.	7 a.m. - 2 p.m. Weekdays 7 a.m. - 11 p.m. Weekends	2 p.m. - 7 p.m.
Cost per kWh (rounded)	$0.014	$0.067	$0.203

* *Off-peak time window reflects status at the time of publication.*

[49] Ibid.
[50] Georgia Power. "Plug-In Electric Vehicle." https://www.georgiapower.com/residential/billing-and-rate-plans/pricing-and-rate-plans/plug-in-ev.html

FRAMEWORK FOR DEVELOPING A NEW HIGHWAY FUNDING SOLUTION

Current Federal Fuels Tax Model

The motor fuels excise tax was created in 1932 to be used as a deficit reduction tool; in 1956 the role of the tax was shifted, and receipts were transferred to the Highway Trust Fund and thus linked fuel taxes with highway investment.[51]

In the mid-1990s the Internal Revenue Service (IRS), U.S. Department of Transportation (U.S. DOT), and the motor fuel industry designed the Excise Summary Terminal Activity Reporting System (ExSTARS) in large part to combat tax evasion.[52] The program worked to decrease the number of entities responsible for paying the fuels tax by monitoring movement of fuel into or out of an IRS-approved terminal, thus decreasing evasion and improving the efficiency of collections.[53] There are fewer than 3,000 fuel tax collection locations operated by 300 distinct entities that pay the fuel tax. The motor fuel industry has similarities to U.S. utilities, and it is possible that a similar connection between utilities and the IRS could be developed.

Creating a Framework for Electric Fuel Taxes within the Utilities

There are 2,938 electric utilities in the U.S.[54] Utilities are categorized into three groups:

- investor-owned;
- cooperatives; and
- publicly owned.

While there are only 168 investor-owned companies, this small group has the majority of customers as shown in Figure 2.[55]

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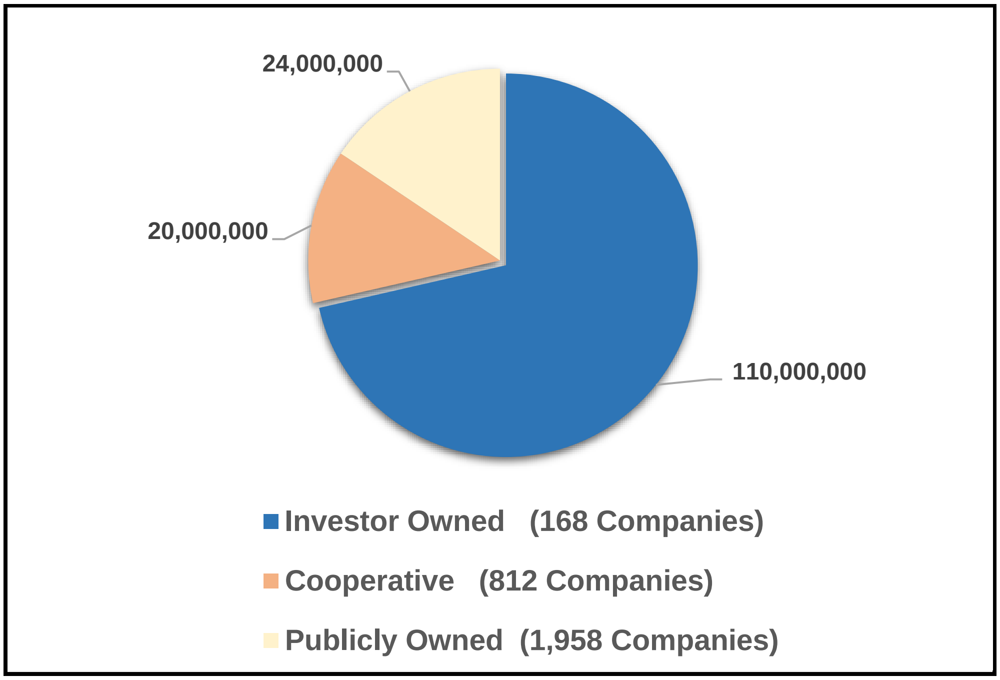
[51] Lowry, Sean. (August 12, 2015). "The Federal Excise Tax on Motor Fuels and the Highway Trust Fund: Current Law and Legislative History." Congressional Research Service. https://nationalaglawcenter.org/wp-content/uploads/assets/crs/RL30304.pdf
[52] IRS. "Excise Summary Terminal Activity Reporting System (ExSTARS)." https://www.irs.gov/businesses/small-businesses-self-employed/excise-summary-terminal-activity-reporting-system-exstars
[53] IRS. (May 2019). "Motor Fuel Excise Tax EDI Guide." https://www.irs.gov/pub/irs-pdf/p3536.pdf
[54] U.S. Energy Information Administration. (August 15, 2019). "Investor-owned utilities served 72% of U.S> electricity customers in 2017." Today in Energy. https://www.eia.gov/todayinenergy/detail.php?id=40913
[55] U.S. Energy Information Administration. (2021). "Table 5.1 Sales of Electricity to Ultimate Customers: Total by End-Use Sector, 2011 – June 2021 (Thousand Megawatt hours)." Electric Power Monthly. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_01

