WA RUC

Road Usage Charge Financial Model

July 2022

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Glossary

Definitions of terms and abbreviations specific to the pilot project are as follows:

TERM	DEFINITION
AV	Autonomous Vehicles
BNEF	Bloomberg New Energy Finance
DOL	Department of Licensing
EIA	Energy Information Administration
Gas Tax	Motor Fuel Tax
HPMS	Highway Performance Monitoring System
ICE	Internal Combustion Engine
IPUMS	Integrated Public Use Microdata
MaaS	Mobility as a Service
MPG	Miles Per Gallon
NHTS	National Household Travel Survey
OFM	Office of Financial Management
PHEV	Plug-in Hybrid Vehicle
Pilot Project	The terms 'pilot' and 'pilot project' refer to the Washington State Road Usage Charge pilot.
Pilot Participant	A pilot participant is an individual with a road-charge-liable vehicle who is recruited to participate in the Washington RUC pilot. Pilot participants are liable for the road usage charges incurred for their registered vehicles when they drive on a road network that consists of public, private, and out-of-state roads.
RUC	Road Usage Charge
UI	User Interface
U.S.	United States
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled
WA RUC	Washington Road Usage Charge
WFH	Work From Home

Executive Summary

In 2012, the Washington Legislature instructed the Washington State Transportation Commission (WSTC) to determine the feasibility of transitioning from the gas tax to a Road Usage Charge (RUC) system of paying for transportation. Additionally, the Legislature directed the formation of a blue-ribbon panel of public and private sector stakeholders called the Washington RUC (WA RUC) Steering Committee to assist in the design and testing of RUC in Washington. As a follow-up to the WSTC's earlier work, the "Forward Drive" research project began in October 2020. This document summarizes one task of the Forward Drive research project, which was to update the existing revenue estimation model, study various future transportation energy scenarios and provide estimates of near and longer-term RUC revenue in the State of Washington for the years 2030, 2040, and 2050.

This effort involved the development of a methodology and analytical tool for the estimation of long and short-term revenue to replace the fuel tax which is expected to decline because of changes in the vehicles fuel efficiency as well as emergence of electric vehicles. The scope of this analysis is limited to passenger cars and light trucks and excludes heavy commercial vehicles, as heavy commercial vehicles are not part of the RUC research in Washington.

Factors that have been included in this analysis include:

- Baseline VMT forecast from multiple sources
- Changes in telecommuting trends due to COVID-19
- Reduction in certain types of trips due to e-commerce
- Potential impact of another pandemic
- Level of electrification of vehicle fleet
- Vehicle fleet composition of the State of Washington
- Emergence of autonomous vehicles (AVs) and shared ride

Developing policy alternatives for RUC using the above factors involves numerous uncertainties. Several potential factors contribute to the revenue forecasts—some that are dependent upon each other and some that are not clearly defined. When uncertainties exist and an absolute forecast is not appropriate, depiction of a single state of the future is generally not realistic or helpful. The concept of "Scenario Planning" is helpful in such situations because it builds upon multiple "futures" while providing a better understanding of the implications and/or paths that lead to those future states. In the case of this study, the scenario planning approach was applied by developing multiple combinations of the above factors in the form of scenarios discussed later in this document. **Figure ES-1** shows the schematic representation of the above-described concepts of scenario planning.

As shown in **Figure ES-1**, the traditional planning techniques involve specific "point forecasts" related to key elements of the study. This type of approach is generally adopted in long-range transportation planning which relies on forecasts of population, employment, and other demographic variables. The other type of planning approach, which is called "Risk Analysis", generally involves the development of ranges of outcomes. The scenario planning process looks at multiple depictions of future with the goal of finding the most suitable path to handle any potential state of future.

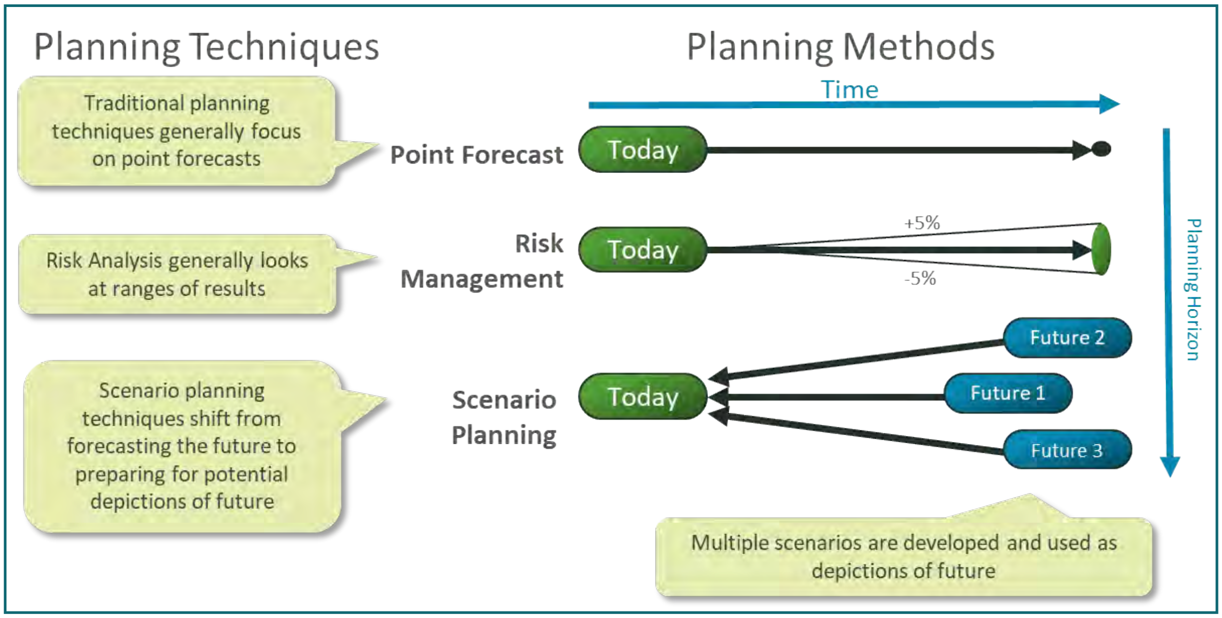


Figure ES-1 Comparison of Various Planning Processes

The other major task in this study was the development of an updated financial model. The model was developed using available datasets pertaining to the factors mentioned above. Further details of various datasets, their sources and processing are provided later in this document. The general analytical approach is shown in **Figure ES-2**. The overall analytical approach begins with VMT forecasts corresponding to a specific scenario. The total VMT is first adjusted to only include passenger vehicles and light trucks, as heavy commercial vehicles are not part of the RUC research in Washington. VMT is further adjusted for several other factors, such as potential effects of telecommuting and e-commerce (described later in this chapter). Electrification and vehicle automation effects are applied based on aggregate forecasts and assumptions corresponding to scenarios. VMT is then disaggregated by fuel efficiency and fleet age, and a forecast is developed for cars and light trucks. Various policy choices, such as RUC rates and transition strategies, are then applied to the VMT to determine gross revenue, which is subjected to adjustment for cost of collection to provide estimates of net revenue for 2020 through 2050.

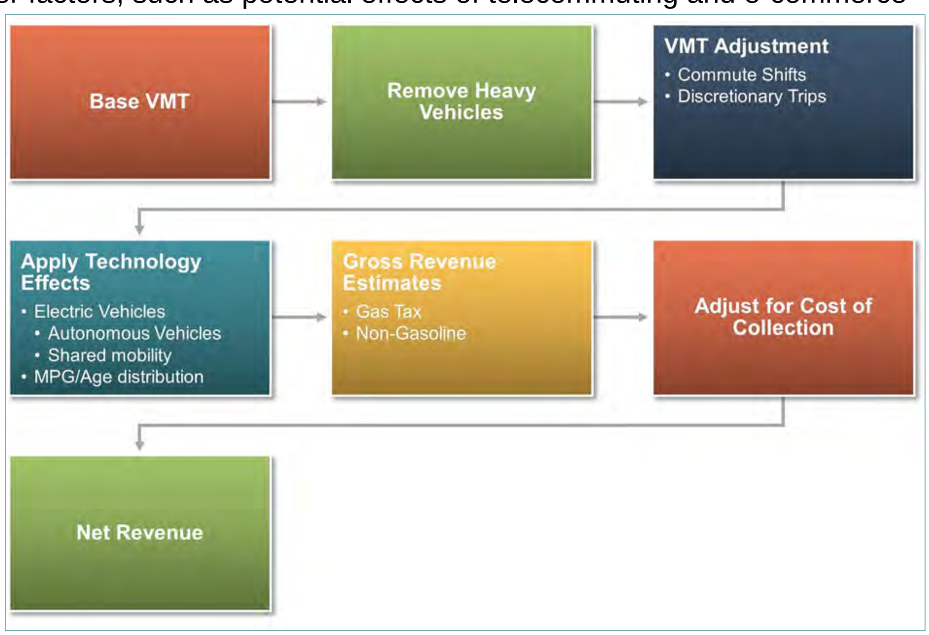


Figure ES-2 Overall Analytical Approach

The model development process involved using the previously described datasets to develop a spreadsheet-based analytical model that could integrate the datasets in an internally consistent manner and allow the user to analyze different combinations of input assumptions. Several datasets were processed and integrated within the model. Details of the process are provided in subsequent chapters of this document. A list of some data types and their corresponding sources are as follows:

- Vehicle Miles Traveled:
  - Washington State Office of Financial Management (OFM)
  - Federal Highway Administration, Highway Performance Monitoring System (HPMS)
  - U.S. Energy Information Administration (EIA)
- Commute Patterns and Occupations:
  - Integrated Public Use Microdata (IPUMS)
  - U.S. Census Bureau, National Household Travel Survey (NHTS)
- Energy/Fuel Consumption and Electrification:
  - U.S. Energy Information Administration (US EIA)
  - Bloomberg New Energy Finance (BNEF)
- Vehicle Fleet and Fuel Efficiency:
  - Washington State Department of Licensing (DOL)

Another concurrent task was the development of scenarios to be analyzed using the updated financial model. Scenario development was based on the following considerations:

- Scenarios cannot be defined in ‘isolation’ using only a single factor (e.g., ‘Low Economic Growth’).
- Analyzing all possible combinations of the factors is not practical.
- Define a ‘Baseline Scenario’ using appropriate factor ranges that could represent a normal continuation of life.
- Define scenarios that may cover a range of potential conditions, such as representing aggressive to moderate growth in various factors.
- Identify several ‘plausible’ combinations to develop a reasonable number of preliminary scenarios to analyze.

Based on the above approach, the following five scenarios were formulated:

- **Neutral:** Represents a continuation of ‘past’ (pre-pandemic) growth and passive technology adoption
- **Cruise Control:** Represents a ‘moderate’ increase in growth and a slightly faster AV technology adoption compared to Neutral
- **Overdrive:** Represents an ‘aggressive’ economic growth and high electrification and technology adoption
- **Shared Drive:** Variant of Overdrive, with increased adoption of shared mobility while still including aggressive growth
- **Low Gear:** Represents slow growth in electrification and vehicle autonomy

Figure ES-3 provides a ‘qualitative’ comparison of various scenarios in terms of low, medium, and high values of factors used for scenario definition.

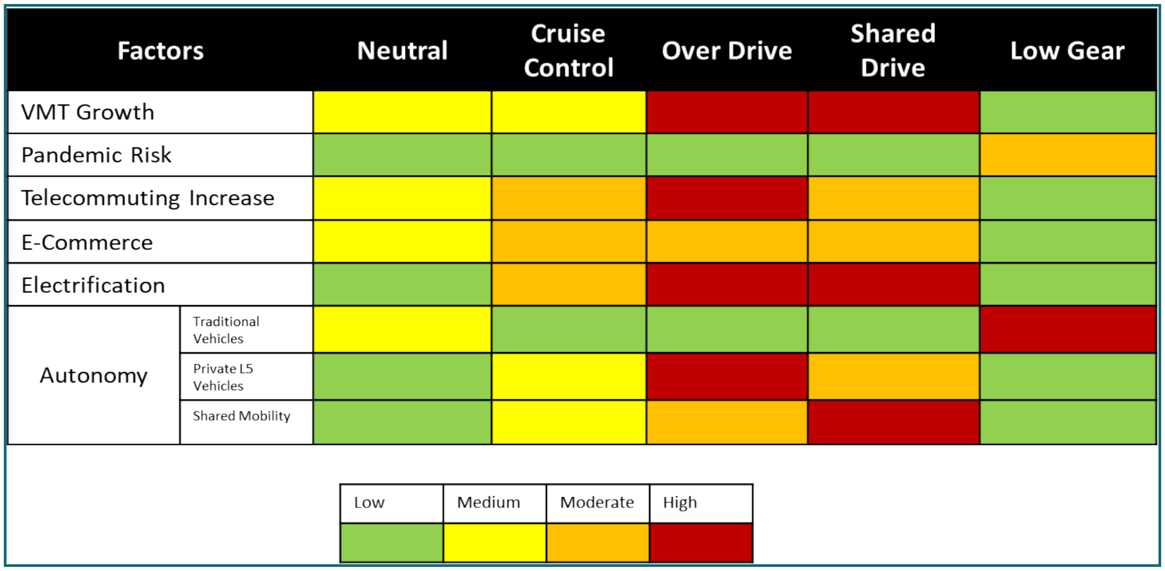


Figure ES-3 Qualitative Representation of Scenarios

The development of the financial model and scenarios was followed by using the model to analyze the scenarios. In addition to the spreadsheet, a User Interface (UI) was developed to support users’ interaction with the model. While the model itself is a self-contained spreadsheet, the use of the interface allows for quick setup of various scenarios or adjusting a scenario being analyzed. The UI is developed using Python programming language and does not require any additional licensing.

The UI is designed to work in conjunction with the model spreadsheet, which can also be used directly by experienced users. The results from any input method are reflected in the ‘Report’ and ‘Outputs’ tabs of the spreadsheet. **Figure ES-4** shows the UI and resulting ‘Report’ tab of the spreadsheet. **Figure ES-4** is only intended to illustrate the logical flow of information from the UI to the spreadsheet model. The report image is for illustrative purposes only.

