The Financial and Policy Impact of Electric Vehicles and Improved Fuel Economy on Delaware's Motor Fuel Tax Revenue

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Prepared for the
Delaware Department of Transportation

Prepared by
Philip Barnes, Policy Scientist

Institute for Public Administration
Biden School of Public Policy & Administration
University of Delaware

UNIVERSITY OF DELAWARE
BIDEN SCHOOL OF PUBLIC POLICY & ADMINISTRATION

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Contents

Acronyms

DelDOT – Delaware Department of Transportation

DMV – Division of Motor Vehicles

EV – electric vehicle

GPS – global positioning system

HUF – highway use fee

ICE – internal combustion engine

kWh – kilowatt-hour

MBUF – mileage-based user fee

MFT – motor fuel tax

MPG – miles per gallon

OBD – onboard diagnostics

PHEV – plug-in hybrid electric vehicle

TTF – Transportation Trust Fund

VMT – vehicle miles travelled

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Executive Summary

Two unavoidable technological changes will negatively impact Delaware's motor fuel tax (MFT) revenue and the long-term health of the Transportation Trust Fund that is critical to the development, operation, maintenance, and management of the state's transportation and transit systems. First, gasoline and diesel vehicles are becoming more efficient and can drive more miles on the same amount of fuel. Second, electric vehicles (EVs) are becoming more popular, yet their owners pay no motor fuel tax because the vehicles are powered by batteries. The EV transition in Delaware was codified in a state regulation finalized in November 2023. The regulation requires that 82% of all new vehicle deliveries to Delaware in 2032 must be zero-emission vehicles. Given these technological inevitabilities of improved fuel economy and EV sales, and the fact that both changes will depress motor fuel consumption in Delaware, analyses are required to inform a path forward. A financial analysis is required to forecast MFT revenue; and once the magnitude of the revenue shortfall is estimated, a policy analysis can help illuminate the options available to address the budget challenge and identify policy tradeoffs.

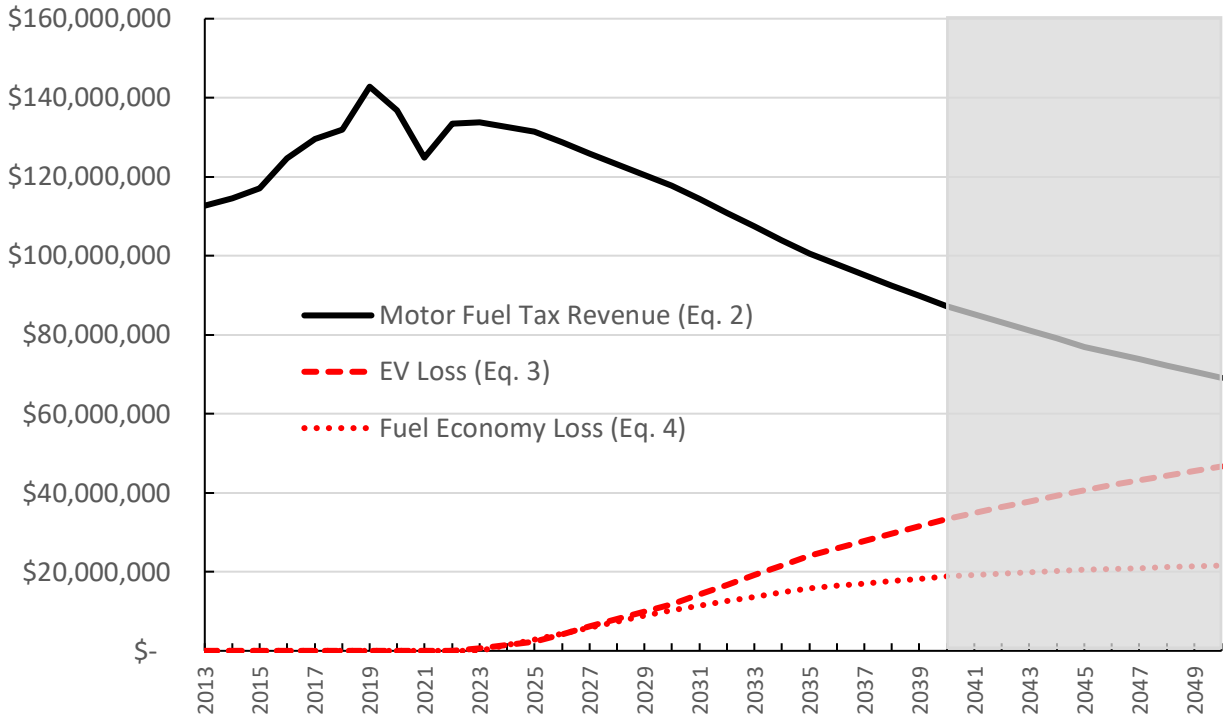
This analysis is broken into two parts: a quantitative financial analysis and a qualitative policy analysis. The financial analysis uses a simple method and data generated by a Delaware Department of Transportation consultant to estimate the state's MFT revenue out to 2040.[1] For comparison and to communicate the magnitude of the two technological changes expected, two loss estimates are provided, one each for EVs and fuel economy improvements. The results of the analysis are presented in Table 1 and Figure 1 below. Note that the equations referenced in the table and figure are detailed in the appendix.

Table 1. Motor Fuel Tax Revenue and Loss Estimates

Estimate	2030 (M)	2035 (M)	2040 (M)	2045 (M)	2050 (M)	2030–2040 Cumulative (M)	2030–2050 Cumulative (M)
MFT Revenue (Eq. 2)	$117.7	$100.5	$87.2	$77.0	$69.1	$1,117	$1,884
EV Loss (Eq. 3)	$11.8	$24.0	$33.5	$40.7	$46.7	$256	$666
Fuel Economy Loss (Eq. 4)	$10.3	$15.9	$18.8	$20.5	$21.6	$167	$372

[1] The consultant provided values to 2050, but this extended time horizon introduces a high level of uncertainty for any legitimate policy development. For this reason, MFT revenue and loss estimates in this analysis are provided beyond 2040 for illustrative purposes only (and are shaded grey in tables and charts), and 2040 is used as the latest year for any discussion of the results and should be used as the limit for any policy development.

Figure 1. Motor Fuel Tax Revenue and Loss Estimates



The table and figure above indicate that Delaware's MFT revenue will decline in the future through a combination of EV sales and fuel economy improvements. Attention then turns to the policy options available to address the MFT revenue decline and each option's suitability across a range of relevant criteria. A qualitative policy analysis was therefore conducted to evaluate the policies and identify their tradeoffs. The policies identified for the analysis include:

1. **EV Fee:** An annual fee on electric vehicles
2. **Highway Use Fee:** An annual fee on EVs and fuel-efficient internal combustion engine (ICE) vehicles
3. **Mileage-Based User Fee:** A fee on all vehicles for the number of miles driven
4. **Public Charging Fee:** A fee on the electricity put into an EV battery at a public charging station
5. **Retail Delivery Fee:** A fee added to retail orders that are delivered using a vehicle
6. **Increase MFT:** An increase in the rate charged per gallon of motor fuel tax
7. **Increase Tolls:** An increase in the rate charged at toll collection points
8. **Increase Division of Motor Vehicles (DMV) Fees:** An increase in vehicle registration and document fees
9. **Maintain Existing Policies:** Do nothing and continue the current policy approach

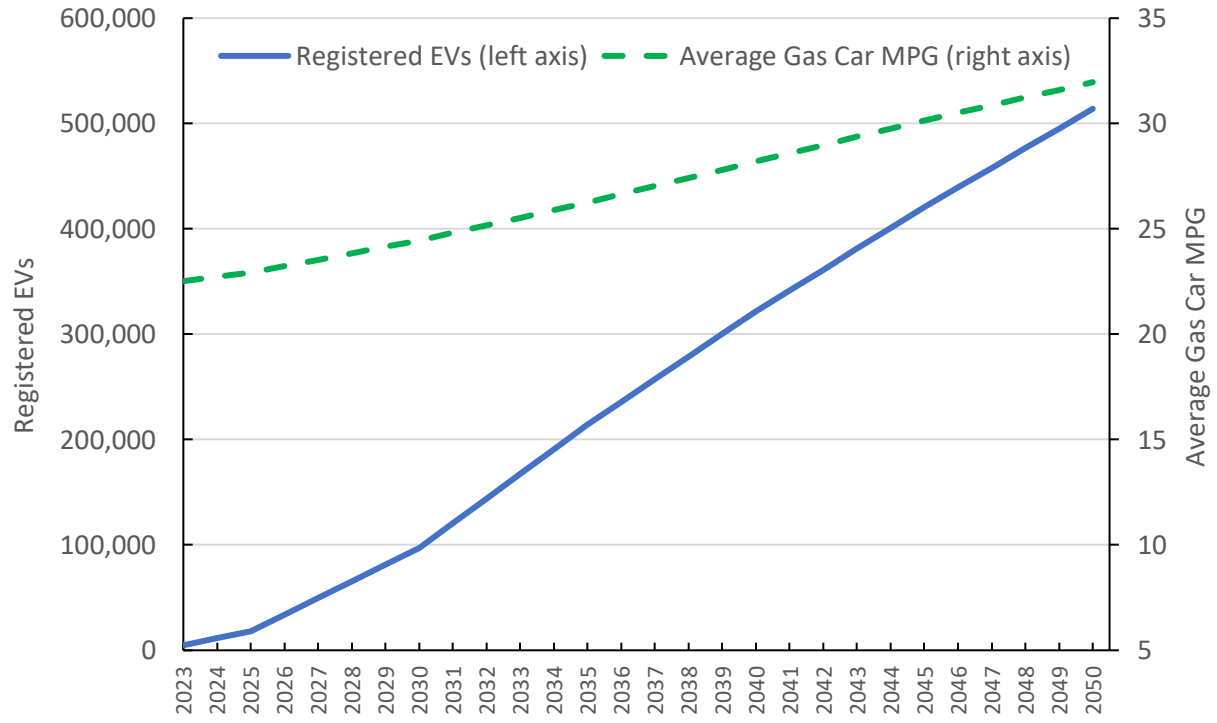
All policy options were qualitatively evaluated against four criteria: effectiveness (will the policy generate revenue?), equity (is the policy fair?), social acceptability (will the public support or oppose the policy), and administrative feasibility (how difficult is the policy to implement?). All policies evaluated for the analysis come with tradeoffs where they judged favorably against certain criteria but less favorably against others. For example, the mileage-based user fee policy could be very effective at raising needed revenue to shore up Delaware's Transportation Trust Fund, but it is challenging to implement and administer. Conversely, maintaining the existing revenue generating system and policies does not impose an additional administrative burden, but in the long term it will not sustain or grow the Transportation Trust Fund because MFT revenue will decline for the reasons already identified. A full accounting of the tradeoffs for each policy is contained in the body of Part 2 of the report.

