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Pay-As-You-Go Driving: Examining Possible Road-User Charge Rate Structures for California

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MTI MINETA TRANSPORTATION INSTITUTE

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CSUTC California State University Transportation Consortium

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REPORT 23-30

PAY-AS-YOU-GO DRIVING: EXAMINING POSSIBLE ROAD-USER CHARGE RATE STRUCTURES FOR CALIFORNIA

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16. Abstract
This report lays out principles to help California policymakers identify an optimal rate structure for a road-user charge (RUC). The rate structure is different from the rate itself. The rate is the price a driver pays, while the structure is the set of principles that govern how that price is set. We drew on existing research on rate setting in transportation, public utilities, and behavioral economics to develop a set of conceptual principles that can be used to evaluate rate structures, and then applied these principles to a set of mileage fee rate structure options. Key findings include that transportation system users already pay for driving using a wide array of rate structures, including some that charge rate structured based on vehicle characteristics, user characteristics, and time or location of driving. We also conclude that the principal advantage of RUCs is not their ability to raise revenue but rather to variably allocate charges among various types of users and travelers. To obtain those benefits, policymakers need to proactively design rate structures to advance important state policy goals and/or improve administrative and political feasibility.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report lays out principles to help California policymakers identify an optimal rate structure for a road-user charge (RUC), a fee that vehicle owners would pay for each mile driven on public roads. The rate structure is different from the rate itself. The rate is the price a driver pays, while the structure is the set of principles that govern how that price is set. For example, do all drivers pay the same flat rate? Or is the price higher for vehicles that are larger, or pollute more, or drive at congested times?

STUDY METHODS

We drew on existing research on rate setting in transportation, public utilities, and behavioral economics to develop a set of conceptual principles that can be used to evaluate rate structures, and then applied these principles to a set of mileage fee rate structure options.

FINDINGS

Transportation system users already pay for driving using a wide array of rate structures. Some of the charges that drivers pay are undifferentiated among users (e.g., annual vehicle registration fees in some states that are the same for all light-duty vehicles). Alternatively, other charges adopt a rate structure based on vehicle characteristics (i.e., bridge tolls that vary by vehicle weight), user characteristics (i.e., carpool discounts for toll lanes), or time or location of use (i.e., parking lot rates that vary by weekend vs. weekday).

The principal advantage of RUCs is *not* their ability to raise revenue, but to variably allocate charges among various types of users and travel. There are much simpler and more efficient ways to raise money than road user charges, such as via property and sales taxes. Like its predecessor, the motor fuels tax, RUCs can fairly and reasonably charge travelers according to how much they use roads and the variable costs imposed by their travel.

***An*y RUC rate structure (even a flat one) will influence travel behavior and, in turn, California's ability to attain its economic, environmental, equity, and safety goals.** The economics literature has shown that variations in the cost of driving influence where, when, and how far individuals and businesses drive, and whether they choose to travel by other means. Thus, no matter how RUC rates are structured, they will influence driver behavior in ways supportive of or counter to state goals. Over the longer term, RUC rates will also influence vehicle purchase choices, as well as residential and employment location decisions.

Rate structures can be proactively designed to advance important state policy goals and/or improve administrative and political feasibility. For example, the state could provide all drivers with some relatively low-cost travel allotment by using a block-rate RUC. This structure charges all vehicles the same modest flat rate per mile up to a threshold (e.g., 5,000 miles/year), after which the per-mile fee increases for additional miles. This option would provide basic road access for low-income drivers without the need to vary rates by owner characteristics. Also, the state could reduce the cost to build and maintain the transportation system by varying rates according to vehicle weight and number of axles to minimize road damage. Finally, offering a lower rate to qualifying low-income drivers or to drivers of low-polluting vehicles may increase both equity and the acceptability of the RUC.

POLICY RECOMMENDATIONS

Consider multiple criteria when choosing a rate structure: Decision-makers must identify both the desired program outcomes and secondary impacts that they wish to either promote or avoid. Raising revenue is typically a primary motivation for any RUC rate structure, but it is also essential to clearly identify and prioritize the economic, environmental, equity, and other outcomes to be advanced through the RUC.

Avoid a flat-rate rate structure, which would be a step backward for many of California's most important policy goals. While a flat-rate structure could raise adequate revenue, it would likely stimulate driving choices that run directly counter to state priorities such as reducing road maintenance costs and vehicle emissions. A flat-rate RUC would perform worse on these dimensions than the current motor fuel taxes.

Look for RUC rate structures that account for the multiple costs imposed by travel. Benefits of these multi-part rate structures include:

- *Proactively advancing California's economic, environmental, and equity goals:* The economic signals sent to drivers would incentivize behaviors that support these goals.
- *Simplifying transportation taxes and fees:* A multi-component RUC rate structure could effectively replace not only fuel taxes but other fees such as annual registration fees on heavy vehicles.
- *Increasing political acceptability:* Polling evidence suggests that some multi-criteria rate structures may be as acceptable, or possibly even preferred, to the public as flat rates.

Conduct a new Highway-Cost Allocation (HCA) Study for California. HCA studies are technical assessments of whether various classes of road users are paying more or less in road-user taxes and fees than the costs imposed by their road use. These studies can consider road system wear and tear, air pollution, climate change, noise, safety, congestion, and so on. A comprehensive HCA study will provide decision-makers with important information on how various potential RUC rate structures might reasonably and fairly charge various road users in proportion to their costs imposed.

1. INTRODUCTION

This research report lays out a set of principles that the State of California can use to identify an optimal rate structure for any mileage-based road-user charge (RUC) programs that it may adopt in the future. The rate *structure* is different from the rate itself. The rate is the price a driver pays, while the structure is the set of principles that govern how that price is set. Defining the RUC structure is separate from (even if related to) decisions about actual *prices*.

We can use California's iconic Golden Gate Bridge as an example: the current toll rate structure on the bridge charges different prices to different vehicles based on (1) the number of axles, (2) how the driver makes the toll payment (with a FasTrak transponder, a license plate account, or by invoice), and (3) the number of passengers (for 2-axle vehicles). These three factors seek to (1) account for the disproportionate road space consumed, and wear and tear imposed by, commercial trucks and other heavy vehicles, (2) account for the variable administrative costs of processing various types of toll payments, and (3) motivate drivers to carpool in order to reduce vehicle traffic on the bridge. Within this structure, the managing authority sets different prices for multiple permutations of the three factors, ranging from $6.40 for a 2-axle carpooling vehicle paying with FasTrak to $65.85 for a 7-axle truck paying by invoice.[1] The prices, furthermore, can change *within* the structure; the structure is a guide for setting the price. Inflation or other criteria might lead the bridge authority to charge higher or lower prices, but if the structure is preserved, then smaller vehicles will always be charged less than larger ones, high-occupancy vehicles charged more than low-occupancy ones, and so on.

Decades of discussions about RUCs in the United States, including in California, have usually been motivated by a need to generate revenue. Raising revenue to support California's extensive network of streets, roads, and highways (the road network) is a challenging policy issue for the state for several reasons. First, the road network is extremely expensive to build and maintain–the state's 2022-23 budget allocated almost $20 billion to the California Department of Transportation (Caltrans) alone–so the state must meet large ongoing revenue needs.[2] Second, streets bring not just "private benefits" (residents can access a grocery store to buy food, and businesses can get their products to those stores to be sold) but also public ones (society at large benefits when residents have the food needed to keep them alive and healthy). The public benefits suggest that society has an incentive to provide some level of road service to everyone, even those who cannot afford to pay much for system use. Third, a RUC, regardless of policymakers' intentions, can never be only or entirely about raising revenue. Any change to a tax or fee will change the cost of traveling, and thus change driver behavior. Therefore, depending on how it is structured, a RUC will change how much people drive, when and where they drive, and what kind of vehicles they drive. While it may be difficult to predict precisely how a RUC rate structure will influence travel choices, policymakers must nevertheless grapple with that challenge to avoid unintended negative consequences.

1 Golden Gate Bridge Highway & Transportation District, "Tolls & Payment," Golden Gate Bridge, July 1, 2022, https://www.goldengate.org/bridge/tolls-payment/.

2 California Legislative Analyst's Office, "The 2022-23 California Spending Plan: Transportation," *Budget and Policy Posts* (blog), September 29, 2022, https://lao.ca.gov/Publications/Report/4628.

The national conversation about mileage fees as a possible replacement for state and federal fuel taxes has taken on new urgency for policymakers in recent years with the growth in electric vehicle sales and government policy initiatives to transition the national fleet away from the gasoline and diesel-burning internal-combustion engine (ICE) vehicles that generate fuel tax revenue. In California, Governor Newsom made headlines in January 2021 when he issued Executive Order N-79-20, which directed state agencies to plan for ending the sale of new motor vehicles fueled by internal combustion engines (ICE) by 2035.[3] Rising sales of electric vehicles in California in recent years have led many transportation experts to conclude that a transition away from ICE vehicles is inevitable, even if experts disagree on the exact rate of the fleet turnover and whether ICE vehicles will ever completely disappear. The electric-vehicle manufacturer Tesla made headlines when it was revealed that for 2022 it was second only to Toyota in the total number of new vehicles sold in California and that it also produced the two top-selling new vehicles in the state, the Model Y and Model 3.[4]

While such a transition away from ICE vehicles could substantially reduce emissions of greenhouse gasses and air pollutants, the change would also decimate the revenue available for transportation. Excise and sales taxes on gasoline and diesel motor fuel are currently the largest source of revenue for statewide transportation capital investments, operations, and maintenance. In fiscal year 2021-2022, taxes on petroleum-based fuels generated $8.4 billion ($7.1 billion for gasoline and $1.3 billion for diesel) for the State of California.[5] And the revenue impact from dwindling ICE vehicles will be major, even if the transition progresses more slowly than anticipated by the current policy environment. A study by Agrawal, et al., projected that future state transportation revenues under different scenarios estimated that the revenue from gasoline excise taxes could vary by as much as $2 billion a year in 2040, depending on the proportion of zero emission vehicles (ZEV) vs. ICE vehicles in the state.[6]

Numerous RUC pilots and research studies have been completed nationally to inform debates over both the viability and desirability of enacting a RUC.[7] California has been at the forefront of this work since 2014, when the state began a series of ambitious

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3 State of California, Executive Department, "Executive Order N-79-20," September 23, 2020, https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.

4 Reuters, "Tesla's Model Y and Model 3 Top-Selling Vehicles in California in 2022," February 8, 2023, https://www.reuters.com/business/autos-transportation/teslas-model-y-model-3-top-selling-vehicles-california-2022-2023-02-08/; Zachary Shahan, "Tesla Is #2 Best Selling Auto Brand In California," *CleanTechnica* (blog), March 9, 2023, https://cleantechnica.com/2023/03/09/tesla-is-2-best-selling-auto-brand-in-california/.

5 California Department of Tax and Fee Administration, "Gasoline Tax Data (Table 24A), Grid View," CA.gov, 2023, https://www.cdtfa.ca.gov/DataPortal/dataset.htm?url=FuelGasJetStats; California Department of Tax and Fee Administration, "Diesel, IFTA, Alternative Fuels Data (Table 25B), Grid View," CA.gov, 2023, https://www.cdtfa.ca.gov/DataPortal/dataset.htm?url=FuelDiesAltTaxStats.

6 Asha Weinstein Agrawal et al., *The Impact of the COVID-19 Recovery on California Transportation Revenue: A Scenario Analysis through 2040* (San Jose: Mineta Transportation Institute, December 2020), https://transweb.sjsu.edu/sites/default/files/2054-Agrawal-Impact-COVID-19-Recovery-California-Transportation-Revenue.pdf.

7 Mineta Transportation Institute, "MTI Mileage Fee Research and Information Directory (MFRID)," Mineta Transportation Institute, October 7, 2020, https://transweb.sjsu.edu/mfrid.

RUC pilot projects to explore technical challenges like data security and protection of participants' privacy, methods to collect accurate mileage data, and different payment options like monthly billing vs. paying at the fuel pump or electric charging stations.[8]

Across the U.S., the pilots and research studies have often devoted much less attention to the subject of the current report: how should RUC rates be *structured*? The majority of current RUC programs adopted in the U.S., and a number of the pilot programs, have used a flat rate structure. For example, Oregon's ORegO program charges 1.8¢/mile, Utah's Road Usage Charge Program charges 1.5¢/mile,[9] Colorado's 2016-2017 pilot charged 1.2¢/mile,[10] and California's 2017 Road Charge Four-Phase Demonstration pilot charged 1.8¢/mile.[11] The only complexity added to these rate structures is that some cap the annual amount paid by drivers. With a few exceptions such as the Washington Transportation Commission and the Eastern Transportation Coalition,[12] the planning and policy development documents for the flat-rate RUC programs have frequently glossed over why the flat-rate structure was chosen over other options, even though detailed explanations are usually provided to explain how the specific per-mile price was set.

Despite the predominance of flat-rate RUC structures in current California policy conversation and RUC programs in other states, a number of alternative rate structures have been studied and tested in the U.S. and internationally. In 1978, New Zealand adopted a RUC program that has gradually expanded to cover all heavy-duty vehicles and light-duty diesel vehicles. Rates vary by vehicle classes, as defined by weight and number of axles.[13] Similarly, four states in the U.S. charge so-called "weight-distance" fees on heavy-duty vehicles, with Oregon's adopted 90 years ago in 1933.[14] Additionally, many European countries levy distance-based tolls on heavy-duty vehicles. The rate structures

8 California State Transportation Agency, *California Road Charge Pilot Program 2017 Final Report*, Senate Bill 1077, 2017, https://caroadcharge.com/media/htbpngos/rcpp-final-report-a11y.pdf; California Road Charge, *California Four Phase Demonstration Comprehensive Report*, 2022, https://caroadcharge.com/projects/california-four-phase-demonstration/; RUC West, *Regional RUC Pilot Project Final Report*, 2022, https://caroadcharge.com/media/10tbtqci/rucwest_regionalruc_stsfa2017_pilotevaluationreport_110821_ada.pdf.

9 Utah Office of Administrative Rules, "Rule 17: Road Usage Charge Program," R926-17 Utah Administrative Code § (2023), https://adminrules.utah.gov/public/rule/R926-17/Current%20Rules?searchText=R926-17; Utah DOT, "Utah's Road Usage Charge: Frequently Asked Questions," 2022, https://roadusagecharge.utah.gov/faq.php.

10 Colorado Department of Transportation, *Colorado Road Usage Pilot Program Final Report* (Denver: Applied Research and Innovation Branch, December 2017), https://www.codot.gov/programs/ruc/documents/rucpp-final-report.

11 California Road Charge, *California Road Charge Four-Phase Demonstration*, Final Report (Sacramento, August 2022), https://caroadcharge.com/media/rkqfswef/ca_ruc_comprehensive_report_8-30-22_remediated.pdf.

12 Washington State Transportation Commission, "Appendix A-15: RUC & Rate-Setting," in *Washington State Road Usage Charge Assessment*, 2020, https://waroadusagecharge.org/wp-content/uploads/2020/01/WA-RUC-A-15-RUC-Rate-Setting.pdf; Eastern Transportation Coalition, *2018 – 2019 Multi-State Truck Pilot Final Report*, Mileage-Based User Fee Study, July 2020.

13 Washington State Transportation Commission, "Appendix A-15: RUC & Rate-Setting."

14 Oregon Department of Transportation, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program* (Salem, Oregon: Oregon Department of Transportation, November 2007), https://www.myorego.org/wp-content/uploads/2017/07/RUFPP_finalreport.pdf; Heather Ness, "Remember Your State Tax Obligations," *Truck News* (blog), May 25, 2021, https://www.trucknews.com/blogs/remember-your-state-tax-obligations/.

depend on vehicle weight, axels, and emissions category, with markups for trucks over 3.5 tons gross weight, travel in mountainous areas, and to cover the external costs of air and noise pollution.[15]

More recently, RUC pilots in Puget Sound, Washington (2004-2006),[16] Oregon (2006-2007),[17] and Minnesota (2013)[18] experimented with charging higher rates for travel in congested places and/or during congested periods. The Eastern Transportation Coalition, which has done some of the deepest research into possible RUC rate structures for heavy-duty vehicles, ran a National Truck Pilot (2020-2021) that varied the per-mile rate by vehicle fuel efficiency.[19] Other pilots that based rates on fuel efficiency are the National Evaluation of Mileage Charges for Drivers (2008-2010),[20] Virginia's Mileage Choice Program for fuel-efficient and electric vehicles, and California's forthcoming SB 339 Road Charge Pilot.[21] Finally, the U.S. has long experience with RUC-like charges in the form of state weight-distance fees on trucks, including Oregon and New Mexico.

Determining tax rates and charges for public services are always politically fraught, and setting RUC rates are no exception. Ultimately, RUC rate structures and levels must be based on normative judgements about *who* should pay and *how much*. However, the state must begin to grapple directly with these thorny policy choices if it is to move past pilots towards real-world implementation. We contribute to the discussion about RUC rate structure by laying out a set of principles and evaluation strategies that state officials can use to evaluate proposed RUC rate structures. This kind of analysis will generate promising RUC rate structure options that can then be further explored with technical analyses to predict outcomes under different pricing scenarios.

To develop the ideas presented in the report, we drew from several bodies of research and consulted with professionals experienced in how transportation agencies set tax and fee structures and rates. We reviewed the RUC literature itself for guidance on setting rate structures, the specific structures discussed in scholarly studies and used in pilots.

15 Werner Rothengatter, "Environmental Charges Levied on Heavy Goods Vehicles in the EU," in *Balancing Nature and Civilization - Alternative Sustainability Perspectives from Philosophy to Practice*, ed. Yoshitsugu Hayashi, Masafumi Morisugi, and Sho-ichi Iwamatsu, vol. 32, SpringerBriefs in Environment, Security, Development and Peace (Cham: Springer International Publishing, 2020), 77–91, https://doi.org/10.1007/978-3-030-39059-4.

16 Puget Sound Regional Council, *Traffic Choices Study: Final Report* (Seattle, April 2008).

17 Oregon Department of Transportation, *Oregon's Road Usage Charge: The OreGO Program, Final Report* (Salem: Oregon Department of Transportation, April 2017), https://www.oregon.gov/ODOT/Programs/RUF/IP-Road%20Usage%20Evaluation%20Book%20WEB_4-26.pdf.

18 Minnesota Department of Transportation, *Connected Vehicles for Safety, Mobility, and User Fees: Evaluation of the Minnesota Road Fee Test* (Roseville, Minnesota: Minnesota Department of Transportation, February 2013), http://www.dot.state.mn.us/mileagebaseduserfee/pdf/EvaluationFinalReport.pdf.

19 Eastern Transportation Coalition, *Exploration of Mileage-Based User Fee Approaches for All Users*, February 2022, https://tetcoalitionmbuf.org/wp-content/uploads/2022/02/Exploration-of-Mileage-Based-User-Fee-Approaches-for-All-Users_Condensed-1.pdf.

20 Paul F. Hanley and Jon G. Kuhl, "National Evaluation of Mileage-Based Charges for Drivers: Initial Results," *Transportation Research Record* 2221, no. 1 (January 1, 2011): 10–18, https://doi.org/10.3141/2221-02.

21 Road Charge Technical Advisory Committee, *SB 339 Pilot Design Recommendations* (Sacramento: California Transportation Commission, June 29, 2023), https://catc.ca.gov/-/media/ctc-media/documents/ctc-committees/road-charge/sb-339-road-charge-pilot-design-recommendations-report-a11y.pdf.

We also reviewed studies of public opinion and stakeholder views on various forms of transportation pricing and taxation. Broadening the focus, we then moved out to seek lessons from how rate structures are designed for other transportation charges, as well as for public utilities such as water and electricity.

An overarching theme in this report is that a rising price to use the road, like virtually any rising price, will result in some combination of changed revenue and changed behavior. Compared to a free road paid for by revenues unrelated to driving (like a sales tax), a road with a price (e.g., via a toll or RUC) will both increase revenue and reduce driving. As we compare various possible rate structures in this report, the goals of raising revenue and changing behavior (to reduce road damage, vehicle emissions, or traffic congestion) exist in some tension. If the price of driving under a RUC is relatively low, people will be likely to pay and drive as much or more as they did with fuel tax finance. The RUC in this case might raise substantial revenue, but compared to a RUC with higher prices, it would increase road damage, vehicle emissions, and congestion delays. Conversely, a higher, variable-rate RUC might reduce road damage, emissions, and congestion, but raise less revenue in the process than a lower price that did not deter as much driving.

The remainder of the report is organized as follows. Chapter 2 lays out conceptual approaches and other evaluation criteria that can be used to identify the strengths and drawbacks of any proposed RUC rate structure. Chapter 3 then presents an overview of the wide diversity of rate structures that have been applied in transportation and public utilities (electricity, water, and telecommunications) to charge system users. Recognizing that it is also important to consider how the state would manage potential rate structure and price changes over time, the chapter presents a parallel exploration of different methods used to adjust rates/rate structures over time as may be needed. Chapters 4 and 5 draw from the preceding chapters and illustrate a sketch evaluation of six different possible rate structures, looking at how effectively each structure might reach intended program goals, equity, and implementation feasibility.

2. CONCEPTUAL APPROACHES AND EVALUATION CRITERIA FOR SETTING EFFICIENT AND EQUITABLE RUC RATES

This chapter sets out different conceptual frameworks and evaluation criteria that can help policymakers evaluate different options for RUC rate structures. Section 2.1 provides a quick primer on what we can learn from the behavioral economics literature about how changing prices for travel impact driver behavior. This knowledge is critical to predicting the outcomes of different RUC rate structures. Sections 2.2. and 2.3 present two conceptual approaches that could be used to identify an appropriate RUC rate structure. The first approach (section 2.2) is to choose the rate structure based on thorough consideration of the desired RUC program outcomes. This approach, grounding choices about RUC rate structure in a clear sense of the purpose(s) of the fee, is critical to ensuring a successful RUC program. A principal benefit of RUCs is that they can be designed to do more than raise revenue; other possible outcomes are to improve transportation system performance by, for example, reducing carbon emissions, pavement damage, or traffic congestion. And even if the RUC program goal is solely to raise revenue, different rate structures may prove more effective than others at raising predictable sums of the desired amount over time. The second conceptual approach (section 2.3) is to design a rate structure that charges drivers in proportion to the marginal costs imposed by each trip. Section 2.4 lays out three other critical considerations that determine the desirability of a particular approach to rate setting: administrative feasibility, political feasibility, and equity implications. The concluding section emphasizes the need to identify a rate structure that is not only conceptually sound but also feasible to implement and equitable.

2.1 INSIGHTS FROM ECONOMICS: HOW DRIVERS RESPOND TO PRICE SIGNALS

Much of the discussion below draws on the premise that any price that drivers face, whether a new charge or a change to an existing charge, influences behavior. (This is, of course, a fundamental principle of economic theory.) Therefore, predicting the outcomes of any RUC rate structure requires understanding how drivers and shippers are likely to respond to both the *rate structure* and *price level* of a RUC. The most likely near-term responses are to change the timing, distance, destination, or sharing of vehicle trips, depending on the structure and level of RUC pricing. Over the longer term, some RUC rate structures and prices could lead travelers to shift the types of vehicles they drive, as well, if the rate structure incentivizes that. This section briefly summarizes some of the key lessons from research into how changing marginal travel costs influences travel choices.

The Impact of Marginal Driving Costs on Mileage Driven

Introducing a RUC will change the marginal cost of driving, regardless of whether the state implemented the RUC in addition to or as a replacement for fuel taxes. This section explains how we can draw from economics principles and the research literature to estimate how individual drivers and fleet managers may respond to a RUC. The discussion draws heavily from the literature on changing gasoline prices, which presents drivers with a situation similar—though not identical—to a RUC.

Drivers, like consumers purchasing most services and goods, are sensitive to price changes. If the marginal price of travel drops, such as through a lower gas-tax rate, people will typically drive more miles. Conversely, as the marginal cost of driving increases, such as with increasing fuel costs, people will tend to consume less fuel. An important distinction here is that drivers have many options for reducing their fuel consumption, in both the short and longer terms, and not all of these involve driving less. Driving less aggressively, sharing rides (and fuel costs) with others, improving vehicle maintenance, and switching to more fuel-efficient vehicles can all improve fuel costs without driving less. A per-mile RUC, in contrast to fuel taxes, can only be avoided by driving less. Reductions in miles traveled can occur in many ways: drivers can forgo some trips, share rides with others, switch to other modes such as public transit, or substitute closer destinations for farther ones (e.g., shopping at a nearby grocery store instead of a preferred one farther away).