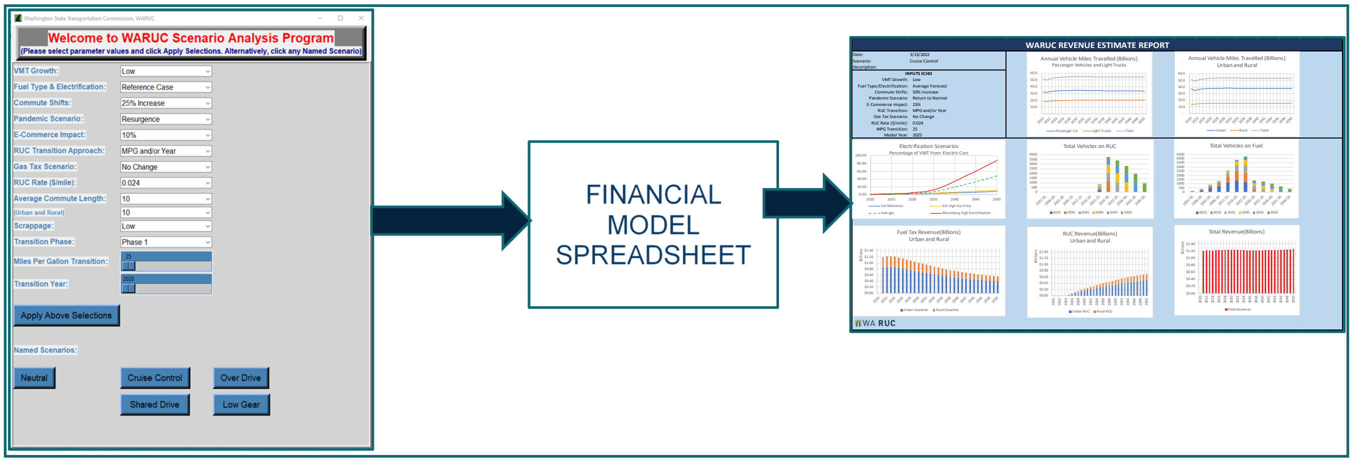


Figure ES-4 Overall Structure of the Financial Model

The financial model was then used to analyze the scenarios described above. One of the key elements of defining scenarios and then quantifying them was to better understand the sensitivity of RUC revenue against various factors mentioned earlier. Estimated revenue for various scenarios is summarized in **Figure ES-5**.

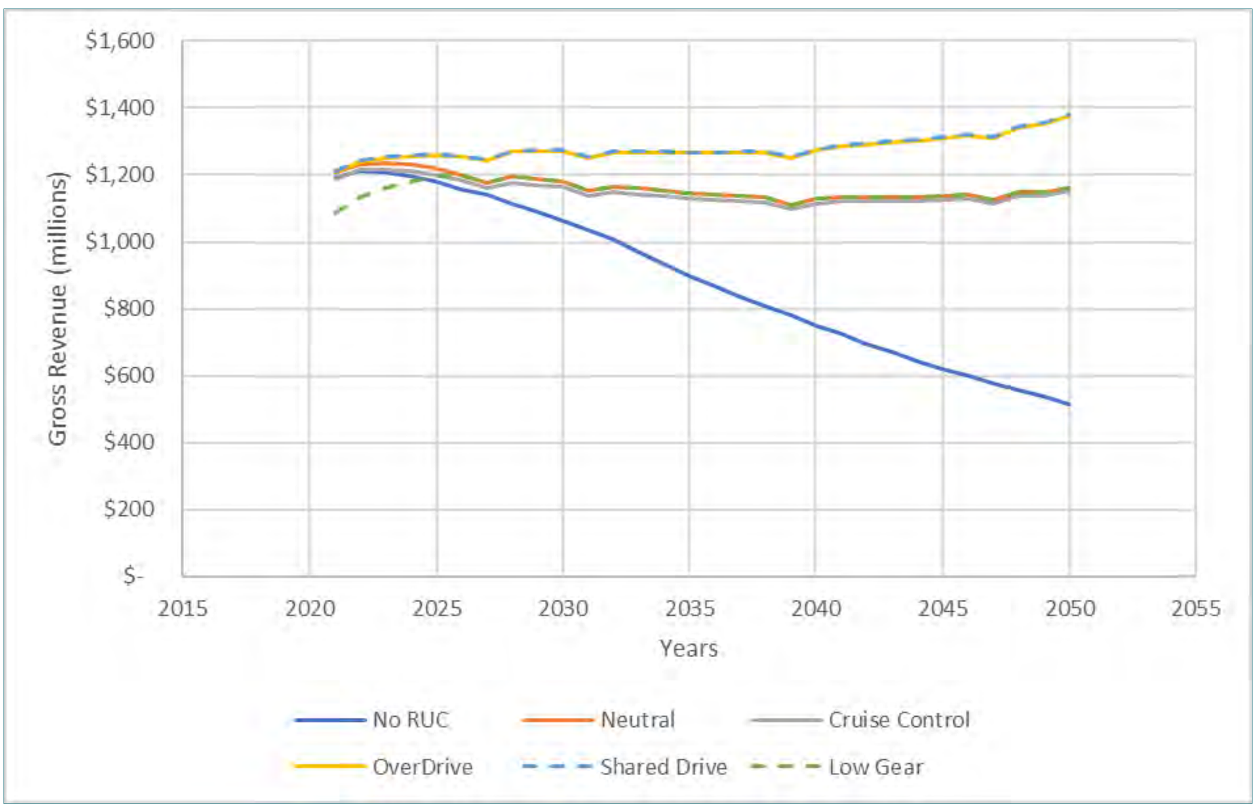


Figure ES-5 Gross Revenue by Scenarios (millions)

As shown in **Figure ES-5**, the "No RUC" scenario revenue continues to fall and is a testament to the importance of RUC to replace the gas tax revenue. The other hypothetical scenarios illustrate varying levels of revenue. On the higher end, the "OverDrive" and "Shared Drive" almost follow the same trajectory, which implies that the net effect of shared autonomous type services on the "big picture" will be relatively small. On the low side, the "Neutral" and "Low Gear" scenarios almost overlap except for the first few years showing a downturn of revenue in case of another pandemic. The "Cruise Control" revenue is slightly below that of "Neutral", which indicates the "cautious" nature of this scenario.

The gross revenue was further adjusted based on the estimated cost of revenue collection to determine the net revenue for each scenario. **Figure ES-6** provides a graphical summary of net revenue for the RUC scenarios.

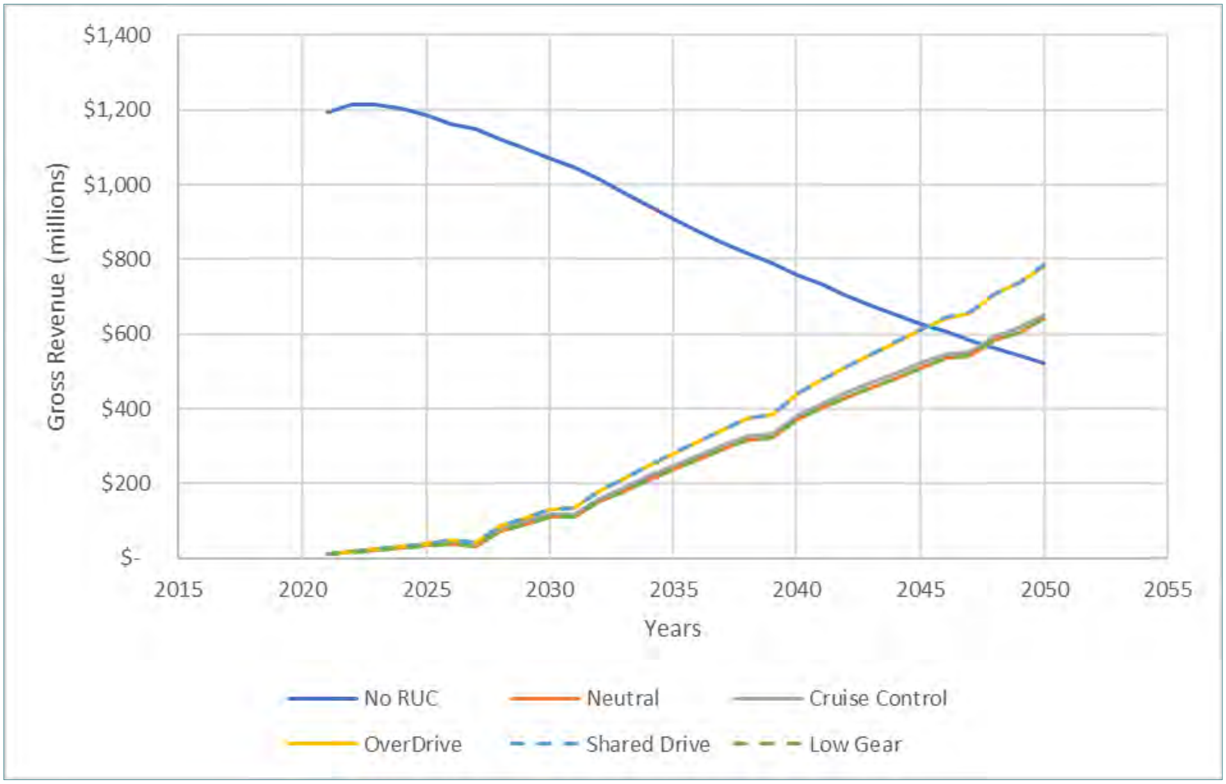


Figure ES-6 Net Road Usage Charge Revenue by Scenarios (millions)

The analysis of multiple scenarios and the results based on the tool developed for this study suggests that the tool can be used to further analyze these or other scenarios and the model shows intuitive response to scenario-specific assumptions.

1.0 INTRODUCTION AND BACKGROUND

1.1 History of Road Usage Charge in Washington

In 2012, the Washington Legislature instructed the Washington State Transportation Commission (WSTC) to determine the feasibility of transitioning from the gas tax to a Road Usage Charge (RUC) system of paying for transportation. Additionally, the Legislature directed the formation of a blue-ribbon panel of public and private sector stakeholders called the Washington RUC (WA RUC) Steering Committee to assist in the design and testing of RUC in Washington. Over the ensuing seven years, an in-depth analysis and year-long pilot project was developed, which launched in 2018. More than 2,000 drivers from across the state, and a small pool from neighboring states, volunteered to participate in the RUC pilot project. Test-driving concluded in January 2019 with more than 15-million miles reported. Findings and policy recommendations from this initial process were published in January 2020 as the *Washington State: Road Usage Charge Assessment – Final Report*.

1.2 Forward Drive Research

The Forward Drive research project began in October 2020 as a follow-up to the WSTC's earlier work, based on legislative direction to continue researching and developing solutions to various unaddressed issues. One task of the Forward Drive research project was to update prior financial analysis of RUC in Washington. The goals were to (1) develop a tool that assesses how a RUC system would perform as a long-term revenue source, (2) tests mileage reporting methods, and (3) analyze the impact of a RUC from a social equity standpoint. The research needed to accomplish these goals comprises five primary activities: new mobility and RUC; equity analysis; updated mileage reporting methods; administrative cost reduction; and testing, analysis, and reporting of implementation alternatives. The current document covers the work performed as part of the new mobility and RUC research with the goal of development of a tool for the revenue analysis of RUC.

1.3 Prior Studies

Formal analysis of RUC in Washington began in December 2012 subsequent to the following four studies that analyzed long-term transportation funding needs in Washington State:

- Long-Term Transportation Financing Study (2007)
- Implementing Alternative Transportation Funding Methods (2009)
- Washington Transportation Plan (2010)
- Connecting Washington (2012)

The 2012 Regular Session of the 62nd Legislature passed a Supplemental Transportation Budget that funded the WSTC to determine the feasibility of transitioning from the gas tax to a RUC system of paying for transportation. This initial work focused on the feasibility of such a program based on specific criteria, initial policy evaluation and research, initial public attitude assessment, and development of a work plan. The Steering Committee unanimously concluded that a RUC is feasible and recommended it for further study. Work has since proceeded in three phases: Phase I – Initial Assessment and Concept Development (2012–2015), Phase II – Pilot Testing and Policy Issues Analysis (2016–2020), and Phase III – System Readiness and Continued Research (2021–Present).

1.3.1 Phase I: Initial Assessment and Concept Development (2012–2015)

During the course of Phase I, the WSTC and Steering Committee investigated the feasibility of a RUC to replace the gas tax and discussed its operational and financial implications. The analysis of this period was organized into five groupings:

- Group 1: Conduct public outreach, engagement, and education that measures public perspectives, gathers input, and provides information.
- Group 2: Define the policy frameworks and narrow the objectives of a potential RUC system.
- Group 3: Establish operational concepts that achieve the policy objectives.
- Group 4: Conduct initial investigations into system design alternatives to carry out the operational concepts, leaving details for Phase II.
- Group 5: Develop initial business analyses that evaluate costs, risks, transition issues, and interoperability of RUC, with detailed development in Phase II.

Phase I concluded with developing a business case that tested the viability of adopting a RUC under a range of forecasts and operational scenarios. The business case investigated three operational concepts: time permit, odometer charge, and differentiated distance charge. The Steering Committee determined that the business case for road usage charging was affirmed as a long-term gas tax replacement and that all three operational concepts should proceed for further study. The WSTC found continued value in further refining operational concepts and policies to better prepare for eventual implementation. Pursuant to this objective, pilot alternatives were developed, and federal funding was secured to conduct the pilot.

1.3.2 Phase II: Pilot Testing and Policy Issue Analysis (2016–2020)

In mid-2016, the U.S. Department of Transportation awarded a $3.5 million Surface Transportation System Funding Alternatives grant to Washington to conduct a 2,000-vehicle statewide, live pilot test of a RUC system. The pilot sought to explore the geographic issues and the interoperability of a RUC system between Washington and Oregon and internationally with British Columbia. Two-hundred vehicles were recruited from British Columbia, 20 vehicles from the State of Oregon RUC program (OReGO), and seven drivers from Oregon. Washington participants were recruited from five geographic areas: Central Puget Sound, Eastern Washington, Northwest Washington, South-Central Washington, and Southwest Washington. The pilot tested interoperability issues and travel patterns across the three jurisdictions through the three reporting methods identified in prior work for further study: Mileage Permit, Odometer Charge, and Automated Distance Charge with Mileage Meter. Furthermore, the pilot assessed how the RUC compares to Washington’s (then) $150 annual registration surcharge for electric vehicles in terms of preferability from a funding standpoint and whether a RUC would impair consumers’ rate of adoption of EVs in Washington State. The initial grant covered all Stage 1 aspects of the pilot testing program (pilot preparation and setup activities).

Following the success of Stage 1, Washington applied for and received an additional $4.6 million grant to fund State 2 – Live Pilot Test, and Stage 3 – Evaluation. The WA RUC Live Pilot was conducted from January 2018 through January 2019, following an extensive outreach and end-to-end testing of the proposed RUC prototype. In addition to the geographical considerations, the pilot sought to (1) gauge motorists’ reactions and preferences concerning a RUC charge, (2) measure and assess public acceptance factors, and (3) test the WA RUC prototype under live operating conditions.