The policy adjustments that need to occur in response to the MFT challenge will involve a robust debate of the tradeoffs. The public should be engaged in that conversation, and the Delaware Department of Transportation can help facilitate broader public support for policy change by designing and implementing an information campaign that highlights the fiscal and practical importance of the state's Transportation Trust Fund, the challenge faced by declining MFT revenue, and the policy options that are available.

Introduction and Problem Definition

The transition to electric vehicles (EVs) is well underway and will have direct consequences on transportation and infrastructure funding because EVs do not pay motor fuel taxes (MFTs) that help replenish federal and state transportation trust funds. Delaware's shift to EVs was codified in a state regulation finalized in November 2023 (McVety, 2023). The regulation requires that 82% of all new vehicle deliveries to Delaware in 2032 must be zero-emission vehicles. As the number of EVs in Delaware grows, a second technological change will occur: gas- and diesel-powered internal combustion engine (ICE) vehicles will become more fuel efficient and will drive more miles between trips to the pump. A Delaware Department of Transportation (DelDOT) consultant modeled the impact of the new regulation on EV adoption and produced an estimate for the number of registered EVs in the state. The consultant also modeled the expected improvements to fuel economy of ICE vehicles. These estimates are show in Figure 2 below.

Figure 2. Estimates of Registered EVs and Fuel Economy in Delaware

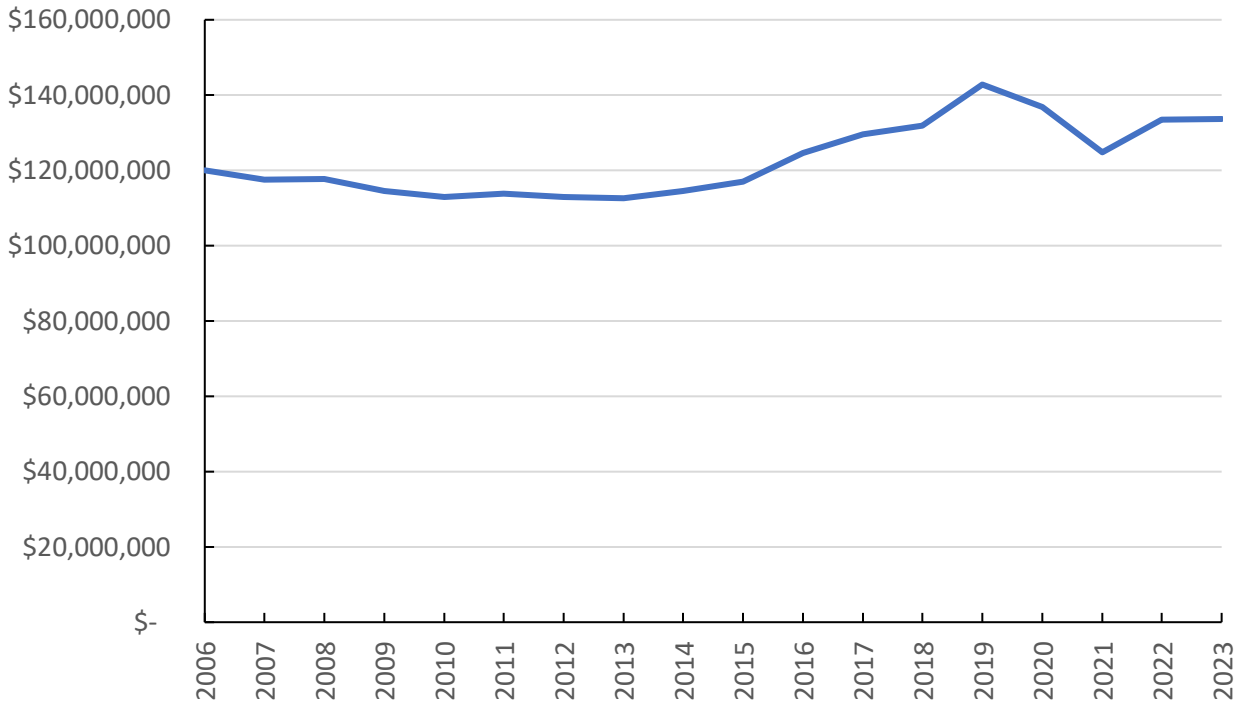


Source: (Independent DelDOT Consultant, 2024)

The combined impact of these inevitable forces means that motor fuel tax will decline in the future, all else being equal. This is not an obvious outcome if one only looks only at historical MFT revenue which, on average, has increased slightly over the years (see Figure 3 below). Except for a sharp decline in revenue in 2020 and 2021 due to the reduction in travel at the start

of the COVID-19 pandemic, Delaware's MFT shows an overall upward trend and has nearly returned to pre-pandemic levels despite the fact that the state's MFT rates have not changed since 1995.

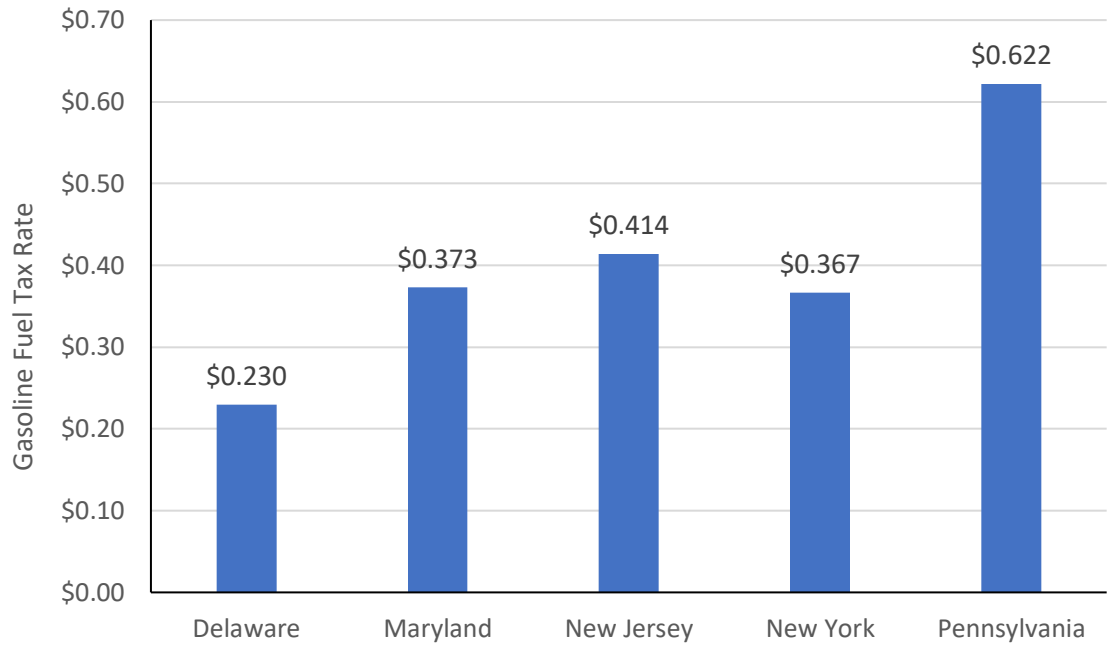
Figure 3. Delaware's Motor Fuel Tax Revenue History



Source: (DelDOT, 2022, 2023)

Delaware's MFT rates are $0.23 per gallon of gasoline and $0.22 per gallon of diesel. In 2023, the average Delaware motorist paid approximately $142 in state fuel taxes, but the state receives more annual MFT revenue than it does from Delawareans only. There are several explanations for why Delaware overachieves on MFT revenue. First, because the state's MFT rate is lower than neighboring states (see Figure 4 below). Travelers commuting to or passing through Delaware may decide to save money by filling up before leaving the state.