The most extensive body of research on how changing travel prices influence driving choices are studies of the price elasticity of demand for gasoline in light-duty vehicles. This research is slightly imperfect for our purposes because it examines changes in fuel consumption rather than changes in miles driven, and people can, again, reduce their fuel consumption without reducing their driving (e.g., by switching to more fuel-efficient vehicles or driving more carefully). Nevertheless, we can draw some reasonable conclusions from this literature, the primary one being that the demand for driving, as represented by fuel purchases, is inelastic, which means that prices change proportionally more than driving does. Specifically, even substantial increases in fuel prices generally lead to only modest decreases in fuel consumption (and travel), at least in the short term. This is probably because driving is mostly a planned behavior around which people's lives (and firms' activities) are organized in space and time, such that consuming less fuel—such as by sharing rides or buying a more fuel-efficient car—entails multiple, interlocking decisions.

Recent literature reviews have found that elasticities in the U.S. range between -0.05 to -0.37. In other words, for every 10.0% increase in the price of gasoline, consumption drops somewhere between 0.5 and 3.7%.[22] For example, if the price elasticity of gasoline is at the extreme end of this range, -0.37, and the price of gasoline rises 10% from $4.00 to $4.40 per gallon, then an average driver who typically purchase 50 gallons of gasoline a month will respond by reducing fuel purchases to 48.2 gallons per month—only about 1.9 gallons less. As Lewis, Levin, and Wolak observe, elasticities closer to the high end demonstrate the potential for reducing fuel consumption through policies that raise gasoline prices.[23]

The research into the elasticity of gasoline prices–and thus, with some qualifications, the elasticity of a RUC–has found that the elasticity will vary depending on economic conditions, trip purpose, and driver or vehicle characteristics (vehicle fuel efficiency, annual mileage,

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22 Lutz Kilian and Xiaoqing Zhou, "Gasoline Demand More Responsive to Price Changes than Economists Once Thought," Federal Reserve Bank of Dallas (blog), June 16, 2020, https://www.dallasfed.org/research/economics/2020/0616; Kenneth Gillingham and Anders Munk-Nielsen, "A Tale of Two Tails: Commuting and the Fuel Price Response in Driving," *Journal of Urban Economics* 109 (January 1, 2019): 27–40, https://doi.org/10.1016/j.jue.2018.09.007; Laurence Levin, Matthew S. Lewis, and Frank A. Wolak, "High Frequency Evidence on the Demand for Gasoline," *American Economic Journal: Economic Policy* 9, no. 3 (August 2017): 314–47, https://doi.org/10.1257/pol.20140093.

23 Levin, Lewis, and Wolak, "High Frequency Evidence on the Demand for Gasoline."

household income, and availability of transit as an alternative mode).[24] For example, a 2023 study by Kilian and Zhou found that drivers are more sensitive to gasoline price changes in states with lower real personal income, higher unemployment rates, larger rural populations, fewer public transit commuters, and more registered vehicles per capita.[25] A 2015 study by Dillon, Saphores, and Boarnet found that when gas prices rose by 1.0%, households did not change work trips but did decrease driving for non-work purposes by 0.17%.[26]

Only a few studies look directly at the relationship of most interest for this report: how drivers change vehicle miles traveled (VMT) in response to gasoline price fluctuations. (The research discussed above explored how changing fuel prices influenced fuel consumption, which is only an indirect measure of VMT.) One such study by Gillingham explored how VMT for vehicles up to six years old changed in response to gasoline price spikes from 2006 to 2008.[27] He concluded that drivers responded with notable reductions in VMT; the price elasticity of gasoline was -0.22. He also found that the elasticity increased along with income for the middle-income groups and speculated that two factors may explain the finding: that middle-income households make more discretionary trips that are easy to curtail, and/or that these households have multiple vehicles and can switch some of their driving to the more fuel-efficient ones. Echoing these findings about how responses vary by income, Wenzel and Fujita found that Texas households in zip codes with lower median incomes were more price sensitive to increasing fuel prices than were households in higher-income zip codes.[28] That study also found that drivers reduced VMT more in fuel-inefficient vehicles than fuel-efficient vehicles. Finally, the 2015 study by Dillon, Saphores, and Boarnet mentioned above found that drivers reduce non-work trips when gasoline prices rise.[29]

A much smaller body of literature has estimated the price elasticity of diesel fuel for heavy-duty vehicles. The impact is also trickier to model than elasticities for passenger travel because shippers have more options than personal travelers for how they respond to

24 Frank Goetzke and Colin Vance, "An Increasing Gasoline Price Elasticity in the United States?," *Energy Economics* 95 (March 1, 2021): 104982, https://doi.org/10.1016/j.eneco.2020.104982; Gillingham and Munk-Nielsen, "A Tale of Two Tails"; Kenneth Gillingham, Alan Jenn, and Inês M. L. Azevedo, "Heterogeneity in the Response to Gasoline Prices: Evidence from Pennsylvania and Implications for the Rebound Effect," *Energy Economics, Frontiers in the Economics of Energy Efficiency*, 52 (December 1, 2015): S41–52, https://doi.org/10.1016/j.eneco.2015.08.011; Chien-Chiang Lee and Godwin Olasehinde-Williams, "Gasoline Demand Elasticities in the World's Energy Gluttons: A Time-Varying Coefficient Approach," *Environmental Science and Pollution Research* 28, no. 45 (December 1, 2021): 64830–47, https://doi.org/10.1007/s11356-021-15615-6.

25 Lutz Kilian and Xiaoqing Zhou, "Heterogeneity in the Pass-Through from Oil to Gasoline Prices: A New Instrument for Estimating the Price Elasticity of Gasoline Demand," SSRN Scholarly Paper (Rochester, NY, 2023), https://doi.org/10.2139/ssrn.4410253.

26 Harya S. Dillon, Jean-Daniel Saphores, and Marlon G. Boarnet, "The Impact of Urban Form and Gasoline Prices on Vehicle Usage: Evidence from the 2009 National Household Travel Survey," *Research in Transportation Economics*, Sustainable Transportation, 52 (October 1, 2015): 23–33, https://doi.org/10.1016/j.retrec.2015.10.006.

27 Kenneth Gillingham, "Identifying the Elasticity of Driving: Evidence from a Gasoline Price Shock in California," *Regional Science and Urban Economics*, SI: Tribute to John Quigley, 47 (July 1, 2014): 13–24, https://doi.org/10.1016/j.regsciurbeco.2013.08.004.

28 Tom Wenzel and K Sydny Fujita, *Elasticity of Vehicle Miles of Travel to Changes in the Price of Gasoline and the Cost of Driving in Texas* (Berkeley: Lawrence Berkeley National Laboratory, March 2018), https://eta-publications.lbl.gov/sites/default/files/_lbnl-2001138.pdf.

29 Dillon, Saphores, and Boarnet, "The Impact of Urban Form and Gasoline Prices on Vehicle Usage."

higher fuel prices, including raising prices charged to customers, changing driving behaviors that will save fuel (e.g., driving more slowly or reducing idling), changing fuel purchase locations (e.g., purchasing fuel in states with lower fuel prices and/or taxes), or changing vehicle type and loading patterns to move freight onto vehicles that consume less energy per ton-mile of freight. A pair of 2015 studies from Winebrake, et al., concluded that diesel fuel price elasticities were very small or even zero for both single-unit and combination heavy-duty vehicles.[30]

Evidence from pricing driving to reduce congestion offers another window into how drivers change how much, when, and where they drive in response to rising and falling prices. Numerous states have adopted variable pricing on toll lanes, with rates rising during more congested periods and falling when congestion is light or nonexistent. By using these price signals, it has been possible to keep traffic flowing smoothly because some drivers will travel at other times, shift to other routes, travel on other modes, forgo some trips altogether when prices are higher. For example, the Colorado Department of Transportation estimates that its I-70 Mountain Express lanes have reduced travel times by 21%, and an evaluation of LA Metro's I-10 and I-110 Express Lanes found that the impacts on congestion were "generally positive."[31] Outside the United States, Singapore, London, and Stockholm are known for highly successful congestion-pricing schemes that have dramatically reduced central-city traffic congestion by charging tolls to enter during busy periods.[32]

Finally, cities have in recent years experimented with another form of congestion pricing to manage traffic demand: variable street parking meter rates. An evaluation of Los Angeles' pilot program with variable meter rates found that the policy helped move the city towards its goal of 70% to 90% occupancy in metered spaces in order to eliminate drivers circling (termed "cruising") for available parking. Similarly, researchers concluded that a similar program with variable meter pricing for the City of San Francisco (SFPARK) led to increased transit use and slightly fewer vehicle miles traveled during peak periods.[33]

30 James J. Winebrake et al., "Fuel Price Elasticities for Single-Unit Truck Operations in the United States," *Transportation Research Part D: Transport and Environment* 38 (July 1, 2015): 178–87, https://doi.org/10.1016/j.trd.2015.05.003; James J. Winebrake et al., "Fuel Price Elasticities in the U.S. Combination Trucking Sector," *Transportation Research Part D: Transport and Environment* 38 (July 1, 2015): 166–77, https://doi.org/10.1016/j.trd.2015.04.006.

31 Colorado Department of Transportation, *I-70 Mountain Express Lanes* (Washington, D.C.: Federal Highway Administration, May 15, 2022), https://rosap.ntl.bts.gov/view/dot/63510; Jeremy Schroeder et al., *Los Angeles Congestion Reduction Demonstration Express Lanes Program : National Evaluation Report.* (Washington, D.C.: Federal Highway Administration, August 1, 2015), https://rosap.ntl.bts.gov/view/dot/3556.

32 Kiran Bhatt et al., *Lessons Learned from International Experience in Congestion Pricing.*, August 1, 2008, https://rosap.ntl.bts.gov/view/dot/16555; London City Hall, "Millions of Londoners Breathing Cleaner Air Thanks to ULEZ Expansion," July 19, 2022, https://www.london.gov.uk/press-releases/mayoral/londoners-breathing-cleaner-air-thanks-to-ulez.

33 Chandra Kiran B. Krishnamurthy and Nicole S. Ngo, "The Effects of Smart-Parking on Transit and Traffic: Evidence from SFpark," *Journal of Environmental Economics and Management* 99 (January 1, 2020): 102273, https://doi.org/10.1016/j.jeem.2019.102273.

The Impact of Marginal Driving Costs on Vehicle Purchase Choices

A related body of research looks at how changing marginal travel costs—usually measured in terms of fuel prices—affects vehicle purchase decisions. For example, Jeihani and Sibdari analyzed how fuel prices influenced U.S. automobile sales from 1990 through 2007.[34] They found a noticeable change in vehicle purchase choices about two years after a significant increase in gas prices: greater demand for hybrid vehicles and decreased demand for sport utility vehicles (SUVs). More recently, Ruckdashcel analyzed 2009–2017 new vehicle customer satisfaction surveys and concluded that for every dollar increase in gasoline prices, the fuel efficiency of vehicles purchased improved by about 10%.[35] Yet other studies have looked at how fuel prices influence the decision to purchase electric vehicles. Khattak and Khattak found from an analysis of 2017 National Household Travel Survey data that higher fuel prices influenced the likelihood that a consumer would choose a battery electric vehicle.[36]

2.2 DESIGNING RUC RATES TO ACHIEVE PROGRAM OUTCOMES

In order to identify the optimal RUC rate structure, decision-makers need to first identify the specific goals that that RUC will be designed to achieve. Raising revenue is almost certainly a goal for a RUC that will be fundamental to selecting the rate structure. However, like any price, the RUC rate will influence user behavior, whether intended or not. Decision makers can deliberately design the rate structure to influence transportation choices in ways that support—or at least don't undermine—other policy objectives like environmental sustainability or social equity.

Raising Revenue

In California, a primary motivation for pursuing a RUC is to reliably raise revenue to replace a gradually sun-setting fuel tax. The amount of revenue raised will depend on whether state officials seek to simply replace fuel tax revenues "lost" to the increased use of non-gasoline or -diesel vehicles, or to raise more revenues for transportation-related expenditures. (In addition to fuel taxes, funds for transportation are currently drawn from dozens of other sources, including vehicle fees, property taxes, sales taxes, and general funds.[37]) The potential for a RUC to raise such a large amount of revenue requires careful consideration of multiple factors related to the rate structure, even before considering the specific *prices* set under that rate structure.

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34 Mansoureh Jeihani and Soheil Sibdari, "The Impact of Gas Price Trends on Vehicle Type Choice" 11, no. 2 (2010).

35 James D Ruckdaschel, "The Influence of Gasoline Prices and Consideration Sets on the Fuel Economy of New Vehicle Sales" (Cambridge, Massachusetts Institute of Technology, 2020), https://dspace.mit.edu/bitstream/handle/1721.1/132862/1263346730-MIT.pdf?sequence=1&isAllowed=y.2020

36 Zulqarnain H. Khattak and Asad J. Khattak, "Spatial and Unobserved Heterogeneity in Consumer Preferences for Adoption of Electric and Hybrid Vehicles: A Bayesian Hierarchical Modeling Approach," *International Journal of Sustainable Transportation* 17, no. 1 (January 3, 2023): 1–14, https://doi.org/10.1080/15568318.2021.1975327.

37 Asha Weinstein Agrawal, Kevin Yong Lee, and Serena Alexander, *How Do California's Local Governments Fund Surface Transportation? A Guide to Revenue Sources* (Mineta Transportation Institute, November 2021), https://doi.org/10.31979/mti.2021.1938A.

One key consideration is whether the rate structure relies on a large enough tax base that the total amount of revenue desired can be maintained over time. A RUC rate structure based just on mileage should be able to generate similar amounts of revenue to fuel taxes over time, assuming that the RUC doesn't lead drivers to significantly change their behavior compared to what they would have done under the fuel tax, something unlikely unless the price per mile is much higher than the per-mile cost of paying fuel taxes. Conversely, a rate tied to on-board carbon emissions, such as one where the rate per mile rises with estimated carbon emissions per mile traveled, could gradually lose its revenue-generating potential if the vehicle fleet becomes largely electrified. (Such a transformation is currently called for in California policy, including from Governor Gavin Newsom's 2020 Executive Order that directs the state to work towards ending sales of motor-fuel cars and light trucks by 2035.[38]) In this case, the RUC would share the same weakness as current fuel taxes: the RUC will over time reduce the number of higher-priced miles driven in ICE vehicles, gradually undermining the program's ability to raise revenues from all road users.

A second key consideration is whether the rate structure allows revenue to grow in proportion to inflation. If a rate is not somehow pegged to the changing value of a dollar, then the amount of revenue it raises might fall steadily in real terms unless the rate structure and/or prices are regularly revised. This problem has been repeatedly discussed with respect to fuel taxes, which the federal government and most states traditionally structured as cents-per-gallon rates that require legislative action to adjust the rate.[39] Conversely, taxes linked to prices whose revenues are dedicated to transportation—such as sales taxes on fuel purchases—continue over time to generate similar amounts of revenue in inflation-adjusted dollars.

A third key consideration is to identify how *predictable* the revenue streams will be, since managing transportation systems efficiently requires knowing how much revenue will be available into the future. Reliably projecting transportation funding requires a revenue forecasting model that accounts for some combination of driver behavior inputs (e.g., choices drivers make about how many miles to drive, where they drive, and what vehicles they drive) and macro-economic and social factors (e.g., inflation, population size, and the cost of owning and operating a vehicle). Rate structures requiring fewer driver behavior model inputs make it moderately easier to project revenue, though in all cases models are rarely accurate predictors more than a couple of years into the future.

Improving Transportation System Performance

Transportation pricing can encourage people to make transportation choices that support broader social goals. These goals could be internal to the transportation system, such

38 State of Office of Governor Gavin Newsom, "Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change," September 23, 2020, https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/.

39 Peter G. Peterson Foundation, "It's Been 28 Years Since We Last Raised the Gas Tax, and Its Purchasing Power Has Eroded," March 16, 2021, https://www.pgpf.org/blog/2021/03/its-been-28-years-since-we-last-raised-the-gas-tax-and-its-purchasing-power-has-eroded.

as reducing traffic congestion, reducing the cost of building and maintaining roads, or improving safety. Or the goals could be external to the transportation system, such as reducing air pollution and/or greenhouse gas emissions.

Air pollution and greenhouse gasses are part of what we call the “social costs” of driving. The social cost of a trip refers not only to the private costs, like the prices travelers pay for vehicles, fuel, fares, and the like, but also the external costs that travelers occasion, like emissions, noise, road damage, and delays imposed on others. How we price transportation has an important effect on shaping the size of these social costs.

With a RUC, the rate structure could be set so that drivers pay enough in fees to cover the marginal social cost of each trip. Travelers who value a given trip enough will pay that cost, and make the trip as planned, and their payments will provide the funds needed to cover the costs they impose. Travelers who do not value the trip as much as the cost of the RUC charge will modify their behavior in some way. They may forego the trip altogether, but they might also travel by a different mode (i.e., public transit or carpooling), choose a different, closer destination (if a RUC is levied per mile traveled, closer destinations are cheaper), or substitute something else for the trip (i.e., ordering online delivery instead of driving to a store, or conducting meetings over video-conferencing instead of in person). For low-income households, the price of fuel (into which excise and sales taxes are bundled) can represent a substantial cost burden. Likewise, were a RUC to replace a fuel tax, it could also impose a substantial cost burden on lower-income households. It thus may be appropriate for the government to assist those households with RUC payment, much as it does for other essential services like electricity. We discuss this more below.

What is important for now is the idea that a rate can do more than just raise revenue. Different rate structures can help manage the negative externalities (or social costs) that driving imposes. These externalities—principally pollution, carbon emissions, congestion, crashes, and road damage—impose very large costs on California’s people and economy, and internalizing them could make the state’s transportation system more efficient, equitable, and sustainable. We discuss the most important of these externalities below.

Road damage: One way for a RUC rate to improve system performance is through charging vehicles in proportion to the damage they inflict on roads and bridges. Specifically, heavier vehicles would pay more per mile than light-duty vehicles because the former require more complex road construction and inflict considerably more damage on roads, thus requiring much more extensive road maintenance. Because road damage from trucks depends significantly on the axle weight for loaded trucks, a weight-based component to a RUC could incentivize shippers to choose vehicle types and loading practices that reduce axle weight and, hence, road damage.

Traffic Congestion: Another way a RUC rate could improve road system performance is by reducing traffic congestion through a congestion charge. As discussed above, a congestion price is a charge that varies with demand for the road. The price can vary in real time, or be based on prior data to have scheduled charges that vary by time and place. The purpose of the congestion charge is not to punish those driving at high demand times, but to make travel more reliable and quicker, which benefits both drivers and others who benefit directly or indirectly from auto and truck travel. A RUC could be structured so that drivers pay higher prices to drive on certain congested roads and highways in order to keep traffic flowing smoothly.

Crash risk: Yet another way for a RUC rate to improve system performance is for the rate structure to incentivize drivers to purchase safer vehicles and drive them more prudently by charging a higher RUC rate for vehicles and/or drivers with greater risks of crashes. Decades of research have shown that the likelihood of death or serious injury for a person struck by a motor vehicle depends significantly on the type, design, and weight of the vehicle.[40] For example, the risk of injury or death to pedestrians is much higher when they are struck by heavier vehicles or vehicles with higher bumpers.

Pollution and environmental damage: A RUC rate could reduce the environmental effects that driving imposes on surrounding areas. RUC rate structures can help reduce carbon emissions, air pollution emissions, and other environmental considerations. Pollution produced as an externality from driving is mostly a function of the vehicle characteristics and road conditions, especially fuel type, and to a lesser extent a function of road conditions and driver behavior. Fine and ultrafine particulate matter, which are a particular problem with diesel engines, are most problematic for those who live, work, study, or play near roadways; the precursors of ozone, or smog (HCs and NOx), are more regional in their effects; and greenhouse gas emissions, which contribute to climate change, are global in scope.

Noise: Growing evidence shows that noise pollution is a significant public health concern.[41] A RUC rate structure that assesses higher fees on vehicles with loud engines and tires could encourage drivers to purchase quieter vehicles or, when they have a choice among vehicle types, to drive more of their miles in the quieter vehicles.

40 Ralph Nader, *Unsafe at Any Speed*, 25th Anniversary edition (New York: Knightsbridge Pub Co Mass, 1991); Jeya Padmanaban, "Influences of Vehicle Size and Mass and Selected Driver Factors on Odds of Driver Fatality," *Annual Proceedings / Association for the Advancement of Automotive Medicine* 47 (2003): 507–24; Jason D. Lemp, Kara M. Kockelman, and Avinash Unnikrishnan, "Analysis of Large Truck Crash Severity Using Heteroskedastic Ordered Probit Models," *Accident Analysis & Prevention* 43, no. 1 (January 1, 2011): 370–80, https://doi.org/10.1016/j.aap.2010.09.006; Alena Høye, "Vehicle Registration Year, Age, and Weight – Untangling the Effects on Crash Risk," *Accident Analysis & Prevention* 123 (February 1, 2019): 1–11, https://doi.org/10.1016/j.aap.2018.11.002; Jingwen Hu et al., "Understanding the New Trends in Pedestrian Injury Distribution and Mechanism through Data Linkage and Modeling," *Accident Analysis & Prevention* 188 (August 1, 2023): 107095, https://doi.org/10.1016/j.aap.2023.107095; Cody Nehiba, "Essays on Transportation Externalities" (UC Irvine, 2019), https://escholarship.org/uc/item/9c6071s1.

41 Abel E. Moreyra et al., "The Impact of Exposure to Transportation Noise on the Rates of Myocardial Infarction in New Jersey," *Journal of the American College of Cardiology* 79, no. 9_Supplement (March 8, 2022): 1148–1148, https://doi.org/10.1016/S0735-1097(22)02139-8; Jesse D. Thacher et al., "Exposure to Transportation Noise and Risk for Cardiovascular Disease in a Nationwide Cohort Study from Denmark," *Environmental Research* 211 (August 2022): 113106, https://doi.org/10.1016/j.envres.2022.113106; Jesse D. Thacher et al., "Long-Term Exposure to Transportation Noise and Risk for Type 2 Diabetes in a Nationwide Cohort Study from Denmark," *Environmental Health Perspectives* 129, no. 12 (December 2021): 127003, https://doi.org/10.1289/EHP9146.

2.3 CONCEPTUAL APPROACH: PAY IN PROPORTION TO COSTS IMPOSED

Many utility and transportation rate structures are based, at least loosely, on the principle that users should pay charges in proportion to the cost of delivering the service. For example, if it costs eight cents to produce an additional kilowatt-hour (kWh) of electricity, then electricity should be priced such that users pay at least eight cents per kWh. Otherwise, the electric system will need to be subsidized.[42]

With roads, the cost structure is somewhat different, as roads do not have large ongoing production costs equivalent to burning fossil fuels to produce electricity. Like electricity and other utilities, the road system has high upfront construction costs and ongoing maintenance costs, but there is no need to "make some road" for every new road user in the same way that every new act of electricity consumption requires a new kWh or portion thereof. As such, road agencies do not face the same fiscal imperative to meter by use, and the consequent absence of direct pricing has implications for how well the road system performs. Because roads do not have a charge analogous to the electric meter, road users do not face a monetary incentive to drive less on certain roads at certain times.[43] However, policymakers developing new road-user charges such as a RUC have the opportunity to revisit whether it is desirable to link user fees to costs imposed.

Types of Costs Imposed: Direct Costs to Provide Roads vs. External Costs on Society at Large

Conceptually, the costs associated with each driving trip can be divided into two groups. The first is the direct costs to provide transportation infrastructure and services. These have traditionally been born by the agencies that build and maintain roads and highways, typically local, county, regional, and state, and federal departments of transportation (DOTs). The second category of costs are those external to the transportation system. These costs have typically been born either through government spending in programs other than those designed as "transportation" or by individual residents and businesses. For example, when vehicles generate air pollution, affected individuals will bear the costs either through ill health (untreated health impacts) or the cost of accessing medical treatment. In addition, public agencies may pay some of the health care costs and/or pay for programs designed to mitigate the effects of vehicle emissions. Current examples of the latter include support for public transportation (to provide an environmentally-friendly alternative to driving) and subsidies to encourage the purchase of electric and other zero emission vehicles (ZEVs).

