RUC AND RURAL DRIVERS

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Preface

Hawaii pays for the repair and upkeep of its state roads and bridges from taxes and fees on highway users. Funding sources for this repair and upkeep include vehicle registration fees, weight taxes, rental car surcharges, and motor fuel taxes. Historically, motor fuel taxes have generated the largest share of money for state roads and bridges. At 16 cents per gallon on gasoline and diesel, motor fuel taxes are the only revenue source based on how much drivers use the road network. Hawaii's counties also tax fuel in order to pay for county roads, at rates that vary from 16.5 to 23 cents per gallon. Additionally, the Federal government funds the Highway Trust Fund using a federal tax of 18.4 cents per gallon of gasoline, and 24.4 cents per gallon of diesel.

As Hawaii residents purchase new cars that consume either less fuel, or none at all, the amount of county, state, and federal funding available for roads in Hawaii from the fuel tax is declining. Moreover, the historical link between how much people drive, and how much they pay to use the roads, is fading. Although declining motor fuel consumption is a welcome trend for meeting energy and environmental goals, the Hawaii Department of Transportation (HDOT) has identified it as a risk to the sustainable and equitable funding of its roads and bridges.

In 2016, HDOT commissioned a feasibility study of transitioning from taxation of fuels to taxation of miles driven as the basis for road funding. The study concluded that a per-mile road usage charge (RUC) is feasible for Hawaii, but that several major issues must first be addressed.

RUC is a concept where roads are funded by charging vehicle owners an amount based on how much they use those roads. However, there are many details to consider before RUC can be enacted into law or implemented into practice.

In 2017, HDOT secured federal funding to perform more in-depth research into RUC. From 2018-2019, HDOT conducted this research which included a statewide telephone survey of residents, holding a series of focus groups, hosting 13 public meetings across all six islands, broadcasting an online virtual public meeting, as well as meeting with dozens of stakeholders (including county officials, neighborhood boards, civic groups, environmental organizations, chambers of commerce, etc.). Building on the earlier feasibility study, this "discovery" phase of RUC research revealed several community concerns regarding the potential transition from the "taxing of fuel" model to a "fee based on miles driven" model.

HDOT and its team of Hawaii Road Usage Charge (HiRUC) researchers reviewed these concerns carefully in order to fully understand their meaning, origin, and degree of urgency. Broadly speaking, the concerns fall into three categories:

- Often, public **perceptions** are expressed as concerns. For example, some members of the public believe that a RUC system will unfairly burden rural residents. To address perception-based concerns, HDOT conducted research to determine whether there was a factual basis for these assertions and if so, what approaches exist to address these claims through policy or system design adjustments.
- The operational **challenges** that a RUC system will face are also often identified as concerns. For example, some stakeholders and members of the public worry that a RUC system would be costly to administer, as compared to the current system of fuel taxation. To address these operational and technical challenges, HDOT conducted research to better understand and improve the RUC system design.

- Sometimes, a policy **choice** is expressed as a concern. Lawmakers and system designers will have to make many choices when creating a RUC program. For example, they must choose a rate, which can be a simple flat rate per mile for all cars, or can vary based on the type of vehicle. Some members of the public would prefer a RUC system that incorporates vehicle weight, or vehicle emissions, as a factor in the rate. HDOT conducted research into the various policy choices available, as well as the relative impacts, strengths, and weaknesses of each approach.

Given the varying concerns and topics they span, HDOT decided to organize further research into these topic areas. For each topic area, a “policy paper” was initiated to summarize the nature of the concern (or concerns) within the topic area, the results of research, the analysis into the concerns, as well as the implications of the research on RUC policy or system design.

The purpose of these policy papers is not to contain recommendations or clear answers on what precisely HDOT or the Legislature should do. The purpose of each policy paper is to provide adequate background and analysis to support decision-making by lawmakers and system designers as they contemplate the enactment of a RUC system.

Executive Summary

The topic of potential differential impacts of a road usage charge on urban and rural residents has received significant public comment during the HiRUC Demonstration project. Public comments during community meetings held in the spring of 2019 noted that much of the state is rural, and there are concerns among rural residents that a shift from motor fuel taxes to a road usage charge will unfairly burden them.

This report presents findings of an analysis of the difference in costs that might be borne by urban and rural vehicle owners from an alternative road usage charge to the current state gas tax. It estimated, based on the distances each vehicle was driven, that the difference between the amounts a vehicle owner would pay in gas tax and based on a road usage charge, and then evaluated whether these costs varied differently in urban and rural areas as defined by the U.S. Census. A total of 814,227 vehicles with vehicle registration mailing addresses in Hawaii were included in the analysis. This represents about 52 percent of all vehicles registered as passenger vehicles in the state's vehicle registration database.

This analysis yielded the following key results:

- Vehicles with rural addresses travel up to 3 miles per day more than vehicles with urban addresses, except within Maui County where the difference is negligible.
- In all four counties, vehicles registered to urban addresses average slightly higher fuel economy ratings, primarily because they tend to be newer vehicles. (See Table 2).
- Rural drivers currently pay more in gas taxes on average than their urban counterparts, both in gross annual payments (25% more) and on a per-mile basis (7% more).
- By changing from gas taxes to a road usage charge, 90 percent of all vehicles would fall within the range of paying $35 more or less than they currently do per annum.

A shift to a flat-rate road usage charge of 0.8 cents per mile would result in slightly higher costs for urban drivers and even smaller cost increases for rural drivers. The cost differences are summarized in Table 1. Table 2 summarizes the distances driven and fuel economy by county and area type.

Table 1: Average Cost Difference for Vehicles in Urban and Rural Areas

AREA TYPE	AVERAGE ANNUAL COST INCREASE UNDER STATE RUC OF 0.8 CENTS/MI VERSUS STATE GAS TAX OF 16 CENTS/GAL	AVERAGE ANNUAL COST INCREASE UNDER STATE RUC OF 0.7462 CENTS/MI VERSUS STATE GAS TAX OF 16 CENTS/GAL
Rural	Increase $1.32 per year	Savings of $3.97 per year
Urban	Increase of $5.02 per year	Increase of $0.50 per year

The analysis presented in this paper assumed a revenue-neutral rate of 0.8 cents per mile, which was established early in the HiRUC project and rounded up to the nearest tenth of a penny for simplicity of communicating with survey recipients. Using the actual revenue-neutral rate rounded to more decimal points based on the vehicles analyzed from the state registry resulted in a more precise rate of $0.007462 per mile. This rate would yield an average annual savings for rural drivers of $3.97, and an average annual increase in cost for urban drivers of $0.50.