The percentage of pilot participants by geographic area and percentage of overall miles driven in the pilot (both values rounded to the nearest whole percent) are shown in **Figure 3-1**.

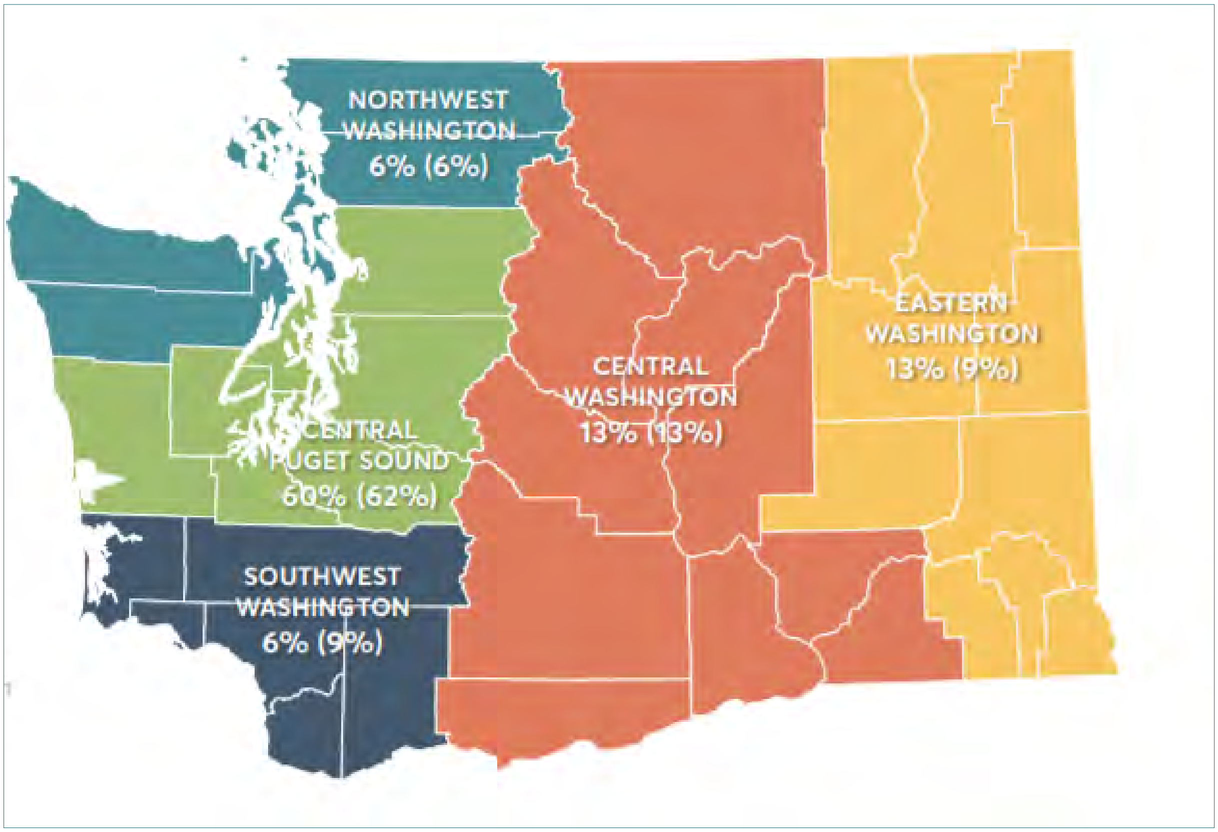


Figure 1-1 Pilot Participant Distribution and Population Distribution

After operating for a year across a range of demographics and geographies, user surveys indicated a strong increase in favor of a RUC-based system; 68 percent of participants preferred it over the existing gas tax or equal to the gas tax, compared to 52 percent at the beginning of the pilot. Only 19 percent preferred the gas tax over RUC at the pilot's conclusion while undecided participants decreased from 28 to 8 percent. The pilot identified five critical factors for public acceptance and areas of potential further study: privacy, simplicity, choice, transparency, and equity. Furthermore, the pilot did not fully determine if switching from the gas tax to a RUC would be worth the higher costs of collection at the same tax rate. Phase III, documented in the subsequent chapters of this report, provides further clarification regarding long-term revenue forecasts for the gas tax and the phasing-in of a RUC.

2.0 STUDY OBJECTIVES

2.1 Broad Objectives

Broad objectives of this study were to develop a framework and a tool for revenue estimation for the State of Washington based on a RUC program. Both short- and long-term RUC revenue would be estimated by incorporating future transportation energy and mobility scenarios. It is essential that the tool can address possible combinations of factors that impact road travel; these factors include, but are not limited to, vehicle miles travelled (VMT), telecommuting trends, and electric vehicles emergence as well as connected and autonomous vehicle (AV) deployment forecasts paired with a range of revenue collection methods.

2.2 Major Tasks

2.2.1 Financial Model Update

An important component of the revenue forecasting tool was an update of the 2015 Washington RUC financial model. Telecommuting, especially during the COVID-19 pandemic, is an important consideration factor, as is the inclusion of e-commerce effects on overall travel. Another element was to estimate operational costs based on different mileage reporting methods.

2.2.2 Scenario Development and Analysis

Rather than relying on fixed forecasts, this study developed unique scenarios with varying combinations of multiple factors. These scenarios involved both urban and rural contexts to reflect the differences in vehicle fleets and miles traveled by passenger vehicles and light-duty trucks. Urban and rural distinctions were similarly made to reflect potential commute shifts and the increase in work-from-home (WFH) rates, attributable to the COVID-19 pandemic. Several data sources were used for developing the VMT forecast scenarios.

2.2.3 Revenue Estimates

For each scenario developed, the revenue estimates included RUC revenue as well as estimated state motor vehicle fuel tax revenue. An estimation of base case without a RUC implementation was also incorporated into the model to aid decision-makers in conducting trade-off analysis.

The financial model was used to analyze several scenarios using a range of temporal assumptions in terms of RUC implementation. Some of these assumptions include vehicle model year, vehicles fuel efficiency changes over time, and charging models based on fuel-efficiency. Fuel tax revenues collected was calculated based upon the miles traveled by vehicle not participating in RUC and the fleets average fuel economy. Further details of these analyses are provided in subsequent chapters of this document.

2.2.4 User Guide, Technical Memorandum, and Virtual Presentation

In addition to the financial analysis model and tool, the following deliverables were also prepared:

- Technical memorandum (in narrative format with graphics) covering the scenario generation process, scenarios developed, inputs, assumptions, outputs, findings, and conclusions.
- User Guide for RUC financial model (for WSTC staff) documenting inputs, outputs, assumptions, and instructions.
- PowerPoint presentations (slide decks) summarizing scenario generation process, scenarios developed, outputs, findings, and conclusions.

3.0 SCENARIO PLANNING

3.1 Scenario Planning Rationale

Developing policy alternatives for a RUC involves numerous uncertainties. Several potential factors contribute to the revenue forecasts—some that are dependent upon each other and some that are not clearly defined (e.g., external factors). For example, an increase in telecommuting trends has the potential to reduce VMT, while an increase in autonomous vehicles (AV) will likely increase VMT as a result of accrued miles between destinations and pickup/drop-off locations; additionally, the number of trips may increase because passengers experience congestion less negatively than drivers. When several uncertainties exist and an absolute forecast is not appropriate, depiction of a single 'state' of the future is generally not realistic or helpful. The concept of 'scenario planning' is helpful because it generates multiple 'futures' while providing a better understanding of the implications and/or paths that lead to those future states.

3.2 Scenario Planning vs. Traditional Planning

The scenario planning approach is to gather information about the factors that could potentially impact the future and then develop various plausible combinations thereof. While the traditional planning process focuses on generating a single prediction of the future, the scenario planning process focuses on preparing for what the future *might* entail. Scenario planning helps decision-makers to reduce uncertainty, broaden their perspectives, and increase flexibility in the decision-making process. A comparison between traditional (forecast-based) decision-making and scenario-based decision-making is provided in **Table 3-1**:

Table 3-1 Scenario-Based Decision Planning

	TRADITIONAL PLANNING	SCENARIO PLANNING
What is identified?	One future world	Several varying but plausible worlds
Can we influence the future?	The future is used as a target	The future worlds are identified independently
How is the world described	The future is described as a series of variables	Each world is described as a story
How are decisions made?	Choose decisions that give highest expected utility	Choose strategic decision that is a winner in all scenarios, or is robust across them

As shown in **Table 3-1**, the traditional planning process generally assumes a point forecast that implies a single state of the world, while the scenario planning approach aims to develop several plausible worlds that are assumed to have equal probability of occurrence. The ability to influence the future is implied in the traditional planning process by treating the future as a target (e.g., population and employment reaching a certain level). The scenario planning process does not imply our ability to influence the future by independently identifying different states of the future. In traditional planning, the future is generally defined as a series of variables, while in scenario planning, the futures are defined as stories (e.g., 'a world with most people working remotely'). Finally, the process of choosing a deci sion is generally based on the 'utility' of the choice, while in scenario planning, the choice of final decision is based on selecting an approach that best manages all scenarios and is robust enough to handle the uncertainties.

Figure 3-1 provides an infographic comparison of various planning processes.

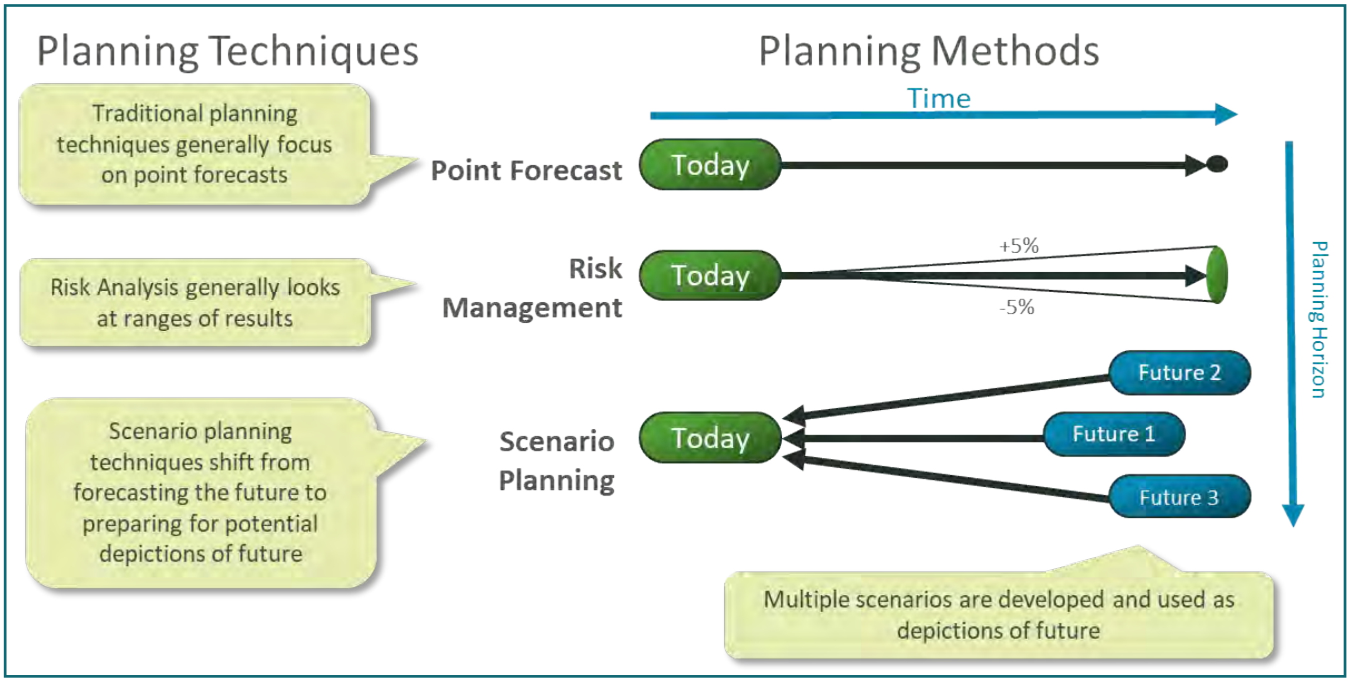


Figure 3-1 Comparison of Various Planning Processes

3.3 Scenario Planning Application to Washington Road Usage Charge

Telecommute pattern estimation, EV adoption, and force majeure event evaluation are highly uncertain factors that warrant the use of scenario planning instead of a single depiction of future. Therefore, the scenario planning approach provides more flexibility to respond to a broader array of potential future outcomes. It was necessary to develop a tool that could analyze a virtually limitless number of scenarios while specifically focusing on the few scenarios identified through a 'scenario development process,' as explained in subsequent chapters of this document.

4.0 ANALYTICAL APPROACH

4.1 Overall Analytical Approach

The overall analytical approach begins with VMT forecasts corresponding to a specific scenario. The total VMT is first adjusted to only include passenger vehicles and light trucks, as heavy commercial vehicles are not part of the RUC research in Washington. VMT is further adjusted for several other factors, such as potential effects of telecommuting and e-commerce (described later in this chapter). Electrification and vehicle automation effects are applied based on aggregate forecasts and assumptions corresponding to scenarios. VMT is then disaggregated by fuel efficiency and fleet age, and a forecast is developed for cars and light trucks. Various policy choices, such as RUC rates and transition strategies, are then applied to the VMT to determine gross revenue, which is subjected to adjustment for cost of collection to provide estimates of net revenue for 2020 through 2050. **Figure 4-1** provides a graphical depiction of the revenue forecasting process.