42 This principle truly is loosely followed—the real-world problem of pricing electricity to both recover costs and manage demand is extraordinarily complicated. But the basic idea of metering is built on the need for customers to cover the costs of service. See Borenstein and Bushnell "Do Two Electricity Pricing Wrongs Make a Right? Cost Recovery, Externalities, and Efficiency," *American Economic Journal: Economic Policy* 14, no. 4 (November 2022): 80–110, https://doi.org/10.1257/pol.20190758.

43 Michael Manville and Miriam Pinski, "The Causes and Consequences of Curb Parking Management," *Transportation Research Part A: Policy and Practice* 152 (October 1, 2021): 295–307, https://doi.org/10.1016/j.tra.2021.07.007.2021

Costs Paid by Transportation Agencies

The key costs associated with providing the road system typically consist of high upfront construction costs and comparatively small annual operations and maintenance (O&M) costs. (While the O&M costs for any one year are small compared to initial construction costs, over time O&M costs are a significant cost burden as the road system ages.) In the U.S. context, these road provision costs have typically been paid by transportation agencies, drawing on a wide variety of revenue sources. Most revenue collected from drivers and vehicle owners is dedicated to these purposes, but governments typically must rely on a variety of other sources as well. In California, one large source of revenue has been local-option sales tax increases assessed by counties and dedicated to transportation expenditures.[44]

As noted briefly above, different vehicles and trips impose widely varying costs on the road systems. With respect to construction, the price of land on which roads are built varies significantly between, for example, the center of a large metropolitan area and a lightly populated desert. Similarly, the width of the highway, and the associated construction costs, reflect projected levels of traffic demand across all types of traffic at the time of construction. Further, the width of lanes, the slope of roads, the thickness of pavements, and the strength of bridges are typically governed by the size and number of heavy trucks traversing that road or bridge.

Once a road is constructed, vehicle travel imposes O&M costs, but no additional construction costs unless the road is expanded in response to chronic congestion or rebuilt at the end of its useful life. Operating costs are typically modest and include cleaning and lighting roadways, maintaining traffic signalization, closed-circuit cameras, traffic enforcement, and roadside service patrols.

Some of these O&M costs, such as maintaining road lighting, do not plausibly vary much across different types of road users. However, other maintenance costs that different vehicles inflict on roads vary enormously. In general, vehicle wear and tear varies non-linearly by axle weight and road load capacity. Heavily laden trucks impose—and low load-capacity road beds incur—the most road damage and thus also the highest maintenance costs.[45]

In sum, the various costs of building, operating, and maintaining roads, at the margin, are largely attributable to particular classes of travelers and trips. For example, heavy vehicles require construction of more expensive pavement and more frequent pavement maintenance. In addition, constructing freeways to accommodate large flows of travel in congested urban areas requires extremely expensive construction projects. In the latter example, urban freeway costs are driven up by factors such as the high price of urban land and the complexity of mitigating noise and environmental impacts on surrounding communities.

44 Hannah King et al., "LOST and Found: The Fall and Rise of Local Option Sales Taxes for Transportation in California Amidst the Pandemic," in *Pandemic in the Metropolis: Transportation Impacts and Recovery*, ed. Anastasia Loukaitou-Sideris et al., Springer Tracts on Transportation and Traffic (Cham: Springer International Publishing, 2023), 63–78, https://doi.org/10.1007/978-3-031-00148-2_5.

45 These relationships between vehicle axle loads and road load capacity are discussed in more detail in Section 4.2 below.

External Costs

In addition to the direct, internal costs of road construction, operations, and maintenance, driving also imposes external costs on other travelers, people who live and work near roads, society at large, and the planet. These costs are termed "external" because they typically are not paid for, or even understood, by the travelers who impose them.

An important principle of microeconomics is that internalizing these external costs by making people and firms pay for the costs they impose on others is both efficient and fair: efficient because travelers are discouraged from making trips that they value less than the marginal social cost of a given trip, and fair because people should not have to bear the brunt of others' travel decisions (being stuck in traffic, breathing vehicle exhaust, and so on) without any compensation.

The external costs of driving are many and include costs imposed on other vehicle drivers (when drivers add to congestion delays and increase crash risk), pedestrians and cyclists (when drivers injure or kill walkers and riders),[46] residents adjacent to roads (when driving noise and vehicle emissions harm public health), and society as a whole (when driving increases greenhouse gas emissions and alters the climate). The problems associated with external costs, and the economic and social benefits that accrue from "internalizing" them, are well established in the economics literature. There is also an extensive long literature examining the many significant external costs of vehicular travel, and ways they might be internalized.[47]

The User-Pays Concept in Practice: The Adoption of Fuel Taxes

The idea that users should pay for the cost of their driving is by no means a new one. A century ago, fuel taxes were adopted on the premise that they would be a fair way to raise revenue for roads because they were a user fee. In the early twentieth century, automobile use was burgeoning and generating demand for new and improved roads to drive on. The most common way to finance roads in this era was to charge landowners adjacent to roads for the cost of building and maintaining them. This system made sense for local streets and roads that were primarily used by and benefited abutting landowners (and indeed most local streets are maintained by property taxes today). However, this logic broke down as country roads evolved into highways where most travelers were passing through and not accessing adjacent property.

The solution to this dilemma of a fair way to raise money for roads was ultimately settled in the 1920s and 1930s with the adoption of taxes on the gasoline and diesel motor fuels used by cars and trucks. The fuel tax was quickly adopted by all 50 states and, eventually, the federal government as well, due to its simple elegance as a user fee. Those who drove on roads paid for them when they purchased fuel; those who drove more, paid more; and

46 Though these costs are substantially, though not entirely, internalized by insurance the motorists are required to carry. See Edlin and Karaca-Mandic, "The Accident Externality from Driving."

47 Aaron S. Edlin and Pinar Karaca-Mandic, "The Accident Externality from Driving," *Journal of Political Economy* 114, no. 5 (October 2006): 931–55, https://doi.org/10.1086/508030; Anthony Downs, *Still Stuck in Traffic: Coping with Peak-Hour Traffic Congestion* (Brookings Institution Press, 2004), https://www.jstor.org/stable/10.7864/j.ctt1vjqprt; Currie and Walker, "Traffic Congestion and Infant Health."

those who drove heavier, thirstier trucks paid more. The easy-to-understand, simple-to-administer fuel taxes were widely viewed at the time as a fair way to make the growing number of drivers pay for expanding networks of roads and highways.[48]

The User-Pays Concept in Practice: Highway Cost Allocation Studies

Starting in the 1930s, highway agencies developed methodologies to analyze the extent to which drivers of different types of vehicles were paying their “fair share” for the road system. While the cost of construction road systems is largely related to how many vehicle miles the roads must accommodate, wear and tear on roads depends much more on the weight of vehicles. Specifically, heavy vehicles, particularly trucks, inflict far more pavement damage than lighter vehicles.

Since those early studies, the federal government and more than half of states have produced so-called Highway Cost Allocation (HCA) studies to help them set appropriate fuel tax rates and other taxes or fees on vehicles.[49] Although the studies often engendered fierce political debates among competing auto and trucking interest groups that tended to overshadow the analysis in HCA studies, one primary outcome has been setting different per-gallon rates for gasoline and diesel fuel to reflect the greater road-damage caused by trucks (typically diesel fueled) than light-duty vehicles (typically gasoline fueled). HCA studies have also been used to vary the rates for heavy-vehicle registration fees and per-mile fees according to different classes of heavy vehicles. Thus, a RUC based solely on miles driven would poorly track the costs imposed by various types of vehicles.

48 Brian D. Taylor, Eric A. Morris, and Jeffrey R. Brown, *The Drive for Dollars: How Fiscal Politics Shaped Urban Freeways and Transformed American Cities* (New York: Oxford University Press, 2023).

49 Wilfred Owen, *A Study in Highway Economics* (Cambridge: The Society, 1934), https://catalog.hathitrust.org/Record/001108709; C. B. Breed, C. Older, and W. S. Downs, *Highway Costs: A Study of Highway Costs and Motor Vehicle Payments in the United States* (Association of American Railroads, January 30, 1939), https://trid.trb.org/View/91137?ajax=1; Patrick J. Balducci et al., *State Highway Cost Allocation Studies* (Washington, D.C.: National Academies Press, 2008), https://doi.org/10.17226/14178; Mehedi Hasnat et al., *Volume II: North Carolina Highway Cost Allocation and Revenue Attribution Study* (Raleigh: North Carolina Department of Transportation Research and Development Unit, September 2021); Bismark Agbelie, “Impact of Highway Nonuser Revenue on Equity Ratio: Exploratory Analysis,” *Journal of Infrastructure Systems* 27, no. 3 (September 1, 2021): 04021017, https://doi.org/10.1061/(ASCE)IS.1943-555X.0000631; Jeff Davis, “Senators Request New Highway Cost Allocation Study,” Eno Center for Transportation (blog), May 21, 2021, https://www.enotrans.org/article/senators-request-new-highway-cost-allocation-study/.

Highway Cost Allocation Studies

Since 1937, the federal government and more than half of states have used Highway Cost Allocation (HCA) studies as a tool to set appropriate fuel tax rates. HCA studies are technical assessments of whether various vehicle classes are paying their "fair share" in road-user taxes and fees. The studies do this by estimating and comparing the cost responsibility and revenue contribution for a set of defined vehicle classes.

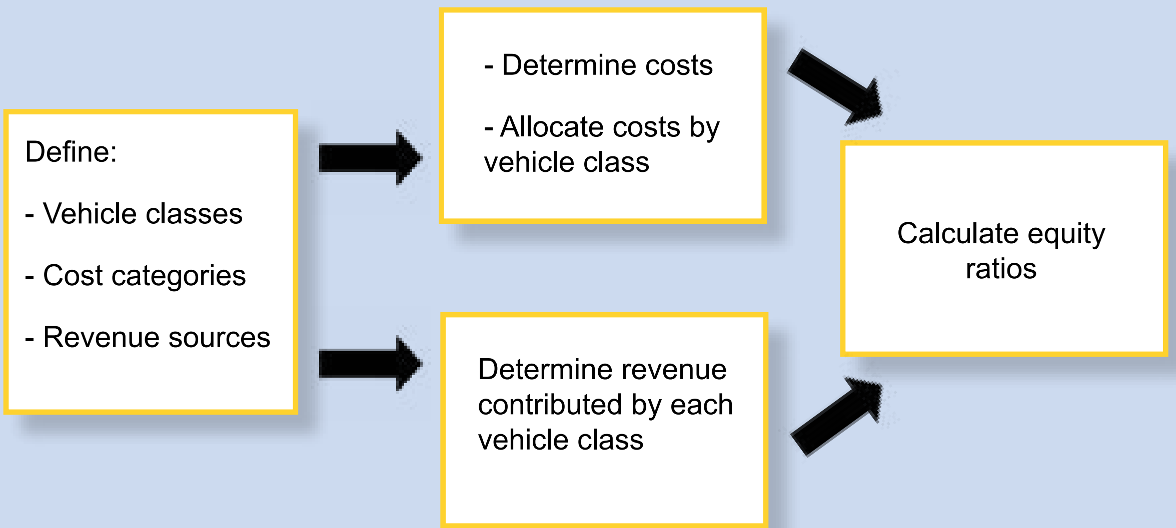

Figure 1. The HCAS Process

These findings are then compared in so-called "equity ratios." An equity ratio greater than one represents a vehicle class paying more than the costs that class imposes on the system, while a ratio less than one represents a class paying less than the costs it imposes on the system.

Continued on next page...

Table 1. Sample Equity Ratios from the 1997 FHWA Highway Cost Allocation Study

Ratios of 2000 Federal User Charges to Allocated Costs by Vehicle Class	
Vehicle Class / Registered Weight	**Ratio**
Autos	1.0
Pickups/Vans	1.4
Buses	0.1
Passenger Vehicles	1.1
Single-Unit Trucks	
≤25,000 pounds GVW	1.5
25,001–50,000 pounds GVW	0.7
>50,000 pounds GVW	0.5
Total Single-Unit	0.9
Combination Trucks	
≤50,000 pounds GVW	1.6
50,001–70,000 pounds GVW	1.1
70,001–75,000 pounds GVW	1.0
75,001–80,000 pounds GVW	0.9
80,001–100,000 pounds GVW	0.6
>100,000 pounds GVW	0.5
Total Combinations	0.9
Total All Vehicles	1.0

Source: Federal Highway Administration, *Federal Highway Cost Allocation Study: Final Report* (Washington, D.C.: U.S. Department of Transportation, August 1, 1997), https://rosap.ntl.bts.gov/view/dot/13475.

Several elements of the HCA study methodology can inform how RUC rates are structured and prices determined:

1. *Defining vehicle classes:* HCA studies typically group light-duty passenger vehicles into one class, motorcycles into another, and then create classes for heavy-duty vehicles based on some combination of weight, axle configuration, and fuel type. The number of vehicle classifications has ranged from 7 to 20.

2. *Identifying what costs should be considered:* HCA studies have typically categorized costs as “common costs” that all vehicles impose more or less equally (e.g., Highway Patrol, the Department of Motor Vehicles); road system construction and maintenance costs; and “external costs” such as air pollution or congestion.

3. *Identifying cost allocators:* Cost allocators are the metrics used to assign costs to different road user classes. Some of the most common allocators are vehicle miles traveled, the space a vehicle needs (vehicle length and width), and the load (axle weight or gross vehicle weight).

2.4 OTHER CONSIDERATIONS: IMPLEMENTATION FEASIBILITY AND EQUITY

In addition to the outcome-oriented goals for road user taxes and fees above, three key implementation considerations are the administrative feasibility, political feasibility, and the equity impacts of the rate structure.

Administrative Feasibility

For any tax, administrative feasibility and enforcement are critical decision factors. Key considerations include the cost to the taxing agency of administering the fee program, potential for fraud, and potential for billing errors. How well a RUC rate performs depends on many details of the structure, but two key considerations are:

- **Does the fee rate vary according to specific characteristics of the person or other entity paying?** Fee rates that differ according to *who* pays typically require more complex administration, since it is necessary to document their relevant characteristics. For example, many utilities offer discounted rates for low-income households, thus requiring a process to assess which families qualify for the discounts.

- **Does the fee rate vary according to characteristics of what is being taxed?** If so, then it is necessary to verify those characteristics, making administration more complex. For example, some vehicle registration fees depend on the vehicle type and a congestion toll depends on the time and location of travel. In contrast, the fuel tax rate is the same for all drivers, in all situations.

  Various RUC rate structure proposals that have been proposed and evaluated vary enormously in their complexity, though even the simplest proposal requires collecting revenue from every vehicle owner, which is a major administrative process in comparison to the current system of fuel tax collections. The most administratively simple proposals often call for a flat rate on all miles traveled, with no variation by vehicle weight, emissions, or characteristics of the vehicle owner. For these proposals, an annual odometer check might be all that is needed to assess how much the vehicle owner owes. At the other extreme, the rate could vary according to factors such as the vehicle owner's characteristics (e.g., income), where the miles were driven (e.g., charge for driving on private roads), or time of the day (e.g., higher rates for freeway travel during rush hour). These more complex systems could require tracking where and when miles are traveled, as well as verifying the vehicle owner's personal characteristics.

Political Feasibility

An assessment of political feasibility must consider the perspectives of numerous stakeholder groups: elected officials, since they would, presumably, vote to adopt a RUC rate structure; the general public, whose views influence elected officials and who might be asked to vote in a referendum; and key stakeholder groups, who also tend to have considerable influence on policy-making. Stakeholders who are likely to be most active on the details of RUC policy are the trucking industry, privacy advocates, environmental advocates, social justice advocates, and anti-tax groups.

A full assessment of RUC rate political feasibility needs to consider two factors: the feasibility of establishing an initial RUC rate structure and prices, and the feasibility of adjusting the structure and/or rates over time. The example of the fuel taxes illustrates the importance of planning for the latter. Because the federal fuel tax and most state fuel taxes do not adjust with inflation or fuel economy, the inflation-adjusted revenue per mile driven has fallen over time, unless elected officials take the very public step of voting to either raise the rates or link them to an economic indicator like inflation. By contrast, sales tax revenue increases as prices rise, with no need for any governmental action.

Equity Implications

Introducing any specific RUC rate structure will change the price of driving paid by various travelers and vehicles, so it is important to consider equity impacts. Equity in transportation and public finance can be reasonably defined in many ways, and often is. For example, equity can be defined in terms of geographies:

- How do rural drivers fare relative to urban drivers?
- How much do Northern and Southern California drivers pay relative to one another?

various stakeholder groups:

- How much would drivers in low-income households pay in absolute terms, and relative to drivers in higher-income households?
- How much do people of color pay relative to white drivers?
- How much do heavy trucks pay relative to passenger cars?
- How much should zero-emission vehicles pay relative to those in gasoline or diesel engine vehicles?

and across individuals:

- Are members of the same group (low-income drivers, truckers, etc.) treated somewhat equally relative to other members of that group?[50]

The point here is not that equity is too multifaceted to systematically evaluate in developing a RUC rate structure, but rather *because it is multifaceted* it must be evaluated systematically and carefully. For example, in California, most people rely at least in part on travel by private vehicle to access basic services and opportunities such as jobs, education, shopping, and

50 Brian D. Taylor and Alexandra Tassiello Norton, “Paying for Transportation: What’s a Fair Price?” *Journal of Planning Literature* 24, no. 1 (August 2009): 22–36, https://doi.org/10.1177/0885412209347156.

medical care. Although low-income families tend to drive less than higher-income families, the cost of that driving consumes a major portion of their household budgets. As a result, even small increases in costs due to a RUC (as well as property, sales, and fuel taxes to pay for transportation) can be difficult for low-income families to absorb.[51] For example, an analysis of how much California households paid in gasoline taxes in 2017 found that the cost was around 1.5% of the weekly budget for households earning up to $24,000 annually, but only about 0.3% of the weekly budget for high-income households.[52]

How might equity with respect to income be addressed in a RUC? Rate structures that adjust prices based on ability to pay are common in public utilities, where "lifeline rates" lower the amount lower-income households pay for electricity, water, and the like. Utility prices are not typically waived for everyone because some people struggle to afford the cost; rather, the prices are adjusted down to ease the financial burden on low-income rate-payers. As a result, higher- and lower-income rate payers still pay for electricity and water, and the amount they pay still varies by level of use. But lifeline rates ease the burden on households with the least means that are most sensitive to prices. Utility pricing and lifeline rates are discussed further in subsequent chapters of this report.

To consider another example in transportation, public transit fares often vary (at least indirectly) based on ability to pay. Reduced fares for seniors, children, students, and those with disabilities are common across transit systems; these attributes are considered crude proxies for income. In addition, more and more transit systems are offering low-income discounts to travelers who qualify for other means-tested programs like utility lifeline rates, subsidized school lunches, or food support through the Supplemental Nutrition Assistance Program.[53]

Finally, in addition to the potential cost burdens of a RUC are its potential equity benefits. There is considerable evidence that the public health costs of unpriced roads fall disproportionately on low-income households and people of color. Therefore, structuring a RUC to encourage the purchase and use of cleaner vehicles, and/or to reduce congestion-exacerbated vehicle emissions, could reduce these costs for the most vulnerable neighborhoods.[54] We explore many of these equity issues further later in this report.

2.5 THE CHALLENGE: BALANCING ACROSS PROGRAM GOALS, FEASIBILITY, AND EQUITY

The key challenge for policymakers is to identify a rate structure that is fair and conceptually sound, achieves important goals, and is feasible to implement. Rate structures that perform well under some of these criteria may perform poorly under others, and no rate structure

51 Evelyn Blumenberg and Asha Weinstein Agrawal, "Getting Around When You're Just Getting By: Transportation Survival Strategies of the Poor," *Journal of Poverty* 18, no. 4 (October 2, 2014): 355–78, https://doi.org/10.1080/10875549.2014.951905.

52 Samuel Speroni et al., *Charging Drivers by the Gallon vs. the Mile: An Equity Analysis by Geography and Income in California* (San Jose: Mineta Transportation Institute, September 1, 2022), https://doi.org/10.31979/mti.2022.2238.

53 Hannah King and Brian D. Taylor, Considering Fare-Free Transit in The Context of Research on Transit Service and Pricing: A Research Synthesis (Los Angeles: UCLA Institute of Transportation Studies, January 31, 2023), https://doi.org/10.17610/T6161T.

54 Manville and Goldman, "Would Congestion Pricing Harm the Poor?"

will perform well under all of them. However, some structures will prove more effective across the full set of criteria than others, and it is important to consider multiple criteria to avoid unintended negative consequences later on.

3. AN OVERVIEW OF RATE STRUCTURE OPTIONS USED IN TRANSPORTATION AND UTILITIES

This chapter provides an overview of the very wide diversity of rate structures that are currently applied in transportation and utilities. In Section 3.1 we present a conceptual approach to classifying different rate structures and provide examples of how each of the structures are currently used in the United States. Section 3.2 then lays out different processes that could be used to adjust RUC rates over time, again providing current examples of each approach.

The examples shared in this chapter are intended to illustrate for RUC policymakers the many different options they may wish to consider for RUC rates, in essence providing a “menu” of conceptual approaches to choose from. Including examples of the approach demonstrates that there is precedent for choosing any of them for a future RUC program, even if the example comes from somewhere other than a prior RUC pilot—or from outside transportation altogether.

We look beyond just examples of RUC rate structures because, as noted in the introductory chapter, to date there has been relatively modest research and policy discussion of rate structure options for RUC programs.

3.1 CONCEPTUAL APPROACHES TO SETTING RATE STRUCTURES

Table 2 presents an overview of five conceptual approaches to setting rate structures: undifferentiated rates, or rates that vary by vehicle characteristics, by user characteristics, by amount consumed, and by the time and/or place of use. Then, the following text provides more examples from transportation and utility pricing to illustrate each of the conceptual approaches.

It should be noted that many specific charges and fees fit under more than one of the rate structure categories described. In some cases, we highlight different aspects of certain cases as examples of a given rate structure, even though it may relate to several.

Table 2. Overview of Rate Structure Options and Examples

Category	Structure	Transportation Examples	Utility Examples
Undifferentiated	Subscription-style	Registration fee ZEV fee Early RUC pilots and programs European light-duty vehicle vignettes	Streaming video/music services
	Per amount-consumed	Fuel tax Toll roads Distance-based transit and commuter rail fares Early RUC pilots and programs	Electricity Water
	Per-trip pricing	Most fixed-route, fixed-schedule public transit Bridge tolls Delivery/ride-hail surcharges	
Vary by vehicle characteristics	Varies by weight	Toll road rates by vehicle class (weight) Truck weight-distance fees Battery weight fee for EVs Vehicle weight registration fees Parking charges by weight	
	Varies by vehicle axle count	Tolls that vary by axle count Bridge tolls	
	Varies by vehicle value	Vehicle insurance Registration fee add-ons Vehicle property tax	
	Varies by emissions	ZEV emissions for HOV/HOT lanes Discounts or rebates for low-emissions vehicles Congestion charge exemptions Pollution charge	
	Varies by vehicle size	Over-dimensional vehicle operation permits Oversized vehicle parking rates	
	Varies by tire type	Studded snow tire tax	
Varies by user characteristics	Varies by vehicle occupancy	Carpool exemptions and discounts Parking charge carpool discounts	
	Varies by payment method	Roadway tolling Transit	
	Varies by driver income	Tolling Discounted transit fares	Electricity and water low-income programs Electricity two-step rate programs Telecommunications Lifeline program

TABLE 2, continued.

Category	Structure	Transportation Examples	Utility Examples
Varies by amount consumed	Per unit consumed	Most RUC pilots, Oregon RUC, Utah RUC Toll roads Distance-based transit & commuter rail fares	
	Increasing block rate	Parking charges where hourly prices rise with time	Electricity
	Decreasing block rate		Water
	Cost-capping	Some RUC pilots Transit fares with per-week maximums	Water (cap for utilities)
Vary by place of use	Place-based rates	Congestion charges	Rural electricity, water, wastewater, telecommunications
	Facility-type rates	HOT lanes	Long-distance phone calls
Vary by time of use	Real-time pricing	Congestion charges Ride-hailing	Electricity
	Time-of-use pricing	Oregon RUC Congestion pricing	Electricity
	Critical-peak pricing		Electricity

Undifferentiated Rates

The simplest of rates are those that do not vary by any of the factors described above. These rates treat each user more-or-less the same. We detail three such rate structures below and provide examples of each.