Table 2: Average Daily Distance Driven and Average Vehicle Miles per Gallon for Urban and Rural Vehicles (by county)

COUNTY	AREA TYPE	AVERAGE MILES PER DAY	AVERAGE MPG[1]
Statewide	Urban	22.6	23.4
	Rural	26.3	21.8
Hawaii	Urban	25.5	22.0
	Rural	28.6	21.7
Kauai	Urban	23.6	21.6
	Rural	25.1	21.4
Maui	Urban	23.1	22.6
	Rural	23.4	22.0
Honolulu (Oahu)	Urban	22.6	23.8
	Rural	25.0	23.0

[1] The calculation of average miles per gallon includes MPGe (miles per gallon estimates for electric vehicles).

Definitions & Abbreviations

TERM/ABBREVIATION	DEFINITION/DESCRIPTION	REMARKS
ACS	American Community Survey	
DIT	Department of Information Technology	
EPA	U.S. Environmental Protection Agency	
MPG	Miles per Gallon	
MPGe	Mile-per-gallon equivalents	Estimated by EPA for electric vehicles
NEV	neighborhood electric vehicles	
PMVI	periodic motor vehicle Inspection	
RUC	road usage charge	
VIN	Vehicle Identification Number	

1. Introduction

The topic of potential differential impacts of a road usage charge (RUC) on urban and rural residents has received significant public comments during the HiRUC Demonstration project. During community meetings held in the spring of 2019, members of the public noted that much of the state is rural, and there are concerns among rural residents that a shift from motor fuel taxes to RUC will unfairly burden them.

One commenter at the Kona community meeting noted, “The islands are rural. The people who have less money live further away.” Another commenter suggested that “RUC is going to be a regressive charge on rural communities, especially those people who must live in outlying areas and may work in lower wage jobs”.

This report presents findings of an analysis of the effects a RUC might have on drivers who live in rural and urban areas. The analysis utilized odometer readings and specific vehicle make and model information collected at annual periodic motor vehicle inspections (PMVI) for passenger vehicles and combined that data with U.S. Environmental Protection Agency (EPA)-estimated vehicle fuel economy. Vehicles were identified as rural or urban according to the U.S. Census Bureau’s definition of urban areas. Using geospatial data from the U.S. Census Bureau, which identifies urban areas in Hawaii and the mailing address used for the vehicle’s registration, vehicles with addressers within designated urban areas were placed in the urban category, with all others being defined as rural (see methodology, section 2.8). A detailed picture of the impacts of RUC compared with motor fuel taxes can be developed by using data on distances driven by a large number of passenger vehicles in the state.

2. Methodology

This chapter describes the methodology used to prepare Hawaii's anonymized vehicle data for analysis of the impacts of a RUC on urban and rural residents.

2.1. Overview

To ascertain whether potential impacts of a RUC impact urban and rural areas differently, data from state and federal sources were combined and analyzed. Vehicles were classified as urban or rural based on the registered vehicle owner's mailing address, which mapped to urban or rural areas per U.S. Census Bureau definitions. Odometer readings taken during the two most recent vehicle inspections were used to estimate annual travel as was information on vehicle make, model, and vehicle identification number (VIN) number.

There are 1,570,422 vehicles registered in Hawaii, with all data held on behalf of the four counties by the Honolulu Department of Information Technology (DIT). At each stage of the data preparation, some records were screened out due to entries containing invalid data. These types of data issues resulting in records being removed from the analysis are discussed subsequently. Ultimately, 814,227 vehicles were included in the analysis. The relative proportions of vehicles, by county, used in the final analysis are similar to the total of Active and Inactive vehicles in the DIT registry.

All data used for this analysis are from November 2019 and earlier. Therefore, they reflect pre-COVID-19 travel patterns.

The following high-level tasks were completed to prepare data for analysis:

1. Obtain and review anonymized vehicle registry from DIT.
2. Obtain and review anonymized vehicle inspection data from PMVI.
3. Calculate annualized mileage from PMVI data based on at least two odometer readings.
4. Merge DIT datasets and annualized mileage from PMVI dataset.
5. Decode VINs to reveal vehicle details such as vehicle make, model, year, EPA mileage estimates, fuel type, and engine/motor type.
6. Adjust mailing address data to match standard address formats and geocode addresses.
7. Determine whether addresses are in urban or rural areas and merge decoded VIN data with urban/rural assignments
8. Clean merged data by removing incomplete records.

The DIT and PMVI data and decoded VIN data were the same as that used to create the Driving Reports (mailers) for the HiRUC demonstration project. However, some of the vehicles excluded from the Driving Report mailers were included in this analysis, such as vehicles corresponding with owners' mailing addresses that had changed from one county to another, vehicles that had failed their most recent safety inspection, and vehicles that are a part of a fleet. Whereas Driving Reports were created only for those vehicles with recent (typically one to three months) "passed" inspections, this analysis used a single data snapshot to analyze the entire passenger fleet, including those whose most recent inspection pass date was over one year old.

One additional difference between Driving Report creation and this analysis is related to mailing address data cleansing. In preparing Driving Reports to physically mail, mailing addresses were verified against a commercial National Change of Address (NACO) database. Addresses that did not pass a range of validity tests were excluded from receiving mailers. By contrast, this analysis investigated addresses that did not pass NACO validation and manually corrected many of them so they could be included.

Additional data included in this analysis were obtained from the U.S. Federal Highway Administration and U.S. Census Bureau and included the following:

- Urban Area/Urban Cluster definitions (2019 vintage)
- Census Tract Boundaries (2018 vintage)
- 2018 American Community Survey (ACS) 5-year estimates of mean and median household income (Table S1901)
- 2018 ACS 5-year estimates of per-capita income (Table S1902)
- 2017 National Household Travel Survey

2.2. Step 1: Obtain and Review Anonymized Vehicle Registration Data from City and County of Honolulu Department of Information Technology

Data were delivered to the HiRUC Demonstration project team by DIT in December 2019[2] and contained the following data fields, See Table 3.