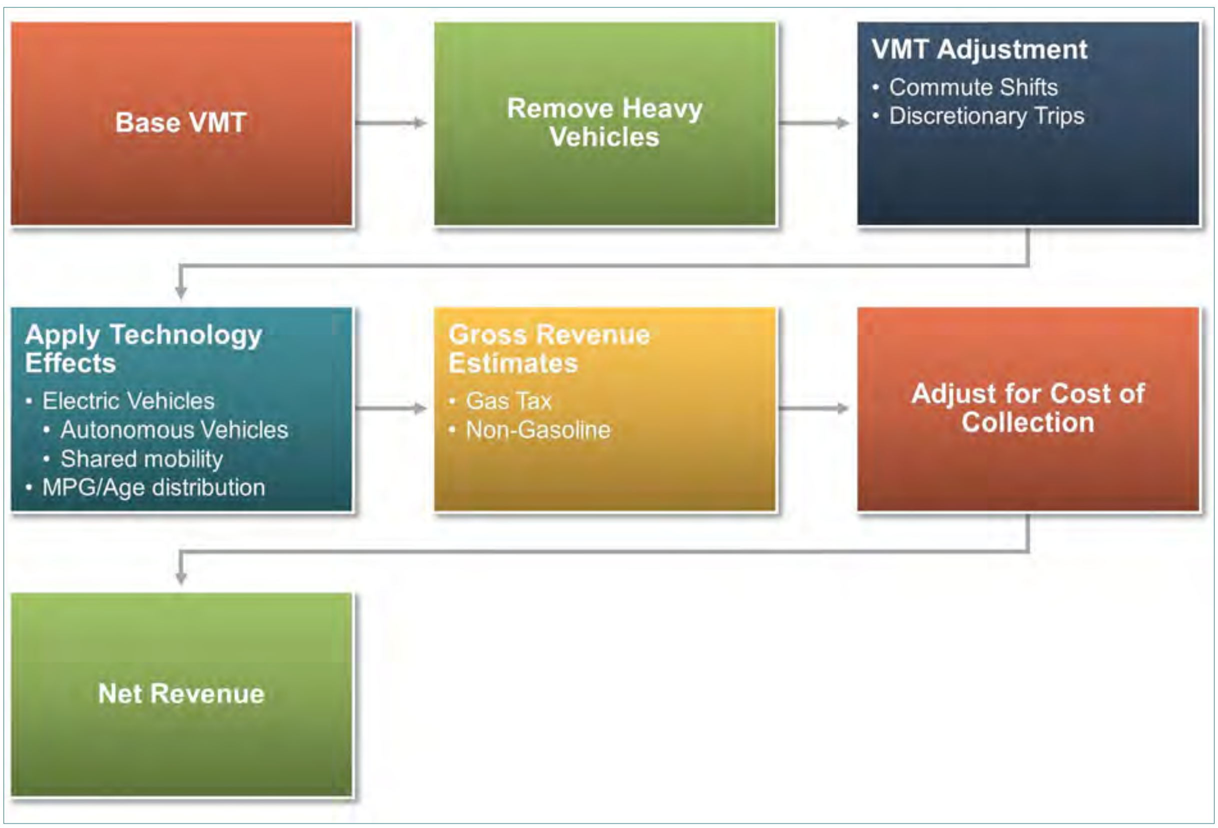


Figure 4-1 Overall Analytical Approach of Revenue Forecasting

4.2 Major Assumptions

Some assumptions were made to simplify the analytical process:

- **VMT Growth.** Factors such as socioeconomic growth will continue to impact the overall VMT growth. However, certain trends, especially those resulting from the COVID-19 pandemic, will impact traffic levels—the most significant trend is telecommuting. Industries and occupations that are more suitable for telecommuting will be the main contributors toward increased telecommuting and reduced travel for the foreseeable future.

- **Electrification.** Rural adoption of electric vehicles and full AV will lag by approximately 5 years, as compared to the corresponding urban adoption.
- **Financial Assumptions.** Financial models involve many assumptions related to inflation, discount rate, user costs to purchase mileage reporting devices, and back-office costs involved in revenue collection; such cost elements are summarized in **Table 4-1**.

Table 4-1 Assumed Cost Values

COST CATEGORY	VALUE
Inflation based on 2019 CPI (% per year)	1.4%
30-year nominal discount rate (% per year)	3.1%
Device comms paid by state (% of total cost)	100%
Percentage of nonpayment/underpayment recovered by collections	37%
Collections cost for slow pay/bad debt	16%
Credit card merchant fee – flat	$0.10
Debit card merchant fee – flat	$ 0.10
EFT flat fee per transaction	$0.01
Credit card merchant fee – %	1.55%
Debit card merchant fee – %	0.80%
IT equipment acquisition (if new)	$10,000,000
IT equipment acquisition (if integrated)	$5,000,000
IT software acquisition	$20,000,000
Software licenses (annual cost)	$100,000
Hours per FTE	2000
Staff per manager, audit division	10
Staff per manager, account management division	20
Managers per office assistant	3
Manager annual salary	$100,000
Program manager annual salary	$150,000
IT maintenance per year as a percentage of capital costs	10%
IT major maintenance as a percentage of capital costs	70%
Frequency of major maintenance in years	8
Audit materials cost per audit	$1.50
Burden rate	1.7%
Outreach/education per new account	$1.00
Outreach/education per existing account	$0.50

4.3 Sources of Data/Information

Primary data types and their corresponding sources of information are as follows:

- Vehicle Miles Travelled:
  - Washington State Office of Financial Management (OFM)
  - Federal Highway Administration, Highway Performance Monitoring System (HPMS)
  - U.S. Energy Information Administration (EIA)
- Commute Patterns and Occupations:
  - Integrated Public Use Microdata (IPUMS)
  - U.S. Census Bureau, National Household Travel Survey (NHTS)
- Energy/Fuel Consumption and Electrification:
  - U.S. EIA
  - Bloomberg New Energy Finance (BNEF)
- Vehicle Fleet and Fuel Efficiency:
  - Washington State Department of Licensing (DOL)

Details of application and use of the aforementioned datasets is provided in the subsequent paragraphs.

4.4 Data Analysis

This chapter briefly explains how data from various sources were processed and used in the analysis as inputs. The explanation is followed by details pertaining to the financial model development (which provides the connection between various datasets).

4.4.1 VMT Forecast

The Transportation Forecast Revenue Council adopted the September 2021 Transportation Economic and Revenue Forecasts for 2020–2043 to serve as the baseline for a Medium VMT forecast within the model. Data was extrapolated through the Year 2050, based on a 5-year rolling average of existing trends. High and Low VMT scenarios were developed based on EIA's *Annual Energy Outlook 2021, (*Table 41: Light-Duty Vehicle Miles Traveled by Technology Type*).* The ratio of miles within Low and High economic growth scenarios was calculated on an annual basis relative to the Reference Case. These ratios were then multiplied by the Transportation Forecast Revenue Council's adopted forecast to calculate High and Low VMT forecasts.

Table 4-2 Summarizes various annual VMT forecasts as described above.

Table 4-2 Annual Vehicle Miles Traveled Forecasts

YEAR	LOW	MEDIUM	HIGH
2021	149,754	156,726	155,531
2022	55,889	159,929	162,930
2023	159,269	162,696	167,487
2024	161,555	164,693	171,375
2025	163,156	166,512	175,032
2026	163,703	168,290	177,411
2027	164,237	169,838	179,583
2028	164,761	171,085	181,562
2029	165,074	172,164	183,124
2030	165,451	173,175	184,588
2031	165,377	174,258	185,492
2032	165,371	175,463	186,182
2033	165,140	176,775	186,804
2034	164,854	177,104	187,386
2035	164,610	177,397	187,918
2036	164,396	177,701	188,428
2037	164,183	177,923	188,892
2038	163,954	178,066	189,357
2039	163,737	178,167	189,780
2040	163,614	178,274	190,263
2041	164,426	178,704	191,933
2042	164,074	178,855	192,267
2043	163,966	179,584	192,776
2044	163,455	179,587	192,702
2045	163,554	179,931	193,305
2046	163,637	180,324	194,159
2047	163,532	180,710	194,971
2048	163,524	181,146	195,918
2049	163,473	181,521	196,944
2050	163,452	181,910	198,199

Sources: The Transportation Forecast Revenue Council's adopted September 2021 Transportation Economic and Revenue Forecasts for 2020–2043. Volume III, Washington State Department of Transportation Alternative Vehicle Miles Traveled Forecasts. U.S. Energy Information Administration Annual Energy Outlook 2021, Table 41: Light Duty Vehicle Miles Traveled by Technology Type.

VMT was then split into urban and rural contexts, then into passenger vehicle and light truck classifications. Urban and rural splits were calculated for each functional class based on the 2020 HPMS Mileage and Daily Travel Summary*.* VMT is attributed to passenger vehicles and light trucks for each functional classification within urban and rural contexts (per HPMS urban and rural VMT distributions for the Years 2015–2019) (FHWA HPMS Table VM-4).

Table 4-3 Summarizes daily VMT for urban and rural areas with Washington.

Table 4-3 Urban and Rural Vehicle Miles Traveled Summary

2020 HPMS MILEAGE AND DAILY TRAVEL SUMMARY								
AREA TYPE	INTERSTATE	PRINCIPAL ARTERIAL FWY/EXP	OTHER PRINCIPAL ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL	TOTAL
Rural	11,589	4,616	6,067	5,635	8,787	2,674	2,963	42,331
Urban	27,805	13,967	23,689	18,840	8,120	385	11,470	104,277

Source: HPMS

4.4.2 Integrated Public Use Microdata Data

The Integrated Public Use Microdata Data (IPUMS) for Washington State was used as a basis for estimating potential impacts of changes in commuting patterns on overall travel. The IPUMS data, derived from the U.S. Census, provided the basis for calculating the implications of increasing WFH rates in both urban and rural areas. The process initially determined the proportion of working population who are most prone to telecommuting. This involved identifying job categories that had a relatively high WFH trend prior to the COVID-19 pandemic protocols. IPUMS organizes occupations into more than 350 classifications; for each classification it provides the location, commute mode, and WFH rates. Workers were split into urban and rural areas according to the urban and rural geographies defined in the *2020 HPMS Mileage and Daily Travel Summary* (which are based on census metro/micropolitan survey areas). Each job classification was flagged for a potential increase in WFH. For example, between software engineers and steelworkers, the software engineers have a higher WFH potential. Based on this occupational classification, the total number of employees in fields/industries with WFH growth potential in urban and rural contexts was calculated.

Figure 4-2 provides a graphical summary of the methodology previously described.

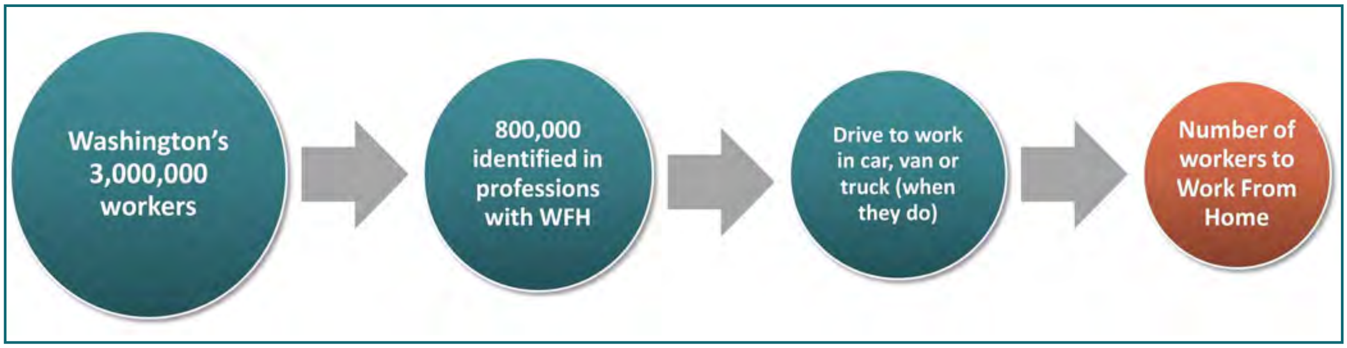


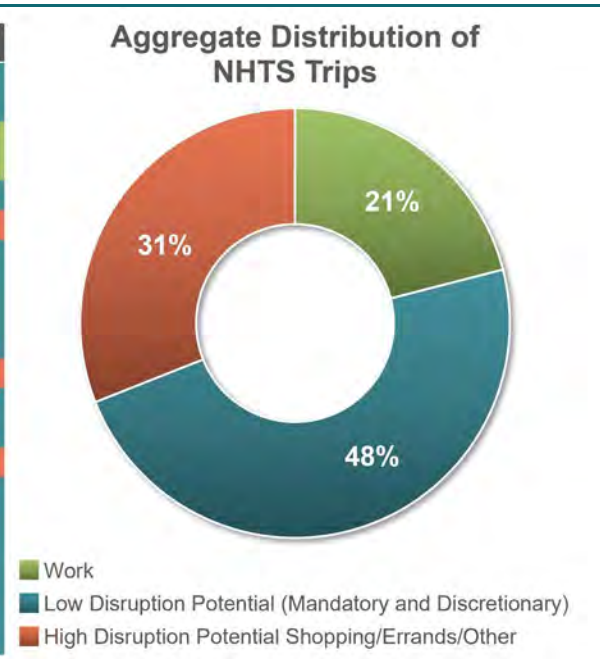
Figure 4-2 Work from Home Methodology

4.4.3 National Household Travel Survey Data

The 2017 NHTS data was utilized for two purposes. First, it enabled the disaggregation of VMT by broad purposes to isolate trips that may be disrupted by e-commerce or delivery services. Second, the average commute lengths derived from NHTS data were used to calculate VMT using the trips from the telecommute analysis. The statewide average commute length was calculated as 10 miles, which is the default length used for calculating the impact of increases in WFH on aggregate VMT.

Figure 4-3 provides a graphical summary of various aggregated trip purposes derived from NHTS data.

Trip Types/Purposes	Percentage
Regular home activities (chores, sleep)	4%
Work from home (paid)	0%
Work	18%
Work-related meeting / trip	3%
Volunteer activities (not paid)	1%
Drop off / pick up someone	15%
Change type of transportation	1%
Attend school as a student	1%
Attend child care	0%
Attend adult care	0%
Buy goods (groceries, clothes, appliances, gas)	14%
Buy services (dry cleaners, banking, service a car, pet care)	2%
Buy meals (go out for a meal, snack, carry-out)	10%
Other general errands (post office, library)	3%
Recreational activities (visit parks, movies, bars, museums)	9%
Exercise (go for a jog, walk, walk the dog, go to the gym)	8%
Visit friends or relatives	7%
Health care visit (medical, dental, therapy)	2%
Religious or other community activities	2%
Something else	1%



Note: Numbers may not add up due to rounding.