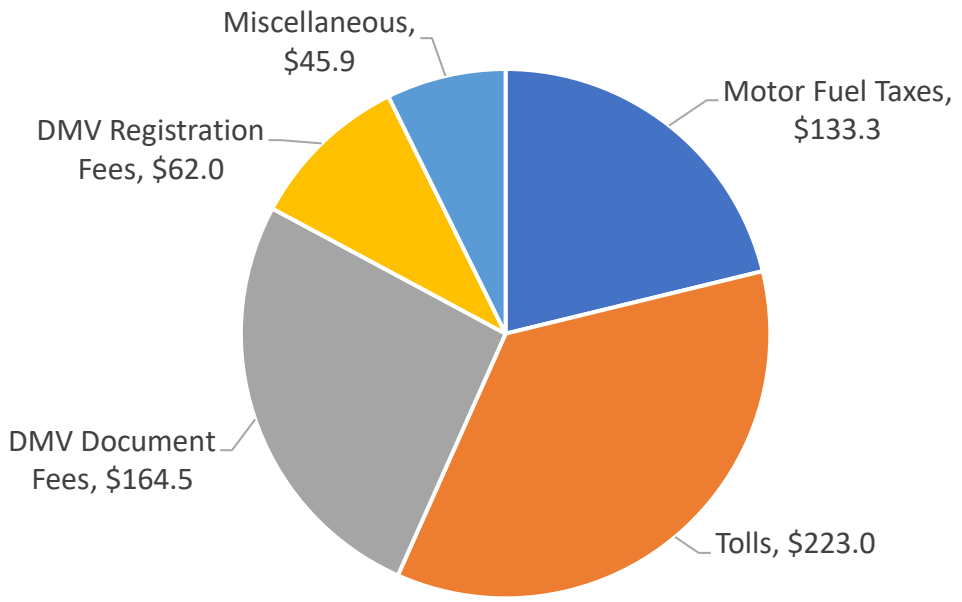
Figure 4. Gasoline Fuel Tax Rate in Delaware and Neighboring States



Source: (Hoffer & Dobrinsky-Harris, 2023)

The seasonality of Delaware's tourism industry is another likely explanation for why the state overachieves on MFT revenue. Motor fuel consumption increases during the summer months when people from around the region and country come to visit Delaware and its beaches. These guests will travel extensively in the state and fill up their vehicles, yet those vehicles are registered outside of Delaware and are not included in the state's vehicle counts. Despite Delaware overachieving on MFT revenue, the combined impact that EVs and fuel economy improvements will have on MFT is a predictable and unavoidable challenge for the state since MFT is the third largest source of revenue for the Transportation Trust Fund (TTF) as show in Figure 5. In the 2023 fiscal year, the TTF received $628.7M in revenue, with MFT accounting for $133.3M of the total (DelDOT, 2023).

Figure 5. Fiscal Year 2023 Delaware TTF Revenue (dollar values in millions)



Source: (DelDOT, 2023, p. 104)

The TTF is an essential fiscal component of the state's transportation systems and infrastructure. Established in 1987 via an act of the Delaware General Assembly, the TTF is administered by the Delaware Transportation Authority, a government-owned corporation, and it receives continuous revenue from multiple sources show in Figure 5. In 2015, the Delaware General Assembly strengthened protections on the use of these revenues by amending the state's constitution to create a "locked-box" around the TTF (Lavelle, 2015). Under this constitutional amendment, TTF revenue can only be allocated for capital expenditures on the public transportation system, debt service, and other transportation-related purposes including operating expenses for the Delaware Department of Transportation. The state's sole public transit provider, Delaware Transit Corporation, is subsidized through the TTF. TTF revenue is also instrumental in providing matching funds for federal grants (surface transportation, transit, etc.) and for payments to bondholders. The financial health of Delaware's TTF is indispensable to the development, operation, maintenance, and management of the state's transportation and transit systems (DelDOT, 2022).

While revenue flows to the TTF have remained stable over the years, the combined impact of increased sales of EVs and plug-in hybrid electric vehicles (PHEV) along with improved fuel economy in traditional ICE vehicles will depress MFT revenue. This expected revenue loss will strain the TTF and a policy response is needed to mitigate the impact.

The following analysis is designed to inform the policy conversation on how to address the combined MFT challenge posed by EVs and fuel economy improvements in ICE vehicles. It is divided into two parts. Part 1 provides a quantitative estimate of the expected MFT shortfall for Delaware in the years to come. Indeed, to have a thoughtful, informed, and rational policy debate, it is first necessary to articulate the magnitude of the issue. Thus, the goal of Part 1 is to estimate the impact that EVs and improved fuel economy will have on Delaware's MFT revenue so that decision-makers, stakeholders, and the public can engage in a policy discussion with a common understanding of the challenge faced. Part 2 of the analysis provides a qualitative summary and evaluation of the policy options available to address the MFT challenge and presents a neutral and objective view of the tradeoffs between these options.

Part 1 begins with a literature review of attempts from other states to calculate the MFT impact of EVs and improved fuel economy. The literature is synthesized to create a methodology for projecting the MFT shortfall for Delaware. Next, data sourced from a third party is used to complete the financial analysis and the results are presented along with a brief discussion. Part 2 begins with a review of the basic qualitative method for policy analysis. Policy options that could be implemented to address the expected MFT revenue challenge are defined. Criteria used to assess these policy options are also defined, and then the options are evaluated against each of the selected criteria. A discussion follows and concluding remarks are provided. Importantly no recommendation is made for any particular policy direction. However, it is argued that Delawareans should be engaged and educated on the nature of the MFT challenge so that when policy changes are proposed, legislated, and implemented, the broader public will understand and appreciate the need to act.

Part 1 – Quantitative Financial Analysis

Literature Review

The published literature on calculating MFT impact of EVs and fuel economy is not extensive; yet within the literature that does exist, there appears to be a variety of methods ranging from the simple to the progressively complex. A basic method for determining MFT revenue in any given year is to multiply the total number of vehicles by the average annual vehicle miles travelled (VMT) and the fuel tax rate, and then divide by the average fuel economy of ICE vehicles in the state. This method was used to estimate future MFT revenue in Alabama, Indiana, and Iowa (Iowa DOT, 2018; Konstantinou et al., 2023; Xu et al., 2020). The same approach was also used to estimate future MFT revenue at the national level (Davis & Sallee, 2020; Short & Crownover, 2021).

There are more complex methodologies that attempt to provide better estimates using a more granular lens. One analysis for Virginia used a county-by-county bivariate count model and found that EV ownership and hence MFT revenue loss was higher in counties with greater population density, percentage of residents over 65 years old, percentage or residents with graduate degrees, and household size (Jia et al., 2019). In Utah, researchers utilized a parameterized and calibrated version of the federal Energy Emissions Reduction Policy Analysis Tool to estimate data inputs and outputs, including MFT revenue (Chamberlin et al., 2015). The common outcome of these studies, regardless of the method used, was that MFT revenue declines in the future as ICE vehicles become more fuel efficient and EVs constitute a larger and larger percentage of the state's overall vehicle fleet.

Methodology

Reviewing the literature cited above, a method can be rationalized to estimate MFT revenue loss in Delaware. First, although there is some variability across Delaware's three counties, it does not make sense to utilize the method employed in Virginia with its demographically and spatially diverse set of 132 counties. Second, the Energy Emissions Reduction Policy Analysis Tool is no longer available for use on the Federal Highways Administration's website.[2] Therefore, a simple method is a sufficient, straightforward, and expedient approach to calculating MFT revenue for Delaware. The method is explained and outlined in greater detail in the appendix, but the basic arithmetic principle is that MFT generated by any non-EV is equal to the total number of vehicles (V) divided by the vehicle's fuel economy (miles per gallon–mpg) multiplied by the vehicle miles travelled per year (VMT) multiplied by the fuel tax rate (τ) for the vehicle's

[2] https://www.planning.dot.gov/FHWA_tool/default.asp

fuel type (MFT = V/mpg * VMT * τ). Summing the different vehicle types (100% ICE, hybrid, PHEV, trucks) and fuel types (gas, diesel) for any given year will yield the total MFT generated in that year. The appendix details the full methodology for the financial analysis and offers a discussion of data sources and assumptions.

Results

Although the DelDOT consultant provided values to 2050, this extended time horizon introduces a high level of uncertainty for any legitimate policy development. For this reason, MFT estimates in the following results are provided to 2050 for illustrative purposes only; 2040 is used as the latest year for any discussion of the results and should be used as the limit for any subsequent policy development. Delaware's MFT revenue and loss estimates are presented in Table 2 and Figure 6 below. For readability, losses are colored red and shown as positive numbers in both the table and the figure. The table also offers cumulative revenue and loss estimates for the period from 2030–2040 and, for illustrative purposes only (greyed out columns), cumulative estimates for the 2030–2050 period.

Table 2. Motor Fuel Tax Revenue and Loss Estimates

Estimate	2030 (M)	2035 (M)	2040 (M)	2045 (M)	2050 (M)	2030–2040 Cumulative (M)	2030–2050 Cumulative (M)
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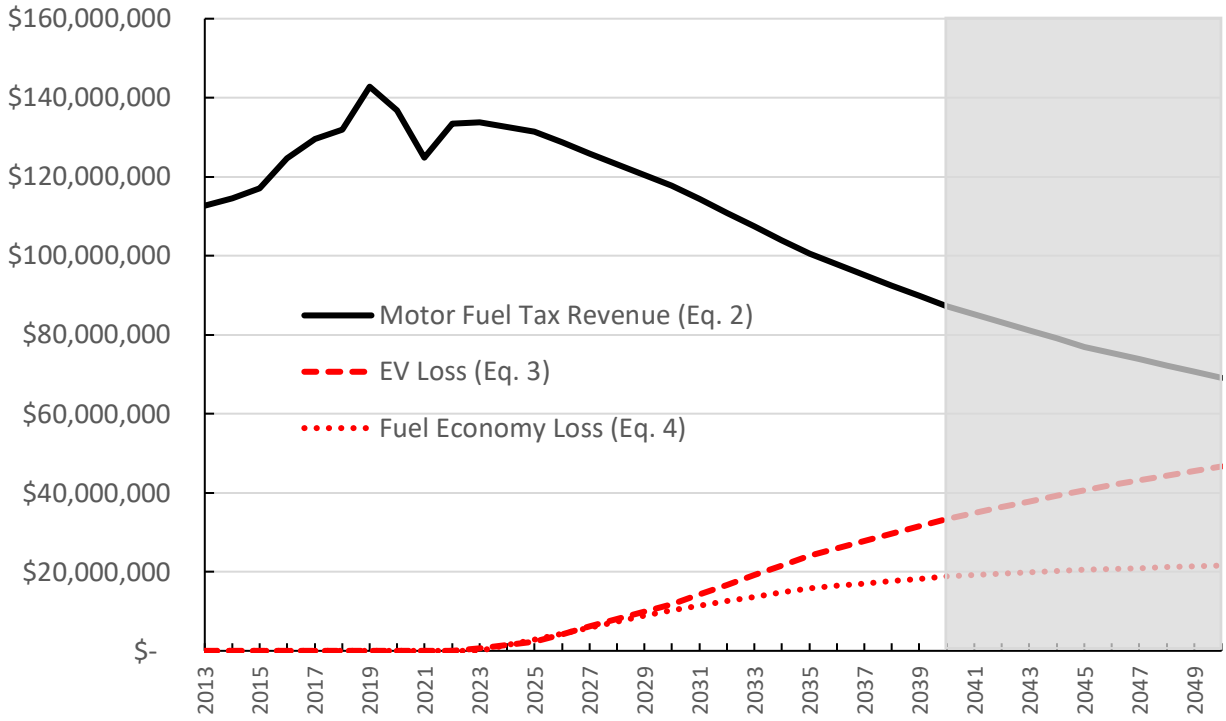
Figure 6. Motor Fuel Tax Revenue and Loss Estimates