The mailing address provided at the time of vehicle registration was requested from DIT so that a differential geographic analysis on the impacts of a RUC could be conducted.

The DIT dataset contained records for 1,570,422 unique vehicles, determined by VIN.[3] Of these, 1,540,991 showed Active or Inactive registration status (Table 4). Both Active and Inactive status vehicles were carried forward for detailed analysis under the assumption that many, if not most, Inactive vehicles have a temporarily lapsed registration and would still have sufficient PMVI history to estimate travel behavior and potential impacts of RUC.

[2] DIT file offload dated 11/22/2019.
[3] VIN, rather than license plate, is used to identify unique vehicles throughout the analysis, since a particular vehicle may have several license plate numbers over time.

Table 3: DIT Vehicle Registry Data Format

DATA ITEM	DESCRIPTION	
Plate Number	License plate number. Has a variety of formats, some of which are dependent upon the type of vehicle, exemption code, and special interest groups	
Serial Number, VIN	VIN. Not valid prior to 1981 models or for vehicles manufactured for foreign markets	
Vehicle Make	Identifies vehicle manufacturer	
Type of Vehicle*	Identifies the body type of the vehicle	
Model Year	Vehicle model year	
Safety Check Expiration	Month and year of PMVI expiration	
Odometer Reading		
License Status	A – Active/new T – Transfer P – Dealer record (privatization) I – Inactive/no renewal J – Junked	R – Retired S – Stored X – Reclassified V – Insurance salvage M – Shipped out of state
Registered Owner Address**	Mailing address of registered owner	
Registered Owner City/State/ZIP Code**	State abbreviations are validated	
County Code	O – Oahu H – Hawaii	K – Kauai M - Maui
Registered Owner Name	Last name, First MI & Co-owners	

**** During data cleansing, it was determined that some recreational, off-road, and farm vehicles are registered as "passenger." These were excluded from the analysis.***
*****During data cleansing, it was determined that some registrations record mailing addresses at P.O. Boxes, mailbox services such as FedEx Office stores, and out-of-state locations.***

Table 4: Summary of Department of Information Technology Registration Status (Active or Inactive) by County

COUNTY	NUMBER OF VEHICLES WITH REGISTRATION STATUS A OR I	PERCENTAGE OF ALL STATEWIDE VEHICLES WITH A OR I REGISTRATION STATUS[4]
Hawaii	254,585	17%
Kauai	105,597	7%
Maui	226,366	15%
City and County of Honolulu (Oahu)	954,443	62%
	1,540,991	

Note: The 29,431 vehicles comprising the difference between total unique vehicles and the summary shown in Table 4 had a registration status other than Active or Inactive, such as Stored, Retired, or Junked.

[4] Figures do not add to 100% due to rounding.

2.3. Step 2: Obtain and Review Anonymized Vehicle Inspection Data from PMVI

An export of the PMVI database was also obtained for November 2019. This dataset is the source of odometer readings used to calculate annualized travel, by vehicle. Table 5 describes the PMVI dataset.

Table 5: Summary of Periodic/Annual Motor Vehicle Inspection Data

FIELD NAME	DATA TYPE	LENGTH	DESCRIPTION	ALLOWED VALUES
vehiclevin	VARCHAR2	100	Vehicle Identification Number	
licenseplatenumber	VARCHAR2	100	License Plate Number	
inspectiondate	DATE	22	Date of inspection in the format of dd/mm/yyyy hh:mi:ss	
Station_id	NUMBER	20	Inspection station ID	
County_name	VARCHAR	20	The county of the inspection station	Hawaii, Kauai, Maui, Honolulu
Vehiclemileage	VARCHAR	100	Vehicle mileage	
Vehiclemileagemeasurement	VARCHAR	10	Unit used in the mileage, KM for kilometer, MI for mile	KM,MI
Inspection passfail	VARCHAR	1	Inspection result, P for Pass, F for Fail	P,F
Vehicleyear	NUMBER	4	Vehicle year	
Vehiclemake	VARCHAR	100	Vehicle make	
Vehiclemodel	VARCHAR	100	Vehicle model	
Vehicletypecode	VARCHAR	5	Code to indicate vehicle type	AMB, AMBU, BUS, CAR, MCYC, MPED, TRK, TRL
Twoyearinspectioncertissued	VARCHAR	100	Indicates if the two-year inspection certificate is issued	Y, N
Gvw	VARCHAR	1000	Gross vehicle weight	
Reinspectionyn	VARCHAR	1	Indicates if this is a re-inspection	Y,N

The data were reviewed to identify unique vehicles, by VIN, with at least two inspection records containing odometer readings. Both passed and failed inspections were considered valid for this purpose, provided the inspections did not occur on the same date and odometer readings were captured for each inspection.

Unique vehicles (949,589) with at least two odometer readings were identified in the November 2019 PMVI dataset.

Late-model (model year 2018–2020) vehicles generally did not have two odometer readings in the dataset, because new vehicles are not required to obtain a safety inspection for two years. As a result, these vehicles were excluded from the analysis (those model year 2018 vehicles with two inspections were included). Some vehicles built prior to 1981 were also excluded due to inconsistent data in the VIN column. The exclusion of new vehicles generally corresponds with removing higher-income and urban households from the analysis, since urban households tend to purchase and operate newer vehicles. Newer vehicles also tend to have better fuel economy than older vehicles. Table 6 shows the breakdown of passenger vehicles by model year.

Table 6: Percent of Passenger Vehicles, by Model Year Category

VEHICLE MODEL YEARS	PERCENTAGE OF REGISTERED PASSENGER VEHICLES
1921–1980 – Inconsistent VIN Formats, Excluded from Analysis	0.08%
1981–2017 – consistent VIN Format, Considered for Analysis	87.95%
2018–2020 – Consistent VIN Format but Probable Insufficient Odometer Readings; may be Excluded from Analysis	11.97%

2.4. Step 3: Calculate Annualized Mileage from Periodic/Annual Motor Vehicle Inspection

PMVI data for the 949,589 vehicles with at least two odometer readings were used to calculate annualized mileage. Since the "annual" vehicle inspection rarely occurs at exactly 12-month intervals, annualized mileage was calculated as follows:

- A judgment was made to include vehicle records in the analysis only if the two most recent inspection dates were at least eight months apart and contained odometer readings. Eight months was deemed a sufficient period of time to determine a reliable annualized number of miles driven. If the two recent inspection dates were at least eight months apart:
  (1) Calculated difference between most recent odometer reading and next most recent odometer reading.
  (2) Calculated number of days between most recent inspection and next most recent inspection, using the *inspectiondate* field.
  (3) Divided the result of (1) by the result of (2) to estimate daily mileage.
  (4) Multiplied the result of (2) by 365 to estimate annual mileage.
- If the wo most recent inspection dates were fewer than eight months apart, prior inspection data were searched in reverse order until an inspection at least eight months prior to the most recent one was found. Odometer data from that date were used, following Steps (2), (3), and (4) above.

