March 29, 2018

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2018 MAR 29 P 2:49

PUBLIC UTILITIES
COMMISSION

The Honorable Chair and Members of the
Hawai'i Public Utilities Commission
Kekuanaoa Building, 1st Floor
465 South King Street
Honolulu, Hawai'i 96813

Dear Commissioners:

Subject: Docket No. 2016-0168
EV-F and EV-U Pilot Extension
Electrification of Transportation Strategic Roadmap

In accordance with Decision and Order No. 34592,[1] filed June 2, 2017 in the subject proceeding, the Hawaiian Electric Companies'[2] respectfully submit their Electrification of Transportation ("EoT") Strategic Roadmap ("Roadmap"). The Roadmap represents a straightforward guide, based on input from stakeholders, transportation and technical experts, policymakers, non-government organizations and perhaps most importantly, customers, for turning the Companies' transportation transformation plans into actions.

The Roadmap describes a number of steps to accelerate the EoT, including: (1) increasing electric vehicle ("EV") adoption by helping to lower costs and educating customers; (2) accelerating the buildout of EV charging infrastructure; (3) supporting the electrification of buses and other heavy equipment; (4) incentivizing EV charging to align with grid needs and save drivers and utility customers money; and (5) coordinating with ongoing grid modernization and planning efforts to help maximize the use of renewable resources. With these and other actions described in the Roadmap, the State can enhance its energy security and accelerate its transition from fossil fuels to renewable resources, both for the production of electricity and for ground transportation, while at the same time helping to facilitate more renewable resources online and helping to lower energy costs for customers.

If you have any questions on this matter, please call Brennon Morioka, General Manager, Electrification of Transportation at 543-7570.

Sincerely,

Daniel G. Brown
Manager, Regulatory Non-Rate Proceedings

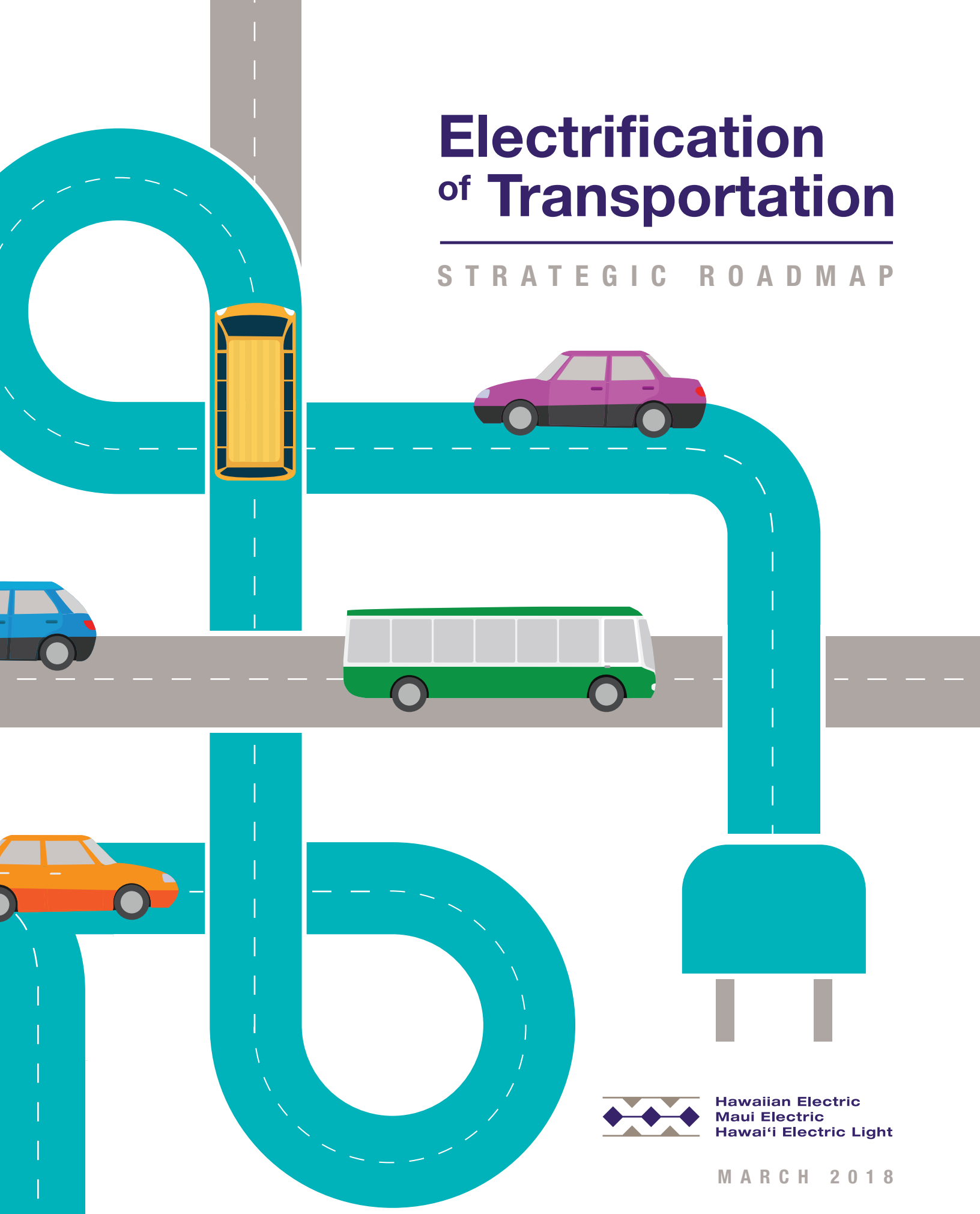
Attachment

c: Division of Consumer Advocacy
Department of Business, Economic Development, and Tourism

[1] See Ordering Paragraph 1.E at 68 ("The Companies shall file their 'Electrification of Transportation' strategy by or before March 31, 2018.").
[2] The "Hawaiian Electric Companies" or "Companies" are Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc. and Maui Electric Company, Limited.

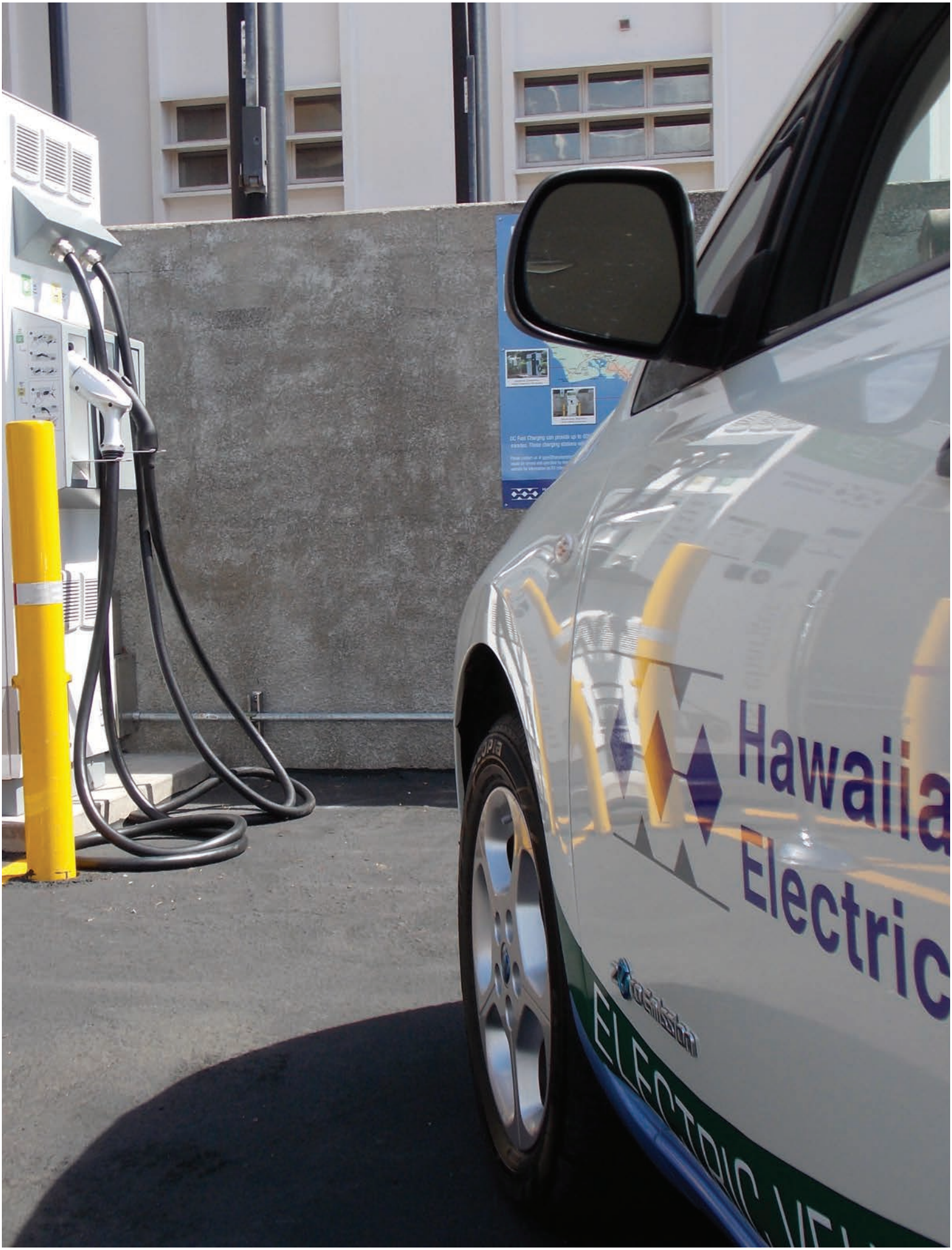
Electrification of Transportation

STRATEGIC ROADMAP



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

MARCH 2018


Hawaiia
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ELECTRIC VE

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Executive Summary

Here's what Hawai'i looks like in 2045:

The majority of vehicles on the road are running on electrons, not gas. There are tiny coupes, luxury sedans, pickups, motorcycles, SUVs, delivery vans, scooters, tour buses and sporty red convertibles. Autonomous cars, once a novelty, are a significant presence, running their sophisticated sensors and software off batteries charged at midday, when smart-charging rates are cheapest.

Shared vehicles, operated on technology platforms by neighbors, coworkers and students, are almost exclusively maintenance-free electric vehicles. Their batteries are topped off during the day by the autonomous charging services operating in popular parking areas, or at one of thousands of public chargers when excess solar production prompts a special pricing alert to drivers. Affordable ride pooling services have tamed traffic in urban areas and make it easy for elders, people with disabilities, and others who don't drive to get around.

Streets are quieter, with the rumble and growl of internal combustion engines replaced by the whir of EVs. Carbon emissions are significantly lower. During the day, most islands are using clean renewable resources like solar, wind and geothermal to meet all of the demand for electricity. Thanks to the reliably predictable times at which drivers have been incentivized to charge their cars, nearly every watt produced is a watt efficiently used, an essential requirement of a standalone island grid.

Most important, the charging of vehicles – especially trucks, buses and other heavy equipment – has made more room on the grid for nearly 200,000 new private rooftop solar systems since 2018, as well as numerous grid-scale renewable energy projects offering low-cost energy to every customer.

The Hawai'i of 2045 is powered by a clean energy ecosystem that hums with efficiency, using technology, advanced grid infrastructure and public policy to make the most of the state's renewable resources. Little is wasted because ground transportation and energy use are linked to optimize daytime charging and to use EVs as a key grid service resource.

"Most important, the charging of vehicles – especially trucks, buses and other heavy equipment – has made more room on the grid for nearly 200,000 new private rooftop solar systems since 2018,..."

This purposeful alignment provides obvious benefits to the efforts to reach Hawai'i's 100 percent renewable energy goal and to slow climate change. The good news is that if this alignment is deliberate and not haphazard, it will also strengthen the state's economy.

It could create $550 per EV in benefits to every utility customer over the next 27

years, and three times more if charging is "smart" and done at optimal times.

That's more than $311 million in potential benefits to the entire state once we add the gasoline and maintenance savings to EV drivers. Even at this relatively early stage of adoption, drivers need to get into the habit of charging smart, by avoiding evening peak hours and plugging in during the day or late at night. This will decrease the need for distribution system upgrades and support our ability to cost-effectively integrate solar energy.[1]

And long before we get to 2045, charging vehicles and equipment will lower the unit cost of electricity to everyone by spreading the utilities' fixed revenues across more kilowatt-hours. For example, charging a bus is equivalent to the energy used by 14 typical homes. This, combined with smart charging, will improve the cost-effective utilization of each island's grid infrastructure for the benefit of every customer and our state economy as a whole.

Because of its unique role as both the planner and operator of the grid infrastructure that will fuel the fleet of tomorrow, Hawaiian Electric – working with third-party charging providers, automakers, technologists, community planners, customers and other stakeholders – is in the best position to turn plans into actions. This roadmap is a straightforward guide to those actions and how Hawai'i can make the most of the global revolution that is transforming transportation.

The journey has already begun. Hawai'i has nearly 7,000 EVs registered, second only to California in per capita adoption rate. In 2017, Hawai'i's four counties announced their commitment to 100 percent clean transportation by 2045 and the conversion of their own fleets by 2035. The City and County of Honolulu is already testing electric buses with an eye toward replacing its diesel-powered fleet; other counties are considering similar moves.

[1] See Walton, R. January 31, 2018, "Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investment."

To build on this momentum and accelerate this journey, here are five key short-term steps that this plan will describe in greater detail:

1. Boosting EV adoption by working with automakers, dealerships and advocates to lower the cost and educate customers.
2. Accelerating the buildout of charging infrastructure, especially in workplaces and multi-unit dwellings. Providing a critical backbone of reliable, public utility-owned chargers as the launching point from which the broader electric transportation and third party charging market in Hawai'i can expand and solidify. Identifying and providing make-readies in gap areas to create opportunities for third party chargers that optimize grid and customer locations to meet driver needs.
3. Supporting bus operators in transitioning to electric with targeted outreach and programs that reduce the upfront cost and provide practical charging solutions. From there, efforts can move to trucks and heavy equipment.
4. Creating grid service opportunities by leveraging demand response programs and rates that incentivize EV charging to align with grid needs and save money for both drivers and all grid customers.
5. Coordinating with ongoing grid modernization and planning efforts to ensure smooth integration of EVs into energy delivery networks and maximizing use of renewable resources.

These steps will help position Hawai‘i to be ready when the price point for electric vehicles matches that of internal-combustion vehicles, which is expected by 2025. By planning now for this fundamental shift in consumer preferences, we can ensure the efficient sequencing of upgrades to the grid, influence consumer behavior and avoid a chaotic outcome that is costly to fix retroactively and could potentially slow the state's march toward energy independence.

Many of the tactics described in this plan have been road-tested by other utilities, most notably in California, which has led the nation in developing successful policies and technology-driven programs that have aligned the interests of manufacturers, consumers, local governments and the state's ambitious renewable energy goals.

Examples of successful programs in California and elsewhere are cited throughout this plan. These examples are a reassuring reminder that although much work lies ahead in the transition from fossil fuels, Hawai‘i doesn't have to "reinvent the wheel" and can learn from the experiences of other jurisdictions. And yet, the opportunity from these programs to yield combined benefits for the transportation and energy sectors and customers in our state are even more acute in the context of our isolated island geography and our state's 100 percent renewable energy policy.

Hawaiian Electric employed a structured, data-driven approach to arrive at this vision for our role in the transportation transformation. We also consulted stakeholders, transportation and technical experts, policymakers, and non-government organizations. And we relied on our own experience with electric vehicles, which dates to the 1960s and today includes a fleet that is 14 percent hybrid or fully electric.

Perhaps most important, we and other Drive Electric Hawai‘i partners talked to customers with and without EVs, and asked them about their transportation needs and interests. Their insights helped inform a set of guiding principles that were used to ensure that our priority remains customer and community value.

These conversations also helped prioritize our actions. For example, we heard from many apartment and condominium dwellers who want to drive an EV, but are hesitant because they lack convenient access to chargers. Because this is such a large potential market, especially in Honolulu, developing partnerships with building managers and exploring pilots used successfully in other markets is a key action step.

With this and other actions described in this plan, Hawai‘i can enhance its energy security and clean energy economy and accelerate its transition from fossil fuels to renewables, both for the production of electricity and for ground transportation.

And here's the best part: If this plan works right, EVs can be both a clean, stylish form of transportation and a flexible piece of grid hardware that will make it easier to bring more renewable resources online and lower energy costs for everyone.

1. Our approach to developing Hawaiian Electric's EoT Strategic Roadmap

Renewable energy growth and electrification of transportation are complementary, greater clean energy impacts and customer value can be created by achieving both in tandem.

Go. David Ige, in his 2017 and 2018 State of the State addresses, outlined a vision for how Hawai'i can expand on its clean energy progress.[1] He describes a transition that includes both rapid expansion of renewable energy and electrification of transportation, stating that "reducing Hawai'i's reliance on fossil fuels in transportation is a key component of our renewable energy goal."

So we know our destination. The purpose of this Roadmap is to lay out the best route to get there. And like any journey, one of the most productive mapping methods is to talk with experts who are on similar journeys, as well as people who have ideas about what they'd like to see along the way.

This chapter describes how we drew our Roadmap relying on the expertise and resources of the entire Electrification of Transportation (EoT) sector. Our process combined customer and stakeholder input with stringent analysis and a review of industry best practices.

Guiding Principles help avoid detours

To ensure that we stayed on course, and to guide our discussions with EoT experts, the Hawaiian Electric team developed a set of Guiding Principles (see Figure 1). These principles provided a critical foundation for

[1] Ige, David 2017. "2017 State of the State Address." https://governor.hawaii.gov/main/2017-state-of-the-state-address/

Figure 1. Guiding Principles for EoT Strategic Roadmap Development

Increase customer options (with a simple customer experience)
Enable greater customer engagement, empowerment, and options for utilizing and providing transportation services

Maintain the safety and reliability of the grid
Maintain and enhance the safety, security, reliability, and resiliency of the electric grid, at a fair and reasonable cost, consistent with the state's energy policy goals

Provide benefit to all customers
Facilitate comprehensive, coordinated, transparent, and integrated grid planning across distribution, transmission, and resource planning

Ensure optimized utilization of resources and electricity grid assets to minimize total system costs for the benefit of all customers

Ensure fair compensation for electric grid services and benefits to and by customers and other non-utility service providers

Align with other utility programs aimed at achieving 100 percent RPS
Align and synergize with other transformation and market initiatives such as defined grid service needs, demand response, distributed energy resources, the power supply improvement plan, grid modernization and integrated grid planning.

Develop EoT products and services through innovation and partnership
Hawaiian Electric cannot achieve these goals on our own. We will build coalitions to work together in a coordinated manner and leverage EoT industry resources and enable EoT partners to provide value to customers

decision-making as we moved through the development of our Roadmap.

Note that customer value and societal benefit are embedded within each of these principles. By keeping sight of these essential guideposts, we worked to avoid getting detoured by any number of "roadside attractions," including speculation about technological breakthroughs, advanced vehicle designs and future demographics.

We next undertook extensive information gathering to ensure that our strategy was informed by our customers, stakeholders, and the latest expert thinking on EoT.

Our information came from six key sources:

1. Stakeholder engagement, via a workshop and small group meetings;

2. Customer research, including panels and surveys of those that do and do not own EVs, plus one-on-one conversations with large customers;

3. A review of Hawai'i's clean energy and EoT policy context, including relevant regulatory proceedings and decision and orders;

4. A literature review on EoT market barriers and solutions, including calls with industry experts;

5. A survey of mainland U.S. utility filings and decisions on EoT action; and

6. Expert knowledge and modeling from retained consultants Energy and Environmental Economics (E3), CALSTART and Integral Analytics.

The information collected from these sources informed the remainder of our Roadmap.

A key element of our engagement was a November 9, 2017 EoT Stakeholder Workshop hosted by Hawaiian Electric with 85 participants. These included national, state and local government representatives, representatives from the U.S. military, members of Drive Electric Hawai'i, auto dealer representatives, automakers, charging providers, union representatives, transportation network company (TNC) operators, and advocacy groups. Figure 2 provides photos of the day.

The workshop agenda consisted of:

a. Presentations by E3 and CALSTART on the state of EoT technology and policy around the world,

b. Panel session with policy and industry experts that sought to highlight the key opportunities, barriers and issues surrounding EoT in Hawai'i, and

c. Breakout groups involving all attendees, which were designed to ensure we heard the full spectrum of perspectives on EoT benefits, barriers, knowledge gaps, and potential solutions.

Appendix B: Agenda for Hawaiian Electric's EoT workshop, November 9, 2017 provides additional detail on the agenda, and Appendix C: Invitees to Hawaiian Electric's EoT workshop, November 9, 2017 is a list of invitees and attendees.

Figure 2. Photos from Hawaiian Electric's November 9, 2017 EoT workshop

Source: Hawaiian Electric

After the workshop, we emailed all 142 invitees an online survey to ensure that we captured any opinions that were not proffered at the Workshop. Appendix D: Follow-up online survey sent to invitees to Hawaiian Electric's EoT Workshop, provides a copy of this survey. We received 30 responses.

In addition to this workshop and survey, we held follow-up conversations by phone and in-person with a number of key stakeholders, including meetings on O‘ahu, Hawai‘i Island, Maui, and Moloka‘i.

We have also been engaging through one-on-one conversations with a number of large customers, for example all three counties, the state Department of Transportation, the University of Hawai‘i, Matson Navigation, Kahului Airport, private bus service providers, and large commercial landowners. The aims of these conversations have been to raise the profile of EoT, share information, hear customers’ plans, and understand what they would find most useful from the utility.

Our policy, proceeding and literature reviews were extensive, as was our survey of national utility filings on EoT. These were supplemented by in-person and phone conversations with a number of experts, including EoT program leads at mainland utilities with significant EoT programs, TNC and car share operators, NGOs, automakers, charging providers and those who are implementing low- and moderate-income EoT programs.

Figure 3 provides a list of all the stakeholders and experts that we engaged with during the development of this EoT Roadmap, either at the workshop, by phone, in person, or through responses to our written

Figure 3. Organizations that provided input to the EoT Strategic Roadmap

Automakers and Dealerships
Proterra
BYD
Ford
Nissan
Tesla
Chanje Energy
Hawai‘i Auto Dealers Association

Charging Solution Providers:
Greenlots
OpConnect
ChargePoint
Hitachi (JUMPSmart)
Mobi Freewire
FleetCarma

Fleets:
Uber
Lyft

Bus Service Providers:
JTB Hawai‘i
O‘ahu Transit Services
Roberts Hawai‘i

Advocacy Groups and NGOs
Blue Planet Foundation*
Distributed Energy Resources Council
Elemental Excelerator
Maui Economic Development Board
Ulupono Initiative*
O‘ahu Economic Development Board
Forth
GoGreen Culture Foundation
Big Island EV Association

Labor
IBEW Local 1260

Public Agencies, Offices, and Representatives
Office of the Governor
Dept. of Commerce and Consumer Affairs, Consumer Advocate*
Public Utilities Commission staff
Dept. of Business Economic Development and Tourism, Energy Office*
Dept. of Education
Dept. of Transportation*
- Highways Division
- Airports Division
- Harbors Division

Office of Senator Lorraine Inouye
Dept. of Transportation Services
Honolulu City Council members
Hawai‘i County Council members
Maui County Council members
County of Hawai‘i
- Research & Development

City and County of Hawai‘i
- Office of Climate Change, Sustainability, and Resiliency
- Dept. of Transportation Services

County of Maui
- Office of Economic Development

U.S. Army
U.S. Navy
Hawai‘i Sustainability Coordinator
Honolulu Board of Water Supply
Environmental Protection Agency - Hawai‘i
University of Hawai‘i at Mānoa
University of Hawai‘i at Maui
Hawai‘i Natural Energy Institute
Maui Metropolitan Planning Org.

Other
Hawai‘i Energy
Matson Navigation

Mainland Utilities
Southern California Edison
San Diego Gas & Electric
Southern Company
Portland General Electric
Pacific Gas & Electric

Consultants
Energy and Environmental Economics (E3)
CALSTART

Hawaiian Electric* and Affiliates
Business Development & Strategic Planning
- EoT
- Demand Response
- Business Development

Public Affairs
- Government & Community Affairs
- Corporate Communications Customer Service
- Customer Solutions
- Marketing

HEI— Strategic Planning
Planning & Technology
- Technical Planning Services (Forecasting)
- Distribution Planning
- Advanced Planning

Legal
Energy Delivery—Fleet Services
Maui Electric Company
Hawai‘i Electric Light Company

*Drive Electric Hawai‘i Member

survey. We propose to continue these conversations as part of our EoT initiatives, as described in Chapters 6 – 8. A number of these stakeholders and experts have provided letters of support for our Roadmap – see Appendix A: Stakeholder letters of support.

Our strategy development also incorporated significant customer research on EoT. We drew from six surveys and focus groups commissioned by various parties in Hawai‘i:

- From February 2014 - Ward Research performed a focus group related to EVs for Hawaiian Electric, specifically on the impact of the companies' EV pilot rates on the adoption of EVs.

- From 2015 - Needs Assessment Survey which asked all respondents what would make them most likely to eventually purchase an EV.

