Transportation Funding Tools for California
Literature Review

March 2025

Transportation
CALIFORNIA

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On behalf of the Transportation California Board of Directors and staff, I am pleased to introduce this independent study on transportation funding tools for California. It couldn't come soon enough.

California's rapid deployment of zero-emission and fuel-efficient vehicles leads the nation in advancing climate goals and cleaning the air in our communities, but unintended consequences must be resolved.

According to an assessment by the California Transportation Commission, state and local governments are expected to lose $31.1 billion in revenue for transportation infrastructure over the next decade. California cannot afford to let that happen.

As more Californians switch to electric and newer, more fuel-efficient vehicles, fewer drivers are paying their fair share of the gas taxes that local communities rely on to fix essential roads, enhance public safety and improve public transportation.

Transportation California is taking an evidence-based approach to achieve sustainable transportation funding through a revenue-neutral solution. NEWROAD Consulting, an internationally recognized transportation solutions expert, researched all viable transportation funding options to help state and local leaders identify a solution that works for all Californians.

This is not an easy conversation, but time is running out. The current funding system is becoming increasingly unfair and insufficient to meet Californians' needs.

We share this study transparently to help inform policymakers as they take on California's looming transportation funding crisis and prioritize new ways to fund our multimodal system that 39 million people rely on to get from one place to another.

Sincerely,

Steve Clark, Chair
Transportation California

About Transportation California

Transportation California is a non-partisan, non-profit coalition representing the statewide transportation construction industry that designs, builds, maintains, and repairs California's multimodal transportation system. Founded in 1990, today its member companies and groups account for more than 200,000 California jobs. We advocate for policy solutions to improve our multimodal transportation system, grow our economy, and enhance our quality of life. Our mission is to develop robust, sustainable, and dedicated funding to properly maintain California's multimodal transportation infrastructure and build the transportation system of the future.

Report prepared by Nina Elter and Peter Carr.

NEWROAD Consulting is a strategic planning consultancy dedicated to help accelerate the transition to a sustainable transportation system and a NetPositive future. Combining deep expertise in transportation funding, road pricing, tolling, and transportation policy with innovative and holistic approaches, NEWROAD helps clients navigate complex challenges and design equitable, efficient, and sustainable solutions. We provide data-driven insights and practical recommendations to support decision-makers in addressing the evolving needs of transportation systems. Learn more at newroad.consulting.

Contents

Acronyms & Abbreviations

ACC II	Advanced Clean Cars II
BEV	Battery Electric Vehicle
CARB	California Air Resources Board
CalSTA	California State Transportation Agency
CTC	California Transportation Commission
DBC	Distance-Based Charges
EV	Electric Vehicle
FHWA	Federal Highway Administration
GHG	Greenhouse Gas
HTF	Highway Trust Fund
ICE	Internal Combustion Engine
IFTA	International Fuel Tax Agreement
IRA	Inflation Reduction Act
IRP	International Registration Plan
kWh	Kilowatt-Hour
LAO	Legislative Analyst's Office
MPG	Miles Per Gallon
MPGe	Miles Per Gallon Equivalent
MBUF	Mileage-Based User Fee
PHEV	Plug-In Hybrid Electric Vehicle
RIF	Road Improvement Fee
RUC	Road Usage Charge
SB 1	Senate Bill 1 (Road Repair and Accountability Act)
SIRC	Strategic Innovation for Revenue Collection
STSFA	Surface Transportation System Funding Alternatives
TIF	Transportation Improvement Fee
TRIP	The Road Information Program
VMT	Vehicle Miles Traveled
WMT	Weight Mileage Tax
ZEV	Zero-Emission Vehicle

Executive Summary

Overview

Drawing from extensive literature and case studies across the United States (U.S.) and abroad, this report identifies and evaluates multimodal transportation funding tools that could supplement existing mechanisms and/or eventually replace the fuel excise tax as the predominate funding tool as California transitions toward a zero-emission vehicle (ZEV) future.

There are many options available to the State of California to raise revenue for multimodal transportation infrastructure. To assess the opportunities and challenges among various funding tools, this study isolated seven principles of "good taxation" and other positive attributes associated with the existing fuel excise tax model – including broad applicability, user-and usage-based structure, and a large, stable revenue stream. By applying these principles, policymakers can create funding mechanisms that are fair, efficient, and reflective of public value. The principles served as the foundation of the comparison of funding tools done during the literature review. Each tool presents distinct benefits and trade-offs, with none being a one-size-fits-all solution.

The results of this report suggest there are three preferred options for supplementing and/or eventually replacing the fuel excise tax in California: 1) expand the fuel tax model to apply to new 'fuel types' such as electricity, 2) a pure road usage charge (RUC) model; and 3) a gradual transition mixed model combining fuel taxes for gasoline and diesel vehicles with RUC for ZEVs. Each option reflects various trade-offs between simplicity, equity, practicality, and other policy objectives.

While the option to expand the fuel tax model builds upon familiar systems, it struggles to address the complexities of alternative fuels and raises equity concerns. The pure RUC model offers long-term equity and efficiency but demands substantial upfront change. The mixed model balances these considerations, providing a pragmatic transition to a sustainable funding system.

California's choice of pathway will depend on its ability to align and balance public acceptance, administrative feasibility, and long-term policy goals, ensuring that the transportation system remains both fair and financially sustainable.

California can lead in creating a sustainable, equitable transportation funding system. By combining innovative tools like RUC with established practices, California can address immediate challenges while paving the way for a robust and resilient infrastructure. Acting now ensures that California's state highways, local streets and roads, bridges, bicycle and pedestrian infrastructure, and transit systems continue to support the State's economy and communities for generations to come.

Growing Funding Challenge

Expected Revenue Decline 2023/24 vs. 2034/35
-$5 billion (65 %) from gasoline excise tax
-$290 million (20%) from diesel excise tax
-$420 million (32%) from diesel sales tax

Table 1: Expected Revenue Decline

California faces urgent challenges to maintaining its transportation infrastructure. Traditional revenue streams are diminishing due to advancements in fuel efficiency, which reduce the revenue gathered per vehicle mile travelled on California's roads, and the increasing adoption of ZEVs, which creates a hole in the road funding system, allowing some road users to use their vehicles without paying their 'fair share'. Research shows that ZEVs only pay approximately 40 percent of what an average Internal Combustion Engine (ICE) vehicle contributes in fuel taxes alone. As a result, the state expects a 31% reduction in transportation funding revenue over the next decade – or approximately $31.3 billion – due to ZEV adoption and improved fuel efficiency.[1]

Policymakers will need to address these challenges through ongoing, piecemeal adjustments and additions to existing tools, or through a deliberate reshaping of the revenue tools available to ensure everyone who uses or benefits from California's surface transportation network makes a fair contribution to their sustainable operation and upkeep.

Project Approach

The project, commissioned by Transportation California (TC), explored potential sustainable alternatives or additions to the fuel excise tax as California transitions towards a ZEV future, conducted in the form of a literature review.

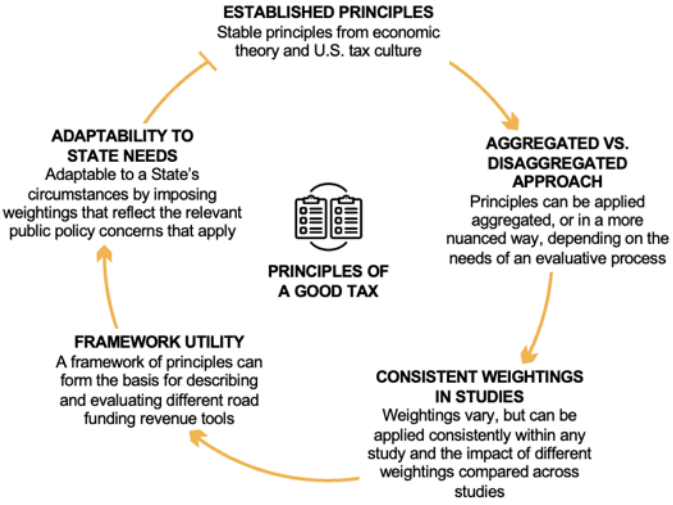

Figure 1: Principles of a good tax

Designing an effective road funding system requires balancing revenue generation with supporting the delivery of public value across the wider policy program and being responsive to modern challenges and popular concerns. There has been extensive research into what constitutes a 'good' tax and a 'good' tax system, and there is considerable overlap in the literature on the principles that inform these distinctions. Adam Smith, credited with the seminal articulation of the principles of good taxation, asserted that a tax should exhibit the characteristics of fairness, certainty, convenience and efficiency. Subsequent economists have elaborated on this base to recognize the efficacy of differential pricing recognizing willingness to pay (e.g., Jules Dupuit), and differential pricing to induce the internalization of costs and alter behavior (e.g., "Pigouvian taxes").

[1] Legislative Analyst's Office. (2023). *Zero-Emission Vehicles and Their Impact on Transportation Funding*. Retrieved from https://lao.ca.gov/reports/2023/4821/ZEV-Impacts-on-Transportation-121323.pdf

Paying for roads and road use are also important sources of discipline. Revenue tools that directly target road-related activities can have the effect of ensuring that those people consuming or benefiting from roads internalize the costs of their choices. This can incentivize them to consider their use of, or reliance on, roads.

Numerous studies have since arrived at an established core of seven principles that are recognized in contemporary U.S. tax analysis and informed the evaluative framework for this project. Thus, a good tax and tax system is characterized by adherence to the ideas of simplicity, robustness, fairness and equity, sustainable revenue, efficiency, security, and integration.

Figure 2: Principles

To give best effect to these principles, a sustainable road funding system requires a mix of tools to address the diverse ways people use and benefit from the network. By combining the strengths of complementary tools, the system ensures that everyone contributes their fair share. It balances the contributions of direct users, like drivers and industries that use the roads day-to-day, with those of indirect beneficiaries, such as businesses and communities, gaining economic and social value from the actions of those actually using the roads. Because of this, jurisdictions across the U.S. and the world have developed a wide array of road funding revenue instruments, and each jurisdiction is almost unique in the particular combination and balance of tools it uses.

For this project, tools were grouped into five families of tool types: three reflecting the user pays focus (input-based, impact-based, and presence-based) and two encompassing the beneficiary-pays focus (amenity-based, and commerce-based). Each of these families offers a particular way to link contributions to road usage and benefits. Within these, a total of 20 generic revenue tool types were identified for consideration.

Shortlisting Viable Transportation Revenue Tools

Fuel taxes have been the backbone of road funding for a century for good reason: they were effective. That effectiveness came from the fuel tax being both a user- and a usage-charge, they used to cover the full taxable base covering all motor vehicles and all roads, and they could deliver a significant amount of revenue for relatively little cost.

By considering the things that made fuel taxes effective it was possible to narrow the range of contenders to seven tools: the fuel excise tax itself; fuel sales taxes; a kilowatt-hour (kWh) tax on electric fuel; fixed access (registration) charges; time-based charges like the vignette system used in Europe; distance-based charges as are being piloted and introduced across many states in the U.S. and around the world; and within-area tolls/charges.

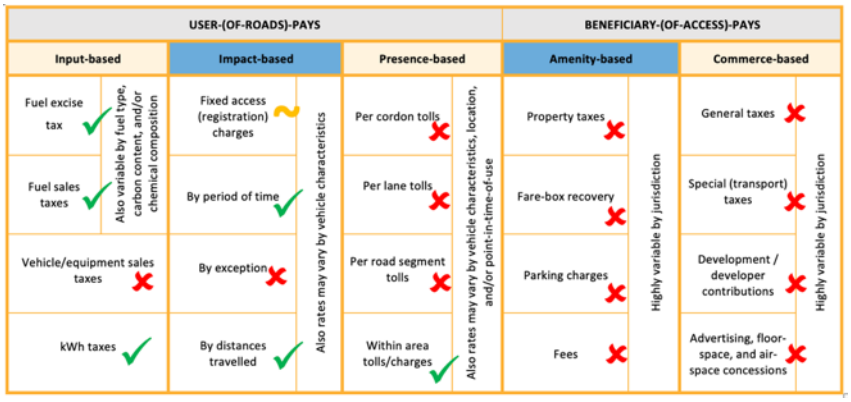

Figure 3: Transportation Revenue Tools

California Context

It is no simple thing to add a new revenue tool, and it is important to ensure any such tool is tailored to the needs and context of the jurisdiction that might adopt it. Transportation in California is financed through a blend of federal, state, regional, and local sources. These streams collectively fund planning, construction, operation, maintenance and renewal of the state's expansive network of highways, roads, transit systems, and active transportation infrastructure.

At the same time, California is not just being confronted with the need for a replacement, or supplemental, revenue tool to respond to the ongoing evolution of its vehicle fleet. Additional revenue is also needed. California's aging transportation network requires substantial investment to address deteriorating roads, aging bridges, and the escalating costs of congestion, poor road conditions, and vehicle repairs, all of which burden drivers and businesses. Climate change impacts, including sea level rise, flooding and extreme heat, further threaten infrastructure, while inflation continues to drive up construction and maintenance costs.

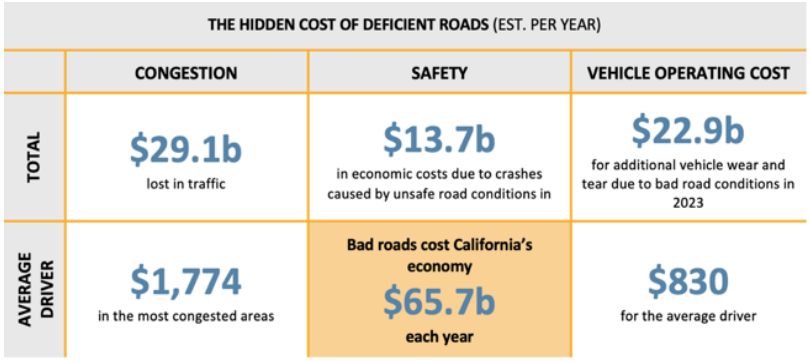

Figure 4: The hidden cost of deficient roads

California has already taken steps to respond to the need for increased and sustainable revenue. Most notably, the state enacted the Road Repair and Accountability Act of 2017 (SB 1), with an annual investment estimated at $5.4 billion. To fund this additional investment, SB 1 introduced increases to the gasoline and diesel excise taxes, and indexed them to inflation, while also increasing the diesel sales tax and introducing the Transportation Improvement Fee (TIF) which is a variable rate registration fee on all ICE vehicles, and the Road Improvement Fee (RIF) which is another registration fee charge specifically on ZEVs. California has also undertaken pilots of distance-based charging tools (e.g., RUC) and technologies.

There is, therefore, a foundation of active measures and lessons learned from pilot projects upon which to build and evolve California's road funding revenue system to better ensure its effectiveness, efficiency, and equity.

Project Findings

The project found that there was ample literature available, based on real-world practices as well as grounded theory, to describe the best way of using each of the seven types of tools investigated. All seven of the tools demonstrated the potential to be useful. However, few of them showed the potential to serve as the direct, solitary replacement for the gas tax or as a principal part of a suite of measures to replace the gas tax.

Continued reliance on input-based taxes (fuel excise tax, registration fee, kWh tax) presented a feasible option. However, the diversification of fuel types in modern vehicles suggested there would need to be a suite of tools available, including both fuel excise taxes and kWh taxes, to recover the equivalent amount of the historic gas tax.

Of the impact-based tools, distance-based charging was best suited as a stand-alone replacement. Neither time-based charges nor fixed access (registration) charges presented as able to supply the levels of revenue needed without introducing significant equity and affordability challenges.

Further, where states of similar household wealth have researched the potential affordability of lump-sum fixed access charges, their findings suggest that the RIF and TIF may already take California's use of fixed access charges up towards the practical limit. This is also before the equity challenges of larger fixed access charges are considered. Even so, these rates do not fully or evenly cover the revenue gap being created by the uptake of ZEVs and hybrid vehicles.

Of the one presence-based tool considered, within-area tolls/charges, all three of the variations lacked the reach across the network and vehicle fleet needed to fairly raise the revenues required. The sales tax-based retail delivery fee option could supply a good quantity of revenue, but never enough on its own. The tolling-based approach was financially inefficient as a pure, statewide revenue tool. The distance-based charging (e.g. a per mile charge within a defined area) approach was both untried and difficult to distinguish from a 'standard' location-based distance-based charging program such as a statewide RUC program, i.e. it would most likely be 'a part of', not stand-alone.

Consequently, the two most promising tools among the seven for modern road funding to supplement and/or eventually replace the fuel tax, were kWh taxes, and distance-based charges.

Implications for California

There is, therefore, a case to consider introducing either a distance-based charge program or kWh tax mechanism. This in turn pointed to three pathways for further investigation:

1. **Expanded Fuel Tax Model:** The first pathway builds on the existing fuel tax model, expanding it to include new fuel types such as electricity and hydrogen. Taxes would be based on the fuel's estimated range (MPGe) and collected at the point of dispensing, ensuring a familiar pay-at-the-pump process for drivers. While this approach minimizes disruption, it faces challenges in capturing at-home EV charging and managing increased administrative complexity with a wider variety of taxed fuels.

2. **Pure RUC Model:** The second pathway envisions a pure RUC model, replacing all fuel taxes with a system that charges vehicles based on the distance they drive. This approach provides the most equitable and straightforward way to align tax contributions with actual road use. Variable rates could reflect vehicle characteristics, such as weight or axle configuration. However, implementing a pure RUC model would require significant investments in technology, public outreach, and policy development, as well as solutions for privacy concerns and enforcement.

3. **Mixed Model:** The third pathway proposes a mixed model, combining fuel taxes for gasoline and diesel vehicles with RUC for alternative fuel vehicles. This gradual transition allows the system to adapt over time while sparing the majority of drivers from immediate changes. The mixed model also provides flexibility to address equity concerns as ZEV adoption grows. However, challenges remain in integrating heavy and hybrid vehicles, ensuring fairness across different vehicle types, and managing out-of-state vehicles.

Each pathway reflects a trade-off between simplicity, equity, and practicality. While the fuel tax model builds on familiar systems, it struggles to address the complexities of alternative fuels, as well as the equity issues due to various fuel efficiencies. The pure RUC model offers long-term equity and efficiency but demands substantial upfront change. The mixed model balances these considerations, providing a pragmatic transition to a sustainable funding system.

California's choice of pathway will depend on its ability to align and balance public acceptance, administrative feasibility, and long-term policy goals, ensuring that the transportation system remains both fair and financially sustainable.

Conclusion

California has the opportunity to lead in creating a sustainable, equitable transportation funding system. By combining innovative tools like RUC with established practices, the state can address immediate challenges while paving the way for a robust and resilient infrastructure. Acting now ensures that California's roads and transit systems continue to support its economy and communities for generations to come.

1.0 Introduction

1.1 Purpose

This report provides observations and findings from a literature review on potential replacement options for the fuel excise tax. It also identifies key topics that need careful considerations when developing legislation for such a transition.

Commissioned by Transportation California (TC), this report supports the state-wide transportation construction industry's advocacy goals to replace – or supplement - the fuel excise tax with a sustainable, robust, equitable, and dedicated revenue stream(s). With the transportation sector evolving and traditional revenue sources dwindling, this effort is a critical step towards securing California's transportation future.

Through a detailed, yet concise overview, this report brings together existing research and practical information regarding transportation revenue tools and how states, the federal government, and other countries are replacing fuel excise taxes with more sustainable, robust funding mechanisms to fund transportation infrastructure.

The literature review considered California's specific policy and funding landscape, discussing how existing research applies to this effort, and identifying any gaps in the existing research that could impact any subsequent change program.

1.2 California's Road Funding Challenge

One of the most significant consequences of California's efforts to decarbonize the transportation sector is the disruption of the fuel excise tax as the primary funding mechanism for improving state-wide surface transportation infrastructure.

National and state policies around vehicle fuel efficiency, ZEVs and electrification have fast-tracked the timeline for action to replace the fuel excise tax which will be obsolete as ICE vehicles are phased out. California's Advanced Clean Cars II (ACC II)[2] regulation requires that all new vehicle sales in the state are ZEV by 2035.

In a study on the impact of the Inflation Reduction Act's (IRA)[3] on electrification rates for light- and heavy-duty vehicles, the International Council on Clean Transportation found that the cost of an electric vehicle (EV) will be less than a comparable ICE vehicle in 2027-2028. The same study found that with the IRA's incentives and state policies such as ACC II, "by 2030, electric vehicle sales shares are estimated to range from 48% to 61% in the light-duty sector, increasing to 56%–67% by 2032, the final year of the IRA tax credits. For heavy-duty, zero-emission vehicle sales share is estimated to range from 39% to 48% by 2030 and from 44% to 52% by 2032."

[2] California Air Resources Board. (2022). *Advanced Clean Cars II*. Retrieved from https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii

[3] International Council on Clean Transportation (ICCT). (2023). *The Inflation Reduction Act's Impact on Electric Vehicles in the United States*. Retrieved from https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf

The California Legislative Analyst's Office (LAO) released a report[4] in December 2023 estimating that under the state's climate strategy transportation revenues will decline by (31%) – or, according to the California Transportation Commission (CTC) approximately $31.3 billion[5] – over the next decade. Dwindling revenues will have a deleterious effect on the condition of the state-wide transportation system, overall economic health, jobs and economic opportunity, environmental impacts, and overall quality of life.

1.3 Similarities with Other Jurisdictions' Challenges

California is not alone in the U.S. facing challenges of this nature. Every state is confronting the prospect of declining fuel tax revenues as the proportions of high fuel efficiency vehicles and ZEVs increase.[6] The failure to maintain the real value of federal fuel taxes means the Highway Trust Fund (HTF) is in dire straits. Consequently, California is now one of 37 states that are conducting research and pilot programs to replace the fuel tax with an alternative funding mechanism(s).[7]

The primary replacement method under study is a per-mile fee, referred to as a "road user charge" (RUC) in California and as a "vehicle miles travelled" (VMT) or "mileage-based user fee" (MBUF) fee elsewhere. Other alternative funding mechanisms such as annual registration fees and kWh taxes are being explored as supplements, but none as vigorously as a RUC.

Three states (Oregon, Utah, Virginia) have transitioned their RUC pilot programs into full-fledged voluntary programs, one (Hawaii) introduced a phased mandate from 2025; and the federal Infrastructure Investment and Jobs Act (IIJA) has authorized a federal pilot program.

The U.S. is not alone in needing to address the implications of diminishing revenues from fuel taxes. All Organization for Economic Cooperation and Development (OECD) nations are grappling with comparable challenges.[8] Similar to the U.S., the range of studies from these nations and international bodies exhibit a strong preference for some form of distance-based charging or another; however, there is also some consideration of other tools. Perhaps the most significant difference is that European studies often place equal or greater emphasis on demand management and environmental objectives compared to revenue generation.

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[4] Legislative Analyst's Office. (2023). *Zero-Emission Vehicles and Their Impact on Transportation Funding*. Retrieved from https://lao.ca.gov/reports/2023/4821/ZEV-Impacts-on-Transportation-121323.pdf

[5] California Transportation Commission (2024). *State and Local Transportation Needs Assessment.* Retrieved from https://catc.ca.gov/-/media/ctc-media/documents/programs/sb1121/2024/9-18-2024-stakeholders-needs-revenue-gap-analysis-final-a11y.pdf

[6] ITF. (2023). *Decarbonisation and the Pricing of Road Transport: Summary and Conclusions*. ITF Roundtable Reports. No. 191. OECD Publishing. Paris. https://www.itf-oecd.org/sites/default/files/docs/decarbonisation-pricing-road-transport.pdf pg 10; Coyle D. (August 2011). *From Fuel Taxes to Mileage-Based User Fees: Rationale, Technology, and Transitional Issues: Final Report*. CTS 11-16. Department of Applied Economics University of Minnesota. https://conservancy.umn.edu/server/api/core/bitstreams/be2bf26c-ea0c-4082-89fb-e50be1c25700/content pp 9-13.

[7] Eno Center for Transportation. (2023). *Driving Change: Advice for the National VMT Fee Pilot*. Retrieved from https://enotrans.org/wp-content/uploads/2023/09/Driving-Change-Advice-for-the-National-VMT-Fee-Pilot.pdf

[8] ITF 2023:10-11.

1.3.1 Issues with the Federal HTF

Fuel efficiency and the growing number of ZEVs are impacting the federal fuel tax, just as much as it affects state fuel tax revenues. The effect is worsened by the fact that the federal gas tax has remained unchanged since 1993, leading to decreased purchasing power due to inflation.

In October 2024, the monthly treasury report reported a $21 billion cash deficit in fiscal year 2024[9], up from a 11.9 billion cash deficit in the prior year. This new deficit level was $6.8 billion worse than what had been forecasted by the nonpartisan Congressional Budget office (CBO) in its June 2024 baseline. Looking at the 10-year forecast, it is predicted that the HTF will run out of money in 2028, as summarized by ENO Center for Transportation.[10]

The HTF did run into trouble before and transfers from general funds ensured its continuation. However, relying on general budgets poses significant risks due to anticipated strains from various obligations, notably healthcare. The U.S. Government Accountability Office (GAO) projects that federal spending on major healthcare programs, as a share of GDP, will increase by 47% over the next two decades.[11] This escalation is expected to significantly contribute to the federal deficit, potentially limiting the availability of general funds for other purposes.

1.4 Implications for the Literature Review

The wealth of literature available on road funding tools provided a solid foundation for the review. Numerous studies explore individual tools in detail, evaluating how each fit within the larger transportation funding system. In the U.S. alone, a near-comprehensive collection of research has examined the options most likely to replace or supplement fuel taxes, assessing their compatibility with the countries and each state's constitutional and legislative frameworks.

Given the breadth of research and the variety of approaches, establishing a clear analytical framework was crucial to lay the groundwork necessary to compare and contrast different funding options.

[9] U.S. Department of the Treasury. (2024, September). Monthly Treasury Statement (MTS) September 2024. https://www.fiscal.treasury.gov/files/reports-statements/mts/mts0924.pdf

[10] Davis, J. (2024, October 21). Highway Trust Fund ran $21 billion deficit in FY 2024. Eno Center for Transportation. https://enotrans.org/article/highway-trust-fund-ran-21-billion-deficit-in-fy-2024/

[11] U.S. Government Accountability Office. (n.d.). Federal Health Care Spending. https://www.gao.gov/federal-health-care-spending

2.0 Targeting the Study

2.1 Value and Nature of Roads[12]

2.1.1 Roads are Good

Transportation, especially surface transportation, is the heartbeat of modern economies, touching every part of our social and economic lives. It not only helps us overcome the barriers of distance but also fuels possibilities by connecting people, sparking business growth, and allowing communities to thrive. Road transportation is vital, supporting the journeys that are too spread out for air, rail, or water to handle, or too challenging for active or micro-mobility modes, like cycling or scooters. In this way, roads empower interaction, trade, and development on every level, from local neighborhoods to entire regions.

Roads offer three broad kinds of benefit:

1. **Greater access and freedom:** Roads provide reliable access to any place, whether for work, family, or leisure. From the first mile to the last, roads make it possible to reach loved ones, pursue education, and connect with opportunities across any distance.

2. **Efficiency and sustainably:** Roads - especially when well-designed, built and maintained - enable faster, more efficient movement of goods and people, reducing strain, energy use, emissions, and vehicle wear-and-tear - making transportation not just practical, but more sustainable.

3. **Safe, dedicated spaces for travel:** By separating travel from other land uses, roads create safer, more efficient spaces for movement. This reduces conflicts, eliminates wasteful duplications, and unlock land for other purposes, enhancing overall quality of life.

These widespread benefits enrich our lives in ways both big and small, justifying the shared investment in road infrastructure. Roads don't just connect us - they support the everyday connections and opportunities that make life meaningful.

2.1.2 Roads Require Funding

While roads offer significant benefits, they come with similarly significant costs. They occupy land that might otherwise be put to other productive uses. Building, operating, and maintaining roads requires materials and labor. This includes essential assets like culverts, bridges, markings and signage - all of which need funding for construction, upkeep, and eventual renewal or removal. Roads also face natural wear from weather and geological forces, and their heavy use accelerates this process, necessitating regular investment to keep them safe and effective.

[12] This section draws on the summaries provided in: Birchall M. (2024) *Driving Change: How Road Pricing Can Improve Our Roads*. The New Zealand Initiative. Wellington. https://www.nzinitiative.org.nz/reports-and-media/reports/driving-change-how-road-pricing-can-improve-our-roads/document/847; Carvalho R. (2019) *The Price is Right: The road to a better transport system*. New Zealand Initiative. https://www.nzinitiative.org.nz/reports-and-media/reports/the-price-is-right-the-road-to-a-better-transport-system/document/597; Coyle 2011:4-8.

Investing in regular road maintenance delivers economic, environmental, and social benefits. It reduces GHG emissions by improving vehicle efficiency on smoother surfaces[13], lowers vehicle operating costs through reduced wear and tear, and enhances road safety by preventing hazardous conditions. Well-maintained roads support economic growth by facilitating trade, attracting investment, and cutting transportation costs.

Preventive maintenance also results in long-term cost savings by extending pavement lifespan and delaying costly reconstructions. Overall, maintaining roads ensures efficiency, safety, and sustainability, benefiting communities and economies alike.

Over time, a range of revenue tools have evolved to support road funding. These tools draw contributions from road users and influence the choices of those who benefit from or rely on road infrastructure. Through these tools, everyone who interacts with the road system plays a part in sustaining this vital resource.

2.1.3 Roads are Not Public Goods

Unlike true public goods, services or commodities that everyone in society can use without reducing their availability to others, roads can become congested. Certain types of roads - like freeways, toll roads and expressways - are intentionally designed to restrict access for specific users, ensuring efficient traffic flow and safety. These characteristics align more closely with private goods than with traditional public goods.