MFT revenue is estimated to decline from $133.3M in 2023 to $87.2M in 2040. Cumulative revenue generation during the period from 2030 to 2040 exceeds $1,100M. Annual losses from EVs are estimated to increase to $33.5M in 2040, with a cumulative loss over the period from 2030 to 2040 of $256M. The magnitude of annual losses from fuel economy improvements is comparable to those from EVs over the next several years but then starts to lag EV losses as EVs make up an increasingly larger percentage of the state's vehicle fleet. Cumulative losses from fuel economy improvements between 2030 and 2040 are estimated at $167M.

Discussion of MFT Revenue and Loss Estimates

Motor fuel tax revenue is the third largest source of revenue for Delaware's Transportation Trust Fund. As more Delawareans purchase and drive fuel-efficient ICE vehicles and fully electric vehicles in the future, this technological transition will depress motor fuel sales in the First State and consequently reduce motor fuel tax revenue. The preceding analysis showed that the combined impact of EV sales and fuel economy improvements will significantly reduce the state's MFT revenue-generating capability.

The salient point of the above analysis is that Delaware's MFT revenue stream will face two simultaneous technological challenges. One is the EV transition. The second is the expected improvements in fuel economy for ICE vehicles. Both technological improvements—EVs and fuel

economy improvements—will reduce MFT revenue. As Delaware's policymakers, administrators, stakeholders, and driving public engage in a conversation around policy mechanisms to replace lost MFT revenue so the state's transportation infrastructure can be built, operated, and maintained, they should avoid fixating on only one kind of vehicle fuel (electricity, gasoline, diesel, etc.). This is worth reiterating: Delaware's MFT challenge is not simply an EV issue or a fuel economy issue, but both, and the policy conversation should incorporate both vehicle fuel types rather than focusing exclusively on one or the other. Failure to do so increases the likelihood of ineffective and sub-optimal outcomes. Part 2 of this analysis identifies, describes, evaluates, and compares the policy options that could address Delaware's MFT challenge.

Part 2 – Qualitative Policy Analysis

Part 1 of this analysis showed that MFT revenue losses from the EV transition and fuel economy improvements can be significant over the long term. Additional revenue sources must be identified, evaluated, discussed, designed, legislated, and implemented to replace Delaware's expected MFT revenue loss and ensure that the state's TTF remains in good fiscal health. The following qualitative policy analysis identifies, describes, and evaluates the policy options that are available to address the MFT challenge.

Methodology

The methodology utilized policy analysis that follows a series of sequential steps (Bardach & Patashnik, 2015; Majchrzak & Markus, 2013). First, policy options that could potentially address the issue at hand are identified, described, and presented. Next, a set of evaluative criteria are selected and defined. The evaluative criteria are then applied consistently across the policy options to assess whether, and to what degree, the options meet the criteria definitions.

All policy options will be evaluated against each criterion using research, logic, and reason. The analysis will consider applied and scholarly literature, gray literature, and market data and studies. This policy analysis is qualitative, with categorical descriptors provided instead of quantitative numbers or scores. Once all policies are assessed against each criterion, the results are reviewed, the tradeoffs between the policy options are highlighted, and the analysis is written up and communicated. Policy analyses can include an additional step to make formal recommendations of which policy option(s) possess the best balance of tradeoffs. This study will not make a recommendation, however, and the results will be communicated objectively so that Delaware's policy decision-makers, administrators, and public stakeholders can informatively debate policy goals, tradeoffs, and strategies. Due to the qualitative nature of the analysis, follow-up analyses are likely needed to quantify details of each revenue-generating policy option. Although the present analysis does not provide this quantitative level of specificity, it is a helpful starting point to launch an informed debate on the policy options that could address Delaware's expected MFT revenue losses.

Policy Options

In this section, the policy options that could potentially address the MFT revenue shortfall are identified and described. The objective here is to lay out the menu of possible policy options, not to judge or evaluate them (that will occur later). To identify these policy options, research was conducted to learn what policies other states are considering or have already implemented to replace declining MFT revenue. The results of this research are presented below.

Alternative Fuel Vehicle Fee

At the time of publication, thirty-four states charge EV owners an annual fee, and twenty-six charge an annual fee on PHEVs. Annual fees range from $50 to $221 on EVs and from $35 to $150 on PHEVs.[3] Several states index these fees to inflation, but most do not. Michigan and Oklahoma have a tiered fee structure based on vehicle weight because heavier vehicles cause more wear-and-tear on the roads (Igleheart, 2023). Fees are typically collected as part of the vehicle registration process and are commonly allocated to the state's transportation trust fund. Some states elect to use a portion of the fees to support EV charging infrastructure.

Highway Use Fee

In 2020, Virginia created and implemented a highway use fee (HUF) designed to replace lost MFT revenue from both EVs and fuel-efficient ICE vehicles. EV owners and owners of ICE vehicles that get better than 25 mpg must pay the annual fee. For EV owners, the fee is calculated as 85% of what the owner would pay in MFT if they drove the average annual vehicle miles traveled by the typical Virginian (11,600 miles in fiscal year 2021) in a vehicle getting the Virginian average fuel economy of 23.7 mpg (Virginia Department of Motor Vehicles, 2021). For owners of fuel-efficient ICE vehicles, the fee is calculated as 85% of the difference of what they would pay in MFT in a 23.7 mpg vehicle traveling 11,600 miles versus what they would pay based on 11,600 miles traveled at their vehicle's rated fuel economy.[4] Vehicles exempt from the HUF include motorcycles, mopeds, vehicles with a gross weight greater than 10,000 pounds, and government-owned vehicles. Virginia collects HUFs during vehicle registration. Vehicle owners subject to the HUF can voluntarily opt into the state's mileage-based user fee program in lieu of paying the fee (see next subsection).

Mileage-Based User Fee

A mileage-based user fee (MBUF) system assesses a charge on vehicles for the distance traveled rather than the quantity of fuel used to power the vehicle. While many pilot programs exist, Oregon, Utah, and Virginia have actually legislated and implemented voluntary MBUF systems. All three MBUF systems differ in particular ways: vehicle eligibility, mile tracking method, fee structure, fee collection method, and treatment of out-of-state miles.

In Utah, only fully electric vehicles can enroll in their MBUF program. Hybrids, including PHEVs, and ICE vehicles cannot participate. Oregon allows any vehicle to register and participate in

[3] To see the list of state fees at the time of writing, visit: http://tinyurl.com/3sfbxxxf

[4] The Virginia fuel tax rate is $0.298/gallon, thus an EV owner would pay the full HUF of 0.85 * 11,600 miles * $0.298/gallon / 23.7 mpg = $123.98. An ICE vehicle owner getting 35.0 mpg would pay a HUF of 0.85 * 11,600 miles * $0.298/gallon * (1 / 23.7 mpg - 1 / 35.0 mpg) = $40.03.

their MBUF program, while Virginia allows EVs, hybrids, and ICE vehicles with a fuel economy of 25 mpg or better the opportunity to participate. Vehicle eligibility in Virginia's MBUF system is consistent with their HUF program.

A straightforward method of tracking vehicle miles is by using a global positioning system (GPS) device plugged into a vehicle's onboard diagnostics (OBD) port, which is standard for all vehicles manufactured after 1996. The device connects to a third-party app installed on the driver's cell phone and sends the data to the MBUF system administrator for processing. A method suitable for vehicles without an OBD Port involves periodic odometer readings, either through self-reporting or vehicle inspections. All three states use both GPS and non-GPS methods to track vehicle miles.

Another consideration is the fee structure and fee collection method. Utah charges $0.01/mile capped annually at the state's annual EV fee of $130.25. Oregon charges $0.019/mile with no annual cap. Virginia charges a fee of $0.0107/mile capped at the state's HUF. In all states, regardless of whether a driver uses GPS or non-GPS tracking, fees are collected through the system administrator's app. In Utah and Virginia, value is pre-loaded and the fees are removed after each drive, similar to E-ZPass. In Oregon, participants receive and pay quarterly invoices through the app.

MBUF system designers must also decide how to treat miles driven outside of the home state. Utah and Virginia's programs do not differentiate between in-state and out-of-state miles, so drivers still accrue fees regardless of where their driving occurs. Oregon drivers using the GPS option are not charged for out-of-state miles, but those using the non-GPS option are charged.