Figure 2: U.S. Utility Customers[56]



In 2020, electric utilities accrued revenues of more than $390 billion. The utilities will likely see this revenue grow in the coming decades as the electric vehicle fleet expands.

Using EV figures found previously in this research, if one million BEVs drive an average of 11,599 miles each year – at 28 kWh of energy per 100 miles – each will consume 3,248 kWh annually. At 13.8 cents per kWh this will generate $448 in revenue per vehicle for utilities, or $448.1 million per one million BEVs. By 2029, assuming the previously discussed BEV fleet size of 15.2 million, revenue for the utilities would climb to just under $7 billion annually.

Utilities could also benefit financially from the marketing of off-peak electricity to EV users.[57] As discussed earlier, the tools necessary for off-peak electricity programs for EVs allow for the discrete measurement of residential electric vehicle fuel consumption. In separating out vehicle kWh consumption from all other consumption at a residence, utilities could act as the collection point for a kWh road use tax.

Without smart charger/smart meter technology, however, assessing taxes becomes far more challenging for the utilities.

[56] Ibid.
[57] Trabish, Herman. (January 28, 2019). "An emerging push for time-of-use rates sparks new debates about customer and grid impacts." Utility Drive. https://www.utilitydive.com/news/an-emerging-push-for-time-of-use-rates-sparks-new-debates-about-customer-an/545009/

Electric Fuel Consumption Points

Most electric fuel is consumed in a residential setting, as shown in Table 9.

Table 9: Location of kWh Consumption[58]

Period	Location	Percent of Consumption
Weekday	Residential	91%
	Commercial (Level 2)	7%
	Commercial (DCFC)	1%
Weekend	Residential	86%
	Commercial (Level 2)	12%
	Commercial (DCFC)	2%

While kWh consumed for transportation at commercial sites are small compared to residential consumption, they are easily measured by the utility and electric fuel dealers. Simply put, these kWh are generally not mixed in with other types of electricity use.

Residential consumption is more challenging as it is mixed in with all other electricity consumption. As noted above, the smart meter and smart charger address that problem.

[58] Ibid.

SUMMARY AND OPTIONS FOR IMPLEMENTATION

Summary of Tax Issue and Potential Solutions

The federal fuel tax has not been raised since 1993 despite the growing need for an increase in HTF revenues. BEVs are growing in popularity but currently do not pay federal fuel taxes, thus widening the gap between revenue generated and infrastructure funding needs. Projections indicate that the U.S. BEV fleet will increase by a factor of fifteen in the coming decade, further depleting HTF income. It is estimated that this will produce a gap of more than $1 billion annually in the coming years.

A tax on BEV electricity usage represents an opportunity for the federal government, through a partnership with electric utilities, to collect revenue based on highway use. Like gasoline and diesel tax revenue, that money would be reinvested in the nation's infrastructure through the HTF.

Electricity consumed by BEVs is a taxable good which can be measured by kWh via smart meters and smart chargers. This analysis estimates that a tax of $ 0.021 per-kWh is an equivalent charge to what is paid through the existing federal fuel tax.

Additionally, the federal electric fuel tax concept has the potential to be efficiently collected (unlike the VMT tax) through the use of a small number of transaction points, while at the same time tying the tax to road use. A tax on electricity has the potential to achieve the same cost of collection efficiency as the gasoline tax.