However, building and maintaining effective road networks is an exceptionally complicated task, often involving conflicting stakeholder interests, ever-shifting objective conditions, uncertainty, and uneven access to information. Without proper management, these challenges can lead to inefficient networks that either under-serve communities - resulting in congestion and long travel times - or over-serve them, using excessive land and creating negative side effects.

To address these complexities, it is vital to use public administration institutions and processes to coordinate the supply and operation of road networks, balancing community needs with efficient and sustainable development.

2.1.4 User Pays, by Usage, is a Logical Approach

Paying for roads and road use are important sources of discipline. Experience shows that roads, when underpriced or funded entirely by public money, are more likely to be overused. Relying solely on public funds - especially when the public typically has very low awareness of how roads are actually paid for and what they cost - makes roads appear as free goods, leading to inefficiencies and strain on the network.

To address this, effective road funding tools often apply two complementary approaches: **user-based and usage-based charges.**

[13] FHWA. N.d. Vehicle Fuel Consumption And Pavement Characteristics. Retrieved: https://www.fhwa.dot.gov/pavement/sustainability/articles/vehicle_fuel.cfm

USER-BASED CHARGES	USAGE-BASED CHARGES
This approach ensures that those who use the road network contribute to its upkeep. It assigns costs based on the fact of road use, helping recover expenses from individuals who benefit from the system, and, in turn, impose some degree of wear. This fosters a sense of responsibility among users, encouraging them to consider the value of the roads they rely on.	This approach goes a step further by linking costs to the *amount and quality* of road usage. By charging based on factors like distance travelled, vehicle weight, or specific types of roads used, this method aligns contributions with the actual impact each user has on the infrastructure. Usage-based charges offer a fairer distribution of costs and help to balance road supply with the real demand of users.

Table 2: User-/Usage-Based Charges

The physical characteristics of roads, the vehicles using them, and their interactions create observable and measurable patterns of wear and impact. These patterns make it possible to assess and allocate costs across all users, ensuring that each user pays in proportion to the demand they place on the network.

By encouraging users to internalize the costs of their choices, revenue tools can promote mindful use of the road network. In this way, combining user-based and usage-based charges can help maintain a reasonable balance between road supply and demand, ensuring the infrastructure serves practical needs effectively.

The added benefits of well-maintained roads, funded proportionately by those who use and benefit from them, underscore the urgency of finding sustainable revenue tools to replace the fuel tax. Acting promptly to develop these tool(s) is critical to ensure that road networks continue to deliver quality and efficiency and are ready to meet future demands.

2.2 Value and Nature of Revenue Instruments

2.2.1 Systems of Tools

No single tax or fee can cover all aspects of road funding effectively. Just as national tax systems rely on multiple instruments to ensure fair contribution for all liable parties, a robust road funding system requires a mix of revenue tools to reach diverse users and cover different types of costs.

There are too many different parties who benefit from or impose costs on the road network, in too many ways, making it impossible for one tool to manage all needs comprehensively. Every revenue tool has its own strengths, limitations, and blind spots. For example, some tools may be better placed for common costs, others may perform better for costs that depend on road usage.

Therefore, an effective road funding system includes a range of tools to ensure comprehensive coverage of all user groups and interests, reducing the chance for any group to avoid fair contribution or engage in rent-seeking behaviors. By combining different tools, the system can likely better balance fairness and efficiency in funding the road network.[14]

[14] National Conference of State Legislatures. (2001). *Principles of a High Quality State Revenue System* (4th Edition). https://www.cga.ct.gov/2005/pridata/Studies/pdf/Tax_Forum_Snell_Principles_Handout.PDF pg 9.

2.2.2 Determining What 'Good' Looks Like

Nations and states use various methods to fund their road networks, shaped by their unique political and policy environments. **There are many ways to raise revenue and different interpretations of these methods.** Each approach reflects the specific opportunities, constraints, and values of the jurisdiction. This makes the designing of an effective tax system not only a technical task but also one that must align with local context and priorities.

Despite differences, there are general principles of 'good taxation' that provide a foundation of comparing road funding systems and other mechanisms. While there are many ways to raise revenue, there are no perfect solutions, and different interpretations of core taxation principles reflect the subjectivity of observers and the need for trade-offs. It is often impossible to treat all principles equally, as each observer may weigh them differently based on specific goals and constraints[15].

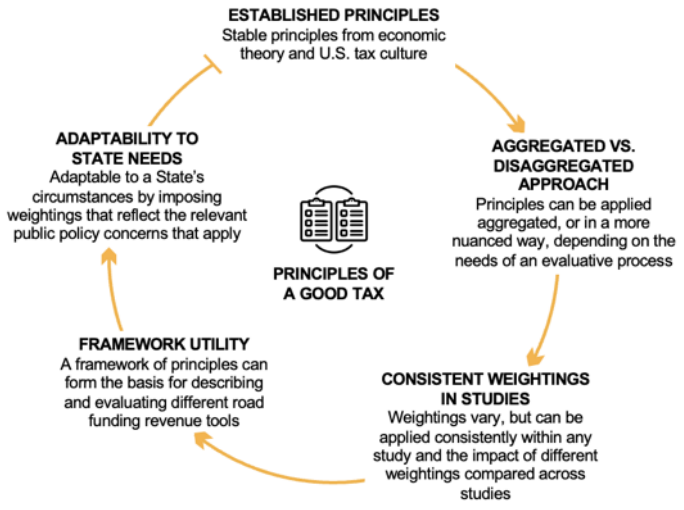

Figure 5: Principles of a good tax

The goal was not to identify an objectively *true* set of principles, but rather to isolate the most commonly accepted principles as a basis for the literature review. Taxes serve specific purposes, and they can be judged as 'good' or 'bad' based on how well they fulfil those purposes. Their performance depends both on their inherent qualities and the context in which they are applied.

Principles help define what makes a tax system 'good'. The principles and criteria were derived from the basic, fundamental concepts or foundational theories in economics and taxation.

[15] Ministry of Transport. (November 2014a). *Future Funding: Summary Report*. New Zealand Government. Wellington. https://www.transport.govt.nz//assets/Uploads/Report/ff-summary-report.pdf

From our analysis, we learned that a stable set of principles exists for evaluating road funding tools, rooted in economic theory and adapted to the U.S. tax context. These principles, while general, provide a solid foundation for comparing and assessing various revenue instruments. Though different studies[16] may prioritize principles differently, consistent application of these weightings within a study allows for meaningful comparison. Ultimately, a framework of principles is a valuable tool for evaluating road funding options, as it can be tailored to reflect the specific public policy concerns of a state or country at any given time.

Theory provides a structured approach to analysis, enabling abstract thinking which reduces clutter and helps focus on what is important. However, balancing abstract principles with real-world specifics is crucial, as determining what is important can bias the analysis. To manage this complexity, recent studies were examined to see how well they adhered to good tax principles and whether these principles have evolved.

In reviewing practical examples of road funding tools, the focus was on how tax principles are applied in real-world context and how they adapt to meet evolving public needs. These examples show that tax principles must grow alongside values and public policy, creating a fairer and more responsive road network. The federal Surface Transportation System Funding Alternatives (STSFA)[17] and Strategic Innovation for Revenue Collection (SIRC)[18] programs highlight a shift towards user-and usage-based approaches such as distance-based charges. The progression from STSFA to SIRC reflects an evolving understanding of tax principles, emphasizing balanced methodologies that consider fairness, efficiency, and potential unintended impacts.

State programs added further insight. California's Road Charge program emphasizes privacy as a core value[19], while Washington State's 13 guiding principles ensure public engagement is prioritized, reflecting what matters to users[20]. Colorado's Road Usage Charge Pilot highlights privacy, cost-efficiency, and fairness as top priorities[21]. These programs show that when funding systems address public concerns, they create trust and engagement, supporting the everyday needs of those who depend on our roads.

[16] E.g. NCSL 2001; Association of International Certified Professional Accountants. (2017). *Tax Policy Concept Statement 1 Guiding principles of good tax policy: A framework for evaluating tax proposals*. https://us.aicpa.org/content/dam/aicpa/advocacy/tax/downloadabledocuments/tax-policy-concept-statement-no-1-global.pdf

[17] Retrieved 9 June 2024 https://www.fhwa.dot.gov/fastact/factsheets/surftransfundaltfs.cfm?_gl=1*12t2kcn*_ga*MTQzNDM1OTUwOC4xNjk0NDY0MDY2*_ga_VW1SFWJKBB*MTcxNzg5NjkzNi4yLjAuMTcxNzg5NjkzNi4wLjAuMA..

[18] Retrieved 9 June 2024 https://www.fhwa.dot.gov/bipartisan-infrastructure-law/sirc_fact_sheet.cfm?_gl=1*10wt8qc*_ga*MTQzNDM1OTUwOC4xNjk0NDY0MDY2*_ga_VW1SFWJKBB*MTcxNzkwNTg0NS40LjAuMTcxNzkwNTg0NS4wLjAuMA

[19] California State Transportation Agency. (2017). *California Road Charge Pilot Program: Final Report*. https://dot.ca.gov/-/media/dot-media/programs/road-charge/documents/rcpp-final-report-a11y.pdf

[20] Washington State Transport Commission, Washington State Department of Transport. (2016). *Washington State Road Usage Charge Steering Committee Briefing Book*. WSTC. Olympia, Washington. https://www.waroadusagecharge.org/media/WSTC-RUC-SC-Meeting-Nov-9-Briefing-Book-20161104_v04c.pdf

[21] CH2M, WSP & PRR. (2017). *Colorado Road Usage Charge Pilot Program Final Report*. CDOT-2017-11. Colorado Department of Transport. Denver, Colorado. https://rosap.ntl.bts.gov/view/dot/39191

From this analysis, an expanded set of seven guiding principles was developed: **Simple, Robust, Fair & Equitable, Sustainable Revenue, Efficiency, Security, and Integrated.**

Figure 6: Principles

This framework brings traditional tax principles into today's context by including considerations such as data privacy and the need for complementary, cohesive tax tools.

Class	Criterion	Performance standard
Simple	Know what is owed	Parties to the tax should be able to calculate in advance what will be owed.
	Know how to pay	Parties to the tax should know in advance how to pay the tax.
Robust	No false positives	The tax should not be imposed on parties not engaged in the target activity.
	No false negatives	The tax should not miss parties who are engaged in the target activities.
	Hard to avoid/evade	The tax should limit the scope for evasion.
	Enforceable	There should be sufficient information available to determine the fact and magnitude of liability and current compliance status of a liable party.
Equitable and Fair	Transparent	The purpose of the tax and the use of the revenues generated should be known to taxpayers.
	Just	A party incorrectly taxed should have access to an effective remedy.
	Vertical equity	Parties should pay in relation to their means/benefits.
	Horizontal equity	Parties in the same circumstances should pay the same.
	Equivalent exchange	The return on tax paid and the effort required to pay the tax should be in proportion to the value of the tax and effort.
Efficient	Low administration cost	The tax should be inexpensive for government to operate.
	Low compliance cost	The tax should be inexpensive for parties to comply with.
	Good revenue	The potential revenue should be worth the effort required to gather it.
	Supports choice	The tax should not distort parties' choices.
	Reduces externalities	The tax should encourage parties to internalize the full cost of their choices.
Sustainable Revenue	Enduring revenue	The targeted activity should be likely to keep delivering necessary, sufficient and proportionate revenues over time.
	Enduring instrumentality	The instrument should be likely to remain effective at gathering revenues over time.
Secure	Privacy respecting	Only necessary and sufficient personal private information should be gathered.
	Safe-guarded	Personal private information should be kept secure, and the integrity of liability, compliance and administrative data should be protected.
Integrated	Complementary	The tax works with and alongside other tax and non-tax instruments to optimize coverage and effectiveness without duplication.
	Inter-operable	The means of compliance is usable for compliance with similar provisions in other jurisdictions.

By applying these principles, policymakers can create funding mechanisms that are fair, efficient, and reflective of public value and the values served as the foundation of the comparison of funding tools done during the literature review. For further details on the approach, please refer to *Appendix 2*.

2.2.3 Identifying Possible Revenue Tool Options

In understanding who benefits from road use and who might contribute to their funding, key stakeholders can be identified: **direct users and consumers on the one side and indirect beneficiaries on the other.** Direct users, such as everyday drivers and industries dependent on transportation, bear costs directly tied to road demand and wear. However, roads also serve a broader group, including landowners, businesses, and the public at large, by enhancing access and providing economic and social benefits that strengthen communities.

While listing funding tools for roads and other surface transportation options is relatively simple, and the compiling of inventories has been attempted[22], the real challenge lies in ordering these tools to enable effective analysis and comparison. Each funding tool has unique characteristics shaped by local context, meaning what might seem illogical from an external perspective can make sense when viewed locally. Grouping these tools by their core elements - their instrumentality - rather than design details, allows for clearer, more objective analysis. While some argue that road funding should reflect consumer and beneficiary use to balance costs and optimize network efficiency, the reality today is more complex.

Globally, road funding comes from various sources, often indirectly, chosen for convenience, pragmatism, revenue security, constitutional factors, and, at times, a lack of thoughtful design. For example, fuel taxes in some jurisdictions fund both general and road-specific funds and influence consumer behavior through incentives like bio-fuel discounts.

We categorized the tools into five primary families based on the type of activity taxed, each further divided into four types:

- **Input-based taxes:** Prepaid taxes for potential road use targeted at things that are specifically bought or used to enable road transportation. While straightforward to collect, they may not reflect actual usage levels.
- **Impact-based taxes:** Taxes based on actual or potential road use. These provide a more proportional link to usage but can be more complex to assess.
- **Presence-based taxes:** Taxes for vehicle presence within specific network areas, varying significantly based on tax purpose (e.g. delivery charges within designated areas).
- **Amenity-based taxes:** Taxes on activities that benefit from road access, proportional to the benefit level.

[22] Ministry of Transport (November 2014b). *Future Funding: Revenue tools for transport*. New Zealand Government. Wellington; The Eastern Transportation Coalition. (January 2024). *Compendium of Revenue Alternatives in Response to Fuel Economy Improvements and Vehicle Fleet Electrification*. https://tetcoalitionmbuf.org/wp-content/uploads/2024/05/TETC-Compendium-Resource-Report_FINAL.pdf

- **Commerce-based taxes:** Taxes on activities not directly related to road usage, but benefiting in some way from the access and activity roads support, with varying revenue potential and benefit connections.

USER-(OF-ROADS)-PAYS						BENEFICIARY-(OF-ACCESS)-PAYS			
Input-based		Impact-based		Presence-based		Amenity-based		Commerce-based	
Fuel excise tax	Also variable by fuel type, carbon content, and/or chemical composition	Fixed access (registration) charges	Also rates may vary by vehicle characteristics	Per cordon tolls	Also rates may vary by vehicle characteristics, location, and/or point-in-time-of-use	Property taxes	Highly variable by jurisdiction	General taxes	Highly variable by jurisdiction
Fuel sales taxes		By period of time		Per lane tolls		Fare-box recovery		Special (transport) taxes	
Vehicle/equipment sales taxes		By exception		Per road segment tolls		Parking charges		Development / developer contributions	
kWh taxes		By distances travelled		Within-area tolls/charges		Fees		Advertising, floor-space, and air-space concessions	

Table 3: Transportation Revenue Tools

This categorization provides a structured approach for analyzing funding tools, supporting more targeted discussions around road funding sustainability.

Certain taxes, like sales taxes, can appear in both input-based and commercial-based families, depending on how they are applied. For example, while a general sales tax is grouped under the commercial family of taxes, a sales tax that applies only to vehicle equipment, for road funding purposes, is treated as an input-based tax.

Appendix 3 provides a more detailed discussion of the inventory and why certain tools were categorized the way they were.

2.3 Value and Nature of Gas Taxes

2.3.1 What Gas Taxes Did Well

The key goal of the project was to explore alternative funding tools that can effectively supplement and/or replace fuel taxes in the long run. By seeking a replacement, we recognized that fuel taxes have provided valuable advantages worth preserving, though some of these strengths have lessened with changes in vehicle technology and fleet composition.[23]

One key strengths of the fuel tax is that it acts both as a user-charge and a usage-charge:

[23] Montana Legislative Fiscal Division. (November 2021). *Electric Vehicles and Montana Highways*. Presentation. https://www.leg.mt.gov/content/publications/fiscal/2023-Interim/November-2021/Electric-Vehicles-and-Montana-Highways.pdf

As a **user**-charge	As a **usage**-charge
It recovers costs from people who use the road network and impose costs, aligning responsibility with road use.	It scales with the level of road use, tying the tax to the quantity and quality of wear that users place on the network.

Table 4: User-/Usage-Based Charges

Fuel taxes have historically offered other key advantages. They effectively taxed a broad base of activity and were universally applied to *all* vehicles, ensuring consistent coverage across the entire taxable road network at all times.

In this regard, the goal of a new funding tool is not merely to supplement or replace the fuel tax, but to replicate its reach and effectiveness.

Another advantage of fuel taxes is that, even in their diminishing state, they generate significant revenues with relatively little distortionary impact on consumer choice. Road user demand is relatively inelastic in response to fuel prices, and the tax contribution to fuel prices is both low and stable, even when indexed to inflation or actively managed.

When transitioning to new funding solutions, retaining these qualities - broad applicability, user-and usage-based structure, and a large, stable revenue stream - will be essential for a sustainable, effective and fair road funding framework.

2.3.2 Comparing the Alternatives with the Positive Features of Fuel Taxes

The following figure provides a high-level assessment of the twenty (20) tools, including *current* fuel taxes, against the positive features of *historic* fuel taxes.

	Road user pays	Based on use of roads	All vehicles	All road use	Large revenue
Input-based taxes					
Fuel excise tax	✓	✓	~	✓	✓
Fuel sales tax	✓	✓	~	✓	✓
Vehicle/equipment sales tax	✓	~	✓	~	~
Kilowatt hour charge	✓	✓	~	✓	✓
Impact-based taxes					
Fixed access charges	✓	X	✓	~	✓
By period of time	✓	✓	✓	~	✓
By exception	✓	✓	~	✓	X
By distance travelled	✓	✓	✓	✓	✓
Presence-based taxes					
Per cordon tolls	✓	✓	~	X	✓
Per lane tolls	✓	✓	~	X	✓
Per road segment tolls	✓	✓	~	X	✓
Within-area tolls/charges	✓	✓	~	~	✓
Amenity-based taxes					
Property taxes	X	~	X	X	✓
Fare-box recovery	X	~	~	~	~
Parking charges	X	X	~	~	✓
Fees	X	X	X	X	~
Commerce-based taxes					
General taxes	X	X	X	X	✓
Special (transportation) taxes	X	X	X	X	✓
Development contributions	X	X	X	X	~
Advertising etc. concessions	X	X	X	X	~

Table 5: Revenue tools assessment against positive features of historic fuel taxes

2.4 Short-Listing the Tools to be Studied in Detail

2.4.1 Pros and Cons of the Long-Listed Tools

Input-Based Tools

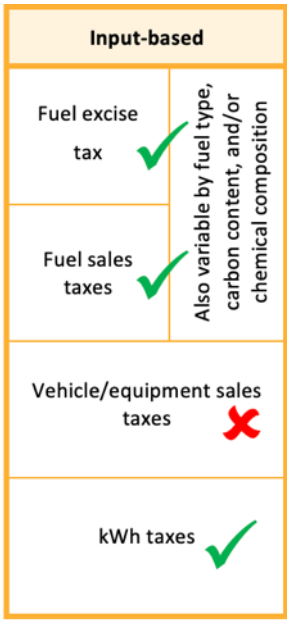

Table 6: Input-based tools

It is not possible to immediately exclude fuel taxes themselves, either in their usual volumetric form (excise tax) or in their sales tax like form. While there are increasing equity challenges, a potential tax per kWh for electric vehicles suggests that fuel taxes might still be retained for ICE vehicles - unless these vehicles are included under a different tool, such as a distance-based charge. In this scenario, kWh tax would not fully replace the fuel tax but would serve as a parallel taxation measure for electric vehicles.

Other taxes, such as those on vehicle or equipment sales, are less likely to be a reasonable prospect to replace the fuel tax. They are poor proxies for road usage, and their revenue streams can be unpredictable. At higher tax rates, these tools risk becoming more regressive and may even create undesirable behaviors, like delaying the purchase of replacement tires or even safer, more modern vehicles. Consequently, these options were excluded from further analysis.

Impact-Based Tools

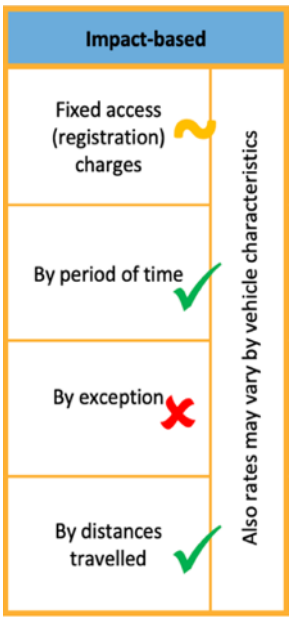

Table 7: Impact-based tools

Time-based and distance-based taxes both have potential that merit further exploration.

Fixed access (registration) charges fall into a grey area. They rely heavily on averaging instead of actual usage of roads, and as rates increase, their performance against vertical equity criteria degrades. However, they have a strong theoretical justification: many road network costs are fixed, incurred regardless of the marginal user's impact, and can thus be treated as 'common costs'. Fixed access charges, especially when incorporated into annual vehicle registration, offer a convenient and horizontally equitable way of allocating these costs. There may be room to expand their use as a viable alternative, warranting further consideration.

By contrast, 'by exception charges', such as overweight permits, are often highly equitable along the vertical dimension. However, as the name suggests, these charges apply in specific, exceptional cases, which limits their ability to provide a consistent revenue stream. Consequently, these charges have been excluded from further investigation as a supplement and/or future replacement of the fuel excise tax.

Presence-Based Tools

Presence-based	
Per cordon tolls ✗	Also rates may vary by vehicle characteristics, location, and/or point-in-time-of-use
Per lane tolls ✗	
Per road segment tolls ✗	
Within area tolls/charges ✓	

Table 8: Presence-based tools

The final family of user-pays tools, presence-based charges, presents a set of near universal challenges when considered as a supplement and/or replacement taxing mechanism. These charges are primarily designed to generate revenue from specific locations and their instrumentality renders them unfit for wide scale application, especially on low-traffic roads.

An exception to this limitation could be within-area charging. Although this tool type still does not necessarily charge for all travel on every road - for instance, per-delivery fee represents a 'within-area' charge that excludes private travel - area charges can be quite effective when applied in densely populated areas or entire economic zones. In these settings, within-area charges can assume many features of a universal mechanism without becoming a full-fledged distance-based charging regime. It is on this basis area-based charges were included for further investigation. While similar to a cordon charge, area charges manage the 'gaming risk' that cordon charges create and have the ability to be more equitable because of the closer alignment to actual road use.

Beneficiary-Pays Tools

Amenity-based		Commerce-based	
Property taxes ✗	Highly variable by jurisdiction	General taxes ✗	Highly variable by jurisdiction
Fare-box recovery ✗		Special (transport) taxes ✗	
Parking charges ✗		Development / developer contributions ✗	
Fees ✗		Advertising, floor-space, and air-space concessions ✗	

Table 9: Amenity- and Commerce-based tools

The two families of beneficiary-pays tools - amenity-based and commerce-based taxes - were excluded from further research.

Shifting to these tools would represent a significant shift in the tax burden from road users, moving away from the user/usage-pay principle that is central to equitable and sustainable road funding.

2.4.2 Final Short List

In conclusion, it was decided to focus the in-depth investigation of alternative road funding revenue tools on these seven (7) tools:

1. **Fuel Excise Taxes:** A fixed price tax that is attached to the price per gallon of fuel (cents per gallon / by fuel type).
2. **Fuel Sales Taxes:** A sales tax attached to the price of fuel (% of fuel price).
3. **Kilowatt-Hour Taxes:** An attempt to replicate the fuel tax for electric vehicles. When an electric vehicle is charged a tax liability is incurred per kWh of energy transferred (cent per kWh / % of kWh price).
4. **Fixed Access (Registration) Charges:** A flat-rate tax paid when registering a vehicle.
5. **Time-Based Charges:** A flat fee paid for using roads over a specific period of time, such as a day, month, or year, usually for highways or main roads but sometimes including local roads.
6. **Distance-Based Charges:** A per-mile charge (cent per mile / by vehicle).
7. **Within-area Tolls/Charges:** A charge for travelling within a defined area of interest.

2.5 Where else the Short-Listed Tools are Being Explored

Below is a summary of the range of examples of the short-listed tools available for investigation. *Appendix 4* provides more detailed information on examples of each of the short-listed tools.

Fuel Excise Taxes

Fuel excise taxes are used throughout the U.S. by the federal and state governments, and right across the wider world. Concerns with the dwindling revenue base, emissions, and equity issues are shared across every jurisdiction.[24]

Fuel Sales Taxes

Sales taxes on fuel for general revenue purposes are common around the world and are usually - outside of the U.S. - applied as value-added taxes (VAT[25]).[26] In the U.S., five states (California, Hawaii, Illinois, Michigan, and New Jersey) apply percentage-based retail sales taxes on fuels.

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[24] ITF 2023:10-11.

[25] [25] A VAT is a consumption tax assessed on the value added in each production stage of a good or service. Every business along the value chain receives a tax credit for the VAT already paid. The end consumer does not, making it a tax on final consumption

[26] Tax Policy Center (January 2024). *How could we improve the Federal Tax System? Value Added Tax.* Briefing Book. Urban Institute & Brookings Institution. https://www.taxpolicycenter.org/briefing-book/what-vat pp1-3.

Kilowatt-Hour (kWh) Taxes

Currently unique to the U.S., eight state programs have been legislated to tax kWh[27], with six actively operating, primarily targeting public charging stations to recover revenue from out-of-state drivers. An additional seven states have proposed, but not passed, kWh taxes.

Fixed Access (Registration) Charges

Fixed access charges in the form of vehicle registration charges are employed in all states across the U.S. and in virtually every nation around the world.[28] Internationally there is a wide range of practices around the use of revenue from fixed access charges, from simply recovering the cost of administrative process and related compliance activities (e.g., California before 2017) all the way through to providing revenue for new infrastructure (e.g., New Zealand).

Time-Based Charges

Time-based charges are predominantly used in Europe, where they are referred to as 'vignettes'. There are currently ten programs in place; however, European Union legislation is pushing a shift toward distance-based charges.[29]

Distance-Based Charges

The type of tool receiving the most attention and thorough study over the past decade, both within the U.S. and abroad, is a distance-based charge. These are variously referred to as Mileage-Based User Fee (MBUF), RUC, Vehicle Miles Travelled (VMT) taxes, or Weight-Mile Taxes (WMT).

In the U.S, states currently applying some form of RUC for trucks are Connecticut, Indiana (EVs), Kentucky, New Mexico, New York, and Oregon. Four states have legislated a RUC for light vehicles (Oregon, Utah, Virginia and Hawaii). Tolling-based RUC is used extensively across Europe for heavy vehicles, while Iceland has become the first European country to introduce a distance-based charge on light electric vehicles.

Since 1978 New Zealand has had RUC in place for heavy vehicles and light diesel vehicles. The program has been extensively reviewed, reformed, and evaluated, and recently expanded to include all light electric and hybrid vehicles.

Within-Area Tolls/Charges

The primary distinction of within-area charges is that they apply a different rate of tax to the standard on taxable activity within a defined area, for a given policy purpose (e.g., raising revenue for special projects or to manage demand). To do so, these charges rely on other existing technologies. The three approaches identified are: using a sales tax methodology; using a tolling methodology; and using a location-enabled distance-based charging methodology.

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[27] Atlas Public Policy. (October 2024). *Charging the Charge Considerations for Per-kWh EV Charging Tax Policy*. The Eastern Transport Coalition. https://tetcoalition.org/wp-content/uploads/2022/09/Charging-the-Charge-Primer-on-Per-kWh-Tax-Policy_FINAL.pdf pg 4.

[28] Skinner M. (May 2024). *Regulatory Impact Statement: An Increase in Annual Motor Vehicle Licence Fees*. Ministry of Transport. New Zealand Government. https://www.transport.govt.nz/assets/Uploads/Regulatory-Impact-Assessment-Increasing-annual-vehicle-licence-fees-2024..pdf pp 9-10.

[29] Directive 1999/62/EC and Directive (EU) 2022/362 refer.

Distinct from the cordon charges often used for congestion charging, within-area charges apply to movement into and within areas and are an emerging tool, drawing from a variety of methods, and are only in limited use:

- Sales-tax based: retail delivery fees have been introduced only in the U.S. by two states, with at least four others considering the option.
- Tolling-based: the London Congestion Charge is regarded in the literature as the only operational example - distinct from the cordon and corridor congestion pricing schemes in Stockholm and Singapore[30] - although SmartMove is being mooted for Brussels.
- Location-enabled distance-based: Oregon has tested per mile rates differentiated by location/area as part of its program of RUC technology testing. Since January 1st, 2025, Denmark has implemented a within-area charge, in the form of a low emission zone as part of the nationwide distance-based charging scheme for heavy vehicles.[31]

[30] Ministry of Transport et al. (July 2020). *The Congestion Question: Technical Report*. New Zealand Government. https://www.transport.govt.nz/assets/Uploads/Report/TheCongestionQuestionsTechnicalReport.pdf pg 42.
[31] Retrieved 14 January 2025 https://vejafgifter.dk/en/how-much-do-i-have-to-pay/

3.0 California

3.1 California Realities: Transportation Funding Overview

Roads and highways are the backbone of the economy, allowing California motorists to travel 316.9 billion miles annually and carrying a significant portion of the $2.8 trillion worth of commodities shipped to and from the state each year.[32] With nearly 400,000 lane miles of roads, California has the second largest network in the U.S. after Texas. However, the state's large population means there are ten people per lane mile, the third highest ratio in the country after Hawaii and New Jersey.[33] But conditions on the network are deteriorating, as the need for transportation improvements far exceeds the amount of state and federal funding available.