Since 2018, Delaware has taken a leading role in a MBUF pilot with states along the east coast. As a member of The Eastern Transportation Coalition (formerly the I-95 Corridor Coalition), hundreds of Delawareans and stakeholders in the trucking/freight industry have participated in the pilot. The lessons learned in the pilot program can help inform key policy discussions and designs to address challenges such as cross-state mileage accounting, privacy, and program fairness.

Public Charging Fee

This policy assesses a fee on the electricity drivers purchase when charging their vehicles at any public charging stations. Georgia, Iowa, Kentucky, Montana, and Oklahoma use a per kilowatt-hour (kWh) fee system where the driver pays a surcharge for the electricity delivered by the station (Jaros & Hoffer, 2023).[5] The per kilowatt-hour fee is the EV analog to traditional motor

[5] Georgia will charge $0.0284/kWh starting in 2025, Iowa charges $0.026/kWh, Kentucky charges $0.03/kWh, Montana charges $0.03/kWh, and Oklahoma charges $0.03/kWh.

fuel taxes. Recognizing that not all stations charge by the kilowatt-hour, Utah implemented a 12.5% tax on retail sales of electricity on a per kilowatt-hour or a subscription basis (Schultz & Harper, 2023). Taking a different approach, Washington imposes an annual flat registration fee for public charging station ports. Washington's fees differ based on the charging port speed with different rates for Level 2 and Level 3 direct current fast charging ports (Das et al., 2021).

This policy option is a surcharge added to the cost of a charging session. It should not be confused with the cost of charging levied at state-owned chargers (Hansen, 2021). For example, at many Delaware transit hubs, DelDOT provides charging stations and currently charges a $0.15/kWh fee (with some chargers switching to an hourly fee after two hours of charging). This nominal fee is meant to be revenue neutral and is set to recover the cost of the electricity and system maintenance, so it is not allocated to the TTF. The policy option defined here, a public charging fee, is an additional surcharge that would be added to all public stations, not just state-owned chargers. The five other states that levy this surcharge on a per kilowatt-hour basis set it at approximately $0.03/kWh.

Retail Delivery Fee

A retail delivery fee is a fee added to retail orders delivered by motor vehicles that use public infrastructure. Colorado and Minnesota impose such fees. Colorado's fee began in 2022, while Minnesota's will begin in 2024. The two designs differ, but important elements include eligible orders, the fee rate, the fee collection method, and product exemptions.

Each state classifies order eligibility differently and sets a different fee rate. In Colorado, orders are eligible if they are delivered in the state and subject to the state's sales tax (Fenberg et al., 2021). In Minnesota, eligible orders must be delivered in the state, over $100, and subject to the state's sales tax. Clothing counts toward eligibility even though it is not subject to Minnesota's sales tax (Hornstein & Dibble, 2023). Colorado charges $0.28 per order and the fee is indexed to inflation. Minnesota charges $0.50. In both states, the retailer is allowed to pay the fee on behalf of the consumer. If the retailer instead collects the fee from the consumer, they are required to itemize it separately from other delivery fees on the invoice.

Colorado exempts orders from the fee if the item(s) are exempt from sales tax, wholesale orders, or digital goods. Furthermore, businesses with $500,000 or less of retail sales in the prior year are exempt from collecting the fee (Fenberg et al., 2023). Minnesota exempts orders that are exempt from sales and use tax (not including clothing) and retail sales that include food, food ingredients, prepared food, food or beverage service establishments, drugs and medical devices, accessories, and supplies, or baby products. In Minnesota, a business that has $1,000,000 or less of retail sales in the prior year is also exempt from issuing the fee.

Increase Motor Fuel Tax Rate

Since 2013, no fewer than 33 states have raised their motor fuel tax rates (National Conference of State Legislatures, 2023). Delaware's rate was last increased to $0.23/gallon in 1995, and the state could increase it again to derive more MFT revenue. Additionally, the state could index the rate to inflation so that it increases (or decreases) automatically over time. Delaware could also index MFT rate increases to vehicle fuel economy improvements, as Georgia does, to alleviate shrinking revenue from increased efficiency (Roberts et al., 2015).

Increase Tolls

Delaware collects significant revenue, approximately $242M per year, from tolls on State Route 1, Interstate-95, and U.S. Route 301 (Majeski, 2024). The current toll rates, particularly for State Route 1 and Interstate-95, have not been adjusted in many years (O'Malley, 2014). The state could consider raising tolls to generate additional revenue for the TTF.

Increase Division of Motor Vehicles Fees

In October 2015, the Delaware Division of Motor Vehicles (DMV) increased several fees (Starkey, 2015). Notably, the motor vehicle document fee was raised from 3.5% to 4.25% per $100 of a vehicle sale price. The document fee is a one-time fee paid by the vehicle owner at the time of first registration. Other fees that were increased in 2015 included license and registration late renewal fees, fees for the reinstatement of suspended or revoked licenses, title fees, as well as duplicate document, license, title, and validation sticker fees. The state could revisit DMV fees, including document and registration fees that already flow to the TTF, and consider raising them again to generate additional revenue.

Maintain Existing Policies

Delaware does not levy an EV or PHEV fee, administer a HUF or MBUF system, assess fees on charging, or levy an e-commerce delivery fee. Tolls on Delaware roads are periodically reviewed and adjusted but have never been increased specifically to recoup lost MFT revenue from EVs and fuel-efficient ICE vehicles. Moreover, the state's MFT rates of $0.23/gallon for gasoline and $0.22/gallon of diesel have not increased since 1995. The state could maintain this existing policy approach to the problem.

Evaluative Criteria

In this section the criteria that will be used to evaluate the aforementioned policy options are presented and defined. The selected criteria were chosen based on the practical impact and ability of a proposed policy to address the expected MFT revenue decline. With any analysis,

different stakeholders would select and prioritize different criteria that matter most to them and their stake in the issue. The four criteria that were selected for this analysis were chosen to represent the perspective of public administrators and managers, notably DelDOT leadership. Furthermore, the policy analysis is Delaware-centric meaning that the evaluation prioritizes the impact on Delawareans and Delaware state government as opposed to non-Delawareans and authorities in other states. This is reflected in the definitions of each evaluative criteria below.

Effectiveness

Will the policy option generate enough revenue to close the expected MFT shortfall and maintain Delaware's Transportation Trust Fund in good standing? If financial data on any of the policy options is available from other states, it will be used and compared to that state's MFT revenue to help determine effectiveness.

Equity

Is the policy option fairly applied and assessed on all Delawarean road users in an even-handed way, or are some users disproportionately burdened? When appropriate, consideration is given to the concepts of horizontal and vertical equity (Litman, 2024; McDaniel & Repetti, 1993). In condensed terms, horizontal equity asserts that users of a service should pay an amount proportional to their usage (user fee) whereas vertical equity means that users of a service pay relative to their means (ability to pay).

Social Acceptability

Will the Delaware public support or oppose the policy option and to what extent? When available, public opinion research (surveys, polls, focus groups, etc.) at the national, regional, or state level will be used to help evaluate policies for social acceptability.

Administrative Feasibility

How difficult will it be for Delaware government entities to implement and administer the policy option, and does it require new systems, structures, and/or human resources? To judge this criterion, consideration is given to DelDOT and the state's existing administrative frameworks and how well the policy options can leverage them.

Rating System

Each policy option from the preceding section will be evaluated against the four criteria presented in this section. They will be qualitatively assessed and rated using logic, reason, and available evidence. The rating system used in the analysis is analogous to a six-point Likert scale

that avoids a neutral option (Chyung et al., 2017). For each criterion, one of six qualitative descriptors will be assigned to each policy:

Effectiveness: Deeply ineffective, ineffective, slightly ineffective, somewhat effective, effective, highly effective

Equity: Deeply inequitable, inequitable, slightly inequitable, somewhat equitable, equitable, highly equitable

Social Acceptability: Deeply socially unacceptable, socially unacceptable, slightly socially unacceptable, somewhat socially acceptable, socially acceptable, highly socially acceptable

Administrative Feasibility: Deeply administratively challenging, administratively challenging, slightly administratively challenging, somewhat administratively feasible, administratively feasible, highly administratively feasible

Policy Evaluation

This section presents a qualitative narrative-based evaluation of each policy option against each of the four criteria. When a policy option is assessed, it is evaluated independently of all the other policy options. In other words, it is assumed that the policy under evaluation is the only option available and it is judged as such. In the subsequent discussion section, thoughts are offered on combinations of policy options that would, if adopted and implemented together, change the independent assessments presented here.

Alternative Fuel Vehicle Fee

In theory, an alternative fuel vehicle fee can be established in Delaware that would generate the same amount of MFT revenue lost from EVs, and it would do so in perpetuity if the fee is indexed to inflation (Konstantinou et al., 2023). However, this policy would not apply to fuel-efficient ICE vehicles so total MFT revenue would still be insufficient relative to the current baseline. Therefore, this policy is somewhat effective at mitigating the expected MFT shortfall. The policy is also somewhat equitable for the same reason. While EV owners will be paying a fairer share compared to less fuel-efficient ICE vehicles, fuel-efficient ICE vehicle owners will still be underpaying. There is evidence that EVs are driven fewer miles than their ICE counterparts, which suggests horizontal equity is compromised. This is partially offset by the heavier weight of EVs that put added wear and tear (and maintenance costs) on the road system (Zhao et al., 2015). In terms of social acceptability, there are currently far fewer EV owners than ICE vehicle owners in Delaware, so this policy would only impact a small fraction of the state's population. ICE vehicle owners would likely be neutral or supportive of this policy. While EV owners will not be enthusiastic about paying an additional annual fee for their vehicles, and the EV industry

lobby is likely to object, some will understand the need to raise revenue and will not strenuously oppose a fee (Williams, 2022). Those EV owners who will object will be small in number because there are so few EV owners at present. Overall, this policy is socially acceptable in the short term. Regarding administrative feasibility, the fee can be collected through the same systems used by the Delaware DMV. Although there will be challenges with fee establishment, collection, and enforcement, the policy's simplicity and ability to leverage existing DelDOT systems means that the policy is administratively feasible.

