Transportation Infrastructure Funding with an Electrified Fleet

A Discussion for the State of Vermont and Beyond

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ABSTRACT

Transportation infrastructure funding has long relied on user fees assessed on gasoline consumption. These fees have lost purchasing power as they have not tracked inflationary pressures and increasing numbers of fuel efficient vehicles further erodes the vital source of revenue. The emergence of alternative fueled vehicles powered with new energy sources will exacerbate the long term trend of limited funding for critical infrastructure maintenance.

Electric vehicles (EVs) are a type of alternative fueled vehicle offering the potential for enhanced environmental and economic well-being through reduced air emissions, lower energy costs, and increased energy security. EVs can be easily charged at home to meet most daily travel needs and are starting to gain in number on our nation's highways. Current impediments of high initial purchase prices and shorter ranges of operation are expected to decrease as incremental improvements to the underlying technologies drive down costs and increase range.

This paper reviews the history of the most important current transportation user fee, the motor fuels tax, and considers criteria for funding mechanisms applicable to alternative fuel vehicles, such as Vehicle Miles of Travel (VMT) user fees. Electric utility tariffs on EV electric use are proposed as an acceptable transition from the gas tax to regulated utility rates for EV contributions to infrastructure funding.

Vermont's transportation system is used as an example of how EV related transportation funding prospects could be implemented at the state level.

INTRODUCTION

The State of Vermont's transportation funding methods have generally followed the national trends of the United States. This research paper examines Vermont's current transportation funding system and considers policy options for the state to respond to the potential disruption electric vehicles (EVs) may create for infrastructure financing. Vermont's interest in clean fuel vehicles and keen concerns of policymakers to address chronic transportation funding gaps provides unique opportunities to reconsider our historic sources of transportation infrastructure funding. Many states share in the issues and opportunities facing Vermont and the potential measures described in this paper could be employed elsewhere.

TRANSPORTATION INFRASTRUCTURE FUNDING - PAST AND PRESENT

History of Transportation Related Taxes

The United States has funded transportation infrastructure through a variety mechanisms over the history of the nation. Dating back to the middle ages in England a system known as statute labor, or labor levies, was developed whereby residents of communities were required to maintain rights-of-way near their property. Tolled turnpikes emerged as a replacement for statute labor in the 18th century as a more reliable means of improving traveled ways (*1*). These turnpikes were not popular with travelers which induced states and municipalities to take over the private turnpikes as opportunities arose. States then funded roads through general funds and an assortment of special fees until 1919, when Oregon was the first state to enact a gasoline tax. Many states followed suit soon thereafter, with Vermont establishing a 1¢ gas tax in 1923.

The Federal government enacted a 1¢ national gasoline tax in 1932 as a deficit reduction measure. The federal tax was not set aside for roads until the Federal Aid Highway Act of 1956 established the transportation trust fund to underwrite construction of the interstate highway network (*2*).

Additional taxes and fees related to the purchase of vehicles, tires, vehicle registration and operator's licenses also make significant contributions to transportation funding, but motor fuel taxes are acknowledged to be the single largest source of funding (*3*). While many aspects of life today are markedly different than they were 80 years ago, the present funding system's reliance on a combination of federal, state and local motor fuel taxes to support the construction and maintenance of the nation's transportation systems has changed very little (*4*).

Current Motor Fuel Taxes in Vermont

Vermont vehicle operators pay the state and federal fees listed in Table 1 through wholesale fuel distributors who include the taxes in the per gallon prices at the pump. The state collects an excise tax of 20¢ on each gallon of gasoline combined with a 2% sales tax on the retail value of gasoline, which is calculated as a per gallon increment updated quarterly, currently assessed at 6.83¢ (*5*).

TABLE 1 Vermont 2012 Motor Vehicle Fuel Taxes (cents/gallon)

Jurisdiction	Gasoline	Diesel
Federal	18.4	24.4
State of Vermont	26.8	29.0
Total	*45.2*	*53.4*

Although diesel fuel is assessed at slightly higher rates, passenger vehicles operating on gasoline are the primary source of transportation fund revenues in Vermont and nationally. Approximately 15% of Vermont's 390 million gallons of motor vehicle fuel sold for highway use was diesel (*6*), while nationally the figure is about 20% of the 170 billion gallons of fuel sold (*7*). Given these considerations and the fact the majority of electric vehicle (EV) sales are light duty vehicles, this discussion will focus on gasoline infrastructure payments.