3.2 Funding Landscape

Transportation in California is financed through a blend of federal, state, regional, and local sources. These streams collectively fund planning, construction, operation, maintenance and renewal of the state's expansive network of highways, roads, transit systems, and active transportation infrastructure.

3.2.1 Federal Contributions

Federal funds are allocated through the HTF. Programs managed by the Federal Highway Administration (FHWA)[34] and Federal Transit Administration (FTA)[35] direct these funds to state and local projects based on formulas provided in Federal legislation[36], with additional grants targeting multimodal transportation infrastructure, goods movement and freight, and climate-resilient infrastructure improvements.

Funds in the federal HTF come from a variety of taxes on highway fuel, tires, heavy vehicle use tax, and truck/trailer sales taxes. Most of the revenue is raised through fuel excise taxes, which are currently set at 18.4 cents per gallon for gasoline, and 24.4 cents for special fuel (primarily diesel). Rates have not been raised since 1993.

3.2.2 State Contributions

Fuel Excise Taxes[37]: Excise taxes on gasoline and diesel represent the largest share of state transportation revenue. SB 1 in 2017 increased these rates and indexed them to inflation, bolstering funding for maintenance and new projects.

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[32] TRIP. (2020, April). *California Transportation by the Numbers: Meeting the State's Need for Safe, Smooth, and Efficient Mobility*. https://tripnet.org/wp-content/uploads/2020/04/TRIP_Fact_Sheet_CA.pdf

[33] Retrieved 30 November 2024. https://www.titlemax.com/discovery-center/which-states-have-the-most-miles-of-roadway-per-person/

[34] U.S. Department of Transportation. (n.d.). Overview of Funding and Financing | DOT Navigator. U.S. Department of Transportation. https://www.transportation.gov/grants/dot-navigator/overview-funding-and-financing-usdot

[35] Metropolitan Transportation Commission. (n.d.). *Federal Transit Administration (FTA) Grants*. Metropolitan Transportation Commission. https://mtc.ca.gov/funding/federal-funding/federal-transit-administration-fta-grants

[36] Federal Highway Administration. (n.d.). *Motor Fuel Data*. U.S. Department of Transportation. https://www.fhwa.dot.gov/policyinformation/motorfueldata.cfm

[37] Retrieved 26 November 2024. California Department of Tax and Fee Administration. Sales Tax Rates for Fuels. https://www.cdtfa.ca.gov/taxes-and-fees/sales-tax-rates-for-fuels.htm

State Sales Tax[38]: State sales taxes are collected on gasoline, diesel[39], aviation gas and jet fuels. California is one of only five states in the U.S. that collects a percentage-based sales tax on fuel (Note: revenues generated from the sales tax on gasoline are allocated for non-transportation related purposes).

Vehicle Taxes and Fees[40]: Registration fees, truck weight fees[41], and the TIF and RIF supplement state revenue. Both TIF and RIF were recently introduced, whereby RIF is focused on recovering revenue from EVs and TIF recovering additional revenue from all vehicles. The registration charge in California is one of the most complex and expensive in the nation, with multi-layered fees depending on the age, weight and type of vehicle.

REGISTRATION FEE	AMOUNT	APPLIES TO	PURPOSE
Base Fee	$74	All Vehicles	Funds basic DMV operations and road maintenance
CHP California Highway Patrol Fee	$32	All Vehicles	Supports CHP operation and traffic safety programs
TIF Transportation Improvement Fee	$32 - $227 based on vehicle value	All Vehicles	Funds road + transportation infrastructure improvements
VLF Vehicle License Fee	0.65% of vehicle value	Most Vehicles	A property tax on vvehicles that goes to local government for general services
County/District Fee	Varies by location	All Vehicles	Supports local transproation and air quality programs
Smog Abatement Fee	$20	Vehicles 6 years old or less	Funds air quality improvement programs
Alternative Fuel/Technology Registration Fee	$3	Alternative fuel Vehicles	Supports programs related to alternative fuel vehicles
Alternative Fuel/Technology Smog Fee	$8	Alternative fuel Vehicles	Funds emission testing programs for alternative fuel vehicles
RIF Road Improvement Fee	$118	ZEV model year 2020 or later	Compensates for lost gas tax revenue from electric vehicles to fund road maintenance
Weight fee		Commercial Vehicles	Offset road damage caused by heavier vehicels

*Light-Duty commercial vehicles also pay a (limited) weight fee, and there is a separate table for EVs with different weight groups.

Table 10: California registration charges

Cap-and-Trade Revenues: These funds support transit and rail projects aimed at reducing GHG emissions, aligning with California's climate goals.

General Fund Transfers: Occasionally, allocations from the state's General Fund support transportation initiatives.

[38] Retrieved 26 November 2024. California Department of Transportation. Caltrans Facts. https://dot.ca.gov/programs/research-innovation-system-information/caltrans-facts

[39] Retrieved 26 November 2024. California Department of Tax and Fee Administration. Tax Rates – Special Taxes and Fees (Publication L-504). https://www.cdtfa.ca.gov/formspubs/l504.pdf

[40] Retrieved 26 November 2024. California Department of Motor Vehicles. Registration Fees. https://www.dmv.ca.gov/portal/vehicle-registration/registration-fees/

[41] Retrieved 26 November 2024. California Department of Motor Vehicles. Collection and Payment of Fees and Penalties: Weight Fees. https://www.dmv.ca.gov/portal/handbook/vehicle-industry-registration-procedures-manual-2/collection-and-payment-of-fees-and-penalties/weight-fees/#:~:text=A%20weight%20fee%20is%20due,purpose%20(VC%20§9400).

3.2.3 Regional and Local Contributions

Local Option Sales Taxes: Approved by voters in many counties to fund specific transportation projects.

Transit Fare Revenues: Generated by local transit agencies.

Property Taxes and Developer Fees: Supplementing funding for localized infrastructure projects.

Toll Road Revenue: Some projects incorporate private investments, allowing private entities to fund, construct, or operate infrastructure in exchange for future revenues, such as tolls.

3.3 The Issue with the Fuel Tax

Fuel taxes have long been the backbone of California's transportation funding, as they have been for the country overall. However, this primary revenue source is steadily declining resulting in California's transportation funding system facing significant funding challenges due to several trends:

3.3.1 Improved Fuel Efficiency

Advances in vehicle technology have significantly reduced fuel consumption. Average vehicle fuel economy rose from 15 miles per gallon (mpg) in the 1970s to more than 25 mpg in 2025. While this challenge is not unique to California, the state's per capita consumption of petroleum products is lower than all but five other states in the U.S., with 15.5 barrels per year, compared to the national U.S. average of about 22 barrels per capita related to transportation. [42]

3.3.2 Adoption of Zero-Emission Vehicles

California leads the nation in ZEV adoption, accounting for approximately 35%[43] of all EVs in the U.S. The ACC II established a year-by-year roadmap so that by 2035 100% of new cars and light trucks sold in California will be zero-emission vehicles, including plug-in hybrid electric vehicles.[44]

3.3.3 California Funding Decline Predictions

The timing and extent of transportation revenue impacts depend on various factors, including the speed of the state's transition to ZEVs, which introduces significant uncertainty. However, if California continues its GHG reduction and ZEV adoption strategies - as is likely - an accelerating downward spiral of total fuel tax revenue is expected over time.

Expected Revenue Decline 2023/24 vs. 2034/35
-$5 billion (65 %) from gasoline excise tax
-$290 million (20%) from diesel excise tax
-$420 million (32%) from diesel sales tax

Table 11: Expected revenue decline

[42]California Energy Commission & California Department of Tax and Fee Administration. (2024). 2024 Review of the Price of Gasoline in California and Related Impact on State Revenues. https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

[43] National Renewable Energy Laboratory. (2024). Electric Vehicle Registrations by State. U.S. Department of Energy. https://afdc.energy.gov/data/10962

[44] California Air Resources Board. (2022, August 25). California moves to accelerate to 100% new zero-emission vehicle sales by 2035. https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035

In December 2023, LAO estimated that under the state's climate strategy transportation revenues will decline by (31%) – or, according to the CTC approximately $31.3 billion – over the next decade.

In March 2024, the Mineta Transportation Institute released a report analyzing ten (10) future scenarios. While acknowledging the challenges of long-term predictions, it estimates annual revenues by 2040 could range anywhere from $4.81 billion to $12.5 billion, a span that makes it challenging to plan[45]. Some scenarios project annual revenue dropping by over $1 billion below 2024 levels by 2027.[46]

These projections are largely driven by assumptions about decreasing gasoline and diesel consumption due to improved fuel efficiency and the increasing adoption of ZEVs, with variations depending on the transition scenario considered.

However, declines are expected even absent the state's climate policies, with the transition away from gasoline and diesel - and associated tax revenues their consumption generated - exacerbating these impacts. Under this scenario revenue is still expected to decline by 13% over the next decade.[47]

Gasoline excise tax revenue is expected to decline more sharply than diesel tax revenue due to two key factors:

1. *High ZEV Adoption in Light-Duty Vehicles:* The transition to ZEVs is concentrated in the light-duty vehicle sector, which consumes most of the gasoline. In contrast, medium- and heavy-duty vehicles, which primarily use diesel, are expected to see limited ZEV adoption in the near term, resulting in an expected moderate increase of diesel consumption due to growing demand for goods transportation, which drives higher VMT in this sector.

2. *Reduction in Per Capita Vehicle Travel:* The LAO anticipates a reduction in vehicle miles travelled per capita for light-duty vehicles, further decreasing gasoline consumption.

[45] Agrawal, A. W., Nixon, H., & Murthy, V. (2024). *Transportation Revenue Options: Gas Taxes, Electric Vehicle Fees, and Mileage Fees*. Mineta Transportation Institute, San José State University. Retrieved from https://transweb.sjsu.edu/sites/default/files/2312-Agrawal-Transportation-Revenue-Fuel-Taxes-Electric-Vehicles.pdf
[46] Mineta 2024.
[47] LAO 2023.

3.4 Impacts on Infrastructure and Programs

If no alternative funding mechanism is found, the revenue decline will result in certain state transportation programs having less capacity to support state and local transportation projects and activities. Programs which are more reliant on gas tax revenues will be affected more. Overall, the decline in fuel tax revenues directly affects the condition and capacity of California's surface transportation infrastructure, including components that support transit, bicycle, and pedestrian travel.

NOTABLE 2034/35 PREDICTIONS OF HIGHLY AFFECTED PROGRAMS[48]		
-26% **Caltrans' highway maintenance and rehabilitation programs** will be the most heavily impacted, with a predicted decrease of $1.5 billion	**-26%** Funding provided to **cities and counties for local streets and roads** will also experience significant reductions, with a predicted decrease of $900 million	**1/3rd** **State Transit Assistance program**, which is solely support by diesel sales tax revenue, is predicted to experience funding declines of about $300 million

Table 12: LAO 2023 Predictions highly affected programs

[48] LAO 2023 December.

3.4.1 Bad Roads Aren't Cheap

There are many financial advantages of maintaining pavements in good condition, including reduced costs, reduced disruption and environmental benefits, while neglecting maintenance leads to increased deterioration.[49]

California's deteriorating road conditions impose significant economic burdens on its residents and the economy. A 2018 TRIP report[50] estimated that deficient roads cost California's economy $61 billion annually, with the impacts falling into three main categories: safety, congestion, and additional vehicle operating costs.

Looking at more recent numbers in the 2024 report[51], the costs have increased to $65.7 billion, roadway-related traffic crashes accounted for $13.7 billion in economic costs in 2022, while congestion in the state's most traffic-heavy areas resulted in $29.1 billion in lost time and wasted fuel, costing the average driver three (3) full days a year.

Poor road conditions also contribute to $22.9 billion in additional vehicle operating costs statewide, in repairs, depreciation, and extra fuel and tire wear, translating to $830 for the average driver each year. These hidden costs underline the urgent need for a sustainable funding solution to replace the declining revenues from the fuel tax.

THE HIDDEN COST OF DEFICIENT ROADS (EST. PER YEAR)			
	CONGESTION	**SAFETY**	**VEHICLE OPERATING COST**
TOTAL	**$29.1b** lost in traffic	**$13.7b** in economic costs due to crashes caused by unsafe road conditions	**$22.9b** for additional vehicle wear and tear due to bad road conditions in 2023
AVERAGE DRIVER	**$1,774** in the most congested areas	**Bad roads cost California's economy** **$65.7b** **each year**	**$830** for the average driver

Table 13: The hidden cost of deficient roads. Source: TRIP

[49] Save California Streets (2023). *California Statewide Local Streets and Roads Needs Assessment.* Retrieved from https://savecaliforniastreets.org/wp-content/uploads/2023/05/Statewide-Needs-2022-FINAL.pdf.
[50] TRIP. (2018, August). *Los Angeles Transportation by the Numbers: Meeting the Region's Need for Safe, Smooth, and Efficient Mobility*. https://tripnet.org/wp-content/uploads/2018/08/CA_Los_Angeles_Transportation_by_the_Numbers_TRIP_Report_Aug_2018.pdf
[51] TRIP 2024.

3.5 Recent Notable Changes

3.5.1 Gas Tax Swap

In 2010 the sales tax on gasoline was reduced and replaced with an increase in the fuel excise tax. The so-called *gas tax swap* reduced the state's sales tax to 2.25% but added an excise tax of 17.3 cents per gallon. The goal was to raise the same amount of money as the previous system, so the new increment of excise tax was adjusted each July to retain revenue neutrality.

Additionally, this bill shifted past and future transportation-related debt service repayments on general obligation bonds from the general fund to the fuel excise tax fund.

3.5.2 The Road Repair and Accountability Act of 2017 (SB 1)[52]

SB 1 provided the first significant, stable, and on-going increase in state transportation funding in more than two decades. Annual investment is estimated at $5.4 billion to fix roads, freeways and bridges in communities across California and puts more dollars towards transit and safety. The funds will be split equally between state and local investments.

SB 1 PROMISED TO[53]		
Provide **$5.4b/yr** of funding for state highways and local roads; and improve public transportation, walking and biking	Generate **90,000 jobs** a year	To cost the average Californian less than **50 cents/day**

Table 14: SB 1 promises. Source TC Factsheet

To fund the bill, adjustments to fuel excise and sales taxes were introduced. Additionally, it indexed fuel taxes and fees to inflation to ensure revenue remains consistent over time and provides accountability, as revenues must be spent on transportation projects and programs.

TYPE	SB1 CHANGE	CURRENT RATE (24/25)
Gasoline excise tax	+$0.12/gallon	$0.596/gallon
Gasoline sales tax	No change	2.25% (+ local taxes)
Diesel excise tax	+$0.20/gallon	$0.454/gallon
Diesel sales tax	+4%	13%

Table 15: California fuel tax rates

[52] California State Legislature. (2017). Senate Bill No. 1: Road Repair and Accountability Act of 2017. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB1

[53] Transportation California. (2020). SB 1 Fact Sheet. https://transportationca.com/wp-content/uploads/SB1-factsheet.pdf

Furthermore, SB 1 created two new transportation funding mechanisms:

TYPE	SB1 CHANGE	CURRENT RATE (24/25)
TIF (NEW)	$25-175	$32 – 227
RIF (NEW)	$100	$118

Table 16: TIF and RIF rates

Transportation Improvement Fee (TIF)

The TIF charges vehicle owners an annual fee based on the current market value of a vehicle at the same time vehicle registration fees are due. Revenues are used to repair roads, bridges, etc. and provide road maintenance. It is adjusted annually for inflation based on the California Consumer Price Index and is dedicated to transportation. Estimated revenue from TIF for FY 2024-25 is about $2.46 billion[54].

Road Improvement Fee (RIF)

The RIF applies to ZEVs with the model year 2020 or newer. It is a flat fee charged at the time of registration renewal. It is not assessed on the initial registration of a newly purchased ZEV from a licensed vehicle dealer. The fee is adjusted to inflation and is dedicated to transportation. The fee was implemented to ensure these vehicles contribute to road funding. Estimated revenue for FY 2024-25 is approximately $129.93 million.

3.5.3 SB1 Progress

PROGRESS AS OF SEPTEMBER 30, 2024[55]		
279,440 Jobs created	**14,403** Projects received SB 1 funding a year	**$21.5b** invested
8,590 Projects completed	**3,677** Projects in progress	**2,136** Projects planned

Table 17: SB 1 progress as of September 30, 2024. Source Rebuilt California

3.6 Impacts, Future Directions and Innovations

3.6.1 Status and Outlook

California's transportation network is at a critical juncture, with aging roads and bridges that require significant investment to ensure safety, efficiency, and economic stability. While the design, construction, and maintenance of transportation infrastructure support hundreds of thousands of jobs and sustain key industries like tourism, agriculture, and manufacturing, the system's deterioration

[54] California Department of Transportation. (2024). *2024-25 Transportation Financing Package Summary*. https://dot.ca.gov/-/media/dot-media/programs/budgets/documents/fin-pkg-summary-2024-25-ada-signed-final.pdf
[55] Retrieved November 27, 2024. California Department of Transportation. (n.d.). *SB 1 by the Numbers*. Rebuilding California. https://rebuildingca.ca.gov/sb-1-by-the-numbers

imposes growing costs on drivers and businesses. Congestion leads to lost productivity, and poor road conditions result in higher vehicle repair and operating expenses.

While SB 1 has delivered critical improvements and set plans in motion, the scale of the challenge requires further action to meet the state's long-term funding needs. Addressing these gaps will be essential to preserving California's transportation infrastructure and achieving its broader economic and environmental goals.

 **OVERVIEW**		
45% of California's major roads are in poor or mediocre conditions.	**6%** of California's bridges are rated in poor/structurally deficient conditions.	Approximately **7.1 million** full-time jobs in key industries like tourism, retail sales, agriculture and manufacturing are completely dependent on the state's transportation network.
The design, construction and maintenance of transportation infrastructure supports approximately **420,000** full-time jobs across all sectors of the state economy.	A total of **56%** of the state's bridges are at least **50 years** old, an age when many bridges require significant rehabilitation or replacement.	Most roads today are at least **40 years** old. While roads may be resurfaced, they will continue to age and reach a point of deterioration where reconstruction is necessary for roads to be safe.

Table 18: State of California's infrastructure 2023. Source: TRIP

3.6.2 Impact of Insufficient Funding

If no additional funding is found, the estimated funding reductions will limit programs' capacity to support state and local transportation projects and activities. However, demand for transportation spending on maintenance and capital projects is likely to increase in the coming years due to factors such as climate change, which will cause damage and undermine existing transportation infrastructure. Additionally, maintenance needs may be exacerbated by additional road wear due to increasing vehicle weights, or increased torque, particularly as more of the state's vehicle fleet transitions to ZEVs, which tend to be heavier than conventional vehicles. While there is ongoing debate about the extent to which this weight difference impacts road wear, further research may be needed to give the public confidence that the rates charged to ZEVs fairly reflects the impact they have on the roads.

The state also may need to make additional expenditures within the transportation sector to meet its goals of reducing VMT, such as expanding transit services and biking and walking infrastructure.

3.6.3 Roadway Improvements can Reduce Traffic Crashes and Save Lives

From 2019 through 2023, 20,131 people died on California's highways, an average of 4,026 annual fatalities. Traffic crashes in California imposed a total of $41.1 billion in economic costs in 2023. TRIP[56] estimates that a lack of adequate roadway safety features, while not the primary factor, was likely a contributing factor in approximately *one-third* of all fatal traffic crashes.

3.6.4 Predicted Climate Change Impact on California's Infrastructure

Climate change will impact transportation infrastructure in California in several ways. These include sea-level rise undermining coastal railways and bridges, intense storms causing mudslides and flooding of highways, and heatwaves leading to buckling and rutting of roads. Existing transportation infrastructure will need to be modified or relocated to remain usable, and planning, construction, and maintenance processes will increasingly need to account for the effects of climate change to maintain the infrastructure's longevity, adding more costs to the system.[57]

3.6.5 Inflation of Construction Costs

According to the FHWA's National Highway Construction Cost Index (NHCCI), construction costs have experienced significant increases in recent years. Between the first quarter of 2021 and the first quarter of 2024, the NHCCI rose by approximately 59%. This surge reflects escalating expenses in labor, materials, and other inputs essential for highway construction projects.[58] While the inflation seems to be slowing down, compared to rates observed in 2021 and 2022, the period of high inflation may not be over. In any event, prices are likely to continue to rise.

3.6.6 Future Innovations

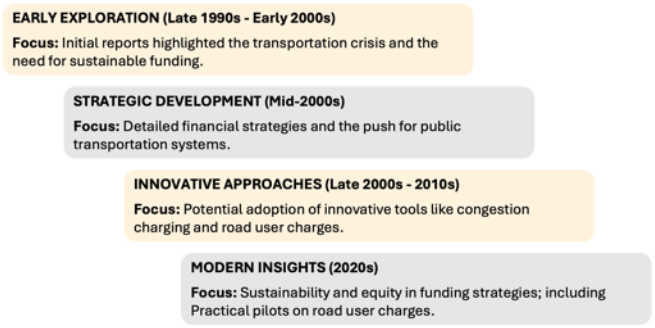

Figure 7: California future funding explorations

A significant amount of research has been done on future funding solutions in California. Overall, the journey reflects an evolving understanding of the complexities of transportation funding.

Initial efforts focused on modelling and quantifying the challenges and identifying broad solutions. The program then gradually moved towards investigating specific financial instruments and innovative funding mechanisms. Public sentiment underscores the importance of integrating environmental and equity considerations into funding strategies, aiming for a sustainable and inclusive transportation future.

[56] TRIP 2024
[57] Legislative Analyst's Office. (2022, April 5). Climate Change Impacts on California's Transportation System. https://lao.ca.gov/reports/2022/4576/Climate-Change-Impacts-Transportation-040522.pdf
[58] Federal Highway Administration. (2024). *National Highway Construction Cost Index (NHCCI) Analysis and Narrative: 2024 Q1*. U.S. Department of Transportation. https://www.fhwa.dot.gov/policy/otps/nhcci/NHCCI_Narrative_Article_2024_Q1.pdf

There are many parties that have conducted research on the topic and related areas. Funding tools studied include, congestion pricing, emission-based charging, EV fees, fuel taxes, sales tax, tolling and managed lanes, transportation utility fees, value capture mechanisms, vehicle registration fees, and most often distance-based charging.

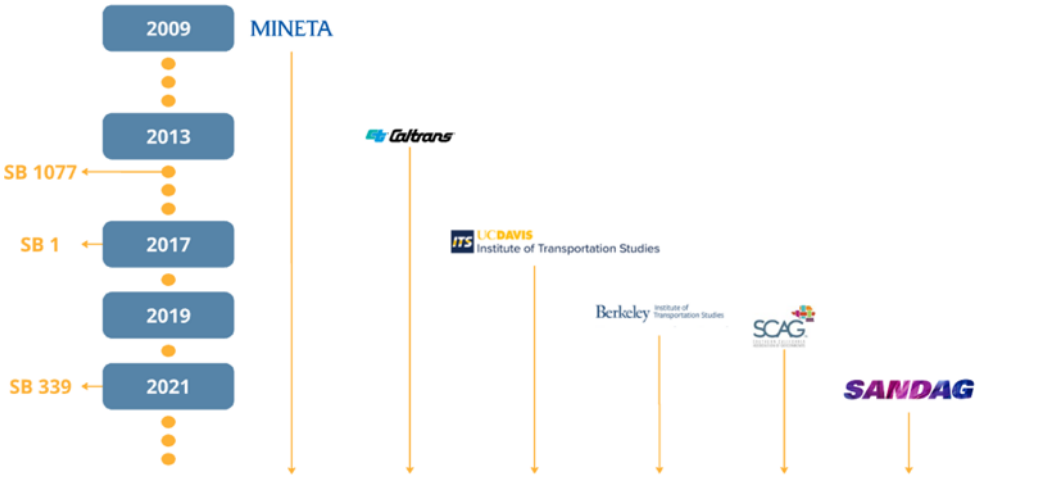

Figure 7: Future Funding Research

It appears that the first California RUC pilot program, and its results from Caltrans, may have created significant traction for other research, as an increased number of reports can be found from around 2017.

Overall, a couple of consistent key interests and topics emerged: **Privacy + Data Security, Equity** and **Fairness in Tax Burden Distribution**, and the preference of **Simplicity and Low Administrative Costs.**

3.6.2 Practical Future Funding Studies

In recent years, the state has conducted several pilot efforts that have focused on studying various aspects of implementing a distance-based charge:

2017

Road Charge Pilot. In 2014 SB 1077[59] required CalSTA to test the feasibility of implementing a road charge. The pilot was completed in 2017. Results demonstrated the feasibility of a road charge system, highlighting the importance of simplicity, transparency, and addressing privacy concerns to gain public acceptance and to prevent fraud.[60]

2021

Regional Pilot. This federally co-funded pilot study tested how to accommodate multiple sets of road charge requirements, processes, systems, and rates from across different states and/or jurisdictions. The pilot was conducted by Oregon and California - through Caltrans - and was completed in 2021. Results indicated that a clearinghouse could be beneficial in supporting the interoperability of a road charge.[61]

2022

Four-Phase Demonstration Pilot. This federally co-funded pilot tested the collection of a road charge through several technologies. The pilot was completed by Caltrans in 2022. Results indicated that leveraging existing models simplifies adoption, reduces costs, and benefits all stakeholders. Integration with existing systems has proven secure and reliable, while simplicity and transparency boost public acceptance. Addressing privacy concerns, minimizing complexity, and ensuring accessibility for underserved populations remain challenges. Clear communication and enforcement of business practices are essential for maintaining high standards and trust.[62]

2023

Public and Private Roads Pilot. This federally co-funded pilot tested the ability of current GPS technologies to differentiate between public and private roads in a road charge system. Caltrans completed testing for this pilot in the fall of 2023[63].

2024

Road Charge Revenue Collection Pilot. In 2021 SB 339, Wiener[64] required CalSTA to conduct a road charge pilot study that identifies and evaluates issues related to the collection of revenue for a RUC program. The project, currently underway, collects payments from participants and studies the impact of varyingRUC rates. The legislation requires CalSTA to provide the Legislature with a final report by December 31, 2026. An interim report[65] suggest a potential implementation pathway, developed in collaboration with several agencies.

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[59] California State Legislature. (2014). Senate Bill No. 1077: Vehicles: Road Usage Charge Pilot Program. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201320140SB1077

[60] California Road Charge Pilot Program 2017, December.

[61] RUC West. (2021, November 8). Regional Road Usage Charge Pilot Evaluation Report: STSFA 2017. https://caroadcharge.com/media/10tbtqci/rucwest_regionalruc_stsfa2017_pilotevaluationreport_110821_ada.pdf

[62] California Road Charge Pilot Program. (2022, August 30). California Road Usage Charge Comprehensive Report. https://caroadcharge.com/media/rkqfswef/ca_ruc_comprehensive_report_8-30-22_remediated.pdf

[63] Retrieved 26 November 2024. California Department of Transportation. Public/Private Roads Project. https://caroadcharge.com/projects/public-private-roads-project/

[64] California State Legislature. (2021). Senate Bill No. 339: Vehicles: Road Usage Charge Pilot Program Extension. https://legiscan.com/CA/text/SB339/id/2280020

[65] California Road Charge Pilot Program. (2024, July 1). SB 339 Interim Pilot Report. https://caroadcharge.com/media/3gcpdr0y/ca-sb-339-interim-pilot-report_final_508c.pdf

In addition to the work being undertaken in California, the state has also been part of other regional studies via RUC America.[66] [67]

4.0 Findings

4.1 Literature Review Summary Results

The literature review considered the instrumentality of each tool. Delivery on principles was ranked positive (✓), neutral (~) or negative (✕). A detailed assessment by tool can be found in *Appendix 4.*

4.1.1 Fuel Excise Tax

The fuel excise tax is a simple, well-understood mechanism that is easy for the public to understand, and inexpensive and straightforward to administer.[68] The estimated cost to collect a standard fuel tax ranges from a reported range of "well under" one percent of revenue collected[69], to 1.5%, for an average of 1.1%[70].