Where the inspection record indicated mileage reported in kilometers, measurements were converted to miles.

The input data for this step were the full PMVI dataset (Table 5). The output was the *Mileage Table*, the format of which is summarized in Table 7.

Table 7: Mileage Table Format

FIELD NAME	DATA TYPE	LENGTH	DESCRIPTION
FirstOdoDate	DATE	30	Inspection date of FirstOdo (first odometer reading)
LastOdoDate	DATE	30	Inspection date of LastOdo (most recent odometer reading)
FirstOdo	NUMBER	7	Previous (if more than 8 months before most recent) or earlier odometer reading
LastOdo	NUMBER	7	Most recent odometer reading
VIN	VARCHAR	17	Vehicle identification number
Mileage	NUMBER	7	LastOdo – FirstOdo (miles driven between two inspections)
InspectionInterval	NUMBER	4	Number of days between FirstOdoDate and LastOdoDate
AnnualizedMileage	NUMBER	7	Annualized mileage

Vehicles with a calculated average daily mileage greater than 500 miles were flagged as having a probable odometer read error. In some cases, simple data entry error is suspected. In others, it is suspected the 10-mile decimal was recorded as part of the odometer reading, leading to inflated measurements. For instance, the actual odometer readings may have been 11,095.7 and 42,089.6, approximately one year apart, for an average daily mileage of 82 miles, but the data were recorded in PMVI as 110,957 and 420,896, resulting in an average daily mileage of 820 miles. Since there is no way to confirm this observation, the record is excluded from analysis. Another possible reason for inflated mileage calculations is that the odometer reported kilometers, but the PMVI inspector noted miles as the unit of measure. In all, 1,486 vehicles were excluded at this stage.

2.5. Step 4: Merge Records from Department of Information Technology Dataset and Periodic/Annual Motor Vehicle Inspection-derived *Mileage Table*

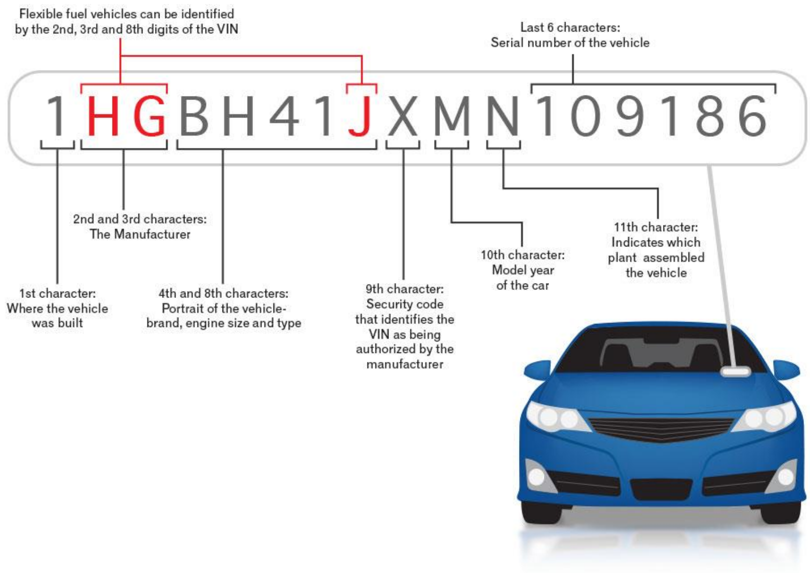
Next, the DIT dataset (Active and Inactive registrations only) were merged with the Mileage Table. There were 913,420 VIN matches between the two tables.

2.6. Step 5: Decode Vehicle Identification Numbers to Vehicle Details and Assign Environmental Protection Agency-Estimated Fuel Economy

Since 1954, all vehicles manufactured in the United States have been assigned a VIN. Until 1981, the format of the VIN was unstandardized and varied among manufacturers and even from year to year. The National Highway Traffic Safety Administration issued standards for VIN formats for vehicles destined for the U.S. market beginning with the 1981 model year.

The standardized VIN format is 17 characters and provides information about the vehicle’s make, model, model year, the location where it was assembled, trim characteristics (including engine type), and options (Figure 1).

Figure 1: Structure of Standard 17-Character Vehicle Identification Number[5]



One of the necessary conditions for effective data analytics using the Hawaii vehicle registry was to have a clean and rich set of vehicle data. Data entry errors, especially on the vehicle make, model, and year are a common occurrence, and the state's vehicle registry does not store EPA-estimated fuel efficiency values. Further, since the vehicle details recorded in the DIT data are owner-reported, independent verification of some details was necessary.

To address this issue, a tool was developed to decode a comprehensive set of vehicle data.

VINs from the DIT vehicle registry were "decoded" using a service hosted by DataOne Software. The DataOne database only contains VINs for model year 1981 and newer complete[6] passenger vehicles that were manufactured for the U.S. market. As such, older vehicles, heavy vehicles and those manufactured for commercial purposes, and vehicles sold as incomplete chassis do not decode.

Of the 913,420 unique vehicles that had a match in both the DIT registry and the Mileage Table, 95.4 percent successfully decoded to report vehicle model year, make, model, and EPA estimated fuel economy.

A review of un-decoded VINs identified several categories of vehicles that are (1) in the DIT vehicle registry and (2) have undergone periodic inspections under the state's passenger vehicle inspection program:

- Large vehicles such as dump trucks, owned by state and county agencies
- Small Neighborhood Electric Vehicles (NEV) such as shuttles and golf carts

[5] yourmechanic.com, "How to Read a VIN," November 2016.
[6] VINs for vehicles manufactured and sold as incomplete chassis do not decode to an EPA-estimated MPG.