- In 2016, Ulupono Initiative surveyed EV drivers statewide to learn what factors drivers considered when charging vehicles at public stations, and also inquired about time-of-use (TOU) rates and an EV demand response (DR) program

- Finally, in 2017 Hawaiian Electric commissioned two surveys on EV charging: one of non-EV owners to better understand purchasing likelihood and influences/constraints; another was of EV owners to better understand their charging habits and preferences for EVs.

Finally, our EoT consultants, E3 and CALSTART, provided input, assistance with stakeholder engagement, and modeling. E3 regularly advises utilities, regulators, automakers, electric vehicle service providers (EVSPs) and other stakeholders on EoT barriers and policy, and have also performed numerous technical studies on aspects of EoT. A major focus of their work has been exploring the potential for EV charging load to facilitate integration of variable renewable generation (especially solar) via smart charging measures. E3 also performed the investment modeling for the companies' updated Power Supply Improvement Plan (PSIP), which was leveraged to produce the EoT modeling presented in this roadmap. CALSTART is North America's leading consortium on advanced transportation technologies. They are a non-profit organization and nationally renowned as a strategic broker that provides expertise to assist organizations in planning, developing, testing and implementing clean transportation and mobility programs. They provided input on the barriers and issues facing the medium-duty, heavy-duty and off-road electrified vehicle segments, and assisted with our stakeholder engagement.

Analysis of EV adoption, loads, benefits and costs

Hawaiian Electric also performed analysis to assess the grid impacts of EoT on the companies' system and the cost impacts on its customers. To inform the utility's planning processes, Hawaiian Electric, with input from consultant Integral Analytics, developed a forecast for light-duty electric vehicle adoption and associated loads. Further detail on this forecast is provided in Chapter 3 and Appendix E: Electric vehicle forecast methodology and assumptions.

"Our strategy development also incorporated significant customer research on EoT. We drew from six surveys and focus groups commissioned by various parties in Hawai‘i."

Working with E3, we combined these EV adoption and load forecasts with Hawaiian Electric's system data and the latest industry cost estimates for EVs to provide a cost-benefit analysis of personal electric vehicles, using O‘ahu as an initial case study (O‘ahu currently accounts for 60 percent of registered, taxable passenger vehicles in the state).[2] This assessment used established Standard Practice Manual cost-benefit

[2] DBEDT Monthly Energy Trends, January 2018, http://dbedt.hawaii.gov/economic/energy-trends-2/

methodologies,[3] which E3 has in recent years applied to EoT for utilities and regulators in California, Washington state, Oregon, New York, and Ohio. The analysis also builds directly from work performed by E3 for Hawaiian Electric's 2016 Power Supply Improvement Plan filing,[4] making use of the same grid modeling and data inputs for generating resource availability and costs, operating conditions, fuel costs, and discount rate. In Hawai'i, as in all jurisdictions in which E3 has performed this analysis, E3 found that the adoption of EVs creates net economic benefits to society as a whole, as well as to Hawaiian Electric's non-EV-driving customers. This is true even with Un-Managed Charging, but incentivizing Smart Charging is illustrated to create even more significant net benefits as it increases the use of low-cost renewable energy and defers distribution system upgrades (see Chapter 3).

In addition to assessing the direct economic benefits of EVs, we worked with E3 to evaluate the reductions in fossil fuel use and carbon dioxide emissions that are projected to stem from EV adoption. The results of all these analyses are provided in Chapter 3.

Defining Hawaiian Electric's role in EoT

Equipped with an understanding of the benefits from EoT, we sought to create a strategy for Hawaiian Electric's role in promoting EoT and enabling cost-effective, proactive grid integration that is consistent with the Guiding Principles outlined above and provides maximum customer value.

We began with a Technology and Barriers Assessment, drawing from all the information sources listed previously. This is presented as Chapter 4. This allowed us to select and sequence electrified vehicle technologies for focus, by considering a) technologies' state of maturity and commercialization, b) their cost premium compared with conventional vehicles, and c) their suitability for Hawaiian Electric's service territories. This resulted in a near-term focus on widespread adoption of electric light-duty vehicles and electric buses. It also enabled us to identify the key barriers to adoption and system integration challenges faced by each technology and each customer segment.

The next step was to determine the right role for Hawaiian Electric in helping to overcome these adoption barriers and promote smart charging. We combined the information gathered from all our sources to assess the actions that are needed from across the EoT industry and policy landscape to lower barriers and promote adoption. From there, we applied a 'Funnel' to filter for the Hawaiian Electric actions that we are ultimately proposing. Figure 4 displays this Funnel. We filtered for actions that will create value for Hawaiian Electric customers, and which will harmonize with our existing programs and planning processes. Internal discussion, feedback from stakeholders, and the guidance provided by the Commission also made it clear that Hawaiian Electric's actions should leverage the companies' unique capabilities and cost advantages and enable industry partners to do the same. Finally, it is important that our proposed actions build on utility action tried in other regions, while considering conditions unique to Hawai'i and key differences between islands. Chapter 5 provides additional detail on this Funnel process and summarizes the companies' proposed EoT initiatives. Chapters 6 through 8 drill down on details of our proposed initiatives for light-duty vehicles, buses, and other vehicles, respectively.

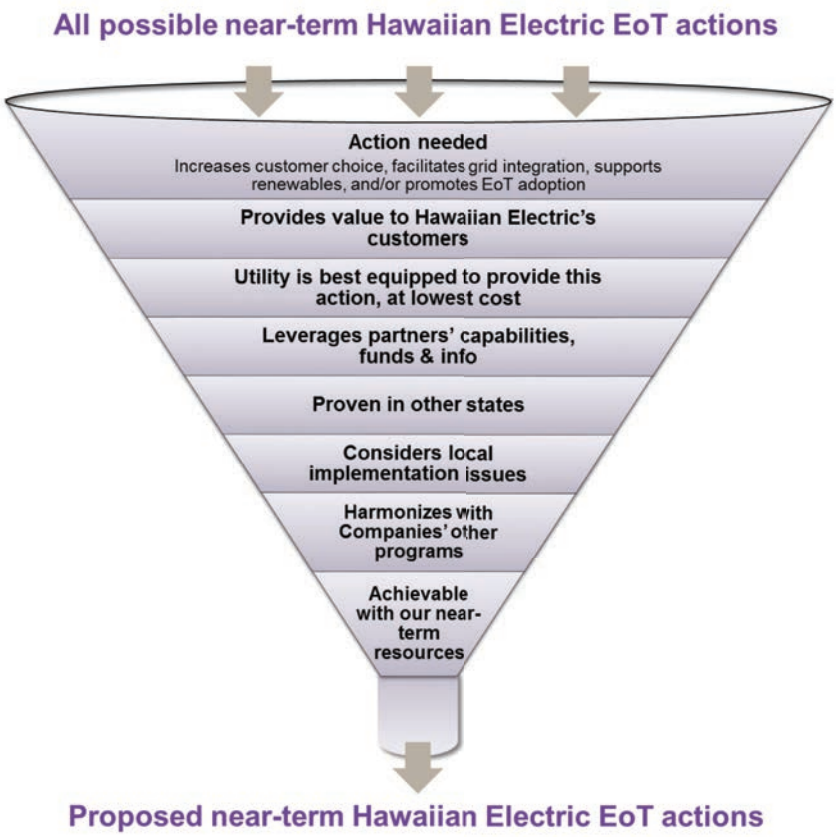
Considering alternative pathways to decarbonized transportation

This Roadmap focuses on battery electric and plug-in hybrid vehicles. Renewable

[3] California Standard Practice Manual, 2001, http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

[4] Docket No. 2014-0183, Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited, PSIP Update Report: December 2016 filed December 23, 2016.

Figure 4. Funnel applied to select proposed near-term Hawaiian Electric EoT actions



liquid and gaseous fuels are also used in Hawai'i today and may play a part in the state's clean transportation future, especially for some modes of transportation that are difficult to electrify. There may be future opportunities for Hawaiian Electric to create customer value through initiatives focused on these vehicle types, in particular by integrating renewable energy through the production of hydrogen or synthetic methane with surplus wind or solar energy. However, given the rapid advancement of EVs, Hawaiian Electric considers the more immediate opportunity and imperative to be supporting their deployment and preparing for their cost-effective, safe, reliable integration into the grid. We therefore do not propose any near-term initiatives on alternative renewable transportation fuels and vehicles, but plan to monitor development of these technologies and to engage further as opportunities emerge to create customer value through utility action.

A note on word choices

In this document, 'EV' is used to mean a plug-in electric vehicle, i.e. a fully battery-electric vehicle, or a plug-in hybrid. 'Hawaiian Electric' and 'the companies' are used interchangeably to refer collectively to Hawaiian Electric Company, Maui Electric Company, and Hawai'i Electric Light Company. A full list of acronyms and abbreviations can be found in Appendix G: Acronyms and Abbreviations.

Organization of the Roadmap

The remainder of this document is organized as follows

Chapter 2 describes the policy backdrop for EoT in Hawai'i

Chapter 3 provides an assessment of the value of EoT to Hawaiian Electric customers

Chapter 4 is a technology and barrier assessment across all classes of electrified transportation

Chapter 5 details the process by which we narrowed in on Hawaiian Electric's proposed role in EoT, and summarizes the resulting proposed initiatives

Chapters 6, 7 and 8 provide the details of our proposed EoT initiatives for light-duty vehicles, buses, and other vehicles, respectively

Chapter 9 drills down on the intersection of this EoT Strategic Roadmap with Hawaiian Electric's existing plans and programs, and finally

Chapter 10 identifies the chapters that directly address the requests made by the Commission in Decision and Order No. 34592

Appendix A: Stakeholder letters of support, provides stakeholder letters of support for our Roadmap

Appendix B: Agenda for Hawaiian Electric's EoT workshop, November 9, 2017, is the agenda for Hawaiian Electric's EoT workshop

Appendix C: Invitees to Hawaiian Electric's EoT workshop, November 9, 2017, lists invitees to the workshop

Appendix D: Follow-up online survey sent to invitees to Hawaiian Electric's EoT Workshop, is the follow-up online survey sent to workshop invitees

Appendix E: Electric vehicle forecast methodology and assumptions, provides our EV forecast methodology

Appendix F: Cost-benefit analysis methodology and assumptions describes our cost-benefit analysis methodology and assumptions

Appendix G: Acronyms and Abbreviations, list of acronyms and abbreviations used in this document

2. Background and policy context: Electrified transportation in Hawai‘i

This chapter details the policy backdrop against which Hawaiian Electric developed our EoT Strategic Roadmap, and also describes EoT actions taken by the companies to date.

EV sales are growing internationally, buoyed by significant policy efforts

As shown in Figure 5, electric vehicle markets around the world are growing, and this growth is expected to continue. Aggressive public policies in China, Europe, California and nine U.S. states that have signed on to the Zero-Emission Vehicles (ZEV) regulation[1] are delivering an electric vehicle market transformation. Vehicle price forecasts continue to be revised downward as battery prices plunge:[2] Bloomberg New Energy Finance now projects that EVs will reach price parity on an unsubsidized basis with internal combustion engine vehicles by 2025.[3] Meanwhile, electric vehicle range is expanding as the energy density of battery packs increases.

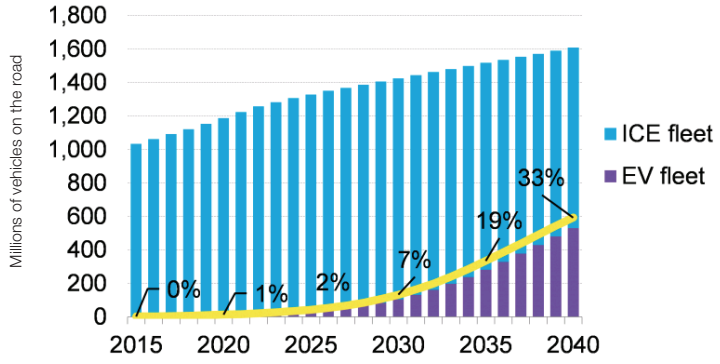
This projected growth in sales is being propelled and enabled by the proliferation of national, state, local and utility actions to

[1] Section 177 of the federal Clean Air Act (42 U.S.C. Sec. 7507) permits states to adopt California's tailpipe emissions standards instead of the less stringent federal standards. Current ZEV States are Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, and Oregon.

[2] Bloomberg New Energy Finance, July 2017. "All Forecasts Signal Accelerating Demand for Electric Cars" https://about.bnef.com/blog/forecasts-signal-accelerating-demand-electric-cars/

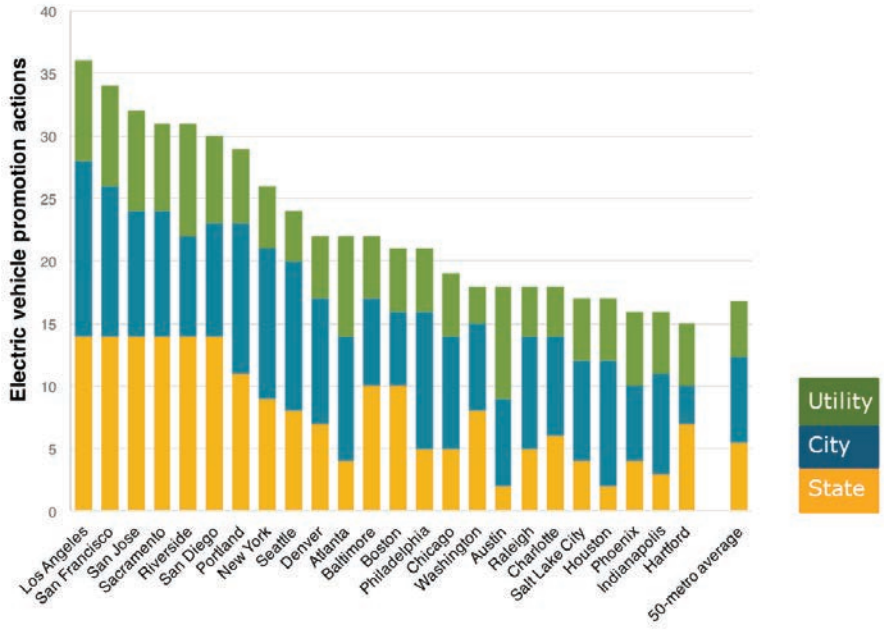
[3] Bloomberg New Energy Finance, July 2017, "Electric Vehicle Outlook 2017, https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF_EVO_2017_ExecutiveSummary.pdf

Figure 5. Bloomberg New Energy global forecast of electric light-duty vehicles versus internal-combustion engine (ICE) vehicles (millions of vehicles on the road)



Source: Bloomberg New Energy Finance, See https://insideevs.com/bloomberg-new-energy-finance-increased-plug-ins-global-share-forecast-to-54-by-2040/

Figure 6. ICCT's Count of EV Promotion Actions for the Top 24 U.S. Metropolitan Areas



Source: ICCT, October 2017, "What is Driving the U.S. Electric Vehicle Market?," presentation, EVS30, Stuttgart, Germany

promote and plan for EVs. Figure 6 shows a summary from the International Council on Clean Transportation (ICCT) of the number of actions undertaken as of October 2017 in the top 24 U.S. metropolitan areas that are most active on EV policy. These actions have included purchase incentives, parking and HOV lane benefits, building code initiatives, infrastructure buildouts, tax credits, rate discounts, and vehicle sales mandates.

Hawai'i is a leader in EV adoption

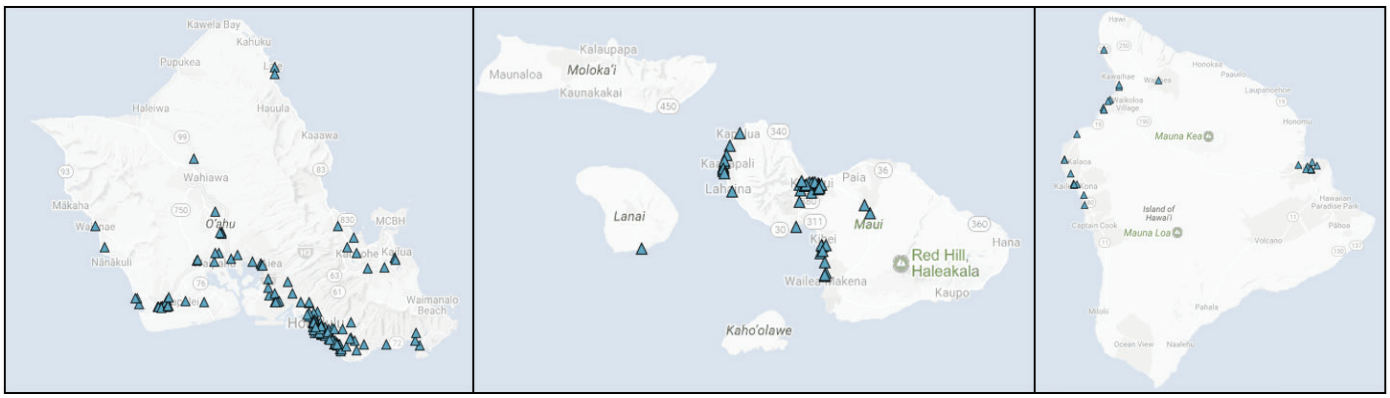
Hawai'i is home to a small but fast-growing fleet of electric vehicles. As of January 2018, there are 6,748 passenger electric vehicles in the state, less than one percent of registered light-duty vehicles, but a 29.7 percent increase over the previous year. This significant expansion is driven by consumer preferences in Hawai'i, where electric vehicle sales are more than double the U.S. average.[4] Hawai'i consumers' preference for EVs has led to Hawai'i becoming the number two state in terms of per-capita EV sales between 2011 and 2016.[5]

As discussed in Chapter 4, additional public charging infrastructure will be needed to sustain growth in Hawai'i's electric vehicle market. There are currently 542 electric vehicle charging ports that are available to the public: 69 DC fast charger ports (which fully charge a vehicle in approximately half an hour) and 473 slower, Level 2 ports (which take 5 – 6 hours for a full charge).[6]

There are also issues with the reliability of public charging on the islands. A forthcoming study suggests that approximately 8 percent of public charging plugs were out of order as of April 2017, according to

[4] Global Automakers 2017. "drivingzev: Hawai'i." http://drivingzev.com/zev-state/hawaii
[5] Shahan, Zachary 2017. "U.S. Electric Car Sales By State – Who's #1, Ohio or California." Clean Technica. https://cleantechnica.com/2017/05/04/us-electric-car-sales-state-whos-1-ohio-california/ accessed 2/13/2018
[6] U.S. Department of Energy 2017. "Hawai'i Transportation Data for Alternative Fuels and Vehicles." https://www.afdc.energy.gov/states/hi. Accessed 12/10/2017

Figure 7. Public EV Charging Stations on O'ahu, Maui, Moloka'i, Lāna'i and Hawai'i



Source: Adapted from U.S. Department of Energy, "Alternative Fueling Station Locator." https://www.afdc.energy.gov/locator/stations/results?location=Hawai'i accessed 12/10/17.

data from the U.S. Department of Energy's (DOE) Alternative Fuels Data Center. That study further suggests that this is likely an underestimate of out-of-service chargers, since the DOE frequently removes charging locations with out of service charging ports from their database.

Hawai'i state and local policies are supporting the EoT transformation

Electrification of transportation is a pillar of Hawai'i's climate, clean energy and energy independence policy goals. In June 2017, Governor Ige signed Act 32, making Hawai'i the first state to align its energy and environmental policy with the 2016 Paris Climate Agreement.[7] The Paris Agreement calls for emissions reductions that are consistent with at least a 2-degree-celcius stabilization pathway.[8] Hawai'i must undertake a rapid transition of its energy economy if this target is to be met.

A key element of this transition is Hawai'i's precedent-setting 100 percent renewable portfolio standard (RPS) by 2045. Hawai'i has been a leader in establishing, and meeting, high renewable generation policy targets. As early as 2004, Hawai'i had set a standard of 20 percent renewable energy by 2020. In 2009, that standard was strengthened to 40 percent by 2030. With 26.8 percent renewable generation in the fourth quarter of 2017,[9] Hawaiian Electric has already exceeded the state's original RPS goal and is on pace to meet both the 2030 and 2045 standards. In fact, Hawaiian Electric intends to meet the 100 percent renewable energy standard by 2040, five years ahead of schedule.[10]

Recognizing the key role of EoT in the state's decarbonization policy, Hawai'i has made significant state policy commitments that aim to foster the state's electric vehicle market. Existing EoT policies include

- Act 164 (2015): Establishing a working group to study barriers to EV charging infrastructure in multi-family developments. This working group developed a report that recommends strategies to accelerate development of electric vehicle charging infrastructure in multi-family communities. A key conclusion is that utilities are well positioned

[7] Act 32 (SLH 2017), S.B. 559, S.D. 1, H.D. 2, C.D. 1 (2017). https://www.capitol.hawaii.gov/session2017/bills/SB559_CD1_.htm

[8] UNFCCC. 2015. The Paris Agreement. Conference of the Parties Twenty-first session Paris, 30 November to 11 December 2015. http://unfccc.int/paris_agreement/items/9485.php

[9] Hawaiian Electric 2018. "Renewable Portfolio Standard ("RPS") Compliance." https://www.hawaiianelectric.com/about-us/key-performance-metrics/renewable-energy

[10] Hawaiian Electric 2016. "Hawaiian Electric Companies submit updated 30-year energy plans charting a course to 100 percent renewable energy." https://www.hawaiianelectric.com/hawaiian-electric-companies-submit-updated-30-year-energy-plans-charting-a-course-to-100-percent-renewable-energy-

to help multi-family developments overcome barriers to EV infrastructure development. Hawaiian Electric plans to use the working group's report as a launching point for its multi-family EoT initiatives.

• HRS § 291-72 (2013): Establishing an 'Anti-ICEing' law that institutes fines for conventional vehicles that park in spaces reserved for electric vehicles

• HRS § 291-71 (2012): Requiring that public parking facilities with at least 100 parking spaces have one space dedicated for EV use and EV charging. This law also provides that EVs with an electric vehicle license plate may use high-occupancy (HOV) lanes, regardless of the number of passengers and are exempt from certain parking fees

• HRS § 196-7.5 (2013): Requiring that owners of multi-family or town-home units be allowed to install electric vehicle chargers

• HRS § 226-10 (2011): Establishing economic development objectives that include research and development of non-fossil fuel and energy efficient modes of transportation

• HRS § 226-18 (2011): Establishing that the policy of the state is to promote alternate fuels and transportation energy efficiency

• HRS § 103D-412 (2009): Making EVs the first priority when state government agencies procure new light-duty vehicles

In 2008, the State of Hawai'i, U.S. Department of Energy and Hawaiian Electric signed a memorandum of understanding known as the Hawai'i Clean Energy Initiative (HCEI). HCEI's goal is to transform Hawai'i's entire economy by transitioning to clean energy, replacing dependence on imported fossil fuel with indigenous renewable energy resources. More broadly, the initiative sought to create an entrepreneurial clean-energy jobs sector that could potentially join the military and tourism as one of the state's leading industries. Nationally, HCEI remains an unprecedented collaboration of diverse participants, including representatives of government, energy companies, non-profits and advocacy groups, with technical assistance from the federal network of national energy labs.

At first, work focused almost exclusively on electricity production, leading to a tripling of renewable resources online across the state. In 2014, the state and the Department of Energy committed to an updated initiative, known as HCEI 2.0, with a heightened emphasis on reducing petroleum use in the more disparate and decentralized transportation sector.

Local city and council initiatives are seeking to build on these state actions. Most significantly, the mayors of Hawai'i's four counties have jointly pledged to eliminate fossil fuel use from ground transportation by 2045.[11] The mayors used the recent Malama Honua Worldwide Voyage by the Polynesian ocean sailing canoe Hokule'a, with its message for people across the world to take care for the planet and make it sustainable – as the backdrop for their commitment. Nainoa Thompson, master navigator, of Hokule'a, stated "It's a moment of history, it's a moment of vision, it's a moment of making promises, it's a moment of courage and it's a moment of unity."[12] As part of the announcement, the City and County of Honolulu and County of Maui announced plans to transition to 100 percent clean fuel fleets by 2035.

These jurisdictions have already begun down the path to low-emissions fleets. In August 2017, the City and County of Honolulu committed to replace its fleet of 1,900 on-road vehicles with zero-emissions alternatives and committed $10 million for an electric bus pilot.[13] That funding has been supplemented by an additional $1.45 million from the U.S. Department of

[11] Pacific Business Journal, 2017, "Hawai'i counties pledge to eliminate fossil fuels from ground transportation." https://www.bizjournals.com/pacific/news/2017/12/12/hawaii-counties-pledge-to-eliminate-fossil-fuels.html accessed 12/20/17

[12] Honolulu Star Advertiser, December 13, 2017, "Hawai'i's mayors pledge to halt use of fossil fuel vehicles by 2045."

[13] City Council City and County of Honolulu, Resolution No 17.238. "Urging the City Administration to Initiate the Transition to an All Zero-Emissions Vehicle Motor Pool and Automotive Fleet."