Fuel excise taxes are treated as user charges but can be vulnerable to revenue loss through legal exclusions, error, omission, and evasion, particularly in systems that use dyed fuels. This leakage often goes under-monitored and widely tolerated.[71]

While effective in many ways, fuel excise taxes are inherently highly regressive[72] as input-based taxes, placing a disproportionate burden on lower-income users, raising concerns about equity. Additionally, fuel excise taxes have limited influence on user behavior since any impact depends on fuel prices in relation to household and business budgets.[73] Politically, it is challenging to use fuel excise taxes to drive up fuel costs enough to influence behavior, especially during periods of economic pressure. As such, other targeted tools may be more effective for encouraging specific behaviors.[74]

[66] California Road Charge. (n.d.). RUC America Reports. https://caroadcharge.com/partners/ruc-america-reports/
[67] Oregon Department of Transportation. (n.d.). RUC America. https://www.oregon.gov/odot/rucamerica/pages/default.aspx
[68] Bacon R. (September 2001). *Petroleum Taxes: Trends in Fuel Taxes (and Subsidies) and the Implications*. The World Bank Group. Private Sector and Infrastructure Network. https://documents1.worldbank.org/curated/en/355551468780299588/pdf/23942-Replacement-file-240BACON.pdf
[69] Milestone Solutions/CDM Smith. (January 2022). *Removal of Fuel Taxes*. Hawaii Road Usage Charge Demonstration. https://hiruc.org/wp-content/uploads/2022/08/D-7-HiRUC-Removal-of-Fuel-Taxes.pdf pg7.
[70] Fleming D. (November 2012). *Dispelling the Myths: Toll and Fuel Tax Collection Costs in the 21st Century*. Policy Study 409. Reason Foundation. https://a8d50b36.rocketcdn.me/wp-content/uploads/2012/11/dispelling_toll_and_gas_tax_collection_myths.pdf pg17.
[71] Fleming 2012; McGowen P et al. (November 2011). *Montana Fuel Tax Refunds: Draft Final Report*. Western Transportation Institute. https://westerntransportationinstitute.org/wp-content/uploads/2016/08/4W2968_Final_Report.pdf
[72] National Surface Transportation Infrastructure Financing Commission (2009), quoted in Coyle 2011:14.
[73] Bacon 2001: 2; Willberg M. (June 2018). *Impact Summary: Increases to Petrol Excise Duty and Road User Charges*. Ministry of Transport. New Zealand Government. https://www.transport.govt.nz/assets/Uploads/RIA/RIS-Funding-the-Government-Policy-Statement-on-land-transport-2018-SIGNED.pdf pg 11.
[74] E.g. Parliamentary Budget Office. (September 2022). *Fuel Taxation in Australia*. Australian Government. https://www.pbo.gov.au/sites/default/files/2023-03/Fuel%20Taxation%20in%20Australia%20PDF.pdf

PRINCIPLES	CRITERION	FUEL EXCISE TAX
SIMPLE	Know what is owed	✓
	Know how to pay	✓
ROBUST	No false positives	~
	No false negatives	✓
	Hard to avoid/evade	~
	Enforceable	~
EQUITABLE & FAIR	Transparent	~
	Just	~
	Vertical equity	✗
	Horizontal equity	✗
	Equivalent exchange	~
EFFICIENT	Low administration cost	~
	Low compliance cost	~
	Good revenue	✓
	Supports choice	✗
	Reduces externalities	✗
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✓
	Inter-operable	✓

Table 19: Fuel excise tax against principles

In terms of revenue sustainability, fuel excise taxes continue to offer a stable method, even as ICE vehicles gradually decline. Their efficacy helps minimize revenue losses, keeping monitoring and enforcement costs low. Importantly, fuel taxes do not require the collection of personal data, maintaining privacy for users.

Finally, the simplicity and specificity of fuel excise taxes make them well-suited for integration into larger management and operational frameworks, providing a dependable, integrated tool within the transportation funding landscape.

Summary

While often viewed as a proxy road user charge, fuel excise taxes are more accurately categorized as general revenue tools. They are most effective when kept simple and universal, though this simplicity means they rate poorly in terms of equity.

Their decline is not a consequence of problems with the instrumentality, but due to significant contextual factors: political neglect of the real value of tax rates, improved engine efficiency, and the rise of affordable alternative-fuel vehicles. In fact, one analysis distills the main drawbacks of fuel excise taxes to two fundamental issues: they are taxes; and they involve burning fossil fuels.

4.1.2 Fuel Sales Tax

Fuel sales taxes are straightforward for consumers to understand and relatively easy for businesses to pass on, though the filing process can be challenging, particularly for smaller businesses.[75] The administrative cost is often in the range of 1.0-6.5% of revenue.[76]

Broadening the tax base allows for lower tax rates to meet revenue goals, which reduces incentives for tax evasion and enhances transaction reporting for monitoring and enforcement.

[75] Tax Policy Center. (January 2024). *How could we improve the Federal Tax System?* National Retail Sales Tax. Briefing Book. Urban Institute & Brookings Institution. https://www.taxpolicycenter.org/briefing-book/what-experience-other-countries-national-retail-sales-taxes

[76] President's Advisory Panel on Federal Tax Reform. (November 2005). *Simple, Fair, and Pro-Growth: Proposals to Fix America's Tax System*. Final Report. Chapters 8 & 9. https://govinfo.library.unt.edu/taxreformpanel/final-report/TaxPanel_8-9.pdf pp199, 221.

PRINCIPLES	CRITERION	VALUEMETRIC FUEL SALES TAX
SIMPLE	Know what is owed	~
	Know how to pay	~
ROBUST	No false positives	~
	No false negatives	~
	Hard to avoid/evade	✗
	Enforceable	✗
EQUITABLE & FAIR	Transparent	~
	Just	✓
	Vertical equity	✗
	Horizontal equity	✗
	Equivalent exchange	✗
EFFICIENT	Low administration cost	✓
	Low compliance cost	~
	Good revenue	✓
	Supports choice	✗
	Reduces externalities	✗
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✓
	Inter-operable	✓

Table 20: Fuel sales tax against principles

However, fuel sales taxes face inherent equity issues, like other input-based taxes.[77] Horizontal equity concerns are largely built into the structure, while vertical equity could only be improved with additional measures, such as tax credits or transfer schemes alongside the fuel sales tax. Broadening the tax base also boosts efficiency, as compliance and administrative efforts yield greater returns when taxable transaction volumes and values are higher, making the system more cost-effective.

Fuel sales taxes offer a stable revenue source, as ICE vehicles are expected to remain in the fleet for years, sustaining the tax base even amid a gradual shift towards alternative fuels. Additionally, these taxes safeguard user privacy since they don't require personal or private data collection. While fuels represent a relatively narrow commodity group, fuel sales taxes are most effective when integrated into a broader sales tax system, with fuel-generated revenue specifically earmarked for road funding.

Summary

Sales taxes, a fundamental component of tax systems, excel as general revenue mechanisms. However, while they are powerful as broad revenue instruments, sales taxes face limitations when used for targeted purposes, as is the case with fuel sales taxes. Like fuel excise taxes, they lack horizontal and vertical equity and have minimal influence on consumer behavior. Combined with the administrative complexity required for a comprehensive fuel sales tax, these limitations underscore the challenges of relying solely on this tool for dedicated road funding.

[77] Ibid. pg 4; Office of the Minister of Transport. (December 2017). *Introduction of a Regional Fuel Tax*. Advice to Cabinet. New Zealand Government. https://www.transport.govt.nz/assets/Uploads/Cabinet/Cabinet-paper-regional-fuel-tax.pdf pp10-11.

4.1.3 kWh Taxes

PRINCIPLES	CRITERION	KILOWATT-HOUR TAXES
SIMPLE	Know what is owed	~
	Know how to pay	~
ROBUST	No false positives	✓
	No false negatives	✗
	Hard to avoid/evade	✗
	Enforceable	✗
EQUITABLE & FAIR	Transparent	✗
	Just	~
	Vertical equity	✗
	Horizontal equity	✗
	Equivalent exchange	✓
EFFICIENT	Low administration cost	~
	Low compliance cost	~
	Good revenue	~
	Supports choice	✓
	Reduces externalities	~
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✗
	Inter-operable	~

Table 21: kWh tax against principles

The kWh tax, while promising as a funding tool, comes with unique considerations and challenges.

It is most practical when implemented through a '*pay-at-the-pump*' arrangement, either at public charging stations or as part of an automated system for home charging. Requiring individuals to file tax returns for electricity used in charging is shown to impose a significant compliance burden that households find either obscure or too complex, while the cost of pursuing these debts may be disproportionate to the value of the tax itself.[78]

A critical factor in making the kWh tax effective is taxing at-home charging, which minimizes exclusions and boosts revenue. However, it comes with significant set-up and administration costs due to the need for household sub-metering, or high risks of revenue leakage if sub-metering is not pursued.[79] No successful implementation exists at the time of writing this report.[80]

Like traditional fuel taxes, the kWh tax faces inherent equity challenges, with both horizontal and vertical equity concerns that impact fairness across different income levels and vehicle types.[81]

Efficiency is another area of concern, as there are notable setup costs associated with implementing kWh taxes at public charging stations. However, the large scale of these facilities allows for cost recovery over time. In contrast, metering at home is less efficient, as it serves fewer vehicles and could become obsolete if an EV is no longer based there. The cost per home could be an annualized amount of 5% of revenue, additional to the estimated 5-11% annual collection cost.[82]

[78] TETC 2024:50.
[79] Atlas Public Policy 2024:8-9.
[80] Vermont Public Utility Commission. (June 2019). *Promoting the ownership and use of electric vehicles in the State of Vermont*. Report to the Vermont State Legislature. https://www.driveelectricvt.com/Media/Default/docs/Vermont_PUC_Electric_Vehicle_Report_June2019.pdf pg 34.
[81] CDM Smith 2022; *Vermont Road Usage Charge Study: Final Report*. Vermont Agency of Transportation. https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Final%20Report%20of%20VT%20RUC_vfinal.pdf
[82] No single source addressed this directly, but it can be constructed from the data provided across multiple sources: CDM Smith 2022:59; TETC 2024:52; Segale J. (January 2022). *Vermont Electric Vehicle Road Usage Charge Study: Recommendations and Next Steps*. Vermont Agency of Transportation. https://legislature.vermont.gov/Documents/2022/WorkGroups/House%20Transportation/Electric%20Vehicles/W~Joe%20Segale~Vermont%20Electric%20Vehicle%20Road%20Usage%20Charge%20Study~1-12-2022.pdf pg 2; Vermont Commissioner of Public Service. (2013). *A Study on Replacing Motor Fuel Tax Revenues Not Collected from Plug-In Electric Vehicles*. Section 28 of Act 12 of 2013. https://publicservice.vermont.gov/sites/dps/files/documents/Transportation_LandUse/Goal1/Act12,%20sec28%20EV%20fees%20study.pdf pg 3.

In terms of sustainability, a kWh tax offers the potential for steady, long-term revenue if the initial investments are made. Privacy is maintained through the 'pay-at-the-pump' model, as it requires minimal personal data collection, respecting user security. Compliance can also be cost-effectively monitored and enforced by leveraging existing infrastructure and processes, though the net cost remains higher than that of traditional fuel taxes and may require measures that seem intrusive to ensure compliance, in particular considering home charging.

Summary

The kWh tax is a relatively new addition to the toolkit. It is probably most fairly characterized as experimental. The states attempting the method are still working on how to optimize its efficacy, define best practices, and accumulate the necessary underpinning infrastructure. The tool is nowhere near as simple as it is sometimes made out to be. It is seriously hamstrung as a revenue tool if only deployed as a literal 'pay-at-the-pump' solution at public charging stations, especially considering that 80% of EV charging is done at home.[83] Like fuel taxes, it faces equity challenges by using 'fuel' as a proxy for road usage, which typically improves with newer vehicles. Ultimately, the kWh tax presents both opportunities and challenges in creating a sustainable road funding solution.

4.1.4 Fixed Access (Registration) Charges

Fixed access or vehicle registration charges are a well-recognized funding mechanism with both strengths and limitations.

Public understanding is high, as people intuitively connect paying a registration fee with the right to use roads. This straightforward transaction is easy for users to comply with, making it a simple, effective tool in road funding.

Vehicle registration systems are generally robust and supported by strong enforcement, ensuring compliance. While these charges tend to be regressive due to their flat rate, they allow for nuanced taxation based on factors like vehicle size, weight, age, power type, and value.[84] This flexibility makes it possible to adjust rates according to vehicle characteristics, and if payment is allowed in smaller, more frequent instalments (e.g., monthly or quarterly), the financial burden on lower-income households can be reduced.

Fixed access charges are efficient, though constrained by the amount that can be added to the registration process without making it prohibitively expensive, especially for low income households.[85] If added to an annual licensing process, the cost to tax is negligible; however, if administered as a stand-

[83] Atlas Public Policy 2024:7.
[84] TETC 2024:48; VCPS 2013:6.
[85] Skinner 2024:21.

PRINCIPLES	CRITERION	FIXED ACCESS (Registration) CHARGES
SIMPLE	Know what is owed	✓
	Know how to pay	✓
ROBUST	No false positives	~
	No false negatives	✓
	Hard to avoid/evade	✓
	Enforceable	✓
EQUITABLE & FAIR	Transparent	✗
	Just	✓
	Vertical equity	~
	Horizontal equity	✗
	Equivalent exchange	✓
EFFICIENT	Low administration cost	✓
	Low compliance cost	✓
	Good revenue	✓
	Supports choice	✗
	Reduces externalities	✗
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✗
	Inter-operable	✓

Table 22: Registration charges against principles

alone transaction, administration can be equivalent to 10-30% of revenue.[86] Cost limitations can be offset somewhat by digital compliance channels, which enable larger fees to be split into affordable payments over time.

These charges also offer sustainable revenue over the long term. However, they are unlikely to replace fuel taxes as the primary source of road funding because the required rates to generate the same net revenue would be highly regressive.[87]

In terms of security, while registration requires gathering personal information to link a vehicle to its owner, this data does not need to be shared with tax records, and effective privacy and security protocols are available to manage data responsibly, even in cases involving law enforcement.

From an integration standpoint, fixed access charges have a valuable role in covering costs that are not directly linked to road usage.[88]

Summary

There is a clear role in any road funding regime for fixed access (registration) charges. As with any tool, they have their limits and cannot be all things for all situations. However, there is usually a clear set of residual or common costs that these charges are well able to collect fairly, leaving the user charge type instruments to gather revenue reflecting the marginal costs of actual road use (e.g. greater distances travelled and/or higher operating weights).

Where states of similar household wealth to California have researched the potential affordability of lump-sum fixed access charges, their findings suggest that the RIF and TIF may already take California's use of fixed access charges up towards the practical limit. This is also before the equity challenges of larger fixed access charges are considered. Even so, these rates do not fully or evenly cover the revenue gap being created by the uptake of ZEVs and hybrid vehicles.[89][90]

[86] Ministry of Transport (November 2014c). Future Funding: The sustainability of current transport revenue tools model and report. New Zealand Government. Wellington. pg6.
[87] Ibid. 21.
[88] RUC Review Group. (March 2009). An Independent Review of the New Zealand Road User Charging System. New Zealand Government. Wellington. https://www.transport.govt.nz/assets/Uploads/Report/RUC-Final-Report.pdf pp47-48.
[89] Hawaii Department of Transportation. (2022). Hawaii Road Usage Charge Demonstration Final Report. Vol I-II. https://hiruc.org/final-report/
[90] Washington State Transport Commission. (January 2024). *Forward Drive road usage charge research and pilot: Final report of findings*. WA RUC. https://www.waroadusagecharge.org/media/final-report/DIGITAL_WA%20RUC%20Final%20Report%20January%202024_v2.pdf

4.1.5 Time-Based Charges

PRINCIPLES	CRITERION	BY PERIOD OF TIME CHARGES
SIMPLE	Know what is owed	✓
	Know how to pay	✓
ROBUST	No false positives	✗
	No false negatives	✓
	Hard to avoid/evade	✓
	Enforceable	✓
EQUITABLE & FAIR	Transparent	~
	Just	✗
	Vertical equity	✗
	Horizontal equity	✗
	Equivalent exchange	~
EFFICIENT	Low administration cost	✓
	Low compliance cost	✓
	Good revenue	✓
	Supports choice	✗
	Reduces externalities	✗
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	~

Table 23: Time based charges against principles

Time-based charges, also known as vignettes, are another straightforward tool, easy for both users to understand and administrators to manage.[91] This simplicity is both a strength and a limitation, achieved by averaging costs across users and consolidating charges into traditional, often larger time blocks that may no longer align with modern usage patterns or support equity goals.[92]

Vignettes are robust and relatively easy to enforce, though enforcement can sometimes show bias in targeting efforts.[93] While the tool lacks nuance in rate-setting and minimum liabilities, it is seen as fair when it serves to collect revenue from drivers who might otherwise contribute nothing or to reduce the burden on infrequent users.[94] Ideally, users would be allowed to buy time-based charges in smaller increments of access, better reflecting actual road use and offering a more balanced exchange of value for taxpayers.

In terms of efficiency, vignette charges work best for covering fixed or 'common costs' associated with road networks, as they don't directly reflect usage but rather the opportunity to use the network. For this reason, they're not well-suited to pricing externalities, except in cases where vehicle characteristics (e.g. weight or emission) can inform rate adjustments. (if supported by comprehensive, centralized vehicle data). The 'use-it-or-lose-it' aspect of time-based charges may encourage greater vehicle use, counter to congestion and emissions goals.[95] However, with collection costs of between 1-5% of revenue, the tool is financially efficient.[96]

Vignettes maintain high levels of privacy, requiring minimal personal data, and involve little inter-jurisdictional data or revenue exchange.

[91] Booz & Co. (February 2012). *Study on Impacts of Application of the Vignette Systems to Private Vehicles –FINAL REPORT*. Prepared for: European Commission Directorate – General for Mobility and Transport. https://transport.ec.europa.eu/document/download/ad36ce6b-0fb8-4882-b595-f414baa9fc56_en?filename=2012-02-03-impacts-application-vignette-private-vehicles.pdf&prefLang=sk pp4-5, 11.
[92] European Commission 2013:3.
[93] Booz & Co 2012:13.
[94] Carey P. (January 2013). *The European Experience Of Motorway Vignette Schemes For Cars*. Paying for Roads: What is the way forward? Supplementary Paper. Independent Transport Commission. 94.pdf (theitc.org.uk) pg 12.
[95] Booz & Co 2012:24; Carey 2013:12; European Commission 2013:8.
[96] Booz & Co. 2012:41-42.

Summary

Time-based charges provide sustainable revenue, drawing on a stable base of taxable activity. They are, in effect, a form of fixed access charges, offering simplicity, robustness, and privacy, making them well-suited for recovering general road costs, particularly for occasional or seasonal users. While they may not meet all public policy objectives, their straightforward nature makes them a viable component of a broader road funding strategy, particularly when paired with other, more usage-based tools.

4.1.6 Distance-Based Charges

PRINCIPLES	CRITERION	BY DISTANCE CHARGES
SIMPLE	Know what is owed	✓
	Know how to pay	~
ROBUST	No false positives	~
	No false negatives	~
	Hard to avoid/evade	~
	Enforceable	~
EQUITABLE & FAIR	Transparent	~
	Just	✓
	Vertical equity	~
	Horizontal equity	✓
	Equivalent exchange	~
EFFICIENT	Low administration cost	✓
	Low compliance cost	~
	Good revenue	✓
	Supports choice	✓
	Reduces externalities	~
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	✓
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✓
	Inter-operable	~

Table 24: Distance-based charges against principles

Distance-based charges represent a shift in mindset for the public, requiring individuals to become more aware of their tax obligations and responsibilities beyond simply paying for fuel. Although the process is more involved than traditional fuel taxes[97] transactions can still be kept straightforward.[98]

These charges need careful design to prevent evasion, but with robust systems, compliance rates can approach those of vehicle registration.[99]

Distance-based charges also offer significant flexibility in rate-setting, allowing for nuanced adjustments to address equity concerns and avoid the inequities implicit in input-based taxes.[100]

Efficiency is critical for distance-based charges and digital technologies can help reduce administrative costs without necessarily tracking vehicles. Providing online compliance options and digital credentials can simplify processes.

Flexibility in compliance frequency is also beneficial, e.g., allowing commercial operators to use higher transaction frequencies for cash flow management while households may prefer fewer transactions to balance paperwork and financial impact.

Administrative and compliance costs for distance-based charges - at scale - are generally in line with other road funding tools, with costs equivalent to 5% or less of revenue achievable, depending

[97] CALSTA 2017:51.
[98] CALSTA 2017:59.
[99] Allen + Clarke. (December 2016). *Evaluation of the new Road User Charges System: Cycle three evaluation report*. Ministry of Transport. Wellington. https://www.rules.transport.govt.nz/assets/Uploads/Report/RUC-Evaluation-Cycle-3.pdf pp 57-78; New Zealand Transport Agency. (2023). *National Land Transport Fund Annual Report*. New Zealand Government. https://www.nzta.govt.nz/assets/resources/annual-report-nzta/2022-23/nltf-annual-report-2022-23.pdf pg 53.
[100] Coyle 2011:32-34.

on the technology used, i.e. manual reporting of odometer readings can be relatively inexpensive.[101]

Jurisdictions have options to tailor programs based on policy goals and cost tolerances.[102]

In terms of sustainability, distance-based charges have a reliable future, with projected demand for surface transportation ensuring a robust taxable base.

Privacy concerns are addressed by using information already found in the vehicle or toll registers, supplemented with periodic odometer readings, following proven privacy and security best practices. While adding location data could raise privacy issues, this is manageable through adherence to established standards and establishing an appropriate statutory framework,[103] with public trust depending on institutional transparency and appropriate data handling in practice.[104]

Interoperability across borders requires careful planning and a consistent approach for counting, reporting, and apportioning distances travelled in each jurisdiction, enabling a cohesive application of distance-based charges.

Summary

Distance-based charges introduce a more mindful approach to road funding, requiring active public engagement while offering a flexible, equitable, and sustainable revenue stream. With thoughtful design, they can balance robustness, efficiency, and privacy. By focusing on interoperability, policy goals, and cost management, distance-based charges can complement other tools within an integrated road funding framework, aligning well with future transportation needs.

Distance-based charging is the only proven tool that has the potential to generate sufficient revenue to eventually be a full replacement of the fuel tax.[105]

[101] Hawaii Department of Transportation. (2022). Hawaii Road Usage Charge Demonstration Final Report. Vol I-II. https://hiruc.org/final-report/ Vol II.E3.14-20; New Zealand transport Agency (2023) *Waka Kotahi New Zealand Transport Agency annual report*. New Zealand Government. https://www.nzta.govt.nz/assets/resources/annual-report-nzta/2022-23/waka-kotahi-annual-report-2022-23.pdf page 142. LAO 2023.

[102] Bryer N. (February 2023). *Costs of a RUC Program*. Paper to IBTTA. WSP. https://www.ibtta.org/sites/default/files/documents/2024/Baltimore/Nate_Bryer.pdf page 14.

[103] CALSTA 2017:64.

[104] Coyle 2011:43.

[105] Ministry of Transport. (November 2014). *Future Funding: The sustainability of current transport revenue tools model and report*. New Zealand Government. Wellington. pp 5, 12; Washington State Transport Commission. (January 2024). *Forward Drive road usage charge research and pilot: Final report of findings*. WA RUC. https://www.waroadusagecharge.org/media/final-report/DIGITAL_WA%20RUC%20Final%20Report%20January%202024_v2.pdf pg 17.

4.1.7 Within-Area Tolls/Charges

PRINCIPLES	CRITERION	WITHIN AREA CHARGES
SIMPLE	Know what is owed	✓
	Know how to pay	✓
ROBUST	No false positives	✓
	No false negatives	~
	Hard to avoid/evade	~
	Enforceable	~
EQUITABLE & FAIR	Transparent	~
	Just	✓
	Vertical equity	~
	Horizontal equity	~
	Equivalent exchange	~
EFFICIENT	Low administration cost	~
	Low compliance cost	~
	Good revenue	~
	Supports choice	✓
	Reduces externalities	~
SUSTAINABLE REVENUE	Enduring revenue	✓
	Enduring instrumentality	~
SECURE	Privacy respecting	✓
	Safe-guarded	✓
INTEGRATED	Complementary	✓
	Inter-operable	✓

Table 25: Within-are charge against principles

Within-area tolls and charges are operationally complex, yet they can be implemented in ways that are clear and easy for users to understand. Their enforceability is high, and they can be designed with features to enhance compliance. However, their nature makes them more susceptible to fraud/tax avoidance, requiring active management to maintain effectiveness.[106]

These charges are not inherently inequitable and can be tailored or supported by other tools to address any negative equity impacts. However, current experience suggests managing for equity outcomes is difficult and the three main variations of the tool - tolling[107], retail delivery fees[108], and location-enabled distance-based charging[109] - present the issues each in their own unique way, and certainly not always badly.

In terms of efficiency, the three main approaches vary considerably. Tolling-based methods consume a sizable portion of the revenue they collect (39%[110]). Retail delivery fees are inexpensive for the government to administer (under 1% of revenue[111]) and yield strong revenue – if added to an existing sales tax mechanism. Distance-based methods fall somewhere between these two (3.3-27%[112]). Tolling approaches are likely to be most effective when also used to achieve social welfare goals.[113]

Revenue sustainability is a strength of within-area charges, particularly in densely populated areas, where they can provide a steady funding source, contingent on political support.[114] Privacy is a consideration, as within-area charges using tolling or

[106] https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/congestion-charge-evasion
[107] Amies N. (September 2021). *Family association criticises government over proposed kilometre tax*. The Bulletin. https://www.thebulletin.be/family-association-criticises-government-over-proposed-kilometre-tax; Ministry of Transport et al. 2020:49.
[108] CDM Smith. (June 2024). Retail Delivery Fee Analysis. Washington State Transport Commission. https://leg.wa.gov/JTC/Documents/Studies/2023%20studies/retail%20delivery%20fee/RetailDeliveryFeeAnalysis_FinalReport.pdf ES5; Mandal A. Bhatt M. (July 2024). *Retail Delivery Fees are not the Panacea for States' Transport Budget Woes*. https://www.taxfoundation.org/blog/retail-delivery-fees-states-transport-budget/
[109] Oregon Department of Transportation. (April 2022). *Local RUC Project Evaluation Report to the Secretary*. Local Road Usage Charge Pilot Project. https://www.oregon.gov/odot/Programs/RUF/OReGO_FASTAct_STSFA2017_LOCALRUC_PilotEvaluationReport.pdf page 24.
[110] Croci E. (2016). *Urban road pricing: a comparative study on the experiences of London, Stockholm and Milan*. Transportation Research Procedia 14 (2016) 253 – 262. Urban Road Pricing: A Comparative Study on the Experiences of London, Stockholm and Milan (sciencedirectassets.com) page 257.
[111] CDM Smith 2024:ES2,ES4
[112] Bryer 2023:14
[113] CDM Smith 2024:ES2,ES4; Croci 2016:257.
[114] Transport for London. (June 2007). *Impacts Monitoring – Fifth Annual Report: June 2007*. Transport for London. https://content.tfl.gov.uk/fifth-annual-impacts-monitoring-report-2007-07-07.pdf pp136-139; CDM Smith 2024:ES2, 11-18.

GPS-based tracking technologies can be intrusive. However, evolving best practices are in place to mitigate privacy risks.

Finally, within-area charges are flexible and can be seamlessly integrated with other funding tools within a jurisdiction or across borders, enabling them to complement other revenue systems.

Summary

Within-area charges offer a versatile option for road funding in high-activity areas. Although they are operationally complex and require careful management to prevent revenue leakage, they provide a sustainable, flexible, and adaptable revenue source. With thoughtful design, privacy protections, and integration capabilities, within-area charges can be an effective part of a broader road funding strategy, tailored to local needs and supported by a strong policy framework.

Within-area charges as considered in the project are three quite distinct mechanisms: one based on tolling, another on sales taxes, and the last on location-enabled distance-based charging. The assessments made here average them out to some degree, so it is important to recognize their particular strengths and weaknesses:

- Tolling-based systems, like the London Congestion Charge, are expensive to run. While they generate revenue, their value is in their ability to deliver net social benefits, in particular in relation to the externalities generated when you get large concentrations of motor vehicle activity, e.g. congestion, emissions, and amenity loss.
- Retail delivery fees are relatively cheap to run and can yield proportionally large revenues. However, they are somewhat blunt and can impose significant compliance costs, leading to a heightened risk of accidental or deliberate non-compliance and evasion if not carefully targeted.
- Programs that piggy-back on location-enabled distance-based charging systems to apply additional charges inside areas of interest, across the whole fleet of a jurisdiction are unproven. Currently, their affordability - if applied across the whole vehicle population - is poor, and they can prompt privacy concerns among the public. However, they offer a promise of more nuanced pricing than tolling systems can support, at a potentially lower cost to deploy and operate.

4.1.8 Summary and Comparison

Each tool presents distinct benefits and trade-offs, with none being a one-size-fits-all solution. Traditional tools like fuel excise and fuel sales taxes offer simplicity and stability but struggle with equity and adaptability. Newer tools like kWh and distance-based charges provide greater alignment with modern transportation trends but require more complex implementation and privacy considerations.

Time-based, fixed access, and within-area charges serve specialized roles, suitable for specific contexts like occasional use, urban areas, or high-traffic zones.

PRINCIPLES	CRITERION	FUEL EXCISE TAX	VALUEMETRIC FUEL SALES TAX	KILOWATT-HOUR TAXES	FIXED ACCESS (Registration) CHARGES	BY PERIOD OF TIME CHARGES	BY DISTANCE CHARGES	WITHIN AREA CHARGES
SIMPLE	Know what is owed	✓	~	~	✓	✓	✓	✓
	Know how to pay	✓	~	~	✓	✓	~	✓
ROBUST	No false positives	~	~	✓	~	✗	~	✓
	No false negatives	✓	~	✗	✓	✓	~	~
	Hard to avoid/evade	~	✗	✗	✓	✓	~	~
	Enforceable	~	✗	✗	✓	✓	~	~
EQUITABLE & FAIR	Transparent	~	~	✗	✗	~	~	~
	Just	~	✓	~	✓	✗	✓	✓
	Vertical equity	✗	✗	✗	~	✗	~	~
	Horizontal equity	✗	✗	✗	✗	✗	✓	~
	Equivalent exchange	~	✗	✓	✓	~	~	~
EFFICIENT	Low administration cost	~	✓	~	✓	✓	✓	~
	Low compliance cost	~	~	~	✓	✓	~	~
	Good revenue	✓	✓	~	✓	✓	✓	~
	Supports choice	✗	✗	✓	✗	✗	✓	✓
	Reduces externalities	✗	✗	~	✗	✗	~	~
SUSTAINABLE REVENUE	Enduring revenue	✓	✓	✓	✓	✓	✓	✓
	Enduring instrumentality	✓	✓	✓	✓	✓	✓	~
SECURE	Privacy respecting	✓	✓	✓	✓	✓	✓	✓
	Safe-guarded	✓	✓	✓	✓	✓	✓	✓
INTEGRATED	Complementary	✓	✓	✗	✗	~	✓	✓
	Inter-operable	✓	✓	~	✓	✓	~	✓

Table 26: Overview: Funding tools against principles

Ultimately, a balanced road funding strategy will likely involve a combination of these tools, tailored to meet diverse policy objectives, technological advances, and the evolving needs of road users. By leveraging the strengths and addressing the limitations of each tool, policymakers can create a robust, equitable, and sustainable road funding framework for the future.