- Vehicles sold as incomplete chassis. These are typically customized to support various trades (e.g., plumbing and electrical contractors) or converted to various types of transit vehicles, dump trucks, or flatbed trucks.
- Dune buggies and other small recreational (generally off-road) vehicles
- A range of Subaru, Toyota, and Nissan passenger cars. It is possible this is due to an omission in the DataOne database. It is equally possible these vehicles were not manufactured for the U.S. market and were imported to Hawaii.

Examples of un-decoded VINs are provided in Table 8.

Table 8: Examples of Invalid and Undecoded VINs not Included in Project Analysis

VIN	VEHICLE TYPE	COMMENTS
52CG2DGA4E0004293	Polaris ATV/Buggie	Off-road/Recreational Vehicle
17N330126JW009148	1988 John Deere Tractor	Tractor – Not a Legal Street Vehicle
10RLA2B46BA000654	EZGO Golf Cart	
FG1351	Unknown	Appears to be a license plate number rather than a VIN.
P6EA43399	Unknown	

EPA provides three estimates of vehicle fuel economy for vehicles: highway, city, and combined. Highway miles per gallon (MPG) is an estimate of the expected fuel economy in free-flow, highway speed conditions. City MPG is an estimate of the expected fuel economy in lower speed, stop-and-go conditions typical of city driving. Combined fuel economy is a weighted average of city and highway MPG (55 percent city value and 45 percent highway). Most passenger vehicle make/model combinations decode to more than one set of MPG estimates due to variations in vehicle trim or equipment. For instance, a 2014 Nissan Cube 1.8S has an EPA combined city/highway MGP estimate of either 27 or 28 MPG, depending on the transmission. For the purposes of this analysis, the project team used combined MPGs and, where there was more than one for a given vehicle model, took the average of all decoded MPGs for all traditional internal combustion and conventional hybrid vehicles.

The EPA fuel economy estimates for electric vehicles are presented as mile-per-gallon equivalents (MPGe) so that they can be incorporated into Corporate Average Fuel Economy (CAFE) analysis. For the purposes of estimating motor fuel tax payments, these figures are not valid. So, for all fuel-efficient or alternative-fuel vehicles, the MPG was set to zero.

With the exception of vehicles that could be definitively identified (via manual inspection of VINs) as passenger fuel-efficient or alternative-fuel vehicles, vehicles with un-decoded VINs were not included in any further analysis.

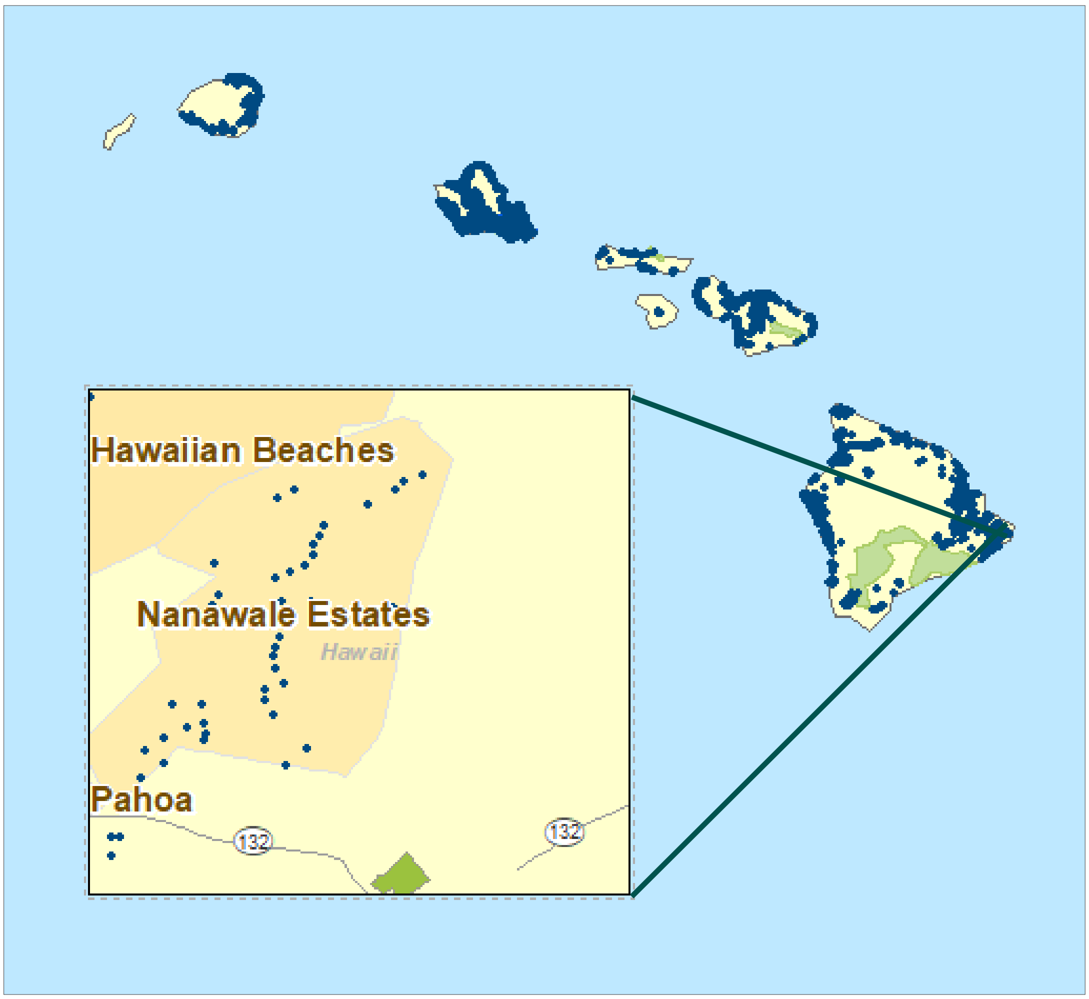
2.7. Step 6: Clean Mailing Address Data and Geocode Addresses

The next step was to map vehicles to their addresses. ESRI's Streetmap Premium geocoding service was used. This was done so that vehicles could be assigned accurately to either rural or urban areas.

The first run through the geocoding routine placed only about six percent of the dataset. Vehicles could not be mapped as a result of a range of issues with mailing addresses, including incorrect or malformed ZIP codes, street names being spelled differently or incorrectly, city names being spelled differently or incorrectly, and incorrect street numbers. A significant data cleansing effort was undertaken, after which 81 percent of vehicles were located successfully using the geocoding service. This includes out-of-state addresses.