- **Subscription-style charge:** Vehicle owners pay a set daily, weekly, monthly, or annual fee for usage of the road, regardless of usage.
    - **Annual Vehicle Registration Fee:** Some states charge vehicle owners who drive on public roads a set fee that is unaffected by mileage driven or value of the vehicle that exists in addition to and regardless of money collected via the gas tax. For example, the set of annual fees charged to vehicle owners in California includes a flat "California Vehicle Registration Fee" at $61 annually for all light-duty vehicles as of 2023. (Other components of the annual registration fees include one that varies by vehicle value, the Transportation Improvement Fee, which we discuss again later.[55])
    - **Annual ZEV Fee:** Because ZEVs do not use gasoline or diesel and thus do not pay road user fees by proxy through the fuel tax, some states charge annual fees to ZEV users to recoup that lost revenue. As part of SB 1, California began charging zero-emissions vehicles (ZEV) an annual Road Improvement Fee (RIF) of $100, which is adjusted each year to inflation; the RIF as of 2023 is $108.[56]
    - **RUC:** Many early RUC programs include a version of this flat fee option as a means of allowing users to protect their privacy and not be "tracked." For example, Virginia offers drivers of newer, fuel-efficient vehicles a Highway Use Fee.[57] Under this structure, drivers pay the same amount, regardless of how many miles they drive. (Alternatively, they may opt into a RUC.) Utah offers a similar program: Utah drivers of alternative fuel vehicles pay $130.25 as of 2023 for a flat fee upon registration.[58]
    - **Light-duty vehicle vignettes:** Several European countries issue time-based passes known as vignettes to use main roads, such as limited access highways and arterials. Countries include Austria, Bulgaria, Czechia, Hungary, Romania, Slovakia, Slovenia, and Switzerland, and rates range from a weekend ($5.85 (USD) in Bulgaria) to an annual vignette (the highest is $152.27 per year in Hungary).[59]

55 California DMV, "Registration Fees," California DMV, 2023, https://www.dmv.ca.gov/portal/vehicle-registration/registration-fees/.
56 "SB 1, Transportation Funding," Pub. L. No. SB-1 (2017), 1, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB1; California DMV, "Registration Fees."
57 Virginia DMV, "Virginia's Mileage Choice Program," 2022, https://www.dmv.virginia.gov/general/#va_mileage_choice.asp.
58 Utah DOT, "Utah's Road Usage Charge: Frequently Asked Questions."
59 Washington State Transportation Commission, "Appendix A-15: RUC & Rate-Setting."

- **Per-amount-consumed pricing:** Pricing structures can be assessed based on the amount of a product consumed. In the case of driving, this is miles driven. Under a flat rate structure, vehicle owners pay the same per-mile amount for all miles for all vehicles (or at least all light-duty vehicles). This is what most existing and pilot RUC programs have done, and it is what has been most often discussed in the research literature and by policymakers. For other examples, the unit might be different, but the concept is relatively similar.

  - **Fuel taxes:** The gas and diesel taxes at the federal level and in most states is a function of cents per gallon of gasoline purchased. For example, in 2023 California charged gasoline users 54¢ per gallon. The federal fuel tax rates, unchanged since 1992, are 18.4¢ per gallon for gasoline and 24.4¢ per gallon for diesel fuel.[60]

  - **RUC:** Most early RUC programs have used a flat per-mile charge. For example, California's 2017–2018 RUC pilot charged users 1.8¢ per mile.

  - **Toll roads:** The spirit of pricing on many toll roads is a charge per mile driven (although most facilities charge different rates for different vehicle types and/or methods of payment; see below). However, in large part due to the legacy of manually paying tolls, toll road facilities generally charge at set checkpoints, with amounts that scale up based on the number of checkpoints (roughly equivalent to the distance) a driver has passed by. Examples of this include the New Jersey Turnpike, the Massachusetts Turnpike, and the Pennsylvania Turnpike, among others.[61]

  - **Distance-Based Transit Fares and Commuter Rail:** Some rail operators, like BART in the San Francisco Bay Area, the state's commuter rail operators, and some express bus services, charge distance-based fares. Commuter rail operators have adopted this practice more commonly, often using an origin zone structure to charge a fare based on how far away an inbound trip originated or how far an outbound trip terminated. Outside of California, the Washington Metropolitan Transit Authority (WMATA) charges riders by distance traveled as well as by time of day, with rates higher during the morning and afternoon rush hours lower at other times, based on when the user scanned their fare media into the system and when they scanned to exit.

  - **Electricity:** Most electric utilities charge a per-kilowatt-hour rate for electricity consumed. This rate is loosely tied to the marginal cost of producing the electricity.

60 U.S. Energy Information Administration, "Federal and State Motor Fuels Taxes," February 2023, https://www.eia.gov/petroleum/marketing/monthly/xls/fueltaxes.xlsx.

61 New Jersey Turnpike Authority, "2023 Toll Rate Schedule Class 1," 2023, https://www.njta.com/media/7189/2023_tollschedule_tpk-c1.pdf; Massachusetts Department of Transportation, "Toll Calculator," Mass Turnpike, 2023, https://www.ezdrivema.com/TollCalculator; Pennsylvania Turnpike Commission, "2023 Toll Schedule," January 8, 2023, https://files.paturnpike.com/production/docs/default-source/resources/tolls/toll-schedule-2023/tollschedule_2023_tolls.pdf?sfvrsn=99216ac6_2.

- **Water:** Most water rates are flat-rate fees determined administratively and often do not reflect scarcity.[62]

- **Per-trip pricing:** Vehicle owners pay a rate per-trip regardless of that trip's length. This rate could be structured such that each trip segment of a tour counts, or that each trip tour is charged, based on some cut-off point that a trip be included in the same base rate. An additional layer could include charging increasing rates for trips of different distance ranges, such that short trips cost less and longer trips cost more; but, rather than a true mileage-based fee, this would still be dependent on the individual trip.

  - **Most transit:** Most transit pricing is established as a fee per boarding. Some waive the boarding fee at transfer points to establish a per-trip fee, instead.

  - **Bridge tolls:** Most bridges charge a toll for a single use of the bridge, rather than how many miles are traveled on the facility. A particularly relevant example here is the San Francisco-Oakland Bay Bridge, which charges a single toll to westbound traffic (into San Francisco), while eastbound trips (out of San Francisco) are free. The westbound toll is the same, regardless of whether the vehicle user exits at Yerba Buena and Treasure islands (roughly halfway across the bay) or continues on to San Francisco. (Of course, most major bridges do not have mid-bridge exits.)

  - **Delivery or ride-hail trips:** Several states have begun or have explored charging per-trip fees on consumer delivery or ride-hail trips. Minnesota approved one such proposal in 2023 as part of its state transportation spending package, which assesses 50¢ per retail delivery (e.g., Amazon and DoorDash), excluding food, medical supplies, and baby products.[63] Similarly, in 2017 Chicago began charging 72¢ per ride-hail trip, and in 2020 the City of Berkeley adopted a 50¢ charge for single-rider ride-hail trips and a 25¢ charge for shared ride-hail trips originating within city limits.[64]

Rates that Vary by Vehicle Characteristics

Many transportation rates vary by vehicle type. Factors frequently used to establish vehicle classes include the vehicle's weight and/or axle count, personal versus commercial vehicles, value, emissions rating, size, or even tire type.

62 Sheila M. Olmstead, Michael W. Hanemann, and Robert N. Stavins, "Water Demand under Alternative Price Structures," *Journal of Environmental Economics and Management* 54, no. 2 (September 1, 2007): 181–98, https://doi.org/10.1016/j.jeem.2007.03.002.

63 "HF 2887 Conference Committee Report," Pub. L. No. HF 2887 (2023), https://www.revisor.mn.gov/bills/text.php?number=HF2887&version=0&session=ls93.0&session_year=2023&session_number=0&type=ccr.

64 Benjamin P Fay and Carolyn Liu, TNC-User Tax: Getting Rideshare Companies to Pay Their 'Fare' Share (League of California Cities, May 7, 2021); John Greenfield, "Once Again Chicago Leads the Way, Passing a Tax to Help Get Uber and Lyft under Control," Streetsblog Chicago (blog), November 26, 2019, https://chi.streetsblog.org/2019/11/26/once-again-chicago-leads-the-way-passing-a-ride-hail-tax-to-help-get-uber-and-lyft-under-control/.

- **Rate varies by vehicle weight:** This rate structure affects heavy-duty vehicles the most. Rates can be pegged to either empty (unladen) or full (laden) weights. The former is much easier to administer but can incentivize firms to overload their vehicles, thus increasing road damage. The latter is more cumbersome to administer but can be effective in minimizing heavy vehicle road damage.

    - **Toll roads:** Some toll roads have different rates for different vehicle weights, usually defined by vehicle class. For example, while the Pennsylvania Turnpike has a toll schedule that scales up based on distance traveled on the facility, it also has 9 different schedules: one for each vehicle class. Passenger cars (Class 1) that travel the length of the east/west facility are charged $45, while the heaviest trucks (over 100,000 pounds) (Class 9) are charged $315.[65]

    - **Truck weight-distance fees:** A few states charge a fee per-mile that varies based on truck weight. The Oregon Department of Transportation charges trucks a weight-distance fee, which considers the weight of a truck greater than 26,000 pounds and the number of miles driven on Oregon public roads.[66] Per-mile rates increase with weight.[67] Any taxes paid on fuel for the truck are credited back to the amount of tax due.[68] For example, a truck weighing in at 26,001 pounds pays 7.2¢ per mile, whereas a truck weighing 79,000 pounds pays 23.7¢ per mile. For trucks over 80,000 pounds, rates differ by both the weight and the number of truck axles, ranging from 18.8¢/mile for an 81,000-pound truck with nine axles to 33.3¢/mile for a 97,000-pound truck with five axles. All trucks are able to subtract the amount of fuel tax they paid in Oregon during the taxable time period (but not for fuel purchased in other states).New Mexico uses a similar, albeit less complex system: its weight-distance fee ranges from 1.1¢/mile for trucks weighing 26,001–28,000 pounds to 4.4¢/mile for trucks weighing 78,001–80,000 pounds, with discounts for trucks that predominantly only haul one-way.

    - **Vehicle (battery) weight for EVs:** Although EVs offer vehicle emissions savings, their batteries are generally heavy, causing them to weigh more than equivalent ICE vehicles. In 2023, Norway began taxing EVs—which constitute nearly 90% of the new car market in the country and were previously exempt from weight tax—the equivalent of $1.26 USD per kilogram of vehicle weight above 1,100 pounds.[69]

    - **Vehicle weight:** Regardless of vehicle propulsion system, light-duty vehicles can also be charged road and/or parking fees by weight. Washington D.C. assesses higher registration fees for heavier vehicles, and in 2024 will be raising those rates to increase more steeply with vehicle weight. D.C. vehicle registrants will continue

65 Pennsylvania Turnpike Commission, “2023 Toll Schedule.”

66 Oregon Department of Transportation, “Report Your Taxes,” Commerce and Compliance Division, accessed November 21, 2022, https://www.oregon.gov/odot/MCT/Pages/ReportYourTaxes.aspx.

67 Oregon Department of Transportation, “Mileage Tax Rates,” January 1, 2022, https://www.oregon.gov/odot/Forms/Motcarr/9928-2022.pdf.

68 Oregon Department of Transportation, “Oregon Monthly/Quarterly Mileage Tax Reports,” January 2023, https://www.oregon.gov/odot/Forms/Motcarr/9915.pdf.

69 David Zipper, “If You Want a Car This Heavy, You Should Pay Through the Nose,” *Slate*, January 31, 2023, https://slate.com/business/2023/01/electric-cars-hummer-ev-tax-fees-weight-joe-biden.html.

to annually pay $72 for cars weighing 3,500 pounds or less, but increased rates will be $175 for vehicles 3,500–5,000 pounds, $250 for vehicles 5,001–6,000 pounds, and $500 for vehicles over 6,000 pounds. D.C. officials cite the increased danger large vehicles pose to non-vehicular road users and added environmental harms as reasons for the tax increase.[70] As of July 1, 2023, Montreal charges vehicle owners of lighter and/or cleaner vehicles less for residential parking permits in the Rosemont-La Petite-Patrie neighborhood. Owners of clean vehicles below 3,200 pounds or any vehicle below 2,500 pounds pay $115 CAD annually, while owners of clean vehicles over 3,700 pounds or any other vehicle over 3,200 pounds pay the top rate at $205.[71]

- **Parking charges:** Parking rates sometimes vary according to vehicle weight. In 2024, Lyon, France will adopt a parking tariff system that charges different rates for parking permits based on vehicle weight, with some exceptions for EVs and vehicles owned by lower-income households. Vehicles weighing less than 2,200 pounds will pay the lowest-tier rate (€15 per month), vehicles between 2,200 and 3,800 pounds will pay the middle-tier rate (€30), and vehicles over 3,800 pounds will pay the highest rate (€45).[72]

- **Rate varies by vehicle axle count:** Vehicle owners pay rates that vary based on the number of axles and/or tires the vehicles have because (outside of bridges) it is the maximum axle weights, and not the overall vehicle weight, that are most directly related to payment damage. For example, a three-axle box truck may be charged based on the number of axles alone (unladen), or based on the loaded vehicle weight (laden) divided by the three axles.

  - **Toll roads:** Most major toll road facilities charge more for vehicles by either number of axles or vehicle class. For example, Massachusetts and New Jersey turnpikes charge rates that scale up by distance traveled, they also have different rates based on the number of vehicle axles.[73]

  - **Higher bridge tolls on heavy vehicles:** Most bridges charge higher tolls for vehicles with more axles—again in general a proxy for vehicle weight. For example, the San Francisco-Oakland Bay Bridge charges $7 for light-duty vehicles with two axles and between $17 and $32 for vehicles with more than two axles.[74]The major New York City area bridges operate similarly.[75]

70 Chelsea Cirruzzo and Cuneyt Dil, "D.C. Wants to Tax Heavier Cars," Axios, June 7, 2022, https://www.axios.com/local/washington-dc/2022/06/07/dc-car-weight-tax.

71 Gersh Kuntzman, "Steal This Idea: The Larger the Car, the More You Pay to Park," Streetsblog USA (blog), May 16, 2023, https://usa.streetsblog.org/2023/05/16/heres-a-big-idea-the-larger-the-car-the-more-you-pay-to-park-the-damn-thing/.

72 Hannah Thompson, "French First as City Brings in Parking Charges Linked to Car's Weight," *The Connexion*, May 31, 2023, https://www.connexionfrance.com/article/French-news/French-first-as-city-brings-in-parking-charges-linked-to-car-s-weight.

73 Massachusetts Department of Transportation, "Toll Calculator"; New Jersey Turnpike Authority, "2023 Toll Rate Schedule Class 1."

74 FasTrak, "San Francisco-Oakland Bay Bridge," accessed November 21, 2022, https://www.bayareafastrak.org/en/tolls/san-francisco-oakland-bridge.shtml.

75 Triborough Bridge and Tunnel Authority, "Crossing Charges Tables," 2021, https://new.mta.info/sites/default/files/2018-11/B%26T_toll_tables_merged-11-20.pdf.

- **Rate varies by vehicle value:** Vehicle owners pay varying mileage-based rates based on the value of the vehicle being driven, such that less-valuable vehicles (which are more common in lower income households) pay less, while more-valuable vehicles pay more.

    - **Vehicle insurance:** A substantial portion of how auto insurers determine their premiums is based on the value of the vehicle, among other factors.

    - **Registration fee add-ons:** In addition to the standard registration fee, add-on registration fees like California's annual Transportation Improvement Fee (TIF), which ranges from $25 to $175, also depend on the vehicle's value.[76]

    - **Vehicle property tax:** Some value-based fees are charged at the point of purchase. For example, California charges vehicle owners the upfront Vehicle License Fee, which is 0.65% of the vehicle purchase price.[77]

- **Rate varies by emissions:** Vehicle owners pay per-mile rates that vary based on their emissions ratings. This rate type could vary in complexity: rates could be based on an average per-mile rate for highway and city miles driven or separately for the two, as driver emissions tend to vary based on driving conditions. Examples of these rates run the spectrum from incentive-based charges to penalizing charges, including:

    - **Discounts and rebates for low-emissions vehicles:** Governments have sought to incentivize the purchase of ZEVs by discounting and/or rebating their costs, both with respect to purchase prices upfront and user fees assessed thereafter. For example, Singapore reduces its road taxes for electric cars by 34% off the standard rate and provides a rebate of up to 45% off the Additional Registration Fee at the point of purchase.

    - **Congestion charges:** At least one congestion pricing program includes discounts or exemptions for low-emissions or zero-emissions vehicles. London's congestion charge has always included some sort of exemption for low-emission vehicles. This takes two forms: a discount and a pollution charge. First, since 2021, fully-electric vehicles have been exempted from the 15-pound congestion charge, although beginning in 2025, that exemption will end. Second, from 2017 to 2019, the Toxicity Charge (T-charge) added a 10-pound charge on top of the 15-pound congestion charge for older, more-polluting vehicles during congestion zone hours (7 AM to 6 PM). From 2019 to 2021, the Ultra-Low Emission Zone (ULEZ) replaced the T-charge, which expanded its geography and charged 12.5 pounds per day, in effect all day. In 2023, the ULEZ will extend to all of greater London.[78]

    - **Pollution charge:** Some governments charge fees to vehicles that pollute more. The Milan EcoPass program, which ran from 2008 through 2011, charged ICE vehicles a fee to enter a designated cordon zone in the central city. The daily

76 Martin Wachs, Hannah King, and Asha Weinstein Agrawal, *The Impact of ZEV Adoption on California Transportation Revenue.*
77 California DMV, "Registration Fees."
78 London City Hall, "Millions of Londoners Breathing Cleaner Air Thanks to ULEZ Expansion."

fee ranged between €2 and €10 depending on the vehicle's emissions class, while ZEV vehicles paid no fee. Unlike most direct road pricing programs, the EcoPass's stated goal was reducing pollution, rather than reducing congestion.[79]

- **Rate varies by vehicle size:** Vehicle owners pay different per-mile rates based on the size of the vehicle, such that over-sized vehicles that consume more roadway space incur higher rates.
    - **Over-dimensional Vehicles Permit:** Larger vehicles can be charged additional fees for operating on certain roadways. For example, in New York City, the city's DOT requires vehicles exceeding set dimensions (13.5 feet in height, 8 feet in width, and 55 feet in length) to purchase Over-dimensional Permits at $35 for each trip leg.[80]
    - **Private vehicle parking:** Particularly in dense cities with limited available land for parking, private parking lots and structures sometimes charge extra for oversize vehicles. In New York City, most private parking operators charge extra for vehicles longer than 181 inches or taller than 65 inches.[81]
- **Rate varies by tire type:** Different tire types can cause differing levels of damage to the road. Users of damaging tires like studded snow tires can be charged extra for them; however, in some cold weather climates, it may make sense to incentivize rather than disincentivize their use for safety purposes.
    - **Studded snow tires:** States and provinces have taken varied approaches to studded snow tires. On the one hand, the tires increase traction; on the other hand, they cause additional damage to the pavement and reduce its lifespan. Alaska charges a $5 fee for studded tires and restricts the time of year and geographic areas in which they can be legally used.[82] Washington State charges a $1 fee on every retail tire sold and adds a $5 for studs.[83]

Rates that Vary by Household or Driver Characteristics

Some rates—in both transportation and the utilities sector—vary based on the characteristics of the household, driver, or user. In many cases, these rates either seek to encourage sharing among users or to ease price burdens on income-constrained users.

79 Paolo Beria, "Effectiveness and Monetary Impact of Milan's Road Charge, One Year after Implementation," *International Journal of Sustainable Transportation* 10, no. 7 (August 8, 2016): 657–69, https://doi.org/10.1080/15568318.2015.1083638.

80 New York City Department of Transportation, "Overdimensional Permits," Motorists & Parking, 2023, https://www.nyc.gov/html/dot/html/motorist/oversize.shtml.

81 Icon Parking, "Oversized Vehicle Parking + What Is Considered Oversized," Icon Parking, August 16, 2022, https://iconparkingsystems.com/cms/news/oversized-vehicle-parking-considered-oversized/.

82 P.J. Hill, "Studded Tires Increase Road Costs. Those Who Use Them Should Help Pay.," *Anchorage Daily News*, December 13, 2021, sec. Opinions, https://www.adn.com/opinions/2021/12/13/studded-tires-increase-road-costs-those-who-use-them-should-help-pay/.

83 Washington Department of Revenue, "Tire Fees and Studded Tire Fees," 2022, https://dor.wa.gov/taxes-rates/other-taxes/tire-fees-and-studded-tire-fees.

- **Rate varies by vehicle occupancy:** Vehicle owners pay different per-mile rates based on a vehicle's occupancy, such that single-occupancy vehicles pay more, double-occupancy vehicles receive a discount, and vehicles with three or more occupants receive a deeper discount.

    - **Carpool exemptions and discounts:** Toll roads and high-occupancy/toll (HOT) lane facilities sometimes vary their pricing schemes based on vehicle occupancy. California's FasTrak-enabled HOT lanes allow carpool users to adjust their transponders to indicate vehicle occupancy, which allows those vehicles to drive in the HOT lane at a discounted rate or for free. Examples include the SR-237 Express Lanes in Santa Clara County and the I-880 Express Lanes in Alameda County, which both offer half-off tolls for 2-person carpools and free for carpools of 3 or more. In Southern California, the I-10 and I-110 ExpressLanes in Los Angeles County offer toll-free HOT lane use to carpools of 2 or more, except during peak hours on the I-10 freeway when carpools of 3 or more are required for the toll exemption.[84]

    - **Parking charge carpool discounts:** Although not a road user charge, many paid parking facilities, especially those controlled by employers, charge discounted rates for those who carpool. For example, users of city-owned parking structures in downtown Sacramento are eligible for a shared parking permit at 25% off regular price, with each carpool participant responsible for their portion of the remaining amount of the permit.[85]

- **Rate that varies by payment method:** Vehicle owners pay different rates based on how they pay for the charge. This can include rates that vary based on frequency of payment (e.g., monthly versus annually) or by payment type (e.g., credit card versus personal check or cash).

    - **Roadway tolling:** Most toll roads have different prices for those paying with transponder systems like FasTrak compared with those paying by video-and-mail-based toll invoicing or human-operated toll booths. For example, The Toll Roads in Orange County charge rates that are roughly 50¢ higher for those who do not use FasTrak or a pre-established account; to pass through the mainline toll on SR-73, the off-peak toll is $6.60 for account holders and $9.00 for non-holders.[86]

    - **Public transit:** Transit passes often come with advantages over paying in cash. The Santa Monica Big Blue Bus offers its riders a $1.10 per fare per ride for

84 Valley Transportation Authority, "Carpool Occupancy Changes Coming to SR-237 Express Lanes October 2, 2020," September 16, 2020, https://www.vta.org/blog/carpool-occupancy-changes-coming-sr-237-express-lanes-october-2-2020; Metropolitan Transportation Commission, "I-880 Express Lanes," FasTrak, accessed April 20, 2023, https://www.bayareafastrak.org/en/tolls/i-880-express-lanes.shtml; Los Angeles Metro, "Using Metro ExpressLanes," Metro ExpressLanes, accessed April 20, 2023, https://www.metroexpresslanes.net/how-it-works/using-metro-expresslanes/.

85 City of Sacramento, "Carpool Discount," Parking Services, 2022, https://www.cityofsacramento.org/Public-Works/Parking-Services/Discount-Programs/Carpool.