Figure 8. Honolulu Mayor Kirk Caldwell joined by other Mayors and representatives, including Master Navigator Nainoa Thompson, at Pokai Bay to announce the counties' commitment to using renewable energy to power their government vehicles by 2035

Source: Hawaiian Electric

Figure 9. Honolulu Mayor Kirk Caldwell, joined by Hawaiian Electric CEO Alan Oshima, OTS General Manager Roger Morton, Deputy Director of Transportation Services Jon Nouchi, and other stakeholders at a January 2018 press conference announcing the arrival of the first battery electric bus provided by ProterraManager Roger Morton, Deputy Director of Transportation Services Jon Nouchi, and other stakeholders at a January 2018 press conference announcing the arrival of the first battery electric bus provided by Proterra

Source: Hawaiian Electric

Figure 10. OTS bus drivers at Middle Street Transit Center standing in front of Honolulu's first transit electric bus being tested on O'ahu roads

Source: Hawaiian Electric

Transportation.[14] Along with these financial commitments, the Honolulu City Council directed its staff to adopt an all-electric bus transition plan. [15] In January 2018, the City and County of Honolulu demonstrated its first battery electric bus on loan from Proterra Inc. That bus represents the beginning of a project that will test battery electric buses on 23 routes throughout Honolulu. Hawaiian Electric will support both initial pilots and future projects by assisting with the charging infrastructure necessary to serve these vehicles.

Hawaiian Electric is promoting and planning for EoT

Hawaiian Electric supports deployment of and planning for electric vehicles through a combination of fleet procurements, rate design, customer education, charging infrastructure, and innovative pilot projects.

Membership of Drive Electric Hawai'i

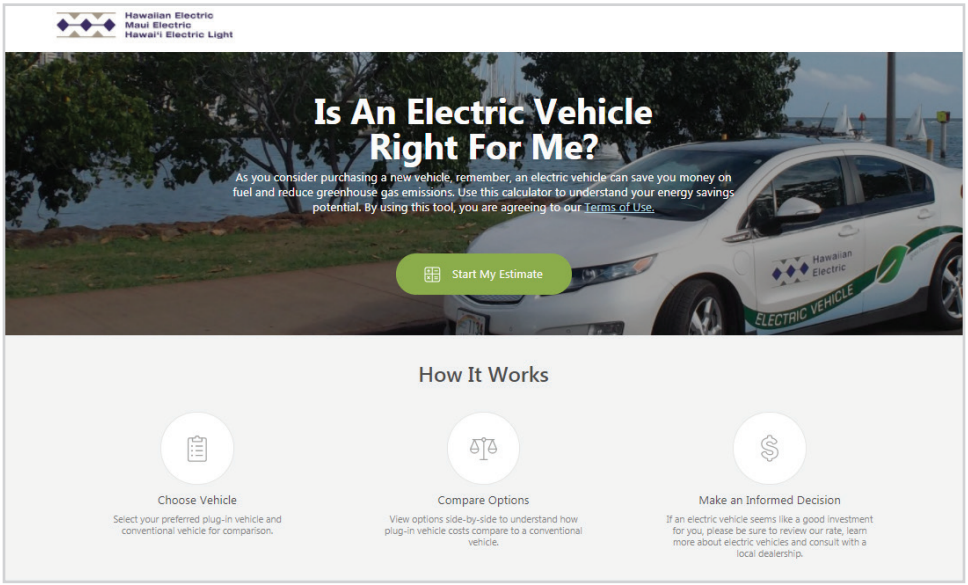
Hawaiian Electric's EoT efforts are integrated with complementary initiatives managed by state and local governments, automakers and community groups. In 2016, Hawaiian Electric facilitated and entered into a memorandum of understanding[16] with the Hawai'i State Energy Office, the State of Hawai'i Department of Transportation (HDOT), the Division of Consumer Advocacy, Blue Planet Foundation, Ulupono Initiative, Kaua'i Island Utility Cooperative (KIUC), and Rocky Mountain Institute to establish the Drive Electric Hawai'i Initiative. It is designed to align each member's EoT work, with a shared vision of electrified transportation fueled by 100 percent renewable energy. The state's four counties are also in the process of joining Drive Electric Hawai'i as members.

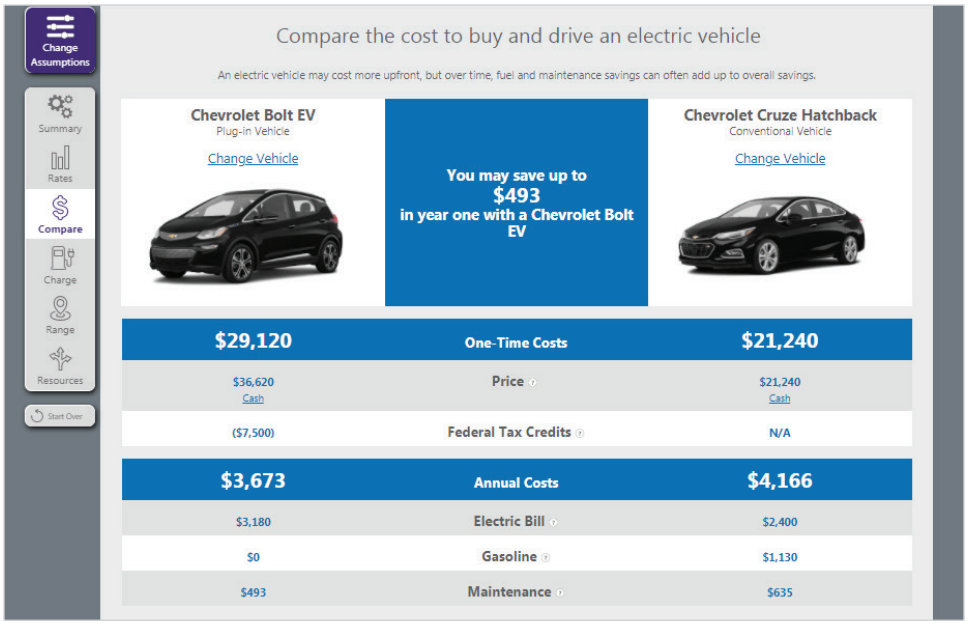
Customer education

As described above, Hawaiian Electric has learned that successful customer engagement is critical to both encourage electric vehicle adoption and gain customer participation in EV programs. In response to this need, Hawaiian Electric has developed the EV WattPlan tool to help customers compare electric vehicles (see Figure 11) and a spreadsheet tool to allow customers to

[14] United States Department of Transportation. "Fiscal Year 2017 Low or No-Emission (Low-No) Bus Program Projects." https://www.transit.dot.gov/funding/grants/fiscal-year-2017-low-or-no-emission-low-no-bus-program-projects
[15] City Council City and County of Honolulu, Resolution No 17.237. "Urging the City Administration to Implement a Pilot Program, Adopt a Comprehensive Transition Plan and Move to all Zero-Emission Electric Buses."
[16] Drive Electric Hawai'i, 2016, "Memorandum of Understanding," https://www.driveelectrichi.com/media/1085/drive-electric-hawaii-mou-121616.pdf

Figure 11. Screenshots of EV WattPlan tool





Source: https://hawaiianelectric.wattplan.com/ev/

understand how available rates affect their cost of ownership.[17] In addition to this tool to aide potential EV owners in making the decision to purchase an EV, the companies have extended outreach by participating in ride and drives, energy and EV fairs, and sustainability forums in all three companies' service territories. Hawaiian Electric has also participated in multiple community outreach events including the Hawai'i Auto Show and the Building Industry Association's annual Home and Remodeling Show to expose the broader public to the benefits of owning an EV (see Figure 12).

[17] Hawaiian Electric, "Is an Electric Vehicle Right for Me?" https://hawaiianelectric.wattplan.com/ev/, accessed 12/20/17

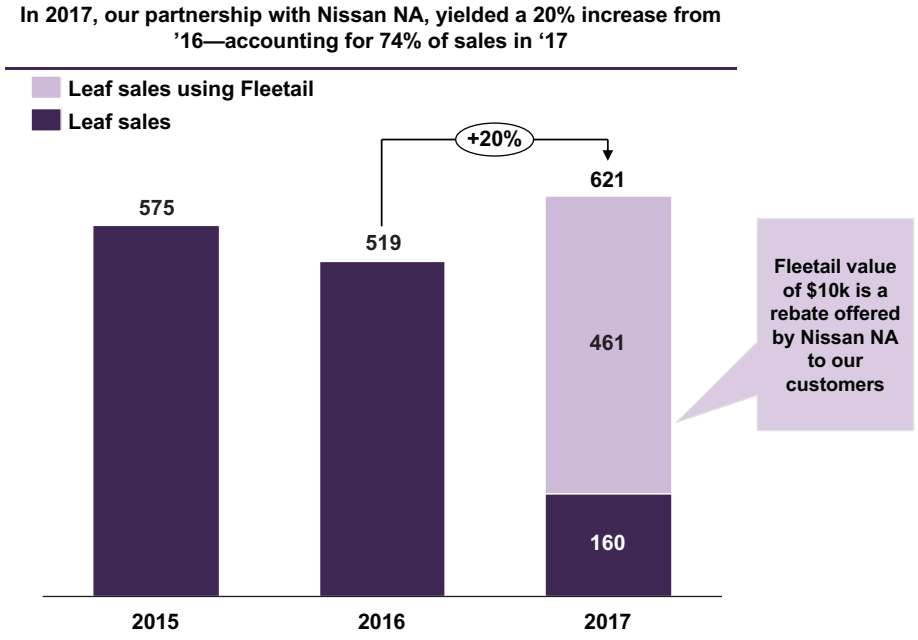
Figure 12. Hawaiian Electric employees sharing EV facts with the community at the "Grow Hawaiian Festival," a celebration of Hawai'i's culture, native plants, and sustainability hosted at the Bishop Museum in 2017

Source: Hawaiian Electric

Lowering the cost of EVs

Hawaiian Electric has also worked with automakers and local dealerships to provide access to discounted zero-emission vehicles for employees and customers. Programs targeted at Hawaiian Electric employees extend fleet pricing for participating EV brands. In 2017, Hawaiian Electric partnered with Nissan to extend a $10,000 rebate on the Leaf model to all customers in Hawaiian Electric's service territory. 461 customers took advantage of this "Fleetail" rebate, equivalent to 74 percent of all Leaf sales in the state that year. The rebate contributed to a 20 percent increase in Leaf sales from 2016 to 2017, after a drop over the previous year (see Figure 13). Hawaiian Electric has recently announced BMW's $10,000 rebate for the electric i3 through January of 2019, and we are hopeful that it will match the success of the Nissan Leaf rebate.

Figure 13. Sales impacts of Hawaiian Electric's partnership with Nissan NA



Source: Hawaiian Electric and Nissan NA

Figure 14. EVs for a Better Hawai'i event, at which HEI donated electric vehicles to various non-profits

Source: Hawaiian Electric

Figure 15. Hybrid Drive Bucket Truck in Hawaiian Electric's fleet

Source: Hawaiian Electric

Finally, Hawaiian Electric Industries, through its charitable foundation, HEI Charitable Foundation, donated 20 electric vehicles to non-profits across the state both to promote EV use and reward organizations dedicated to making Hawai'i a better place. These partnerships and promotional activities lower the cost of EV ownership for customers and employees, while promoting the EV inventory of local dealers.

Company Fleet

Electric vehicles have been a priority for Hawaiian Electric's fleet procurement for almost two decades. Hawaiian Electric adopted this strategy to both support electric vehicle adoption and reduce fuel consumption, the single largest operating expense for company fleets. Hawaiian Electric's initial procurement focused on passenger vehicles, but has since expanded to include

hybrid electric bucket trucks and off-road vehicles. The companies also joined Edison Electric Institute's (EEI's) Fleet Electrification Commitment, a pledge that companies will invest at least 5 percent of their annual fleet acquisition budgets to plug-in vehicles and technologies.[18] As of January 2018, Hawaiian Electric leads the state in electric fleet conversions, with 14 percent of our fleet (204 vehicles). This includes electrification of sedans, bucket trucks, forklifts, man-lifts, carts and other equipment. Along with more efficient conventional vehicles, these vehicles have tripled fleet-wide miles-per-gallon equivalent from 8.66 in 2008 to 24.89 in 2017.

Workplace Charging at Hawaiian Electric Locations

Hawaiian Electric has installed a DC Fast Charger in its headquarters garage for fleet charging that employees can reserve for 15 minutes per day, five times per week. As detailed in Chapter 6, Hawaiian Electric plans to expand support of workplace charging at its Honolulu, Waiau, Kahului, and Hilo locations in 2018, and to collect data from these charging solutions to inform future programs.

Rates

In 2013, the Commission approved electric vehicle rate pilots to promote charging during periods when grid impacts are lower.[19] Schedule EV-F is a non-demand rate targeted at chargers installed by businesses on public sites and Schedule EV-U applies to DC fast chargers installed by Hawaiian Electric. Both rates are based on time-of-use and do not include demand charges. This rate design removes peak demand-related disincentives associated with traditional designs, but continues to provide consumers with a price signal to charge during low-cost periods. These rates encourage development of electric vehicle charging infrastructure at commercial properties, multi-family dwellings and car rental locations. Based upon a consensus among protestors to Transmittal No. 12-05, in Transmittal No. 13-07, the Commission's Decision and Order No. 31338 allows Hawaiian Electric to install DCFC at up to 25 utility-metered accounts throughout the companies' service territories.[20]

In 2016 Hawaiian Electric filed in Transmittal No. 13-07, a request for a five-year extension of the Schedule EV-F and Schedule EV-U pilots.[21] In its Decision and Order No. 34592, the Commission approved the five-year extension and aligned rates on both schedules with TOU-RI rates from Docket No. 2014-0192.[22] Customers under the TOU-RI rate have the option to adopt time-of-use rates to both their household and electric vehicle load, or have the rate apply only to electric vehicle charging.

JUMPSmart Maui

The JUMPSmart Maui pilot project stems from a research and development agreement reached by former President Obama and former Prime Minister Hatoyama of Japan.[23] This agreement led to a task force that evaluated common clean energy solutions for Hawai'i and Okinawa. The project team for this pilot includes Hawaiian Energy, EPRI and Hitachi. JUMPSmart Maui is split into Phase I and Phase II.

Phase I of project had three objectives

1. Increase the efficiency of Hawaiian Electric's grid by shifting electric vehicle charging off peak hours, potentially to night-time hours to avoid curtailment of wind generation.

2. Test autonomous controls to allow electric vehicles to respond to grid needs.

3. Provide stabilizing, or balancing, services to manage power quality.

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[18] Edison Electric Institute, 2014. "EEI Announces Industry Commitment to Fleet Electrification at White House Roundtable" http://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20Announces%20Industry%20Commitment%20to%20Fleet%20Electrification%20at%20White%20House%20Roundtable.aspx

[19] See Tr. 13-07, Decision and Order No. 31338, filed July 1, 2013.

[20] Ibid

[21] Hawaiian Electric, 2017, "Hawaiian Electric Companies' EV fast charger program extended." https://www.hawaiianelectric.com/hawaiian-electric-companies-ev-fast-charger-program-extended

[22] Hawai'i Public Utilities Commission, Docket No. 2014-0192.

[23] EPRI, 2016, "JUMPSmart Maui Demonstration Project Phase Assessment." https://www.epri.com/#/pages/product/3002007129/

Figure 16. JUMPSmart Maui equipment providing charge to EVs

Phase I of JUMPSmart Maui yielded insights into how Hawaiian Electric can operationalize smart charging technologies. The pilot demonstrated that load can be shifted away from peak hours and that EV batteries can provide services to maintain power quality. Phase I also revealed areas where further work is needed. Although charging times shifted to off-peak periods, charging still occurred before the middle of the night when wind curtailment is highest. Additionally, recruiting volunteers to participate in the pilot proved more challenging than expected. An important lesson from this pilot was that scaling innovative V2G technical solutions requires concomitant attention to customer outreach.

Phase I provided data and learnings that were used in Phase II of JUMPSmart Maui. This second phase was recently completed. Key priorities of this phase included: continuing work to align charging with renewable energy generation, research on vehicle-to-home (V2H) services, and coordination of electric vehicle services with other distributed energy resources to create virtual power plants.

The public charging infrastructure installed under the JUMPSmart Maui program was recently rebranded to EVOhana.

OATI Electric Vehicle DR Aggregation

Maui Electric Company, in partnership with Open Access Technology International, Inc. (OATI), enrolled 40 customers who own Nissan Leafs in a pilot program to provide grid services through their Level 2 chargers. This program involved installing devices to allow communication with customer devices and to collect data on their usage. Each EV was shown to be able to follow charge and discharge instructions provided. Maui Electric used a performance scoring methodology adopted in PJM — an organized electricity market that incorporates large quantities of demand response — to evaluate the pilot. The typical score for the aggregated resource on that methodology was 91 percent well above the 75 percent performance score that is the threshold for PJM participation.

Overall, participants in this pilot express satisfaction, many enrolling in response to the program's branding as a "sustainable energy program." However, customers' vehicles were only available to respond less than half the time, providing insight about how the number of customers enrolled in future programs may translate into flexible loads that can respond to grid signals.

Understanding the grid impacts of DC fast chargers

Hawaiian Electric has recently implemented two additional pilot projects designed to better understand and manage the grid impacts of DC fast chargers: [24]

- **Kapolei Common 'Buffering':** One strategy, piloted in Kapolei Commons in cooperation with EPRI, uses a 12 kWh battery to reduce power demanded from the grid (also called 'buffering'). This battery-DC fast charger configuration allows up to 50 kW of power supplied to an electric vehicle while only requiring 23 kW from the grid.

- **Ward Avenue AutoDR:** Hawaiian Electric has implemented a DC fast charger project, in partnership with Greenlots and EPRI, to demonstrate the demand response capabilities of DC fast chargers at Hawaiian Electric's headquarters. This project applies OpenADR standards to allow rapid reductions in power consumptions, from 50 to 25 kW, in response to grid needs.

Lessons from the JUMPSmart Maui, OATI, and the above DCFC pilots will be used to inform Hawaiian Electric's proposed EoT initiatives (see Chapters 6 - 8).

Mobile charging

Hawaiian Electric has evaluated different business models for mobile charging. The Company has supported Elemental Excelerator and FreeWire technologies to deploy two mobile DC fast chargers at Honolulu's Airport Trade Center. This battery-based technology allows for flexible DC fast charging services that can be used in a parking garage structure or multi-unit dwelling while reducing the initial infrastructure upgrades necessary for DC fast charging. FreeWire's Mobi units also allow a fast charger to be moved to a vehicle in need of a charge.[25] Data collection from these mobile charging units can assist in the companies' understanding of the capabilities of mobile charging technologies in serving as a grid resource including load shifting, peak shaving, and load curtailment through demand response. Hawaiian Electric will continue to monitor advancements of mobile charging technologies.

Supporting harbor electrification

Ports are important partners in comprehensive EoT in Hawai'i. Matson, Inc. currently operates four cranes on all-electric shore power and one crane powered by a diesel generator. Matson plans to add new electric cranes and switch the diesel-powered crane to electric shore power. Hawaiian Electric is working with Matson to implement the electrical upgrades necessary to support these activities to reduce diesel usage via electrification.

Supporting Honolulu to electrify buses

Hawaiian Electric supported the City and County of Honolulu in its Federal Transit Administration Low or No Emission Vehicle (Lo-No) Grant application to purchase and test electric buses and chargers. The City was awarded $1.45 million[26] that will be combined with local City funds to purchase four electric Gillig buses and two to three charging stations. Hawaiian Electric continues to support and advise the City on charging and electrical infrastructure options compatible with its transit center and bus deployment operations to achieve initial electric bus operations in 2019.

National EoT Funding can benefit Hawai'i residents

National policy and programs are important complements to state, local and Hawaiian Electric efforts. As part of its proposed EoT initiatives, Hawaiian Electric proposes to promote and leverage federal sources of funding wherever possible (see Chapters 6 - 8).

[24] Hawaiian Electric, 2017, "Electric Vehicle Pilot Rates Report," https://www.hawaiianelectric.com/Documents/clean_energy_hawaii/electric_vehicles/annual_report_commercial_ev_charging_pilot_rates_2016.pdf

[25] Elemental Excelerator 2016. "FreeWire Technologies, Energy Excelerator, and Hawaiian Electric Bring Mobile Electric Vehicle Charging to Hawai'i." https://elementalexcelerator.com/latest/articles/freewire-technologies-energy-excelerator-and-hawaiian-electric-bring-mobile-electric-vehicle-charging-to-hawaii/

[26] Federal Transit Administration, "Fiscal Year 2017 Low or No-Emission (Low-No) Bus Program Projects," https://www.transit.dot.gov/funding/grants/fiscal-year-2017-low-or-no-emission-low-no-bus-program-projects

Federal electric vehicle tax credit

The U.S. Federal tax code grants a credit up to $7,500 credit per EV. Each automobile manufacturer has a 200,000-vehicle quota, at which point the credit begins to phase out.

Volkswagen Settlement – Environmental Mitigation Fund

Hawai'i will receive a share of the Volkswagen Diesel Settlement. The state has already received $2.5 million in funds directly from Volkswagen and will receive an additional $8.125 million from the settlement's Environmental Mitigation Trust. These funds may be used during the ten year period ending 2027 to mitigate excess nitrogen oxide emissions that result from non-compliant Volkswagen vehicles. The list of ten Eligible Mitigation Actions includes EV charging infrastructure, shore power conversion in ports, and electrification of buses, trucks, airport GSE, forklifts and port handling equipment. Beneficiaries may use up to 15 percent of their allocation on EV charging infrastructure (approximately $1.5 million in Hawai'i). DBEDT is the agency responsible for allocating these funds to projects in Hawai'i.

Volkswagen Settlement – Electrify America

As part of is diesel emissions settlement, Volkswagen has also capitalized the $2 billion Electrify America initiative to expand zero-emission vehicle infrastructure and awareness over a ten year period ending 2027. $800 million of those funds will be used in California alone. The remaining funds will be used to develop a long-distance highway charger network and support community-based local charging networks. $300 million of these non-California funds have been planned, with $190 million intended for the highway charger system, $60 million on community charging networks and the remainder for public education and administrative costs. Electrify America has produced a list of 11 metro areas where activities will be targeted, none of which are in Hawai'i.

US Department of Transportation Federal Highway Administration alternative fuel corridors

In 2016, HDOT and the U.S. Department of Transportation (DOT) Federal Highway Administration announced that seven routes

Figure 17. Alternative Fuel Corridors on Maui

Source: U.S. Department of Transportation, Federal Highway Administration, "EV Charging, Maui, HI." https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/maps/evmaui/ accessed 2/10/18

Table 1. Federal EV Infrastructure Funding in a Global Context

Country	Population	Program	Budget
Japan	130 million	Next Generation Vehicle Charging Infrastructure Program	Up to $1 billion
Germany	80 million	Level 2 and DC Fast Chargers	$285 million
Netherlands	17 million	Curbside charger subsidy	$33 million
United Kingdom	65 million	Curbside and DC fast chargers	$37 million
United States	320 million	ARRA	$15 million

Source: Hall and Lutsey 2017, "Emerging Best Practices for Electric Vehicle Charging Infrastructure," ICCT, https://www.theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

on Maui and O'ahu have been designated as "signage ready" alternative fuel corridors. These corridors will have clear signs that indicate where EV chargers are located. The designation is also meant to encourage further EV infrastructure development along the routes.

USEPA Clean Diesel Program

The U.S. Environmental Protection Agency (USEPA) operates a Clean Diesel Program that provides rebates and grants to replace diesel buses, trucks, and off-road vehicles with low-emitting alternatives. The grant funding under this program has been used by some jurisdictions to replace diesel vehicles with electric alternatives. The Hawai'i Department of Health received $339,263 from this program in 2017, which will leverage an additional $1.32 million from state funds and participating fleets to replace the engines on four old public works trucks at the Honolulu Board of Water Supply, as well as replace an old diesel transit bus with an all-electric bus.[27]

Federal Government Funding Context

The federal government plays a limited role in supporting EV charging infrastructure relative to leading countries. Table 1 compares U.S. government budgets to other wealthy countries. The budget data in Table 1 may not include all programs that could support charging infrastructure. However, the data does demonstrate that some smaller countries have substantially higher EV charging infrastructure budgets available compared to the United States.

Hawaiian Electric's EoT Strategic Roadmap builds on a number of existing proceedings and documents

This Roadmap is submitted in the context of a number of proceedings that address overlapping goals and planning processes. These overlaps are discussed further in our proposed EoT initiatives (Chapters 6 – 8) as well as in a standalone chapter (Chapter 9).

Hawai'i Public Utilities Commission Inclinations

In 2014, the Commission issued a document, "Commission's Inclinations on the Future of Hawai'i's Electric Utilities," that articulated its vision for the future of the electricity sector in Hawai'i.[28] The Commission provided direction in three areas that touch on EoT:

[27] "Hawaii receives $340,000 EPA grant for clean air project on Oahu," Pacific Business News, 1/30/18.

[28] Hawai'i Public Utilities Commission 2014. "Exhibit A: Commission's Inclinations on the Future of Hawai'i's Electric Utilities." https://puc.hawaii.gov/wp-content/uploads/2014/04/Commissions-Inclinations.pdf

• **Creating a 21st Century Power Generation System** stresses the importance of long-term planning to integrate the maximum quantity of cost-effective renewable resources while continuing to maintain reliable service. The Commission advised Hawaiian Electric to consider new demand-side and distributed resources on an equivalent basis with investments in conventional generation. Deploying new load management techniques, including smart charging of EVs, is among the recommended renewable integration strategies

• **Creating Modern Transmission and Distribution Grids** urges Hawaiian Electric to develop an advanced grid architecture that integrates customer-owned distributed energy resources with the bulk power system while providing benefits to all grid users. The Commission envisions a proactive approach to long-term distribution system planning that factors in stakeholder participation and exploits opportunities to reduce grid upgrade costs via deployment of DERs. Targeted investment in advanced metering infrastructure may be justified to realize bi-directional power and information flows with customer-sited resources (including EVs) provided they help to improve customer service and realize efficiencies.