Viability of the Current Funding System

Existing fuel taxes continue providing significant contributions to infrastructure funding, but they have not kept up with the rate of inflation for construction costs associated with maintaining existing highways and building new facilities. The advent of more efficient vehicle technologies has placed further strains on revenues (*8, 9*). Anticipated increases in the US Corporate Average Fuel Economy (CAFE) standards jointly promulgated by US EPA and NHTSA are expected to continue reducing motor vehicle fuel consumption through internal combustion engine (ICE) vehicle improvements and the inclusion of significant numbers of EVs in the fleet out to the year 2035 and beyond (*10*).

Several comprehensive studies performed at the national and state levels have concluded actions to address these funding difficulties are needed to ensure transportation systems continue providing for the movement of people and goods under reasonably adequate conditions for the traveling public (*11, 12, 13, 14*).

FUTURE OPTIONS FOR TRANSPORTATION USER FEES

Motor Fuel Tax Adjustments

Congress established the National Surface Transportation Infrastructure Financing Commission as part of the SAFETEA-LU federal transportation authorization in 2005. This commission was charged with examining current transportation funding difficulties and recommending solutions. The final report on the Commission's activities was issued in 2009 and included a variety of policy options to address both current and anticipated future shortfalls in transportation funding needs (*13*). Increased motor vehicle fuel taxes were proposed as a short term option to bolster revenues. Other studies have similarly recommended fuel tax indexing to an inflation measure, instituting sales taxes on the value of fuel sales or making other incremental adjustments (*11, 12, 15*). The fuel tax collection mechanisms are already in place with relatively low costs of administration, so adjusting this source is a fairly straightforward exercise if there is political will exists to advance this. However, these studies also recognize the need to find new revenue streams disconnected from gasoline and diesel sales as more alternative fueled vehicles enter the fleet and avoid these taxes entirely.

Vehicle Miles of Travel User Fees

The Vehicle Miles of Travel (VMT) user fee or Mileage Based User Fee (MBUF) concept has received considerable attention as an option to equitably collect fees from highway users in a manner more in keeping with the benefit principle of taxation where users are assessed a proportional share of the cost of providing transportation according to the benefit they obtain from the use of the system (*2*). A variety of literature is available on how VMT fees could be established (*16*), how much revenue they might collect (*17*) and how impacts of the fee might affect different socio-economic and geographic populations (*18*). VMT fees clearly have many attractive qualities from an economic theory perspective and pilot studies have supported the

technical viability of this approach (*19*). However, there are significant barriers to widespread implementation in states and/or nationally due to privacy concerns and an associated lack of political support for new funding mechanisms (*20, 21, 22, 23*).

Tolling and Value Pricing

Additional funding options which do not rely on controversial monitoring techniques or waning fuel taxes are clearly needed to provide more reliable sources of infrastructure funding. Increased uses of tolling and value pricing can provides users with more attractive transportation options based on their willingness to pay under scarce conditions. These alternatives are receiving significant attention in larger metropolitan areas across the country and are frequently recommended in funding commission reports. The administrative costs for implementing tolling and HOT lane systems have decreased as electronic tolling technology, such as the EZ Pass system widely used on the east coast, replaces toll booth operators handling cash. However, rural states like Vermont have not yet found ways to cost-effectively institute these systems on state highways and are generally restricted from doing so on the interstate system under present federal law.