A disproportionate number of un-located vehicles were registered in Kauai, Maui, and Hawaii Counties. An effort was made to manually locate as many of these as possible using web research and Google Maps, to reduce the chance that Honolulu City and County would be over-represented in the analysis. Ultimately, 121,716 addresses, accounting for 14 percent of vehicle mailing addresses in Hawaii, were placed manually. Figure 2 illustrates the result of the geocoding activity. Each blue dot represents one vehicle.

Figure 2: Vehicles Mapped to Owner's Mailing Address

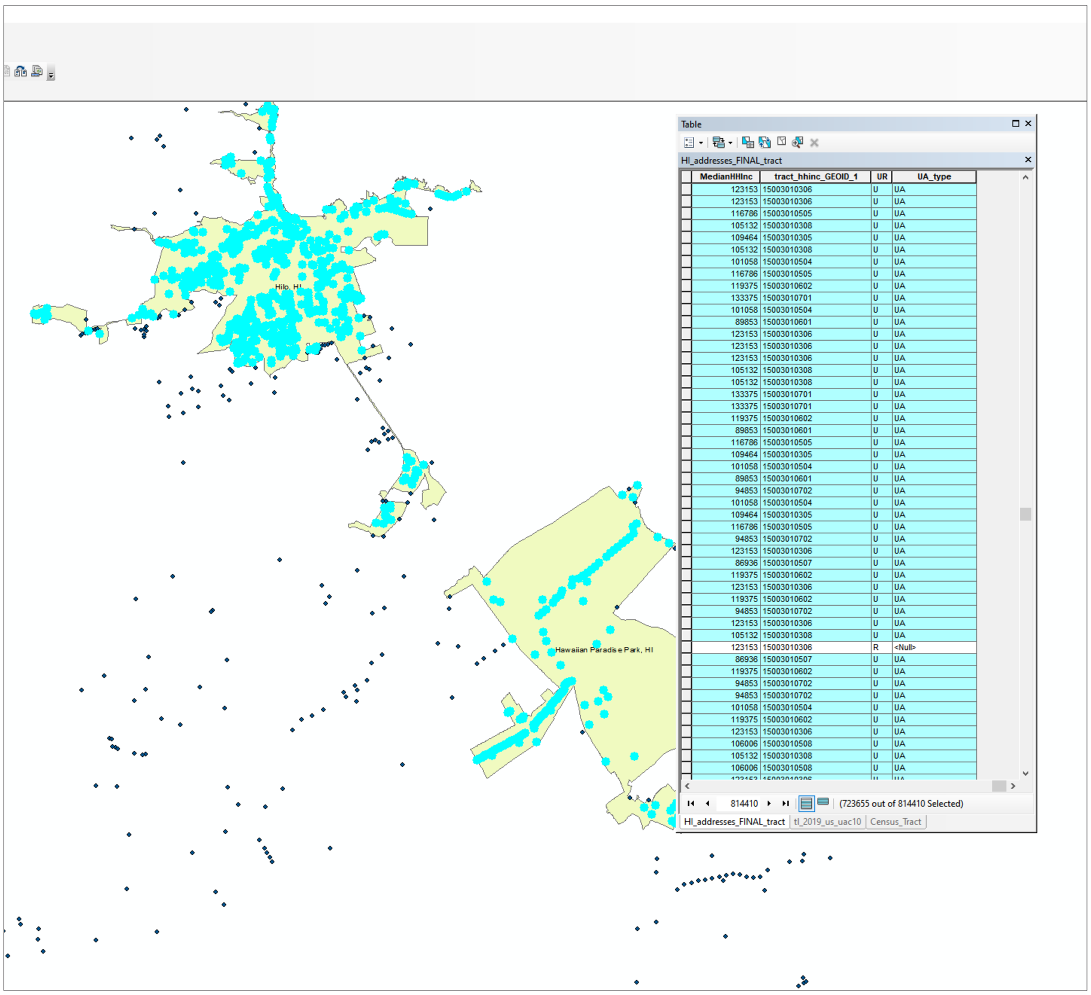


Addresses outside Hawaii were located, but they are excluded from the detailed analysis since it is not possible to assign them to the "rural" or "urban" categories for Hawaii. A significant number of rental cars have registration mailing addresses outside Hawaii and, therefore, were excluded from this analysis.

2.8. Step 7: Determine Whether Vehicle Addresses are in Urban or Rural Areas

To assess potential differential impacts of a RUC in different parts of the state, it was necessary to identify each vehicle as being located in an urban or rural location. Using geospatial data available from the U.S. Census Bureau, the project team selected all vehicle addresses that intersect locations defined by the Census Bureau as “urban” and assigned them “urban” status, as shown in Figure 3. Vehicle addresses outside urban areas were assigned “rural” status.

Figure 3: Assignment of Urban and Rural Designations



2.9. Step 8: Clean and Finalize Data

At this stage, there is a dataset with vehicle details (make, model, MPG), annual vehicle mileage, and urban/rural designations. There were 813,851 vehicles (89 percent of all vehicles with a DIT registration record and at least two inspection odometer readings) ultimately included in the detailed analysis.

Vehicles were excluded from the analysis at each step of data preparation. Reasons vehicles were excluded from the detailed analysis include:

1. Vehicle mailing address is outside Hawaii.
2. Vehicle mailing address could not be located inside Hawaii.
    a. Address in the DIT database could not be matched.
    b. Address in the DIT database is incomplete.
    c. Address in the DIT database does not exist.
    d. Address in the DIT database is a P.O. Box or Rural Route that could not be resolved to a Census Tract or ZIP Code Tabulation Area (ZCTA).
3. Vehicle's VIN did not decode to an EPA-estimated MPG. Reasons this may have occurred include:
    a. Vehicle is not a light passenger vehicle. While heavy vehicles are not required to undergo PMVI, a number of large vehicles are found in both the DIT and PMVI databases.
    b. Likewise, a number of golf carts, dune buggies, and NEV were identified.
    c. Vehicle was not manufactured for the North American market.
    d. Vehicle was manufactured prior to 1981.

The exact number of vehicles falling into each of these categories was not determined because it does not have bearing on this research, but the number is included in the total for "undecoded VIN."