• **Policy and Regulatory Reforms to Achieve Hawai'i's Clean Energy Future** describes how the state's electric utilities will need to transform their business models to adapt to 21st century technology advances, customer requirements and policy objectives. The Commission asserts that Hawaiian Electric will see new investment and revenue-earning opportunities as its core mission shifts from power supply to energy delivery. Another aspect of this transformation should be time- and location-differentiated rate structures that align customers' incentives with the needs of an increasingly renewable and distributed grid.

Hawaiian Electric's electrification of transportation strategy is designed to be consistent with the principles set out by the Commission. Indeed, Hawaiian Electric is already implementing the Commission's vision through a number of electric vehicle pilot programs. These programs — described in greater detail below — test the ability of electric vehicles to provide grid services, as well as new operational paradigms where Hawaiian Electric enables the aggregation of customer resources to support grid operations. Furthermore, since the Commission's inclinations document was released, Hawaiian Electric has made progress implementing rate-structures that provide customers with price signals to shift EV charging from peak to off-peak hours.

"Hawaiian Electric's electrification of transportation strategy is designed to be consistent with the principles set out by the Commission."

Demand Response (DR)

The goal of Hawaiian Electric's proposed Demand Response portfolio is "to provide cost-effective dispatch options for each island's system operations and, correspondingly, to help provide all customers with lower bills, while giving individual customers an additional option to help reduce their energy bills further by participating in a DR program."[29] In Docket No. 2015-0412, Hawaiian Electric's original DR Portfolio application was filed on December 30, 2015. A revised DR Portfolio that updated DR potential and cost-effectiveness was filed on February 10, 2017. In addition, on December 18, 2017 Hawaiian Electric filed a draft Grid Service Purchase Agreement, a proposed contract mechanism for the aggregators for Commission consideration and review. Further, in tandem with the DR Portfolio docket, Hawaiian Electric recently was granted approval[30] for a Demand Response Management System (DRMS), to manage customer-sited energy resources, including EVs. This application was approved in

[29] See Hawaiian Electric's DR Portfolio application, filed on December 30, 2015 in Docket No. 2015-0412.

[30] See Decision and Order No. 34884 issued on October 18, 2017 in Docket No. 2015-0411 "For Approval to defer certain computer software development costs for a Demand Response Management System, to accumulate an allowance for funds used during construction during the deferral period, to amortize the deferred costs, and to recover deferred, amortized costs through the Renewable Energy Infrastructure Surcharge."

October 2017, with go-live date slated for December 2018.

On January 25, 2018, the Commission issued Decision and Order No. 35238 ("D&O No. 35238") approving the DR Portfolio tariff structure framework which includes four grid service tariffs, rate schedules and riders upon which the DR programs are to be deployed. The Commission directed the companies to begin immediate implementation of rate schedules and riders for O'ahu and Maui, and staged implementation of additional rate schedules and riders by island.[31] The expectation is that the companies will proceed with implementation of the DR portfolio with customer acquisition by the third quarter of 2018.

Grid Modernization Strategy (GMS)

The overall goal of the grid modernization is to deploy modern grid investments at an appropriate priority, sequence and pace to cost-effectively maximize flexibility, minimize the risk of redundancy and obsolescence, deliver customer benefits and enable greater DER and renewable energy integration. On June 30, 2017, Hawaiian Electric filed an initial draft of its GMS describing how new technology will help triple private rooftop solar and make use of rapidly evolving products including storage and advanced inverters. The final GMS was filed on August 29, 2017. On February 8, 2018, the Commission issued an order setting forth next steps and directives for the utilities to implement the GMS. Hawaiian Electric has begun work to implement the GMS by issuing solicitations for advanced meters, a meter data management system, and communications network; Hawaiian Electric is working toward filing its application with the PUC for the first implementation phase in the second quarter of 2018.

Distributed Energy Resources (DER)

The companies are currently engaged in Phase II of the Commission's investigative proceeding on DER (Docket No. 2014-0192). DER Phase II is focused on developing a longer-term, competitive market structure for maximizing the benefits of DER in Hawai'i. The Commission divided Phase II into Technical and Market Track issues. The DER Parties focused on Technical Track issues in 2017, collaborating through various working groups, which culminated in the filing of several stipulations and statements of position. In October 2017, the Commission ruled on the various positions, and approved two new DER Programs – Customer Grid Supply Plus ("CGS+") and Smart Export -- and two new advanced inverter functions – Volt-Var and Frequency-Watt. The companies filed tariffs and officially launched the programs on February 20, 2018. The Market Track is expected to start in 2018. The Commission has identified multiple issues for evaluation during the Market Track, including alternative rate designs, rate unbundling, improved DER integration and aggregation, cost allocation for upgrades related to DER integration, and sunset dates for existing DER tariffs.

Power Supply Improvement Plan (PSIP) and Integrated Grid Planning (IGP)

The companies' PSIP, filed December 23, 2016,[32] adhered to several key Renewable Energy Planning Principles[33] which will help guide the companies through the grid transformation to 100 percent renewable energy. The companies filed their IGP update on March 1, 2018 in accordance with Commission Decision and Order No. 34696 issued on July 14, 2017 in Docket No. 2014-0183. Integrated grid planning will combine customer-centric resource, transmission, and distribution planning to holistically assess the physical, operational, technological, and behavioral changes to the electric grid necessary to enable safe, reliable, and affordable service that satisfies customers' evolving service expectations and use of distributed resources. This new IGP process will consider a full range of options and more effectively evaluate the final set of short-term solutions to meet Hawai'i's resource, transmission, and distribution needs defined in technology neutral terms.

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[31] See Docket No. 2015-0412, D&O No. 35238, filed January 25, 2018.

32 Docket No. 2014-0183, Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited, PSIP Update Report: December 2016 filed December 23, 2016.

[33] Hawaiian Electric Renewable Energy Planning Principles available at https://www.hawaiianelectric.com/Documents/about_us/our_vision/RE_planning_principles.pdf

3. EoT will provide value to Hawaiian Electric customers

The electrification of the state's transportation sector will create significant benefits for Hawaiian Electric's customers, by providing:

- **New mobility choices**
- **Economic value for EV drivers and non-EV drivers alike**
- **Energy security, through reduced reliance on imported fossil fuels**
- **Reduced emissions of greenhouse gases, and**
- **Reduced exposure to noise pollution and particulate emissions**

EoT provides new transportation choices

The EV transition is coming, and Hawaiian Electric is committed to supporting customers' expanding range of transportation choices. Automakers have announced dozens of electric vehicle models spanning a wide range of classes (see Figure 18). Bloomberg predicts the upfront cost of a mid-range EV will reach parity with a conventional, internal-combustion-engine (ICE) vehicle by 2025.[1] Because electricity is cheaper than gasoline per mile, there are already some EVs that are cheaper on a lifetime total cost of ownership basis than a comparable ICE vehicle.[2] With this expanding range of model options, increasing electric mile ranges, and decreasing upfront costs, EoT will soon provide customers with a significant increase in practical and desirable mobility choices.

EoT will create economic benefits for all customers: adopters and non-adopters

Hawaiian Electric retained Energy and Environmental Economics, Inc. (E3) to perform an economic analysis of EoT in Hawai'i, using light-duty vehicle electrification on O'ahu as an initial case study and focusing on the 2018 – 2045 period. This timeframe was selected to coincide with the company's long-range planning efforts accepted by the Commission[3] and the state's 100 percent RPS goal, which includes the recent Mayors' Pledge on the decarbonization of Hawai'i's vehicles (see Chapter 2). The analysis builds directly upon work performed by E3 for Hawaiian Electric's 2016 Power Supply Improvement Plan filing,[4] using of the same grid modeling and data inputs for generating resource availability and costs, operating conditions, fuel costs, and discount rate.

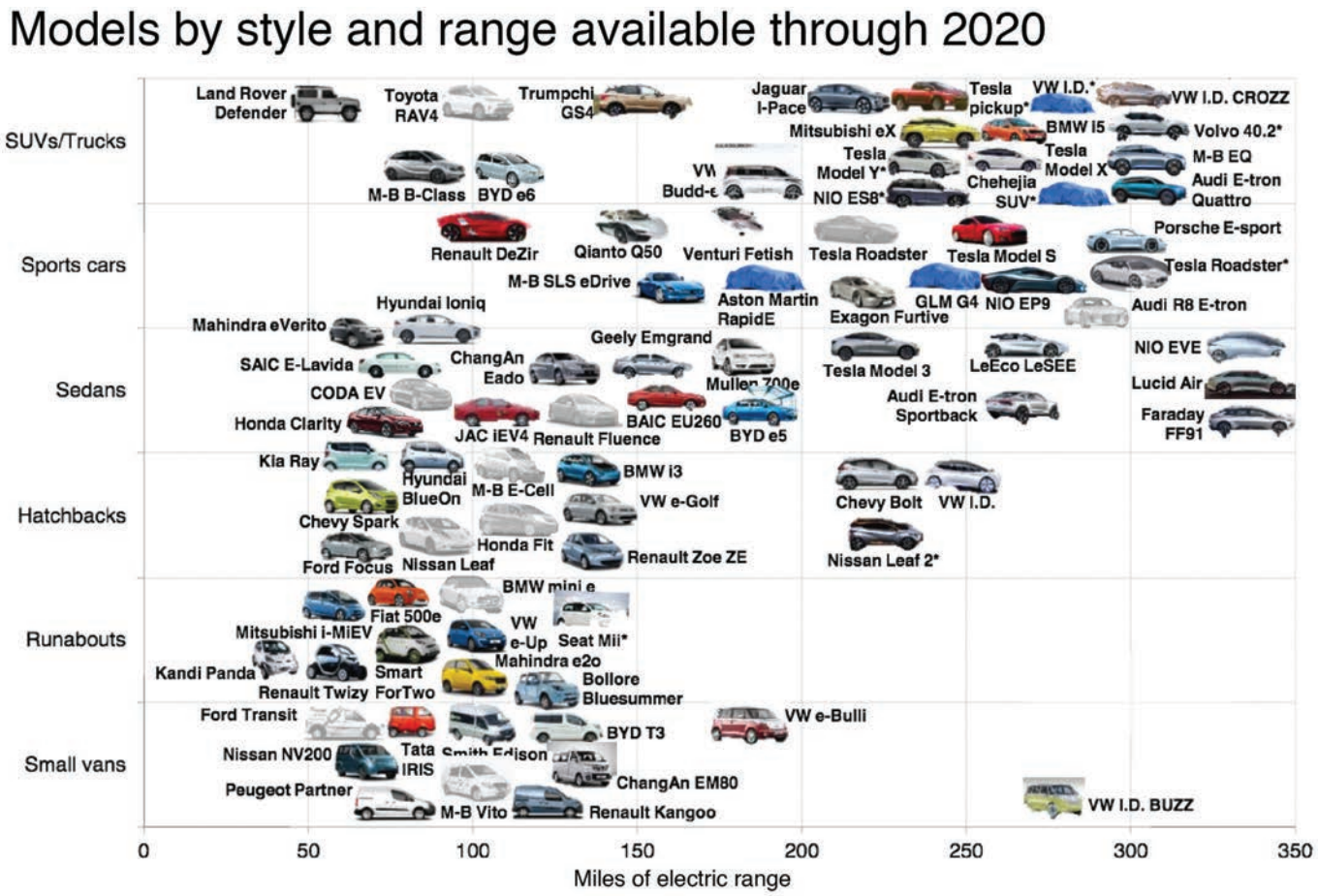
[1] Bloomberg New Energy Finance, June 2017, "Electric Cars to Reach Price Parity by 2025," https://about.bnef.com/blog/electric-cars-reach-price-parity-2025/

[2] Based on analysis completed on Hawaiian Electric's EV Watt Plan tool found at https://hawaiianelectric.wattplan.com/ev/. Assumptions used in the analysis were: daily round trip miles equal to 30 miles and average bill estimate set to $200/month for both the Volkswagen e-Golf 2017 model and Volkswagen Golf 2017 model sedans.

[3] Hawaiian Electric, July 2017, "Regulators Accept Hawaiian Electric Companies' Plan to Reach 100 percent Renewable Energy,"https://www.hawaiianelectric.com/regulators-accept-hawaiian-electric-companies-plan-to-reach-100-renewable-energy

[4] Ibid.

Figure 18. Bloomberg New Energy Finance's 'Electric Car-Boom'



Source: Bloomberg, April 2017, "The Electric-Car Boom is So Real Even Oil Companies Say It's Coming," https://www.bloomberg.com/news/articles/2017-04-25/electric-car-boom-seen-triggering-peak-oil-demand-in-2030s

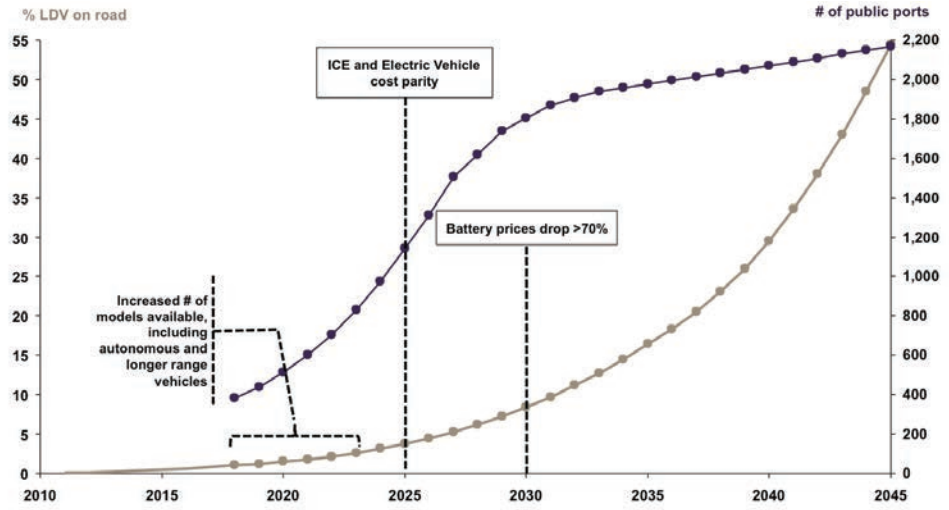
E3's analysis shows that EoT will create economic benefits for Hawaiian Electric's customers according to two cost-benefit perspectives:

- The total state 'energy wallet'– the money spent on transportation over this period – is expected to decrease with each personal light-duty vehicle replaced with an electric model on retirement. The gasoline and maintenance savings provided by EVs are expected to soon outweigh the costs to buy EVs and charging equipment, make electricity system upgrades, and provide the electricity needed to fuel the vehicles.

- The increased energy demanded by EV drivers to charge their vehicles creates benefits for all Hawaiian Electric's customers, not just EV drivers. This is because as EV drivers demand more energy, the utility's fixed costs for generating and distributing energy are spread across more kWh units. This creates net benefits for all customers.

To support these economic analyses and the Company's Integrated Grid Planning process, Hawaiian Electric developed an EV adoption forecast for each county its service territory. This adoption forecast represents one potential EV future based on an analysis that utilizes key observed data in macro-level Bass Diffusion and Agent-Based models. Details describing the methodology are provided in Appendix B: Agenda for Hawaiian Electric's EoT workshop, November 9, 2017. The resulting forecast for personally-owned, light-duty electric vehicles ('personal LDVs') and public charging ports on O'ahu is shown in Figure 19. According to

Figure 19. Hawaiian Electric's personal light-duty EV adoption forecast, O'ahu, 2010 – 2045



Source: Hawaiian Electric

this forecast, 55 percent of personal LDVs on O'ahu roads in 2045 are projected to be fully electric, supported by approximately 2,200 public charging ports. Note that this forecast captures public charging ports that are owned and operated by all EVSPs, not just Hawaiian Electric.

Hawaiian Electric further developed an hourly load forecast associated with this personal LDV adoption forecast. This 'Non-managed Charging' load shape assumes that the majority of EV charging occurs at home.[5] It further assumes that most EV drivers are on Hawaiian Electric's flat "R" Residential rate for their home charging, with little incentive to charge their vehicle at any time other than right when they get home from work.[6] This means that charging is forecasted to be highly coincident with Hawaiian Electric's 7 – 9pm distribution system peak load. An additional Smart Charging case, described below, assumes a more work-dominant, daytime charging scenario. See Figure 33.

E3 combined these EV adoption, public charging port, and load forecasts with system data from Hawaiian Electric's PSIP filing and the latest cost estimates for EVs to provide the two cost-benefit perspectives described above. Figure 20 shows that each EV purchased when an internal combustion engine (ICE) is retired improves the "energy wallet" for O'ahu – the amount state residents spend on transportation – by an average of approximately $1,800 ($2017 NPV). As the upfront cost of EVs comes down over the next several years (E3 assumes 2025 parity with ICE vehicles, in line with Bloomberg's projections),[7] the gasoline and maintenance savings from EVs are projected to outweigh the costs to buy the vehicles and charging equipment, make electricity system upgrades, and provide electricity to fuel the vehicles. The federal tax credit is assumed to expire at the end of 2021, and therefore is not assumed to provide significant long run benefits.

Scaling these 'Un-managed charging' results to Hawaiian Electric's adoption forecast reveals a net benefit of $203 million ($2017 NPV) to O'ahu "energy wallet" for personal LDVs over the 2018 – 2045 period. These economic benefits can be increased

[5] This assumption was based on: Ulupono Initiative, 2016, "Survey of Electric Vehicle Drivers in Hawai'i" and Hawaiian Electric, 2014, "Electric Vehicle Pilot Rates Final Evaluation Report."

[6] Public and workplace charging are assumed to be billed at other rates – see Appendix F: Cost-benefit analysis methodology and assumptions for details.

[7] Bloomberg New Energy Finance, June 2017, "Electric Cars to Reach Price Parity by 2025," https://about.bnef.com/blog/electric-cars-reach-price-parity-2025/

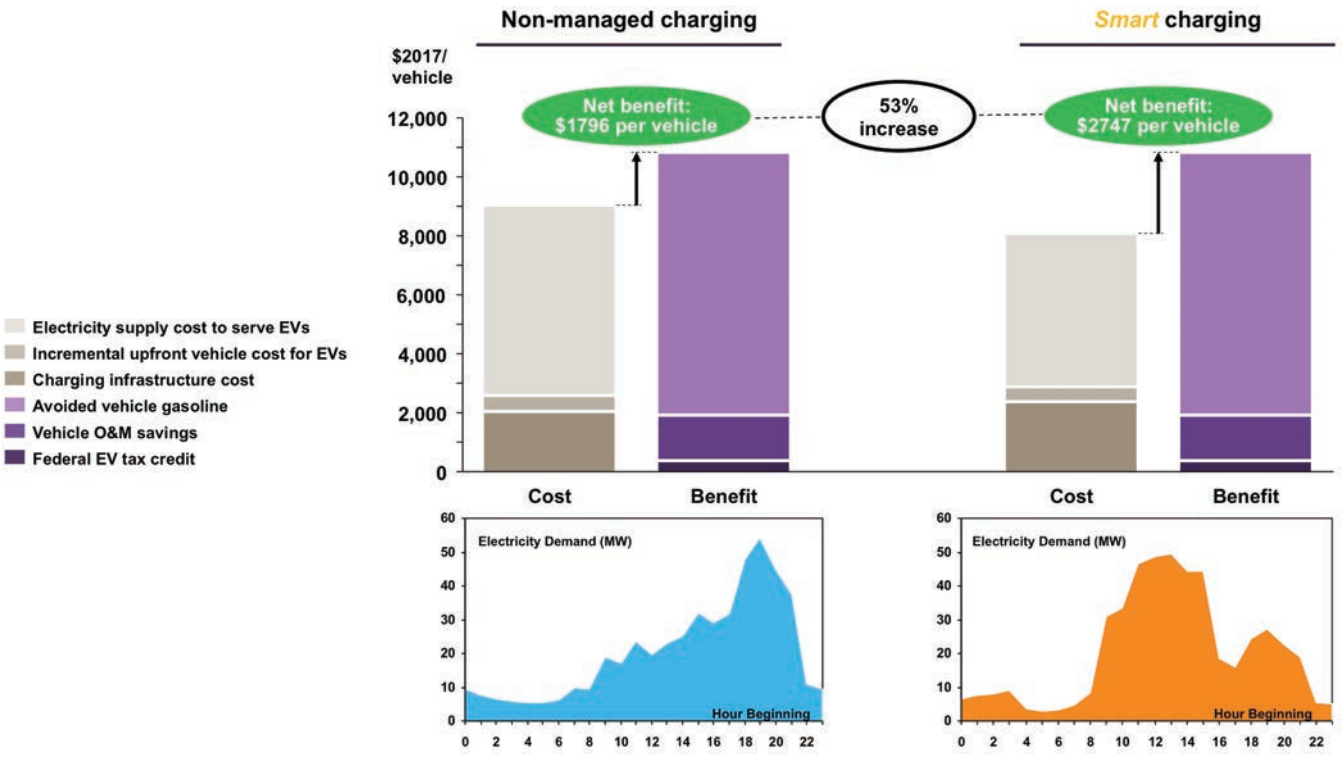
even further by incentivizing smart charging – charging during hours of higher renewable penetration and lower system cost – through rates and/or demand response (DR) programs. Smart charging will also increase the use of the state's renewable energy resources, allowing Hawai'i to realize the synergies between EoT and the RPS targets set forth in state law (see Chapter 2). A recent NREL study highlighted the potential for smart charging to decrease distribution upgrade costs, and the need to engage with consumers early on to affect their behavior and realize this value.[8]

To demonstrate the benefits of smart charging, E3 modeled an illustrative Smart Charging case. This case assumes that 50 percent of the kWh coming from charging at home can now occur at work, during hours when O'ahu electric system is producing its lowest-cost energy. Figure 33 shows a 2030 example of the average weekday charging load for this case. The figure shows that even in this illustrative Smart Charging case, there remains a secondary evening peak from the 50 percent of home charging that was not moved to the workplace. Thus, there is potential to optimize behavior and increase benefits even further by incentivizing drivers to also move their home charging into the later hours of the night.

This Smart Charging behavior lowers the cost to the utility's customers by increasing the amount of low-cost solar that can be integrated into the electricity supply, and by avoiding distribution upgrades that would otherwise be needed to support charging during the evening peak. The result is a 53 percent increase in net benefits, to $2,747 per vehicle, shown in the right-hand panel of Figure 20. Scaling these results to Hawaiian

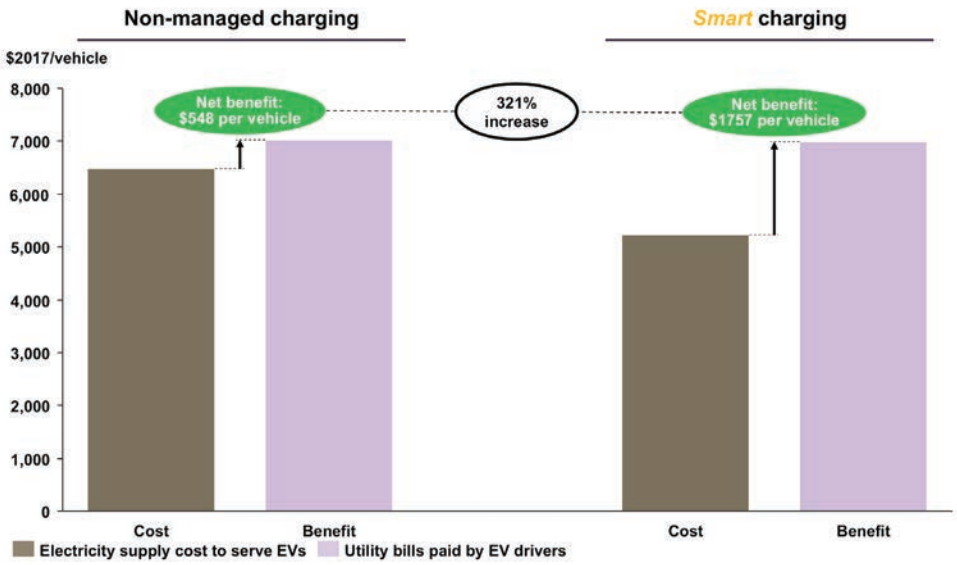
[8] See Walton, R. January 31, 2018, "Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investment."

Figure 20. Direct economic costs and benefits to O'ahu per personal light-duty electric vehicle, NPV 2018 - 2045



Source: E3 analysis

Figure 21. Costs and benefits to Hawaiian Electric customers per personal light-duty electric vehicle adopted on O'ahu, NPV 2018 - 2045



Source: E3 analysis

Electric's adoption forecast reveals a net gain of $311 million ($2017 NPV) to the O'ahu "energy wallet" for personal LDVs over the 2018 – 2045 period.