Alternative Fueled Vehicle Contributions to Highway Infrastructure Funding

Types of Alternative Fueled Vehicles

The anticipated increase in alternative fueled vehicles will present policymakers with unique opportunities to reconsider transportation infrastructure funding. The US Dept of Energy defines and tracks several varieties of alternative fuel vehicles which are not currently assessed user fees in the State of Vermont, including (*24*):

- Electric Vehicles (EVs)
  - Plug-In Hybrid Electric Vehicle (PHEV) – powered by the electricity grid combined with an internal combustion engine (ICE). The portion of energy supplied by gasoline or diesel is subject to normal taxes, but energy from the electric grid is not. The Chevy Volt is an example of a PHEV with about 40 miles of all electric range.
  - All Electric or Battery Electric Vehicles – completely powered by electricity stored in a battery. The Nissan Leaf is an example of an AEV with about 70 miles of range.
- Natural Gas Vehicles (NGVs)
  - Compressed Natural Gas (CNG) – CNG is stored in a pressurized tank to provide adequate range, used across a variety of vehicle platforms from light duty to heavy trucks.
  - Liquefied Natural Gas (LNG) – super-chilled LNG is stored in insulated pressurized tanks. This fuel has a higher energy density than CNG and is typically used in longer range large trucks.
- Hydrogen - vehicles powered with compressed or liquefied hydrogen, generally using fuel cell technology. Very few vehicles in operation or anticipated in the near future as of 2012.

Natural gas powered vehicles (NGVs) currently enjoy lower lifecycle costs for large fleet operators than conventionally fueled vehicles, but the lack of widespread fueling infrastructure presents significant challenges for their growth beyond the fleet operator heavy truck niche,

particularly in more rural states like Vermont where only a fraction of the state's population is served by natural gas utilities. Hydrogen fueled vehicle technology presents many attractive qualities, but currently has little more than experimental use in the United States. Vermont does not anticipate significant numbers of these vehicles in the near future. The remainder of this paper examines issues and funding solutions specific to Electric Vehicles (EVs), but the general technology principles and funding options would apply equally to NGV and hydrogen vehicles should they become more widespread.

Electric Vehicle Systems Technology

Electric vehicles (EVs) appear to be the most promising alternative fuel type for Vermont with several PHEV and AEV vehicles currently on the market as of July 2012 and more anticipated in the near future. These vehicles can be recharged using normal 120 V home outlets or faster charging reliant on 208/240 V supplies (similar to electric dryer or oven voltages in households). According to an analysis completed in 2008 almost 75% of the light duty vehicles in America could charge EVs using existing power generation capacity if charging occurred during off peak hours overnight (*25*). A study of the Vermont electric grid and EV market potential indicates similar results with capacity to power significant portions of the state's vehicle fleet using existing electric utility infrastructure (*26*). EVs could provide significant benefits to the electric grid in the future as Vehicle to Grid (V2G) technology research is underway to allow EVs to essentially act as batteries which utilities could use to meet peak power demands instead of bringing expensive temporary generators online or to provide backup supplies in power cases of power failures (*27*). In addition EVs could lower utility rates through greater use of off-peak power which would allow power suppliers to better capitalize on their investments and widely benefit all utility customers (28).

Research underway at the Idaho National Laboratory indicates most EV owners will charge during off peak hours if utilities develop Time of Use (TOU) rate plans with lower rates for overnight EV charging. Figure 1 on the following page is adapted from a recent presentation documenting charging patterns for over 5,400 chargers installed as part of the EV project (*29*). The graphs on the left side show charging demand in San Diego and San Francisco where the utility has lower TOU plans during late night hours and little charging takes place until after midnight. The graphs on the right for Washington State and Oregon, where utilities have not yet developed and encouraged TOU pricing for EV charging, exhibit broader demand for power over the early evening hours when overall demand for electricity is higher. This suggests uncontrolled charging of EVs will lead to higher and longer peak periods, which could outgrow existing utility infrastructure.

Researchers are investigating ways to allow utilities to automatically interact with vehicles to schedule charging events at optimal times which will likely allow further gains in power efficiency in the future beyond simple TOU plans (*30*).