Finally, if there were to be an adjustment to the federal fuels tax of 18.4 cents, the 2.1 cent kWh could be adjusted accordingly based on percent increase in the fuels tax. This is illustrated in Table 10 below.

Table 10: Matching Federal Fuel Tax Increases with the kWh Tax

	Baseline	Gas +.05	Gas +.10	Gas +.15	Gas +.25	Gas +.50
Fuel Tax (per gallon)	$0.184	$0.234	$0.284	$0.334	$0.434	$0.684
Electric Tax (per kWh)	$0.021	$0.027	$0.032	$0.038	$0.050	$0.078

Concern over Disincentivizing Electric Vehicles

There are concerns that collecting user fees from EVs would act as a disincentive. A 2.1 cent per kWh tax (which would be less than $1 per 100 miles for a typical BEV) would likely not dissuade someone from purchasing an EV. This is particularly true considering the overall fuel costs. As shown earlier in Table 6, electricity costs to drive 100 miles are nearly half of gasoline costs for the same distance. Through off-peak charging, however, electricity costs could be much lower.

Additionally, all projections indicate that the U.S. BEV fleet will see tremendous growth in the coming decades – and states and manufacturers are working to ensure this becomes a reality. California, for instance, intends to use an Executive Order to have 100 percent zero-emissions vehicle sales by 2035, and several other states have followed this lead.[59] Vehicle manufacturer General Motors announced in January 2021 its goal of ending all gasoline-powered car sales by 2035.[60]

That said, there are disincentives that are not related to an electric fuel tax that should be addressed through technology or possibly regulation. These include:

- Range limitations and range anxiety. EVs generally have a lower range than traditional vehicles, and drivers may have concerns that a BEV will not be able to cover a certain distance between charges.

- Duration of charge. EV charge times are substantially longer than refueling a traditional vehicle.

- Electric demand charges. Demand charges typically apply to commercial customers and are based on the highest level of electricity used during a billing period – these costs can be substantial and would impact businesses that use energy during peak demand.[61]

Guiding Principles for Developing a Utility-Based Highway Funding Solution

To ensure that an electric fuel tax is acceptable and feasible, certain policy and operational criteria must be developed. Based on industry discussions and highway funding literature, the following four principals should guide the development of a utility-based highway funding solution:

User Pays Principle. The goal of this funding approach is for EV operators to equitably pay for road use. To accomplish this, the tax must be tied directly to roadway use, and therefore to the use of the electric fuel.

Efficient Revenue Collection. It is critical that administrative collection costs remain as low as possible, and strive for the efficiencies currently experienced with the federal fuel tax. Additionally, and considering the overhead costs of alternative highway funding options such as a VMT tax, it would be reasonable for the utility industry to collect a small fee (perhaps only a small percentage of tax revenues) to cover administrative costs.

Phased Approach. Much like other highway funding alternatives, an electric fuel tax

[59] Office of Governor Gavin Newsom. (September 23, 2020). "Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight against Climate Change." Ca.gov. https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/ ;Joselow, Maxine. (January 8, 2021). "Gasoline Car Sales to End by 2035 in Massachusetts." E&E News. https://www.scientificamerican.com/article/gasoline-car-sales-to-end-by-2035-in-massachusetts/

[60] Ivanova, Irinia. (January 28, 2021). "GM to eliminate gas-burning vehicles by 2035." CBS News. https://www.cbsnews.com/news/general-motors-phase-out-gas-vehicles-2035/

[61] Clean Energy Group and National Renewable Energy Laboratory. "An Introduction to Demand Charges." https://www.cleanegroup.org/wp-content/uploads/Demand-Charge-Fact-Sheet.pdf

could not be immediately implemented at all points of tax collection. A phased approach is recommended.

Public-Private Collaboration. It is critical that the phased plan have input from utilities, government agencies and regulators, highway users and electric fuel dealers.

Moving Forward with a Utility-Based Solution

The following represents an initial framework for implementing an electric fuel tax. While certain details of the plan, such as specific stakeholders, are not identified, it provides a starting point and goals for a phased approach.

There are a variety of charging locations and charging levels in the current market. It is proposed that each be approached separately and across different timelines by key stakeholders such as utilities, electric fuel dealers, technology experts, and government departments of revenue.

All charging models will require a method for utilities to remit payments to revenue collection agencies in a manner similar to the ExSTARS program. This should be developed between the appropriate federal and/or state departments and utility stakeholders.