Highway Use Fee

Virginia's HUF fee generated $59.7M in fiscal year 2023 compared to MFT revenue of $1.36B in the same fiscal year, or about 4.5% of MFT revenue (Virginia Department of Transportation, 2023, p. 12). Considering that the HUF is designed to recoup a portion of lost revenue from both EVs and fuel-efficient ICE vehicles, this policy is effective. When paired with regular motor fuel taxes, the HUF requires EV and fuel-efficient ICE vehicle owners to pay a fairer share of the infrastructure they use. Although the HUF is capped and heavy drivers will not pay for their excess miles, the complimentary MBUF program gives light drivers the option to only pay for the miles they drive. Furthermore, EV and fuel-efficient ICE vehicle owners tend to be wealthier and thus have a higher ability to pay the fees (Hedges & Company, 2019; Muehlegger & Rapson, 2018; Zhao et al., 2015). For these reasons, the HUF can be considered horizontally (user fee) and vertically (ability to pay) equitable. A HUF is likely to be socially unacceptable. While EV owners may understand the need to pay for the infrastructure they use, fuel-efficient ICE vehicle owners may feel they are being double charged (first at the pump and again for the HUF). For this reason, there is likely to be strong opposition to a HUF policy, especially in the absence of any public outreach and education campaign on the need for the program. A HUF would also be administratively challenging. Although the fee can be collected during vehicle registration, fuel efficiency data will need to be collected for each vehicle make and model, and a pricing, auditing, accounting, and reimbursement system will need to be implemented. Virginia HUF rollout was rocky, with thousands of vehicle owners receiving excessive and improper charges (Beasley, 2022).

Mileage-Based User Fee

An MBUF, if it is indexed to inflation and accurately priced with administrative and compliance costs included, would be highly effective over the long term at mitigating MFT revenue losses (Neudorff et al., 2021). An MBUF could do more than supplement MFT revenue, it could replace it entirely (Sorensen et al., 2012). The equity of MBUFs is a well-studied topic. MBUFs are generally considered horizontally equitable, as users pay an amount proportional to the service received (Duncan & Graham, 2013; I95 Corridor Coalition, 2019a). On the other hand, MBUFs are often criticized for being vertically inequitable because flat fees do not accommodate

drivers' ability to pay (Glaeser et al., 2023; Robitaille et al., 2011). Relatedly, there is a belief that rural drivers will pay more through an MBUF system than through the current fuel tax system, although recent analyses dispute that claim (Jacobs Engineering, 2022; Matthews et al., 2021; Speroni et al., 2022). Overall, an MBUF is somewhat equitable. In terms of social acceptability, an MBUF is poorly received when it is presented to the public via polls and surveys due to concerns about fairness and trust in government (Agrawal et al., 2016; Duncan et al., 2020; Duncan, Nadella, Giroux, et al., 2017). Additionally, the OBD monitor and mile-tracking method is shown to raise data and privacy concerns among the driving public (I95 Corridor Coalition, 2019b). However, recent surveys of Delawareans shows that concerns over privacy and personal information is declining (DHM Research, 2020). For these reasons the policy is rated as socially unacceptable. The administrative feasibility of an MBUF is very low because the system is qualitatively distinct from any current or former road usage and payment methods. The number of systems and structures that need to be successfully established and implemented to transition from a fuel tax system to an MBUF would impose a heavy administrative and bureaucratic burden. This is even more relevant for small states like Delaware where out-of-state miles (driven by Delawareans and non-Delawareans) is high relative to larger states. For these reasons, an MBUF system is deeply administratively challenging.

Public Charging Fee

A per-kilowatt-hour fee/surcharge on public EV charging could be considered analogous to the current MFT system. However, while ICE vehicle owners must use filling stations to refuel and cannot avoid paying MFT, EV owners mostly refuel their vehicles at home, beyond the reach of a public charging fee (O'Connor et al., 2023). There are also issues with the reliability of public chargers. One estimate indicates that EV owners are unable to use public chargers approximately 20% of the time for a host of reasons such as malfunctioning stations, charging cables of insufficient length, and long waiting lines (J.D. Power, 2023). If EV owners can only use public chargers a fraction of the time, they will pay fewer public charging fees. Moreover, this policy is not able to recoup lost revenue from fuel-efficient ICE vehicles. For these reasons this policy is ineffective on its own. In terms of equity, this policy would disproportionately burden EV owners who cannot charge at home. This includes those without off-street parking options such as residents of denser urban areas with rowhomes as well as renters whose landlords may not allow installation of fast charging equipment on their properties. There are also demographic components to consider since Black, Hispanic, and lower-income individuals are more likely to be renters (DeSilver, 2021). Therefore, this policy is rated as inequitable. A public charging fee's similarity to the current MFT system is beneficial from a social acceptability perspective. ICE vehicle owners who transition to EVs will recognize and understand the surcharge, assuming they recognize and understand MFTs. At the same time, applying a new fee where none existed previously will always be met with resistance; but, since there are currently

few EV owners relative to ICE vehicle owners, the resistance will be limited. Therefore, the policy is somewhat socially acceptable. The implementation and administration of a public charging fee would require new management, auditing, enforcement, and technological systems. However, these systems are not completely novel because the policy is analogous to an MFT. A public charging fee is somewhat administratively feasible.[6]

Retail Delivery Fee

Spurred by the COVID-19 pandemic and with new retail delivery innovations under development, the retail home delivery sector is expected to continue to grow (Ratchford et al., 2023). From an effectiveness perspective, the important consideration is the extent to which a retail delivery fee can make up for expected MFT revenue losses. Looking at Colorado's retail delivery fee, it generated $68.6M between August 2022 to May 2023, with MFT generating $564M over the same time period (12% of MFT revenue) (Colorado Department of Revenue Office of Research and Analysis, 2023).[7] The policy is currently ineffective on its own, but it could become more effective as the retail delivery sector continues to expand. A retail delivery fee is also questionable from an equity perspective. A flat fee on a service like home delivery could be considered an excise tax, and these types of consumption-specific taxes are seen as inequitable, particularly for lower-income individuals who bear a larger share of the payment burden relative to their ability to pay (Barro, 2017). Furthermore, retail delivery fees are decoupled from direct usage of the transportation system since the recipient of the delivery is not actively putting wear and tear on the system. Thus, a retail delivery fee is horizontally and vertically inequitable. In terms of social acceptability, Delawareans identify with low taxes and fees. As such, a new retail delivery fee would not be welcomed, making this policy socially unacceptable. Colorado is currently the only state with an active retail delivery fee system, and its implementation has been rocky (Eastman, 2022; Huspeni, 2022). Delaware could certainly learn from Colorado (and Minnesota once its fee is implemented) about ways to smooth implementation and management. The Delaware Division of Revenue would be the likely administrator and would need to scale up new systems and resources to successfully oversee

[6] It is important to note that the Delaware law establishing state agency authority to recoup charging expenses at state-owned chargers does not permit those agencies to levy the additional surcharge evaluated here. The law amended language in Title 29 of the Delaware Code and allows agencies to charge fees "so long as the fees do not exceed the agency's cost" (Hansen, 2021). By definition, a surcharge would exceed those costs. Thus, to generate revenue from a charging fee at state-owned chargers, the General Assembly would be required to further amend Title 29 of the Delaware Code.

[7] This information was obtained via personal email correspondence with the Colorado Department of Revenue. The gross retail delivery fee revenue is divided and distributed across several different funds and programs (what the state calls "enterprises"). The breakdown is available on the state's fiscal note for the bill that created the fee (see page 9 of (Legislative Council Staff, 2021)).

collections from all retailers providing delivery. A retail delivery fee is thus slightly administratively challenging.

Increase Motor Fuel Tax Rate

As noted above, the last time Delaware increased the MFT rate was nearly 20 years ago in 1995. Although the policy only targets revenue generation from ICE vehicles, another increase would offset future losses due to reduced fuel consumption and could be slightly effective throughout the period of transition to electric vehicles. The policy would be even more effective if the MFT rate is indexed to inflation like it is in some states. This would help ensure the MFT policy's ability to generate revenue is not eroded by inflationary pressure over time (Dumortier et al., 2017; O'Connell & Yusuf, 2013). For equity, MFT rates are already viewed as inequitable (Glaeser et al., 2023). Raising rates further in the absence of any other policy change would be inequitable because EVs will constitute a larger share of the vehicle fleet (thus placing the TTF revenue burden on ICE vehicle owners) and EVs are primarily owned by higher-income individuals (thus placing the TTF revenue burden on lower-income individuals) (Zhao et al., 2015). There will likely be public opposition to any suggested increase in the MFT rate. Despite the inelasticity of fuel costs to actual consumption and use, the driving public remains emotionally sensitive to increases in fuel price (Boyd-Swan & Herbst, 2012; Prakash et al., 2020). At the same time, public opinion research shows that MFT rate increases can garner support if the need for road maintenance and upkeep is made clear (Agrawal & Nixon, 2013; Fogg et al., 2020; MassInc Polling Group, 2019). An MFT rate increase is therefore rated as slightly socially unacceptable. The policy is rated as highly administratively feasible due to a robust, efficient, and longstanding MFT collection system that already operates in Delaware.