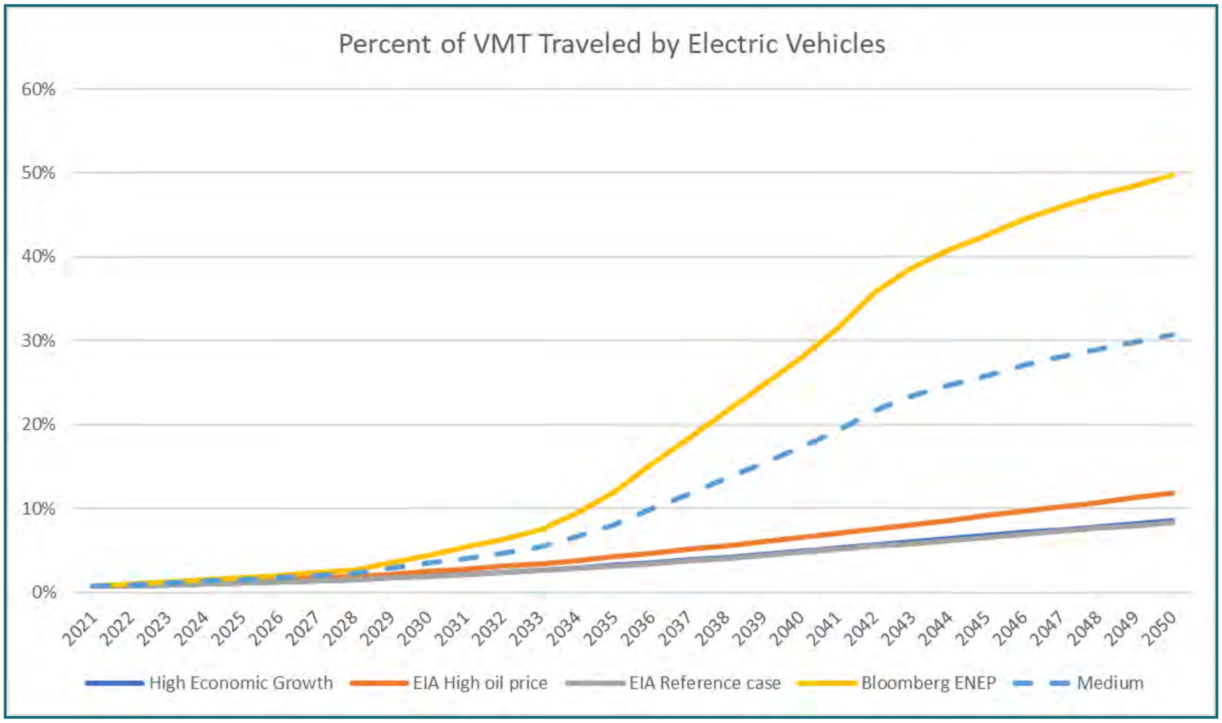
Figure 4-3 Aggregated Trip Purposes

4.4.4 Energy Information Administration Data

EIA data provided forecast information for the proportion of electric vehicles in the fleet and the fleet's fuel economy. EIA forecasts for Reference Case and High Oil price were employed from EIA Annual Energy Outlook 2021, per EIA Table 39: Light-Duty Vehicle Stock by Technology Type and Table 40:

Light-Duty Vehicle Miles per Gallon by Technology Type. A third forecast was calculated based on the average of these two forecasts. Furthermore, vehicle fleet fuel economy from High Oil Price was used to supplement the BNEF electric vehicle forecast. Light-Duty Vehicle Stock and Light-Duty Vehicle Miles per Gallon (MPG) were split into Car and Light-Truck classifications. Average fleet fuel economy and proportion of vehicle fleet by technology type were calculated exclusively on the following attributes: Internal Combustion Engine (ICE), Gasoline-Hybrid, and Electric. The proportions attributable to other technology types (i.e., hydrogen, diesel, diesel-hybrid) were not considered significant enough to be included in the forecast.

Figure 4-4 provides a summary of data obtained from the above sources and the resulting electrification forecast.



Sources: EIA Annual Energy Outlook 2021, Table 39: Light-Duty Vehicle Stock by Technology Type. EIA Annual Energy Outlook 2021, Table 40: Light-Duty Vehicle Miles per Gallon by Technology Type. Bloomberg's New Energy Forecast 2021.

Figure 4-4 Data Summary and the Resulting Electrification Forecast

4.4.5 Department of Licensing (DOL) Data

The Washington State DOL data established the existing fleet profile and basis for forecasting fleet composition by fuel efficiency in terms of MPG for passenger vehicles and light trucks. The data comprised more than 6.7-million records of vehicle identification numbers (VINs) for Washington State along with the geographic information by the census tract. Of the 6,760,697 registered vehicles in Washington, VINs for 6,007,782 were successfully decoded, thereby providing a coverage of 88.9 percent. This decoding provided vehicle classification (passenger vehicle or light truck) and model year. A separate algorithm was developed to determine combined city/highway fuel economy based on model year and vehicle classification. The combined output was detailed, with the number of registered vehicles by year, fuel economy, and classification. From this information, the standard deviation of fleet fuel economy was calculated for each year for passenger vehicles and light-duty trucks. Future fleet fuel economy standard deviation was estimated based on the historical standard deviation. Future number of vehicles—itemized by fuel economy, year, classification, and engine type—was then calculated using Washington's proportion of national vehicle sales. The calculated number was adjusted for higher adoption rates of EVs and Plug-in hybrid vehicles (PHEVs) in the EIA-based forecasts. Meanwhile, the Bloomberg NEF forecast used the OFM overall vehicle forecast, EIA's ratio of ICE to hybrids and PHEV to EVs—paired with scrappage scenarios and vehicle fleet composition forecasts—to estimate the total number of vehicles sold (itemized by vehicle classification and engine type in the State of Washington).

VMT tables were generated for passenger vehicles and light-duty trucks throughout the forecast period. These tables were utilized to model two transitions to RUC, based on vehicle model year and MPG (for ICE, hybrid, PHEV, and EV vehicles).

4.4.6 Urban/Rural Considerations

Analysis of the disparate impacts of a RUC charge on urban and rural contexts is a critical area of inquiry captured within this model:

1. HPMS data is used to capture the differences in rural and urban vehicle fleets. Light trucks with lower fuel economy travel a greater proportion of VMT in rural areas than urban areas, where cars make up a higher proportion of VMT.
2. Potential for increases in WFH was analyzed by using IPUMS data filtered by urban and rural geographies, as defined by Washington State Department of Transportation.
3. Finally, unique vehicle automation rates were used for urban and rural contexts.

4.5 Autonomous Vehicles

In addition to the electrification of vehicles fleet, the analysis and processing needed to incorporate the emergence of self-driven/AV was also undertaken. To quantify the effect of a fully AV on a typical household travel, three hypothetical cases were developed, which involved the following assumptions:

- Household with two workers, each commuting to their place of employment
- Additional trip needed for shopping and errands
- Places of employment were assumed to be 10 and 8 miles away
- Shopping location was assumed to be 7 miles away

With the above assumption, three cases/scenarios were visualized:

- Case 1: Each family member uses a separate gasoline vehicle
- Case 2: Single, Family-Owned Fully Autonomous Vehicle
- Case 3: Complete reliance on shared mobility, Mobility as a Service (MaaS)

4.5.1 Case I: Each Family Member uses a Separate Gasoline Vehicle

Under this assumption, each family member is assumed to use a separate gasoline vehicle for a round trip to work and a trip to the mall, as shown in **Figure 4-5**. This assumption is intended to represent a typical three-car household without any autonomous vehicle or shared ride usage. Given the scenario being represented, this results in a daily VMT of 50 miles.

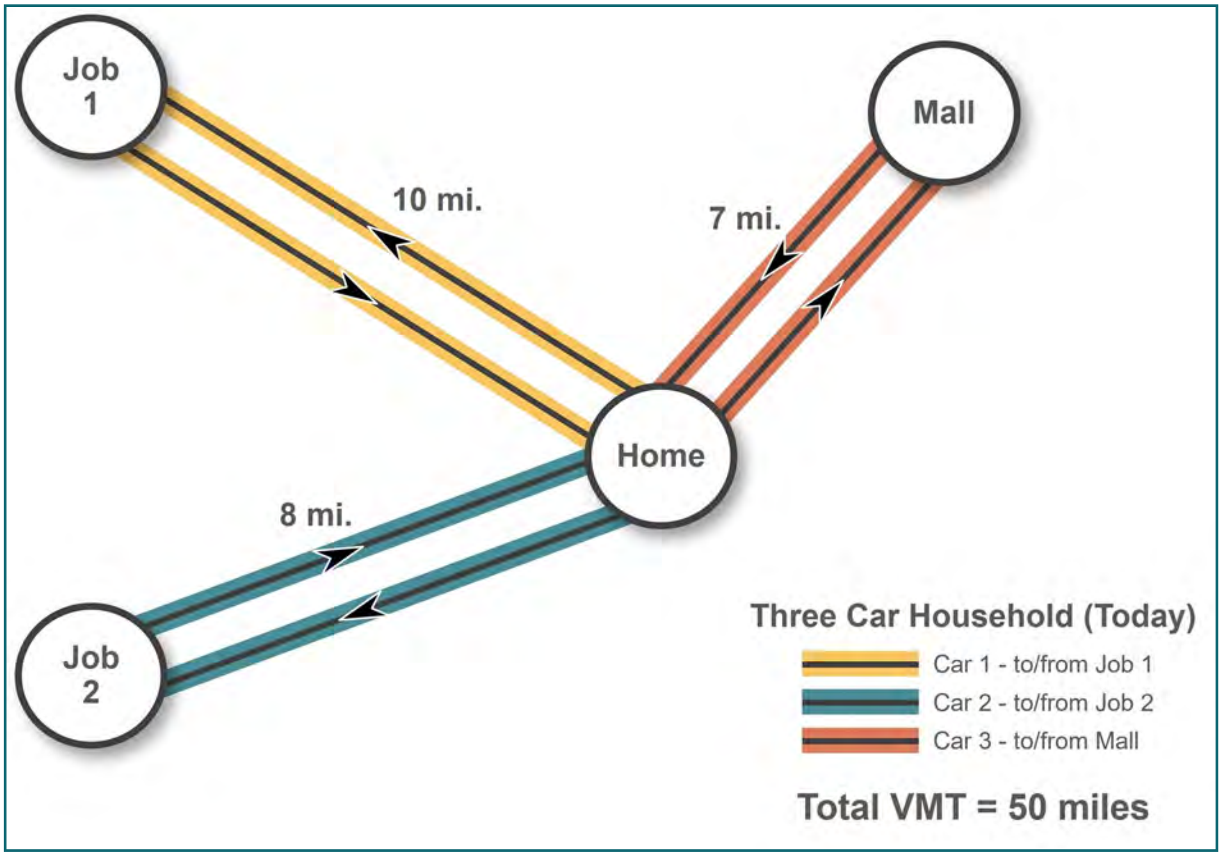


Figure 4-5 Three-Car Household of Today

4.5.2 Case II: Single, Family-Owned Fully Autonomous Vehicle

Under this assumption, the entire family is assumed to own and use a fully autonomous vehicle that makes round trips to both places of employment and a round trip to the mall. In the evening, the vehicle leaves to pick up both people from their place of work and then return them to their home, as shown in **Figure 4-6**. This results in a VMT of 75 miles, 50-percent increase over the traditional household VMT.

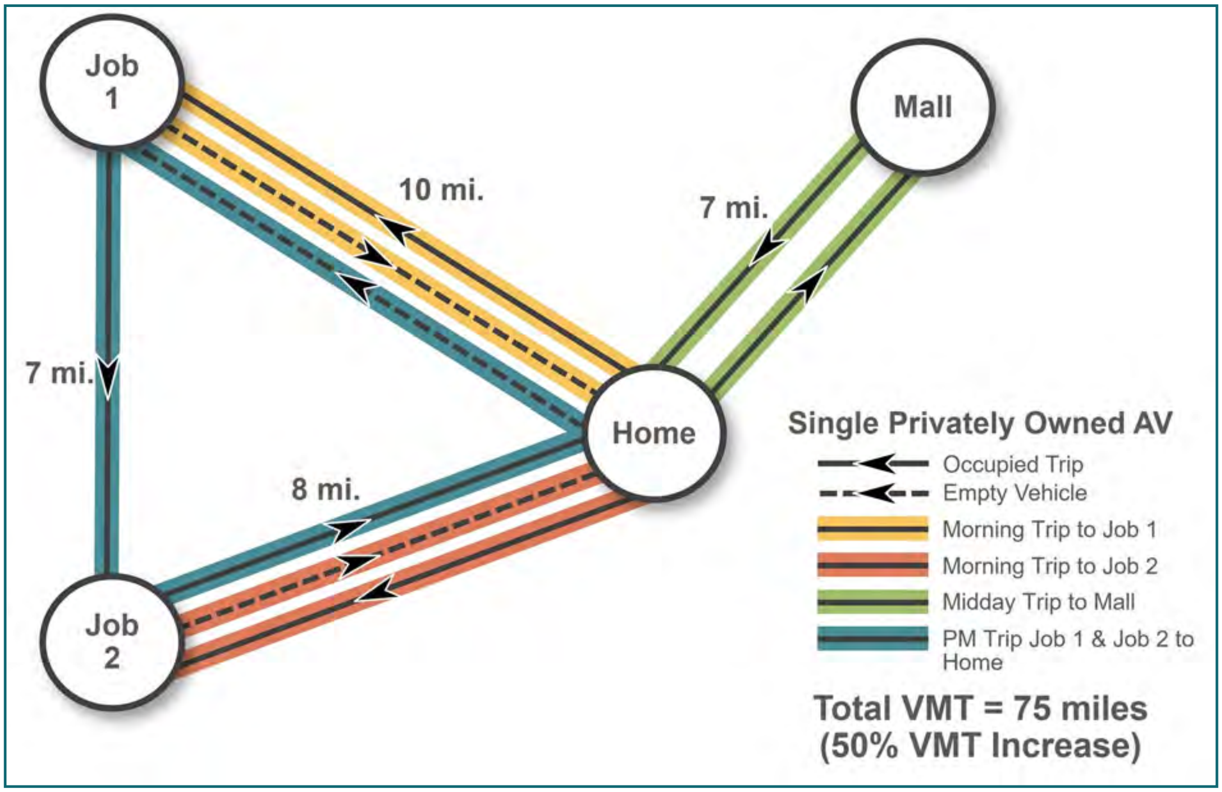


Figure 4-6 Single Privately Owned Autonomous Vehicle

4.5.3 Case III: Complete Reliance on Shared Mobility

This assumption represents a case when a person does not have a privately owned vehicle, and all trips are made using MaaS-type service(s). It is further assumed that the service will have pickup, drop-off, and holding areas that will result in empty vehicles between passenger pickup/drop-off, etc. It is assumed that such areas will be 1 to 3 miles away. This trip pattern is illustrated in **Figure 4-7**. This results in a VMT of 85 miles, 70-percent increase over the traditional household VMT.

This discussion was incorporated into the model in the form of the following assumptions:

- Emergence of AVs will result in an approximate 50-percent increase of VMT.
- Emergence of a predominantly MaaS environment will result in an increase in VMT of about 70 percent.
- It was further assumed that fully autonomous (Level 5) vehicles will all be electric.

The above described VMT increases were applied only to a subset of electric vehicles.