Next, for each vehicle, values were calculated for the following:

- Estimated motor fuel tax paid per mile driven.[7] This calculation uses the vehicle's EPA-estimated city/highway combined MPG value and the state gas tax rate of $0.16 per gallon.
- Estimated annualized motor fuel tax paid.
- Annualized RUC. This calculation is based on a state RUC rate of $0.008 per mile driven (see Section 4. Analysis).
- Difference between estimated annualized motor fuel tax and annualized RUC.

[7] Motor fuel taxes paid are estimates, since the values provided by EPA for fuel economy are estimates. Actual fuel consumption varies based on a number of factors, including travel conditions and driver behavior.

3. Analysis

All modeling is based on a statewide a near-revenue-neutral RUC rate of $0.008 per mile. A revenue-neutral RUC rate means that the revenue brought in by the RUC is equal to revenue currently generated by fuel taxes. For purposes of the HiRUC demonstration, a rate of $0.008 miles was chosen for simplicity, but is actually slightly higher than the true revenue neutral rate due to rounding.

3.1. General Observations: Statewide

At a per-mile RUC rate of $0.008, both urban and rural drivers will see, on average, a slight annual increase in cost. This is because the HiRUC project set the per-mile rate slightly higher than revenue-neutral, due to rounding up for simplicity (Table 9).

Table 9: Average Annualized Cost Difference for Urban and Rural Drivers (Statewide)

CATEGORY	NUMBER OF VEHICLES	AVERAGE ANNUAL STATE GAS TAX PAID AT $0.16/GAL	AVERAGE ANNUAL STATE RUC PAID AT $0.008/MI	AVERAGE ANNUAL COST INCREASE FROM GAS TAX AT $0.16/GAL TO RUC AT $0.008/MI
Rural Vehicles	90,733	$77.40	$78.72	$1.32
Urban Vehicles	723,494	$62.18	$67.20	$5.02

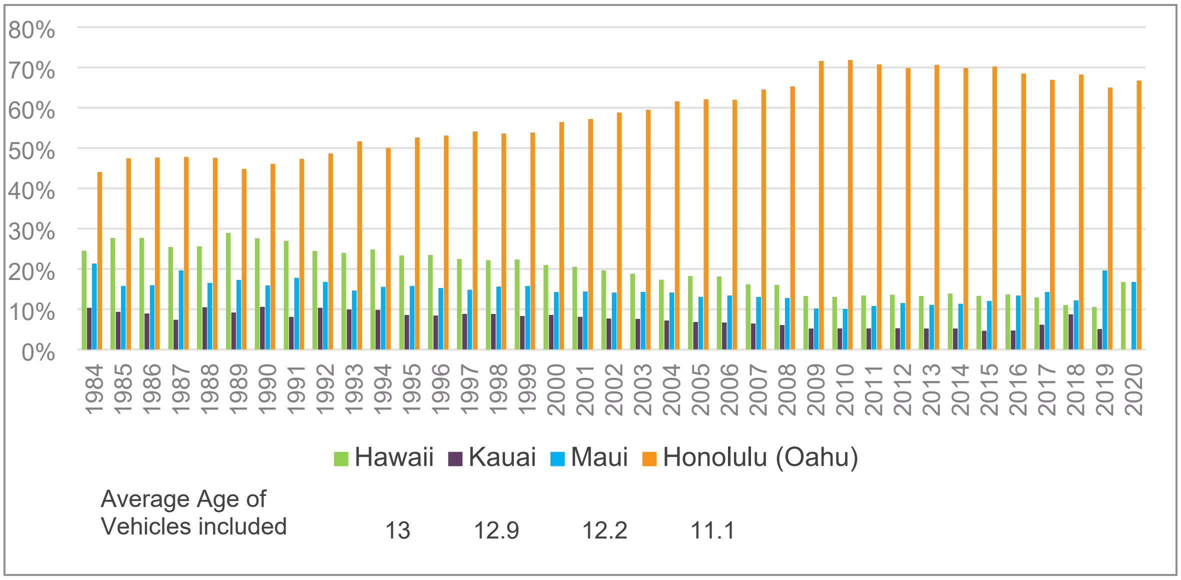
The pattern holds at the county level (Table 10), with average state RUC payment being slightly higher than the current gas taxes. Again, this slightly higher cost is a result of the RUC rate being set slightly higher than the mathematically revenue-neutral level due to rounding, not a result from any variations in driving, vehicle fuel economy, or demographic factors.

Table 10: Average Cost Difference, Road Usage Charge Compared to Motor Fuel Tax, by County

COUNTY	NUMBER OF VEHICLES IN ANALYSIS	AVERAGE ANNUAL COST DIFFERENCE, RUC VS. MOTOR FUEL TAX (DOLLARS)
Hawaii	131,136	1.78
Kauai	51,036	0.25
Maui	104,603	2.94
Honolulu (Oahu)	527,076	6.12

The difference in average RUC paid between counties is driven primarily by the composition of the vehicles within the respective counties. Figure 4 illustrates the distribution of vehicles by model year across the counties. Oahu has a much larger share of late-model vehicles, which generally have better fuel economy than older vehicles. As Honolulu County trends more urban than the other counties, this distribution describes how rural vehicles would not be disproportionately affected by a RUC. A secondary contributor to the average cost difference between counties is average daily miles traveled.

Figure 4: Percent of Vehicles included in the Analysis that are Registered to Each County by Model Year (November 2019)