Increase Tolls

Raising tolls in Delaware could be somewhat effective at generating revenue for the TTF. Currently the state collects approximately $220M annually in State Route 1 and Interstate-95 tolls, so a not-inconceivable 10% increase in rates would bring in an additional $22M per year (Majeski, 2024). On the surface, the equity of tolling is straightforward because it is a true user-fee system. However, there are ability-to-pay (income) and locational (geographic) realities that complicate tolling equity. Evidence suggests that tolls overburden lower-income users and non-resident drivers that use the infrastructure sparingly (Levinson, 2010). It is assumed that Delaware collects a high share of tolls (especially year-round on Interstate-95 and on State Route 1 in the summer months) from non-Delawareans. However, the definition of equity used for this analysis only concerns Delawareans, not non-Delawareans. Considering Delawareans

only, the policy is somewhat equitable.[8] Compared to other revenue generation options, public opinion research indicates that toll increases are somewhat socially acceptable, particularly when the tolling authority clearly communicates how the additional revenue will be utilized (Duncan, Nadella, Clark, et al., 2017; Zmud & Arce, 2008; Zmud, 2008). The administrative feasibility of a toll increase is high because the infrastructure and resources already exist to manage the existing toll system.

Increase Division of Motor Vehicles Fees

When Delaware last increased DMV fees in 2015, the state estimated the change would bring in an additional $24M in revenue per year (Office of the Controller General, 2015). Combined motor vehicle document and registration fees ($226.5M) accounted for approximately one third of the total TTF revenue ($628.7M) in the recent fiscal year (DelDOT, 2023). Fee increases of the same magnitude as in 2015 would immediately generate enough annual revenue to offset losses from EVs and fuel-efficient ICE vehicles. However, the effect of DMV fee increases would diminish over time. This policy is therefore rated as effective. For equity, the horizontal and vertical equity of this policy is poor. Document and registration fees are not user fees, meaning that one can pay these fees on a vehicle but rarely use it. In addition, because they are flat fees, they do not accommodate one's ability to pay.[9] Increasing DMV fees to mitigate expected MFT revenue loss is judged to be deeply inequitable. For the social acceptability criteria, Delawareans will not want to pay more fees. It will be difficult for policymakers and administrators to sell DMV fee increases to replenish the TTF because the fees are not true user fees. At the same time, one-time and annual DMV fees are not as salient as tolls or MFT rates, which vehicle owners experience with much greater frequency. Public opposition, while certain to arise, would likely be less than changes to toll or gas tax rates. Social acceptability is rated as slightly socially unacceptable. The administrative feasibility of increasing DMV fees is very high because the fee assessment, collection, and disbursement system already exists and functions well.

Maintain Existing Policies

If the state were to maintain existing policies, MFT revenue will decline and the TTF will be negatively impacted. This approach is therefore deeply ineffective at addressing the problem (see financial analysis above). While the existing policies are reasonably equitable today because there are few EVs on the road relative to the number of ICE vehicles, that ratio will shift in the future as more drivers purchase EVs. In such a scenario, ICE vehicle owners will be paying

[8] If the definition of equity used for this analysis was expanded beyond Delawareans to include considerations of non-Delawareans, this policy would be less equitable than the rating given here.

[9] Motor vehicle document fees are calculated as a percentage of the vehicle purchase price whereas other DMV fees are fixed.

for the infrastructure that non-MFT paying EV drivers use for free, making the current policy approach inequitable. In terms of social acceptability, maintaining Delaware's existing policies will likely be accepted by the public, at least in the short term. Among Delawareans, the current policies are normalized and continuity is expected, whereas any initial effort to change policies will almost certainly encounter resistance. Longer term, when the TTF shrinks and construction and maintenance of the state's infrastructure is hampered, Delawareans will likely demand change to the status quo. Similarly, the current policies are embedded in public administrative practices and procedures. Thus, administrative feasibility is high because no new systems, structures, or human resources are needed to continue implementing existing policies.

Discussion of Policy Analysis

Few policy options score positively across all criteria and there are obvious tradeoffs to consider. For example, an MBUF is deemed to be the most effective policy option for generating revenue for the TTF, but it is also deeply socially unacceptable and administratively challenging to implement and manage. Likewise, increasing DMV fees is effective at revenue generation and it is administratively straightforward, yet the policy is quite unfair from a horizontal (user) and vertical (income-based ability to pay) equity perspective. The policy tradeoffs will not be universally recognized by all stakeholders, however, since different stakeholders may prioritize certain criterion over others. For instance, someone may value effectiveness much more than administrative feasibility and would not view the tradeoff of an MBUF as problematic.

Although this analysis identified, defined, and evaluated general policy options, focusing in on greater detail reveals specific policy design elements that can be modified or added to mitigate negative outcomes. To give one example, a DMV fee structure could be established so an individual's fee is a function of their income and ability to pay.[10] This design change would enhance the vertical equity of DMV fee increases. Some states are exploring innovative policy designs. Rather than levying a flat annual EV fee like most states, Michigan and Oklahoma base their annual EV fees on a vehicle's weight, with heavier vehicles paying a higher rate. This adjustment to the base policy improves the effectiveness and horizontal equity of an EV fee because it will allow those states to generate additional revenue, and heavier vehicles are more damaging to roadways than lighter vehicles.

The analysis evaluated policy options independently of the others, yet it is possible to consider and envision outcomes of certain policy combinations. An MFT rate was judged to be horizontally inequitable because ICE vehicle owners would continue to subsidize EV owners'

[10] This is the philosophy behind a progressive income tax where higher income earners pay a higher marginal tax rate. This policy detail would undoubtedly add administrative complexity to the DMV fee system however, and it is offered here for illustrative purposes.

usage of Delaware's transportation infrastructure. But if an MFT rate increase is paired with an alternative fuel vehicle fee, the equity critique of an MFT increase is tempered because EV owners are now paying a fairer share. Note that an MFT rate increase coupled with an alternative fuel vehicle fee does not diminish the vertical equity critique against MFTs, so the policy combination can still be criticized from an equity perspective. Relatedly, it is important to remember that the expected revenue losses are not caused solely by EV or fuel-efficient ICE vehicles but rather a combination of the two. Selecting and implementing a single policy option that targets only one of the two fuel types will likely not generate enough revenue to compensate for the losses in a horizontally equitable way. If horizontal equity is a desirable policy outcome, then it is advisable to implement a single policy option that impacts both EVs and fuel-efficient ICE vehicles, or a combination of policy options that cover both fuel types.

Conclusion and Next Steps

Delaware's TTF will see declining MFT revenue in the future due to a combination of improved fuel economy of traditional ICE vehicles and the now-mandated growth in EV sales (McVety, 2023). This revenue loss and impact on the TTF will compromise the ability of the state to maintain its existing roadways, attract federal funds to build new infrastructure, impact the operating budget, and repay bondholders. Policy changes must occur to strengthen the financial position of the TTF. To inform a forward-looking and constructive debate on the matter, this two-part analysis estimated MFT losses, presented a series of policy options, and evaluated them against a range of relevant criteria. The results indicate stakeholders such as policymakers in the General Assembly, administrators at DelDOT, the Delaware driving public, and special interest groups among others, will now need to engage in a lively conversation over policy tradeoffs and a path forward. This analysis can serve as a foundation for that debate, but there are additional efforts that will likely need to occur before a final decision is made on which policy option, or options, can best address expected MFT revenue losses.

First, a limitation of this analysis is that it is both quantitative (financial) and qualitative (policy). While the financial analysis provides real dollar estimates, the subsequent policy analysis offers simple categorical descriptors that are insufficient for assisting with policy design details. For instance, this analysis does not provide detail on the size of DMV fee increases needed to effectively mitigate estimated MFT revenue losses. Further quantitative financial analyses will undoubtedly be needed to illuminate the effectiveness of the policy options and their sensitivity to different fee scenarios.

Second, survey research shows that Delawareans do not fully understand the nature and magnitude of the TTF, MFT, or what is funded with the revenue (DHM Research, 2020). Consequently, it is safe to assume that most Delawareans are unaware of the threats to MFT revenue posed by improved fuel economy and electric vehicles. Thus, any effort to raise additional revenue for the TTF will likely be met with resistance and questions about the need for revenue generation. To prepare the public to engage in the larger policy conversation and to mollify public opposition to every and any possible revenue option, a robust and policy-neutral public education campaign should be designed and launched on the challenge facing Delaware's TTF. DelDOT leadership and the community relations team should therefore consider implementing a multifaceted public education effort to enhance awareness of MFT and transportation funding challenges in Delaware. Some states have created websites and videos

to help educate the public on their TTF problem and Delaware could learn from those experiences.[11]

Once the public is sufficiently knowledgeable on the nature of the problem, they should be invited to explore possible policy options and provide feedback on an acceptable path forward. Innovative strategies can be employed to assist with this aspect of public engagement. For example, as opposed to a text-heavy and content-dense website that one simply browses and absorbs, a modern technique that is shown to enhance civic learning and engagement is gamification, defined as "designing systems, services and processes to provide positive, engaging experiences similar to the engaging experiences games provide, commonly with the aim of motivating beneficial behaviors" (Hassan & Hamari, 2020, p. 1). Balancing the TTF with the challenge of declining MFT revenue lends itself well to gamification. Delaware could create a TTF educational website, and visitors could be invited to role play as the DelDOT Secretary who must decide which policy options and fee rates will cover expected MFT revenue losses, all while balancing competing demands of equity and feasibility.[12] Once an individual playing the game is satisfied with their approach to revenue generation, they could submit their final policy design. Aggregating these submissions would give Delaware policymakers and administrators valuable insight into Delawareans' policy preferences.