4.2 Summary of Observations by Key Principle

4.2.1 Simple

Simplicity for the road user is often a product of one or more of the following:

1. "Hiding" the complexity a step or more back from the road user's point of contact with the tax system, as happens for example with fuel excise taxes, fuel sales taxes, some distance-based charges, and retail delivery fees.
2. Making good, accessible, easy to follow information and education on how to comply widely available through multiple channels, including through 'push media' when a change is being introduced.
3. Practicing the action of paying the tax regularly, allowing the road user to build muscle memory and familiarity, as has been demonstrated in various road usage charge pilots.
4. Keeping the tax mechanism intentionally blunt, sacrificing finesse in favor of simplicity and assurance, as can be the case for example with fixed access (registration) charges and by period of time charges.

Where the technology base exists to have digital services available, there is little reason to rely on bluntness to create simplicity. For example, it does not matter that there are 81 different standard RUC classes under the New Zealand system, because a vehicle will only fit into one such class, and the record of which class (and what tax rate applies) is easily discovered through a quick database query using either the registration plate number or VIN, and relatively easily verified against the relevant vehicle characteristics also held on record. Another example is the registration charge in California, which is very complex, but the user can look up specific costs on the DMV's website by entering their vehicle details.

Sometimes creating a new transaction is unavoidable; however, where it is possible to embed the action of paying tax within something the road user *has to do* or *wants to do*, this greatly increases the simplicity (reduces the marginal additional complexity) of the task.

4.2.2 Robust

A robust tool is not just easy to comply with, but sufficiently difficult to evade, with high enough penalties, that people are deterred from trying. Lower rather than higher rates reinforce this disincentive.

Ideally, proof of compliance will be definitive. To the extent it cannot be, there will be records required to be made and kept, and/or existing systems and checks that can be tapped into, that support triangulation to determine compliance, and to inform the more accurate determination of liabilities and debts when non-compliance is detected.

Exceptions and thresholds should be kept to an absolute minimum as they create opportunities for fraud in support of evasion. If there must be exceptions or thresholds, they should be based on objective, definitive criteria so far as possible.

Because error is a common cause of non-compliance, and debts can often start off very small, enforcement should be empowered to use civil rather than criminal procedures, with an eye to education and bringing people back into compliance. If determining the scale of a liability is a complex undertaking, then giving the tax collector a binding assessment power may be appropriate. If there are criminal offences (e.g. not maintaining compliance equipment in working order), infringement/instant fine options should be available for first offences/as an alternative to taking people to court.

Perceived fairness promotes compliance, so rebate or tax credit provisions, in the event of overpayment, are effective supports for a robust regime.

Enforcement activities - roaming checks, random audits etc. - should be intelligence-led and risk-based, both so that they are perceived as fair and so that they generate higher returns on the effort expended.

4.2.3 Equitable and Fair

Vertical equity is difficult for road funding revenue tools to influence in a positive way. The act of dedicating a tool specifically to funding the road system not only narrows its concern, but logically excludes concern for outcomes besides transportation system outcomes.

Horizontal equity is much easier for transportation taxes to accommodate and promote. Transportation systems are physical things, and costs can be calculated and allocated on the basis of objective material conditions. However, there are multiple dimensions along which horizontal equity might be measured, and any intention to promote horizontal equity should be clearly articulated and the performance parameters equally clearly defined.

Part of what makes a system seem fair is the visible equivalent exchange of value. As such, the use of the funds raised from a transportation revenue tool is important to its legitimacy. Effort needs to be invested in clearly communicating what the funds are being raised for and that they are, in fact, being put to those purposes, and effectively.

4.2.4 Efficient

The easiest way to increase efficiency is to increase the quantity of revenue gathered per transaction. However, there is an inflection point, above which the size of the payment required diverts too much demand and/or induces too much evasion.

Reducing the economic cost per transaction - i.e. both the administration cost and the compliance cost - is the other obvious intervention. The options for doing this vary from tool to tool; however, some generalizations are possible. One option is to provide a digital means of making payment, e.g. an internet payment channel suitable for use with a credit/debit account and a mobile device. Another is to minimize the amount of new information that needs to be supplied as part of each transaction. Physical tokens of

compliance that need to be manufactured, printed, delivered, and/or collected should be avoided. The taxpayer should have some ability to adjust the cadence of payment/compliance to be able to better fit it into their budget and/or routine.

So far as possible, the tax should use pre-existing systems, capabilities, and processes. These should be things the taxpayer generally can't avoid using, e.g. vehicle registration and licensing, periodic business or personal tax reporting. Alternatively, they could be things the taxpayer wants for their own ends, e.g. fuel, or (tax-grade) telematics devices.

To the extent new systems need to be established, the tax should have as broad a base as possible to spread those costs over.

To the greatest extent possible, there should not be exemptions. Such exemptions as there should be few in number, objectively determined, and easy to monitor and enforce.

All transportation taxes have some capacity to induce the taxpayer to internalize indirect costs. However, different tools can have more direct relationships with different externalities. For example, taxes on gasoline and diesel can be adjusted to price carbon content or impurities in support of emissions policies; however, fuel taxes are not good instruments for pricing time-of-day congestion. Using the wrong tool to attempt to address an externality will merely be distortionary.

4.2.5 Sustainable Revenue

In all the cases studied, even if the revenue yields were not sufficient to fund the transportation system through that tool alone, the underlying (taxed) activity could be expected to persist. Even gasoline taxes, despite the forecast downturn, would provide significant revenues for a decade or more.

The greatest risk to any of the tools is loss of legitimacy. Gasoline taxes are at risk of this due to their diminishing efficacy. Although a practical tool, time-based charges, are being phased out in Europe because of their relatively blunt nature. Within-area charges seem to be at heightened risk because they are complex tools that need to deliver specific results to justify their existence; the London Congestion Charge is under scrutiny because it is no longer delivering its core promise; SmartMove in Brussels is yet to launch and is under a cloud because of wider issues with the mobility strategy it is part of.

Gasoline taxes best embody the other critical lesson: rates have to be maintained in real terms relative to the costs attributable back to the population of vehicles or users the particular tool targets. The condition of many gasoline taxes illustrates one dimension of the need for this: preserving the tool from under-charging. However, while indexing rates to inflation and fuel efficiency can manage for this, there is the other risk of over-collecting (over taxing) a population, and tools will ideally have governance mechanisms to guard against this as well.

4.2.6 Secure

Input-based taxes do not rely on personal and private information and are the most secure in that regard. As tools get smarter, they get more intrusive and create new vulnerabilities. However, there are established good practices - including continuous monitoring, learning and improvement - that appear to be applied consistently and from inception.

4.2.7 Integrated

All transportation taxes have the capacity to be deliberately deployed as part of a structured array of revenue tools designed to work together to fairly apportion and gather cost shares, both within a jurisdiction and across jurisdictions. However, this is the exception rather than the norm.

Road network revenue raising is only one area of public policy interest among many and not necessarily the most important: consider how hard it is to maintain real tax rates in normal times, and how easily these rates were discounted in response to cost-of-living pressures in the aftermath of the covid pandemic.

4.3 There is Value in Explicit Cost Allocation

Figure 8: Fair value in return

A consistent theme in the assessment of all seven tools was the importance of having some form of systematic, principled and empirically grounded cost allocation model (CAM) to underpin transparency and to support the attainment of equity goals.

Road tax rates can be set to recover the revenue needed to fund budgeted expenditure. Cost allocation is a systematic process for determining what share of the revenue needed to fund that budget should be raised by each road funding revenue tool and, for each tool, how that burden should be allocated across the vehicles and activities it applies to.

The use of a road generates costs in various ways:

SPACE	MAINTENANCE	EXTERNALITIES
Demand for additional road space	Damage to the road (including maintenance and amortization of initial construction costs, general and unusual weather effects and events, etc.)	Congestion, air pollution (particulates and greenhouse gases), noise, and accidents (health, property damage, etc.)

Table 27: Types of road costs

Ideally expenditure on road networks should occur up to the point where the marginal social benefit equals the marginal social cost. The former concept would include a vast array of benefits such as employment effects, social mobility, and increases in the standard of living that are facilitated by a more efficient transportation network. It is doubtful whether an accurate

model that captures all social costs and benefits can ever be developed. The model's worth depends on its ability to capture the critical issues and yield insights that can be converted into policies which can be applied to the real world to generate the intended effects. A cost allocation model does not deal specifically with the benefit side, although benefits are implicit in the projects approved for expenditure[115].

A CAM is primarily a cost recovery mechanism. Of interest is the degree to which it does this equitably and efficiently. This depends on two factors:

The **theoretical structure** of the model – what is included, what is excluded, how the variables affect each other and so on.	The **actual parameter** values and base data

Table 28: Structure and Parameter

A CAM works through applying a combination of backward and forward-looking data to an attribution framework to answer the following questions:

1. Using budget projections and plans, how much is intended to be spent and on what categories of work?
2. Using data gathered from multiple sources to look backwards, including vehicle register data, odometer readings, and roadside monitoring and enforcement actions, what is the composition of the vehicle fleet and what level of work are the various segments undertaking?
3. Using international and local research, given the nature of the activities to be funded, and the nature of how different classes of vehicle and transportation tasks interact with those activities, to what extent can the costs of any given activity be attributed to a greater or lesser extent to any given class of road vehicle, and what is a fair basis for doing so?

Because any given investment may comprise several attributes, the forward-looking data can involve interrogating projected expenditure down through multiple layers of cost coding. The use of a CAM is not without its areas of debate. What co-efficient to use to recognize the impact of vehicle mass and axle weights on road wear, how to treat space occupied, what costs to include in the cost base, even whether or not funds are hypothecated are all things open to debate and able to be accommodated in the final design of a CAM. The value of a CAM is not in determining '*the truth*', but in providing for a consistent and transparent process for allocating the tax burden that allows for improvement over time and usage patterns shift and better input data becomes available[116].

[115] Infometrics. (December 2008). *Economic assessment of the cost allocation model*. Ministry of Transport Road User Charges Review Group. https://www.transport.govt.nz/assets/Uploads/Paper/Infometrics20Economic20Analysis20of20the20Cost20Allocation20Model.pdf

[116] Department of Infrastructure and Regional Development. (September 2020) *Heavy Vehicle Charges*. Presentation module 4. Heavy Vehicle Road Reform. Commonwealth of Australia. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.infrastructure.gov.au%2Fsites%2Fdefault%2Ffiles%2Fmigrated%2Froads%2Fhe

4.4 Equity-Complexity-Efficiency Trade-Offs are Unavoidable

Delivering on equity outcomes requires good information about what drives inequity. More of this information will be personal or private in nature; all of it needs to be kept secure and managed respectfully.

The systems needed to gather, check, and process this information and to direct interventions inevitably become more complex. They will potentially also be more expensive, although that can be more around needing up-front capital investment to unlock ongoing reductions in operating costs and increased public value.

Digitization can help manage complexity, reduce costs, and provide an accessible user experience. However, introducing new technologies involves increased capital cost and introduces new kinds of risk. The time required to go from a policy decision to a working system can also increase, making the management of public expectations and maintaining a mandate for the change more challenging.

This trade-off exists even with paper-based systems. For example, a one-year duration time license will almost certainly over- and under-charge more road users than a one-week time license might. On the other hand, annual purchasing requires fewer transactions and may be easier to monitor and enforce.

4.5 The Technical Evidence is Readily Available

4.5.1 Good Practices Exist for Every Tool

The literature review revealed significant amounts of information on both what has worked well with each tool as well as what has not. Even relatively new tools like kWh taxes and retail delivery fees have already generated multiple studies, some tackling the theory of each tool, along with others reflecting on the practical lessons emerging from different attempts to implement them.

From this body of work, it was possible to discern what good practice looked like in each case.

Consequently, should a jurisdiction decide to implement any one of the seven tools considered, there is information available to help design a version that is the best it can be in the context of the state choosing to use it.

4.5.2 One Cannot Just ‘Set-and-Forget’ a Tool

The evidence is also clear that no revenue tool is self-maintaining.

For example, indexing fuel tax rates to inflation offers some protection of the real value of the rate, but only as long as the average fuel consumptions remain constant. Improvements in average fuel

avy%2Ffiles%2Fhvrr-consultation-4-hv-charges.pptx&wdOrigin=BROWSELINK; Ministry of Transport. (January 2022). Background to the road user charges (RUC) system. New Zealand Government. https://rules.transport.govt.nz/assets/RUC-CAM.pdf

consumption will erode the tax base, whereas worsening fuel consumption rates will lead to over-taxation (relative to road use).

Good practice is to monitor and adjust road tax rates on a regular cadence. Relatively frequent small increases in tax rates, on a scheduled or other 'no surprises' basis, are less disruptive both to businesses and to household budgets than irregular large changes. The timing of these adjustments can be aligned to budget setting processes to maintain the visible connection between raising revenue and the purposes to which it will be put.

4.6 Ambition Level Matters for Performance

Ambition relates to both the degree of novelty a change process might be proposing, and the degree to which the surrounding system is adjusted to take proper account of a new revenue tool. Higher ambition is associated with better objective performance against the wider suite of principles or policy objectives.

The literature review revealed four concerns that seemed to be less well addressed in the design and operation of the various revenue tools:

1. Whether tools have clear purposes, functions, and expected performances, individually and in the context of the wider revenue system.
2. Whether tools follow established bodies of good practices that relate to the different aspects of their performance, like communicating with taxpayers and citizens, seeking and handling personal and private information and money, and designing processes and interfaces.
3. Whether tools are deliberately tasked to recover fair shares of the cost burden from the segment of road users or road beneficiaries they are designed to reach.
4. Whether tools are continuously monitored, regularly evaluated, and recalibrated as needed to ensure they maintain their effectiveness in fulfilling their allocated role within the policy-defined performance parameters.

Tools did not need to perform poorly against these concerns, yet many did.

The literature suggested two main reasons:

- Older tools, like fuel taxes, fixed-access charges, and time-based charges were introduced a long time in the past, where the tools available, the policy objectives to be served, the nature of demand for road space, and public perceptions of what was fair were simpler and in closer alignment.
- Newer revenue tools, like EV surcharges, kWh charges and retail delivery fees, appear to have been created in a reaction to a need to fill a budget hole rather than as part of a plan to deliberately fund a transportation system. The policy process was not intending an ambitious reform, but a pragmatic adjustment, often seeking to do something 'simple'.

However, simple interventions, implemented quickly, often yielded imperfect results and unintended consequences. So, for example:

- While there are concerns that light EVs are being under-taxed in some jurisdictions, in others, the layering on of additional charges has raised the prospect of them being over-taxed.[117]
- While retail delivery fees generate useful revenues, they cannot do so at the scale that will be required to replace fuel taxes and do so by duplicating existing processes and costs that, in turn, have had to be kept down through large scale exemptions.

In contrast, 'complex' tools like distance-based charges, congestion charges (not addressed in detail in this research), and within-area charges all tended to perform well against both the general principles and against the expected standards of good practice for those tools. This is because proponents needed the public and decision-makers to accept significant changes to how roads, road use, and paying for roads are thought about to build the consent needed to move ahead with change. This, in turn, required the program designers to direct explicit attention towards more than just maximizing revenue and minimizing the cost to the government of raising it.

4.7 Revenue Reform is an Exercise in Change Management

The literature review revealed time and again the importance of recognizing that making major changes to revenue tools and introducing new ones are exercises in change management.

Change processes begin long before a decision to change is made. Typically, the real work only begins once that decision has been made and the mandate for change will be vulnerable until decision-makers and the public are confident that the proposed benefits will eventuate. Continuous attention to maintaining support for the change is needed through design, testing, deployment, and even into ongoing operations.

The most complex part to archive is social and political acceptance. Policymaking is described as a change-oriented activity aimed at transforming, modifying or altering the status quo. If there is no

[117] Jenn A. (December 2018). *Assessing Alternatives to California's Electric Vehicle Registration Fee*. Institute of Transportation Studies. University of California. Davis. https://escholarship.org/uc/item/62f72449 pp 9, 14; Khatib M. (January 2024). *EV drivers in 36 states pay a surplus of fees each year*. EV Hub Data Stories. https://www.atlasevhub.com/data_story/ev-drivers-in-36-states-pay-a-surplus-of-fees-each-year/.

understanding and acceptance of the fact that there is a problem, it will be hard to introduce change and maintain the continuous activity required to bring it into effect.

4.8 Most Promising Tools

All tools considered in this report have the potential to be useful. However, few of them have the potential to serve as a direct replacement for the gas tax or as part of a suite of measures to replace the gas tax as the primary road funding revenue source.

The literature review assessed the short-listed tools against the positive features of the historic fuel taxes. The adjusted ratings below, consider each tool as the primary tool, assuming best practices for its use. A key change is that a stand-alone tool must not only generate *sustainable revenue*, but also ensure it generates *sufficient* revenue.

	ROAD USER PAYS	BASED ON USE OF ROADS	ALL VEHICLES	ALL ROAD USE	SUFFICIENT REVENUE
Input-based taxes					
Fuel sales tax	✓	✓	~	✓	~
Fuel sales tax	✓	✓	~	✓	~
Kilowatt hour tax	✓	✓	~	✓	~
Impact-based taxes					
Fixed access charges	✓	X	✓	✓	~
Time-based charges	✓	X	✓	✓	~
Distance-based charges	✓	✓	✓	✓	✓
Presence-based taxes					
Within area tolls/charges	✓	✓	X	X	X

Table 29: Assessment against positive features of fuel tax

Continued reliance on input-based taxes is a feasible option. However, the diversification of fuel types means there would need to be a suite of tools available, including both fuel excise taxes and kWh taxes, to recover the equivalent of what the historic gas tax could.

Of the impact-based tools, distance-based charging is best suited as a stand-alone replacement. Neither time-based charges nor fixed access (registration) charges can supply the revenues needed without introducing significant equity and affordability challenges.

Within area charges lack the reach across the network and vehicle fleet needed to fairly raise the revenues required.

Consequently, the two most promising tools among the seven for modern road funding, and to - eventually - replace the fuel-tax, are **Distance-Based Charges** and **kWh Taxes**.

1. ***Distance-Based Charges:*** These charges stand out due to their adaptability and alignment with actual road usage. They provide significant flexibility in setting rates based on vehicle type, frequency of use, and other equity-focused factors, making them an equitable option for all users. By leveraging digital technology, distance-based charges can efficiently address compliance and administration costs. This tool is sustainable and scalable, able to grow with transportation demands and shifts in vehicle types. Although more complex to implement, distance-based charges offer the best potential for a long-term funding solution that reflects road usage and supports infrastructure needs, being the only proven tool that has the potential to generate sufficient revenue to be a full replacement of the fuel tax, if applied across all vehicle types.

2. ***kWh Taxes:*** As EVs become more prevalent, kWh taxes provide a sustainable way to generate revenue from EV charging, particularly at public stations. While still in the early stages, kWh taxes hold potential as a privacy-conscious and stable revenue source. If the issue with home-charging could be addressed sensibly, kWh taxes could provide a scalable, adaptable funding stream as the EV market grows. Despite challenges with initial implementation, kWh taxes could be a future-facing option that aligns with the transition toward electric mobility. However, kWh taxes also show a greater equity risk as consumption is dependent on vehicle efficiency.

5.0 Options

Based on the research done, three potential options were developed that could - in theory - be pathways to a future sustainable transportation funding system in California.

NOTE: All three options assume that there could be a fixed access (registration) charge in place that also serves to recover a minority share of the road network funding sought, consistent with good practice design for such tools. Any surcharges based solely on whether a vehicle uses a different motive power/fuel type would be removed (although other surcharges might still apply in relation to other concerns, e.g. air quality standards).

5.1 A Comprehensive Array of Fuel Taxes

5.1.1 Rationale

People understand the relationship between fuel consumption and road use. Despite the inequities that can result, the idea that the more you drive, the more fuel you use, and the more tax you pay, is considered fundamentally fair.

Adopting an array of fuel taxes - for electricity, gasoline, diesel, hydrogen, bio- and renewable fuels, and any other new fuel type that might emerge - works with this general acceptance.

5.1.2 How it Could Look

Each fuel would have its own rate of tax based on the estimated average range per chargeable unit of fuel (miles per gallon equivalents, MPGe). These would need to be reviewed regularly and updated to reflect changes in average fuel economies.

The tax on liquid fuels would be collected in the same manner as is currently the case for gasoline and diesel. Electric fuel would be taxed at the point of dispensing to vehicles, whether at public or private charging points.

From a road user perspective, tax would remain a '*pay-at-the-pump*' activity. From the tax collector's perspective, collecting the tax would involve varying numbers of relationships depending on the fuel type. It would certainly involve working with more parties than is currently the case.

5.1.3 Opportunities

The main advantage of this option is that it minimizes the number of taxpayers confronted with change at any one time. It also bundles up the change with the process of acquiring the new alternatively fueled vehicle, i.e. people who are not changing vehicles do not have to make any other changes either, or certainly not just for the sake of paying tax.

Fuel taxes are paid by visiting out-of-state drivers engaged in driving any meaningful distance on the state's roads. A kWh tax on public charging stations would extend the net to include out-of-state EVs.

The basic mechanisms of volumetric/liquid fuel taxes are well understood and can be copied across to new liquid motor fuel types with relative ease and confidence.

5.1.4 Challenges

While any liquid fuel can be taxed according to the existing model, it cannot be guaranteed that the number of taxpaying entities would remain as low as is currently the case. For example, if hydrogen enters common use with heavy commercial vehicles, it lends itself to localized/decentralized production. Consequently, administration costs and evasion may be higher/more common than is currently the case with gasoline.

This option only achieves fairness if at home EV charging is captured.

- Pennsylvania had attempted to capture at-home charging of light EVs through a tax reporting process; however, this approach is being discarded in favor of a fixed registration fee due to significant compliance challenges.
- Even if smart meters are used in homes to replicate the ease of a pay-at-the-pump type process, which will be an expensive undertaking in its own right, these are easy to bypass to avoid the tax as light EVs can slow charge off standard domestic power points.
- Vehicle data can be drawn on to capture a record of the charge received, and/or artificial intelligence tools may be able, in time, to determine whether and when a household is charging an EV. However, at the point these options start being used, the controls become highly complex and intrusive.

Rate setting for each fuel type will be challenging to do and to explain and justify to the public. It will depend on having good enough information on road use and fuel consumption by fleet segment to arrive at a robust average MPGe.

Because fuels are only proxies for road use, a fuel type that is used by a wide age-range of vehicles, or across a wide range of use cases, is more likely to have a less representative average MPGe and, therefore, be less equitable.

Hybrid vehicles will present equity challenges as the alignment of liquid and electric fuel rates may result in under- or over-charging. Assuming equity is a concern, the sum of registration type fees paid for hybrid vehicles would ideally be adjusted up or down to main average equity.

5.2 Pure RUC Model

5.2.1 Rationale

Once people understand that the distance driven on roads has the most direct relationship to creating and meeting costs of any basis for taxation, they can recognize that counting taxable miles can be fairer than simply charging for fuel. This is especially true if relevant vehicle characteristics are used to set different rates. For example, people intuitively understand why heavier trucks might pay more per mile than lighter cars.

A pure RUC model offers two key advantages: it can be fairer, and it reduces the complexity and potential for confusion that arise from having multiple different fuel taxes for various fuel types.

5.2.2 How it Could Look

The primary feature of this approach is the removal of all (road network funding) fuel taxes and making all vehicles subject to RUC.

The precise details of the RUC scheme are up for debate. However, broad features could reasonably include:

- Different per mile rates according to vehicle gross mass, number of axles, and axle masses, set by an independent pricing authority tasked with meeting revenue performance targets derived from the budgeted and projected cost base.
- An open market of RUC account managers who provide the public facing RUC facilitation, payment and remittance services; leveraging value-added services to bring down the marginal cost to serve and innovate to reduce the cost of compliance for taxpayers.
- An outcome- and standards-based framework, supported by effective auditing and performance management tools, to regulate RUC account managers, processes, and technologies to ensure the effective operation of the program.

5.2.3 Opportunities

Moving all vehicles on to RUC significantly simplifies the administrative demands of the road funding revenue system, improving its efficiency and ease of upkeep. All vehicles will have their cost share and tax rates calculated within the same single process and methodology, reducing duplicative effort, including for smaller scale fuel types.

Moving all vehicles onto RUC will allow road taxes to be levied more equitably based on their actual use of publicly funded roads. This would eliminate the complexity of determining the relative average fuel efficiency of the differently fueled fleets, including hybrid vehicles.

Some vehicle owners may elect to adopt RUC services that collect time and location data, to help identify travel over non-taxable roads for example. Almost any level of uptake will generate road use data that,

when aggregated and anonymized, can greatly enhance the timeliness and richness of data available to network planners. Tax-grade digital systems are, by their very nature, platforms more than merely devices, and their users can potentially gain opportunities to adopt a wide array of safety and productivity enhancing services.

5.2.4 Challenges

There is no single 'right' design for RUC programs. There are good practices that can be applied regardless of the larger design choices. However, several key decisions depend on policy objectives and contextual opportunities and constraints. Such as:

- Whether to adopt regular post-pay transactions or on-demand pre-pay transactions.
- Whether to allow manual transactions or digital ones.
- Whether to charge all vehicles the same rate or have a graduated schedule of per mile fees.
- Whether to apply a different assurance regime to heavy commercial vehicles compared to other vehicles.

These choices are influenced by specific policy objectives and local circumstances.

For most road users, a change to RUC will represent change, not merely for its own sake, but primarily for the government's benefit. This is a cost of change they would not choose to take on for their own purposes. Consequently, the messages about improving equity and fairness, and providing people with information to make better choices about where to spend their transport budget, become more crucial than they would be when introducing other tools.

Revenue neutrality is unlikely to be achievable in any real sense. Either the starting RUC rates will need to be higher than a straight translation from the gasoline tax might suggest, or a lower net yield of revenue will need to be tolerated through the transition period.[118] There may also be a revenue interruption, depending on how the transition from fuel taxes to RUC is timed. This may have implications for budgets, including in relation to any bond servicing obligations.

The changes required are complex, both technically and politically. Consequently, longer lead times are likely to be necessary, especially if greater use of digital technologies is expected or required, or a wider range of suppliers is to be enticed into the market. In turn, change fatigue among decision-makers and the public is a heightened risk.

Enforcement and assurance systems will need to be adapted and empowered to monitor for, and respond to, new risks to the integrity of the revenue system. There is likely to be more non-compliance, including accidental non-compliance, and consequential debt.

If location services are mandated or simply provided for, as part of the RUC system, then the public will need to be given proper assurance around the responsible use of their location data, with an

[118] Ministry of Transport 2014c:10.

appropriately robust and monitored regulatory framework in place to address the privacy implications of this tracking.

Heavy and commercial vehicles are not just 'big cars'. On the one hand, a RUC program is a RUC program. On the other hand, the fair share of road costs attributable to different configurations of heavy vehicles can be quite diverse. The way in which costs are attributed to specific vehicle designs will inevitably incentivize changes in fleet composition.[119] Fleets will often already have fleet-based approaches to managing regulatory and other tax, e.g. their liabilities under the International Fuel Tax Agreement (IFTA) or International Registration Plan (IRP). The optimal design of a RUC program for these vehicles may be quite different to that for private light passenger vehicles. Careful consideration is needed, both for determining the differences in the required regimes and for defining the boundary between them.

Casual vehicles from out-of-state are unlikely to participate in the RUC program unless already enrolled in a compatible one in their home state. An alternative means of charging these vehicles will be needed, such as time-based licenses available at or before the port of entry or via online pre-purchase.

5.1 Mixed model

5.3.1 Rationale

The most common problems with road funding revenue tools is that the rates charged are too low and/or their coverage of the motor vehicle fleet is incomplete. Although the existing fuel taxes are becoming more and more exposed to equity challenges, they are still effective at drawing a contribution towards meeting road network costs from people driving gasoline and diesel-fueled vehicles. However, there is greater inequity in not taxing drivers of alternatively powered vehicles at all, or over-taxing them through a confusion of ad hoc charges.

The mixed model recognizes that, while charging all road use through RUC may be desirable, ultimately easier to understand, and fairer, it involves significant change. To minimize the cost and disruption of change, the mixed model retains gasoline and diesel taxes while introducing RUC for all vehicles using any other fuel type. It relies on the natural evolution of the vehicle fleet to gradually transition people to RUC. This continues until uptake is sufficient to substantially reduce the risk of moving the remaining fleet from fuel taxes to RUC.

5.3.2 How it Could Look

Gasoline and diesel taxes would remain in place, with rates adjusted as necessary to ensure the total revenue collected from these fleet segments is proportional to their estimated net use of the road network.