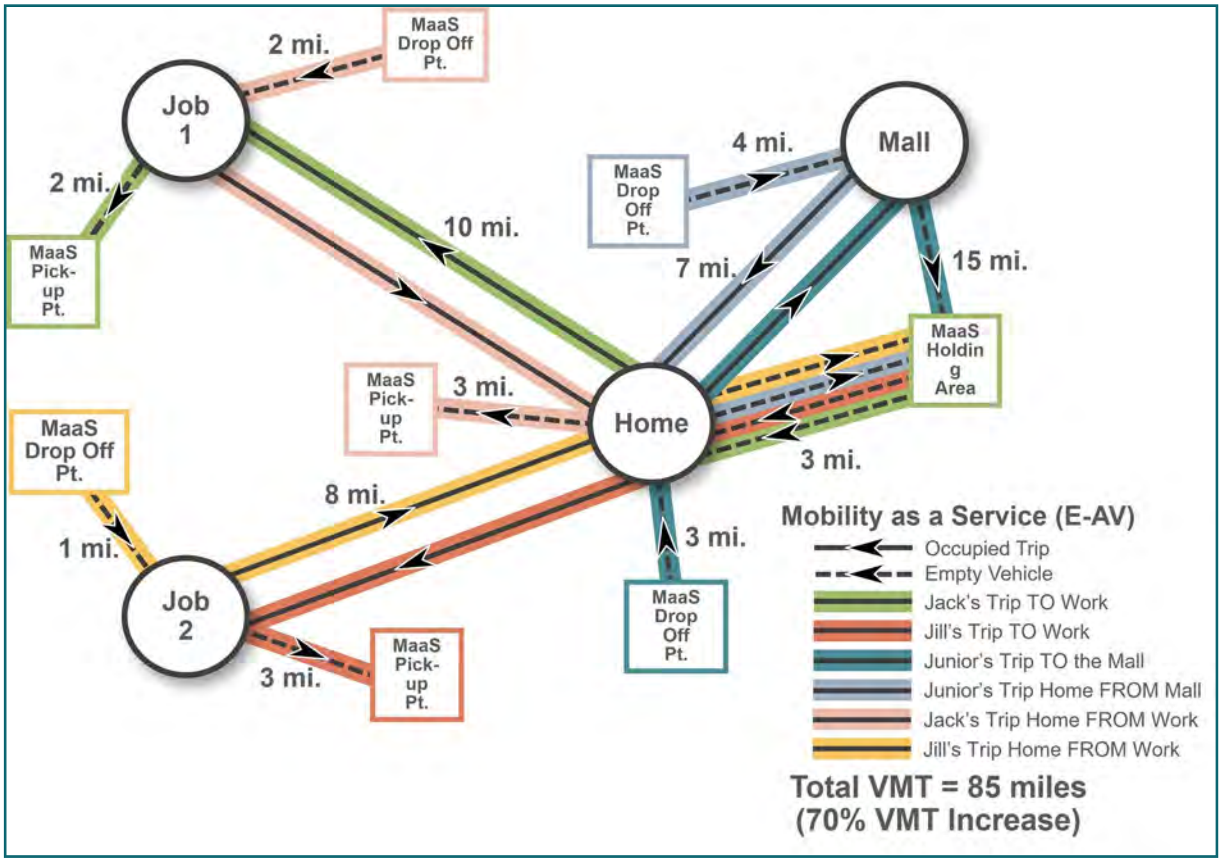


Figure 4-7 Mobility as a Service (MaaS)

4.6 Model Development

The model development process involved using the previously described datasets to develop a spreadsheet-based analytical model that could integrate the datasets in an internally consistent manner and analyze different combinations of input assumptions.

Given that this project is a “Scenario Planning” exercise, the spreadsheet model was developed in such a way that it contains the values of input data corresponding to different choices based on the scenario being analyzed. For example, if a user chooses a VMT growth scenario, the model will use the applicable forecast. Similarly, if a user chooses a particular telecommute scenario, the base VMT would be adjusted accordingly. To implement such functionality, various user choices and realistic ranges of inputs were established as an integral part of model development. Ranges and/or selection choices of primary inputs are summarized in **Table 4-4**.

Table 4-4 Major Factors Implemented in the Model

MODEL FACTOR	RANGES IMPLEMENTED
VMT Growth	Low: Based on EIA Low Economic Growth scenario
	Medium: Washington State Office of Financial Management Forecast
	High: EIA High Economic Growth scenario
Telecommute Shift	Continue as pre-Covid
	25-, 50-, 100-, or 200-percent increase over pre-COVID-19 levels of telecommuting
Electrification Forecast	Low: EIA Reference Case
	High: Bloomberg NEF
	Medium: Average of Low and High
Pandemic Return	Return to Normal
	Pandemic resurgence
E-Commerce Level	Pre-COVID-19 trend
	10-, 25-, or 50-percent additional trips impacted by e-commerce for discretionary purposes
Transition to RUC	Continuation of Fuel Tax
	RUC Implementation based on fuel efficiency and vehicle age
Gas Tax	No change, another rate
RUC Rate	User-provided
Scrappage Scenario	Low, Medium, High
Autonomy	Scenario-specific

The model calculates the potential decrease in VMT attributable to increases in WFH by calculating the impact of a 25, 50, 100, or 200-percent increase in WFH from 2019 conditions. A no change scenario is also included in the model. Furthermore, assumptions regarding the growth rate of employment in occupations with WFH potential and the commute length can be modified by the user for both urban and rural areas to calculate the disparate impact that an increase in WFH would have on commutes based upon location.

4.7 Model User Interface

A User Interface (UI) in addition to the spreadsheet was developed to support users' interaction with the model. While the model itself is a self-contained spreadsheet, but the use of the interface allows for quick setup of various scenarios or adjusting a scenario being analyzed. The UI is developed using Python programming language and does not require any additional licensing.

Figure 4-8 provides a general view of the software environment.

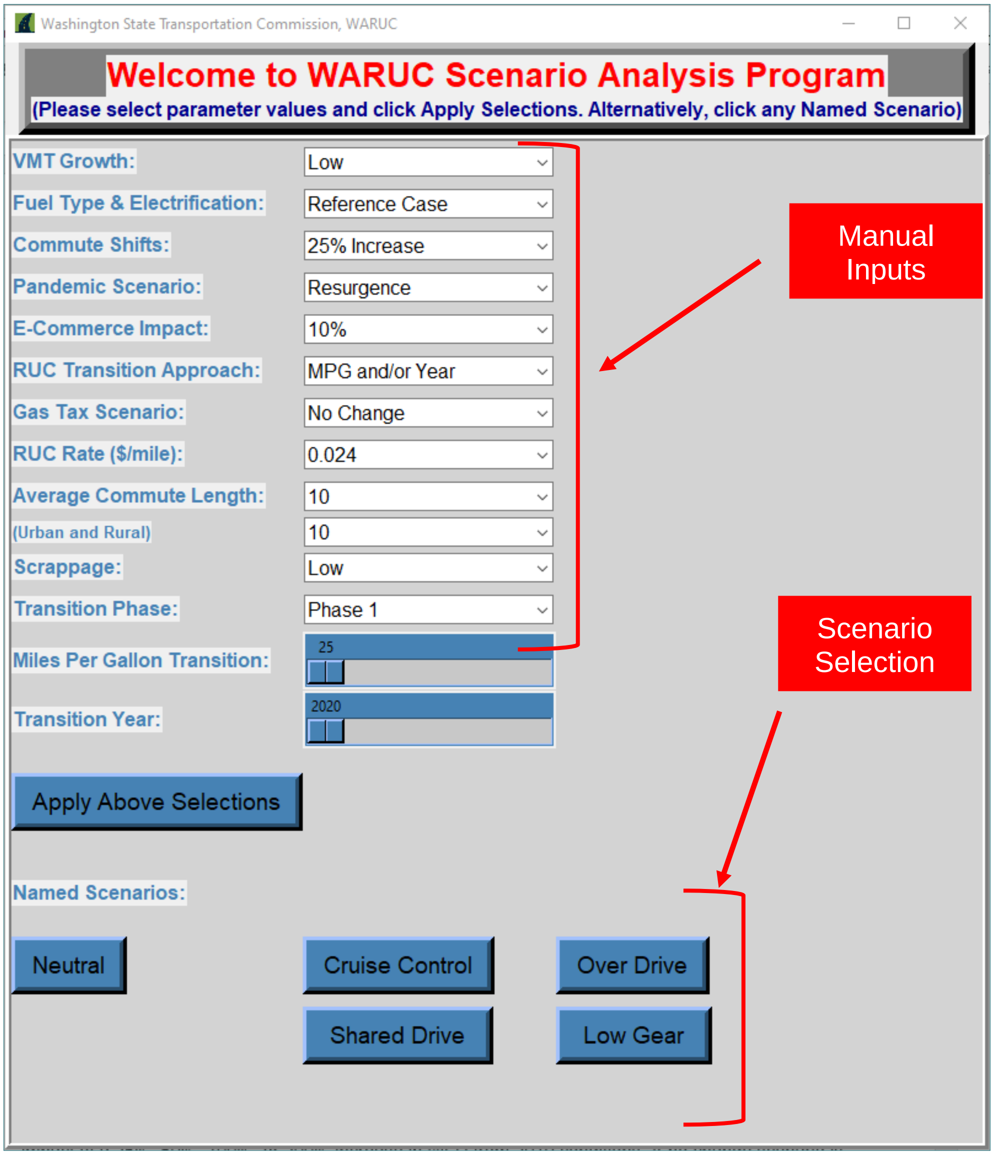


Figure 4-8 Model User Interface

As shown in **Figure 4-8**, the model UI has two input areas. One input area is designed to provide manually selected parameter values in any combination. After selecting the values through easy to use "drop-down" choices, the user can click on the "Apply Above Selections" to implement these choices. The alternate input area is to click on any of the five scenario buttons to select input values already programmed.

The UI is designed to work in conjunction with the model spreadsheet, which can also be used directly by experienced users. The results from any input method are reflected in the ‘Report’ and ‘Outputs’ tabs of the spreadsheet. **Figure 4-9** shows the UI and resulting ‘Report’ tab of the spreadsheet. As mentioned earlier, **Figure 4-9** is intended for illustrative purposes to show the data flow.

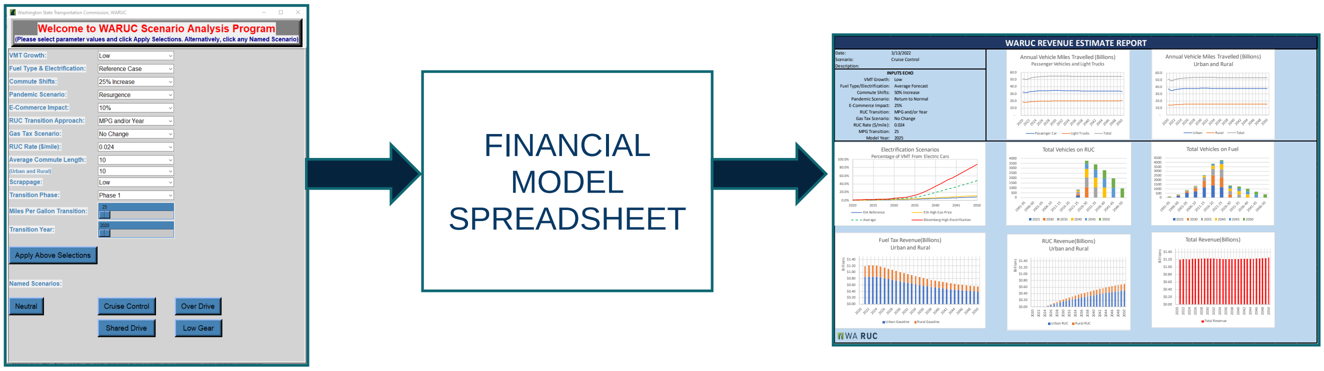


Figure 4-9 Model User Environment and Reporting

4.8 Model Functional Testing

The model underwent functional testing to ensure that specified components are linked correctly to each other and to verify adequate internal integrity within the spreadsheet. Testing was performed manually by changing certain cell values as well as user-modifiable inputs.

The second aspect of model functional testing was to ensure that the changes in the user assumptions and inputs have an intuitively valid effect on the results. For example, increasing the telecommute percentage should cause a decrease in revenue and changing the VMT scenario from ‘Low’ to ‘High’ should increase the revenue. Such verifications were made prior to the actual financial analysis, which is described in subsequent chapters of this document.

5.0 SCENARIO DEVELOPMENT

5.1 Scenario Development Rationale

One of the primary goals of this project was to develop a model and tool to analyze various combinations of factors that may have an impact on RUC revenue. The other task was to identify scenarios that:

- Should cover a broad spectrum of future conditions
- Should be based on factors that have a strong impact on vehicular travel

Based on the above rationale, several factors were identified which have an impact on travel and should be considered in scenario development. These factors are discussed in the following paragraphs.

5.2 Parameters Governing Scenarios

While there can be numerous factors that can be considered as having an impact on the level of road travel, the following factors should be considered from the standpoint of revenue from RUC:

- VMT forecasts
- Electrification forecasts
- Potential shifts in commute patterns
- Possibility of another pandemic
- Impact of e-commerce on road travel
- Temporal and technology consideration of transition to RUC
- Impact of autonomy and/or shared mobility
- Urban and rural separation for revenue
- Vehicle fleet composition and fuel efficiency distribution
- Difference in urban and rural areas

For the purposes of scenario development, the above factors were grouped into the following:

- VMT/Economic growth
- Covid/Pandemic outlook
- Telecommuting impacts
- E-Commerce impacts
- Technology adoption outlook (electrification)
- Autonomy and Shared Mobility impacts

5.3 Initial Scenario Identification (5 Scenarios)

Scenario development was based on the following considerations:

- Scenarios cannot be defined in 'isolation' using only a single factor (e.g., 'Low Economic Growth').
- Analyzing all possible combinations of the factors is not practical.
- Define a 'Baseline Scenario' using appropriate factor ranges that could represent a normal continuation of life.
- Define scenarios that may cover a range of potential conditions, such as representing aggressive to moderate growth in various factors.
- Identify several 'plausible' combinations to develop a reasonable number of preliminary scenarios to analyze.

Based on the above approach, the following five scenarios were formulated:

- **Neutral:** Represents a continuation of 'past' growth and passive technology adoption
- **Cruise Control:** Represents a 'moderate' increase in growth and a slightly faster AV technology adoption compared to Neutral
- **Over Drive:** Represents an 'aggressive' economic growth and high electrification and technology adoption
- **Shared Drive:** Variant of Overdrive, with increased adoption of shared mobility while still including aggressive growth
- **Low Gear:** Represents slow growth in electrification and vehicle autonomy

Figure 5-1 provides a 'qualitative' comparison of various scenarios in terms of low, medium, and high values of factors used for scenario definition.