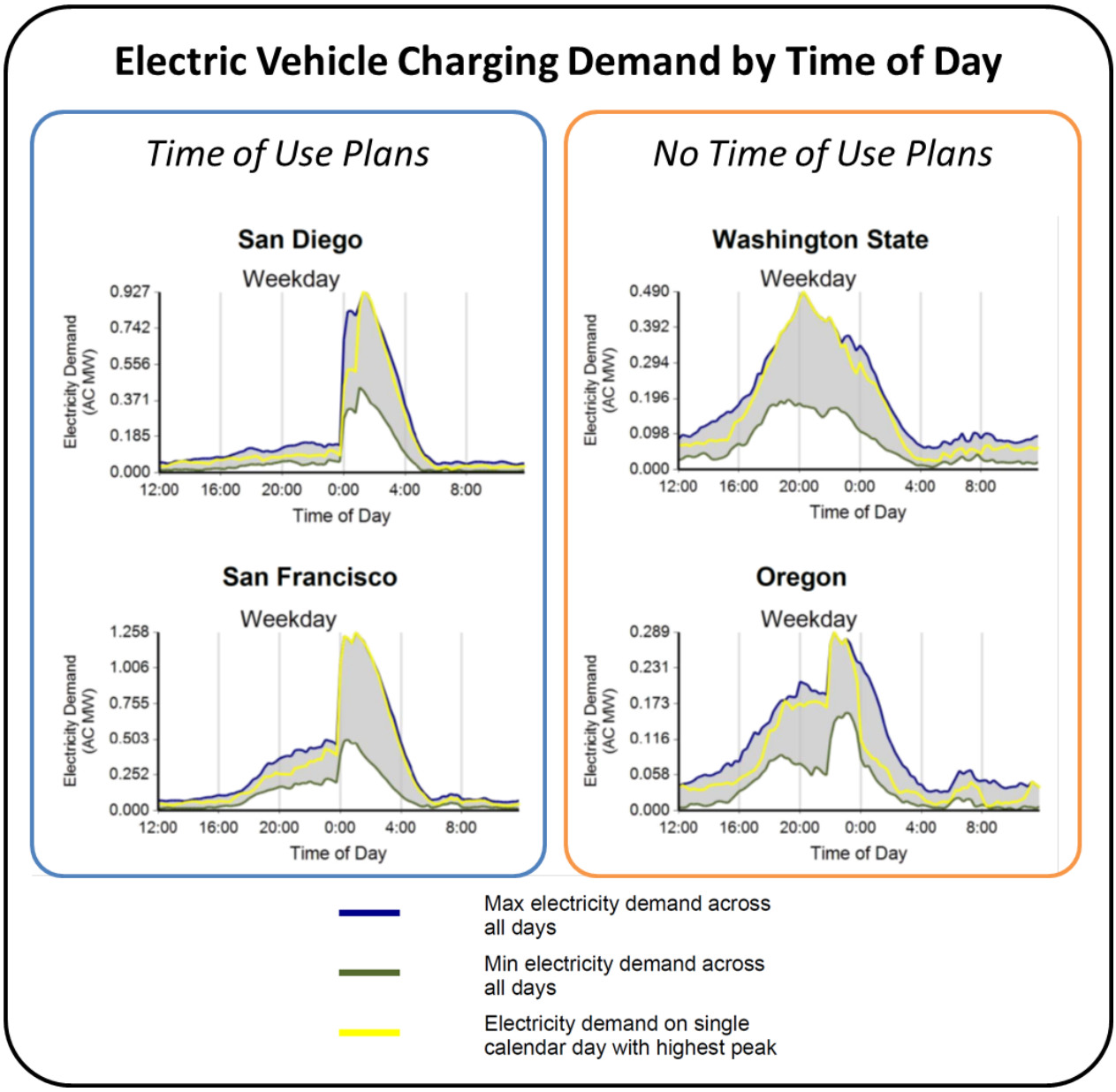

Figure 1 EV Charging Demand by Time of Day, Idaho National Lab EV Project *(29)*

EV Market Penetration

Forecasts of EV sales and associated fleet penetration are highly variable due to difficulties predicting key factors driving EV sales (*9*, *25*, *31*). Although current sales are a small fraction of the overall light duty vehicle market and the future is uncertain, it appears EVs are poised for significant growth in the future. More EVs are being sold now than at the same point following the initial introduction of hybrid vehicles (*7*). Figure 2 on the following page highlights three factors likely to influence sales of EVs:

1. Purchase Price
2. Range
3. Cost of Gasoline

Our discussions with EV stakeholders and the traveling public suggests if significant changes occur in 2 out of 3 of these factors much higher sales of EVs will likely result.