Note that E3's Smart Charging analysis includes the cost of the additional charging infrastructure needed to support this increase in workplace charging, but does not consider any other expenses that may be incurred to induce drivers to shift their charging behavior beyond providing charging at their workplaces. These could include, for example, changes to workplace EV rates. In reality, some portion of the extra $1,000 per-vehicle net benefit may need to be put to this purpose. However, the benefits shown in E3's analysis also do not include additional value that could be created by EVs' provision of grid services that contribute to system stability, such as Fast Frequency Response, Regulating Reserve and Replacement Reserve. Hawaiian Electric's DR Potential Study[9] anticipates that EVs will be an important provider of these services in the future, which will create significant value for the utility's customers that is not captured in this analysis. Hawaiian Electric is proposing several EoT initiatives that seek to induce smart charging of EVs and develop the capabilities of the utility to use EVs as a DR resource. See Chapters 6 and 9 for further detail.

Electrification is also projected to benefit utility customers that do not make the switch to an EV. Figure 21 shows this 'non-participant' analysis for personal light-duty vehicles on O'ahu. As described previously, the utility's fixed costs for generation and distribution are spread across more kWh units as EV drivers demand more energy. This means that EV drivers are expected to pay more in electricity bills than the additional cost that the utility incurs to serve them. This creates net benefits to customers. These benefits can be re-invested in EoT adoption and smart charging efforts intended to kick-start the market and create increased net benefits to customers in the long run.

In E3's case study, drivers of personal LDVs on O'ahu are projected to pay an average of $548 ($2017 NPV) per vehicle more in electric bills than they incur in marginal utility costs. Under the illustrative Smart Charging case described previously, this net benefit

[9] "Revised DR Portfolio Filing" filed on February 10, 2017 in Docket 2015-0412, Attachment A ("Potential Study") at 26.

increases more than three-fold, to $1,757 per vehicle, as drivers charge with more low-cost solar energy in the middle of the day and charging is moved off the system evening peak, avoiding distribution network upgrades.

Scaling these net benefits to Hawaiian Electric's adoption forecast reveals benefits of $62 million ($2017 NPV) to the utility's non-EV drivers over the 2018 – 2045 period as a result of personal light-duty EV adoption on O'ahu. This increases to $199 million in the Smart Charging case.

Additional analysis considered how these net benefits might change under an even higher EV adoption scenario, for example if the state is able to ramp up personal LDV adoption to meet the Mayors' Pledge to eliminate fossil fuel usage from ground transportation by 2045 (see Chapter 2). E3's investigation found that net benefits per vehicle are even higher under a 100 percent adoption scenario for personal light-duty EVs by 2045 than they are under the adoption forecast presented here. In addition, though we have focused here on personal light-duty vehicles as a case study, prior analyses by E3[10] suggests that additional net benefits will accrue to the state as other electrified vehicle types are adopted across customer segments and islands. Hawaiian Electric plans to have E3 complete analyses for the other islands in its service territory in the near-term future.

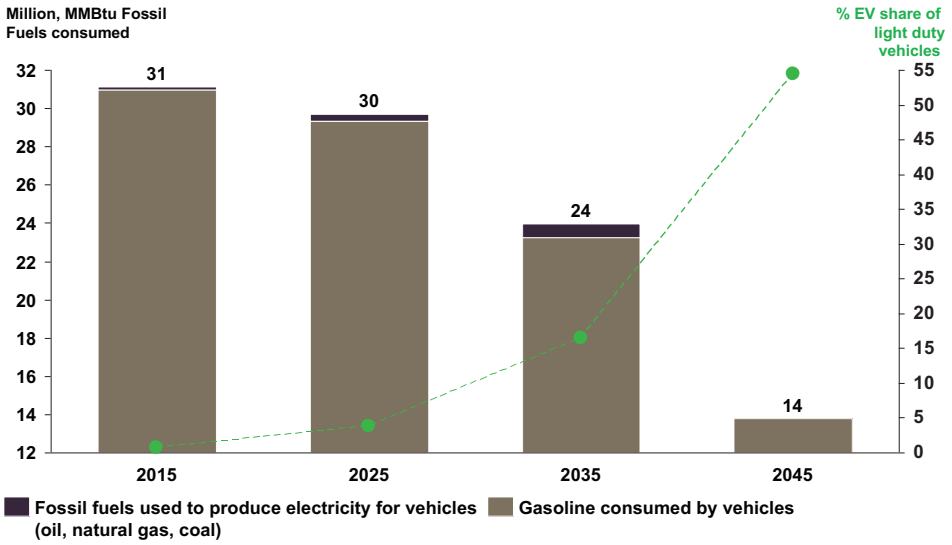
EoT will reduce Hawai'i's reliance on imported fossil fuels

EoT will further benefit Hawaiian Electric's customers by reducing the state's reliance on imported fossil fuels. Due to the state's 100 percent RPS goal, EVs will run on increasingly low-carbon electricity over the coming decades.[11] Each gasoline- or diesel-powered vehicle that is swapped out for an EV will therefore create significant reductions in imported fossil fuels.

[10] For example, California Transportation Electrification Assessment, 2016, "Phase 3-Part A: Commercial and Non-Road Grid Impacts – Final Report," http://www.caletc.com/wp-content/uploads/2016/08/California-Transportation-Electrification-Assessment-Phase-3-Part-A-1.pdf

[11] Hawaiian Electric, December 2016, "PSIP Update Report," https://www.hawaiianelectric.com/Documents/about_us/our_vision/psip_executive_summary_20161223.pdf

Figure 22. Fossil fuel consumption by O'ahu light-duty vehicles, assuming Hawaiian Electric's EV adoption forecast



Source: E3 analysis

For example, analysis by E3 using Hawaiian Electric's EV adoption forecast suggests that EVs will reduce O'ahu annual fossil fuel consumption for light-duty transportation by 56 percent by 2045. See Figure 22. This move from imported fossil fuels to locally-sourced renewable energy represents a significant energy independence benefit to the state.

EoT will decrease the production of greenhouse gases that cause climate change

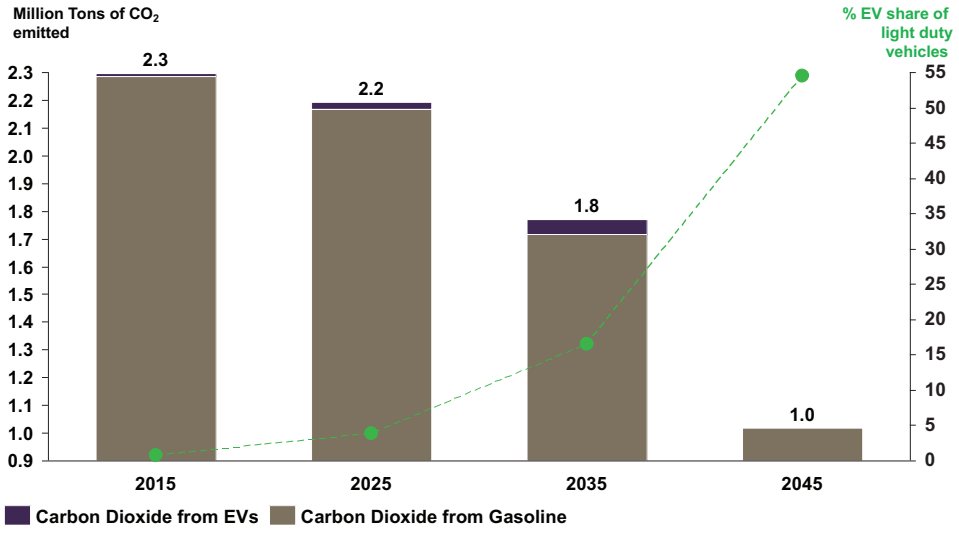
This decrease in fossil fuel use will be accompanied by a corresponding decrease in greenhouse gas (GHG) emissions from transportation. As an example, Hawaiian Electric's adoption forecast for LDVs is projected to lead to a 56 percent decrease in O'ahu's annual carbon dioxide emissions from LDVs by 2045, even despite a small quantity of CO2 emissions from electricity production in the interim years. See Figure 23.

EoT will reduce noise pollution and exposure to diesel particulates for those living and working in our cities and industrial areas

In addition to reducing fossil fuel use and greenhouse gas emissions, EoT will benefit Hawaiian Electric customers by improving local air quality (and associated health outcomes) and reducing noise pollution. Electric vehicles are so quiet that the National Highway Traffic Safety Administration (NHTSA) recently implemented a requirement that all new hybrid and electric light-duty vehicles be manufactured to make slight audible noise when traveling under 30 kilometers per hour, so pedestrians can hear them approaching.[12] Electrified off-road equipment can also reduce noise, benefiting workers and residents near areas with significant industrial activities such as

[12] NHTSA, November 2016, "NHTSA Sets 'Quiet Car' Safety Standard to Protect Pedestrians," https://www.nhtsa.gov/press-releases/nhtsa-sets-quiet-car-safety-standard-protect-pedestrians

Figure 23. Carbon dioxide emissions by O'ahu's light-duty vehicles, assuming Hawaiian Electric's EV adoption forecast



Source: E3 analysis

harbors and airports. As an example, the European Union suggests using electricity instead of diesel equipment to move cargo in its guidance on Noise Management in European Ports (NoMEPorts).[13] Similarly, the U.S. Federal Aviation Administration works to reduce the adverse effects of airport noise on workers and surrounding communities. Their approach to noise mitigation includes electrification of ramps, gates, and other airport vehicles.[14] The hybrid electric bucket trucks in Hawaiian Electric's fleet use their battery to power the boom, reducing noise in residential neighborhoods and extending work hours for crews performing non-emergency work in communities with noise restrictions.

Electric vehicles also produce fewer direct emissions than comparable conventional vehicles.[15] A 2015 study jointly produced by the Electric Power Research Institute (EPRI) and the Natural Resources Defense Council (NRDC) investigated the overall effects of electrifying transportation, and found reductions in emissions across a variety of pollutant types that impact human health (NOx, SOx, particulates, and volatile organic compounds).[16] Most significant for Hawai'i is likely to be the reduction in hyper-local particulate emissions (especially PM2.5) from gasoline and diesel. These particulate emissions are associated with cardiovascular and respiratory health issues.[17] The EPRI study found the highest levels of pollution reduction occurred in major urban areas. Electrification of off-road equipment, such as airport ground support, industrial and commercial equipment, and harbor operations, created particularly significant pollutant reductions. In Hawai'i, EoT is expected to bring the most significant local air quality and health benefits to those living and working in urban areas, such as Waikiki and downtown Honolulu on O'ahu, Kahului, Wailuku, Lahaina and Kihei in Maui County, and Kailua-Kona and Hilo on the island of Hawai'i, as well as in other industrial centers, such Kalihi, Waipahu, and Campbell Industrial Park on O'ahu.

Significant collaboration needed to realize EoT benefits for Hawai'i residents

Despite increasing interest in EoT, Hawai'i is still a long way from the levels of electrified transportation needed to capture the significant potential customer value described here. Recall from Chapter 2 that less than one percent of vehicles registered in the state today are plug-in EVs. There are marketing, informational, and grid integration challenges that must be overcome to kick start Hawai'i transportation markets to deliver these widespread benefits. This transition will require a collaborative effort that leverages the resources and expertise of a large group of stakeholders, and Hawaiian Electric is excited to be a key player. The following chapters outline our proposed strategy. Chapter 4 provides an assessment of the barriers faced by each electrified technology. Chapters 6 – 8 propose a set of ten Hawaiian Electric EoT initiatives, each in partnership with other experts and collaborators, that will assist in overcoming these barriers and realizing the considerable value that EoT can provide.

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[13] NoMEPorts, May 2008, "Good Practice Guide on Port Area Noise Mapping and Management," http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=NoMEports_GPG_PANMM1.pdf

[14] FAA, June 2009, "Record of Approval 14 CFR Part 150 Noise Compatibility Program General Mitchell International Airport Milwaukee, Wisconsin," https://www.faa.gov/airports/environmental/airport_noise/part_150/states/wi/media/roa_wisconsin_060409.pdf

[15] U.S. DOE Office of Energy Efficiency and Renewable Energy, "Reducing Pollution with Electric Vehicles," https://energy.gov/eere/electricvehicles/reducing-pollution-electric-vehicles

[16] EPRI, September 2015, "Environmental Assessment of a Full Transportation Portfolio, Volume 3: Air Quality Impacts," https://www.epri.com/#/pages/product/3002006880/

[17] California Air Resources Board, 2016, "Overview: Diesel Exhaust and Health," https://www.arb.ca.gov/research/diesel/diesel-health.htm.

4. Market, technology and barriers assessment for electrified transportation

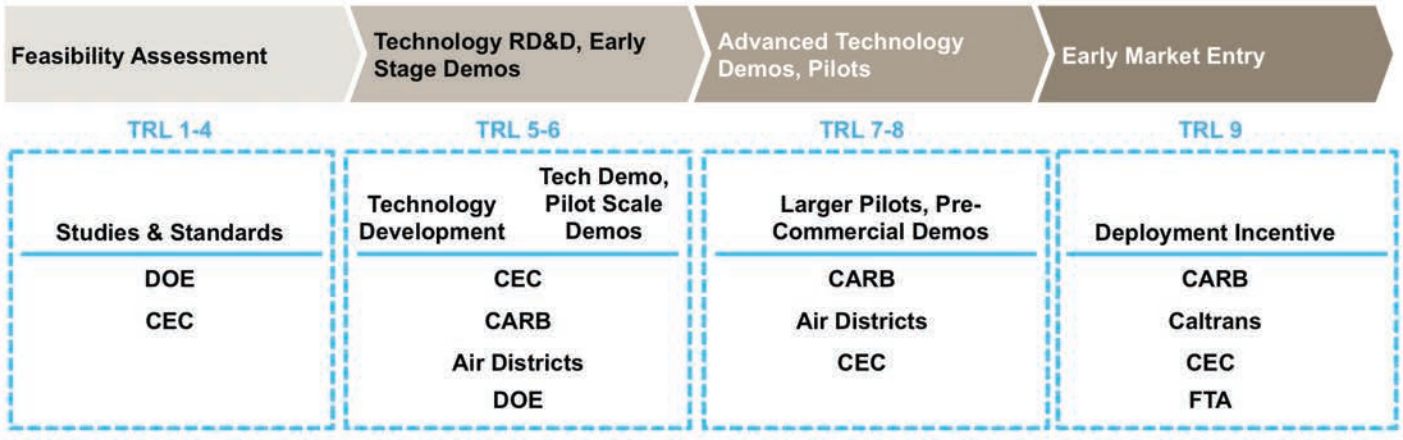
Hawaiian Electric is committed to delivering the many customer benefits to EoT described in Chapter 3. The first step in determining how to support EoT and deliver these benefits was to assess the state of EoT technologies and their market potential in Hawai'i, and determine the barriers to adoption and grid integration that these vehicles face. This chapter presents the results of that assessment, which relied on stakeholder and customer input, literature survey, and expert opinion. It begins by outlining our sources and methods, and then presents our findings for each of the major technologies.

This assessment found that the more mature electrified technologies with significant near-term market potential in Hawai'i are light-duty vehicles and buses. Hawaiian Electric proposes to focus on these vehicles in the near term, while continuing to assess the potential of other electrified technologies for additional focus in the medium and longer term. The following chapters outline our process for determining the utility's role in overcoming the barriers identified (Chapter 5) and present the resulting proposed initiatives (Chapters 6 – 8).

Assessment Approach

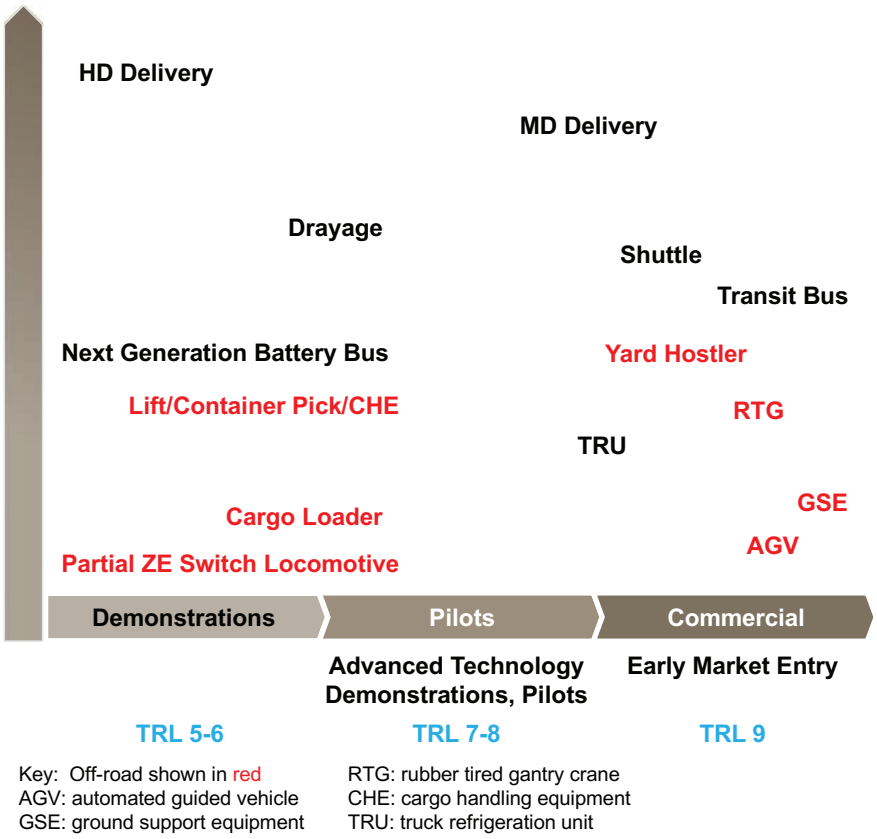
Our assessment of the maturity of electrified technologies relies primarily on analysis prepared by the California Air Resource Board (CARB). CARB's experts regularly review progress toward commercialization of low- and zero-emission vehicle technologies to inform rulemakings on emissions standards, prioritize research and development activities, and allocate grant funding. They assign a Technology Readiness Level (TRL) using a methodology originally developed by

Figure 24. CARB's 'Commercialization Arc,' Showing Stages and Sources of Public Investment



Source: Adapted from California Air Resources Board, 2016, "Overview: Diesel Exhaust and Health," https://www.arb.ca.gov/research/diesel/diesel-health.htm.

Figure 25. CARB's Assessment of technology status for electrified medium-duty and heavy-duty battery-electric technologies



Source: Adapted from California Air Resources Board, 2016, "Overview: Diesel Exhaust and Health," https://www.arb.ca.gov/research/diesel/diesel-health.htm.

NASA.[1] As illustrated in Figure 24, California pursues different types of initiatives to advance clean transportation technologies based upon their maturity.

Hawaiian Electric sees its role primarily as supporting vehicle technologies in the early market entry phase (TRL 9), when its customers will begin deploying new technologies and enjoying the benefits described in Chapter 3. We also plan to provide technical support to commercial and industrial customers interested in demonstrating or piloting medium- and heavy-duty technologies or smart charging technologies at earlier levels of development (TRL 6-8).

Electric cars are clearly in the early commercial phase with some progress evident for light-duty trucks (Classes 1-3, weighing up to 14,000 lbs., and including pick-up trucks, large SUVs and Hummers). Figure 25 is CARB's most recent analysis for medium- and heavy-duty battery electric vehicles. Other mature technologies with significant potential market penetration in Hawai'i are buses, airport ground support equipment, harbor yard hostlers (a type of heavy-duty forklift), automatic guided vehicles (including smaller-scale forklifts), and rubber-tired gantry cranes (used to stack containers). Electrified truck refrigeration units (TRUs) also have potential applications in Hawai'i transporting produce and other perishables. Electrified medium-duty delivery trucks, potentially a significant market in Hawai'i, are currently in the pilot stage, while heavy-duty delivery trucks are still being demonstrated.

[1] Source: CARB, Proposed Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1718_funding_plan_final.pdf

To understand barriers to adoption and the grid planning challenges faced by each electrified vehicle segment, we reviewed:

- Input and feedback collected from stakeholders at the November 19, 2017 EoT workshop and through the follow-up survey (see Chapter 1 for more details)
- Customer research performed by Hawaiian Electric
- Expert knowledge from retained consultants Energy and Environmental Economics (E3) and CALSTART.
- Up-to-date literature from industry-leading sources[2]

At a high level, we found that the barriers facing electrified vehicles across the spectrum of vehicles types fell into the nine major categories outlined in Table 2.

In the sections that follow we delve into the details for each segment, laying out the current state of each technology and the specific barriers and challenges it faces. Chapters 6 – 8 then present the initiatives we propose to overcome these barriers and capture the benefits of EoT for all our customers.

[2] For example:

Coffman, Makena, Paul Bernstein, and Sherilyn Wee. 2017. "Electric Vehicles Revisited: A Review of Factors That Affect Adoption." Transport Reviews 37 (1). Taylor & Francis: 79–93. https://doi.org/10.1080/01441647.2016.1217282.

Franke, Thomas, Isabel Neumann, Franziska Bühler, Peter Cocron, and Josef F. Krems. 2012. "Experiencing Range in an Electric Vehicle: Understanding Psychological Barriers." Applied Psychology 61 (3): 368–91. https://doi.org/10.1111/j.1464-0597.2011.00474.x.

Gavrilovic, Timotej. 2016. "Electric Vehicles as a Grid Resource: Market Size, Initiatives and Resource Potential" gtmresearch https://www.greentechmedia.com/research/report/electric-vehicles-as-a-grid-resource

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Table 2. Barriers and challenges facing EoT adoption and grid integration

Barriers to Adoption	
Limited awareness, understanding, and enthusiasm for electrified vehicles	Awareness of and enthusiasm for electric vehicles remains very low outside of environmentally-motivated early adopters.
Electrified vehicle model availability	Though increasing, the number and type of EV models has historically been relatively small. SUV and light-duty truck models remain limited, as do medium-duty and heavy-duty technologies.
Upfront cost premium of EVs over comparable conventional vehicles	Total cost of ownership can be lower for EVs relative to their internal-combustion engine counterparts, but higher upfront costs, even with available incentives, remains a barrier.
Lack of charging infrastructure, and associated range anxiety	Despite numerous studies showing that 80 percent or more of regular trips can be accomplished with an EV, consumers remain anxious about the ability to take long trips and recharge if their battery is unexpectedly low.
Demand charge costs for bus operators and commercial and industrial customers	Demand charges impose significant costs especially during initial periods of lower utilization.
Lack of dealership incentive to sell EVs	Mainly an issue for the personal vehicle market. There are many anecdotal reports of buyers having to educate the salesperson about EVs and dealers reluctant to forego the higher revenue from ongoing maintenance for ICE vehicles.
Limited availability of trained vehicle service technicians	EVs remain a very low percentage of the overall market, with lower ongoing maintenance costs, limiting incentives to train and hire service technicians
Grid Integration Challenges	
Need to proactively plan to reduce impacts on Hawaiian Electric's distribution grid and associated upgrade costs	Charging loads for EVs are fundamentally different than other end-use load types for which the distribution system has been designed and built, with higher kW demand and potentially higher peak load coincident factors.
Need to incentivize charging that supports renewable integration	Default charging behavior for residential customers tends to be at home during the evening or overnight. Incentives and public and workplace charging infrastructure will likely be needed to encourage daytime charging during periods of high solar generation.

Electrified Bicycles, Scooter and Mopeds

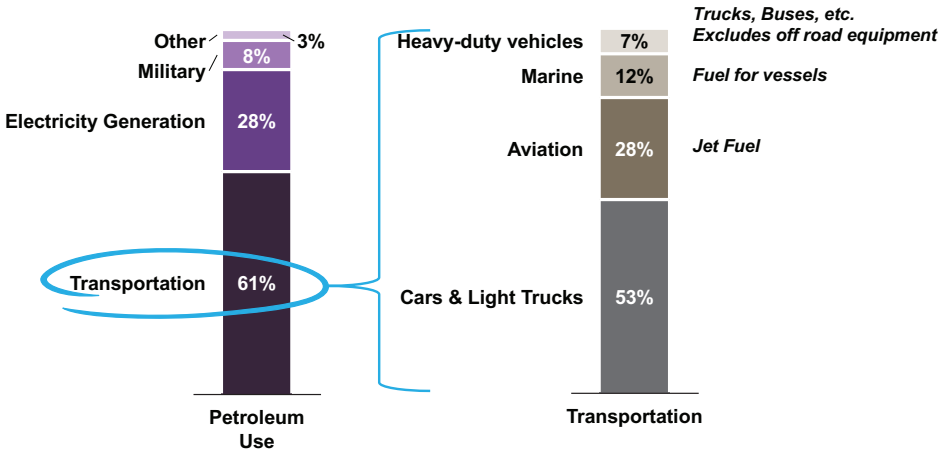
Maturity, Adoption and Market Size

Electrification of small personal mobility devices, such as bicycles, scooters, and mopeds, represents an opportunity for EoT in Hawai'i. These devices range from fully electric systems replacing conventional fossil fuel equivalents (such as electric mopeds replacing gasoline mopeds) to hybrid systems such as electric pedal-assist bicycles, which use batteries and electric motors to augment the power generated by a human rider.

Depending on the size of its battery pack, an electric bicycle in pedal-assist mode can have a range of up 50 miles. Currently less than one percent of Hawai'i commuters use a bicycle while over 60 percent drive alone[3]. For workers commuting longer distance or in more rural areas, commuting by bicycle may be impractical, but for those with shorter commutes, riding an e-bike, e-scooter or e-moped could be a viable alternative to driving. Benefits of these devices include reduced carbon emissions, noise pollution, and local air pollution.