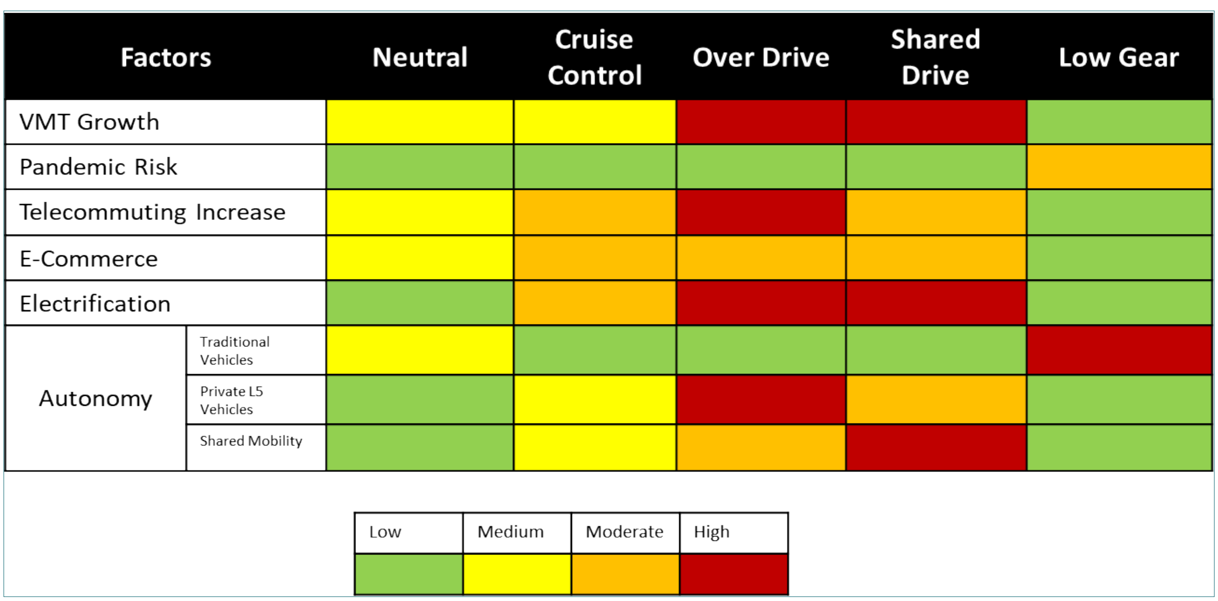


Figure 5-1 Qualitative Representation of Scenarios

5.4 Assumed Ranges of Parameter Values

Based on the intended combination of factors for each scenario, the parameters were assigned specific ranges/vales, as summarized in **Table 5-1**.

Table 5-1 Assumed Values of Factors by Scenario

MODEL FACTOR	NEUTRAL	CRUISE CONTROL	OVER DRIVE	SHARED DRIVE	LOW GEAR
VMT Growth	Medium	Medium	High	High	Low
Telecommute Shift	25%	50%	100%	50%	25%
Electrification Forecast	Low	Medium	High	High	Low
Pandemic Resurgence	None	None	None	None	Resurgence
E-Commerce Level	10%	25%	50%	50%	10%
Gas Tax	No Change	No Change	No Change	No Change	No Change
RUC Rate/mile	$0.024	$0.024	$0.024	$0.024	$0.024
Scrappage Scenario	Medium	Medium	High	High	Low
Autonomy	Low	Medium	High	High	Low

6.0 FINANCIAL ANALYSIS

6.1 Financial Analysis Methodology

Financial analysis included the implementation of the scenarios developed earlier in the model and assessment of the results.

6.2 Results of Financial Analysis

Figure 6-1 through **Figure 6-6** provide an aggregate summary of revenue for each scenario including revenue from fuel tax and RUC. **Figure 6-1** shows the revenue outlook from fuel tax in case of a Neutral scenario without RUC implementation. The continued decline in revenue is due to the increase in fuel efficiency of gasoline vehicles and emergence of electric vehicles. **Figure 6-2** assumes a Neutral scenario with RUC implementation which results in RUC revenue compensating for the revenue loss shown in **Figure 6-1**. The overall revenue continues at the current levels with RUC share increasing over time. **Figure 6-3** shows the revenue outlook corresponding to the “Cruise Control” scenario, which is quite similar to Neutral in terms of revenue outlook which indicates the difference in assumptions between Neutral and Cruise Control scenarios do not have a significant impact on revenue. **Figure 6-4** shows the revenue corresponding to the Over Drive scenario which shows a higher level of RUC adoption and relatively higher rate of decline in fuel tax revenue due to the assumptions of more rapid electrification of vehicles. **Figure 6-5** shows the Shared Drive scenario, which appears very similar to the Over Drive scenario which indicates that the impact of ridesharing on RUC revenue is not significant under the Over Drive and Shared Drive scenario assumptions. **Figure 6-6** represents the Low Gear scenario, which is similar to the Neutral scenario with an adjustment for a potential pandemic during the first five years.

Neutral Without RUC:

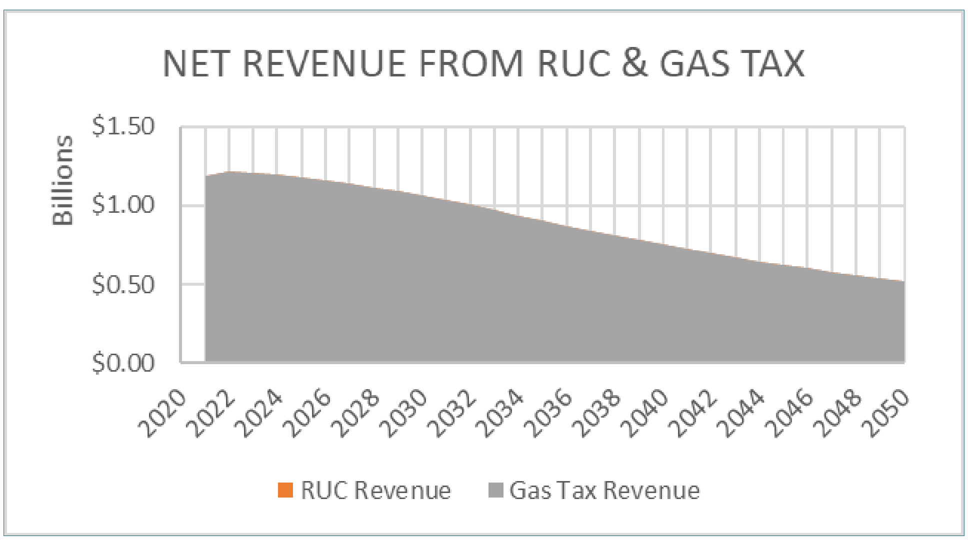


Figure 6-1 Neutral Scenario Without Road Usage Charge

Neutral:

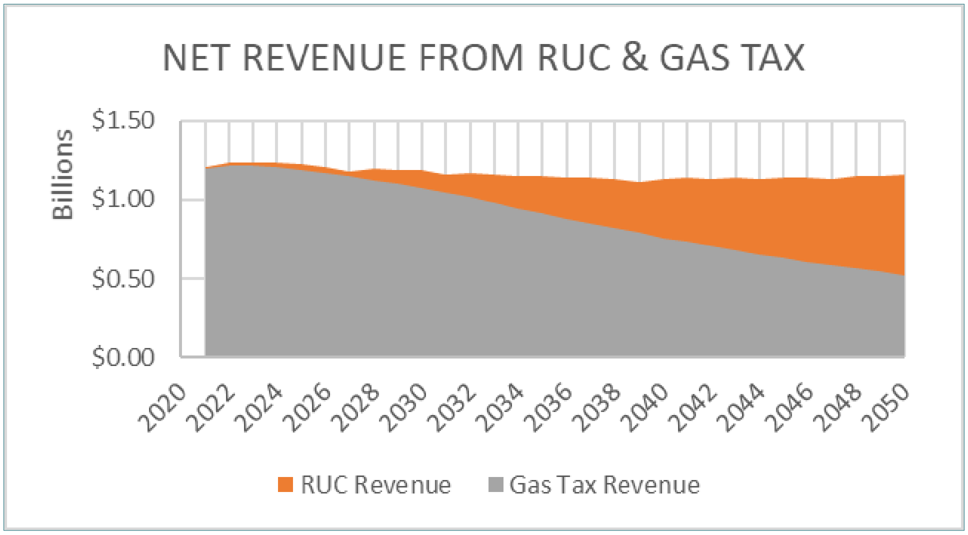


Figure 6-2 Revenue Summary for Neutral Scenario

Cruise Control:

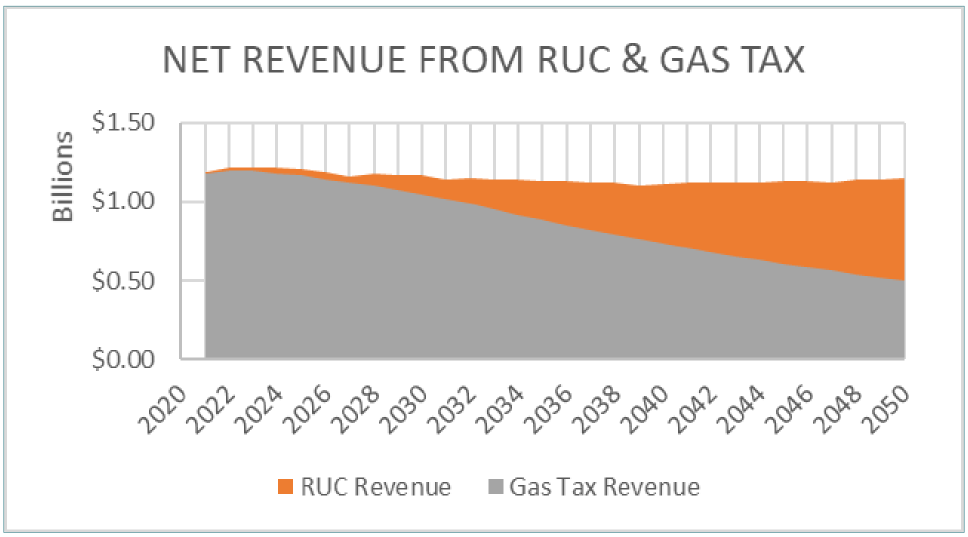


Figure 6-3 Revenue Summary of Cruise Control Scenario

Overdrive:

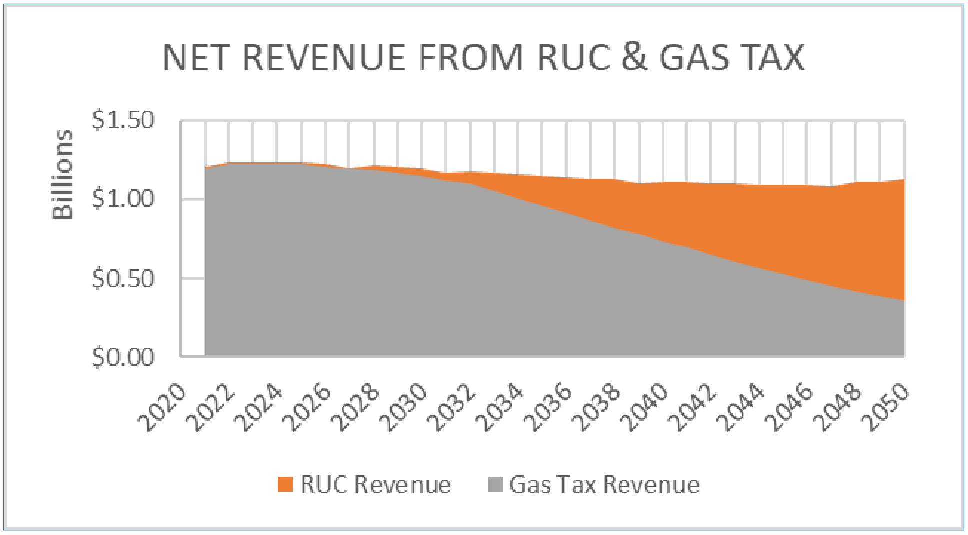


Figure 6-4 Revenue Summary of Over Drive Scenario

Shared Drive:

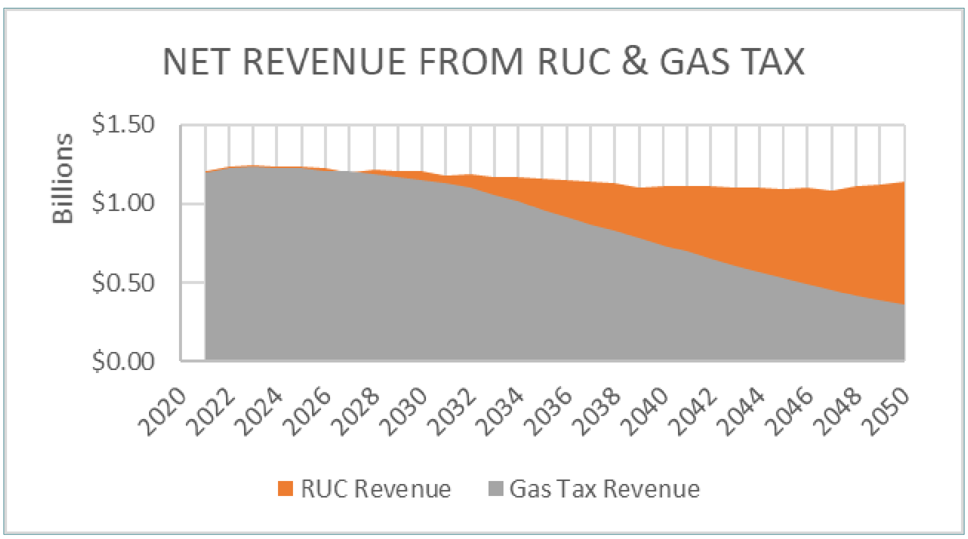


Figure 6-5 Revenue Summary of Shared Drive Scenario

Low Gear:

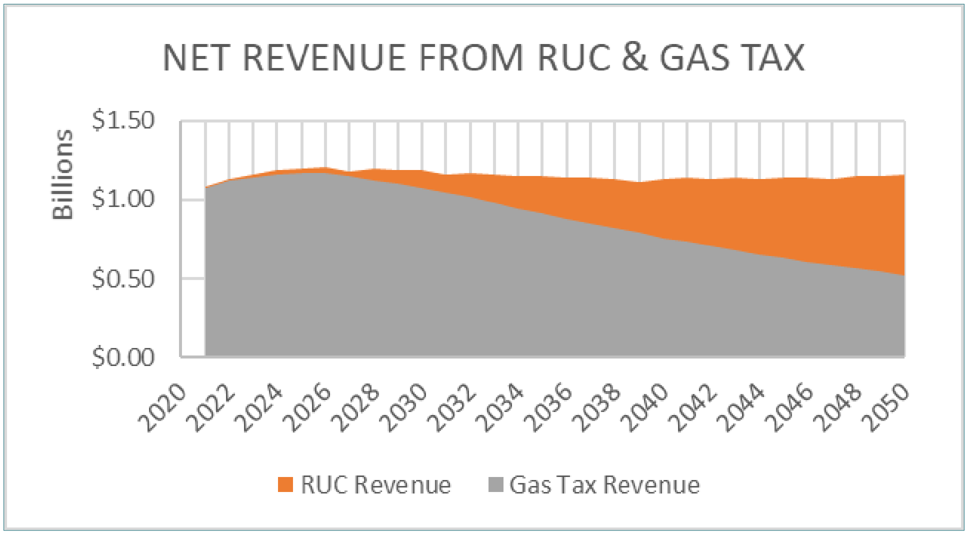


Figure 6-6 Revenue Summary of Low Gear Scenario

6.3 Summary of Results

Table 6-1 provides the tabular summary of gross revenue for various scenarios. **Figure 6-7** provides the corresponding graphical summary. 'Neutral with no RUC; shows to be collecting only $539 million in 2050, less than half of any other scenario. This is attributable to increasing fuel efficiency in the near and middle term, with electrification increasingly weighing on revenues in the medium to long-term. The 'Neutral' scenario assumes an aggressive transition to RUC with all vehicles rated over 30 MPG converting to a RUC in 2025. This dramatically improves the revenue collected forecast over the observation period with estimated 2050 revenues at $1.1 billion. Both these scenarios assumed a 25% increase in work-from-home rates (for jobs classified as having high work from home potential) and a 10% decrease in VMT associated with discretionary travel due to Covid-19's impact on work and e-commerce. 'Cruise Control' assumes a higher shift to work-from-home and decrease in discretionary trips of 50% and 25% respectively, resulting in lower overall VMT and a marginal decrease in revenues compared to 'Neutral. 'Cruise Control' employ a more aggressive automation forecast than 'Neutral'. However, the increase in VMT attributable to automation does not outweigh the decrease due to work from home and discretionary trip reduction. 'Overdrive' assumes a higher shift, 100% increase in work from home and 50% decrease in discretionary trips coupled with a high VMT growth forecast coupled with the highest rate of autonomous vehicle deployment. 'Shared Drive' employs the high VMT forecast with a 50% work from home increase and 50% discretionary trip reduction to deliver slightly less VMT than the 'Overdrive' scenario and moderate autonomous vehicle forecast. Finally, 'Low Gear' employs the same assumptions as the 'Neutral' scenario with lower rates of autonomy and electric vehicle adoption.

Table 6-1 Gross Revenue by Scenarios (in millions)

YEAR	NO RUC	NEUTRAL	CRUISE CONTROL	OVER DRIVE	SHARED DRIVE	LOW GEAR
2021	$1,190	$1,207	$1,188	$1,207	$1,210	$1,084
2022	$1,211	$1,233	$1,214	$1,241	$1,244	$1,133
2023	$1,208	$1,236	$1,217	$1,251	$1,254	$1,161
2024	$1,197	$1,231	$1,211	$1,257	$1,260	$1,181
2025	$1,180	$1,220	$1,200	$1,260	$1,263	$1,196
2026	$1,157	$1,202	$1,182	$1,253	$1,256	$1,202
2027	$1,140	$1,178	$1,160	$1,243	$1,246	$1,178
2028	$1,115	$1,195	$1,177	$1,269	$1,272	$1,195
2029	$1,089	$1,188	$1,170	$1,271	$1,274	$1,188
2030	$1,064	$1,181	$1,163	$1,271	$1,274	$1,181
2031	$1,036	$1,154	$1,137	$1,251	$1,254	$1,154
2032	$1,007	$1,166	$1,149	$1,267	$1,270	$1,166
2033	$970	$1,159	$1,143	$1,266	$1,269	$1,159
2034	$934	$1,153	$1,137	$1,266	$1,269	$1,153
2035	$900	$1,147	$1,131	$1,265	$1,268	$1,147
2036	$867	$1,141	$1,126	$1,265	$1,268	$1,141
2037	$836	$1,136	$1,122	$1,265	$1,269	$1,136
2038	$807	$1,132	$1,118	$1,266	$1,270	$1,132
2039	$779	$1,110	$1,097	$1,250	$1,253	$1,110
2040	$749	$1,128	$1,115	$1,273	$1,276	$1,128
2041	$725	$1,135	$1,122	$1,287	$1,290	$1,135
2042	$696	$1,133	$1,121	$1,291	$1,294	$1,133
2043	$670	$1,134	$1,122	$1,297	$1,301	$1,134
2044	$643	$1,133	$1,122	$1,300	$1,304	$1,133
2045	$621	$1,137	$1,125	$1,308	$1,312	$1,137
2046	$600	$1,141	$1,130	$1,319	$1,322	$1,141
2047	$578	$1,126	$1,115	$1,311	$1,315	$1,126
2048	$558	$1,147	$1,136	$1,340	$1,344	$1,147
2049	$539	$1,150	$1,139	$1,352	$1,355	$1,150
2050	$516	$1,162	$1,151	$1,375	$1,379	$1,162

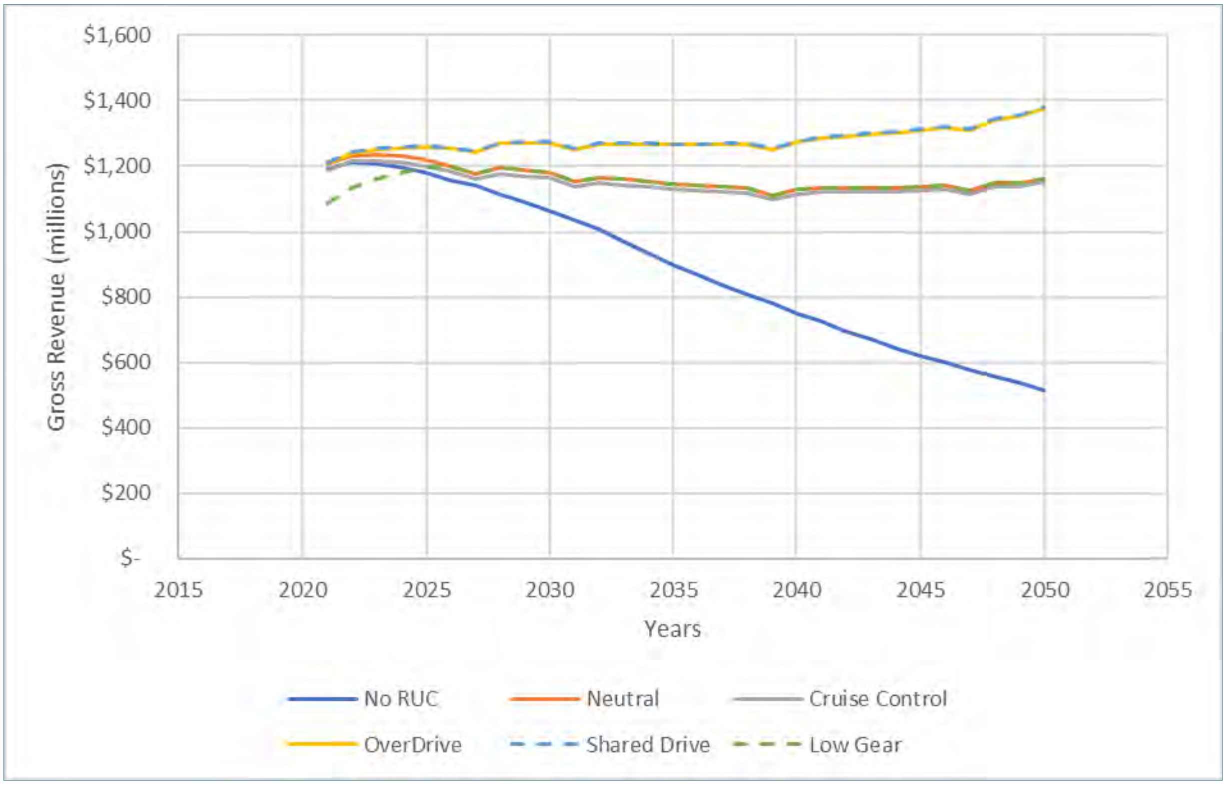


Figure 6-7 Gross Revenue by Scenarios (millions)

The gross revenue was adjusted based on the cost of revenue collection to determine the net revenue by scenarios. **Table 6-2** provides a summary of net revenue by each scenario, and **Figure 6-8** provides the corresponding graphical summary.

As shown in **Figure 6-7**, the "No RUC" scenario revenue continues to fall and. The other hypothetical scenarios illustrate varying levels of gross and net revenue in **Figure 6-7** and **Figure 6-8** respectively.

On the higher end, the "Over Drive" and "Shared Drive" scenarios almost follow the same trajectory, which implies that the net effect of shared autonomous type services on the "big picture" will be relatively small. On the low side, the "Neutral" and "Low Gear" scenarios almost overlap except for the first few years showing an assumed/hypothetical downturn of revenue in case of another pandemic. The "Cruise Control" revenue is slightly below that of "Neutral", which indicates the "cautious" nature of this scenario.

The analysis of multiple scenarios and the results based on the tool developed for this study suggest that the tool can be used to further analyze these or other scenarios and the model shows intuitive response to scenario-specific assumptions.

Table 6-2 Net Road Usage Charge Revenue by Scenarios (in millions)

YEAR	NO RUC	NEUTRAL	CRUISE CONTROL	OVER DRIVE	SHARED DRIVE	LOW GEAR
2021	$ -	$13	$12	$13	$13	$11
2022	$ -	$18	$18	$18	$18	$16
2023	$ -	$23	$24	$25	$25	$21
2024	$ -	$28	$31	$32	$32	$27
2025	$ -	$34	$38	$40	$40	$33
2026	$ -	$38	$44	$47	$47	$38
2027	$ -	$30	$37	$42	$42	$30
2028	$ -	$72	$79	$86	$87	$72
2029	$ -	$91	$99	$108	$108	$91
2030	$ -	$109	$118	$129	$130	$109
2031	$ -	$109	$118	$133	$133	$109
2032	$ -	$150	$160	$178	$178	$150
2033	$ -	$180	$190	$212	$213	$180
2034	$ -	$209	$220	$246	$247	$209
2035	$ -	$237	$248	$280	$280	$237
2036	$ -	$264	$276	$312	$313	$264
2037	$ -	$291	$302	$343	$344	$291
2038	$ -	$316	$327	$373	$374	$316
2039	$ -	$323	$334	$385	$386	$323
2040	$ -	$370	$382	$439	$440	$370
2041	$ -	$401	$414	$477	$479	$401
2042	$ -	$429	$442	$512	$513	$429
2043	$ -	$457	$469	$546	$547	$457
2044	$ -	$482	$495	$577	$579	$482
2045	$ -	$509	$521	$610	$611	$509
2046	$ -	$534	$547	$642	$644	$534
2047	$ -	$541	$554	$657	$659	$541
2048	$ -	$583	$595	$706	$708	$583
2049	$ -	$606	$618	$737	$739	$606
2050	$ -	$641	$653	$784	$786	$641

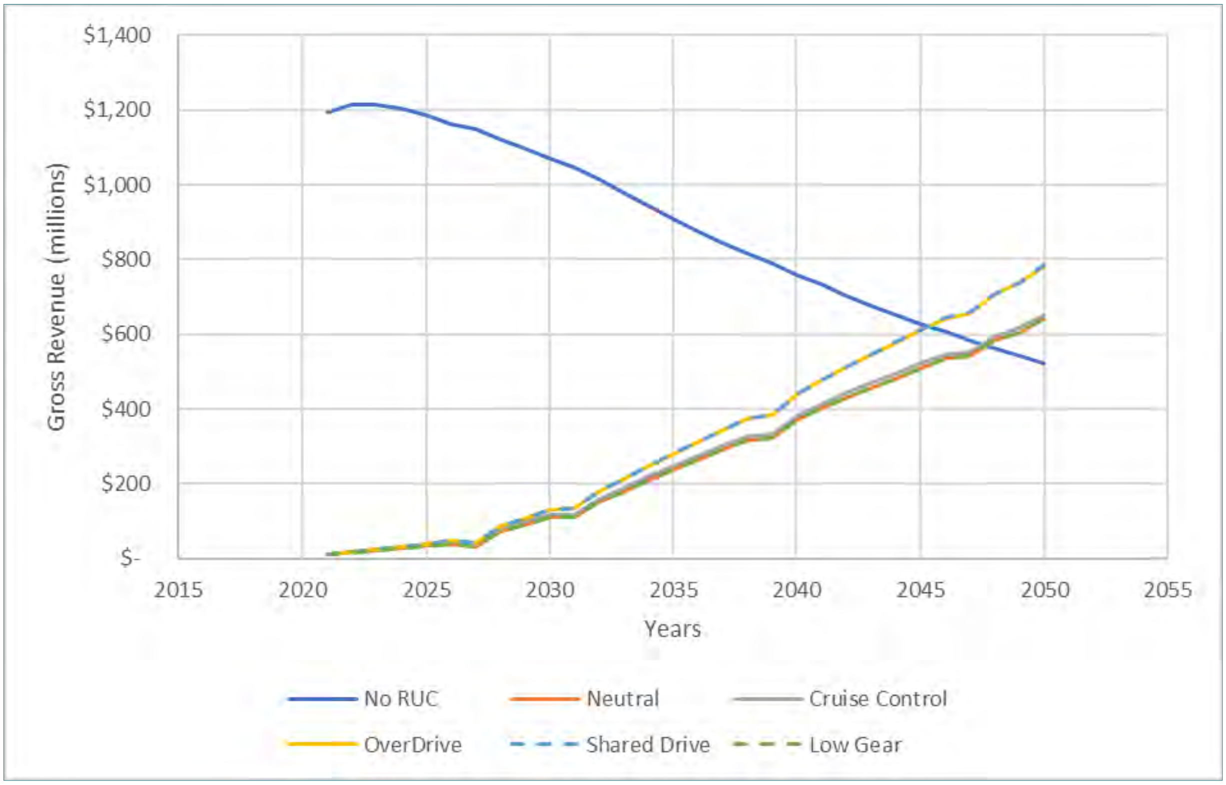


Figure 6-8 Net Road Usage Charge Revenue by Scenarios (millions)