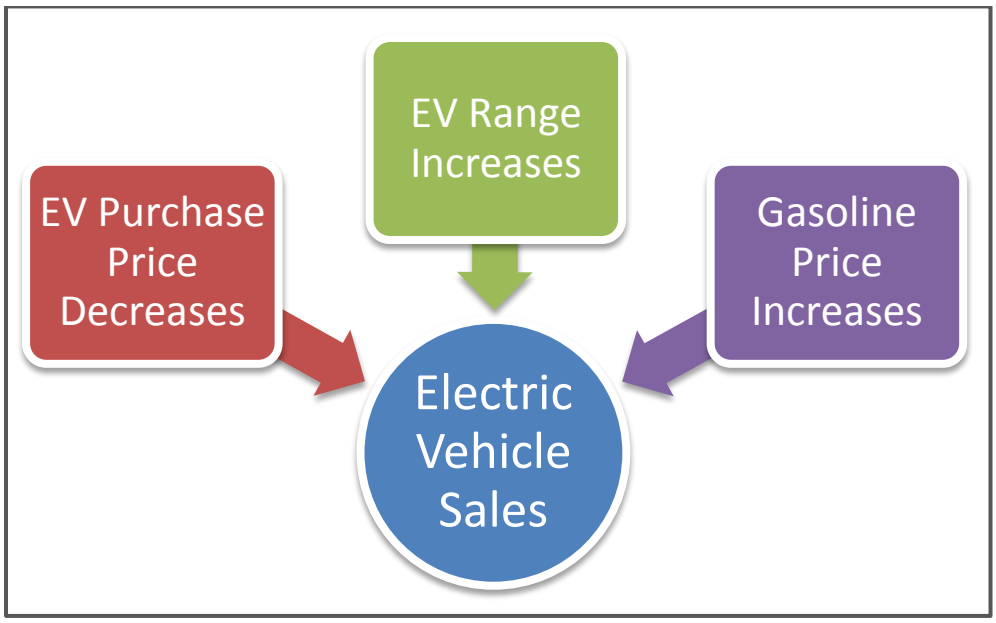

FIGURE 2 Electric vehicle sales influencers.

EV Transportation User Fee Concepts

EVs and other alternative fuel vehicles make up a very small portion of the vehicle fleet at this point. This situation allows considerable latitude in developing rational approaches to user fee assessments. For example, state gas taxes did not receive widespread opposition at the time of their inception because there was only a small population of vehicles in relatively wealthy households (*3*).

The US Government Accountability Office (GAO) has developed guidance to consider when designing user fee systems in use by government entities. The general user fee selection criteria recommended include the following (*32*):

- **Efficiency**: By requiring identifiable beneficiaries to pay for the costs of services, user fees can simultaneously constrain demand and reveal the value that beneficiaries place on the service. If those benefiting from a service do not bear the full social cost of the service, they may seek to have the government provide more of the service than is economically efficient. User fees may also foster production efficiency by increasing awareness of the costs of publicly provided services and therefore increasing incentives to reduce costs where possible.
- **Equity**: Equity means that everyone pays their fair share, but the definition of fair share can have multiple facets, in part because beneficiaries and users may not be the same as discussed in the section “Setting User Fees.” Under the beneficiary-pays principle, the beneficiaries of a service pay for the cost of providing the service from which they benefit. Under the ability-to-pay principle, those who are more capable of bearing the burden of fees should pay more for the service than those with less ability to pay.

- **Revenue adequacy**: Revenue adequacy is the extent to which the fee collections cover the intended share of costs. It encompasses the extent to which collections may change over time relative to the cost of the program. For the purposes of our work, revenue adequacy also incorporates the concept of revenue stability, which generally refers to the degree to which short-term fluctuations in economic activity and other factors affect the level of fee collections.
- **Administrative burden**: This is the cost of administering the fee, including the cost of collection and enforcement, as well as the compliance burden (the administrative costs imposed on the payers of the fee).