3.2. General Observations: Urban and Rural Vehicles

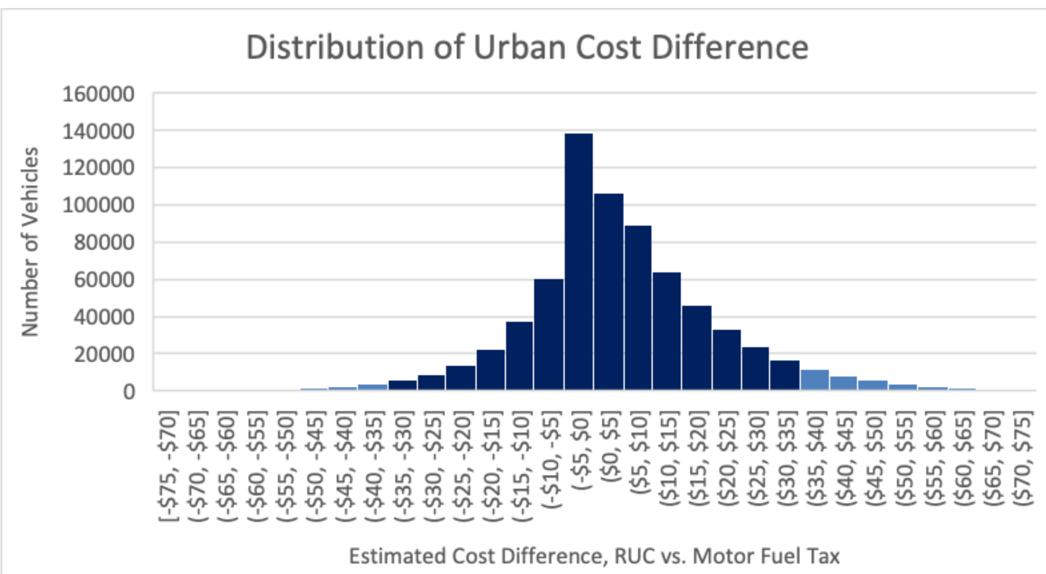
Statewide, vehicles with rural addresses travel slightly more than those with urban addresses, on average. On Maui, the difference is negligible, but other counties range up to 3 miles per day more travel for rural vehicles than for urban. Community feedback from rural drivers indicated that they were concerned about being adversely impacted by a RUC due driving longer distances than urban drivers; the data in Table 8 and Table 9 indicate that they will not be disproportionately impacted. In all four counties, vehicles registered to urban addresses average slightly higher fuel economy ratings, primarily because they tend to be newer. Table 11 summarizes these observations. The net result is that rural drivers currently pay more in gas taxes on average than their urban counterparts, both in gross annual payments and on a per-mile basis. Under a revenue-neutral RUC, they would pay less on average.

The averages illustrate broad trends, but there are some interesting nuances within the urban and rural vehicle populations. While the *average* difference in the annual cost of RUC and motor fuel taxes is quite small, the cost of RUC will be noticeably higher for some vehicles and noticeably lower for others. Figure 5 and Figure 6 illustrate the distribution of cost increase or decrease for urban and rural areas. Overall, 90 percent of all vehicles would see a change of plus or minus $35 in annual costs if a RUC replaced gas taxes.. The distribution for urban areas skews slightly right, in keeping with the overall average higher price of RUC than gas taxes. This is driven by the higher fuel economy distribution of vehicles in urban areas.

Table 11: Average Daily Distance Driven and Average Vehicle MPG for Urban and Rural Vehicles (by County)

COUNTY	AREA TYPE	AVERAGE MILES PER DAY	AVERAGE MPG[8]
Statewide	Urban	22.6	23.4
	Rural	26.3	21.8
Hawaii	Urban	25.5	21.98
	Rural	28.6	21.67
Kauai	Urban	23.6	21.61
	Rural	25.1	21.43
Maui	Urban	23.1	22.61
	Rural	23.4	22.0
Honolulu (Oahu)	Urban	22.6	23.84
	Rural	25.0	22.95

Figure 5: Distribution of Estimated Annual Change in Cost for Vehicles in Urban Areas (note: 90% of vehicles shaded darker blue)



The distribution for rural areas is slightly flatter, suggesting a higher proportion of rural vehicles will see greater increases or decreases than in urban areas.

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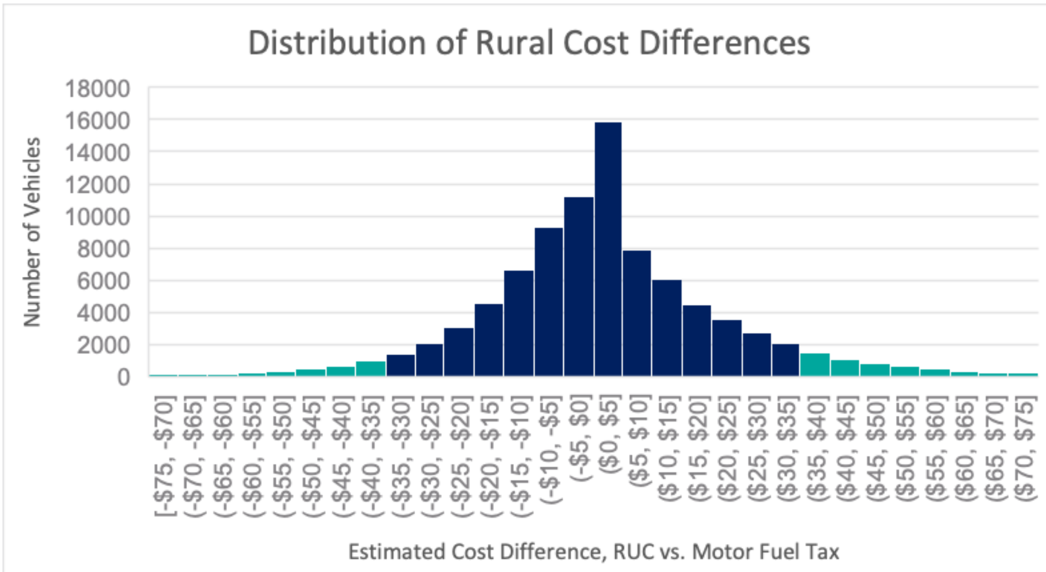
[8] The calculation of average MPG includes MPGe estimates for electric vehicles.

Figure 6: Distribution of Estimated Annual Change in Cost for Vehicles in Rural Areas (note: 90% of vehicles shaded darker blue)



4. Summary

Throughout Hawaii, some vehicles will incur higher costs under a revenue-neutral RUC than under gas taxes, and others will incur lower costs. Those drivers who own less fuel-efficient vehicles would realize a net reduction in cost under RUC, while those with more fuel-efficient vehicles would realize a net increase in cost. The data suggest that on a general level, rural areas will not be impacted more than urban areas. Rural vehicles are, on average, less fuel efficient than those in urban areas, so drivers in rural areas are currently paying more on a per-mile basis. Under a revenue-neutral RUC, rural vehicle owners would, on average save money relative to what they pay today in gas taxes. The distribution of these changes is consistent between urban and rural vehicles across all counties in Hawaii.