86 The Toll Roads of Orange County, "Rate Card" (Transportation Corridor Agencies, July 1, 2022), https://www.thetollroads.com/media/ea0frpeo/fy23_ratecard.pdf.

those with a fare media card or who purchase the fare in the agency's app, while cash riders pay $1.25.[87]

- **Rate that varies by driver income:** Vehicle owners pay varying rates such that different drivers pay different amounts per-mile based on their annual household income. Under this strategy, low-income drivers would pay a lower per-mile rate than higher-income drivers.
    - **Electricity, water, natural gas:** Many utilities have programs that assist low-income households, senior citizens, and disabled users by charging them a lower rate. For example, utilities regulated by the California Public Utilities Commission, including Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDGE), offer two such discounts. The primary program is California Alternate Rates for Energy (CARE), which discounts low-income households' electric bills by 30 to 35% and natural gas bills by 20%, depending on income and household size. Families who are slightly above this threshold may still be eligible for the Family Electric Rate Assistance program (FERA), which offers an 18% discount on electric bills.[88]
    - **Two-step rates:** Another form of rates differentiated by user income is to have users pay a fixed amount that is based on their ability to pay plus a per-unit-consumed rate. California's three largest electric utilities (PG&E, SCE, and SDGE) have jointly proposed to the California Public Utilities Commission (CPUC) a new rate structure in this form that groups customers into four income categories and charges an escalating fixed fee and then assesses a lower per-kilowatt-hour rate beyond the fixed fee. PG&E officials have said that they believe this will give low- and moderate-income customers lower electric bills, on average.[89]
    - **Telecommunications:** The federal government deems telephone and broadband internet as essential communication tools. Accordingly, the Federal Communications Commission's Lifeline program provides discounts on these services to qualified low-income users.[90]
    - **Public transit:** Many transit agencies offer low-income rider assistance programs that include some form of fare discount. For example, Los Angeles County Metropolitan Transportation Authority (Metro) offers a Low-Income Fare is Easy (LIFE) program, which requires an application and verification based on income and household size to receive a one-time 90-day unlimited rides pass

87 Santa Monica Big Blue Bus, "Fare Information," City of Santa Monica, 2022, https://www.bigbluebus.com/Fares/Fare-Information.aspx.

88 California Public Utilities Commission, "CARE/FERA Program," 2021, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/care-fera-program.

89 George Avalos, "PG&E Monthly Bills Could Jump for Many Customers Due to New State Law," *The Mercury News*, April 12, 2023, https://www.mercurynews.com/2023/04/12/pge-month-bill-jump-electric-gas-price-consumer-utility-income-economy/.

90 Federal Communications Commission, "Lifeline Program for Low-Income Consumers," Telecommunications Access Policy Division, January 27, 2012, https://www.fcc.gov/general/lifeline-program-low-income-consumers.

and a subsequent discounted monthly pass rate. King County (Washington) Metro in greater Seattle also offers its ORCA LIFT program, which offers a reduced $1 per ride fare for qualified low-income bus riders.[91]

- **Tolling:** LA Metro offers its low-income ExpressLanes HOT lanes users an application to waive the $1 monthly fee and receive a $25 credit if the applicant earns an income less than twice the federal poverty level.[92]

Rates that Vary by Amount Consumed

Oversight entities can also vary rates for customers based on the amount of the product or service (e.g., road, electricity) the user consumes. This can occur by increasing prices for big consumers, decreasing prices for those same big consumers, or by capping charges at a given threshold amount.

- **Increasing-block (or tiered) rate pricing:** Assuming a per-mile charge, the rate would increase once a driver reaches a new level of accumulated miles driven during the charge period. For example, a driver might pay one cent per mile up through 5,000 miles driven for a year, then two cents per mile for miles 5,001 through 10,000, and then three cents per mile for all miles beyond 10,000.
  - **Parking:** Some parking pricing schemes are set so that parking is free for a short amount of time, such as the first two hours free in a parking structure or curbside spaces designated as short 15-minute-maximum pick-up/drop-off spots. After those initial thresholds, vehicles parked begin incurring scheduled charges. The City of Santa Monica operates its municipal parking structures in this manner, with the first 90 minutes free to park but with most street parking metered.[93]
  - **Electricity:** Although most electric utilities charge on a per-unit marginal cost basis, some have begun to charge using increasing-block rates by cumulative kilowatt-hour. For example, Southern California Edison offers its residential customers a tiered rate option in which they pay 31¢/kWh up to a baseline allocation, 40¢/kWh for kWh consumed between 101% and 400% of the baseline, and a “high-usage” rate of 50¢/kWh for usage beyond 400% of the baseline allocation.[94]
- **Cost-capping:** In the case of a per-mile charge, vehicle owners pay a per-mile fee up to a threshold, at which point their payment would be capped. That threshold could be based on a time interval ranging from daily to yearly.

91 King County Metro, “ORCA LIFT Reduced Fare,” Fares & ORCA Passes, October 13, 2022, https://kingcounty.gov/depts/transportation/metro/fares-orca/orca-cards/lift.aspx.
92 Los Angeles Metro, “Low-Income Assistance Plan,” Metro ExpressLanes, 2022, https://www.metroexpresslanes.net/offers-discounts/low-income-assistance/.
93 Downtown Santa Monica, Inc., “Downtown Santa Monica Parking Info,” Downtown Santa Monica, accessed April 20, 2023, https://www.downtownsm.com/parking-info.
94 Southern California Edison, “Tiered Rate Plan,” Rates, March 1, 2023, https://www.sce.com/residential/rates/Standard-Residential-Rate-Plan.

- **RUC:** Some existing RUC programs stop charging vehicles after they have paid a threshold amount within a given time period. Cost-capping thus serves as a circuit breaker to limit the total amount users pay. For example, Utah's Road Usage Charge bills drivers of some alternative fuel vehicles 1.52¢ per mile, unless the driver opts to instead pay an annual flat fee ($123.25 for EVs, as of 2023).[95] Second, Virginia uses a similar cap on its Mileage Choice Program, such that those users with more fuel-efficient vehicles (any vehicle with a combined fuel efficiency of 25 MPG or greater) who opt into the program cannot pay more than the annual Highway Use Fee that they would otherwise pay. The threshold is roughly the average annual VMT for Virginians, which is 11,600 miles.[96]

- **Public transit:** Some transit agencies use "fare-capping", which means the operator stops charging the traveler additional fares once the payments reach a set threshold, often the cost of a daily, weekly, or monthly pass. Examples of the former include AC Transit and Houston Metro; Portland, Oregon's TriMet uses both daily and monthly caps. London and Dublin also employ fare-capping.[97] This is generally used to prevent low-income riders from paying exorbitant amounts for a single day or week's use.

Rates that Vary by the Location Where Use Occurs

Rates can vary based on where the road or utility is used. There are a variety of reasons for varying this rate, ranging from trying to limit resource consumption in dense areas with high demand to ensuring access to critical resources despite remote location.

- **Place-based rates:** These are rates that vary based on where drivers live and/or work. This would allow drivers in areas with fewer transportation alternatives like transit or active modes to pay less than those who live in areas with alternatives but who choose to drive nonetheless.

  - **Congestion charges:** In a cordon-based congestion charge, such as those in London and Milan, those who drive inside the cordon pay a fee, while those who drive outside do not.

  - **Funding for rural electricity, water, wastewater, and telecommunications:** Building infrastructure to serve rural buildings with utilities service is typically far more costly than linking an additional building in an urban area to existing services. In recognition of this, the United States has for nearly a century provided subsidies and legal requirements for service to rural customers. This began with the Rural Electrification Administration in 1935 and the subsequent Rural Electrification Act of 1936 as part of President Roosevelt's New Deal; in 1994, these powers transitioned into the U.S. Department of Agriculture's Rural

95 Utah DOT, "Utah's Road Usage Charge: Frequently Asked Questions."
96 "Virginia Department of Motor Vehicles," accessed September 19, 2021, https://www.dmv.virginia.gov/vehicles/#highwayuse_fee.asp.
97 TransitCenter, "Cap & Ride," August 15, 2017, https://transitcenter.org/capandride/; TransitCenter, "Fare Capping: A Formula For Fairer Fares," *TransitCenter* (blog), August 17, 2018, https://transitcenter.org/fare-capping-formula-fairer-fares/.

Utilities Service. For example, this program today provides funding assistance to the Denali Commission to lower the electricity costs of area households that would otherwise pay roughly 275% of the national average.[98]

- **Facility-type rates:** These rates vary based on the type of facility used, even within the same zone. This results in drivers being charged for using facilities meant for vehicle throughput, like freeways and major arterials, and not for destination roads, like local streets. Also, these rates can help to capture revenue from and/or avoid diversion from freeways or highways that have road user charges paralleled by streets and roads that do not.

    - **HOT lanes:** HOT lanes offer drivers the ability to pay to use separate lanes that are typically less congested than the parallel free lanes. There are examples of HOT lanes across the United States and California, as noted above in reference to carpool discounts and roadway tolling. While the HOT lanes facilities are tolled, the rest of the parallel facility—and other arterials in the area, if any—remain free of direct road user charges.

    - **Long-distance phone calls:** For many years, telephone companies segmented their rate structures into local and long-distance calling to account for the (then) higher provider costs of carrying long-distance calls. During the early 1980s, long-distance providers would often upcharge long-distance calls beyond their higher provision cost to offset local telephone providers for using their loops, switches, transport facilities, and other calling infrastructure so that local call rates could remain affordable. In 1984, to alleviate the disparity between local and long-distance telephone rates, the Federal Communications Commission (FCC) and local telephone companies employed new strategies to recover the costs of their telephone lines. As facilitated by the FCC, local telephone companies used a system of per-minute access charges to bill newly emerged long-distance companies for starting or ending calls along their network that were lower than previous charging schemes. To offset that, local companies charged their customers per line to support the fixed costs of their infrastructure through monthly subscriber line chargers (SLCs). By the 2000s, most telephone rate regulation onward occurred organically through market-induced competition rather than strict controls by the FCC.[99]

98 U.S. Department of Agriculture Rural Development, "Electric Programs," March 16, 2015, https://www.rd.usda.gov/programs-services/electric-programs.

99 Federal Communications Commission, *Trends in Telephone Service* (Washington, D.C.: Industry Analysis Division, Common Carrier Bureau, August 2011), https://transition.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/trend801.pdf; Federal Communications Commission, "Eliminating Ex Ante Pricing Regulation and Tariffing of Telephone Access Charges," *Federal Register*, Proposed Rules, 85, no. 99 (May 21, 2020): 30899–916; P. Grayston, "Paying for Calls - Paying for Miles: What Can RUC Learn from Changes in the Telecoms Market and the Growth of ITS over the Last 25 Years?," in *Smart Moving Conference*, 2007, https://trid.trb.org/view/841175.

Rates that Vary by the Time When Use Occurs

Analogously to place, rates can vary on time of use. This is usually to discourage use during peak demand hours and encourage a shift in flexible usage to off-peak times. The electricity sector has been especially involved in moving toward these types of rate structures.

- **Real-time pricing (RTP):** Vehicle owners pay per-mile rates that vary based on the demand for a given road segment in real-time. This is a form of congestion pricing, where users of low-demand facilities pay a minimum base rate, while those using high-demand facilities (usually in major metro areas) pay rates that increase based on times and directions most in demand.
    - **Congestion pricing:** Many examples of congestion pricing programs include real-time pricing, wherein the operator sets the price over a road segment based on the current demand for that road space. This typically functions with changeable message boards that display the price for driving to subsequent tolling gantries and/or exit points. The Los Angeles Metro ExpressLanes are an example of this dynamic pricing system. Metro charges a minimum of $0.10 per mile during off-peak hours and $0.35 per mile during peak hours and an all-hours maximum of $2.20 per mile.[100]
    - **Ride-hailing:** Lyft and Uber use pricing algorithms that adjust prices charged to users based on both the demand the system is currently experiencing and the supply of drivers available.
    - **Electricity:** In this method, users pay a rate that varies in real-time based on market demand on the electricity grid. This typically involves displaying rates to consumers on connected thermostats, so they are able to see the fluctuations as they make energy-use decisions.
- **Time-of-Use (TOU) Pricing:** A RUC could vary the per-mile charge based on when the miles are driven, with the purpose of incentivizing driving outside of the highest-demand hours. This functions like dynamic RTP, except that the rates are set by time-of-day, rather than fluctuating instantaneously with demand.
    - **RUC:** In Oregon's 2006–2007 Mileage Fee Concept and Road User Charge Fee Pilot, the state DOT charged users 1.2¢ per mile. Users could opt into a group that instead paid 10¢ per mile during rush hours (7–9 AM and 4–6 PM) in greater Portland and 0.43¢ per mile at all other times and places.[101]
    - **Congestion pricing:** California's SR-91 Express Lanes in Orange and Riverside counties use a variable pricing system that adjusts by time of day. The Orange County Transportation Authority (OCTA) adjusts toll rates no more frequently than every six months, in addition to an annual increase to adjust for inflation. At

100 Los Angeles Metro, "ExpressLanes Toll Increase - December 30, 2022," November 18, 2022, https://www.metroexpresslanes.net/toll-rate-increase-december-30-2022/.

101 Oregon Department of Transportation, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program*.

the time of writing, the highest toll for the roadway's entire length was $15.35, charged Monday through Thursday mornings in the westbound 7 AM hour. The lowest was $3.90.[102]

  - **Electricity:** Time-of-use pricing is similar to RTP in that electricity retailers charge different rates throughout the day, except that here the rates are stable from day to day. For example, Southern California Edison charges residential customers who opt into TOU pricing at 29¢ per kWh from 8 AM to 4 PM, 38¢ per kWh from 4 PM to 9 PM, and 26¢ per kWh from 9 PM to 8 AM. These prices were established based on historic and projected demand.[103]

- **Critical-Peak Pricing (CPP):** CPP is a hybrid of RTP and TOU pricing. Here, the government entity charging for road use would have the ability to increase the price on specific, critical demand periods—think, for example, about the Wednesday before Thanksgiving as a prime day to levy this charge, not to raise revenue but to curtail demand for those not traveling specifically for the holiday.

  - **Electricity:** This pricing scheme is drawn from the electricity market. Under CPP, electricity retailers have the ability to increase the price on specific critical demand periods; retailers typically place a cap on how many days they can designate and charge customers for critical-peak days and usually promise advanced notice of predicted rate increase days.[104] This helps to manage peak loads on, for example, hot summer days. While this reduces information costs for consumers, it does not fully provide real-time incentives to manage loads and avoid electric outages.

3.2 OPTIONS FOR ADJUSTING RATES AND STRUCTURES OVER TIME

Regardless of the rate structure, a persistent challenge to setting fares, fees, and tolls in the public sector is adjusting rates as needed. Doing so is often a complicated process governed by many rules and procedural requirements, and often with multiple governmental entities having some say in the final decision.

Thus, as policymakers adopt a RUC rate structure and set initial RUC rates, they must also consider how they might adjust the rate structure and the rate levels over time. In many of the examples of transportation and network utility pricing described above, both the rate structures and rate levels have been adjusted regularly. While a transition in the U.S. from using the fuel tax to a RUC as a primary means of generating transportation revenue has not yet been tested at scale, the evolution would almost inevitably necessitate adjusting the rate structure and rate levels with some regularity. Accordingly we offer below a menu of options for adjusting rates and structures over time with examples of each, with an overview in Table 3.

102 91 ExpressLanes, "Toll Schedules," October 1, 2022, https://www.91expresslanes.com/general-info/toll-schedules/.

103 Southern California Edison, "Time-Of-Use Residential Rate Plans," Rates, March 1, 2023, https://www.sce.com/residential/rates/Time-Of-Use-Residential-Rate-Plans.

104 Steve A. Fenrick et al., "Demand Impact of a Critical Peak Pricing Program: Opt-in and Opt-out Options, Green Attitudes and Other Customer Characteristics," *The Energy Journal* 35, no. 3 (July 1, 2014), https://doi.org/10.5547/01956574.35.3.1.

Table 3. Options for Adjusting Rates and Structures Over Time

Structure	Transportation Examples	Utility Examples
Votes by elected officials	State and federal fuel taxes Chicago ride-hail tax	
Voter Referendum	Portland (Ore.) fuel tax City/County of San Francisco fee on ride-hail trips Local-Option Sales Tax in Los Angeles County MTC Regional Measure 3 on bridge toll increases	
Programmed automatic adjustments	California SB1 State fuel taxes adjusted to inflation / other price fluctuations Adjusting fuel taxes to other metrics Converting to different tax base Tolling to cover financial obligations	Washington state carbon tax (proposed, failed)
Oversight entity with powers of setting and/or regulating rates	Ride-hails and the California PUC Ride-hails and airport agencies Tolling and state agencies	Water and the California PUC Electricity and Independent System Operators (ISOs)
Owner/operator sets rates	Tolling and independent entities with board of directors	

- **Votes by elected officials:** The simplest of options is to not develop a clear plan and process for adjusting rates and structures, and instead leave the issue to future elected officials to address. This has been the most commonly used tactic for adjusting transportation revenue structures and rates over time, though in practice the adjustments tend to be put off until a looming financial crisis leaves officials with no choice but to raise the tolls, fees, or taxes. While perhaps politically expedient, the result is often an unstable boom-and-bust budgeting that greatly inhibits long-term planning and finance.

    - **Per-gallon fuel taxes:** Unlike a sales tax where the levy is a percentage of the purchase price, motor fuels taxes are typically levied per unit of fuel sold. While there are a growing number of exceptions to this rule across the states, the federal fuel tax remains a fixed per-gallon levy, and Congress has not adjusted the diesel fuel and gasoline rates since 1993. Until the passage of SB 1 in 2017, the same held true in California. From 1994 to 2010, the state legislature set the gasoline tax rate at 18¢ per gallon, though both inflation and increasing vehicle fuel efficiency eroded the taxes buying power over time.[105]

    - **Ride-hail taxes:** Chicago was the first U.S. city to directly tax ride-hail trips. In 2017, the city began adding a flat 72¢ charge to each trip taken in the city. However, in early 2020, Mayor Lori Lightfoot included in her budget a revised congestion- and occupancy-based tax, such that ride-hail users paid less for shared rides and more for rides during peak hours. The budget, with the ride-hail tax included, went to the city council and passed 39 to 11.[106]

- **Voter referendum:** Another means of adjusting rates when needed is to leave it to the voters. Several jurisdictions of varying sizes and levels of government have voted to adjust the rates they pay for or related to transportation uses.

    - **Portland (OR) fuel tax:** In 2016, Portland residents voted to approve a 10¢/gallon fuel tax on top of the existing state fuel tax to fund transportation improvements for four years.[107] Voters renewed the tax in 2020 for another four years and added two cents more in 2022.[108]

    - **City/County of SF and ride-hail:** In 2019, San Francisco voters passed Proposition D to begin taxing ride-hail trips at a rate of 3.25% of the trip price,

105 Anne Brown, Mark Garrett, and Martin Wachs, *The California Fuel Tax Swap* (Los Angeles: UCLA Institute of Transportation Studies, May 2016), https://www.lewis.ucla.edu/wp-content/uploads/sites/2/2016/08/Gas-Tax-Swap-FINAL-REPORT-052706.pdf; SB 1, Transportation Funding.

106 Greenfield, "Once Again Chicago Leads the Way, Passing a Tax to Help Get Uber and Lyft under Control."

107 Carolyn Kramer Simons, "Portland Voters Approve Local Gas Tax Increase," *Transportation Investment Advocacy Center* (blog), May 18, 2016, https://transportationinvestment.org/2016/05/18/may-17-portland-voters-approve-local-gas-tax-increase/.

108 Zane Sparling, "Oregon's Fuel Tax Rises Again, Even as Drivers Buy Less Gas," *Portland Tribune*, November 18, 2021, https://www.portlandtribune.com/news/oregons-fuel-tax-rises-again-even-as-drivers-buy-less-gas/article_15b16de5-a380-5e0d-a56f-ea8de31f57e7.html.

with discounts for pooled rides or rides that end outside city/county boundaries. The only way that Proposition D can be changed is by another ballot proposition, or by its pre-programmed expiration in 2045.[109]

- **Local option sales taxes (LOSTs):** Voters in nearly all metropolitan counties in California have approved at least one local-option sales tax (LOST) dedicated to transportation. These typically increase the existing sales tax by one-quarter to one cent, with the revenues earmarked for expenditure on a list of transportation projects and programs included as part of the ballot measure. Sometimes, voters implicitly alter the LOST rates by stacking a new tax on top of a pre-existing one. For example, in Los Angeles County, voters approved Proposition A in 1980 and Proposition B in 1990, then in 2008 authorized Measure R, each a half-cent sales tax dedicated to transportation improvements. In 2016, voters again authorized an additional half-cent by passing Measure M. The four combined taxes add two cents to every sales-taxable dollar. While these voter-approved LOSTs often have sunset dates after which they expire, LA County's four measures are permanent, and each is associated with a list of projects and programs to be funded by their revenues. The four taxes can only be adjusted or rescinded by voter ballot measures.[110]

- **MTC Regional Measure 3 bridge toll increases:** The Metropolitan Transportation Commission, the metropolitan planning organization for the nine-county San Francisco Bay Area, sent a referendum to voters in 2018 proposing a phased $3 increase in bridge tolls over a six-year period across the region (except for the Golden Gate Bridge). The measure passed, which increased the tolls and included programmed automatic adjustments, which we discuss in the next example.[111]

- **Programmed automatic adjustments:** Program rate structures and levels can automatically adjust based on a predefined set of criteria, such as keeping pace with inflation or to account for the increasing fuel-efficiency of vehicles.

  - **California SB 1:** California shifted its fuel tax to automatically adjust with the passage of SB 1 in 2017. SB 1 increased the California gas tax by 12¢, bringing it to 47¢ per gallon by 2019. Additionally, SB 1 included a provision that adjusts the amount collected per gallon indexed to the California Consumer Price Index (CPI), with a phased approach to increasing the rate between 2017 and 2020. Beginning in 2020, the Board of Equalization began adjusting the rate incrementally on July 1 each year according to the California CPI.[112]

109 Fay and Liu, *TNC-User Tax: Getting Rideshare Companies to Pay Their 'Fare' Share*.

110 Jaimee Lederman et al., "Lessons Learned from 40 Years of Local Option Transportation Sales Taxes in California," *Transportation Research Record: Journal of the Transportation Research Board* 2672, no. 4 (December 2018): 13–22, https://doi.org/10.1177/0361198118782757; King et al., "LOST and Found."

111 Metropolitan Transportation Commission, "Regional Measure 3," March 17, 2021, 3, https://mtc.ca.gov/funding/regional-funding/regional-measure-3.

112 SB 1, Transportation Funding.

- **Other approaches to adjusting fuel taxes for inflation or other price fluctuations:** Several states adjust their fuel taxes automatically to inflation. This is sometimes done in some combination of indexing based on two sources: the CPI and the National Highway Construction Cost Index (NHCCI). In addition to California, Florida, Georgia, Illinois, Indiana, Maryland, Michigan, North Carolina, Rhode Island, Utah, and Virginia all use the CPI (at least in part) to adjust their rates. Alabama and Colorado (beginning in 2032) use the NHCCI. Some states (at least in part) index their fuel tax rates to the per-gallon price of fuel, which captures both the inflation of fuel prices and the fluctuations in the market, including Alaska, Arkansas, Connecticut, Kentucky, Maryland, Nebraska, New Jersey, New York, Pennsylvania, Utah, Vermont, and West Virginia.[113]

- **Adjusting fuel taxes to other metrics:** Inflation and the Consumer Price Index are not the only metrics states use for automatic adjustments. North Carolina adjusts its fuel tax to both the CPI and the state's population. Nebraska adjusts its fuel tax based on the state's appropriations decisions. And in 2015, Georgia became the first state to index its fuel tax to vehicle fuel efficiency standards with a goal of offsetting revenue lost from more efficient vehicles purchasing fewer gallons of gasoline.[114] New Jersey requires its gas tax be reevaluated annually to ensure sufficient revenue to support transportation debts; in 2022, this led to a one-cent decrease.[115]

- **Converting to a different tax base:** Another option for keeping transportation revenues rising in pace with rising costs, travel, or program needs has been to convert the fuel tax from a per-gallon levy to a sales tax on the price of gasoline and diesel fuel. Hawai'i, Illinois, and Indiana do this today.[116]

- **Tolling to cover financial obligations:** Some toll rates are set and adjusted to cover the financial obligations of the toll facility operator. For example, the North Texas Tollway Authority has a set toll rate increase of 2.75¢ per year compounded, adjusted every other year, subject to the authority's annual budget process in which its board reviews their financial obligations to ascertain if there is a continued need for the increase.[117]

- **A carbon tax:** In 2018, Washington state residents voted on Ballot Initiative 1631, which would have instituted a per-ton tax on carbon dioxide emissions. The initiative failed, with 57% of voters rejecting it.[118] However, it too offered an

113 National Conference of State Legislatures, "Variable Rate Gas Taxes," National Conference of State Legislatures, July 14, 2021, https://www.ncsl.org/research/transportation/variable-rate-gas-taxes.aspx.
114 National Conference of State Legislatures.
115 Office of the Governor of New Jersey, "ICYMI: Treasury Announces Gas Tax Rate Will Decrease by 1.0 Cent Effective October 1," Official Site of the State of New Jersey, August 29, 2022, https://www.nj.gov/governor/news/news/562022/20220829b.shtml.
116 National Conference of State Legislatures, "Variable Rate Gas Taxes."
117 North Texas Tollway Authority, "Toll Rate FAQs," 2022, https://www.ntta.org/whatwedo/tollcollrates/Pages/Toll-Collection-FAQs.aspx.
118 Washington Secretary of State, "Initiative Measure No. 1631 Initiative Measure No. 1631 Concerns Pollution," November 6, 2018 General Election Results, November 27, 2018, https://results.vote.wa.gov/results/20181106/state-measures-initiative-measure-no-1631-initiative-measure-no-1631-concerns-pollution.html.

example of pre-programmed scaling of the tax: It began at 15¢/ton, increased by 2¢ per year and adjusted to inflation, until 2035, at which point the law relegated to the state legislature the power of either freezing the rate or allowing the increase to continue.[119]

- **Oversight entity with powers of setting and/or regulating rates:** An independent operator or commission could be tasked with setting the rate structure or levels at regular intervals.