Several of the transportation infrastructure finance studies cited previously in this document also include criteria and principles for setting user fees. The National Surface Transportation Financing Commission (NSTFC) basically endorsed the same criteria as recommended by GAO, but added a fifth consideration to find a fee structure that could apply to other levels of government (*13*):

- **Funding Stream Considerations**, including the overall revenue-raising potential, sustainability, and flexibility of the funding approach
- **Implementation and Administration Considerations**, including the political and legal viability of a particular approach as well as the ease and relative cost of initial implementation, ongoing administration, and enforcement
- **Economic Efficiency and Impact Considerations**, such as the ability of the mechanism to promote efficient use of the system and internalize any adverse side effects
- **Equity Considerations**, including application of the user/beneficiary pays principle and consideration of equity across income groups and geography
- **Applicability to Other Levels of Government**, focusing on the potential applicability of various funding approaches beyond the federal level to state and local government

The potential for increased EV use suggests the public power utility industry may provide information and rate setting experience newly relevant to transportation. Interestingly, public utilities have long dealt with similar issues in determining rate structures under regulatory supervision. One frequently cited text by Bonbright recommends the following tariff evaluation framework which generally encompasses and expands on the GAO and NSTFC factors (*33*):

Adequate and Stable Revenues

1. Effectiveness in yielding total revenue requirements under the fair-return standard without any socially undesirable expansion of the rate base or socially undesirable level of product quality and safety.
2. Revenue stability and predictability.
3. Stability and predictability of the rates themselves.

Cost, Efficiency and Equity

4. Static efficiency of the rate classes and rate blocks in discouraging wasteful use of service while promoting all justified types and amounts of use.
5. Reflection of all of the present and future private and social costs and benefits occasioned by a service's provision.
6. Fairness of the specific rates in the apportionment of total costs of service among the different ratepayers.
7. Avoidance of undue discrimination in rate relationships.

8. Dynamic efficiency in promoting innovation and responding economically to changing demand and supply patterns.

Practicality and Acceptability

9. The related, practical attributes of simplicity, certainty, convenience of payment, economy in collection, understandability, public acceptability, and feasibility of application.
10. Freedom from controversies as to proper interpretation.

Recommended EV User Fee Evaluation Criteria

The above criteria can be blended and grouped according to the type of stakeholder affected. One approach to this exercise arrives at the following criteria for evaluation of alternative fuel vehicle user fees:

Driver Stakeholders

1. Gives drivers stable costs (Cost Stability)
2. Easy to interpret (Ease of Driver Understanding)
3. Avoids undue discrimination between drivers (Driver Equity)

Government / Infrastructure Operator Stakeholders

4. Raises enough revenue for transportation funds. (Short Term Revenue Adequacy)
5. Captures all costs of the transportation system (Long Term Revenue Adequacy)
6. Provides stable revenues (Revenue Stability)
7. Practical to implement (Administrative Ease)

General Economic Considerations

8. Encourages conservation (Static Resource Efficiency)
9. Encourages innovation in responding to demand-supply imbalances such as congestion or new development. (Dynamic Resource Efficiency)
10. Fairly allocates the cost of maintaining transportation infrastructure. (Fairness in Cost Allocation/Causation)

Infrastructure Funding Options for EVs

Many states are working to provide incentives for EV purchases and are not yet ready to propose significant user fees for alternative fueled vehicles which could impact this nascent market. Relatively few of these vehicles are on the road, so there is not a compelling need to take action to institute new fee structures at this point. The Vermont Legislature commissioned a study of alternative fueled vehicles user fees to advance the dialog on these issues before widespread use creates significant revenue losses and imposes difficulties for future policy making (*34*). As of fall 2012 this study remains in process, but the following section reviews several funding options under consideration.

Registration Fees Several states have established separate fee structures for alternative fuel vehicles, including EVs. In some cases these are lower than traditional internal combustion engines while in other cases the fee is in place to recover at least a portion of the revenue lost when EV drivers do not pay motor fuel taxes (*24*). For example, the State of Washington has recently instituted a $100/year fee for EV registrations.