[119] Allen + Clarke. (December 2016). *Evaluation of the new Road User Charges System: Cycle three evaluation report*. Ministry of Transport. Wellington. https://www.rules.transport.govt.nz/assets/Uploads/Report/RUC-Evaluation-Cycle-3.pdf; European Commission 2013.

RUC would be introduced for all vehicles not paying for their road use through one of the two fuel taxes. If and when vehicles using new fuel types, such as hydrogen, are introduced, they would be placed onto the RUC program instead of having a new fuel tax introduced. Hybrid vehicles that also rely on a taxed fuel would require special treatment, such as being charged a lower rate than equivalent pure EVs/ZEVs.

5.3.3 Opportunities:

With more than 1.5 million[120] ZEV vehicles in service, the current level of ZEV uptake in California is high enough that even limited implementation of a RUC scheme should be able to attract multiple private account managers and deliver economies of scale.

This option provides the opportunity to enjoy the best of both worlds. The revenue shortfall threatened by the uptake of ZEVs is addressed in a principled and balanced way, while the vast majority of drivers are spared the apparent and actual costs of change.

- Future movement of these drivers onto RUC then becomes more of an 'opt-in' process as they adopt ZEVs.
- The rate of change can be influenced through vehicle supply-side measures, such as emissions reduction regulations.

The more gradual migration of the fleet over to RUC would provide more time for:

- The RUC services market to develop,
- Suppliers to innovate and explore ways to generate efficiencies and opportunities for value-added services,
- Identifying and resolving teething issues with the program, and
- Field testing and refining audit and enforcement approaches.

[120] Retrieved November 28, 2024. California Energy Commission. Zero-Emission Vehicle and Infrastructure Statistics Collection: Light-Duty Vehicles. https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics-collection/light

5.3.4 Challenges

There is a potential efficiency/pragmatism trade-off to be confronted:

- Although there is a large number of ZEVs in service in California, achieving real economies of scale may depend on bringing the heavy vehicle fleet under the RUC regime sooner rather than later (i.e., not waiting for the accelerated turnover to ZEVs to push the change). This is because heavy vehicles can be expected to deliver more revenue per unit of administrative effort[121]. These vehicles also typically exhibit higher demand for value-added services, for both commercial and regulatory purposes, so their inclusion could help ensure that the market views providing RUC services as an attractive opportunity.
- Alternatively, because of the potential complexities of designing a RUC program for heavy commercial vehicles, as well as the operational complexity for the user, it may be necessary to approach their inclusion in any RUC program on a different timeframe. This approach would focus solely on light ZEVs and accept the optics of a higher administration cost per dollar of revenue over the transition period.

This option does not address the equity issues associated with fuel taxes. These may be amplified, depending on how the system decides to treat hybrid vehicles that rely in part on a taxed liquid fuel. The choices are to:

1. Apply a standard RUC rate and offset or refund fuel taxes paid,
2. Apply a reduced RUC rate, or
3. Not apply RUC at all.

The first approach is complex for the taxpayer, the second will generate debate about the relative fairness of whatever reduced rate is agreed upon, and the last is distortionary.

As with the pure RUC model, vehicles from out-of-state pose a challenge. However, this is amplified under the mixed model. What constitutes a fair approach may differ depending on the vehicle's power source, as a gas-fueled vehicle will pay some tax if it refuels in the state, while an EV would not.

The lower RUC rate for hybrid vehicles that also use a taxed fuel is likely to attract debate around the assumptions used to arrive at the average. There may also be concern from hybrid vehicle owners who consider the average overstates their use compared to that of users of other (e.g., heavier) vehicles. This may result in a call for weight-differentiated rates and a more complicated classification system.

[121] New Zealand Transport Agency administrative RUC data shows that, in the 12 months to 30 September 2024, the ~200,000 heavy RUC vehicles in New Zealand paid NZ$1.35 billion in tax, compared to NZ$0.9billion from the ~900,000 light RUC vehicles. Heavy vehicles averaged NZ$807 per transaction and NZ$6,700 per vehicle per year, as compared with NZ$430 per light vehicle transaction and $1,000 per vehicle per year.

6.0 Discussion & Conclusions

6.1 Discussion

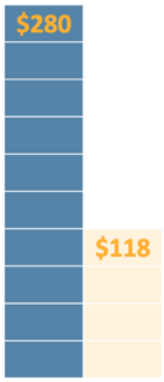
6.1.1 Principles Driving Decisions

Different states, countries, and even stakeholder groups apply varying weightings to the principles guiding transportation funding decisions. In California, based on the overall policy direction to date, the focus of prior research, and discussions within the state, the principles of fairness, equity and efficiency are likely to carry greater significance.

These priorities reflect California's commitment to addressing equity and environmental concerns, while minimizing administrative burdens, and aligning with the state's broader goals for achieving sustainable and transparent transportation funding.

6.1.2 The Role of Zero-Emission Vehicles in Funding Reform

Currently, ZEVs in California are not taxed based on road usage, unlike ICE vehicles, which are taxed via fuel consumption as a usage proxy. Instead, ZEVs are subject to an annual flat RIF charge. This flat rate charge disproportionally benefits high-mileage ZEV drivers, encouraging greater network usage without a proportional increase in tax contribution. As ZEV adoption accelerates in California, revenue from the RIF will likely increase. However, these flat-rate charges are inherently limited in their ability to address infrastructure funding.



*ZEV's only pay **40%** of the fuel tax equivalent compared to the annual state gas tax paid by the average Californian.*

Figure 9: ZEV vs ICE

While the RIF helps address some of the funding gap, ZEVs still pay only about 40% of what an average ICE vehicle contributes in fuel taxes alone. Implementing a kWh charge or a distance-based RUC for ZEVs offers a more equitable solution by linking contributions to actual usage.

However, significant barriers exist for a kWh charge, particularly in addressing home-charging, where the majority of EV charging occurs. Home charging is both cost-effective and convenient for EV owners but capturing this usage in a tax system would require costly infrastructure investments, such as smart meters for every EV owner's place of residence. In contrast, a phased RUC model for ZEVs offers a practical way to begin addressing these equity issues without the immediate need for extensive - and expensive - infrastructure changes.

To ensure that the move from contributing too little doesn't result in contributing too much, it is important that the RIF be revoked when implementing a new charging system.

6.1.3 Challenges of a Full RUC Implementation

Transitioning all vehicles in California to a full RUC model would be a monumental undertaking, given the state's more than 35 million registered vehicles[122]. A sudden shift would face significant logistical, political, and public resistance. A phased approach, beginning with ZEVs, aligns better with the 2035 ZEV adoption mandate and provides a manageable pathway for scaling systems and public acceptance over time.

6.1.4 Mixed Model Shows Merit for California

The mixed model - supplementing existing fuel taxes with a phased transition to a distance-based / RUC model - emerges as the most feasible approach when considering these higher-ranking principles, as it balances equity with the practical realities of implementing system changes.

The fixed access (registration) charge should remain part of the funding system to recover a small share of road network costs, ideally for common costs. Surcharges based solely on a vehicle's fuel type or motive power should be removed, although surcharges addressing other concerns, such as air quality, may still apply.

FIXED ACCESS / REGISTRATION CHARGES • Base Fee • CHP California Highway Patrol Fee • Vehicle License Fee • County/District Fee • Smog Abatement Fee • Alternative Fuel/Technology Registration Fee • Alternative Fuel/Technology Smog Fee • Transportation Improvement Fee • ~~RIF Road Improvement Fee~~ • Weight Fee	**DIESEL EXCISE TAX** **GASOLINE EXCISE TAX** **FUEL SALES TAXES** **NEW: RUC FOR ZEV'S**

Table 30: Potential funding model set up

6.1.5 Advantages of a Mixed Model in the Context of California

1. ***Leveraging Existing Systems:*** The mixed model continues to utilize the existing fuel tax infrastructure, which is efficient and familiar, while gradually addressing its declining revenue and equity gaps. This approach allows for a smoother transition, reducing the lead time needed for implementation, as compared to a full system overhaul.

2. ***Scalable RUC Implementation:*** By initially applying RUC to the smaller population of ZEVs, the mixed model enables California to refine its systems, manage enforcement effectively, and

[122]Retrieved 28 November, 2024. California Department of Motor Vehicles. *California DMV Statistics*. https://www.dmv.ca.gov/portal/file/california-dmv-statistics-pdf/

reduce setup costs. Existing frameworks, such as vehicle registration processes, can be used to validate odometer readings and enforce compliance.

3. ***Technology Integration:*** Retrieving data directly from vehicles for RUC reporting has proven feasible in pilot projects with manufacturers, reducing the need for additional hardware and lowering administrative costs. While the topic is still evolving, the native technology in newer vehicles like ZEVs makes them particularly well suited for this type of reporting. Over time, regulatory frameworks can facilitate broader use of in-vehicle data, ensuring consistency and accessibility for both users and account managers.

4. ***Flexible Rate Setting:*** A RUC allows flexibility in setting rates based on vehicle type, emission factors, and distance traveled. Location-based options could further enhance equity by differentiating rates based on geographic use patterns. However, when starting with a mixed model, the rate differentiation can be kept to a minimum, as only certain vehicle types will be on the system. That said, future scenarios should be considered in system design.

5. ***Public Acceptance and Gradual System Change:*** The phased introduction of RUC allows the public to adjust to a new system incrementally. This reduces resistance, builds trust, and enables the state to demonstrate the benefits of the system before scaling it further.

6.1.6 Acknowledging Limitations

While the mixed model addresses many challenges, it cannot resolve the revenue decline resulting from more fuel-efficient ICE vehicles without aggravating equity issues. However, applying a fixed surcharge to more fuel-efficient ICEs, allowing the excise tax to be set lower than otherwise, is one way to soften the equity impact. These issues would persist until the complete transition to ZEVs and the adoption of a full RUC system. Nonetheless, this approach balances urgency with practicality, providing an effective interim solution that minimizes disruption while paving the way for a more equitable and sustainable funding framework.

6.2 Conclusion

6.2.1 Navigating California's Transportation Funding Future

The mixed model aligns with California's policy objectives and addresses key challenges associated with equity, efficiency, and feasibility. By combining the efficiency of existing fuel taxes with a phased RUC transition, starting with ZEVs, and including hybrid vehicles, the state can manage immediate revenue needs while building a foundation for long-term sustainability in transportation funding. This approach ensures a smoother transition to new tools, balancing the need for quick action with the importance of deliberate and inclusive system design.

While the literature review focused on the instrumentality of various tools, it is evident that successful implementation requires attention to factors beyond the tools themselves. Critical decisions made throughout the process shape not only how effective the tools are but also how they are perceived by stakeholders.

To ensure the effectiveness of any chosen tool(s), they must have a clear purpose, function, and expected performance, both individually and within the larger system. They should align with established good practices, particularly in areas such as public communication, privacy, financial management, and process design. Revenue tools should be designed to equitably distribute the cost burden among road users and beneficiaries, reflecting fairness in policy.

Finally, ongoing monitoring, evaluation, and recalibration are essential to maintain the tools' effectiveness within the defined policy framework. This iterative approach ensures that the tools remain adaptable and capable of meeting California's evolving transportation funding needs.

6.2.2 No Perfect Solution

There will always be trade-offs, and no perfect solution exists. However, it is crucial to make intentional decisions and be transparent about the accepted downsides. For example, while the inequities of the fuel tax between newer and older ICE vehicles may not be resolved immediately, phasing it out over time as drivers transition to ZEVs addresses the issue gradually. This aligns with California's 2035 mandate to end the sale of ICE vehicles, ensuring that policies evolve with the changing vehicle landscape.

6.2.3 Good Practices Inform Better Tools

The literature highlights significant knowledge of what constitutes good practice for different tools. From older mechanisms like fuel taxes to emerging tools such as kWh taxes and retail delivery fees, the collective experience offers insights into theoretical and practical lessons. Jurisdictions can draw on this knowledge to design tools optimized for California's unique needs, ensuring that each option operates effectively within the broader system.

6.2.4 Avoiding 'Set-and-Forget' Approaches

No revenue tool is self-sustaining. Regular monitoring, evaluation, and recalibration are essential to preserve functionality and fairness. For instance, while indexing fuel taxes to inflation mitigates erosion of their value, shifts in fuel consumption patterns can still undermine revenue. Similarly, small, predictable adjustments to tax rates are less disruptive and maintain transparency, fostering public trust and ensuring the connection between revenue and infrastructure goals remains visible.

6.2.5 Ambition Levels and System Design Matter

Tools perform better when their purpose, function, and expected outcomes are clear and when they are embedded within an ambitious, well-thought-out system. High-ambition changes, such as distance-based or congestion charges, often outperformed simpler measures due to their deliberate design and focus on gaining public and political acceptance. In contrast, simple, reactive measures, such as EV surcharges or retail delivery fees, sometimes produced unintended consequences, such as over-taxing certain user groups or failing to scale effectively.

6.2.6 Balancing Equity, Complexity, and Efficiency

Achieving equity often involves trade-offs with complexity and efficiency. Addressing inequities requires detailed information, much of which is personal or private, and this data must be managed securely and respectfully. The systems required to process such data - whether digitized or traditional - tend to be more complex and, initially, more expensive. However, these investments can yield long-term operational efficiencies and public value. Digitization offers opportunities to reduce costs, enhance user experience, and manage complexity.

Simpler approaches, such as flat-rate charges like the RIF, can be administratively efficient but risk inequities, such as disproportionately benefiting high-mileage ZEV drivers. Conversely, more granular approaches, like distance-based charges, are fairer but require more complex systems for implementation and enforcement.

Thoughtful integration of new technologies is essential, as while they can streamline processes, they may also introduce new risks and higher up-front costs. Managing public expectations throughout these transitions is critical to maintaining the mandate for change.

A well-designed funding framework must balance these trade-offs, ensuring equitable cost recovery while maintaining administrative efficiency. Striking the right balance requires thoughtful system design, clear communication with stakeholders, and iterative improvements.

6.2.7 Revenue Reform as Change Management

Introducing new revenue tools or reforming existing ones requires careful change management. Beyond technical design, achieving social and political acceptance is critical. Stakeholders need to recognize the problem being addressed and trust the proposed solution to deliver promised benefits. This process requires sustained engagement and attention throughout design, testing, implementation, and ongoing operation.

6.2.8 Transparency is Important

Impacts from deteriorated roads are estimated to cost the Californian economy over $65 billion per year, costing the average Californian a significant premium. While cost reductions will not be immediate after the introduction of a new tool, it is critical that progress is being made transparent to ensure continued acceptance over time: 'I pay – I get value in return'.

6.2.9 A Path Forward for California

To develop a sustainable, robust, equitable, and dedicated revenue stream to replace, or supplement, fuel taxes, California should embrace a holistic approach. Tools must align with established good practices, equitably distribute costs among users, and evolve through continuous monitoring and adjustment. Importantly, the process of reform must focus as much on public and political buy-in as on technical solutions, recognizing that funding reform is as much about managing change as it is about generating revenue.

By addressing these elements comprehensively, California can create a transportation funding framework capable of supporting its infrastructure needs now and into the future.

About Transportation California

Transportation California is a non-partisan, non-profit coalition representing the statewide transportation construction industry that designs, builds, maintains, and repairs California's multimodal transportation system. Founded in 1990, today its member companies and groups account for more than 200,000 California jobs. We advocate for policy solutions to improve our multimodal transportation system, grow our economy, and enhance our quality of life. Our mission is to develop robust, sustainable, and dedicated funding to properly maintain California's multimodal transportation infrastructure and build the transportation system of the future.

Report prepared by Nina Elter and Peter Carr.

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Appendices
Transportation Funding Tools for California
Literature Review

March 2025

Contents

Appendix 1: Methodology

The literature review began with reviewing a small number of general studies, in particular the 2024 *Compendium of Revenue Alternatives in Response to Fuel Economy Improvements and Vehicle Fleet Electrification* published by The Eastern Transport Coalition, and the 2014 suite of papers from the *Future Funding* project undertaken by the New Zealand Ministry of Transport.

These studies yielded typically cursory analyses of the various principles and tools most commonly encountered in the sphere of road funding revenue tool discourse. In addition, they provided an inventory of jurisdictions doing interesting things in this domain, a curated survey of references, and an abundance of key words, all of which then supported further document searches.

Attention was given to identifying meta-studies from the United States, given the context of the discussions these research is intended to support. Also, the sheer diversity of arrangements across the 50 States was often sufficient to provide a sample reflective of the range of international approaches, with some notable exceptions. The exceptions of note were value-added taxes, which are not used in the United States, and kilowatt-hour charges, which are used only in the United States. Selected international studies were then drawn on to round out the commentary and validate the analysis.

Reviewing the literature involved: using each document's table of contents to identify sections or chapters directly focused on subjects of interest; reviewing executive summaries and conclusions sections for overviews of the document's treatment of those issues; and then exploring other sections or chapters that, based on their topics, might comment, if even tangentially, on the main subjects of interest and provide supporting evidence on points highlighted in the executive summary or conclusion.

General studies tended to address, albeit sometimes in only a cursory way, issues of administrative and compliance ease, equity impacts, and revenue potential. Questions around enforcement, data privacy, and interoperability were usually touched on as well. However, quantitative performance data was not uniformly available and the literature search would then need to dig down through references to find specialized studies, which imposed a significant time-cost on each investigation.

Each reviewer undertook their own review of the literature for each tool. The reviewers then shared their findings and discussed any notable points of difference and the basis for these, before resolving on a shared interpretation, weighting, or conclusion.

Due to the need to develop the analytical framework to inform selecting the target revenue tools, and to select evaluation criteria to guide the literature review, the initial document search and review focused on general discussions of good practices in taxation. To these materials were added various documents produced in support or summary of recent state-level examinations of mileage-based usage fees and other alternative funding tools, to check the extent to which the general

principles of good tax design were applied to and reflected in the design of the various proposed and live pilot programs.

In addition to providing good practice principles and evaluative criteria, this work populated our inventory of possible revenue tools and developed an accompanying taxonomical structure. This taxonomy was synthesized from previous examples from the literature in order to support the process of short-listing the tools subject to deeper investigation.

This work also involved establishing hypotheses as to the performance of each tool against each of the evaluative criteria. The general surveys were relied on in the first instance, along with the prior knowledge of the authors, to attempt to populate these. Where necessary, additional sources were found to inform the initial estimate of performance. This was particularly true for the types of tools subsequently categorized as 'amenity-based' and 'commerce-based'.

The tool-specific reviews started with looking at the kilowatt-hour taxes followed by 'by period of time' charges, with the intent being to use the tools with potentially more contained literature bases to build familiarity with applying the evaluative framework. After these two, fuel excise taxes were explored, followed in order by fuel sales taxes, fixed access (registration) charges, distance-based charges, and, lastly, 'within area' charges.

The tool-specific reviews inevitably influenced each other. The latter reviews often yielded further information of relevance to the earlier reviews. This was especially the case where tools either shared some degree of common instrumentality (e.g. time-based charges, and fixed access (registration) charges), or where in fact they had significantly divergent instrumentalities (e.g., fuel taxes and kilowatt-hour taxes).

Predictably, newer tools suffered for a lack of evaluative studies, and more reliance was made on theoretical estimates, and critique from news articles and op-ed pieces. All conclusions drawn in these cases should be considered interim and indicative of areas where more testing is needed.

The synthesizing process was a chance to sense check the interim conclusions arrived at over the course of reviewing the seven short-listed tools. Particular attention was given to what the treatment of one question with one tool might suggest about gaps or bias in how the same question was addressed for a different tool, and whether the weighting of evidence was consistent from one review to the next.

The synthesis process then revealed areas where additional documents needed to be identified and reviewed to address further questions raised.

Appendix 2: Principles of good taxation

PURPOSE

The purpose of developing the set of good practice tax principles was to provide a structure for gathering data on the degree to which the design of various taxation methods explicitly consider and provide for being 'a good tax'. In consequence of this, the intent of this task was not to attempt to invent an objectively true set of principles. Rather, it was:

1. to compile a *reasonable* set of principles, including options
2. to articulate the reasoning behind the choices made
3. to provide an opportunity to adjust the final set before commencing with the literature review.

The final set of principles would then structure two levels of interrogation of the literature:

1. **Source Analysis**

   Does the document provide information that addresses how tools we are interested in perform relative to the principles identified? Which tools? Which specific examples? Is it a reputable source?

2. **Subject Analysis**

   What does the document tell us about a particular tool's performance relative to the principles? In general? In the specific cases it addresses? What is the quality of the evidence it relies on in each specific case and in relation to each specific criterion?

RATIONALE

Taxes have purposes. Because they have purposes, they can be assessed as 'good' or 'bad' relative to achieving that purpose and, therefore, analysed and assessed to determine to what extent, and/or in what ways, they are so. From this an analyst can discern the causes of a tax's better or poorer performance, including the extent to which its virtues or flaws may be intrinsic in nature or a consequence of context.

METHODOLOGY

The set of good practice tax principles that informed the development of this report was developed from a targeted literature review in three parts.

The first part was concerned with more theoretical studies and international literature, identifying the principles revealed through the application of 'top down' analytical methods. Within this part, consideration was also given to the question of whether the principles could, in fact, be used to

determine and differentiate the efficacy of different revenue tools or different variations of the same tool. This part began with Adam Smith's four principles of good taxation and then explored literature that unpacked and interrogated the underlying complexity of Smith's basic premise. Key resources included the National Conference of State Legislatures' 2001 paper *Principles of a High Quality State Revenue System*, and the Association of International Certified Professional Accountants 2017 paper *Tax Policy Concept Statement 1 Guiding principles of good tax policy: A framework for evaluating tax proposals*. An international perspective was introduced through two New Zealand government documents, themselves drawing on OECD and other international literature, the Inland Revenue Department's 2023 report *Taxation Principles Reporting Bill: A briefing note prepared for the Finance and Expenditure Committee*, and the Tax Working Group's 2019 paper *Future of Tax: Final Report Vol. I*.

The second part focused on grounded theory from across the body of road taxation studies that have been produced in the United States over the last decade or so, which identified the most relevant principles of good tax design as revealed by end user concerns and interests. Within this part, consideration was also given to whether the literature would support addressing the question of whether a type of tax or particular design of that tax was objectively 'good'. This part reviewed the guiding principles and evaluative frameworks that guided the Surface Transportation System Funding Alternatives (STSFA) and the Strategic Innovation for Revenue Collection (SIRC) programs, and the applied frameworks developed and adopted for road usage charges programs in California, Colorado, Hawaii, and Washington State.

The methodological intent in parts one and two was not to provide a comprehensive survey of the literature relating to each approach. Instead the aim was to quickly isolate the most commonly articulated principles.

	Proposed set	Adam Smith	NCSL 2001	AICPA 2017	WSTC 2016-2023	STSFA / SIRC
Simple	Know what is owed	Certain	5. Easy to comply with	2. Certain, 6. Simple	2. Simplicity	Ease of compliance
	Know how to pay	Convenient	5. Easy to comply with	2. Certain, 3. Convenient	2. Simplicity	Ease of compliance
Robust	No false positives	Efficient	4. Equitable	1. Equitable & fair	6. Equitable & fair	Considers equity
	No false negatives	Certain	2. Reliable revenue	10. Minimizes non-compliance	7. Easy to enforce, hard to evade	Enforceable
	Hard to avoid/evade	Certain	2. Reliable revenue	10. Minimizes non-compliance	7. Easy to enforce, hard to evade	Enforceable
	Enforceable	Certain	2. Reliable revenue	10. Minimizes non-compliance	7. Easy to enforce, hard to evade	Enforceable
Equitable & Fair	Transparent	Certain	9. Accountable	9. Transparent & visible	4. Transparent	Public acceptability
	Just	Efficient	4. Equitable	1. Equitable & fair	6. Equitable & fair	Considers equity
	Vertical equity	Fair	4. Equitable	1. Equitable & fair	6. Equitable & fair	Considers equity
	Horizontal equity	Fair	4. Equitable	1. Equitable & fair	6. Equitable & fair	Considers equity
	Equivalent exchange	Efficient	9. Accountable	11. Accountable	9. Accountable	Public acceptability
Efficient	Low administration cost	Efficient	6. Easy to administer	4. Low cost to administer	5. Cost effective & efficient	Low administration cost
	Low compliance cost	Convenient	5. Easy to comply with	3. Convenient, 6. Simple	8. Provides user options	Ease of compliance
	Good revenue	Efficient	2. Reliable revenue	12. Appropriate revenue	5. Cost effective & efficient	Effective user-based revenue gathering
	Supports choice	Efficient	7. Minimizes negative effects	7. Neutral, 8.Economically efficient	13. Complementary policy impacts	Market-based delivery
	Reduces externalities	Efficient	7. Minimizes negative effects	7. Neutral	13. Complementary policy impacts	Congestion mitigation
Sustainable Revenue	Enduring revenue	Efficient	2. Reliable revenue	12. Appropriate revenue	5. Cost effective & efficient	Effective user-based revenue gathering
	Enduring instrumentality	Efficient	2. Reliable revenue	12. Appropriate revenue	10. Flexible & adaptable	Reliable & secure
Secure	Privacy respecting			5. Information security	1. Privacy	Privacy
	Safe-guarded			5. Information security	3. Data security	Reliable & secure
Integrated	Complementary		3. Balanced revenue sources			
	Inter-operable		1. Complementary systems		11. Interoperable with other jurisdictions	Interoperability
			8. Separate from spending			
					12. Phases into operation	Implementable
						Explores a range of alternatives

The third part of the process was to cross-match the two lists to identify, or more probably validate, the core principles and the common evaluative criteria that might show adherence to said principles, as shown in the following image:

FINAL INVENTORY OF GOOD PRACTICE PRINCIPLES

The following figure sets out the proposed set of principles, developed by simply aggregating the various inventories discussed above and grouping and combining the duplicate ideas.

Class	Criterion	Performance standard
Simple	Know what is owed	Parties to the tax should be able to calculate in advance what will be owed.
	Know how to pay	Parties to the tax should know in advance how to pay the tax.
Robust	No false positives	The tax should not be imposed on parties not engaged in the target activity.
	No false negatives	The tax should not miss parties who are engaged in the target activities.
	Hard to avoid/evade	The tax should limit the scope for evasion.
	Enforceable	There should be sufficient information available to determine the fact and magnitude of liability and current compliance status of a liable party.
Equitable and Fair	Transparent	The purpose of the tax and the use of the revenues generated should be known to taxpayers.
	Just	A party incorrectly taxed should have access to an effective remedy.
	Vertical equity	Parties should pay in relation to their means/benefits.
	Horizontal equity	Parties in the same circumstances should pay the same.
	Equivalent exchange	The return on tax paid and the effort required to pay the tax should be in proportion to the value of the tax and effort.
Efficient	Low administration cost	The tax should be inexpensive for government to operate.
	Low compliance cost	The tax should be inexpensive for parties to comply with.
	Good revenue	The potential revenue should be worth the effort required to gather it.
	Supports choice	The tax should not distort parties' choices.
	Reduces externalities	The tax should encourage parties to internalise the full cost of their choices.
Sustainable Revenue	Enduring revenue	The targeted activity should be likely to keep delivering necessary, sufficient and proportionate revenues over time.
	Enduring instrumentality	The instrument should be likely to remain effective at gathering revenues over time.
Secure	Privacy respecting	Only necessary and sufficient personal private information should be gathered.
	Safe-guarded	Personal private information should be kept secure, and the integrity of liability, compliance and administrative data should be protected.
Integrated	Complementary	The tax works with and alongside other tax and non-tax instruments to optimise coverage and effectiveness without duplication.
	Inter-operable	The means of compliance is usable for compliance with similar provisions in other jurisdictions.

The resultant set is longer than even the expanded treatment of Adam Smith's original four key principles.

One driver of this growth is the emergence of concerns for privacy and data security. While some concerns, e.g. for internalising the costs of environmental degradation, are contained within high-level economic principles like efficiency, privacy can be seen as of genuinely new importance

because of how much information and communication technologies have evolved since the eighteenth century.

A further addition to the inventory is the need for explicit consideration of the complementarity of tax instruments. Even in Adam Smith's time, no tax stood completely alone and nations recognised the need for a mix of sales, property and income taxes. The complementarity of a tax instrument speaks to the gap it would leave if removed as much as the space it would occupy if introduced new. In the latter case, the concern is that the tax should not duplicate the job of another tax, even if only partly, as this would lead to double taxation and the introduction of distortionary incentives within the economy.

A final addition is a principle around the idea of interoperability. This could be a sub-set of administrative efficiency as the concern is to reduce the degree of duplicate effort and cost a taxpayer must take on when satisfying essentially identical tax obligations across multiple jurisdictions. However, this could be thought of as the strategic dimension of administrative efficiency: while it sets absolute constraints on the technical design of a tool, conditioning administrative efficiency in the technical and tactical senses, it is concerned with actively shaping the broader relational context within which an instrument functions.

A couple of ideas identified in a few of the inventories have not been carried across to the proposed set. Some of these related to the processes of experimenting with and evaluating possible alternative revenue tools and encouraging the taking of a wider view of possible tools. As such, they do not relate to the particular design and operation of any specific tool.

The NCSL was unique in isolating the principle that "a high-quality revenue system should minimize its involvement in spending decisions and make any such involvement explicit". Our research accepts this idea – that expenditure decisions get made and the funding system is then calibrated to raise the financing and revenues required. However, the processes for giving effect to this principle lie sufficiently outside the tools themselves to be out of scope of our study.

USING THE PRINCIPLES TO GUIDE THE LITERATURE REVIEW

The literature reviewing process required that we have clearly identified evaluative criteria/research questions. The following figure sets out the evaluative criteria developed from the final set of good practice tax principles.