[3] DBEDT, April, 2015. "Commuting Patterns in Hawai'i" http://files.hawaii.gov/dbedt/economic/data_reports/briefs/Commuting_Patterns_Apr2015.pdf

Figure 26. 2014 Petroleum Fuel Consumption in Hawai'i by Sector and Transportation Mode



Source: Hawai'i State Energy Office; ICCT 2015 Hawai'i Transportation Analysis

Barriers to Adoption

The primary barrier to adoption of these personal mobility devices is customer awareness.

Grid Integration Challenges and Opportunities

These devices charge at Level 1 and do not require specialized charging equipment. Like personal LDVs, this charging load likely has significant flexibility that can be harnessed to enable cost-effective grid integration and support renewable energy.

Light-Duty Vehicles

Maturity, Adoption and Market Size

Electrification of LDVs is by far the largest opportunity for EoT in Hawai'i. As shown in Figure 26, the International Council on Clean Transportation (ICCT) calculated that LDVs accounted for 53 percent of petroleum-based fuels consumed by Hawai'i's transportation sector and 32 percent of all petroleum used on the islands.[4] In 2015, 4,079 out of 1.2 million vehicles[5] that were registered on the islands served by Hawaiian Electric were EVs.

Light-duty EV technology is already in the early commercial stage and is maturing steadily. The market for EVs is still very much policy driven, so small manufacturing volumes and ongoing technology development translate into higher costs relative to conventional vehicles. As described in Chapter 2, aggressive public policies in China, Europe, and California and the "ZEV states"[6] are delivering the expected market transformation. The value proposition of EVs is improving as plunging battery prices lower vehicle costs while the increasing energy density of battery packs extends driving range. EV adoption forecasts continue to be revised upward:[7] Bloomberg New Energy Finance now projects that EVs will reach price parity with internal combustion engine vehicles by 2025.[8]

Another indication of maturation is the proliferation of new LDV models expected

[4] ICCT, August, 2015. "Hawai'i Clean Energy Initiative Transportation Energy Analysis" https://energy.hawaii.gov/wp-content/uploads/2011/09/Final_TransEnergyAnalysis_8.19.15.pdf

[5] DBEDT Table 18.09 vehicle registration by county http://files.hawaii.gov/dbedt/economic/databook/2016-individual/18/180916.pdf

[6] Section 177 of the federal Clean Air Act (42 U.S.C. Sec. 7507) permits states to adopt California's tailpipe emissions standards instead of the less stringent federal standards. Current ZEV States are Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, and Oregon.

[7] Bloomberg New Energy Finance, July 2017. "All Forecasts Signal Accelerating Demand for Electric Cars" https://about.bnef.com/blog/forecasts-signal-accelerating-demand-electric-cars/

[8] Bloomberg New Energy Finance, June 2017. "Electric Cars to Reach Price Parity by 2025," https://about.bnef.com/blog/electric-cars-reach-price-parity-2025/

to be introduced in the next few years. As illustrated in the Bloomberg 'Electric Car Boom' figure shown in Chapter 2 (Figure 18), automakers plan to begin selling more than 120 EV models by 2020, many with a range exceeding 200 miles. Notably, the new offerings will include SUVs, which along with pick-up trucks made up 60 percent of new light-duty vehicle registrations in Hawai'i in 2016.[9] An important motivator of this trend is state and national ZEV regulations that effectively require automakers to meet sales targets for EVs. Although many of the governments that have implemented these regulations also provide financial and non-pecuniary benefits to entice shoppers to choose an EV,[10] automakers still must produce vehicles that meet consumers' transportation needs at an acceptable price point in order to comply with these regulations. In this way, the ZEV regulations are increasing the offerings of practical, desirable electric cars.

"Every ride is an opportunity for education. One of the major barriers to EV adoption is lack of EV knowledge. We have the unique ability to get thousands of Hawai'i residents into EVs every month, via the Uber platform."

Tabatha Chow, Uber

Customer Uses for Light-Duty Vehicles

We identified four principal customer applications for LDVs and assessed adoption barriers and grid integration challenges for each separately.

Personal vehicles are owned by individuals or families and account for most of sales and vehicle miles travelled (VMT) today. They are typically used for commuting, running errands, and making trips around the island where they are located.

Networked service vehicles include taxis, limousines and vehicles affiliated with the transportation network companies (TNCs), such as Lyft and Uber. Dedicated service TNC vehicles tend to have high VMT, increasing the savings from EV's lower operations and maintenance and refueling costs. We understand that many taxi drivers in Honolulu rent their vehicle from a taxi fleet operator. There are two main business models for TNC vehicles. Some drivers use their own personal vehicle when providing rides. Alternatively, drivers who either lack a suitable personal vehicle or prefer not to use it for this purpose may rent a car on a weekly basis; the rental fee includes insurance and maintenance. As of mid-2016, Uber had partnerships with Hertz and Enterprise, and Lyft had a partnership with Hertz. In addition, following GM's $500 million investment in Lyft, the companies together launched Express Drive which provides favorable terms on rentals of GM cars to full-time Lyft drivers.[11] GM's Maven Gig spinoff offers Lyft and Uber drivers the opportunity to lease a Chevrolet Bolt in select cities including Detroit, San Francisco, and Washington D.C. The rentals also include charging.[12] None of these rental programs are currently available to TNC drivers in Hawai'i.

Shared vehicles include those in rental and car-share fleets. Many tourists choose to rent a vehicle when they visit Hawai'i, especially visitors to Maui and Hawai'i Island. Hertz and Enterprise have experimented with EVs in their fleets. This customer segment represents a significant potential source of second-hand EVs.

Fleet vehicles both public and private are common in Hawai'i. Fleets widely in annual VMT and range of operation. Fleets have been widely targeted for electrification programs by mainland governments and utilities because their owners are mainly focused on economics. High mileage fleets are strong candidates for electrification as the total cost of ownership declines with increased VMT.

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[9] DBEDT, 2016. 2016 State of Hawai'i Data Book Individual Tables and Updates Section 18 Table 14. http://files.hawaii.gov/dbedt/economic/databook/2016-individual/18/181416.pdf

[10] See discussion in Chapter 4.

[11] Perea, Christian, 2016m "All the Rideshare Vehicle Rental Options Compared," https://therideshareguy.com/all-the-rideshare-vehicle-rental-options-compared/

[12] Hawkins, Andrew, 2017, "GM will rent the Chevy Bolt to Uber and Lyft Drivers." https://www.theverge.com/2017/5/3/15521048/gm-maven-rideshare-gig-economy-uber-lyft

Charging Infrastructure for Light-Duty Vehicles

All light-duty EVs can charge with AC power using J1772 connectors, which have been standardized in the U.S. market. Most are also equipped with a DC fast charging port. There are three main standards for DC charging—CHAdeMo (used by Japanese automakers), Combined Charging System (CCS, used by European and U.S. automakers) and Tesla's proprietary supercharger technology.[13] Since 2010, Hawaiian Electric has deployed 12 public DCFC EVSEs: 8 on O'ahu, 3 on Hawai'i Island, and 1 on Maui.

Despite Hawaiian Electric's offering a development rate for high capacity EV charging (Schedule EV-F), private investment in DC fast charging infrastructure has been minimal in Hawai'i. In 2013, there were three customer accounts on Schedule EV-F on O'ahu for third-party operated DC fast charging. In 2016, all three accounts were closed, and the charging stations were removed. The companies are completing the process of acquiring a DCFC station at the Shops at Mauna Lani from a third-party that no longer wishes to be involved in the EV infrastructure business.

Most non-Hawaiian Electric DCFCs were developed under JUMPSmart Maui, a research project subsidized by the New Energy and Industrial Technology Development Organization (NEDO) of Japan. The charging assets have since been transferred to the Maui Economic Development Board (MEDB) which now owns the charging network on Maui and has rebranded the program as EVOhana. Hawaiian Electric is currently supporting conversations with stakeholders in this project to ensure that these crucial Maui charging assets remain in place beyond the expiration of that project. Tesla currently does not provide any of its DCFC Supercharger locations in Hawai'i, although it has three planned for 2018.[14]

> "It is good for driver partners because EVs are less expensive to fuel and maintain, and riders report a higher satisfaction rating with drivers in EVs. It is good for riders because it provides another incentive to choose to use shared mobility rather than driving their own car. It is good for the industry because every 10 additional EVs driven with Uber has the potential to provide EV ride experiences to thousands of new consumers. And it goes without saying that it is good for the environment." *Jon Isaacs, Uber*

[13] Note that Tesla owners may also purchase a CHAdeMO adapter

[14] Tesla. Map of current and proposed stores and galleries, service centers, and superchargers. Accessed February 27, 2018. https://www.tesla.com/findus

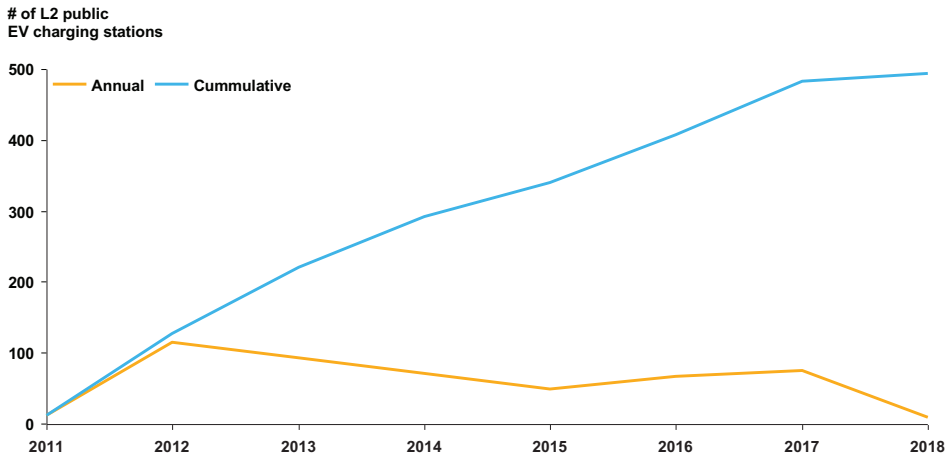
Figure 27. Hawaiian Electric DC Fast Charging station installed at Dole Plantation

Table 3. Count of Public Level 2 EV Charging Ports and Stations in Hawai'i, by EVSP through February 1, 2018

EVSP	Ports	Stations	EVSP	Stations	Ports
Non-networked	217	193	Greenlots	18	18
OpConnect	112	110	AeroVironment	14	13
ChargePoint	88	68	Blink	14	13
SemaCharge	35	35	GE WattStation	13	13
Volta	25	25	RechargeAccess	6	6
Total	**542**	**494**			

Source: PlugShare

Figure 28. Number of Level 2 public EV Charging Stations Installed in Hawai'i through February 1, 2018



Source: PlugShare

In contrast, several companies have deployed Level 2 public charging infrastructure to serve Hawai'i EVs, due to a much more favorable business case for this charging technology. See Table 3.

Electrify America has not announced plans to deploy chargers in Hawai'i as part of the Volkswagen settlement.

Barriers to Adoption

LDVs used in the four customer applications share similar adoption barriers.

Lack of awareness, knowledge, enthusiasm for EVs

This is primarily an issue for the personal and fleet applications. National surveys have found widespread lack of knowledge of the commercial availability of EVs, purchase incentives, fuel and maintenance cost savings, charging options, and their ability to meet most peoples' daily driving needs.[15] Workshop participants agreed that this is one of the most important adoption barriers and stressed the need for programs to educate the general public as well as hard to reach segments.

[15] Jin, Lingzhi and Peter Slowik, 2017, "Literature of electric vehicle consumer awareness and outreach activities" https://www.theicct.org/sites/default/files/publications/Consumer-EV-Awareness_ICCT_Working-Paper_23032017_vF.pdf

Lack of Suitable Models

Most of the light-duty EVs on the market today are sedans, which meet the needs of many drivers but are ill suited for others. In 2016, over 60 percent of new light-duty vehicles purchased in Hawai'i were light trucks.[16] Off-roading needs (due to residential dirt roads) are especially significant on Moloka'i, Lāna'i, and the Hawai'i Island. This issue was among the most widely cited by workshop participants, with one noting that "EVs need to meet the truck culture of Hawai'i."

A confidential needs assessment survey performed in 2015 asked respondents on Hawai'i Island, O'ahu, and Maui what would make them most likely to buy an EV. Among the top four responses was "more choices of EV models." Further education on the capabilities of EVs might lead some customers to reassess their suitability. For example, an EV can produce significantly more torque, especially at low engine RPMs, than a conventional internal combustion engine.[17]

Unfortunately, even when automakers develop electric-drive pickup trucks and SUVs, they may not appear in Hawai'i showrooms. Automakers have an incentive to concentrate vehicles and marketing resources in California and the other ZEV states where they face regulatory obligations to greatly increase EV sales. As long as automakers lose money selling EVs, some may be reluctant to offer them in markets in which they are not required to sell them.[18]

Insufficient charging infrastructure

Insufficient availability of suitable and reliable charging infrastructure is a significant barrier to adoption across all four applications of light-duty EVs. This barrier was a major focus of workshop participants, who raised concerns about minimal availability of multi-family and workplace charging, quantity and location of DCFC, reliability of public chargers and the viability of business models for third party charging providers.

> "Lack of marketing of electric vehicles by OEMs and auto dealerships mean that consumers rarely, if ever, see electric vehicles on television or in other media."
>
> *Shem Lawlor, Blue Planet Foundation*

Personal vehicles: To date most EV purchasers in Hawai'i live in single family residences and can charge at home. Home charging is an elusive option for residents of multi-unit dwellings (MUDs), which are estimated to comprise 38 percent of Hawai'i's housing units. It is costly and complex to install Level 1/Level 2 in MUDs.[19] According to a recent DEBDT study, these challenges include the cost of upgrades to wiring and electrical capacity and for construction to accommodate chargers (e.g. trenching if the parking spot is not sufficiently proximate to electric infrastructure). Other concerns for building owners are the potential loss of parking spots for other vehicles and how to allocate ongoing operation and maintenance (O&M) costs. Limited availability of charging

> "Some people think that electric cars are still a science project and don't realize how applicable these vehicles can be to their lifestyle."
>
> *Jon Nouchi, Deputy Director for the City & County of Honolulu, Department of Transportation Services*

[16] DBEDT, 2016. 2016 State of Hawai'i Data Book Individual Tables and Updates Section 18 Table 14. http://files.hawaii.gov/dbedt/economic/databook/2016-individual/18/181416.pdf

[17] DeBord, Mathew, 2014, "What is Torque and Why Does It Matter That the Tesla D Has So Much Of It?" http://www.businessinsider.com/what-is-torque-and-why-does-it-matter-that-the-tesla-d-has-so-much-of-it-2014-10

[18] DeBord, Mathew, 2017, "FCA loses a staggering $20,000 on every one of its all-electric cars" http://www.businessinsider.com/fca-loses-20000-on-every-one-electric-car-2017-10

[19] DBEDT, December 2015, "Report to the Hawai'i State Legislature. Act 164: Working Group Regarding requests to the board of directors of an association of apartment owners, condominium association, cooperative housing corporation, or planned community association regarding the installation of electric vehicle charging systems," available at http://files.hawaii.gov/dbedt/annuals/2015/2015-act-164-installation-of-ev-charging-stations.pdf

"It's mostly simple elements unknown to non-EV drivers -- like where the chargers are? how far one can really go on a full battery? Can one drive around the island on a single charge? How long does it take to charge the battery when depleted?"

Sharon Williams, University of Hawai'i at Mānoa

at workplaces (Level 1 or Level 2) and scarce public DCFC leave MUD residents without a dependable charging solution, making EV ownership viable only for the determined few.

Even to customers who can charge at home, a robust and reliable network of public chargers, especially DCFC, is essential to building range confidence. No third-party EVSP has yet realized a sustainable business model for DCFC in Hawai'i. Elsewhere, utilities and/or governments have stepped in to fill the gap.[20] Many of the workshop participants expressed concerns about both the availability and reliability of public chargers. While a majority of participants reported charging their vehicles at home overnight, a finding corroborated by a confidential Hawaiian Electric survey of EV owners performed in December 2017 stressed a need for increased availability of charging options, especially for DC Fast Charging in public areas:

We're already having trouble with finding places to charge, and they're building them as fast as possible. But if you're plugging in to charge you're there for an hour possibly two hours. It's just not going to work. If you're talking about an exponential growth of EVs across the island, it's not even going to come close. So you need quick charge, to move people through quicker.

Service Vehicles: Electric taxis and TNC vehicles need access to a reliable and relatively uncongested network of public DCFC so they can recharge swiftly and return to service. They also need to be able to quickly top up their charge, to be able to complete the next ride that is requested.

Shared vehicles: Car-share vehicles are typically used for short duration, short distance trips so they can recharge at the depot. Rental cars need to be able to recharge quickly at or near the depot to return to service quickly. They also require a robust network of charging at destination points (e.g. tourist attractions, resorts, restaurants, retail establishments) for rental car companies to put them in their fleets and customers to be willing to drive them. If DCFC becomes more widely available, car-sharing and rental operators could introduce incentives to reward customers for returning vehicles with a full charge (analogous to rental car agencies charging a premium price for gasoline if vehicles are not returned with a full tank).

Fleet vehicles: These vehicles mainly need to be able to charge at their depot. Overnight charging is likely suited for most fleets but driving patterns vary widely. There may be a need for public DCFC to extend the range of vehicles that accrue high VMT on a regular basis.

Cost premium versus conventional vehicles

This is an issue for all applications, although service and fleet vehicles that are driven intensively will benefit more from the offsetting savings in maintenance and refueling costs. Declining EV costs combined with increasing range and a wider selection of models should bring many consumers to the point of indifference within the next decade. In the interim, getting EVs into rental fleets will accelerate availability of relatively inexpensive second-hand EVs and give more of our customers the opportunity to own one. Some workshop participants were concerned about low resale value for EVs, which they see as increasing the cost premium relative to standard vehicles.

One workshop participant described a related barrier for fleet operators: while many automakers produce stripped-down basic models of conventional models for fleets,

[20] See discussion in Chapter 6.

this is not yet the case for EVs. This makes it harder for EVs to beat the economics of conventional models despite their advantage on O&M and fuel costs.

Lack of dealer incentives to sell EVs

Some workshop participants noted that sales representatives at automobile dealerships were either uninformed about the capabilities and merits of EVs or tried to interest customers in other (conventional) models. They observed that while dealers and their sales staff have no express incentive to sell EVs, they do have a disincentive because EVs will generate less business and profit for the service department and parts shop. This is primarily an issue for the personal vehicle market.

Grid Integration Challenges and Opportunities

As more EVs come online, utilities face the challenge of integrating them proactively and cost-effectively onto their distribution systems. Personal EVs are largely charged at home. Absent incentives for drivers to shift their charging behavior, the average driver is likely to plug into a Level 1 or Level 2 charging port when returning home from work or school. This means that residential EV charging is forecast to be highly coincident with Hawaiian Electric's 7 – 8 p.m. distribution system peak load. In addition, public DC fast charging is forecast to increase in power, with EVSPs beginning to move from today's typical 30-60kW capacity to chargers operating at 350kW and above.[21] At this current stage of the EV transition, many DCFCs are most valuable as "backup" options that reduce range anxiety, and therefore may show fairly low utilization. This infrequent use can cause their load profiles to be "peaky" throughout the day. These factors all contribute to the potential need for distribution system upgrades as EV adoption escalates.[22]

This challenge creates opportunities to save utility and customer costs and increase the state's use of renewables through "smart" charging of EVs. The Cost-Benefit Analysis presented in Chapter 3 demonstrated that net benefits to Hawaiian Electric's customers are expected to more than triple if EV drivers are proactively incentivized to charge when the distribution grid is less congested and renewable energy is abundant. This could be achieved, for example, through:

- Rates, such as time-of-use (TOU) and real-time rates,
- Demand response (DR) programs,
- Workplace charging (during hours of high renewable penetration), and
- Bulk price discounts to commercial fleets, TNC vehicles and taxis to charge during the middle of the day. This incentive fits well with the needs of TNC and taxi drivers, who tend to face lower demand for their services during this time.

> "Electric Lyft would be a perfect customer for solar PV. We can fuel midday if you implement TOU to incentivize the EVs on our platform"
>
> *Jon Walker, Lyft*

As well as simply shifting their charging, EVs can provide value to the companies and their customers by providing other grid services that increase the reliability of the grid and assist with renewable integration. Some workshop participants saw increased availability of workplace charging as an avenue to absorb peak solar generation and lower charging costs. Hawaiian Electric believes that EVs will be capable of delivering each of the four currently filed grid service tariffs in the companies' DR program: capacity, replacement reserves, regulating reserves and fast frequency response. It is projected that automakers, charging providers and technology companies will be able to use their technologies to aggregate individual EVs and fleets to provide these services.

[21] Lambert, F. July 14, 2017, "Porsche installs first ultra-fast 350 kW EV charging station" https://electrek.co/2017/07/14/porsche-350-kw-ev-charging-station and Mitrache, Vlad, 2017, "Ultra-Fast Charging Stations with 500 kW Rates in Development, 0-100 percent in Minutes." https://www.autoevolution.com/news/ultra-fast-charging-stations-with-500-kw-rates-in-development-0-100-in-minutes-120824.html

[22] This distribution system challenge was investigated in a recent NREL study, see Walton, R. January 31, 2018, "Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investment

Work is underway in California to develop recommendations for charging equipment hardware functionality and communication protocols requirements that can further support provision of these services.[23]

Hawaiian Electric proposes to make use of all the tools listed above to proactively encourage the use of EVs as grid assets to minimize costs and maximize the use of the state's renewable resources.

Buses

Buses are the other class of vehicles we identified as a near-term priority for Hawaiian Electric action. This reflects their widespread use in Hawai'i and numerous commercially available models across a range of applications.

Maturity, Adoption and Market Size

In 2015 there were 2,465 buses registered in Hawai'i. Within the Hawaiian Electric service territories, there were 1,886 on O'ahu, 308 on Hawai'i Island, and 188 on Maui.[24] Buses come in many shapes and sizes, but mostly fall into four main categories:

- Transit — TheBus (O'ahu), Hele-On Bus (Hawai'i Island), Maui Bus (Maui)
- Tourist — Roberts, TP Transportation, and Polynesian Adventures are the largest tour bus operators
- School — Public schools mostly use contractors such as Roberts, Ground Transport Inc., Akina, Bus Service and Gomes
- Shuttle — Consolidated Rental Car Facilities (CONRACs), airports (Wiki-Wiki), resorts, etc.

According to CARB's most recent assessment, both transit and shuttle e-buses have reached the commercial stage. CARB reports that all major North American bus makers are producing full-sized battery-electric transit buses, and nearly 20 different models are available.[25] CARB characterizes these transit buses as a "beachhead technology" that will serve as a launch point for development of battery electric shuttle buses, school buses, and delivery vehicles.[26]

Electrified school buses are beginning to reach the market[27] and are already being piloted in several communities in the U.S. and Canada.[28] This technology is likely to get a boost from the Volkswagen settlement. States have broad latitude in spending the

[23] There are currently a number of competing and overlapping communication standards and protocols currently in use and development. In California, a Vehicle-Grid Integration (VGI) Communication Protocol Working Group was initiated in December 2016 with participation by the CEC, CARB, CAISO and Governor's Office and 130 interested stakeholders. The working group evaluated the existing communication protocols in an effort to understand whether one protocol, or a specific combination of protocols, should be required to enable VGI economically and at scale. A staff report summarizing the working group's activity and recommendations was issued in February 2018. See "Assigned Commissioner's Ruling Seeking Comment on Vehicle-Grid Integration Communication Protocol Working Group Energy Division Staff Report," http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M211/K654/211654688.pdf

[24] DEBDT Table 18-08.

[25] California Air Resources Board, 2017. "Proposed Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives" https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1718_funding_plan_final.pdf p. 17

[26] ibid p. II-36

[27] California Air Resources Board, 2015. "DRAFT Technology Assessment: Medium and Heavy-Duty Battery Electric Trucks and Buses" https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf, p. IV- 7 ff.

[28] For example:

Acadia Center, 2017. "No. 1 on Our List of Back to School Supplies: Electric School Buses" http://acadiacenter.org/no-1-on-our-list-of-back-to-school-supplies-electric-school-buses/

Gray, Ryan, 2017. "Largest US Electric School Bus Pilot Comes to California" http://www.stnonline.com/news/latest-news/item/8613-largest-us-electric-school-bus-pilot-comes-to-california

Jossi, Frank, 2017. "Minnesota district to get Midwest's first electric school bus this fall" https://midwestenergynews.com/2017/07/11/minnesota-district-to-get-midwests-first-electric-school-bus-this-fall/

Ontario Ministry of Transportation. "Electric School Bus Pilot Program" http://www.mto.gov.on.ca/english/vehicles/electric-school-bus-pilot.shtml

Vermont Energy Investment Corporation. "Bringing electric school buses to your district" https://www.veic.org/our-results/success-stories/advancing-electric-school-buses

NOx mitigation funds allocated to them in the Volkswagen Environmental Mitigation Trust, and many have expressed an interest in electrifying school buses to capture the added benefit of reducing children's exposure to toxic diesel emissions.[29]

Buses may charge at a depot or, to maintain continuous operation, stop briefly at ultra-fast overhead chargers situated along their route. Proterra pioneered the in-route charging technology, which has been piloted in southern California. Wireless or inductive charging for buses is being demonstrated in several locations including Israel,[30] Sweden[31] and Texas.[32] This technology allows vehicles to charge while driving a short, fixed route or while parked.