These fees are by far the simplest to administer as states already have vehicle registration programs in place and meet many of the proposed evaluation criteria for drivers and government

stakeholders. They do not meet the general economic criteria as users only pay flat fees no matter how much driving they do meaning the efficiency and fairness criteria are not met.

VMT Fees VMT Fees would also meet many of the evaluation criteria and are agnostic to the type of fuel a vehicle consumes, so they are quite relevant to EVs. They would meet the general economic criteria of efficiency and fairness, but currently fall short in the difficulties governments face in implementing these systems and the public understanding of these systems. These issues may be resolved in time, but at present VMT fees are unlikely to be forthcoming in Vermont.

Tolls/Value Pricing As discussed above, these are promising sources of revenue in large metropolitan areas. This source of funding could apply equally to alternative fuel vehicles. However, tolls are not expected to be a practical source of funds in rural states like Vermont due to administrative expenses required to collect the fees and the generally lower traffic volumes on state highways where tolling might be allowed.

Transportation Specific Electric Tariffs This option would establish transportation specific utility rates applied to electricity used for transportation purposes. This concept extends the current transportation motor fuel tax on gasoline and diesel to encompass electricity as a new type of fuel. All of the recommended EV user fee evaluation criteria could be met with this funding mechanism, although this could change depending on the specific implementation actions taken by government and public utilities.

In the near term a static rate on kilowatt hours consumed by vehicle charging could be managed by utilities without undue burden as they already assess state taxes on electric use. Current EVs require about 35 kWh of power (or "fuel") to travel 100 miles. The average vehicle fuel economy in Vermont is about 23 miles per gallon (or 4.35 gallons/100 miles), so approximately 8 kWh of energy is required to get the same travel equivalent as a gallon of gasoline. Vermont's state tax on gasoline is currently 26.83 cents/gal. Applying this to the electric energy equivalent of a gallon of gasoline would result in a tariff of 3.35 cents per kWh to generate similar revenues as conventionally fueled vehicles.

Longer term refinements could take advantage of time of use rates and/or utility smart grid infrastructure as a means of encouraging better economic efficiency through peak power or peak travel demand adjustments to the tariffs. A few potential avenues for future study of these issues include:

- Optimal utility rate-setting practices for EV Time of Use rates
- Advanced Metering Infrastructure (AMI) interconnection with Electric Vehicle Supply Equipment for submetering EV specific kWh
- Discounted pricing or utility payments to customers for potential future grid support services, such as frequency regulation of loads
- Valuation of automated utility control of EV charging using AMI to stagger EV charging times
- Social equity analysis of utility EV charging rates and identification of policies or programs to reduce identified issues
- Policy analysis of the appropriate EV tariff setting venue, such as legislatures, DOTs and / or state utility regulators

The development of this source of funding would require careful consideration of the market forces influencing EV market penetration to avoid reducing the rates of business and consumer adoption by asking too much of this source in the near future.

CONCLUSION

The capability of traditional motor fuel taxes on gasoline and diesel to raise the funds necessary to support transportation infrastructure is expected to continue waning in the future. Alternative fuel vehicles like EVs no longer rely on these commodities and little political will appears to exist to make the significant increases in user fees required to match the inflationary pressures on highway construction over the past 20 years.

The decline of motor fuel taxes could accelerate in the future as EVs appear to be positioned for significant increases in numbers when the cost of these vehicles comes down with maturing technology. In addition, uncertainty over the price of gasoline due to resource scarcity and geopolitical factors could further encourage EV ownership or leasing.

Several states, including Vermont, are currently considering transportation user fees for EVs. Registration fees, VMT fees and tolling all have potential, but currently lack in aspects of the suggested user fee design criteria, such as the ease of implementation and public understanding of the fee structure and use. Electric utility tariffs on electric power used by EVs are an attractive option to transition from the gas tax to new user fees for future vehicles. This system could be enacted relatively easily as electric utilities in Vermont are regulated and already collect taxes and fees on customer billings. Additional research is warranted to develop mechanisms to distinguish transportation uses of electric power.

While the transition to a completely electrified fleet will likely take decades, policy-makers are in a unique position to develop and implement a source of transportation funding to provide long-term sustainable funding for transportation infrastructure.

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