Class	Criterion	Research questions
Simple	Know what is owed	1. How easy is it for a taxpayer to know that they are liable? 2. How easy is it for the taxpayer to know how much they are liable for? 3. How frequently and/or erratically are rates changed?
	Know how to pay	4. How easy is it for the taxpayer to know how to pay? 5. How easy is it for the taxpayer to know when to pay? 6. How easy is it for the taxpayer to actually pay?
Robust	No false positives	7. Does the tool tax people who are not engaged in the targeted activities?
	No false negatives	8. Does the tool fail to tax people who are engaged in the target activities?
	Hard to avoid/evade	9. Is there evasion? 10. What is the nature and scale of evasion?
	Enforceable	11. How easy is it to determine whether a taxpayer is compliant or non-compliant? 12. What is the incidence of non-compliance? 13. What is the cost of non-compliance (cost of enforcement effort, cost to pursue debt, unrecovered debts, and estimated evasion)?
Equitable and Fair	Transparent	14. Can a taxpayer easily determine the purpose and performance expectations of a tax? 15. Can a taxpayer easily determine whether a tax is performing as intended?
	Just	16. Are their refund and redress procedures in proportion to the possibility of over taxation?
	Vertical equity	17. Does the tax add to or subtract from how regressive the system is?
	Horizontal equity	18. Does the tax treat people in the same circumstances the same?
	Equivalent exchange	19. Are the purposes for which the funds are raised considered appropriate by taxpayers? 20. Is the use of funds considered appropriate by taxpayers? 21. Are the returns from the use of the funds considered appropriate by taxpayers?
Efficient	Low administration cost	22. Does the tool raise more revenue than the government expends to operate it? 23. How much does it cost the tool to raise $1 of revenue? 24. At what scale does the tool reach peak efficiency?
	Low compliance cost	25. How much effort is required for the taxpayer to comply? 26. How does compliance with this tax impact on the total compliance burden on taxpayers from across the whole system?
	Good revenue	27. What is the revenue potential of the taxed activity?
	Supports choice	28. Does the operation of the tool distort payers' choices?
	Reduces externalities	29. Does the operation of the tool allow payers to ignore the costs to others of their choices?
Sustainable Revenue	Enduring revenue	30. Is the taxed activity expected to persist over time?
	Enduring instrumentality	31. Is the operation of the tax instrument expected to remain effective over time?
Secure	Privacy respecting	32. Does the tool require gathering personal private information (PPI)? 33. Does the tool actually gather PPI? 34. Does the tool or regime have controls over accessing and using the PPI gathered for other regulatory purposes?

	Secure	35. Are PPI and other records secure against access by unauthorised parties? 36. Are funds secure from theft and fraud?
Integrated	Complementary	37. Does the tax result in double-taxation of the same activity for similar purposes? 38. Does the sum of all taxes leave untaxed a group that should be taxed?
	Inter-operable	39. Can the tax be raised using an existing mechanism or activity, or to raise or inform the raising of other taxes? 40. Can the tax leverage or support other regulatory processes to create a compliance optimising environment?

REFLECTIONS ON THE PRINCIPLES, CRITERIA, AND QUESTIONS

Overall, the evaluative framework did well in directing interrogation of the source materials.

In practice, the evaluative framework presented a much wider range of questions than was systematically commented on in the literature surveyed, even the literature from jurisdictions or studies that identified similar inventories of questions.

In part this can be attributed to the fact that reality is a lot messier than theory:

1. While issues of false positives, false negatives, ease of evasion, and incidence of non-compliance can all be treated as clearly distinct things in theory, in practice they jumble together. They also relate closely to notions of ease of understanding, ease of payment, and perceptions of the equivalence of the exchange.
2. Influencing externalities and being non-distortionary are two sides of the same coin, differentiated more by values-based choices of which activities are 'good' and, therefore, should not be deterred, versus which ones are 'bad' and should be deterred. These inevitably bump up against the discussions of vertical and horizontal equity and circle back to the idea of equivalent exchange.

On this basis, it may be tempting to discard the long list in favour of Adam Smith's core four: fairness, certainty, efficiency, and convenience. But this doesn't solve anything, because a quick comparison of the short list with the long reveals the same challenge of inter-play. Indeed, the value of the longer list is, perhaps, less in being a guide to exploring the literature for answers, and more in being a guide to considering different perspectives and trade-offs. And this desire for transparency is precisely why the long list has grown over time.

One further effect of the evaluative framework is that it encouraged viewing each genus of tool on its own. There was practical benefit to this as it enabled focus. But it was also slightly disingenuous since no single tool was ever or would ever be deployed on its own. Tools are allowed to be bad at some things, because no tool can do everything well, and they all need to be backed up and complemented. The framework did encourage consideration of this complementarity question, but answering this did not lend itself to generalization: complementarity is about a specific tool within its specific system.

REFLECTIONS ON THE OBSERVATIONS

Many of the questions turned attention back towards certain common desirable features relating to the 'how' of the operation of the tools, with four such features standing out in particular:

1. ***Purposiveness:*** tools should have clarity of purpose, function, and expected performance, in itself and in the context of its place in the system.
2. ***Efficacy:*** tools should adhere to, or extrapolate logically from established bodies of good practices that relate to the different aspects of their performance, like communicating with taxpayers and citizens, seeking and handling personal and private information and money, and designing processes and interfaces.
3. ***Intentionality:*** tools should be deliberately tasked to recover fair shares of the cost burden from the various segments of road users and road beneficiaries each is designed to reach.
4. ***Stewardship:*** tools should be continuously monitored, regularly evaluated, and recalibrated at need to preserve each tool's ability to perform its allocated role within the policy determined performance parameters.

Tools did not need to perform poorly against the principles that identified the need for these four things, yet many did, often enough. A lot of the commentary points to an explanation for this: revenue tools have been created in a reaction to a need to fill a budget hole rather than through a plan to systematically fund a transport system. That's not to say they are not useful, and may even be technically good in the narrowest of senses. It's just that the sum of the whole does not add up to what it needs to.

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Appendix 3: Inventory of revenue tools

A3.1 Developing and applying the inventory

PURPOSE

The purpose of the inventory is to provide a complete range of alternative road funding revenue tools. It provides an initial analysis to support identification of a short-list of tools for deeper examination of their advantages and disadvantages through a targeted literature review.

The inventory excludes financing approaches as financing tools rely on revenue tools to service the associated debt (principal and interest). It also does not consider cost allocation and rate- setting, as these activities, while essential, exist and operate externally to individual funding revenue tools.

METHODOLOGY

The inventory was developed through a targeted literature review, starting from summary documents that helped identify and categorise a broad range of road funding revenue tools, before moving on to more specialised considerations of specific tools.

The process of categorisation occurred in parallel with constructing the inventory. An abductive reasoning approach was taken in developing this categorisation. That is, there are many essentially similar inventories of tools, and many essentially similar explanations of the purposes and principles of road taxes. Neither set is sufficiently well formed to support either a deductive or inductive approach to determining an objectively correct taxonomy in the available time. Yet, taken together, they suggested a categorization schema sufficient for the purposes of this report and the conversations it is intended to support.

APPROACH TO CATEGORIZATION

Categorization derives from description and informs further analysis. From this analysis, lessons can be learned and the transferability of those lessons assessed. For description to be helpful to analysis it needed to apply a consistent approach to interrogating each species, genus, and family of tools. This required a taxonomical model.

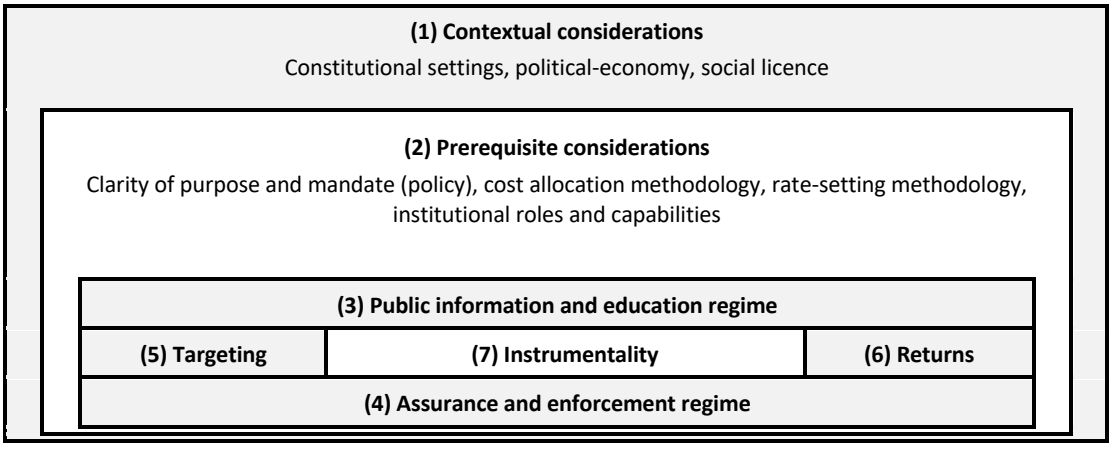
Objectively, there is no such thing as a road funding revenue tool. All such tools are subjective constructs. For example, while fuel taxes are commonly assigned to meet road transport costs, this is not a universal practice. Many jurisdictions around the world direct fuel excise revenues into their general accounts.

The figure below presents an abstract categorization of potential road funding revenue tools.

	Targets road CONSUMERS	Targets road network BENEFICIARIES
To gather REVENUE	**cr.** E.g. fuel taxes	**br.** E.g. general taxes
To recover COST share	**cc.** E.g. mass-distance charges	**bc.** E.g. special taxes
To recognise OPPORTUNITY	**co.** E.g. registration flat fees	**bo.** E.g. property taxes
To change BEHAVIOUR	**cb.** E.g. congestion charges	**bb.** E.g. developer contributions

A purist might expect all road funding revenue to be drawn from consumers and beneficiaries based on cost shares to meet revenue requirements (tools in cc. and bc.), and/or pricing to optimize network use (cb. and bb.). However, in practice, looking across the globe, roads are funded from sources in every part of the schema, even if only indirectly. There are many reasons for this, including convenience, pragmatism, revenue security through diversification, constitutional opportunities and constraints, but also poor tool design.

'Live' tools exist within the layers of specific funding cultures and systems. These layers have important impacts on the function of a tool; however, they are distinct from the tool itself and can be parsed away. The figure below provides a 'big picture' view of the common design considerations that reflect these layers (adapted from Carr 2021; Morello 2021).



The **contextual considerations (1)** determine what is acceptable in a road funding revenue tool. The **pre-requisite considerations (2)** translate those permissions into the legislative scaffolding that fits a specific tool to its context. One way to distinguish contextual considerations from pre-requisite

ones is that context defines what is possible or permissible, while the prerequisites reflect what is actually put in place.

The execution of **public information and education (3)** activities and **assurance and enforcement (4)** activities can be critical to the acceptance and performance of a revenue tool. The ease with which these activities can be performed is also impacted by the design of the tool. However, they again can be treated as independent characteristics. They are important when evaluating a specific tool, but less so when describing it.

The relationship between who or what a tool is **targeting (5)** and what it delivers in **returns (6)** is critical to its perceived legitimacy. There is a clear relationship between targeting and cost allocation, where cost allocation determines how much should be raised from whom, and targeting attempts to give effect to this. These are choices that must be made for any tool. While these characteristics speak to a finite range of options, the number of permutations remains high.

For the purpose of this report, the taxonomy used relies on:

1. Whether the tool is in the order of the road-user/consumer pays or the access-beneficiary pays
2. The targeting characteristics to allocate tools to 'families', and
3. The returns characteristics to differentiate the genera within each family.

Instrumentality (7) is the set of characteristics that most determines the particular look and feel of a tool. Instrumentality is used to define the various species of tool within each genus.

A challenge with instrumentality is that it is potentially highly variable in nature, both between each genus of tool and also within each genus/between each species. For the purpose of providing a basis for consistency, this report applies the following four-piece schema to summarising the instrumentality of different tools:

MEASURING	REPORTING	PAYING	CHECKING
Approach to knowing how much of the taxable activity or commodity there is	Approach to making that information available for tax assessment/compliance assurance purposes	Approach to recovering the tax owed	Approach to ensuring the actions and information relied on are done and correct

The following inventory presents the various funding revenue tools sorted into five families. These families are distinguished by the nature of the activity that the tax taps into and are further subdivided into genera:

1. **Input-Based Taxes** draw revenue from the outlays road users must make in order to be able to physically use the road network. Being pre-paid, input-based taxes charge for the opportunity to use roads, i.e. potential road use. Four genera of input-based taxes are described, differentiated by the input that is being taxed.

2. **Impact-Based Taxes** draw revenue from actual or expected (potential) road use activity. Four genera of impact-based taxes are described, differentiated by the metering process used to determine the quantum of impact.
3. **Presence-Based Taxes** draw revenue from actual road use, charging vehicles for being in particular places on the network. Four genera of presence-based taxes are described, differentiated by the triggering mechanism for recognising and quantifying 'presence'.
4. **Amenity-Based Taxes** draw revenue from activities that are deemed to benefit from the access provided by, and others' use of the road network. Four genera of amenity-based taxes are described, differentiated by the general category of amenity enjoyed.
5. **Commerce-Based Taxes** draw revenue from commercial activities in, on, around or indirectly supported by road use and/or the use of transport assets. Four genera of commerce-based taxes are described, differentiated by the specificity with which commercial activities are targeted.

Appendix 3.2 provides more detail on each family.

The figure below, sets of the five families and 20 genera of revenue tools considered in this report.

<table>
<tr><th colspan="6">USER-(OF-ROADS)-PAYS</th><th colspan="4">BENEFICIARY-(OF-ACCESS)-PAYS</th></tr>
<tr><th colspan="2">Input-based</th><th colspan="2">Impact-based</th><th colspan="2">Presence-based</th><th colspan="2">Amenity-based</th><th colspan="2">Commerce-based</th></tr>
<tr><td>Fuel excise tax</td><td rowspan="2">Also variable by fuel type, carbon content, and/or chemical composition</td><td>Fixed access (registration) charges</td><td rowspan="4">Also rates may vary by vehicle characteristics</td><td>Per cordon tolls</td><td rowspan="4">Also rates may vary by vehicle characteristics, location, and/or point-in-time-of-use</td><td>Property taxes</td><td rowspan="4">Highly variable by jurisdiction</td><td>General taxes</td><td rowspan="4">Highly variable by jurisdiction</td></tr>
<tr><td>Fuel sales taxes</td><td>By period of time</td><td>Per lane tolls</td><td>Fare-box recovery</td><td>Special (transport) taxes</td></tr>
<tr><td colspan="2">Vehicle/equipment sales taxes</td><td>By exception</td><td>Per road segment tolls</td><td>Parking charges</td><td>Development / developer contributions</td></tr>
<tr><td colspan="2">kWh taxes</td><td>By distances travelled</td><td>Within-area tolls/charges</td><td>Fees</td><td>Advertising, floor-space, and air-space concessions</td></tr>
</table>

REFLECTIONS ON THE TAXONOMY AND INVENTORY

Overall, the taxonomy seemed sustainable and helpful.

One of the alleged appeals of kilowatt-hour taxes is that they simulate the operation of volumetric liquid fuel taxes. On that basis, it might have made sense to bundle kilowatt-hour taxes into the fuel excise tax category. Similarly, fuel sales taxes might have been treated as just a variation on fuel excise taxes in the way that indexing rates to inflation and/or setting rates with an eye to pricing lead inputs or greenhouse gas outputs are just variations. However, it quickly became clear that the very different instrumentalities of liquid fuel excise taxes, kilowatt-hour taxes, and (liquid or electric) fuel sales taxes meant that they were all very distinct tools that needed to be treated separately.

Fixed access (registration charges), 'by time of use' charges, and the London Congestion Charge presented a similar conundrum, in that each of them imposed costs on road users in relation to ever more refined slices of time. While it is tempting to separate out the London Congestion Charge because it most obviously relies on tolling technologies, these are for enforcement purposes and are perfectly capable of being used to enforce the other two types of tool. The true distinguishing features of these three genera are the 'deal' implicit in which activities the taxpayers were being charged for and, in tight relationship, the purposes to which the revenues raised were then put. In general, fixed access registration charges were used to gather general revenues, 'by time of use' charges helped pay for roads, and the London Congestion Charge brought mobility.

Noting the London Congestion Charge, in the 'within-area' charges genera was the most problematic. A tool fit into this category because it used 'charging someone specifically for being in an area' as the main distinguishing feature. This yielded three quite distinct species of tools:

1. The (live) London Congestion Charge, as a hybrid of tolling and fixed access/registration charge methodologies
2. The (live) retail delivery fee, as a sales tax based methodology, and
3. The (theoretical) location-enabled distance-based charges based methodology.

This points to a failing in the taxonomy in respect to how 'presence-based' charges were conceived. In particular, tolling was probably split down too much, with tolling by lane, cordon or segment really just being variations on the same theme and not truly distinguishing of separate genera. Combining these into one genus would be more true to the idea that these subtleties in focus just reflect variations in how the location of interest is defined. In contrast, the three approaches to 'within area' charges probably did warrant being separated out for classification purposes.

Noting this, the taxonomy could be revised as shown in the figure below:

User-(of-roads)-pays						Beneficiary-(of-access)-pays			
Input-based		Impact-based		Presence-based		Amenity-based		Commerce-based	
Volumetric fuel taxes	Also variable by fuel type, carbon content, and/or chemical composition	Fixed access (registration) charges	Also rates may vary by vehicle characteristics	Point tolling (e.g. traditional)	Also rates may vary by vehicle characteristics, location, and/or point-in-time-of-use	Property taxes	Highly variable by jurisdiction	General taxes	Highly variable by jurisdiction
Fuel sales taxes		By period of time		Access tolling (e.g. London)		Fare-box recovery		Special (transport) taxes	
Vehicle/equipment sales taxes		By exception		Activity tolling (e.g. delivery-based)		Parking charges		Development / developer contributions	
KWh taxes		By distances travelled		Journey tolling (e.g. distance-based)		Fees		Advertising, floor-space, and air-space concessions	

One effect that this would have had is that discussion of European Electronic Tolling Systems would shift from the 'by distance travelled' genus to the 'journey tolling' genus.

This change to the taxonomical structure would also have encouraged deeper exploration of the three variations considered as 'within-area charges'. However, it would not have significantly expanded the literature base available at this time. Setting the classification issue aside, we believe the findings regarding the suitability of these tools as a replacement for a fuel excise tax remain sustainable.

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A3.2 Descriptions of the families of revenue tools

INPUT-BASED TAXES

Family	Input-based taxes			
Tool	**Fuel excise taxes**	**Fuel sales taxes**	**Vehicle and/or vehicle equipment sales taxes**	**Kilowatt-hour (kWh) taxes**
General description	A fixed price tax that is attached to the price per gallon of fuel.	A sales tax that attaches to the price of fuel, specifically for transport funding purposes (i.e. over and above any general revenue taxes).	A sales tax that attaches to the price of defined commodities or capital assets, specifically for transport funding purposes (i.e. over and above any general revenue taxes).	Kilowatt-hour taxes attempt to replicate the fuel tax for electric vehicles. When an electric vehicle is charged a tax liability is incurred per kilowatt-hour of energy transferred.
Calculation	cent per gallon / by fuel type	% of fuel price	% of price	cent per kWh / % of kWh price
Instrumentality	The tax is paid in bulk by the fuel importer or producer when the fuel is entered to the domestic fuel market. The equivalent of the tax is recovered from end users of the fuel through the pump price. The tax rate may vary across different fuel types to reflect differences in the chemical composition of the fuel, like lead content, ethanol content, use of bio-fuels and so on. Fuel purchase receipts provide proof of compliance by end-users.	The amount of tax owed is a percentage of the value of the fuel. The tax could be levied against the wholesale price of the fuel when being introduced to the market, in which case it functions like the excise. Alternatively, it could be levied against the retail price when being dispensed to consumers, in which case it functions like a standard sales tax. In each case, administration would piggy-back on existing excise or sales tax mechanisms. Fuel purchase receipts provide proof of compliance by end-users.	The amount of tax owed is a percentage of the value of the commodity or capital asset. The consumer pays the tax at the time of purchase. Where the tax functions like a value-added tax, the final amount paid by the consumer comprises compensation to the supplier for the tax already paid, plus the further increment owed based on the value-added. Administration would piggy-back on existing sales tax mechanisms. Fuel purchase receipts provide proof of compliance by end-users.	Although a relatively new tax, there is already significant diversity in how the tax works. One common feature of practice to date is that the tax is levied at charging stations, usually public charging stations, but also private charging stations in some jurisdictions. However, charging in private homes is not covered. The tax charged is often a fixed amount per kilowatt-hour, similar to gas tax; however, examples of the tax being set as a percentage of retail value also exist, similar to a sales tax. The tax is often calculated and charged at the pump; however, the approach of requiring the filing of monthly statements has also been used. In general, electricity purchase receipts provide proof of compliance by end-users. Where users are required to file statements, charging information is also required.

IMPACT-BASED TAXES

Family	Impact -based taxes			
Tool	**Fixed access charges**	**By period of time charges**	**By exception charges**	**By distance charges**
General description	A flat-rate tax paid when registering a vehicle.	A flat rate of tax paid to permit road use for specific increments or periods of time, usually relating to the use of highways or main roads, rather than local roads.	A form of charge applied when operating or intending to operate a vehicle outside of general access criteria (e.g. loaded over standard allowable weights), which is additional to any administrative fees relating to the regulatory action needed to authorise the exception.	A flat per-mile charge.
Calculation	Fixesd/flat amount annually per vehicle registration	per time period charge / by vehicle characteristics	Fixed/flat charge by exception	cent per mile / by vehicle
Instrumentality	These charges use the vehicle registration process to identify and charge vehicle owners. The amount is 'flat' in the sense that it does not vary according to the expected degree of use of the road network, and vehicles of identical class, make and model would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models reflecting a jurisdiction's cost allocation and rate-setting choices. Proof of payment can take the form of new registration plates, decals, or other documents.	The road user purchases the right to drive from authorised vendors. There may be limits on the minimum or maximum time increments that can be purchased. The amount is 'flat' in the sense that vehicles of identical class, make and model, driving for the same period of time would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models, reflecting a jurisdiction's cost allocation and rate-setting choices. Proof of payment usually takes the form of a decal or licence.	The vehicle operator applies for permission to operate a vehicle in some exceptional manner and pays the additional tax, either on application or on approval. The amount is 'flat' in the sense that identical vehicles undertaking identical tasks would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models reflecting a jurisdiction's cost allocation and rate-setting choices. The increments charged for, whether of time or distance, may also influence total taxes due. Proof of payment usually takes the form of a decal or licence. There may be accompanying documentation detailing any conditions applying to the exception.	The vehicle operator is required to maintain accurate and complete distance records for each liable vehicle. In a pre-pay system, these records are used to show that the vehicle concerned has a current valid licence for the total distance driven by that vehicle. In a post-pay system, these records support periodic filing to enable the tax owed to be assessed and paid. The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models reflecting a jurisdiction's cost allocation and rate-setting choices. Proof of payment usually takes the form of a decal, licence or receipt.

PRESENCE-BASED TAXES

Family	Presence -based taxes			
Tool	**Per cordon tolls**	**Per lane tolls**	**Per road segment tolls**	**Within area tolls/charges**
General description	A vehicle is charged a flat fee when it crosses a defined boundary.	A vehicle is charged a fee when it enters a lane of interest within a corridor.	A vehicle is charged fees as it travels along a route, accumulating charges as it enters each new road segment.	A vehicle is charged for travelling within a defined area of interest, accumulating greater charges then more it travels within the area.
Calculation	charge for crossing a certain area / by vehicle type	charge for using specific lane / by vehicle type	charge per road segment / by vehicle type	per mile within a certain area / by vehicle type
Instrumentality	Typically, roadside technology of some description is used, with or without in-vehicle transponders, to register the passage of the vehicle across the boundary of interest. The associated fee may be collected on site if a toll gate and plaza approach is used, or, if some form of free-flow tolling mechanism is used, the liability is registered at the time and place of entry and the cost either charged and then either deducted from a pre-paid account or invoiced for payment in arrears. The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount when crossing the same boundary at the same place and time. However, the rate for any given vehicle class, make or model, location or time may vary relative to other classes, makes or models, or locations and times, reflecting a jurisdiction's cost allocation and rate-setting choices. The onus of proof of payment lies, in the first instance, with the toll operator, which must determine and demonstrate that a toll owed has not yet been paid.	Typically, roadside technology of some description is used, with or without in-vehicle transponders, to register the entry of the vehicle to the lane(s) of interest. The associated fee is collected using some form of free-flow tolling mechanism, with the liability registered at the time and place of entry and the cost either deducted from a pre-paid account or invoiced for payment in arrears. The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount when crossing the same boundary at the same place and time. However, the rate for any given vehicle class, make or model, location or time may vary relative to other classes, makes or models, or locations and times, reflecting a jurisdiction's cost allocation and rate-setting choices. The onus of proof of payment lies, in the first instance, with the toll operator, which must determine and demonstrate that a toll owed has not yet been paid.	Typically, roadside technology of some description is used, with or without in-vehicle transponders, to register the passage of the vehicle along the route of interest. The associated fee is collected using some form of free-flow tolling mechanism, with the liability registered at the time of passage and the cost either deducted from a pre-paid account or invoiced for payment in arrears. The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount when crossing the same boundary at the same place and time. However, the rate for any given vehicle class, make or model, location or time may vary relative to other classes, makes or models, or locations and times, reflecting a jurisdiction's cost allocation and rate-setting choices. The onus of proof of payment lies, in the first instance, with the toll operator, which must determine and demonstrate that a toll owed has not yet been paid.	Typically, roadside technology of some description is used, with or without in-vehicle transponders, to register the passage of the vehicle within the area of interest. The associated fee is collected using some form of free-flow tolling mechanism, with the liability registered at the time of travel and the cost either deducted from a pre-paid account or invoiced for payment in arrears. The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount when moving inside the same boundary at the same place and time. However, the rate for any given vehicle class, make or model, area or time may vary relative to other classes, makes or models, or areas and times, reflecting a jurisdiction's cost allocation and rate-setting choices. The onus of proof of payment lies, in the first instance, with the toll operator, which must determine and demonstrate that a toll owed has not yet been paid.

AMENITY-BASED TAXES

Family	Amenity -based taxes			
Tool	**A tax imposed on property owners by local governments.**	**Farebox recovery**	**Parking charges**	**Fees**
General description	A tax imposed on property owners by local governments.	Users of public transport services pay a fare upon each boarding of the service.	Users of motor vehicles pay a fee when parking a vehicle on the public roadside or public parking lot.	A tax component charged when person pays a fee for some administrative action.
Calculation		per public transport trip / segment	per parking event / per time interval	
Instrumentality	The tax authority takes the tax levy to be raised and apportions the burden across the liable classes of property, which may include real estate and personal and business properties. The tax is usually calculated by taking the fair market value of the property and multiplying it by an assessment ratio and the relevant tax rate. The jurisdiction will hold the record of payment as proof.	A public transport user pays the fare upon boarding. This may be in cash in exchange for a ticket, via a pre-paid ticket or pass, by deduction from a pre-paid account, or by contactless payment via debit or credit card. Fares typically vary by the distance travelled. There may be concessions discounting travel over greater distances and/or greater frequency of use, as well as for vulnerable users (e.g. children, retired persons, or persons on welfare) or special interest groups (e.g. people with disabilities, current serviceman and women or veterans). A physical ticket or electronic record of payment is proof of compliance.	The vehicle operator locates the relevant payment station or parking meter and pays the appropriate fee. Fees typically scale upward as the length of time that the vehicle occupies the parking space increases. Proof of payment takes many forms e.g. remaining time showing on a meter, a visible ticket showing the vehicle is still within its pre-paid allotment, and/or an electronic record of payment is held by the management system.	The payer approaches a vendor or regulator, in person or via some remote medium, with the intention of completing some transaction. The fee and tax component are charged to them at the time of the transaction.

COMMERCE-BASED TAXES

Family	Commerce -based taxes			
Tool	**General taxes**	**Special (transport) taxes**	**Development/developer contributions**	**Advertising, floor-space and air-space concessions**
General description	There is a wide range of general taxes. In general they extract a percentage amount from the activity they target.	An additional component is added to a tax specifically to raise revenue for a transport purpose, over and above what the normal tax recovers.	Third parties involved in developing land for commercial or residential purposes are required, as part of planning approval, to supply an appropriate level of road infrastructure to serve the development. Ongoing operation and maintenance of the assets may remain with the third party or a body corporate formed around the development. Alternatively, these responsibilities may pass to the relevant public body after some defined period of time. These tools reduce the pressure on public revenues.	These tools generate revenue by allowing third parties to rent and derive value from road network assets, e.g. by developing the airspace over a road and on-leasing business or residential premises. These are purely commercial arrangements intended to generate revenue in the same manner as similar private business undertakings.
Calculation	% of price of goods or service			
Instrumentality	General taxes rely on reporting and declarations by those persons and entities earning income, undertaking liable activities, exchanging goods or services for reward, and so on.	Special taxes rely on existing tax mechanism like property taxes, sales taxes, and excises.	The third party agrees to provide the stipulated level of service. The third party recovers the cost through their commercial activities.	The third party contracts to use the asset for a fee. The third party recovers the fee through their commercial activities.

Appendix 4: Assessments of selected tools

A4.1 Fuel Excise Taxes

TOOL DESCRIPTION

A fixed price tax that is attached to the price per gallon/litre or increment thereof of liquid motor fuels.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
The quantities are measured at the area where the fuel is imported or manufactured, when the fuel exits the area.	Reporting is periodic, e.g. monthly. Reporting is supported by comprehensive recording keeping to support verification of fuel volumes.	Payment of the tax is by the licenced importer or manufacturer and is periodic, e.g. monthly. The cost of the tax is recovered/passed on through wholesale and retail pricing.	Compulsory cost and revenue disclosures from multiple parties along the supply and distribution chain provide information that can be used, inter alia, to verify fuel stocks and flows and excise liabilities.