Barriers to Adoption

The main barriers to adoption of e-buses are limited awareness, knowledge and/or enthusiasm among bus operators and the capital cost premium over conventional alternatives (CNG and diesel). Including the cost of the charger, full-size electric transit buses have an up-front premium of about $200,00-$300,000 over diesel buses, which typically cost from $450,000-750,000.[33]

In addition, existing commercial and industrial rate structures are not well suited to early stage deployment of e-buses. With small numbers of buses in a fleet, demand charges can significantly impact customers' bills. As more buses are added opportunities increases to smooth out charging load. This problem is more acute for buses that use in-route charging, as there is little if any latitude to manage the timing of charging sessions to reduce demand charges.[34]

> "School buses present a unique opportunity to create a new day-time load as they are usually idle during school hours and could charge mostly or entirely on solar power."

Grid Integration Challenges and Opportunities

Integrating e-buses into the grid presents both challenges and opportunities, which vary across the four categories. Typical e-bus loads are as high as 500 kW using an overhead charger and 100 kW using a depot charger.[35] Several buses charging simultaneously at the depot could create a load of 0.5 MW comparable to 200 typical homes in the U.S.[36] It is unlikely that depots can be relocated to uncongested parts of the grid, so it will be necessary to coordinate distribution system upgrades with bus operators' plans to electrify their fleets. In Hawai'i, most transit buses are idle at night and can recharge when the distribution grid is least congested. This is likely to be true for most shuttle and tourist buses as well.

School buses present a unique opportunity to create a new day-time load as they are usually idle during school hours and could charge mostly or entirely on solar power. Their large batteries of 150 kWh are also potential sources of ancillary services.

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[29] California Air Resources Board, 2016. "Overview: Diesel Exhaust and Health" https://www.arb.ca.gov/research/diesel/diesel-health.htm; Beatty, Timothy K.M., and Jay P. Shimshack. 2011. "School Buses, Diesel Emissions, and Respiratory Health." Journal of Health Economics. https://doi.org/10.1016/J.JHEALECO.2011.05.017

[30] Fagan, Abigail, 2017. "Israel Tests Wireless Charging Roads for Electric Vehicles" https://www.scientificamerican.com/article/israel-tests-wireless-charging-roads-for-electric-vehicles/

[31] Sisson, Patrick, 2016. "Stockholm's new buses are powered by wireless charging" https://www.curbed.com/2016/12/21/14038784/bus-stockholm-sweden-wireless-charging-transportation

[32] Cole, Jay, 2015. "Texas Gets Its First Two Electric, Wireless Charging Buses" https://insideevs.com/texas-gets-first-two-electric-wireless-charging-buses-video/

[33] Aber, Judah, 2016. "Electric Bus Analysis for New York City Transit" http://www.columbia.edu/~ja3041/Electric%20Bus%20Analysis%20for%20NYC%20Transit%20by%20J%20Aber%20Columbia%20University%20-%20May%202016.pdf

[34] Eudy, Leslie, Prohaska, Robert, Kelly, Kenneth, Post, Matthew, 2016. "Foothill Transit Battery Electric Bus Demonstration Results," https://www.nrel.gov/docs/fy16osti/65274.pdf

[35] Gallo, Jean-Baptiste, Bloch-Rubin, Ted, Tomic, Jasna, 2014. "Peak Demand Charges and Electric Transit Buses: White Paper," http://www.calstart.org/Libraries/Publications/Peak_Demand_Charges_and_Electric_Transit_Buses_White_Paper.sflb.ashx and CALSTART, 2015. "Electric Truck & Bus Grid Integration: Opportunities, Challenges & Recommendations" http://www.calstart.org/Libraries/Publications/Electric_Truck_Bus_Grid_Integration_Opportunities_Challenges_Recommendations.sflb.ashx

[36] Using an assumption of 2.5 kW for a typical home

Four school districts in Massachusetts are currently conducting V2G pilots for school e-buses.[37]

Other On-road Medium and Heavy-duty Vehicles

Trucks are a large and diverse segment with highly varied uses and duty cycles. Medium-duty (MD) trucks (Classes 4-6) range from 14,001 to 26,000 lbs., and their uses include parcel, linen, and snack-food delivery as well as utility service or "bucket" trucks for telecom and electricity services. Heavy-duty (HD) trucks (Classes 7 and 8) weigh over 26,000 lbs., and include long-haul, regional freight delivery, and drayage trucks (which transfer containers from ports to warehouses). Most of these vehicles are present in Hawai'i, except long-haul trucks. The relatively short distances most trucks travel in Hawai'i make electric drive versions suitable for most applications.

"Hawaiian Electric has 29 Class 5 through Class 8 plug-in hybrid bucket and derrick trucks in its fleet."

Medium-Duty Trucks

Maturity, Adoption and Market Size

Medium Duty (MD) trucks, especially last-mile delivery vehicles, are the most advanced electric-drive truck technology. Even on the mainland the relatively short, set routes of most delivery vehicles are well within the 100-mile range of current offerings. Early deployments are proliferating. In 2017, Los Angeles-based Chanje announced that it would begin selling and leasing its fully-electric delivery vans in the U.S. The company is partnering with Ryder Systems, which is offering the vehicles to leasing customers in New York, Chicago and several California cities. Ryder is equipping its rental centers in those cities with charging stations and outfitting maintenance facilities to handle the new vehicles.[38]

Chanje and Ryder are also evaluating deployments in Hawai'i, specifically O'ahu and Maui. Fuso and UPS are piloting battery-electric delivery trucks in New York City.[39] FedEx has been experimenting with electric vehicles in its fleet since 2010.[40] Hawaiian Electric has 29 Class 5 through Class 8 plug-in hybrid bucket and derrick trucks in its fleet.

Barriers to Adoption

The principal barriers to adoption of electric-drive MD trucks are awareness, the cost of dedicated depot chargers, and the upfront vehicle price premium relative to diesel alternatives. The price premium will continue to decline as battery technology improves and manufacturers realize scale economies, lowering the total cost of ownership (TCO). Even with TCO lower than conventional vehicles, smaller fleet operators may still face issues in absorbing the initial capital cost premium. Highly-visible early deployments by fleet giants like FedEx, UPS, Ryder and Pepsi-Frito-Lay are raising awareness of the availability of e-trucks. In the U.S., these are mainly limited to cities with air quality challenges. It may be difficult to attract these vehicles to Hawai'i until the major fleet operators deploy them en masse.

Hawaiian Electric's investigation and deployment of electric bucket trucks revealed an additional concern: the driving schedule for these trucks can be highly variable, as they perform both regularly-scheduled and on-call, emergency work. The latter requires that the trucks must be available and ready to go at a moment's notice. Uses and working conditions also vary so the technology must also be suitable and adaptable to the field conditions and circumstances.

[37] Ayre, James, 2016, "Massachusetts Puts $1.4 Million Into Electric School Bus Pilot," https://cleantechnica.com/2016/08/16/massachusetts-puts-1-4-million-electric-school-bus-pilot-project/

[38] O'Dell, John, 2017, "Drive of Chanje Electric Van Reveals Impressive Vehicle" https://www.trucks.com/2017/11/03/first-drive-chanje-electric-van/

[39] Lillian, Betsy, 2017, "Newly Launched FUSO eCanter to Join UPS, NYC Fleets" https://ngtnews.com/newly-launched-fuso-ecanter-join-ups-nyc-nonprofit-fleets

[40] Woody, Todd, 2012, "FedEx Delivers on Green Goals with Electric Trucks" https://www.forbes.com/sites/toddwoody/2012/05/23/fedex-delivers-on-green-goals-with-electric-trucks/#42ce16b61c6e

Grid Integration Challenges and Opportunities

The duty cycles for these vehicles vary widely: delivery of parcels, by carriers such as FedEx and UPS, often start in the very early morning hours and are often done by 2 or 3 p.m. Produce delivery is often complete by 6 a.m. A number of these vehicles could therefore be available to charge using solar energy in Hawai'i for their full six to eight-hour charging time.

Heavy-Duty Trucks

Maturity, Adoption and Market Size

Heavy Duty (HD) trucks are further from commercial deployment, although recent announcements by Tesla[41] BYD,[42] and Cummins[43] suggest that development of electrified technologies for this segment may be accelerating. CARB has funded a total of 43 zero-emission battery electric and plug-in hybrid drayage trucks serving major California ports.[44] CARB has also funded another project piloting 22 all electric yard trucks and 5 MD vehicles at two rail yards, and one freight transfer yard in Southern California.[45] In Hawai'i, HD trucks are often used to transport goods from seaports to distribution centers and retail establishments – regional freight delivery and drayage trucks. The duty cycles of these applications are a good fit for the introduction of electric trucks.

Barriers to Adoption

One of the main barriers is the high cost resulting from low production volumes, high battery cost, and electric powertrain. In addition, the impact of the size and weight of electric driveline components on HD e-trucks' total payload are not well understood. Lower range limits for fully-electric trucks and the associated need for frequent re-charging present a barrier although they have been steadily improving with improvement in battery technology. The availability of suppliers and vendors is currently limited but increasing. Finally, the demand charges in commercial and industrial rates can significantly increase bills.

Grid Integration Challenges and Opportunities

HD e-truck chargers draw very large loads and may require major infrastructure upgrades at depots. Power supply upgrades may be necessary as well.

Off-road vehicles and equipment

Electrified vehicles and equipment are increasingly available for airports, seaports, and warehouses. According to CARB's assessments many of these technologies are now in the pre-commercial (TRL 7 and 8) or early commercial (TR 9) stages. Deployment is most common at facilities in regions that are in non-attainment for air pollutants and/or where efforts are underway to limit the exposure of surrounding areas to diesel emissions. Most of these technologies are suitable for deployment in the service territory of the Hawaiian Electric utilities. This section surveys the available vehicles and equipment, discusses potential applications, and identifies potential barriers to adoption as well as challenges and opportunities for cost-effective integration on Hawaiian Electric's grid.

Airports

Maturity, Adoption and Market Size

A wide range of electric ground support equipment (e-GSE) is available from multiple manufacturers. E-GSE include pushback

[41] Lambert, Fred, 2018. "A Tesla Semi electric truck could save us 'tens of thousands of dollars a year', says DHL" https://electrek.co/2018/02/23/tesla-semi-electric-truck-savings-dhl/

[42] Hurt, Emma, 2017. "BYD's Truck Chief Confident About Future of Battery-Electric Trucks" https://www.trucks.com/2017/10/26/byd-chief-future-electric-trucks/

[43] Muller, Joann, 2017. "Cummins Beats Tesla to The Punch, Unveiling Heavy Duty Electric Truck" https://www.forbes.com/sites/joannmuller/2017/08/29/take-that-tesla-diesel-engine-giant-cummins-unveils-heavy-duty-truck-powered-by-electricity/#672151c78f1b

[44] Turner, Melanie, 2016. "State to award $23.6 million for zero-emission trucks at seaports" https://www.arb.ca.gov/newsrel/newsrelease.php?id=809

[45] Turner, Melanie, Young, Stanley, 2016. "State to award $9 million for zero-emission trucks at two rail yards, one freight transfer yard in Southern California" https://www.arb.ca.gov/newsrel/newsrelease.php?id=824

tractors, belt loaders, luggage tugs, and water trucks. E-GSE replace diesel fueled equipment and may be fully electric or plug-in hybrid. Conventional hybrid versions are also available for some types of ground support equipment (GSE). Another important technology is pre-conditioned air (PCA) units, which draw on the terminal's power supply to cool aircraft cabins, avoiding the need to run their engines while parked.

Electrified GSE are already in use at numerous major airports on the mainland. A 2016 survey by the National Renewable Energy Laboratory (NREL) found that at least 22 U.S. airports had launched significant e-GSE projects. Seattle-Tacoma, Philadelphia, and Dallas Fort Worth were home to the largest projects, with 230-430 e-GSE in use at each airport. [46] Most major carriers that serve Hawai'i have experience with e-GSE from projects at mainland airports.[47] As of early 2016 Delta Airlines reported that it had electrified 15 percent (or 15,000 units) of its GSE fleet[48] at airports serving Atlanta, Minneapolis-St. Paul, Los Angeles, and Salt Lake City.[49] Alaskan has deployed e-GSE and PCA units at Sea-Tac Airport.[50] United Airlines is deploying GSE at its Chicago O'Hare hub[51] and plans to develop fully electrified "Pad of the Future" facilities as it consolidates and modernizes its aircraft and ground support maintenance facilities at Los Angeles International Airport (LAX).[52]

Electrifying GSE requires coordination between the airport owner/operator, utility, airlines, and third-party ground support service providers.[53] Drivers of GSE electrification include complying with local air-quality regulations, supporting attainment of a city or region's GHG reduction target, and meeting airlines' own sustainability goals. Major renovation or expansion projects at airports provide opportunities for GSE conversions. The federal government has provided grants to help finance electrification projects with funding authorized by the US EPA's Diesel Emissions Reduction Act[54] and the U.S. Department of Transportation's Voluntary Airport Low Emissions Program (VALE).[55]

Hawai'i is well positioned to begin electrifying GSE. Renovations are underway at the state's largest commercial airports, on O'ahu (Honolulu), Maui (Kahului), and Hawai'i Island (Kona). Among projects planned for Honolulu's Daniel K. Inouye International Airport are installation of PCA units and upgraded ground power capabilities at aircraft gates.[56] These projects also provide an opportunity to lay the groundwork for e-GSE by planning for deployment of chargers and upgrading the power supply as needed. Because the state owns and operates Hawai'i airports, HDOT can ensure that the necessary collaboration occurs. Cargo handling operations at military facilities may also provide opportunities to electrify GSE.

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[46] NREL, 2017. "Electric Ground Support Equipment at Airports" https://www.afdc.energy.gov/uploads/publication/egse_airports.pdf

[47] Thomas, Michael, 2016. "Airline's 'other fleet': Science behind ground equipment" http://news.delta.com/airline-s-other-fleet-science-behind-ground-equipment

[48] Ibid

[49] Ibid

[50] Alaska Airlines, 2014. "Sea-Tac Airport Unveils Electrification Project to Save Airlines Millions in Fuel and Dramatically Reduce Greenhouse Gas Emissions" https://www.prnewswire.com/news-releases/sea-tac-airport-unveils-electrification-project-to-save-airlines-millions-in-fuel-and-dramatically-reduce-greenhouse-gas-emissions-250857101.html

[51] Hermes, Jennifer, 2018. "United Airlines & O'Hare Invest Big in Zero-Emissions Ground Support with Grant from EPA" https://www.environmentalleader.com/2018/02/united-airlines-ohare-invest-big-zero-emissions-ground-support-grant-epa/

[52] Los Angeles World Airports. "United Airlines East Aircraft Maintenance" https://www.lawa.org/en/lawa-our-lax/environmental-documents/current-projects/united-airlines-east-aircraft-maintenance

[53] Over half of air carriers worldwide contract with third-party vendors for ground support services. Source: Insider Tradings, 2017. "Aircraft Ground Support Equipment Market Insights and Trends 2017" http://www.insidertradings.org/2017/12/19/aircraft-ground-support-equipment-market-insights-and-trends-2017/

[54] Federal Grants Wire. "National Clean Diesel Emissions Reduction Program" https://www.federalgrantswire.com/national-clean-diesel-funding-assistance-program.html#.WpQ81GrwbRY

[55] Federal Aviation Administration, 2017. "Voluntary Airport Low Emissions (VALE) Program". https://www.faa.gov/airports/environmental/vale/media/VALE-brochure-2017.pdf

[56] Hawai'i Department of Transportation, GCA Update, August, 2017 at pp. 10-11. http://gcahawaii.org/gca_newsletter/DOTGCAAUG2017Final.pdf

Barriers to Adoption

- The higher cost for e-GSE makes it challenging to develop a compelling business case for diesel-to-electric conversions, especially outside of non-attainment areas or without a local GHG reduction target.

- The cost of high capacity charging infrastructure and whether it is the airline's or airport's responsibility.

- Given Hawai'i's isolation, a critical mass of deployment will be needed to ensure that parts and trained technicians are readily available.

Grid Integration Challenges and Opportunities

- Distribution upgrades will likely be needed to accommodate loads for charging and pre-conditioned air units. While e-GSE have low VMT, some types such as pushback tugs, consume large amounts of energy in short bursts. High capacity charging is needed to restore their charge quickly.

- Sophisticated charging management systems are available to optimize charging across an airline's fleet of e-GSE in order to smooth out charging loads and ensure that each piece of equipment is ready when needed.[57]

Harbors

Maturity, Adoption and Market Size

Electrified alternatives are available to replace most diesel-powered cargo-handling vehicles and equipment used at seaports. Electric vehicles at seaports include yard hostlers that move containers within the terminal, rubber tire gantries (RTGs) used in intermodal operations to ground or stack containers, top picks that move containers on and off ships, and Automated Guided Vehicles (AGVs) that move materials around a warehouse. Electrified stationary equipment includes large cranes that lift containers in and out of ships and shore power units that enable ships to shut down their engines while in port. Shore power is the principal electrification opportunity for cruise ships.

> "In January 2018, HDOT's Harbors Division broke ground on the $448 million Kapālama Container Terminal project in Honolulu Harbor, the centerpiece of Hawai'i's Harbors Modernization Plan."

Efforts to improve air quality in the Los Angeles region have been instrumental in driving development of low/no emissions seaport equipment. The original impetus was reducing emissions of criteria pollutants but has expanded to include lowering GHG emissions and reducing exposure of workers and residents of neighboring communities to diesel emissions. Some of the world's most advanced electrified port equipment is being demonstrated or piloted at the Ports of Los Angeles and Long Beach. These efforts are proving transformative: CARB rates several electrified port technologies at TRL 7-9, noting in its latest funding plan that yard hostlers and some other heavy equipment at seaports are "on the cusp of moving beyond pilot to early market deployments."[58]

Seaport electrification requires coordination between the port owner, utility, and shipping companies. Often electrification accompanies major expansion or renovation projects, which provide an opportunity to upgrade the power supply and set aside areas to house chargers for vehicles. Because the state owns, manages, and operates Hawai'i harbors, HDOT can ensure that the necessary collaboration occurs. Cargo handling operations at military facilities may also provide electrification opportunities.

Most of the goods consumed on the Hawaiian Islands pass through its harbors: over 80 percent of all goods are imported, and 98 percent of these arrive by ship.[59] Joint

[57] https://www.afdc.energy.gov/case/2329
[58] CARB Fiscal Year 2017-18 Funding Plan, p. II-17
[59] S&P Global Ratings, 2017, "Summary: Hawai'i Harbor Division Port Authorities," https://hidot.hawaii.gov/harbors/files/2017/02/SP-Global-Ratings-Report-dated-2017.02.02-Hawai'i-Harbor.pdf

Base Pearl Harbor-Hickam on O'ahu is the logistical hub for military bases in Hawai'i and for ships and personnel deployed throughout the Pacific region. Fuel, food, weapons, ammunition, equipment, vehicles, and personal property are among the cargo that land at or transit Pearl Harbor. Hawai'i's commercial seaports comprise an integrated hub and spoke system. Honolulu Harbor is the state's primary shipping link to ports on the Mainland, Pacific Rim, and Asia. Most cargo first arrives there and is then trans-shipped to the other islands. In 2015 Honolulu Harbor ranked 11th among U.S. ports in total volume of container traffic.[60] Interisland shipments include vehicles, fuel, and cement. Hawai'i's seaports also handle a smaller volume of exports, principally agricultural products. Maui's Kahului Harbor and Kawaihae and Hilo Harbors on Hawai'i Island are equipped to handle inter-island container traffic. Except for Kawaihae, these harbors can also handle cruise ships.

The Harbors Modernization Plan aims to address congestion and lack of space at both the hub and the spokes. An additional focus is improving the harbors' capabilities to handle containerized cargo. Plans for O'ahu, Maui and Hawai'i Island include upgrading existing facilities, adding new cargo and passenger terminals, expanding container handling and storage facilities, and extending existing piers.[61] In January 2018, HDOT's Harbors Division broke ground on the $448 million Kapālama Container Terminal project in Honolulu Harbor, the centerpiece of Hawai'i's Harbors Modernization Plan. As part of a parallel expansion and modernization program, Matson is adding and electrifying cranes at its Sand Island Terminal in Honolulu Harbor.[62] In both initiatives, it will be imperative that Hawaiian Electric is intimately involved from the planning process through construction to proactively anticipate the needs of both the HDOT Harbors Division and its tenants.

Barriers to Adoption

- The higher cost for electrified cargo handling equipment makes it challenging to develop a compelling business case for electric conversions, especially outside of non-attainment areas or without a local GHG reduction target.

- Rate design, especially demand charges, may adversely affect the business case.

- Payloads may be lower for some technologies due to the size and weight of the battery.

Grid Integration Challenges and Opportunities

- Power supply upgrades will be needed to accommodate loads for electric cranes and charging of cargo handling vehicles. While these vehicles have low VMT, they consume large amounts of energy in the course of moving cargo around port areas. High capacity charging is needed to restore their charge quickly.

- Given Hawai'i's dependence on imports, ensuring the resilience of the power supply to harbors will be increasingly important as equipment is electrified. Redundant pathways to substations and backup power sources are critical components of grid integration planning for electrified ports.

Warehouses

Maturity, Adoption and Market Size

The light-duty electric forklifts used in warehouses have achieved commercialization and are widely used. Class I and II electric forklifts, which handle pallet sized loads, are ubiquitous.[63] Class I forklifts are mostly designed to be operated by a sitting rider and can typically handle loads up to 8,000 lbs. Class II forklifts are designed to operate without a rider in small spaces, and

[60] US Army Corps of Engineers Waterborne Commerce Statistics Center, U.S. Waterborne Container Traffic by Port/Waterway in 2015 (http://www.navigationdatacenter.us/wcsc/by_porttons15.html)

[61] State of Hawai'i Department of Transportation, Hawai'i Island Commercial Harbors Master Plan Update (http://hidot.hawaii.gov/harbors/files/2013/01/HI-COM-HAR-2035-MP-Final.pdf), Kahului Harbor Development Plan (http://hidot.hawaii.gov/harbors/files/2013/01/Kahului-Harbor-Dev-Plan-FINAL-v2.pdf) and O'ahu Commercial Harbors Master Plan (http://hidot.hawaii.gov/harbors/files/2013/01/O'ahu-2020-Master-Plan.pdf)

[62] https://investor.matson.com/news-releases/news-release-details/matson-signs-contracts-total-six-new-and-upgraded-cranes-0

[63] CARB Fiscal Year 2017-18 Funding Plan, p. II-17

can typically handle loads up to 5,000 lbs. Because they have no emissions, electric forklifts are attractive for indoor use.

Barriers to Adoption

- The initial purchase price is 10 to 20 percent more than for comparable fossil fueled models, although fuel cost savings tend to more than compensate for this premium.

- If the forklift is used during successive eight-hour shifts, it will be necessary to have an additional battery for each shift in order to accommodate recharging time.

- Range and payload capacity may not match conventional models, especially for larger forklifts.

Grid Integration Challenges and Opportunities

- Some of these vehicles can charge overnight, avoiding peak system load hours.

Electric aviation

Small electric airplanes have become a reality. For example, Slovenian aircraft manufacturer Pipistrel has begun producing the Alpha Electro, a 2-seat electric airplane that can fly for an hour. It was expressly designed for training purposes and is being used by flight schools in California and Australia.[64,65] Fuel costs for the Alpha Electro are 90 percent lower than standard trainers. It is also easier to operate and is expected to have much lower maintenance costs due to its much simpler powertrain design.

Flying taxis may soon become a reality. Uber has announced plans to start flying customers in the next five to ten years and is collaborating with NASA, aircraft manufacturers, infrastructure and real-estate partners to develop the vehicles, systems and landing facilities to safely serve fixed routes in congested cities.[66] Other companies developing flying taxis have attracted investment from venture capital funds, aircraft manufacturers Boeing and Airbus, and Jet Blue Airways.[67] These aircraft could also become a good option for short inter-island flights.

Large commercial electrified aircraft could someday take flight. In 2017 Rolls-Royce, Airbus, and Siemens announced a partnership to develop a regional airliner with a hybrid-electric propulsion system. The companies are targeting 2020 for the E-fan X to take its first flight. The demonstration project builds upon ongoing efforts at the companies to develop components to enable electrified flight.[68]

"Flying taxis may soon become a reality. Uber has announced plans to start flying customers in the next five to ten years..."