  - **Ride-hail trips and the California PUC:** In 2019, the California Public Utilities Commission (CPUC) voted to institute a 10¢ per trip "Access for All" fee on each ride-hail trip completed, in addition to the annual fee that ride-hails already paid to the Public Utilities Commission Transportation Reimbursement Account.[120] This fee is collected by the provider (e.g., Lyft and Uber) and paid by the user.[121]

  - **Ride-hail trip and airport authorities:** Many airport authorities assess fees on ride-hail trips that originate (or in some cases terminate) on airport grounds as a condition of access. For example, Los Angeles World Airports (LAWA), the operator of LAX, charges $4 per circuit for ride-hail trips at the airport. LAWA's Board of Airport Commissioners, which is an entity within Los Angeles's city government, has the authority to change the rate.[122]

  - **Tolling and state agencies:** Some state governments choose to control policy on setting toll rate structures and prices. For example, in the State of Washington, the Washington State Transportation Commission sets toll rates and fees within the funding requirements handed down from the state legislature.[123]

  - **Water and California PUC:** When water districts in California wish to change their rate structures or levels, they must apply to the California Public Utilities Commission (CPUC) to do so. For large utilities (10,000 or more connections), the CPUC mandates a formal process of applying for rate changes once every three years in a report that outlines cost projections for the utility and service area. After a prescribed public input process, CPUC commissioners either accept, reject, or revise the utility's general rate case. For smaller utilities (less than 10,000 connections), the process is less formal, with utilities able to request a rate change through a letter and a less-extensive public input process before CPUC commissioners vote on the rate change. Ultimately, while all utilities

119 Robinson Meyer, "Will Washington State Voters Make History on Climate Change?," *The Atlantic*, August 15, 2018, https://www.theatlantic.com/science/archive/2018/08/washington-state-carbon-tax/567523/.

120 California Public Utilities Commission, "Ten Cent 'Access for All Fee' Assessed on TNC Trips Beginning July 1, 2019," June 30, 2019, https://www.cpuc.ca.gov/news-and-updates/all-news/ten-cent-access-for-all-fee-assessed-on-tnc-trips.

121 Fay and Liu, *TNC-User Tax: Getting Rideshare Companies to Pay Their 'Fare' Share*.

122 Los Angeles World Airports, "LAX Ground Transportation Access Fees," August 1, 2018, https://www.lawa.org/-/media/lawa-web/group-and--division/files/accessfees.ashx.

123 Washington State Transportation Commission, *WSTC Tolling Report & Tacoma Narrows Bridge Loan Update*, January 2022, https://wstc.wa.gov/wp-content/uploads/2022/02/2022-0216-WSTC2022-TollingReport.pdf.

themselves request rate changes, the CPUC maintains control over the final rate passed onto users.[124]

  - **Electricity and Independent System Operators (ISO):** In two-thirds of the U.S., including California, independent system operators (ISO) manage the production, distribution, and markets for wholesale electricity. In California, the ISO operates as an intermediary between producers (i.e., electricity-generating plants) and retailers (i.e., companies that meter electricity consumption and bill for it). The ISO is a market facilitator that both centrally plans for electricity distribution across the grid and keeps rates lower for customers by eliminating potential monopoly power from combination producer/retailers like PG&E and SCE.[125]

- **Owner/operators that set rates:** Rate-setting power can also be left to a private or semi-private owner/operator or another independent entity with full control of rates.

  - **Tolling and independent entities with boards of directors:** Some toll road and bridge facilities have independent entities that are charged with setting and adjusting toll rates without other intervention. Examples of this can be found in public-private partnerships. For example, the Indiana Toll Road Concession Company has the power to set toll rates as the operator of the ITR, subject to maximums set forth in their lease with the State of Indiana.[126]

124 California Public Utilities Commission, "General Rate Case Process," Water Division, 2021, https://www.cpuc.ca.gov/about-cpuc/divisions/water-division/water-rates-and-general-rate-case-proceedings-section/general-rate-case-process.

125 S. Borenstein, "Effective and Equitable Adoption of Opt-In Residential Dynamic Electricity Pricing," *Review of Industrial Organization* 42, no. 2 (March 1, 2013): 127–60, https://doi.org/10.1007/s11151-012-9367-3.

126 State of Indiana, "First Amendment to the Amended and Restated Indiana Toll Road Concession and Lease Agreement," September 21, 2018, https://www.in.gov/ifa/files/1st-Amendment-to-ITR-AR-Concession-Agreement-EXECUTED.pdf.

4. A SKETCH EVALUATION OF HOW EFFECTIVELY DIFFERENT RATE STRUCTURE OPTIONS ACHIEVE PROGRAM GOALS

This chapter illustrates how each of six rate structure options performs at achieving the potential RUC program goals laid out in Section 2.4: generating revenue, improving transportation system performance, and progress towards state climate goals. Chapter 5 then presents a parallel sketch evaluation of the implementation feasibility for the rate structure options using the three key criteria described in Chapter 2: administrative feasibility, political feasibility, and equity.

The spirit of this chapter is to consider the RUC *carte blanche*: we do not evaluate the RUC rate structure options in comparison to existing taxes, such as the fuel tax. Instead, the chapter is laid out on the premise that if California eventually chooses to adopt a RUC program, how would different rate structures perform? This approach allows us to focus on how different RUC rate structures might function in the future, past any transition period from current fuel tax structures.

The analyses below use the flat-rate RUC option as a base case to which the other options are compared. We chose the flat-rate option for this purpose because it is both the most "bare bones" RUC and the one most often used in RUC pilot and programs.

4.1 RATE-STRUCTURE OPTIONS EVALUATED

Chapters 4 and 5 present sketch evaluations of six possible road user charge rate structure options. We assume that each of the six structures could raise the transportation revenue that California needs in the short and medium terms, assuming periodic adjustments to the RUC rate prices.

We selected this set of rate structures to illustrate a diversity of options, all with precedent in U.S. transportation policy, that have been discussed as possible ways to structure RUC rates in research, pilots, or programs. In addition, the different rate structures all achieve at least one key benefit in terms of implementation feasibility or achieving state policy objectives.

Table 4. Rate Structure Options Assessed in the Report

Rate Structure	Primary intended benefits (beyond raising revenue)	Rate structure
Flat rate *Per-mile charge across all vehicles*	Maximum simplicity for drivers and tax collection officials	All vehicles pay the same fee per mile
Block rate *Per-mile increases above a threshold of miles*	Offer a base amount of low-cost travel, without the need to vary rates by vehicle type, owner, or location	All vehicles pay the same flat rate per mile up to a threshold per year (for example, 5,000 miles annually), at which point the per-mile fee increases
Axle-weight rate *Rate varies by axle weight*	Reduce cost to build and maintain the transportation system	Rate varies by vehicle class, which is determined by a combination of vehicle weight and axle count
Congestion rate *Surcharge added for miles traveled on congested facilities*	Manage traffic congestion	Flat rate per mile, with a congestion surcharge for miles driven on congested facilities during peak periods
Carbon rate *Rate varies by fuel efficiency*	Encourage use of low- and no-emission vehicles	Rate varies by vehicle efficiency and type
Equity rate *Rate varies by driver income*	Provide low-cost options for low-income travelers	Vehicles pay a flat fee per mile, with a discounted price for low-income travelers

For the sake of analytic simplicity, we selected the six rate structure options to differ from each other in only one key way, but it would be possible to create a rate structure that combines elements from more than one of the rate structures above. For example, California could have an increasing block rate structure, with different rates for each block varying by axle weight. Alternatively, the carbon rate could have a discounted price for low-income drivers. It would even be possible to combine elements from all six structures into a single structure, as illustrated below in the "Everything" rate structure (Table 5). Similar to the analytic structure used in highway cost-allocation studies, the different components are designed to cover specific costs imposed by drivers.

Table 5. The "Everything" Rate Structure

Component	Costs covered
Base costs	Common costs
Road costs	Construction, rehabilitation, and maintenance costs that vary by number and type of vehicles
Climate costs	Programs to reduce GHG emissions from the transportation sector
Local road management costs	Optional components that local governments could opt to collect for include congestion, curb management, noise abatement, local VMT reduction programs, and other system management costs

4.2 REVENUE GENERATION

In theory, all of the rate structure options could be designed to raise any specific amount of revenue, at least in the short and medium terms. In each case, the state could achieve this by setting the price by dividing any desired amount of revenue by the projected number of miles driven at each rate (price) in the structure, while trying to account for the effect (albeit a relatively inelastic one) the rate structure itself will have on driving behavior.

While rates charged could differ in a variety of ways, two differences we highlight here are 1) how they will differ in incentivizing/disincentivizing user behavior, which we turn to in the next section, and 2) the predictability of rates' revenue streams in both the short and longer term. In this section, we compare how predictable the revenue from each rate structure would be as compared with a flat per-mile rate.

Revenue from a flat rate structure (e.g., one cent per mile for all vehicles) is the easiest to project, since there are only two essential assumptions: the RUC rate and the projected number of annual miles that will be driven in light of that rate. Projecting revenue from the increasing block rate is similar to projecting it for the flat rate structure; the only additional complication is estimating how much households and businesses would adjust their driving behavior when moving from one rate tier to another. Each of the four other rate structures would entail increasingly nuanced estimates of how drivers would respond to the various structures and price levels.[127]

Projecting revenues for Options 3 through 5, for example, would entail more complex forecasting models because the rate structures will *by design* encourage changes in driving and vehicle purchases. For example, in the short run a green rate might encourage a household with multiple vehicles to shift some amount of mileage driven to a more fuel-efficient household vehicle and, in the longer run, encourage purchase of a zero-emission electric vehicle. Similarly, a vehicle class rate could encourage truck fleet managers to shift toward different truck/axle configurations and to load trucks to achieve lower vehicle axle weights. Thus, while the total number truck miles may not change, road maintenance costs would likely decline significantly. Forecasting these effects would require models to account for vehicle purchases, axle loadings, and road use.

While it is possible to forecast short-term revenues for any RUC structure and rates with a reasonable level of accuracy, there will inevitably be tradeoffs among revenue generation, improving transportation system performance, and progress towards state climate goals in the design of a RUC. A RUC structure with rates set to maximize revenue generation would almost certainly differ from one designed to minimize road damage and maintenance costs, or one that most reduces vehicle emissions over time. So, for rate structures 3, 4, or 5, if the prices are set to achieve targeted performance goals, the RUC rates would almost certainly need to be regularly adjusted, and the rate structure itself might need to be occasionally amended, in order to achieve revenue collection targets. For example, if RUC rates were much higher for ICE vehicles relative to plug-in hybrids, hydrogen fuel-cell, and electric vehicles, and these higher rates accelerated the shift toward these cleaner vehicles, then revenues collected from ICEs would wane faster over time than they would have otherwise.

127 Agrawal et al., *The Impact of the COVID-19 Recovery on California Transportation Revenue: A Scenario Analysis through 2040*.

Table 6. Assessing Each Rate Structure's Revenue Generation Predictability

Rate Structure	Potential Effectiveness for Revenue Generation
Flat rate *Per-mile charge across all vehicles*	Forecasting revenues from a flat rate RUC entails estimating how different classes of drivers and vehicles would respond to the RUC, given both the rate selected and how that rate would compare with the driving behavior and vehicle mix in the current transportation tax and fee regime. Doing so would be more speculative at the outset, but such forecasts would surely become more precise over time. Because the charge would apply similarly to all vehicles, the revenues generated by it would likely be substantial and consistent.
Block rate *Per-mile increases above a threshold of miles*	Forecasting revenues from a block-rate RUC would be similar to a flat-rate RUC, but here the effects of more than one price tier would be estimated. Under the block rate structure, it is possible that drivers reaching the higher-priced rate would reduce their travel more than they would otherwise do with the flat rate structure. (The price per mile for the expensive block would be higher than the price for the flat-rate RUC, assuming both options aim to raise the same total revenue.) Because the charge would apply similarly to all vehicles, the revenues generated by it would likely be substantial and consistent.
Axle-weight rate *Rate varies by axle weight*	Forecasting revenue from this rate structure would entail analyzing behavioral responses to an axle-weight-based fee structure across different classes of vehicles. While involving more price tier elements, projecting revenues would be similar to the flat- and block-rate schemes above. Because the charge would apply to all vehicles, the revenues generated by it would likely be both substantial and consistent.
Congestion rate *Surcharge added for miles traveled on congested facilities*	Revenue collected from a congestion rate RUC would likely be on top of some other base level RUC, because the charge is typically levied only in routinely congested areas. Because the primary purpose of this rate structure is to reduce localized traffic delays and emissions, the revenues collected would depend on local congestion levels, the RUC rate, and driver responses to them. As the charges are levied in particular locations at specific times, and not on all vehicle travel, the revenues collected are more limited and often earmarked for the construction and operation of the congestion-priced facility and/or for enhanced transportation services, such as express bus service, in the area.
Carbon rate *Rate varies by fuel efficiency*	As the primary goal of this rate structure is to reduce vehicle emissions, forecasting revenues would depend not only on estimating near-term responses to the charge across various classes of drivers and their vehicles, but longer-run shifts in the vehicles owned and operated by households and firms in the state. Given the explicit goal of supporting California's climate goals, the most "successful" realization of this charge would be to accelerate the shift to no-emission vehicles and eventually drive revenues collected down to zero. For this reason, structuring a RUC to rely only on carbon rate pricing would not provide a steady stream of revenues in the long run, and it would thus likely need to be paired with another RUC rate structure.
Equity rate *Rate varies by driver income*	An equity overlay could be applied to any or all of the RUC rate structures described above, with discounts for drivers in lower-income households or some other basis of redistribution. Both the forecasting and reliability of the revenues generated would be similar to the RUC rate scheme described above. The effect on total revenues collected would depend on the level of the discount and whether it would be counterbalanced by increases in rates charged to other classes of drivers or vehicles.

4.3 TRANSPORTATION SYSTEM PERFORMANCE

Beyond just raising revenue, a RUC has the potential to improve the performance of the transportation system. There are four primary ways this improvement can occur: (1) minimizing the construction needs for roads and the ensuing maintenance of them, (2) reducing traffic congestion, (3) improving safety, and (4) reducing vehicle emissions, including greenhouse gas emissions.

We address each of these subcategories below by first explaining how improving the specific aspect of system performance would play out. We then provide some examples from the research literature and case studies of how these objectives have been achieved. Next, we evaluate the potential effectiveness for each of our five rate structures to improve a specific aspect of system performance that aligns with state goals. We show that some rate structures improve only one system performance category, while others have a broader positive effect. Finally, we end each section by reflecting on how effectively a RUC could address this goal.

As we proceed, it is important to note that for all of the expected outcomes in this section we assume the state were to raise roughly the same amount of revenue for transportation purposes from the RUC as it does through the current fuel tax. We assume this for analytic simplicity and do not imply that this should be an explicit goal of any RUC program. We conclude this chapter with a discussion of how these outcomes might vary if the state were to decide it needed to generate more funds from a RUC.

Minimize Road Construction and Maintenance Costs

While private and commercial vehicle travel produces myriad positive and negative outcomes and externalities, driving cars and trucks imposes two direct costs on road systems. First, vehicles on roadways occupy space that cannot be used—at particular times and places—by other vehicles. This is only an issue when the demand for road capacity exceeds the supply, and congestion occurs. The second direct cost is wear and tear on pavements, bridges, and so on.

This second direct cost is both substantial and varies significantly across vehicle types and roadbed capacities. The variance in wear and tear costs is so dramatic that traffic engineers have a rule-of-thumb called the *Fourth Power Rule* to describe it. In a nutshell, the rule says that the relative damage caused by a vehicle is a function of the axle load[128] relative to the road's weight-bearing capacity raised to the fourth power. Thus, a loaded three-axle delivery truck weighing 10,000 pounds would be estimated to cause more than 50 times the road damage per pass on a roadbed designed to accommodate 2,000-pound axle loadings as the damage caused by a 2,500 pound, two-axle passenger car making the same pass on the roadbed:

- Delivery Truck: (10,000 pounds / 3 axles) / 2,000-pound capacity = 1.67; $1.67^4 = 7.77$

- Passenger Car: (2,500 pounds / 2 axles) / 2,000-pound capacity = 0.625; $0.625^4 = 0.15$

- Difference: 7.77 / 0.15 = 51.8

Each pass of this delivery truck on this particular roadway does 51.8 times the wear and tear of each pass by the passenger car. Thus, incentivizing lower axle loads can dramatically lower both initial construction and ongoing road maintenance costs; in addition, somewhat higher up-front construction costs to increase a road's vehicle load capacity can also

128 Axle load refers to the weight collectively borne by the tires directly across from one another on a vehicle. It is generally this weight, and not the total vehicle weight, that determines the road wear and tear caused by a vehicle.

substantially lower ongoing maintenance costs. Indeed, transportation economists have for many years argued that the taxing or pricing of driving should account for the effect of axle weights, or total vehicle weight as a second-best option.[129] Such a taxing schema would lower overall road expenditures by significantly reducing road maintenance costs.

Pricing axle loads would incentivize truckers to both reduce the loads and (over time) increase the number of axles on their trucks; it would, in addition, signal to public agencies that road maintenance savings would often more than offset the costs of building more expensive roads to accommodate heavy vehicles. The example above shows the importance of a road's load capacity, primarily a function of pavement quality and thickness, in addition to axle weight. This relationship, between pavement thickness and road damage, is even less linear than the relationship between axle weight and road damage. Road damage rises to the fourth power of axle weight, but pavement life rises to the seventh power of pavement thickness. Depending on conditions, for example, a rigid pavement that is 11.5 inches thick will last twice as long as one that is ten inches thick.

Additionally, damage to bridges, as opposed to roads, is much more a function of the total weight of all vehicles on the bridge than the absolute weight of any given vehicle. Heavy vehicles like trucks thus still do most of the damage to bridges, but the difference between bigger and smaller vehicles may not be as large.

Over time, of course, lighter cars damage roads as well, but in practice some combination of weather and heavier trucks almost always ends up damaging the road long before this happens. Although the variation in passenger vehicle weights is small compared to the variation among heavy duty vehicles, some light-duty vehicles are considerably lighter than others. Most notably, large SUVs are heavier than small sedans and battery-electric vehicles are much heavier than equivalent ICE vehicles. Additionally, electric vehicles often emit substantially larger amounts of fine particulate matter as a result of tire and brake friction. A weight-based component to a RUC could capture these costs.

129 Kenneth A. Small, Clifford Winston, and Carol A. Evans, *Road Work: A New Highway Pricing and Investment Policy* (Washington, D.C: Brookings Institution Press, 1991).

Table 7. Assessing Each Rate Structure's Effectiveness at Minimizing Road Construction and Maintenance Costs

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	If the charge is equal across all vehicle types, then heavy (and presumably mostly commercial) vehicles would most likely pay considerably less than they do under current fuel tax rates. This could cause an increase in miles driven by heavier vehicles, increasing road damage and requiring more roads to be built to more expensive standards in order to support heavy trucks.
Block rate *Per-mile increases above a threshold of miles*	As with the flat rate RUC, larger, heavier vehicles would pay proportionally less, but would likely drive more per year and thus pay more of the higher tier rates. The result would likely be increased road damage and a shift in cost burden from heavy to light vehicles, though less of both compared with the flat-rate RUC above.
Axle-weight rate *Rate varies by axle weight*	For heavy duty vehicles, this RUC could create a price incentive that would lead shippers to reduce laden weight per axle, thus substantially reducing road damage and maintenance costs in the process. Shippers could accomplish this by reducing the loading of current trucks and/or by shifting fleets to some combination of smaller trucks and more axles. These changes could possibly increase congestion, if the incentive to reduce truck weight resulted in more (smaller) trucks on the road—and greater congestion may stimulate a demand for expensive capacity increases. Light-duty vehicles, which generally have much lower axle weights than heavy-duty vehicles, would pay less than heavy-duty vehicles for less damage caused. (How that rate would compare to a standard per-mile flat rate depends on the balance of revenue needs and rate setting for heavy vehicles.)
Congestion rate *Surcharge added for miles traveled on congested facilities*	This RUC would not incentivize drivers in ways likely to reduce road damage, but this rate structure could reduce road construction costs by reducing demand for expanding chronically congested facilities.
Carbon rate *Rate varies by fuel efficiency*	The fees in a carbon rate would likely motivate a shift toward lighter cars and trucks, since these tend to be more fuel-efficient, thus slightly reducing road damage. However, it's also possible that the carbon rate structure could increase road damage by incentivizing people to replace gas and diesel vehicles with their heavier hydrogen fuel cell or battery electric counterparts, though again the relative damage caused by heavier light-duty vehicles is relatively modest.
Equity rate *Rate varies by driver income*	This rate structure would likely either have no impact on road costs or could possibly increase them. Low-income drivers might slightly increase their driving if the RUC costs are lower than current taxes and fees, but low-income drivers drive far fewer miles annually than their higher-income counterparts, so the impact would likely be small.[a]

[a] Speroni et al., *Charging Drivers by the Gallon vs. the Mile.*

Putting these factors together suggests that a RUC designed to minimize road damage would probably not apply to most vehicles, and that for those heavy-duty vehicles that can appreciably damage roads, the appropriate charge would largely be a function of axle weights and pavement thickness. The same 18,000-pound axle could warrant a 1 cent per mile charge on 11.5 inch thick rigid pavement, but $12.75 a mile on some of the thinnest, least rigid pavement types.[130] An optimal charge, therefore, might need to change during trips (as vehicles move from one type of pavement to another) and across trips (if the state gradually upgrades roads, the charge should fall as well).

Reduce Greenhouse Gas Emissions

Variable RUC rates can incentivize drivers to make travel choices that reduce carbon emissions in three ways. First, and most simply, consider one vehicle and one driver; the

130 Kenneth A. Small and Clifford Winston, "Efficient Pricing and Investment Solutions to Highway Infrastructure Needs," *The American Economic Review* 76, no. 2 (1986): 165–69.

less they drive, the less they pollute, all else equal. Second, consider households, firms, and entities with multiple-vehicle fleets: if fleet owners use their fuel-efficient vehicles more than their least fuel-efficient vehicles, pollution decreases even for the same number of vehicle miles driven. And third, in the long run, when it comes to purchasing new vehicles, finding ways to incentivize the purchase of fuel-efficient or fuel-free low-emissions vehicles can reduce pollution even if driving does not decrease.