WHERE IS THE TOOL IMPLEMENTED

Fuel taxes are universal, applied globally. They are typically levied as a set number of cents per gallon.

Fuel taxes first became part of the government revenue toolkit in the United States of America in 1919, with their introduction in Oregon, followed closely by Colorado and New Mexico that same year. Uptake had expanded to 15 states by 1921, to all 48 continental states by 1929, and into Hawaii in 1932, and Alaska in 1946.

The federal government introduced what was intended as a temporary federal fuel tax in 1932; however, after numerous extensions, the Highway Revenue Act of 1956.

LESSONS LEARNT

Simple

Fuel excise taxes are easy for the public to understand and relatively simple for fuel companies to comply with.

Robust

When authorised as a user-charge, fuel taxes become more exposed to revenue loss through philosophically legitimate exclusions, and through error, omission and evasion. These outcomes

seem under-monitored with a relatively high level of tolerance for leakage where dyed fuel regimes apply.

Equitable and fair

As input-based taxes, fuel taxes tend to be regressive and inequitable.

Efficient

A fuel tax's ability to influence user behaviour is dependent on the net price of fuel relative to cost of living pressures and household and business budget thresholds. It is politically difficult to use taxes to drive fuel prices up to those thresholds. Recent history has shown the opposite: fuel tax rates will come down if cost of living pressures become too strong for prolonged periods of time. As such, it may be more effective to use other, more targeted mechanisms to attempt to influence specific behaviours in specific circumstances, over and above using fuel taxes to generate revenue.

Sustainable revenue

Fuel excise taxes work off a sustainable mechanism. Although internal combustion engine vehicles are beginning to decline as a fleet percentage, they will persist in large numbers for some time to come. The very efficiency of fuel taxes means that these losses – including the cost of monitoring and enforcement to contain and minimize them – do not detract substantially from the revenue stream generated.

Secure

Fuel excise taxes neither need nor gather personal and private information.

Integrated

The simplicity and specificity of fuel excise taxes lends them to integrated management.

SUMMARY ASSESSMENT

While fuel taxes are often thought of as a proxy road user charge, they are by nature best seen as general revenue tools. As such, they work best when kept simple and universal. As such, fuel taxes perform relatively poorly against the various equity measures. However, the instrumentality of fuel taxes remains sound. The decline of fuel taxes is not a consequence of problems with the instrumentality, but due to significant contextual factors: political neglect of the rates of the taxes, improvements in engine efficiency, and the increasing availability of affordable alternatively powered vehicles.

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A4.2 Fuel sales taxes

TOOL DESCRIPTION

A sales tax that attaches to the price of fuel, specifically for transport funding purposes (i.e., over and above any general revenue taxes).

Fuel sales taxes are very similar to volumetric fuel taxes and share many of the characteristics of them. However, the important differences, leading to them being assessed separately are that:

- The rate is levied as a percentage of the value of a fuel transaction, not a fixed amount per unit of volume of fuel.
- The sum of the final tax is 'paid' by the end consumer; however, where the sales tax is applied as a value added tax (VAT), increments of the tax may be remitted by various parties back up along the supply chain, with credits accrued for the taxes paid on their input purchases to prevent double taxation.
- As a consequence of the above, the number of taxation points, from which tax must be collected, rather than being very finite, is very large.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
The quantities are measured through the supply chain from point of entry to point of sale.	Initial and subsequent suppliers declare taxable volumes and associated credits through periodic tax reporting processes.	Tax is remitted by suppliers according to the jurisdiction's payment schedule/ calendar.	Records are kept and made available for audit. These usually include both direct transaction records and records of corroborating information/actions.

WHERE IS THE TOOL IMPLEMENTED

VAT is the world's most common form of consumption or sales tax, in place in more than 160 countries. An exception is the United States, which relies instead on retail sales taxes. Global practice conforms to the idea that retail sales tax rates are generally lower than VAT rates, running 4–6% as opposed to 14–25%.

In the United States, most states exempt liquid motor fuel from general retail sales taxes. However, ten states collect full or partial sales tax in addition to the excise tax.

LESSONS LEARNT

Simple

Fuel sales taxes are easy to understand and to pass through to consumers. Filing processes can be onerous, especially for smaller businesses.

Robust

The broader the tax base, the lower the rate of tax can be to achieve a given revenue target. The lower the tax rate, the less incentive there is for evasion. In addition, the broader base creates more comprehensive reporting of transactions to support monitoring and enforcement.

A VAT methodology, while more administratively demanding, is significantly less susceptible to revenue leakage and miss-targeting, due to the incremental accrual of taxes along the value chain, the more comprehensive reporting framework, and the incentive provided by the availability of tax credits to reduce the marginal cost to the end retailer. Again, these effects are enhanced as the taxed base is broadened.

Equitable and fair

As with any input tax, there are significant equity issues that the tax mechanism itself cannot overcome. The horizontal equity concerns are essentially unresolvable. Addressing the vertical equity concerns would need some form of tax credit or transfers scheme established alongside the fuel sales tax.

Efficient

Broadening the tax base has the further effect of improving the return on administrative and compliance effort because there is an unavoidable minimum level of work involved in filing returns while administrators and taxpayers can enjoy some degree of scale economies as taxable transaction volumes and values goes up.

Sustainable revenue

Fuel sales taxes work off a sustainable mechanism. Although internal combustion engine vehicles are beginning to decline as a fleet percentage, they will persist in large numbers for some time to come.

Secure

Fuel sales taxes do not require the collection of personal and private information.

Integrated

Noting that fuels, while used widely and at scale are still a narrow commodity group, use of a fuel sales tax to generate road funding revenues would make best sense as part of a general sales tax regime with the fuel-related funds hypothecated towards a road fund.

SUMMARY ASSESSMENT

Sales taxes are one of the three core pillars of any tax system. They perform very well as general revenue mechanisms. When implemented as a VAT rather than a retail sales tax, they are a robust mechanism for gathering a strong and steady revenue stream for a government.

However, their strengths as general revenue instruments make them problematic when narrowed down and targeted on specific sub-groups of taxpayers in order to generate revenues for similarly narrow purposes.

Fuel sales taxes share the drawbacks of volumetric fuel taxes – e.g. poor horizontal and vertical equity, weak impacts on consumer choice – without the benefit of the administrative simplicity those taxes reputedly enjoy, especially if the fuel sales tax is required to be robust.

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A4.3 Kilowatt-hour taxes

TOOL DESCRIPTION

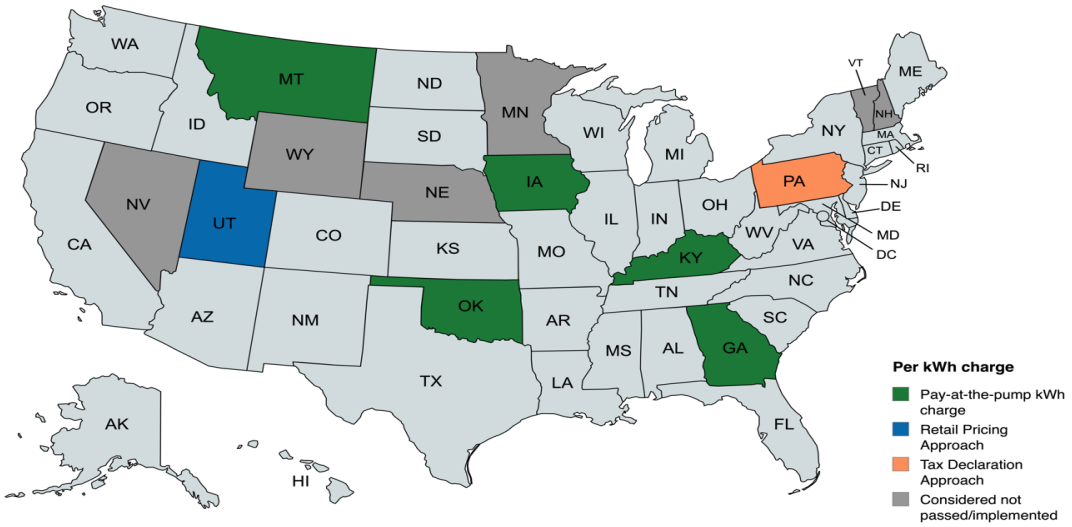
Kilowatt-hour (kWh) taxes attempt to replicate the fuel tax for electric vehicles. The tax applied is often a fixed amount per kWh, similar to gas tax; however, examples of the tax being set as a percentage of retail value also exist, similar to a sales tax. The tax is often calculated and applied at the charging station; however, the approach of requiring the filing of monthly statements has also been used.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
The amount of electricity used to charge an electric vehicle is monitored at the charging point.	The quantity of taxable electricity may be reported at the charging point in real time (e.g., if using a public charger), or need to be recorded and declared (if using a private charger).	A consumer may pay the tax at the charging point as part of the transaction, or in the tax cycle when reporting taxable usage.	Assessing and collecting tax at the public charge point generates auditable records. Assessing private charging is (currently) largely honesty based.

WHERE IS THE TOOL IMPLEMENTED

KWh taxes have been implemented only in the United States. As of the time of this report, eight programs have been legislated, with six currently in operation. The remaining two programs, in Georgia and Wisconsin, will start on January 1, 2025. Pennsylvania will exempt light vehicles and non-commercial heavy vehicles from its program starting in 2025, moving them to a flat registration fee instead.



There are three types of kWh tax approaches:

1. ***Pay-at-the-Pump kWh Tax:*** A flat rate is applied per kWh of charge transferred, currently used at public charging stations in Georgia, Iowa, Kentucky, Montana, and Oklahoma.

2. ***Retail Pricing Approach:*** A tax is applied as a set percentage of the transaction value before other taxes. This is currently used at public charging stations in Utah.

3. ***Tax Declaration Approach:*** A flat rate tax per kWh is calculated based on a monthly return filed by the owner of the charging location, applicable to both home and business locations. This method is currently used in Pennsylvania.

Seven other states have proposed but not passed kWh fee legislation: Kansas, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, and Wyoming. Vermont has considered a kWh tax as an alternative or supplement to fuel taxes for over a decade but has not yet moved forward with it.

LESSONS LEARNT

Simple

A kWh tax is most practical when applied via a 'pay-at-the-pump' type arrangement, whether literally at a charging station, or figuratively as part of an at-home charging arrangement. Requiring individuals to file periodic tax returns imposes a significant compliance burden that, in addition to being difficult to manage, is likely over-sized relative to the value of the tax to be paid.

Robust

Taxing at-home charging is of critical importance to minimizing avoidance and generating a good tax yield. While it provides scale economies to central tax administration, it increases the difficulty and expense of monitoring and enforcing compliance.

Equitable and fair

A kWh tax presents unavoidable issues in relation to both vertical equity and horizontal equity. In this regard the approach is no different to fuel taxes.

Efficient

There are also varying degrees of set-up cost associated with levying the tax at or on public charging stations. However, whereas the metering technology installed at a home will likely support fewer vehicles and might become stranded if an EV is no longer based there, public charging stations have significant scale economies that can be exploited under normal profitable business circumstances to defray the set-up cost over time.

Sustainable revenue

If the investment is made to establish a kWh tax, then the subsequent yields are likely to be enduring.

Secure

There is little to no need for personal and private information to be collected to support any form of pay-at-the-pump program.

Integrated

Monitoring and enforcing compliance can almost certainly be done in a cost effective manner through a mix of leveraging other already existing touch points and processes and introducing selected new ones. However, the net cost will still be much greater than the equivalent costs for a fuel tax and could involve additional, intrusive-seeming measures.

SUMMARY ASSESSMENT

The kWh tax is still new and largely experimental. States that are using it are still working on refining its efficiency, establishing best practices, and building the necessary infrastructure. However, kWh taxes are nowhere near as simple as they are made out to be and need to cover at home charging if they are to replace gas taxes. kWh taxes are regressive, showing the same equity issues as fuel taxes as they use the fuel consumption as a proxy for usage, which typically improves with newer vehicles.

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A4.4 Fixed access (registration) charges

TOOL DESCRIPTION

A flat-rate tax paid when first registering or re-licensing a vehicle, over and above the cost of the registration/licensing activity it accompanies.

These charges use the vehicle registration process to identify and charge vehicle owners. The amount is 'flat' in the sense that it does not vary according to the expected degree of use of the road network, and vehicles of identical class, make and model would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models reflecting a jurisdiction's cost allocation and rate-setting choices. Proof of payment can take the form of new registration plates, decals, electronic records, and/or other documents.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
A vehicle is ascribed an anniversary date at first registration that determines when re-registration needs to occur.	The consumer applies to have their vehicle(s) registered or re-registered.	Tax is paid as part of the registration transaction.	Decals, plates or other signifiers are issued upon completion of the transaction that show that the vehicle has a current registration.

WHERE IS THE TOOL IMPLEMENTED

Vehicle ownership fees as a revenue tool are used in many countries, as well as similar regular taxes for owning specific classes of vehicles. However, in most cases the fees or charges for re-licensing have different purposes; for example, some European countries tend to use them as environmental charges, and others treat the proceeds as general revenue.

In the United States, access/registration charges on private passenger vehicles are state and local level tools, accounting for roughly 33% and 40% of each level's road funding revenues respectively. States are roughly split 50/50 between flat fees and variable fees. The federal access/registration charge only applies to heavy commercial vehicles. In most states, heavy vehicle registration fees increase with vehicle weight. To account for the lost motor fuel tax revenue from increased electric vehicle adoption, 33 states in the US are now collecting an additional registration surcharge on electric vehicles, plug-in light vehicles, hybrid vehicles, and high fuel-efficient vehicles.

LESSONS LEARNT

Simple

The public intuitively recognizes the connection between paying some component of tax to fund roads as part of registering a motor vehicle for use on those roads, and the transaction itself is simple to understand and comply with.

Robust

Vehicle registration systems are robust and usually well supported by enforcement.

Equitable and fair

While fixed access/registration charges tend to be regressive because of the flat nature of the rates commonly applied, they allow for nuanced taxation as they can be scaled to account for vehicle characteristics such as size, weight, age, motive power, and cost. If able to be paid in sub-yearly components – e.g. monthly or quarterly – they also have some potential to overcome the cash flow challenges larger registration charges can impose on low income households.

Efficient

The efficiency of fixed access/registration charges is held back by the limits on how much tax can be attached to the registration process/transaction before it becomes unaffordable. However, that amount is scalable, while leaner, digital, compliance channels allow larger fees to be broken into more affordable payments.

Sustainable revenue

While fixed access/registration charges can recover good, sustainable revenue over time, they would not be expected either to supplant user charges or to be the single greatest source of revenue within the suite of tools.

Secure

Motor vehicle registration is arguably the most intrusive mechanism from a privacy perspective as it requires gathering personal private information in order to attach a vehicle to a liable party. However, it is not essential for this data to accompany the tax compliance record when funds paid are being remitted to the recipient entity. Good practice data privacy and security protocols exist, including in relation to sharing data with law enforcement agencies.

Integrated

There is a place in the system for fixed access/registration charges, specifically in relation to recovering a share of costs that are not directly influenced by actual levels of road use, like weather effects.

SUMMARY ASSESSMENT

There is a clear role in any road funding regime for fixed access/registration charges. As with any tool, they have their limits and cannot be all things for all situations. However, there is usually a clear set of residual or common costs that these charges are well able to collect fairly, leaving the user charge type instruments to gather revenue reflecting the marginal costs of actual road use.

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A4.5 Time-based charges (Vignettes)

TOOL DESCRIPTION

A flat rate of tax paid to permit road use for specific increments or periods of time, usually relating to the use of highways or main roads, rather than local roads, but not exclusively so.

The road user purchases the right to drive from authorised vendors. There may be limits on the minimum or maximum time increments that can be purchased.

The amount is 'flat' in the sense that vehicles of identical class, make and model, driving for the same period of time would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models, reflecting a jurisdiction's cost allocation and rate-setting choices.

Proof of payment usually takes the form of a decal or licence (a "vignette").

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
The consumer determines the period in time that wish to have access to the relevant road(s).	The consumer pre-purchases a block of permitted travel (e.g. 7 days, or a month, or a year) and receives a permit or decal or electronic register entry indicating the time block purchased.	The tax is paid at the time of purchasing the block of permitted travel.	An enforcement officer or mechanism will check the permit and decal to determine if it encompasses the point in time when the check is occurring.

WHERE IS THE TOOL IMPLEMENTED

Charging vehicles to access certain parts of a road network by blocks of time has been a commonly used tool in Europe for both heavy vehicles and light passenger vehicles, and are referred to as vignette charges or vignettes.

The application of vignettes to commercial heavy vehicles was regulated at the level of the European Union (EU) because of the implications for inter-state commerce ("Eurovignette" Directive 1999/62/EC). Vignettes are now to be phased out for heavy vehicles using the core trans-European transport network (TEN-T) in favour of electronic tolling systems.

The application of vignettes to private (i.e. not used for commercial purposes) vehicles had been left to the discretion of individual states; however, individual programs across the EU still need to adhere to overarching principles of non-discrimination and proportionality.

Elsewhere in Europe, Switzerland charges cars for use of its motorways through the Swiss Autobahn Vignette, and Moldova requires all private vehicles using public roads to purchase vignettes. Montenegro had an ecological vignette until 31 December 2011.

LESSONS LEARNT

Simple

The vignette charge is a simple mechanism that is easy to understand and to administer. This simplicity is the chief advantage and disadvantage of the tool. The simplicity is achieved through extensive averaging and by consolidating transactions into previously pragmatic, but now merely habitual, larger blocks of time/liability.

Robust

The vignette mechanism is relatively easy to enforce and is robust. The main issues with the enforcement of vignette charges tends to be bias in the targeting of enforcement effort.

Equitable and fair

Even with more nuanced rate-setting and minimum liabilities, vignettes perform poorly against equity measures and, in consequence, in being able to demonstrate an equivalent exchange of value to the taxpayer. However, the lower the cost (compliance effort plus value of the tax paid), the less important this becomes. And vignettes can be seen as fair where their purpose is to recover taxes from drivers who might otherwise pay nothing, or to reduce the tax burden on drivers who only infrequently (e.g. seasonally) use the taxed road network. However, the charges should be passed through via means that allowed for smaller increments to be purchased more closely matched to the actual road use of the driver/taxpayer.

Efficient

Ideally, vignette charges would be targeted at recovering fixed or 'common costs' incurred by the road network irrespective of demand levels because the basis of taxation is not actual use, but the opportunity to use the road network. For similar reasons, vignettes are poor mechanisms for pricing externalities, except to the extent that vehicle characteristics might inform surcharging or discounting the applicable rate. However, this may be administratively complex at the transaction level if not supported by 'objectively true' vehicle characteristic data in a central digitized motor vehicle register.

Sustainable revenue

Vignette charges are a sustainable means of tapping into an enduring base of taxable activity. The move away from vignette charges is being driven by a desire to apply tools that perform better against a wider set of public policy goals.

Secure

Vignettes require little to no exchange of private personal information, and little to no inter-jurisdictional exchanges of information or revenue, and so are suitable as stand-alone tax instruments.

Integrated

If given a clear role in recovering vehicle costs, vignettes can sit alongside other instruments to round out a comprehensive and complementary taxation regime.

SUMMARY ASSESSMENT

Vignette charges are, in effect, a form of fixed registration charge. They provide an easy to monitor and enforce method of extending fixed access charges to out-of-state vehicles temporarily visiting or transiting through a jurisdiction.

Given their heavy reliance on averaging, vignette charges are better suited to recovering cost types that do not scale with use, or 'common costs', like the provision and maintenance of signage and/or the operation of traffic control devices.

In addition, if used instead of fixed access charges, they provide a mechanism for softening the false positive tax burden imposed by full annual charges on low use seasonal vehicles.

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A4.6 Distance-based charges

TOOL DESCRIPTION

A per-mile/per kilometre charge on vehicle distances travelled.

The vehicle operator is required to maintain accurate and complete distance records for each liable vehicle. In a pre-pay system, these records are used to show that the vehicle concerned has a current valid licence for the total distance driven by that vehicle. In a post-pay system, these records support periodic filing to enable the tax owed to be assessed and paid.

The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount. However, the rate for any given vehicle class, make or model may vary relative to other classes, makes or models reflecting a jurisdiction's cost allocation and rate-setting choices.

Proof of payment usually takes the form of a physical decal, licence or receipt, electronic licence or receipt, and/or database record.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
Each vehicle has a unique, 'always on', distance recorder that counts all distances travelled by the vehicle.	The consumer takes the current reading from the distance recorder and uses this to either identify whether a new permit is needed or to complete a required periodic return and declaration.	Tax is paid at the time of purchasing a new permit or as part of submitting the periodic return and declaration.	Through scheduled safety or random roadside vehicle inspections, or in consequence of a missed payment or shortfall.

WHERE IS THE TOOL IMPLEMENTED

This report is based on evidence from four sets of example distance-based charging programs.

U.S. distance-based charging pilot, including state and multi-state pilots

Since 2006, ten states have conducted around 18 separate pilots addressing a wide variety of scenarios. In addition, The Eastern Transport Coalition has and continues to coordinate an extensive program of single- and multi-state RUC trials.

'Live' distance-based charging systems active in the U.S.

States currently collecting a weight-distance tax for trucks are Kentucky, New Mexico, New York, Oregon, and most recently since 1 January 2023, Connecticut. Indiana passed a distance-based charging program in 2023 for electric trucks that is equivalent to the fuel tax for a given fleet. Rates and weight classes differ from state to state.

States with distance-based charging programs in place for light vehicles are Hawaii, Oregon, Utah and Virginia. Again, the detailed practices vary from state to state. In each case, they focus on collecting road usage charges or 'RUC' from fuel-efficient and/or alternative fuel vehicles. These programs are offered on a voluntary basis, where drivers opting in to pay by the mile are exempted from paying an annual registration surcharge on their vehicles.

European tolling programs

Distance-based charging of heavy vehicles has been in place in Europe since 1999. Austria, Belgium, Bulgaria, the Czech Republic, Germany, Hungary, Iceland, Poland, the Russian Republic, Slovakia, and Switzerland have active programs. Denmark, Lithuania, the Netherlands, and Sweden have heavy vehicle programs under development. Finland, Iceland, the Netherlands, and Norway are considering light vehicle programs.

New Zealand's road user charges program

RUC has been operational in New Zealand since 1978. It was introduced to alleviate the productive sector of the burden and opportunity cost of having to seek refunds from having an excise on diesel and to avoid the enforcement inadequacies of dyed diesel regimes. Approximately 20% of all registered vehicles in New Zealand – 900,000 light vehicles and 200,000 powered and unpowered heavy vehicles – meet their road tax obligations through RUC. In 2021-22, RUC revenues surpassed those from the petrol tax, and RUC is the single largest source of road funding revenue in New Zealand.

LESSONS LEARNT

Simple

Distance-based charges require the public to effect and accept a change in mind-set and become more mindful of the tax burden and their responsibility to meet it. This does not mean the transactions cannot or should not be simple, but they are unavoidably more involved than simply adding (taxed) fuel to a vehicle.

Robust

Distance-based charges can be seriously exposed to evasion if not well designed. However, with careful design, compliance can tend back towards the rate of vehicle registration.

Equitable and fair

Distance-based charges have the ability to apply nuanced rates in response to arrange of equity concerns, and avoid the implicit inequities that come with input-based taxes.

Efficient

Toll-based approaches need to be placed on routes that carry higher volumes of the target vehicles. Permit/licence-based programs need to be able to direct larger volumes through fewer channels to achieve scale economies, and/or to be able to leverage existing public-facing services to bring the administration cost down to the marginal cost of the transaction.

Digital technologies can make a significant difference to administration and compliance costs. However, this does not necessarily mean using them to track vehicles and automate transactions. Simply providing an internet compliance channel and using electronic rather than paper credentials can significantly reduce the perceived hassle and underlying cost to all parties. Allowing taxpayers to pick a cadence of compliance, rather than imposing a relatively high frequency cadence as standard, can also significantly reduce costs. It is likely that commercial operations will tend towards a higher frequency of transactions to leverage existing business processes to smooth cash flows, while households will tend towards fewer, to find a balance between lowering then lump-sum shock relative to the increase in paperwork involved.

In general, distance-based charges have administration and compliance costs within the 'normal' range of road funding revenue tools, with jurisdictions having a range of options to choose from according to their policy goals and cost tolerances.

Sustainable revenue

Projected demand for road transport strongly suggests that the taxable base will persist at levels that would make a distance-based mechanism cost effective.

Secure

Distance-based charges do not require any more information from taxpayers than what is already held in motor vehicle or toll company registers, plus periodic odometer readings. Existing privacy and security best practices – the latter kept up-to-date with the evolving threat-scape – are proven.

Adding location data to the mix increases data quantities and the potential richness of the insight into the lives of individuals if misused. However, again, best practice exists. Assuming best practices are adhered to, the core issue is one of trust and selecting the institutional forms that best meet public expectations.

Integrated

Interoperability of distance-based charges, if needed due to common land borders, must be planned and designed for. However, at its core, this primarily needs an agreed method for counting, reporting and apportioning distances travelled in each jurisdiction.

SUMMARY ASSESSMENT

Distance-based charging is a proven method for raising road funding revenues. As a method it is not a cure for failure to maintain the real value of the revenue gathered and its proportionality to the road funding task it is intended to support.

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A4.7 Within-area charges

TOOL DESCRIPTION

A vehicle is charged for travelling within a defined area of interest, accumulating greater charges the more it travels within the area.

Typically, roadside technology of some description is used, with or without in-vehicle transponders, to register the passage of the vehicle within the area of interest. The associated fee is collected using some form of free-flow tolling mechanism, with the liability registered at the time of travel and the cost either deducted from a pre-paid account or invoiced for payment in arrears.

The amount is 'flat' in the sense that vehicles of identical class, make and model would pay the same amount when moving inside the same boundary at the same place and time. However, the rate for any given vehicle class, make or model, area or time may vary relative to other classes, makes or models, or areas and times, reflecting a jurisdiction's cost allocation and rate-setting choices.

The onus of proof of payment lies, in the first instance, with the toll operator, which must determine and demonstrate that a toll owed has not yet been paid.

INSTRUMENTALITY

MEASURING	REPORTING	PAYING	CHECKING
Roadside technology is used to detect movement into and/or around the area, with charges ascribed. On board units may be used to facilitate identifying the vehicle and its presence, or even to measure the specific distance travelled in-area.	Either the roadside technology reports each instance of a charge being incurred, and the charge time and point (which may affect the spot price), or the on board unit supplies the data on total and/or eligible distances travelled to a secure back-end system.	Pay-as-you go from a pre-charged tolling account, or payment in arrears through billing or tax declarations.	Records are kept. Additional roadside technology, like cameras, may be deployed or cross-purposed to supply information to corroborate liabilities.

WHERE IS THE TOOL IMPLEMENTED

There are very few examples of active within area charging programs. They fall into three categories:

1. Tolling system derived area charges, as used in London, along with the further evolutions of these as proposed for Brussels with the SmartMove program and app.
2. Retail delivery fees, as are emerging in the United States.

3. The experimental application of distance-based charging with differentiated pricing at sub-jurisdictional levels.

LESSONS LEARNT

Simple

Within area charges are operationally complex yet can be delivered in clear and simple ways.

Robust

Within area charges are enforceable and able to be designed with compliance enhancing features. However, their very nature exposes them to a greater risk of revenue leakage.

Equitable and fair

Within area charges are not inherently inequitable and can have their design tailored, or supported by other instruments, to address negative equity impacts.

Efficient

The three general approaches to within area charges perform quite differently in terms of their overall efficiency. Tolling-based approaches consume a significant (minority) share of the revenue they gather, whereas retail delivery fees are cheap for the government to run and relatively lucrative. Approaches based on distance-based charging will fall somewhere in between and, like a tolling-based approach, will probably perform best when also delivering interventions to let net social welfare.

Sustainable revenue

Within area charges make sense when targeting a relatively dense area of activity and, as such, are likely to be able to persist, subject to ongoing political will.

Secure

Within area charges are potentially highly intrusive when relying on tolling or GPS-based tracking technologies. Best practices exist and are being continually evolved to match changes in the threat-scape.

Integrated

Within area charges have no intrinsic barriers to being integrated, either with other revenue tools within a jurisdiction, or across jurisdictions.

SUMMARY ASSESSMENT

'Within area charges' as discussed here are really three quite distinct mechanisms: one based on tolling, another on sales taxes, and the last on distance-based charging. The assessments made here average them out to some degree, so it is important to recognise their particular strengths and weaknesses:

1. Tolling-based systems, like the London Congestion Charge, are expensive to run. While they generate revenue, their value is in their ability to deliver net social benefits, in particular in relation to the externalities generated when you get large concentrations of motor vehicle activity, e.g. congestion, emissions, and amenity loss.
2. Retail delivery fees are relatively cheap to run and can yield proportionally large revenues. However, they are somewhat blunt and can impose significant compliance costs, leading to a heightened risk of accidental or deliberate non-compliance and evasion if not carefully targeted.

3. Programs that piggy-back on location-enabled - distance-based charging systems to apply additional charges inside areas of interest, across the whole vehicle fleet of a jurisdication are unproven. Currently, their affordability – if applied across the whole vehicle population - is poor, and they can prompt privacy concerns among the public. However, they offer a promise of more nuanced pricing than tolling systems can support, at a potentially lower cost to deploy and operate.

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