Each charging level is assessed below.

DC Charging Phase-In. DC charging, referred to also as Level 3 charging, is the most quickly implementable tax option.

Complexity of Implementation. There are fewer than 6,000 DC chargers in the U.S. For their own planning purposes, utilities should be aware of all DC chargers that have been installed on their network, both privately-owned and utility-owned. There would be relatively little complexity in adding a tax electronically to these accounts.

Ease of Tax Assessment. Of the three charging types, DC fast chargers with their 480-volt electrical service are the most likely to be a stand-alone facility with separate meter that measures only transportation fuel. Additionally, the owner of the charging station will be able to accurately assess the kWh transferred to customers.

Potential Timeline. There is a small population of DC fast chargers, and those locations should be highly visible to utilities. With that in mind, it is likely that a federal fuel tax could be implemented within two years or less from when the legislation is passed and requires only administrative coordination between agencies and utilities.

Level 2 Public Charging Phase-In. There are more utility accounts and more electric fuel dealers associated with Level 2 public charging than with DC charging.

Complexity of Implementation. There are nearly 40,000 Level 2 charging stations in the U.S. As with Level 3 chargers, utilities should have a record of and be aware of all public Level 2 chargers that have been installed. There are also numerous public resources for finding the location of Level 2 charging stations that a utility could reference. Some utilities also own Level 2 public chargers. There would again be a relatively low complexity in adding a tax electronically to these accounts.

Ease of Tax Assessment. Level 2 public charging is less likely to be a stand-alone facility with separate meters that measures only transportation fuel. That said, the owner of the charging station will be able to accurately assess the kWh transferred to customers.

Potential Timeline. With a relatively small population that is visible to the utility, it is likely that a federal electric fuel tax could be implemented within 2-3 years or less from when the legislation is passed and requires only administrative coordination between agencies and utilities.

Residential Charging (Level 1 and 2). The majority of charging is done at the residential level. This would be the most complex charging type on which to implement a tax, but would also bring in the largest amount of revenue.

Complexity of Implementation. There are 135 million residential utility customers in the U.S. While this is a large number, less than one percent of these customers are likely to be consumers of electric fuel for transportation.

Residential electric fuel consumers (EV owners) can be identified in three ways:

1. Through EV-specific TOU rate plans that a user registers for.
2. Residential customers that do not register for a TOU rate plan could self-identify as electric fuel consumers with their utility.
3. Map VIN numbers of registered electric vehicles with the addresses of residential utility customers using basic data management software.

Ease of Tax Assessment – TOU Approach. EV-specific TOU rate plans require a smart charger. As mentioned previously, such rate plans can offer a significant discount, but also allow utilities to directly measure the kWh consumed as transportation fuel.

Ease of Tax Assessment – Flat Fee Approach. There are options assessing a tax on EV owners that do not use a smart charger. A first option would be to charge a flat tax based on an annual mileage estimate (e.g. 11,599) and the kWh per mile efficiency of the vehicle. This charge could be as simple as the utility assessing a monthly flat fee to residential customer addresses for each electric vehicle registered at that address. Unfortunately, the flat rate would not be offset by public charging and it is not purely a user-pays tax. These facts alone, along with attractive off-peak TOU rate plans, might move people from the flat fee approach into the TOU approach with smart chargers.

Ease of Tax Assessment – Technology Development Approach. Finally, technology could be developed that allow smart meters, for instance, to identify a vehicle's consumption of electricity. This may require communication directly between the car and a meter. Such technologies are not unheard of, with an example being utilities that are able to control residential HVAC systems during specific times.[62] Ultimately in such cases there is communication between an individual power user and the utility.

Potential Timeline. For TOU rate participants, this plan is quickly implementable, likely within three years of legislation and require only administrative coordination between agencies and utilities. This is due to the larger population that must be measured. For a flat fee, close coordination between utilities, state agencies (Departments of Motor Vehicles) and federal agencies would be needed, possibly increasing the timeline to within five years of legislation. Finally, in addition to the flat fee timeline, the technology development timeline might add additional time as technologies are researched, designed and deployed.

[62] Dominion Energy. *Smart Cooling Rewards.* https://www.dominionenergy.com/virginia/save-energy/smart-cooling-rewards