There is research evidence to support a RUC's ability to contribute toward reduced GHG emissions. The U.S. transportation sector accounts for roughly a quarter of the GHG emissions from the U.S. economy; simply reducing driving is one way to reduce these emissions.[131] One way of reducing driving is to increase the cost of driving, which up until now has occurred primarily through increases in the price of gasoline and diesel fuel, due to fluctuations in global oil prices. But California's fuel mixture requirements, per gallon fuel tax, and retail sales tax on fuel sales also affect the price of fuel and, in turn, driving. As discussed earlier, studies have generally found that gasoline has a small negative price elasticity, such that an increase in fuel price leads to a decrease in miles driven (see Labandeira et al.[132] for a review of a dozen such studies). Increases in fuel prices are also associated with reduced CO_2 emissions: one study found that a 1% increase in fuel price was associated with a 0.19% reduction in CO_2 emissions from passenger cars.[133] Similarly, the London mayor's office estimates that new stricter standards and an expanded range of the ULEZ led to nitrogen dioxide (NO_2) levels 44% lower than they would have been before the changes.[134]

Achieving these emissions reductions in the long run involves a combination of both driving less and deploying newer, more fuel-efficient vehicles, both of which a RUC can help to incentivize. Feebates—rebates of fees paid through the fuel tax for fuel-efficient vehicles paid for by added fees on gas guzzlers—are associated with improved vehicle fuel economy in vehicle purchases.[135] As these vehicles become larger shares of the overall fleet, even with similar or increased travel, emissions can be reduced through an energy use "take back" by as much as 20%.[136]

131 David L. Greene, Howard H. Jr. Baker, and Steven E. Plotkin, *Reducing Greenhouse Gas Emissions from U.S. Transportation*, January 1, 2010, https://rosap.ntl.bts.gov/view/dot/23588.

132 "A Meta-Analysis on the Price Elasticity of Energy Demand," *Energy Policy* 102 (March 2017): 549–68, https://doi.org/10.1016/j.enpol.2017.01.002.

133 Lasse Fridstrøm and Vegard Østli, "Direct and Cross Price Elasticities of Demand for Gasoline, Diesel, Hybrid and Battery Electric Cars: The Case of Norway," *European Transport Research Review* 13, no. 1 (December 2021): 3, https://doi.org/10.1186/s12544-020-00454-2.

134 London City Hall, "Millions of Londoners Breathing Cleaner Air Thanks to ULEZ Expansion"; C40 Cities, *C40 Cities Annual Report 2022*, March 31, 2023, https://www.c40.org/wp-content/uploads/2023/03/C40-Cities-Annual-Report-2022_Published-Online-31-Mar-2023.pdf.

135 David L. Greene et al., "Feebates, Rebates and Gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy," *Energy Policy* 33, no. 6 (April 1, 2005): 757–75, https://doi.org/10.1016/j.enpol.2003.10.003.

136 David L. Greene, James R. Kahn, and Robert C. Gibson, "Fuel Economy Rebound Effect for U.S. Household Vehicles," *The Energy Journal* 20, no. 3 (July 1, 1999), https://doi.org/10.5547/ISSN0195-6574-EJ-Vol20-No3-1.

Table 8. Assessing Each Rate Structure's Effectiveness at Reducing GHG Emissions

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	Because a flat-rate RUC gives drivers no incentive drive more-fuel-efficient vehicles, it would almost certainly not reduce GHGs without additional modifications. (And the RUC would be less effective in this regard, than the current fuel tax.) The only caveat to this is if the rate were to be set very high, then it may disincentivize driving and, hence, emissions.
Block rate *Per-mile increases above a threshold of miles*	Because the price of the rate tiers would increase with driving over a given period of time, a block-rate pricing scheme would tend to encourage less driving and, thus, GHGs, relative to a flat-rate scheme, though how much would depend on the rates across tiers.
Axle-weight rate *Rate varies by axle weight*	A rate that increases per-mile with axle weight could have differing effects on GHG emissions for light- and heavy-duty vehicles, respectively, absent any other rate modifications and as compared with the flat-rate. For light-duty vehicles, a RUC rate that increases per-mile with axle weight could encourage the purchase of lighter vehicles that tend to pollute less.[a] However, for heavy-duty vehicles, the effect would likely be mixed: on the one hand, relying on heavy vehicles with more axles reduces fuel-efficiency, so emissions could improve incentivizing lighter vehicles; however, if this leads shippers to divide heavy loads over multiple lighter trucks, VMT could rise, and with that, emissions.
Congestion rate *Surcharge added for miles traveled on congested facilities*	Miles driven in congestion tend to generate more emissions, all else equal. Reducing congestion via pricing incentivizes carpooling and transit use, both of which reduce emissions per person-mile of travel, roadway-adjacent emissions and public health costs, and global greenhouse gas emissions.
Carbon rate *Rate varies by fuel efficiency*	Carbon rates would vary by vehicle fuel-efficiency and/or emissions level per mile driven. Charging gas guzzlers/gross polluters more per mile incentivizes users both driving less and purchasing cleaner, more fuel-efficient vehicles. However, actual realized carbon reduction would depend on energy sourcing and additional emissions incurred during vehicle production and end-of-life recycling.[b]
Equity rate *Rate varies by driver income*	A rate centered on income equity would afford low-income users lower per-mile rates. Low-income households tend to travel substantially less than middle- and high-income households.[c] Providing low-income households with a reduced rate would help alleviate financial burden and would likely only marginally increase their vehicle travel and emissions. However, low-income households also tend to drive less fuel-efficient ICE vehicles, compared with middle- and high-income households. Providing a discounted per-mile rate to low-income households without any other conditions would indirectly incentivize driving in less-efficient, more polluting vehicles.

Note: EV = electric vehicle; ICE = internal combustion engine; VMT = vehicle miles traveled.

[a] Kea Wilson, "Researchers Are Sounding the Alarm About Heavy EVs — Even in Europe, Where Cars Are Far Smaller," Streetsblog USA (blog), April 3, 2023, https://usa.streetsblog.org/2023/04/03/researchers-are-sounding-the-alarm-about-heavy-evs-even-in-europe-where-cars-are-far-smaller/.

[b] Wilson.

[c] Speroni et al., *Charging Drivers by the Gallon vs. the Mile.*

A RUC's ability to affect positive environmental change would be limited if the various components of the rate structure were collectively capped at only raising the revenue previously raised. However, even in such a circumstance, the RUC revenues collected from the components focused on reducing emissions and congestion, could be rebated in some manner to all taxpayers. This would make these elements revenue neutral even as the motivated significant public benefit.

Again, most studies have found only a modest effect of the price of gasoline on driving and emissions and that the effect is decreasing over time, suggesting that a RUC would also have modest effects on vehicle emissions.[137] In analyzing consumer purchase decisions of Toyota Prius hybrids, Ozaki and Sevastyanova found that saving money on fuel was low ranked by respondents as reasons for purchasing their hybrid, trailing reducing climate change, keeping up with the latest technology, and being socially responsible.[138]

If the state were merely using a RUC to replace current fuel tax revenue, it is likely that RUC rates will not be high enough to substantially influence vehicle purchase and driving decisions. If the state decided to significantly manage emissions through a RUC, the rates would need to vary enough across vehicle types to influence buying and driving decisions, which could be set to raise additional revenue, or to be revenue neutral across vehicle types and purchases. Alternatively, the state could increase effects on vehicle purchase decisions by pairing carbon reduction RUC rates with other policies, such as ZEV purchase incentives.[139] In combination, these policies would improve vehicle fuel efficiency, transition to alternative fuels, and increase efficiency of operation.[140]

Improve Safety and Reduce Crashes

A variable RUC rate can incentivize drivers to reduce their crash risk. Because traffic density is the single-largest predictor of vehicle crashes, an additional vehicle on the road increases the risk of a crash, with all other conditions held constant. Almost all drivers, simply by being on the road, slow other drivers down, and increase the risk that any driver will be involved in a crash. That risk, right now, is largely unpriced. The existing insurance system assigns blame once a crash occurs (legal fault), which is largely done through private but government-mandated driver's insurance, but it doesn't adequately internalize the marginal crash risk that arises from someone deciding to drive rather than walk, take transit, or stay home.

In its simplest form, a RUC to capture crash and safety risk would look a lot like a congestion charge, and a simple congestion charge might in fact proxy fairly well for crash risk. That said, crash risk (and especially expected crash damage, which is risk multiplied by the likely cost) can vary tremendously within the same level of traffic density. An inattentive driver in a heavy vehicle poses a bigger total crash damage threat than an attentive person next to him in a smaller vehicle. Aggressive driving, such as driving quickly and then stopping short, also greatly increases crash risk (as well as, as we note above, increasing pollution). An optimal RUC focused on reducing crashes and improving safety might thus capture not just miles driven, but vehicle weight and some aspects of driving behavior. Indeed, larger and heavier vehicles are associated with additional risks to pedestrians and other non-vehicular road users, especially children.[141]

137 Benjamin Leard, Joshua Linn, and Virginia McConnell, "Fuel Prices, New Vehicle Fuel Economy, and Implications for Attribute-Based Standards," *Journal of the Association of Environmental and Resource Economists* 4, no. 3 (September 2017): 659–700, https://doi.org/10.1086/691688.

138 Ritsuko Ozaki and Katerina Sevastyanova, "Going Hybrid: An Analysis of Consumer Purchase Motivations," *Energy Policy* 39, no. 5 (May 2011): 2217–27, https://doi.org/10.1016/j.enpol.2010.04.024.

139 Christiane Münzel et al., "How Large Is the Effect of Financial Incentives on Electric Vehicle Sales? – A Global Review and European Analysis," *Energy Economics* 84 (October 1, 2019): 104493, https://doi.org/10.1016/j.eneco.2019.104493.

140 Greene, Baker, and Plotkin, *Reducing Greenhouse Gas Emissions from U.S. Transportation*.

141 Mickey Edwards and Daniel Leonard, "Effects of Large Vehicles on Pedestrian and Pedalcyclist Injury Severity," *Journal of Safety Research* 82 (September 1, 2022): 275–82, https://doi.org/10.1016/j.jsr.2022.06.005; Justin Tyndall, "Pedestrian Deaths and Large Vehicles," *Economics of Transportation* 26–27 (June 1, 2021): 100219, https://doi.org/10.1016/j.ecotra.2021.100219.

One study offers evidence that taxation can lead to reduced collisions in trucking. Using weight-in-motion sensor data, Nehiba estimated that a $0.37 per gallon increase in the diesel fuel tax was associated with fewer collisions. However, the complete results of this study lead us to again emphasize the importance of considering RUC rates holistically. In response to the fuel tax increase, the trucking industry also began more fully loading trucks to save on fuel tax, which was associated with a substantial increase in fatal collisions.[142] In sum, achieving a reduction in collisions and improving safety would likely take a RUC that approaches the goal from more than one angle.

Table 9. Assessing Each Rate Structure's Effectiveness at Improving Safety/ Reducing Crashes

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	Unless the flat rate charge were high enough to meaningfully reduce VMT, it would be unlikely to offer any safety improvements or reductions in crash risk.
Block rate *Per-mile increases above a threshold of miles*	While the increasing rates for higher levels of driving would likely have some effect on VMT, unless the per-mile rate in each higher block increased significantly, such that both VMT and thus exposure to other vehicles declined appreciably, the effects on safety would likely be minimal.
Axle-weight rate *Rate varies by axle weight*	A RUC rate that increases per-mile rates with vehicle weight would be likely to improve safety and reduce crashes. Heavier and larger vehicles are significantly more likely to cause serious injury or death than are lighter and smaller vehicles. If the RUC rate for heavy vehicles were high enough to either discourage their use and/or encourage the production, purchase, and use of smaller, lighter trucks, serious collisions could be meaningfully reduced—especially those involving pedestrians and children.
Congestion rate *Surcharge added for miles traveled on congested facilities*	Driving in congestion leads to fewer serious crashes, but more fender-benders. A RUC rate that disincentivizes driving on congested roadways could lead to fewer crashes overall, but other incentives would be required to avoid an ensuing increase in serious or fatal crashes on now-uncongested roads.
Carbon rate *Rate varies by fuel efficiency*	Although the carbon rate would not directly reduce crashes or improve safety, it could potentially produce similar effects as the Axle Weight Rate, by encouraging the purchase and use of smaller, lighter trucks.
Equity rate *Rate varies by driver income*	The income equity rate may cause a marginal increase in VMT among low-income drivers, who are more likely to live in neighborhoods with greater numbers of traffic collisions—and thus more likely to drive in those neighborhoods.[a]

[a] Patrick Morency et al., "Neighborhood Social Inequalities in Road Traffic Injuries: The Influence of Traffic Volume and Road Design," *American Journal of Public Health* 102, no. 6 (June 2012): 1112–19, https://doi.org/10.2105/AJPH.2011.300528; Eric Dumbaugh et al., "Why Do Lower-Income Areas Experience Worse Road Safety Outcomes? Examining the Role of the Built Environment in Orange County, Florida," *Transportation Research Interdisciplinary Perspectives* 16 (December 1, 2022): 100696, https://doi.org/10.1016/j.trip.2022.100696.

Reduce Traffic Congestion

RUC rates can also disincentivize some drivers from driving in congested conditions. Indeed, most researchers agree that pricing is the only way to meaningfully reduce congestion.[143] Examples from congestion pricing in practice can offer insights on how they could be part of a RUC structure and rates. One such example comes directly from a RUC

142 Cody Nehiba, "Taxed to Death? Freight Truck Collision Externalities and Diesel Taxes," *Regional Science and Urban Economics* 85 (November 1, 2020): 103577, https://doi.org/10.1016/j.regsciurbeco.2020.103577.

143 Brian D Taylor, "The Politics of Congestion Mitigation," *Transport Policy* 11, no. 3 (July 2004): 299–302, https://doi.org/10.1016/j.tranpol.2004.04.001.

pilot. Oregon's 2006-2007 RUC pilot charged some participants a differentiated rate: 10¢ per mile during rush hours within the Portland Urban Growth Boundary, and 0.43¢ per mile at all other times and places.[144] VMT reductions for those users who paid the congestion rate were greater in dense, mixed-use areas than in the suburbs, likely because of the availability of alternative travel modes and nearby destinations.[145]

Second, several U.S. States, including California, have implemented high-occupancy toll (HOT) lanes on freeway facilities. As discussed in Chapter 3, HOT lanes are separated lanes that require a pay-per-mile toll to use—in some cases for all vehicles and in others only for vehicles with no or one passenger. Generally, the toll rate varies based on either predicted or revealed roadway density at a given time, with the operator attempting to achieve some set free-flowing traffic goal. Those drivers who wish to drive at the free-flowing speed rather than sit in congestion in the free lanes can do so by paying the toll.[146]

Third, several major cities abroad have implemented area congestion pricing programs: London, Singapore, and Stockholm are the most notable examples. London's central area cordon charge (where drivers pay a fee to enter a central zone) led to a 34% decrease in private vehicle traffic inside the cordon in just the first year of implementation, 2002–2003.[147] Similarly, Stockholm saw between 20 and 25% less traffic during its seven-month congestion pricing trial in 2006; seeing such results, and endorsed by voters, the city's leaders made the program permanent.[148]

Planned satellite-based per-mile tolling pilots in Munich, Germany and Barcelona, Spain illustrate how a RUC might help to reduce congestion. In those programs, users will be alerted by mobile phone app of a fixed fee to access a low-emission zone and a variable fee based on the number of miles traveled, level of usage, and congestion at the time of access in the zone. Both programs have a stated goal of reducing congestion by 10 to 25% and seek to open additional public space previously dedicated to driving and parking.[149]

144 Oregon Department of Transportation, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program*.

145 Zhan Guo, Asha Weinstein Agrawal, and Jennifer Dill, "Are Land Use Planning and Congestion Pricing Mutually Supportive?," *Journal of the American Planning Association* 77, no. 3 (July 1, 2011): 232–50, https://doi.org/10.1080/01944363.2011.592129.

146 Anthony Downs, "Some Like It HOT: High-Occupancy Toll Lanes Work Best on High-Traffic Roads. Without Congestion, Drivers Have Little Incentive to Pay the Toll.," *Brookings* (blog), November 30, 2001, https://www.brookings.edu/opinions/some-like-it-hot-high-occupancy-toll-lanes-work-best-on-high-traffic-roads-without-congestion-drivers-have-little-incentive-to-pay-the-toll/.

147 Jonathan Leape, "The London Congestion Charge," *Journal of Economic Perspectives* 20, no. 4 (August 1, 2006): 157–76, https://doi.org/10.1257/jep.20.4.157.

148 Emilia Simeonova et al., "Congestion Pricing, Air Pollution, and Children's Health," *Journal of Human Resources*, October 14, 2019, 0218, https://doi.org/10.3368/jhr.56.4.0218-9363R2.

149 Tom Stone, "Satellite, Pay-per-Mile Tolling to Be Tested in Munich and Barcelona," *Traffic Technology Today* (blog), April 12, 2023, https://www.traffictechnologytoday.com/news/tolling/satellite-pay-per-mile-tolling-to-be-tested-in-munich-and-barcelona.html.

Table 10. Assessing Each Rate Structure's Effectiveness at Reducing Traffic Congestion

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	A flat per-mile rate provides no incentive to avoid travel on congested facilities. However, if the price is high enough, it might discourage driving overall and thus, on the margin, could reduce some peak-hour driving.
Block rate *Per-mile increases above a threshold of miles*	Any effect that a block rate would have on congestion would likely be modest and indirect. However, the effect could be slightly stronger than a flat-rate structure that raises equivalent revenue, since the rate for the higher block or blocks would be greater. As discussed in Chapter 2, researchers have consistently found that drivers are more likely to reduce travel (or at least fuel consumption) as marginal costs rise. On the other hand, one strong reason to suspect that a block rate would not reduce congestion appreciably is that rural users have slightly higher VMT than urban drivers, and rural drivers who are not typically driving in congested conditions will also be subject to higher-mileage rates despite not generally affecting congestion. In California, for example, an analysis of weekly household mileage concluded that rural households drive 18% more miles weekly than urban households.[a]
Axle-weight rate *Rate varies by axle weight*	Any effect of an axle-weight rate would be indirect. The rate structure could reduce congestion delays if it encouraged more goods movement via smaller, lighter trucks, which tend to consume less "effective road capacity" because they accelerate, decelerate, and turn more like light duty vehicles. However, these improvements might be partially or completely offset by more smaller trucks replacing fewer larger ones.
Congestion rate *Surcharge added for miles traveled on congested facilities*	There is extensive evidence from implemented programs, pilots, and scholarly research that congestion pricing indeed significantly reduces congestion levels, as discussed above and in chapter 2. It seems very likely that fleet managers for heavy-duty vehicles are already limiting travel in congestion because the cost in driver wages is higher for a slower trip in congestion than for the same trip in off-peak times. Thus, less time spent in traffic may well more than offset the higher congestion. Much truck travel is managed by large firms that have access to the data and analysts needed to identify where paying congestion tolls in order to shorten trip time could save enough in salary costs to generate significant savings. On the other hand, smaller shippers and owner-operator trucking businesses are less likely to have the analytic capabilities to identify how much they could reduce costs by reducing congested driving.
Carbon rate *Rate varies by fuel efficiency*	Like the flat-rate structure, the carbon rate would likely do little to directly address congestion.
Equity rate *Rate varies by driver income*	Reduced rates for low-income drivers might encourage slightly more driving from them, but that driving is more likely to be at off-peak hours than for middle- and higher-income drivers. However, most of this encouraged VMT could still occur at peak hours in the absolute, which could increase congestion.

[a] Speroni et al., *Charging Drivers by the Gallon vs. the Mile.*

5. IMPLEMENTATION FEASIBILITY AND EQUITY IMPLICATIONS OF RUCS

This chapter presents a sketch evaluation of how the sample RUC rate structures might perform in terms of the three implementation criteria discussed in Chapter 2. Although the rate structure should be chosen first and foremost to achieve the state's desired goals, it's also essential to determine if the structure is administratively feasible, politically feasible, and equitable.

5.1 ADMINISTRATIVE FEASIBILITY

An obvious goal for a RUC program is to be as administratively manageable as possible, given the context of the other goals the program seeks to achieve. The first task in achieving this is for the state to determine which agency or agencies would be responsible for administering the RUC program and collecting the revenue. In doing so, the state could look for ways to use existing mechanisms for collecting road user revenue, like those used by the California Department of Motor Vehicles (DMV) and tolling authorities. From there, creating an administratively efficient RUC program would require configuring it to the particular rate structures ultimately included in the program.

The administrative feasibility of a RUC depends greatly on which of the rate structures are deployed in an overall RUC program. For example, a simple per-mile rate would be relatively simple administratively, compared to other rate structure options: the agency charged with collecting RUC payments could use an annual odometer reading—which some states (though not California) already collect as part of annual vehicle inspections—to calculate each user's RUC balance due and bill the user as part of other regular annual fee collections. By contrast, implementing a congestion charge requires telling drivers which facilities are congested and how much it will cost to drive on them, and then charging drivers where, when, and for how long they drive on congested facilities. Indeed, collecting a RUC from out-of-state light-duty vehicles would be likely impossible; the state could not require out-of-state vehicles to have on-board devices (OBDs).

However, even the simplest per-mile RUC would inevitably require administratively complex addendums to, for example, account for geography in order to charge out-of-state, Canadian, and Mexican vehicles for their use of California's roads, as well as to credit California drivers for their mileage outside of the state. While we have the technology through OBDs to capture the locations and timing of miles driven, these can raise privacy concerns. Finally, an important note in achieving an administratively-feasible RUC program is to account for the costs of administering the program in setting the rate. There is general agreement that a RUC would be considerably more expensive and complex to administer than California's existing mechanism for collecting road user revenue through fuel taxes. While the exact administrative and collection costs are unclear and are steadily decreasing as technology streamlines our abilities to administer a RUC, nevertheless revenue targets should be slightly higher in order to pay for the program itself.

Table 11. Assessing Each Rate Structure Option's Administrative Feasibility

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	The flat rate is potentially the most administratively simple RUC rate structure. At its most basic, the rate could be based on an annual odometer reading. But even this would require additional and likely complex program add-ons to both charge out-of-state vehicles for using California roads and credit California vehicles for their miles traveled out of state.
Block rate *Per-mile increases above a threshold of miles*	This is nearly as administratively simple as the flat rate, as the only additional requirement is to adjust rates based on how many miles a vehicle has driven.
Axle-weight rate *Rate varies by axle weight*	This structure would apply mostly directly to heavy-duty (and almost exclusively commercial) vehicles, and would likely require building on existing state mileage and weight programs to be more like the more elaborate ones in Oregon and New Mexico. The charges to light-duty vehicles would be similar to those described in the flat-rate and block-rate schemes described above.
Congestion rate *Surcharge added for miles traveled on congested facilities*	Place-based rates for variable congestion charges would likely require that all vehicles using the facility have an OBU transponder, like the FastTrak transponders used on the state's toll bridges and HOT lane facilities. Currently, drivers are not required to have these transponders in their vehicles.
Carbon rate *Rate varies by fuel efficiency*	Fuel economy data are readily available upon purchase of a vehicle to consumers and are easily accessible to rate setters and collectors in national databases.
Equity rate *Rate varies by driver income*	Adjusting rates for low-income users directly addresses income equity issues and likely requires a verification process similar to many other programs that seek to achieve similar goals. It is a cumbersome process for the state to track users' incomes and to phase users in and out of the program as their incomes change. It is also cumbersome for users to continually prove their qualification for a discounted rate. On the other hand, because there are so many means tested programs in the state, a RUC program could simply accept qualification earned for any other official means-tested program (lifeline utility rates, school lunch programs, etc.) to keep eligibility determination as simple as possible.

5.2 POLITICAL FEASIBILITY

Research and state RUC pilot program experience over the past two decades has primarily focused on flat-rate RUC structures, with little exploration of the different sorts of rate structures that we have examined here. However, evidence from both public opinion research and public reaction to RUC pilots and programs offer clues to how the general public may react to different RUC rate structures. The evidence suggests that opinions about RUC rate structures will be influenced by views of the following program design details:[150]

- *Privacy:* Some people worry that a RUC program that collects information on the time and place of travel is an unreasonable government intrusion into their privacy. Certain RUC program designs seek to allay these concerns—for example, data collected and processed by private entities on behalf of the government, or by allowing customers to register with numbered, anonymous accounts—but privacy concerns are often a key reason the public and elected officials may object to a RUC.

150 Asha Weinstein Agrawal, Hilary Nixon, and Ashley M. Hooper, *Public Perception of Mileage-Based User Fees*, NCHRP Synthesis 487 (Washington, D.C.: Transportation Research Board, 2016), https://doi.org/10.17226/23401.