[11] For example, California launched www.caroadcharge.com to coincide with the rollout of their MBUF pilot. Hawaii is implementing an MBUF program in 2025 and likewise created their own website at www.hiruc.org to explain the transportation funding problem and the need for new funding mechanisms. A short video embedded on Hawaii's website (https://www.youtube.com/watch?v=q1XqyaQ-hyU) is particularly informative and concise.

[12] Gamifying the TTF would require significant back-end programming and the quantitative analyses mentioned earlier. One provider of such a service is www.abalancingact.com.

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Appendix – Motor Fuel Tax Financial Methodology

The basic methodology used for the financial analysis is that motor fuel tax (MFT) generated by any non-electric vehicle (EV) is equal to the total number of vehicles (V) divided by the vehicle's fuel economy (miles per gallon) multiplied by the vehicle miles travelled per year (VMT) multiplied by the fuel tax rate (τ) for the vehicle's fuel type (MFT = V/mpg * VMT * τ). Summing the different vehicle types (100% internal combustion engine [ICE], hybrid, PHEV [plug-in hybrid electric vehicle], trucks) and fuel types (gas, diesel) for any given year will yield the total MFT generated in that year. This method is presented in Equation 1 below.

Equation 1. Preliminary Formula for Estimating Motor Fuel Tax Revenue

$$MFT_x = \left[\left(\frac{V_{g,x}}{mpg_{g,x}} + \frac{V_{h,x}}{mpg_{h,x}} + \frac{V_{phev,x}}{mpg_{phev,x}}\right) \times VMT_{gd,x} + \frac{T_{g,x}}{mpg_{gt,x}} \times VMT_{gt,x}\right] \times \tau_g + \left(\frac{V_{d,x}}{mpg_{d,x}} \times VMT_{gd,x} + \frac{T_{d,x}}{mpg_{dt,x}} \times VMT_{dt,x}\right) \times \tau_d$$

where:

MFT_x = Motor fuel tax revenue in year *x*

$V_{g,x}$ = Total number of gas-only passenger vehicles operating in year *x*

$mpg_{g,x}$ = Average fuel economy of gas-only passenger vehicles in year *x*

$V_{h,x}$ = Total number of hybrid passenger vehicles operating in year *x*

$mpg_{h,x}$ = Average fuel economy of hybrid passenger vehicles in year *x*

$V_{phev,x}$ = Total number of plugin hybrid passenger vehicles operating in year *x*

$mpg_{phev,x}$ = Average fuel economy of plugin hybrid passenger vehicles in year *x*

$VMT_{gd,x}$ = Vehicle miles travelled per gas or diesel passenger vehicle in year *x*

$T_{g,x}$ = Total number of gas-only trucks operating in year *x*

$mpg_{gt,x}$ = Average fuel economy of gas-only trucks in year *x*

$VMT_{gt,x}$ = Vehicle miles travelled per gas-only truck in year *x*

τ_g = Fuel tax rate per gallon of gasoline in Delaware

$V_{d,x}$ = Total number of diesel passenger vehicles operating in year *x*

$mpg_{d,x}$ = Average fuel economy of diesel passenger vehicles in year *x*

$T_{d,x}$ = Total number of diesel trucks operating in year *x*

$mpg_{dt,x}$ = Average fuel economy of diesel trucks in year *x*

$VMT_{dt,x}$ = Vehicle miles travelled per diesel truck in year *x*

τ_d = Fuel tax rate per gallon of diesel in Delaware

Delaware's fuel tax rates are $0.23 per gallon of gasoline and $0.22 per gallon of diesel. It is assumed these MFT rates remain fixed for all future years. The values for the remaining variables in Equation 1 were generated by a Delaware Department of Transportation (DelDOT) consultant. The consultant incorporated Delaware's EV regulations passed in 2023 to estimate the values for each variable in five-year intervals starting in 2025. The consultant also estimated the values on a county-by-county basis, thus offering different values for New Castle, Kent, and Sussex Counties.[13] Equation 1 is therefore applied to each county separately and the results are summed to estimate statewide MFT revenue.

The consultant used historical MFT data to calibrate Equation 1 and found that gasoline fuel tax revenue is systematically underestimated by 15%. One possible explanation for this discrepancy might be that Delaware "overachieves" on MFT because its fuel tax rates are lower than neighboring states and travelers commuting to or passing through Delaware decide to save money by filling up before leaving the state.[14] The seasonality of Delaware's tourism industry is also another likely factor. Fuel consumption increases during the summer months when people from around the region and country come to visit Delaware and its beaches. These guests will travel extensively in the state and fuel up their vehicles, yet those vehicles are registered outside of Delaware and are not included in the state's vehicle counts. To calibrate the MFT estimate, a 15% adjustment factor is added to gasoline revenue in Equation 1 to yield Equation 2 below.

Equation 2. Calibrated Formula for Estimating Motor Fuel Tax Revenue

$$MFT_x = \left[\left(\frac{V_{g,x}}{mpg_{g,x}} + \frac{V_{h,x}}{mpg_{h,x}} + \frac{V_{phev,x}}{mpg_{phev,x}}\right) \times VMT_{gd,x} + \frac{T_{g,x}}{mpg_{gt,x}} \times VMT_{gt,x}\right] \times \tau_g \times 1.15 + \left(\frac{V_{d,x}}{mpg_{d,x}} \times VMT_{gd,x} + \frac{T_{d,x}}{mpg_{dt,x}} \times VMT_{dt,x}\right) \times \tau_d$$

[13] https://docs.google.com/spreadsheets/d/1zxasJJKlh1yX4My9qYgDhFxTqiFCMP5eZ0AW9AzNF8M/edit?usp=sharing

[14] Compared to Delaware's $0.23/gallon gasoline tax rate, Maryland's is $0.371/gallon, New Jersey's is $0.414/gallon, New York's is $0.367, and Pennsylvania's is $0.622/gallon (Hoffer & Dobrinsky-Harris, 2023).

In addition to estimating total MFT revenue from Equation 2, from a policy development perspective it is valuable to estimate the separate impact that EVs and improved fuel economy will have on MFT revenue. To calculate the future MFT revenue loss from EVs, it is assumed that each new future EV owner would have purchased a gas-powered passenger vehicle getting the weighted average fuel economy across the range of gas-powered vehicle types (100% ICE, hybrid, and PHEV). Applying the same 15% adjustment factor on gasoline revenue yields Equation 3 below for the estimated MFT loss due to EVs.

Equation 3. Formula for Estimating Motor Fuel Tax Revenue Loss from Electric Vehicles

$$EVLoss_x = \left(\frac{V_{EV,x}}{mpg_{weighted,x}} \times VMT_{gd,x}\right) \times \tau_g \times 1.15$$

where in addition to the variables previously defined:

$EVLoss_x$ = Motor fuel tax revenue loss from EVs in year *x*

$V_{EV,x}$ = Total number of electric vehicles operating in year *x*

$mpg_{weighted,x}$ = Average weighted fuel economy of all gas-powered passenger vehicles in year *x*

To estimate the MFT revenue loss from fuel economy improvements, an alternative scenario is imagined where fuel economy values for ICE-powered vehicles remain fixed at 2023 levels for all future years. Once annual MFT revenue is estimated for this alternative scenario, the actual MFT revenue estimated using Equation 2 is subtracted from the alternative scenario to yield MFT loss due to improved fuel economy.

Equation 4. Formula for Estimating Motor Fuel Tax Revenue Loss from Fuel Economy Improvements

$$\begin{aligned} MPGLoss_x = \Bigg\{ \Bigg[\Bigg(& \frac{V_{g,x}}{mpg_{g,2023}} + \frac{V_{h,x}}{mpg_{h,2023}} + \frac{V_{phev,x}}{mpg_{phev,2023}} \Bigg) \times VMT_{gd,x} \\ & + \frac{T_{g,x}}{mpg_{gt,2023}} \times VMT_{gt,x} \Bigg] \times \tau_g \times 1.15 \\ & + \left(\frac{V_{d,x}}{mpg_{d,2023}} \times VMT_{gd,x} + \frac{T_{d,x}}{mpg_{dt,2023}} \times VMT_{dt,x} \right) \times \tau_d \Bigg\} - MFT_x \end{aligned}$$

where in addition to the variables previously defined:

$MPGLoss_x$ = MFT revenue loss from improved fuel economy in year *x*

$mpg_{g,2023}$ = Average fuel economy of gas-only passenger vehicles in 2023

$mpg_{h,2023}$ = Average fuel economy of hybrid passenger vehicles in 2023

$mpg_{phev,2023}$ = Average fuel economy of plugin hybrid passenger vehicles in 2023

$mpg_{gt,2023}$ = Average fuel economy of gas-only trucks in 2023

$mpg_{d,2023}$ = Average fuel economy of diesel passenger vehicles in 2023

$mpg_{dt,2023}$ = Average fuel economy of diesel trucks in 2023

It should be noted that the MFT revenue loss from fuel economy improvements in Equation 4 is a calculation that ensues after Equation 3 where EVs first make up a larger percentage of the Delaware vehicle fleet and the remaining ICE vehicles in the fleet steadily experience fleet-wide fuel economy improvement. In other words, the MFT revenue loss from fuel economy improvements in Equation 4 is due to greater efficiency of the remaining ICE-powered vehicle fleet after EV sales increase and EVs constitute more of the state's overall vehicle fleet.

As with Equation 2, Equations 3 and 4 are applied to each county and the results are summed to determine statewide estimates. In all instances, linear interpolation is used to determine annual estimates between the five-year increments provided by the DelDOT consultant. Finally, although the consultant provided values to 2050, this extended time horizon introduces a high level of uncertainty for any legitimate policy development. For this reason, MFT estimates in this analysis are provided to 2050 for illustrative purposes only; 2040 is used as the latest year for any discussion of the results and should be used as the limit for any subsequent policy development.

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