- *Fairness:* As noted above, there are many dimensions to assessing RUC equity. Many people assess the fairness of a RUC in the abstract and worry that a RUC will be unfair to low-income drivers or anyone who drives a lot. At other times, views on equity are formed primarily by comparing proposed RUCs to current systems of transportation finance, like fuel taxes. Some people view flat-rate RUCs as fair because all drivers pay the same amount, while others see fuel taxes as fairer than flat-rate RUCs because they charge drivers of fuel-efficient, lower-emission vehicles less than drivers of gas-guzzlers. Yet another concern for some people is the potential for some drivers to evade paying the RUC, creating unfairness for those law-abiding drivers who do pay.

- *Complexity of paying:* Many people prefer a RUC that is both easy to understand and easy to use. People want to be sure they understand the program and can easily predict how much they will pay based on their driving. In addition, most say they do not want the process of paying the RUC to add complexity to their lives. The RUC can be perceived as simple to pay if it is charged together with a bill the household already pays (for example, annual vehicle registration fees, a toll road account, or vehicle insurance). By contrast, a RUC is seen as more worryingly complex if it requires drivers to manage technology that tracks their driving, such as plugging a device into the vehicle's onboard diagnostics (OBD) port or running a special phone app while driving. In addition, programs are perceived as more complex and burdensome if they require creating and maintaining a new account that generates yet another bill that must be paid regularly.

Table 12. Assessing Each Rate Structure Option's Political Feasibility

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	Although policy discussions of RUC rate structures often assume the public will prefer a simple flat rate because it is the simplest to explain, such conventional wisdom is not borne out by an MTI survey series conducted annually from 2010 to 2022.[a] Across a number of rate structure options tested, the flat rate was less popular than several variable rate structures, as explained in the subsequent rows in this table.[b]
Block rate *Per-mile increases above a threshold of miles*	This rate structure has not been extensively studied in the context of U.S. RUC policy. However, the 2022 survey in MTI's annual series found that when U.S. adults were presented with a choice between a flat rate for all or a block-rate structure, 50% chose the block rate option.[c]
Axle-weight rate *Rate varies by axle weight*	While heavy-duty vehicles are typically assessed higher registration rates and fees, and the diesel fuel on which most trucks still run are often taxed at a higher rate than gasoline, these differential rates have long been opposed by trucking interests. Similarly, RUC rate structure like this one that brought mileage fees in line with the disproportionate road damage caused by heavy vehicles would likely be similarly opposed by trucking interests.
Congestion rate *Surcharge added for miles traveled on congested facilities*	The experience of congestion pricing programs in California and elsewhere is that congestion charges tend to be widely opposed before they are implemented by both private motorists and commercial drivers who are skeptical that congestion can be meaningfully reduced. However, support for such pricing tends to increase substantially following implementation when drivers and others can see it work with their own eyes.
Carbon rate *Rate varies by fuel efficiency*	The MTI survey series conducted annually from 2010 to 2022 found that in every year, support was higher for a RUC with the rate linked to the vehicle's emissions of pollutants than for a flat-rate RUC. In 2022, 48% of respondents supported a rate structure where "more polluting" vehicles paid a higher rate, compared to % who supported a flat rate.[d] An earlier survey of Californians found a similar preference for a RUC with variable rates tied to vehicle emissions.[e] Many surveys and focus groups of public opinions on RUCs have also found that a significant number of people oppose the transition from fuel taxes to a flat-rate RUC on the grounds that such a shift reduces the incentive for people to "do the right thing" by purchasing hybrids, plug-in hybrids, hydrogen fuel cell, and electric vehicles.[f]
Equity rate *Rate varies by driver income*	The MTI survey series found clear majority support for the concept of a RUC rate discount for low-income drivers in 2021 (62%) and 2022 (58%).[g]

[a] The reports from each year of the survey can be found at: Mineta Transportation Institute, "MTI Annual Survey of US Public Opinion on Federal Transportation Funding Policy," Mineta Transportation Institute, April 30, 2022, https://transweb.sjsu.edu/about/research-centers/finance/MTI-Annual-Survey.

[b] Asha Weinstein Agrawal and Hilary Nixon, *What Do Americans Think about Federal Tax Options to Support Transportation? Topline Results from Year Thirteen of a National Survey* (San Jose: Mineta Transportation Institute, April 2022), https://transweb.sjsu.edu/sites/default/files/2208A-Agrawal-Nixon-Public-Opinion-Federal-Tax-Options-Transportation-Survey-Toplines.pdf; Hilary Nixon and Asha Weinstein Agrawal, "Would Americans Pay More in Taxes for Better Transportation? Answers from Seven Years of National Survey Data," *Transportation* 46, no. 3 (June 1, 2019): 819–40, https://doi.org/10.1007/s11116-018-9855-x.

[c] Agrawal and Nixon, *What Do Americans Think about Federal Tax Options to Support Transportation? Topline Results from Year Thirteen of a National Survey*.

[d] Mineta Transportation Institute, "MTI Annual Survey of US Public Opinion on Federal Transportation Funding Policy."

[e] Asha Weinstein Agrawal, Jennifer Dill, and Hilary Nixon, "Green Transportation Taxes and Fees: A Survey of Public Preferences in California," *Transportation Research Part D: Transport and Environment* 15, no. 4 (June 1, 2010): 189–96, https://doi.org/10.1016/j.trd.2009.11.003.

[f] Asha Weinstein Agrawal et al., *Public Perception of Mileage-Based User Fees* (Washington, D.C.: Transportation Research Board, 2016), https://doi.org/10.17226/23401; I-95 Corridor Coalition, "Equity and Fairness Considerations in a Mileage-Based User Fee System," March 2019.

[g] Mineta Transportation Institute, "MTI Annual Survey of US Public Opinion on Federal Transportation Funding Policy."

5.3 EQUITY IMPLICATIONS

Transportation finance equity is no simple matter. There are at least three dimensions by which the fairness of a transportation tax, toll, or fee might be evaluated: (1) how individual trips or travelers compare, (2) how various classes of travelers or vehicles compare, and (3) how various places or jurisdictions compare. For each, one could focus only on tax incidence, or more broadly on both prices/taxes paid and transportation benefits received by tax-funded transportation investments. And for all of these, there are at least three defensible philosophical bases for judging transportation finance equity.[151]

Because it is not possible to synthesize all of these dimensions of transportation finance equity in the table below, we offer examples that focus primarily (though not exclusively) on the effects on lower-income travelers. Conceptually, a RUC rate structure would be equitable for low-income travelers if it considers their ability to pay and avoids social exclusion; in other words, the charge either implicitly or explicitly considers the portion of income that a driver would need to pay via a RUC so that it does not prevent low-income people from traveling.[152]

Contrary to popular concerns that a RUC would harm low-income drivers, research evidence supports a RUC's ability to either have no effect on or to improve outcomes for low-income users compared to the status quo, even for a fixed per-mile charge.[153] However, these differences can be modest, and the differences in percentages of income paid to a RUC remain small. Instead, rates can be structured such that lower-income users pay less per-mile than higher-income users. In these instances, the effect on individual welfare is borne from the policy decisions made in rate-setting. Depending on how rates are structured and whether and how revenues are rebated, overall welfare can even increase.[154] Yang et al. found that in Maryland three policy scenarios tested—all of which use per-mile RUC rates that increase with income—protect lower-income households while also generating additional revenue from higher-income households with the most abilities to pay.[155]

In the long run, a RUC's ability to remain equitable for low-income users likely must consider income as a partial determinant in its rate. While it is possible that other rate structures may

151 Taylor and Norton, "Paying for Transportation."

152 Peter Bonsall and Charlotte Kelly, "Road User Charging and Social Exclusion: The Impact of Congestion Charges on at-Risk Groups," *Transport Policy* 12, no. 5 (September 1, 2005): 406–18, https://doi.org/10.1016/j.tranpol.2005.06.007.

153 Speroni et al., Charging Drivers by the Gallon vs. the Mile; Katharina R. Raub, Aaron B. Scholz, and Gernot T. Liedtke, "Impacts of Road User Charges on Individual Welfare—A Pre-Inauguration Exploration for Germany," *Case Studies on Transport Policy* 1, no. 1 (July 1, 2013): 46–52, https://doi.org/10.1016/j.cstp.2013.08.001; Brian A. Weatherford, *Mileage-Based User Fee Winners and Losers: An Analysis of the Distributional Implications of Taxing Vehicle Miles Traveled, with Projections, 2010-2030* (RAND Corporation, April 26, 2012), https://www.rand.org/pubs/rgs_dissertations/RGSD295.html; Lisa Larsen et al., "Equity Evaluation of Fees for Vehicle Miles Traveled in Texas," *Transportation Research Record: Journal of the Transportation Research Board* 2297, no. 1 (January 2012): 11–20, https://doi.org/10.3141/2297-02.

154 David A. Hensher and Corinne Mulley, "Complementing Distance Based Charges with Discounted Registration Fees in the Reform of Road User Charges: The Impact for Motorists and Government Revenue," *Transportation* 41, no. 4 (July 1, 2014): 697–715, https://doi.org/10.1007/s11116-013-9473-6.

155 Di Yang, Eirini Kastrouni, and Lei Zhang, "Equitable and Progressive Distance-Based User Charges Design and Evaluation of Income-Based Mileage Fees in Maryland," *Transport Policy* 47 (April 1, 2016): 169–77, https://doi.org/10.1016/j.tranpol.2016.02.004.

attend to this need indirectly, those relationships may change over time. For example, an increasing block rate structure would implicitly benefit low-income users because they tend to drive less, thereby registering most of their mileage at lower rates.[156] But even if lower income drivers tend to drive less, not all of them do. Over the past two decades, lower-income households have suburbanized and purchased more vehicles than in the past.[157]

Table 13. Assessing Each Rate Structure's Effectiveness at Meeting State Income Equity Goals

Rate Structure	Potential Effectiveness
Flat rate *Per-mile charge across all vehicles*	Like fuel taxes, drivers would pay for transportation in proportion to their travel, which is a measure of fairness. This contrasts from, for example, local option sales taxes earmarked for transportation, which burden road users and non-road users alike to build and maintain transportation systems. Because the fee would relate to distance travel and not fuel used, it would likely shift the tax burden away from larger, heavier commercial vehicles and toward smaller, lighter private vehicles, which could modestly increase the relative transportation tax burden on lower income households.[a]
Block rate *Per-mile increases above a threshold of miles*	This would shift more of the relative tax burden onto heavy road users and away from light road users. Because vehicle travel on average increases with income, the cost burden would shift slightly away from low-income drivers as a group. However, those low-income drivers who drive high VMT would pay more than under the flat-rate structure.
Axle-weight rate *Rate varies by axle weight*	This rate scheme would bring payment of transportation taxes more in line with the wear and tear that various classes of travelers occasion on road systems. With respect to costs imposed on the road system, this would increase one reasonable measure of equity.
Congestion rate *Surcharge added for miles traveled on congested facilities*	Like sales taxes, fuel taxes, and nearly all of the RUC options discussed here, congestion charges are regressive, which can create equity concerns around low-income drivers who drive on tolled facilities at peak hours in peak directions. To the extent a congestion charge also cleans the air, it has some progressive effects as well, but those effects do not necessarily counteract the burden placed on low-income drivers. For these reasons, most discussions of congestion pricing suggest using some of the toll revenue to assist travelers below a certain income level.[b]
Carbon rate Rate varies by fuel efficiency	Because rates would vary based on fuel efficiency and emissions as well as miles driven, and because newer, more expensive cars tend to be cleaner and more fuel efficient, the burden of this tax would likely fall disproportionately on drivers of older cars, who tend to have lower incomes, but also tend to drive less, on average.[c] (The concern about the effect of this rate scheme on lower-income drivers could be addressed in a variety of ways, perhaps by combining with an income equity rate that would qualify low income drivers for a reduced or rebated toll schedule.)
Equity rate *Rate varies by driver income*	The program would explicitly adjust toll rates by income level, increasing income equity in the process.

Note: For the purposes of this discussion, we focus on drivers in low-income households, although equity can also be evaluated by many other factors, including race/ethnicity, immigration status, gender, vehicle type, and geography.

[a] Speroni et al., *Charging Drivers by the Gallon vs. the Mile.*

[b] Michael Manville, Gregory Pierce, and Bryan Graveline, "Guardrails on Priced Lanes: Protecting Equity While Promoting Efficiency," *Transportation Research Interdisciplinary Perspectives* 15 (September 1, 2022): 100652, https://doi.org/10.1016/j.trip.2022.100652.

[c] Speroni et al., *Charging Drivers by the Gallon vs. the Mile.*

156 Speroni et al., *Charging Drivers by the Gallon vs. the Mile*.

157 Elizabeth Kneebone and Emily Garr, *The Suburbanization of Poverty: Trends in Metropolitan America, 2000 to 2008*, Metropolitan Opportunity Series (Washington, D.C.: Brookings Institution, 2010).

As noted at the outset, the equity effects of these various toll schemes should probably be evaluated across multiple dimensions, and not only with respect to income. Given these many dimensions, there is not a single most equitable RUC pricing scheme, but rather variance and tradeoffs among various types of equity and units of analysis. Equity adjustments can be applied to any of the first five tolling schemes outlined here, as each one raises different equity issues.

6. CONCLUSION

This chapter concludes the report in two sections. The first draws together key themes that arose in the previous chapters, and the second offers cross-cutting recommendations for policymakers.

6.1 PUTTING RUCS IN CONTEXT

California's major roads have, for the better part of 100 years, been funded largely through taxes on fuel. Taxes on gasoline and diesel fuel covered most of the cost of building and much of the cost of maintaining roads. With this tax policy, people and firms that drive more tend to pay more, and drivers of large, fuel-thirsty vehicles that account for an outsized share of the wear and tear on roads and bridges also pay more. Conversely, drivers of vehicles that burn less or no fuel and thus pollute less, pay less. In these ways, the fuel tax structure apportions payments among different types of travelers and vehicles in rough proportion to the amount that taxpayers drive, damage roads, and pollute. Despite ongoing debates over the details of this apportionment of costs among various classes of fuel tax payers (such as auto clubs and trucking associations), this system of taxing for transportation has widely been viewed as fair.

But until California raised fuel tax rates in 2017 for the first time in a quarter century, fuel tax revenues were falling behind road maintenance needs. And with the ongoing shift toward high-efficiency, low- and no-fuel vehicles that pay much lower or no fuel taxes—which is a positive transition, motivated partly by fuel tax incentives—the future of fuel tax revenues is uncertain. In addition, the public costs of driving are not limited to miles driven, road wear and tear, and tailpipe emissions. There are many other public costs that drivers don't cover: injuries and deaths associated with vehicle collisions, greenhouse gas emissions that contribute to climate change, delay imposed on others when driving in traffic, and more. These "external costs" of driving are substantial, and the frequent focus of public policy. But the fuel taxes paid by drivers don't come close to directly compensating others for these external costs of driving.

Today California, like many states, is approaching a crossroads. We are more aware now of these external costs of driving, and better equipped with both the means and motivation to reduce them. We are also aware that the fuel tax, long the workhorse of financing roads, is not as effective as it once was at raising revenue. This reduced efficacy owes in part to the rise of vehicles that use less fuel, and in part to a longstanding "cents-per-gallon" rate structure that makes the fuel tax politically difficult to increase. The relative decline of the fuel tax, particularly at the federal level, in combination with an increased policy focus on ways to improve the performance and sustainability of the road system, has led officials in California to consider new ways of charging for roads.

This report has examined how a road user charge, were the state to adopt one, might structure its rates. We have shown in this report that the answer to that question is both critically important to public policy goals adopted by the state, and not as simple as it might initially seem. Perhaps our single most important takeaway is that the proper structure of a RUC will depend on what we want the RUC to do. Broadly speaking, prices of any sort will do some combination of two things: raise revenue and change behavior. A flat-fee

RUC designed solely to raise revenue would have a different rate schedule, and possibly a different charging mechanism, than a RUC designed solely to reduce the negative externalities of driving. And a RUC that tries to balance these objectives will have yet a different structure. Those two principal goals, moreover, are not the only ones a RUC might have. We have shown that road user charges can also be designed to minimize road damage and maintenance costs, or reduce traffic congestion. These goals would imply rates that vary by axle or vehicle weight, or time of day and location.

Pricing—for roads or anything else—should be responsive to demand without confusing consumers (in this case, drivers and fleet managers). Road user charges that are easy to understand and transparently related to public policy goals are most likely to be accepted politically, raise needed revenue, and influence travel behavior in socially beneficial ways. The federal fuel tax was explicitly related to constructing the Interstate Highway System after the Second World War, which led to bipartisan support for increasing the fuel tax multiple times. But with the Interstate system complete, the goals of the federal surface transportation program have become more diffuse. As a result, support for increasing the federal fuel tax to keep up with inflation and increasing fuel efficiency has withered. This, in turn, has made it difficult to raise needed revenue and adequately account for the environmental damage caused by gasoline and diesel fuel. Similarly, road and bridge tolls that do not vary by time, location, or direction may raise revenue, but do little to manage road wear and tear and the chronically congested parts of our transportation system.

In other words, how we collect money for our transportation system importantly affects how people use these systems and, in turn, the public sector costs in building, operating, and maintaining these systems. A local option sales tax may generate revenues for transportation, but in a way that can exacerbate our transportation challenges: it does not differentiate between frequent and occasional users of the systems, between heavy and light vehicles, between polluting and clean vehicles, between trips made in rush hour or the middle of the night, or between lower- and higher-income travelers. And if drivers are shielded from these distinctions, transportation costs and problems are likely to increase.

In sum, there is much to be said for responsive, dynamic prices—and modern technology today allows for road pricing to advance public policy goals that were unimaginable just a few years ago. But more is not necessarily better. A price consisting of a plethora of elements, and/or prices that change constantly to reflect up-to-the-second conditions, may simply confuse drivers. So while structuring road user charges to encourage less road damage, cleaner vehicles, and less rush hour driving would benefit the transportation system, environment, and economy, trying to account for every conceivable external cost of driving in exquisite detail would likely end up undermining its objectives.

6.2 SUMMARY OF FINDINGS

Transportation system users pay a wide array of tax, fee, and charge rate structures: Current transportation taxes, fees, and charges are structured in widely varying ways that can classified as follows:

Table 14. Examples of Rate Structure Types

Classifications	Examples
Undifferentiated	Annual vehicle registration fees that are the same for all vehicles, gasoline fuel taxes, RUC pilots that offered a choice to pay a single charge per year rather than paying by the mile
Vary by vehicle characteristics	Bridge tolls that vary by vehicle class (weight), High-occupancy/toll (HOT) lanes that charge lower rates for ZEVs, taxes for snow tires
Vary by user characteristics	HOT lanes rates that are lower for carpools, discounted transit fares for low-income travelers or youth
Vary by amount consumed	Distance-based commuter rail fares, hourly parking charges, transit fares that cap cost at a certain amount per day, week, or month
Vary by time or location of use	HOT lane rates that vary by congestion levels, parking lot rates that vary by weekday/weekend, street parking rates that vary by neighborhood

The *raison d'être* of RUCs is to variably allocate charges among various types of users and travel. If the goal were simply to raise money, there are much simpler ways to do this (such as via property and sales taxes) than via road user charges. Like its predecessor the motor fuels tax, RUCs aim to fairly and reasonably charge travelers according to how much they use roads and the variable costs imposed by their travel.

***Any* RUC rate structure will influence travel behavior one way or another, and in turn will affect attainment of California's economic, environmental, equity, and safety goals.** The behavioral economics literature has shown that variations in the cost of driving influence where, when, and how far people and businesses drive, and whether they choose to travel by other means. Over the longer term, driving costs also influence vehicle purchase choices, as well as residential and employment location decisions. In general, the effects of transportation tolls and taxes on travel outcomes are not determinative, but neither are they trivial.

Rate structures can be designed to target important state policy goals and/or improve administrative and political feasibility. The table below describes six different rate structures and some likely benefits of each. California could also create a rate structure that combines elements from more than one of the rate structures, such as a block-rate structure that takes into account vehicle axle weight, carbon emissions, congestion, and the vehicle owner's income.

Table 15. Likely Benefits of Rate Structure Types

Rate Structure	Description	Likely benefits (beyond raising revenue)
Flat rate	All vehicles pay the same fee per mile.	Maximum simplicity for drivers and elected officials; undoubtedly popular with drivers of heavy vehicles and gas guzzlers, who will now pay less.
Block rate	All vehicles pay the same modest flat rate per mile up to a threshold (e.g., 5,000 miles/ year), after which the per-mile fee increases for the next 5,000 miles, and so on.	Low base rates for the first increment of miles driven offers relatively low-cost travel to all households and businesses, without the need to vary rates by vehicle type, owner, or location.
Axle-weight rate	Rate varies by vehicle class, which is determined by a combination of vehicle weight axle count.	Reduces cost to build and maintain the transportation system, and allocates those costs fairly among road users on the basis of road damage caused.
Congestion rate	Flat rate per mile, with a congestion surcharge for miles driven on congested facilities during peak periods.	Manages traffic congestion, which saves travelers time and money, and reduces per-mile emissions.
Carbon rate	Rate varies by fuel efficiency.	Reduces carbon emissions and air pollutants by encouraging the purchase and use of cleaner vehicles.
Equity rate	Vehicles pay a flat fee per mile, with discounted rates for low-income travelers.	Provides a low-cost option for low-income travelers.

6.3 RECOMMENDATIONS FOR POLICYMAKERS

We end the report with four specific recommendations for policymakers who need to determine an appropriate RUC rate structure.

Consider multiple criteria when choosing a rate structure: Decision-makers must identify both the desired program outcomes and secondary impacts they wish to either promote or avoid. Raising revenue is a primary goal for any RUC rate structure, but it is also essential to clearly identify and prioritize the economic, environmental, equity, and other outcomes to be advanced by the RUC. The challenge is to identify rate structures that are feasible and desirable from *multiple* policy and feasibility dimensions.

Avoid a flat-rate rate structure, which would be a step backward for many of California's most important policy goals. While a flat-rate structure could raise adequate revenue, it would also stimulate driving choices that run directly counter to state priorities such as reducing road maintenance costs and vehicle emissions. A flat-rate RUC will perform worse on these dimensions than the current motor fuel taxes.

Look for RUC rate structures that account for the multiple costs imposed by travel. Such structures will raise revenue, lower transportation, environmental, and economic costs, and advance state goals and priorities. The potential benefits of these multi-part rate structures include:

- *Proactively advancing California's economic, environmental, and equity goals:* The economic signals sent to drivers would incentivize behaviors that support these goals.

- *Simplifying transportation taxes and fees:* A multi-component RUC rate structure could effectively replace not only fuel taxes but other fees such as annual registration fees on heavy vehicles.

- *Increasing political acceptability:* Polling evidence suggests that some multi-criteria rate structures may be as acceptable to the public as flat rates, or possibly even preferred. Also, the public and stakeholder groups may be more tolerant of perceived drawbacks to the RUC if the program replaces a complex web of existing fees and taxes with one single charge.

Conduct a new Highway-Cost Allocation (HCA) Study for California. HCA studies are technical assessments of whether various classes of road users are paying more or less in road-user taxes and fees than the costs they impose. Early studies focused exclusively on road system wear and tear, but over time they have broadened to include contributions to air pollution, climate change, noise, safety, congestion, and so on. A comprehensive HCA study will provide decision-makers with important information on how various potential RUC rate structures would fairly and reasonably charge various road users in proportion to the costs imposed.

Don't forget fuel taxes: RUCs will be closely intertwined with them for the foreseeable future. We have intentionally focused on RUC rate structures in this report without comparing them to fuel taxes in order to make clear the trade-offs among different rate structures. However, it is worth noting that an appropriate rate structure for a RUC must inevitably depend on what becomes of California's fuel taxes. Many public agency officials in the state report aspiring to an end to internal combustion engine driving, which would end the fuel tax as well. That outcome, however, is a long-term one, as it will likely take decades after ending the sale of new internal combustion vehicles for (nearly) all of these vehicles to cycle out of the fleet. Indeed, how swiftly Californians transition away from internal combustion engine vehicles will depend at least in part on whether and when the state changes existing fuel tax policy. This is because taxing gasoline is likely to accelerate the transition to electric driving, while not taxing it will, at the margin, discourage the adoption of zero-emission vehicles. Thus, policymakers will need to consider how the fuel tax and the RUC interact.

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