Hydrogen fuel-cell vehicles

Fuel-cell vehicles and equipment are a zero emissions alternative to EVs. Like EVs, fuel-cell vehicles (FCVs) employ electric drive for propulsion, but the electricity that powers them is produced onboard via a chemical reaction. Hydrogen from the vehicle's storage tank reacts with oxygen from the ambient air in the fuel-cell stack, generating electricity. Water vapor is the only tailpipe emission from FCVs. Fuel-cell models have been developed for light, medium, heavy-duty and some off-road vehicles. Across the board FCVs currently trail their battery-electric counterparts in technological maturity and adoption. As for EVs, advances in fuel-cell technology have been spurred by significant public investment and regula-

[64] Moore, Jim, 2016, "Electric Aviation Made Practical: Trainers to Depart Traffic Pattern," https://www.aopa.org/news-and-media/all-news/2016/october/19/electric-aviation-made-practical

[65] Lambert, Fred, 2018, "A new battery-electric airplane goes into production as popularity grows with flight schools," https://electrek.co/2018/01/10/battery-electric-airplane-production-pipistrelp-alpha-electro/

[66] https://www.bloomberg.com/news/articles/2018-01-22/uber-ceo-sees-flying-cars-across-u-s-skies-within-10-years

[67] Daisuke Wakabayashi, "Flying Taxis May Be Years Away, but the Groundwork is Accelerating," New York Times, February 27, 2018.

[68] Bellamy, Woodrow, 2017, "Airbus E-Fan X First Flight to Occur in 2020," http://www.aviationtoday.com/2017/11/28/airbus-e-fan-x-first-flight-occur-2020/

tions such as California's ZEV program for LDVs and Innovative Clean Transit measure for buses.

Fuel-cell technology currently has some advantages over battery-electric technology, but it also has significant drawbacks. FCVs' main advantage is that they can match the driving range of gasoline and diesel vehicles on a single tank of fuel that can be dispensed rapidly. The range gap is closing, however, as battery costs decline and energy density increases. In addition, deployment of ultra-high speed fast charging will enable battery-electric vehicles to cover long distances by reducing charging time to as little as 15 minutes.[69]

Developing refueling infrastructure for FCVs presents much greater challenges than for EVs. The existing electricity grid provides the foundation for EV charging networks and light-duty EVs always have the option of trickle charging using conventional outlets. FCVs require a completely new network of refueling stations as well as a hydrogen storage and distribution system. Several companies including Air Liquide, Linde and Shell are constructing public refueling stations in the U.S., Europe, and Asia, but their business model still depends heavily on government funding. New infrastructure is also needed to produce hydrogen for FCVs. Currently hydrogen for various industrial applications is produced from natural gas via steam reformation. Additional processing is necessary to achieve the level of purity required for FCVs. Alternatively, pure hydrogen may be produced from water by electrolysis at a higher cost. Hydrogen may be produced on-site or at a centralized facility. Centralized production offers scale economies, but distributing it consumes energy and creates additional emissions. Compression, pumping and storage of hydrogen consume additional energy and increase emissions.

Today, neither battery-electric nor fuel-cell vehicles are truly zero-emission on a well-to-wheels basis. Both technologies result in upstream emissions, from generation of electricity and production of hydrogen respectively. Eliminating emissions from hydrogen produced by steam reformation requires a 100 percent renewable natural gas feedstock, such as biogas.[70] Upstream emissions for battery-electric vehicles will fall over time and eventually reach zero as Hawaiian Electric progresses towards meeting the state's 100 percent RPS goal. This is also the case for hydrogen produced via electrolysis. As renewable electricity becomes more available and with it the need for storage, electrolysis offers a way to convert excess electricity into hydrogen for future use.

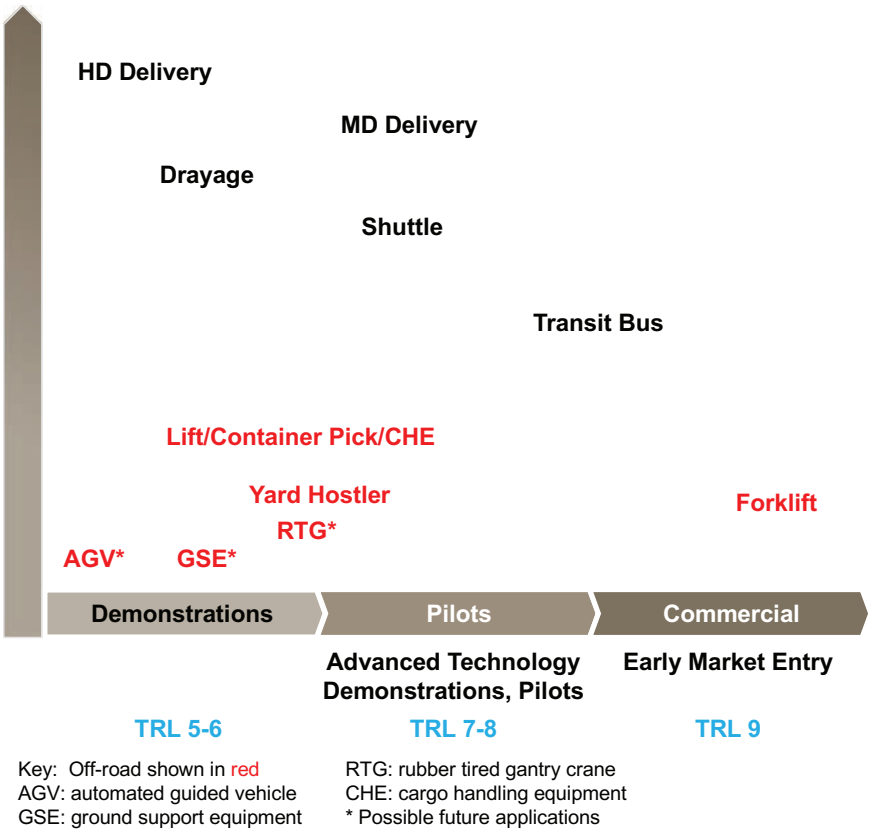
FCVs are also considerably less efficient than battery-electric vehicles on a well-to-wheels basis, requiring more energy per mile travelled.[71] Meeting the energy needs of a FCV-based fleet would require more grid infrastructure than needed to support a battery-electric-based fleet.

EVs and FCVs are often cast as rivals in a race to become the dominant ZEV technology, but for many applications fuel-cells may actually be a complement rather than a competitor to battery-electric technology. Fuel-cells can serve as a range extender in battery-electric vehicles,[72] as a gasoline powered electric generator does in the Chevrolet Volt and BMW i3 today. Similarly, fuel-cells may be paired with batteries in buses and trucks to extend the range of electric-drive. Battery-dominant fuel-cell buses have been produced and are in the development and testing stages for heavy-duty trucks.

Light-duty FCVs are in the early commercial stage of deployment. Several automakers have introduced FCVs since Toyota launched the Mirai in 2015, and global

[69] Lambert, Fred,2017, "BMW and Porsche join forces to enable 15-min electric car charging at 450 kW charge rate," https://electrek.co/2017/12/05/bmw-porsche-electric-car-charging-450-kw-charge-rate/
[70] ICCT, pp. 6-9.
[71] Argonne National Laboratory, Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways (https://greet.es.anl.gov/files/c2g-2016-report), Table 36, p. 61.
[72] CARB Fiscal Year 2017-18 Funding Plan, p. II-21

Figure 29. CARB's Assessment of technology status for fuel-cell electric technologies



Source: Adapted from CARB, pp. II-22 – 23.

sales were projected to top 6,000 vehicles in 2017.[73] Toyota, Hyundai, Kia, Honda, Mercedes-Benz, and BMW are among the automakers that currently or soon will offer light-duty FCVs. Major impediments to adoption are FCVs' high cost relative to conventional models, scarce public hydrogen dispensing infrastructure, and the high cost of hydrogen compared to gasoline.

Fuel-cell versions also lag the maturity and adoption of EVs in the medium and heavy-duty and off-road applications. CARB's most recent assessment of fuel-cell technology, shown in Figure 29, identifies only forklifts as having reached commercial status.[74] Although their high cost relative to conventional models remains a challenge, many of these models are not dependent upon availability of public refueling infrastructure. Local delivery vehicles and buses can refuel at their depot, and off-road equipment can refuel at the facility where it is deployed (e.g. warehouse, port). Unlike electricity for battery-electric vehicles, the cost of hydrogen for FCVs is high relative to today's diesel prices. Other barriers to adoption are similar to those for their battery-electric counterparts: lack of understanding of the business case for FCVs (other than forklifts), limited choice of vendors and models, and an undeveloped service and support network.[75]

Fuel-cell transit buses are approaching the early commercial stage (TRL 9) and have

[73] https://www.gasworld.com/more-than-5500-hydrogen-fuel-cell-vehicles-sold-so-far-says-information-trends/2013903.article
[74] CARB Fiscal Year 2017-18 Funding Plan, p. II-20
[75] CARB, pp. II-22 – 23.

been piloted in California, Europe, and Japan.[76] Their longer range (300 miles) and faster refueling offer advantages relative to battery electric buses. These strengths may be less valuable in Hawai'i, since transit buses travel relatively short distances on O'ahu and Maui and are parked overnight at their depot (allowing ample time to recharge). Range is still the biggest challenge on Hawai'i Island with its cross or circle-island routes. Fuel-cell shuttle buses are less advanced (TRL 7) though a fuel-cell bus will be included in a one-year pilot study comparing fuel-cell, compressed natural gas (CNG), and battery electric buses for the consolidated car rental facility at the Daniel K. Inouye International Airport in the coming year. One application where FCVs are widely seen as especially promising is long-haul trucking. The need to carry very heavy loads over long distances makes this segment especially challenging to serve with battery-electric vehicles. This is not a relevant segment for Hawai'i.

Autonomous driving technologies

Visions of self-driving cars ferrying people to and from work and school, running errands for their owners, and parking themselves now dominate media coverage of autonomous driving. This future is probably further away than some bolder projections foresee, however autonomous driving technologies are advancing rapidly and are already being deployed in all transportation sectors. Automation of LDVs has been underway for decades, with computers increasingly assisting drivers (cruise control and lane keeping) and gradually taking over some functions entirely (lane changing and parking). Electrification will likely hasten deployment of autonomous driving technologies because connected, electric-drive vehicles are best suited for automation. Mass deployment of fully autonomous vehicles could radically transform personal mobility, mass transit, and goods movement, reshaping urban landscapes—for better or worse.

Governor Ige hopes to position Hawai'i in the vanguard of vehicle automation. In November 2017, he issued Executive Order 17-07, which created a Connected Autonomous Vehicle (CAV) contact in the Office of the Governor and directed DoT, DPS, and DBEDT to "work with companies seeking to do self-driving vehicle testing." The order notes that Hawai'i is in a unique position to bolster CAV research because of its mild weather, ideal road conditions, robust telecom infrastructure, and favorable government policies for Zero Emission Vehicles.

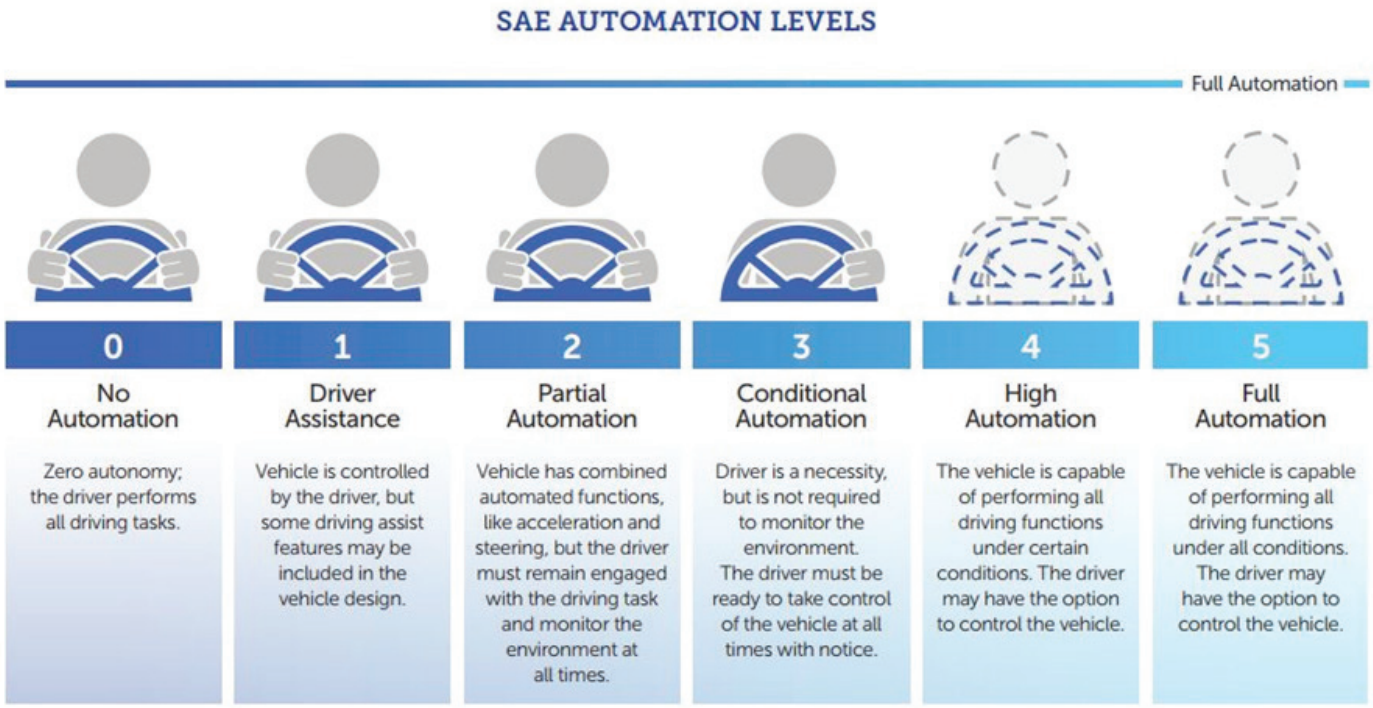
Automation of driving goes hand-in-hand with electrification of vehicles. EVs are better suited for automation than ICE vehicles. This is because their relatively simple electric drive-train is more easily controlled by computers than are the many complex, integrated, mechanical components in conventional vehicles. Also, EVs can be more easily refueled autonomously.

Development and deployment of automatic driving technologies are proceeding incrementally. To map the pathway to full automation the Society of Automotive Engineers (SAE) created the classification system illustrated in Figure 30. Automakers and fleet owners are keenly interested in testing Level 4 (High Automation) as they strive to reach to Level 5 (Full Automation). At Level 4, the vehicle can operate without human oversight under select conditions (e.g. on highway or in clear weather) or in specific geographic areas (e.g. on campus or military base). The ultimate goal is to achieve Level 5 where the driverless vehicle can operate on any road under any condition without human oversight or input. Only at this stage is a vehicle truly driverless, making it possible to eliminate costly components such as the steering wheel and the accelerator and brake pedals.

Applications that will easily adopt to automation are those that are operate on fixed routes, such as transit and shuttle services, and in off-road locations such as warehouses, bus depots, and harbor terminals. Autonomous public shuttles are being tested in different weather and road conditions

[76] ICCT 10/2017, p. 5.

Figure 30. Levels of Vehicle Automation



Source: Society of Automotive Engineers, National Highway Traffic Safety Administration, 2018, "Automated Vehicles for Safety," https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

in Minnesota, Florida, and California.[77] In many European seaports, including Rotterdam and Hamburg, automated guided vehicles are used to move containers from the vessel, and electrified rail-mounted automated stacking cranes are used instead of diesel powered rubber-tire gantry cranes. The Middle Harbor terminal in Long Beach, California is currently implementing phase one of its automation project.[78] Hawai'i seaports, airports and resorts offer many opportunities to deploy these technologies.

Taxi and TNC fleets are attractive early targets for automation of LDVs, with significant investments being made by automakers and TNC companies alike. Waymo and Uber have also been testing ride-hailing services using automated vehicles in Arizona, Pittsburgh, and California. In 2016 Ford announced plans to begin deploying a fully autonomous version of its Fusion hybrid in a ride-sharing service by 2021 and last year formed a partnership with Lyft to develop a software interface between Ford's self-driving cars and Lyft's app.[79]

Automation of taxi and TNC fleets offers many potential benefits. Fleet automation and electrification would increase utilization of public and workplace charging infrastructure, enhancing benefits of electrification for utility customers. More people, including low-income, disadvantaged, elderly, and disabled could have access to transportation that meets their needs. More intensive utilization of shared vehicles and charging infrastructure would lower the cost of mobility. Diminished need for parking spaces would free up curbsides and parking lots for other purposes, including bike lanes, parks and housing. People would be able

[77] Moore, Janet, 2017, "Minnesota DOT Begins Winter-Testing Autonomous Shuttle," http://www.govtech.com/fs/Minnesota-DOT-Begins-Winter-Testing-Autonomous-Shuttle.html
[78] Port of Long Beach, 2018, http://www.polb.com/about/projects/middleharbor.asp
[79] Hawkins, Andrew, 2017, Ford and Lyft will work together to deploy autonomous cars," https://www.theverge.com/2017/9/27/16373574/ford-lyft-self-driving-car-partnership-gm

to work, converse or watch television while traveling. The downside of inexpensive CAVs is that more people might chose to own a car and to have it drive them places, leading VMT to rise. In fact, without increased vehicle sharing (pooling) and use of public transport, studies suggest that autonomous vehicles could increase congestion and emissions.[80]

Public policy will play a key role in enabling testing of autonomous vehicles on public roads. On February 26, 2018,[81] California's Department of Motor Vehicles published new rules allowing testing of autonomous vehicles without (backup) drivers on public roads. Soon thereafter, Arizona's governor took action by issuing an executive order (2018-04) on March 1, 2018[82] to allow autonomous vehicles without drivers. There are 21 states that have regulations related to autonomous vehicles, 19 of those enabling tests on public roads.[83]

[80] U.C. Davis, 2017. "Three Revolutions in Urban Transportation". https://steps.ucdavis.edu/wp-content/uploads/2017/05/ITDP-3R-Report-v6.pdf

[81] https://www.dmv.ca.gov/portal/wcm/connect/a6ea01e0-072f-4f93-aa6c-e12b844443cc/DriverlessAV_Adopted_Regulatory_Text.pdf?MOD=AJPERES

[82] https://azgovernor.gov/governor/news/2018/03/governor-ducey-updates-autonomous-vehicle-executive-order

[83] Izadi-Najafabadi, "1Q2018 Intelligent Mobility Market Outlook," Bloomberg New Energy Finance, 01FEB2018.

5. Defining Hawaiian Electric's role in EoT

We applied a structured process to drill down on the right utility role

Hawaiian Electric seeks to work pro-actively with industry and policy partners to address the challenges described in Chapter 4 and create customer value from EoT. To determine the most valuable role for the companies, we applied a structured filtering process informed by Commission guidance, our Guiding Principles, stakeholder input, customer research, experience from Hawaiian Electric pilots, literature survey, and our review of existing mainland programs.

We considered the full range of potential utility roles for each vehicle type and customer segment, and selected those that we believe will be most effective in creating value while leveraging the unique strengths of the utility and capitalizing on our partners' strengths. To make these selections, we developed an Action Funnel based on the guidance provided in Commission Decision and Order No. 34592, our Guiding Principles (see Chapter 1), and feedback we received in conversations with stakeholders and experts. This funnel is provided in Figure 4.

We propose EoT actions that take advantage of the unique strengths of the utility and leverage our partners' strengths

Applying our Action Funnel resulted in a range of proposed Hawaiian Electric EoT actions, which we have combined into ten broader EoT Initiatives. Each of these proposed initiatives involves partnership with and enabling of other organizations and industry players. They envision a range of roles for Hawaiian Electric: we propose to take the lead in addressing some adoption and integration challenges, while playing a supporting role for others. Table 4 provides a list of all ten initiatives.

Chapters 6 through 8 provide details on each of our proposed initiatives and the justification for our selection through the funnel process outlined above: Chapter 6 presents our light-duty vehicle initiatives, Chapter 7 covers buses, and Chapter 8 addresses other vehicle types. For each initiative, the companies propose actions in the near term (initiated in the next 1-3 years), medium term (3 – 5 years), and long term (5-10 years).

Broadly, these initiatives combine to form the following role for Hawaiian Electric:

1. We will sequence our focus on vehicle and customer segments.

- To boost EoT adoption as quickly as possible and at lowest cost, we will focus in the near term on commercially-available electrified technologies. This means promoting wide-scale adoption of light-duty vehicles and electric buses, while supporting

Table 4. Hawaiian Electric's proposed EoT initiatives

Initiative #1:	Work with partners to deliver education and outreach campaigns to drivers, dealerships, fleet managers, and taxi and TNCs
Initiative #2:	Continue to electrify Hawaiian Electric's own fleets as availability of electrified vehicle technologies expands and total cost of ownership (TCO) comes down
Initiative #3:	Work with partners to find ways to lower EV purchase costs
Initiative #4:	Investigate and develop opportunities to lower customer bills in return for "smart" charging of vehicles and provision of grid services.
Initiative #5:	Expand access to charging for customers living in multi-unit dwellings (MUDs), i.e. condominiums and apartment buildings
Initiative #6:	Expand availability of workplace charging
Initiative #7:	Expand availability of public charging
Initiative #8:	Engage the tourism industry
Initiative #9:	Encourage and enable electrification of smart charging of buses
Initiative #10:	Encourage and enable electrification of medium and heavy-duty vehi cles and off-road equipment as technologies mature and become commercially available at reasonable cost.

pilots of cranes, forklifts and airport preconditioned air units (see Chapter 4).

- We will electrify significant miles and create significant value, visibility, and driver exposure by focusing on fleets.

- We will take advantage of the increasing trend toward shared mobility, and the flexibility of Transportation Network Vehicles (TNC, e.g. Lyft and Uber) and taxis to charge during the day when the system is producing low-cost solar.

- Meanwhile, we will lay the groundwork for broad electrification of other segments, by proactively engaging customers and monitoring emerging technologies.

2. We propose a number of proactive near-term EoT actions.

- We will focus on education and awareness, partnering with and leveraging investment from others with common goals who do this well. We will also support partners in reducing the upfront cost of EVs, especially for low- and middle-income customers.

- We will create grid service opportunities, increase value to all customers, and grow the use of renewables by leveraging DR programs, rates, and other utility programs that align with Hawaiian Electric's defined grid service needs and are interoperable with existing and planned technologies.

- We will continue electrifying Hawaiian Electric fleets and installing workplace charging for our employees, to lead by example, identify implementation challenges, and share best practices with customers and partners.

- We will jumpstart charging infrastructure buildout in segments where there is not currently a business case for private sector engagement, or where split ownership incentives or other barriers need to be addressed. Specifically, we propose the following efforts:

  - Creating partnerships to spur charging solutions in workplaces and multi-unit dwellings (MUDs) that currently face challenges due to split incentives between

owner, manager, and drivers, as well as permitting challenges and significant upfront cost. This will include piloting the provision of make-ready infrastructure[1] where this is cost-effective for Hawaiian Electric customers. MUDs are an important focus for unlocking EV adoption across the islands, and our focus on workplace charging will enable us to align charging with grid needs and make use of increased solar resources.

- Owning and operating a critical backbone of public DC fast chargers, beginning with the 25 already approved, to ensure a constant, reliable charging network for all light-duty EV drivers that is sufficient to remove range anxiety and promote EV adoption. We propose to provide Level 2 charging or make-readies in select, high-need public locations where the private sector has not filled gaps in the charging network. We also propose to incentivize third-party charging providers to build public charging at locations on the utility's distribution network that are not highly constrained. This will include providing make-readies where cost-effective for Hawaiian Electric customers.

- Collecting and using data from our existing and future charging solutions to enhance customer experience, inform future needs and siting, and increase the value that EoT provides to the grid.

- We will provide outreach and support to bus operators to engage them in electrification. We propose to offer a battery service agreement[2] that reduces the upfront cost of electric buses, as well as a rate that reduces the ongoing operating costs.

Our initiatives will foster opportunities for third parties in the EV charging market

Hawaiian Electric seeks to support the market for third-party EVSPs in the state. Our proposed initiatives aim to maximize customer value from EoT by taking on roles that the utility is best equipped to fill, while leveraging maximum private investment from the third-party charging market.

Our proposed initiatives will foster opportunities for third-party EVSPs in a number of ways. First, a number of our initiatives are designed to generate interest in EVs in Hawai'i and jumpstart EV adoption in the state. This will spark a larger and broader electric vehicle market for EVSPs. These initiatives include

- Promoting EVs through outreach and education

- Supporting partners to lower upfront EV purchase costs, and

- Filling critical gaps in the public charging network where there has not been a business case for third-party providers to install and reliably maintain charging. Hawaiian Electric expects this 'critical backbone' to represent a very small fraction of the public infrastructure ultimately needed to support EVs in Hawai'i

Second, actions by Hawaiian Electric will directly influence customers to install charging from third-party charging providers. These include

- Supporting multi-unit dwellings and workplaces to install charging by providing education on the benefits of EV charging,

[1] http://www.eei.org/issuesandpolicy/electrictransportation/Documents/Accelerating_EV_Adoption_final_Feb2018.pdf for description and chapters 6 and 7 for detailed references related to recent approved make-ready programs.

[2] https://www.greenbiz.com/article/heres-what-would-drive-even-more-electric-buses-us-cities?utm_source=newsletter&utm_medium=email&utm_term=newsletter-type-verge&utm_content=2018-03-14&utm_campaign=newsletter-type-verge-110028&mkt_tok=eyJpIjoiTlRFNVlXRXlORFJsTlRVMyIsInQiOiIwNXkyR3NxQSt1cE1kanl2Skk0YjFDRGVjQU5TTkwwaXFtMlNUalJUZ1BJM0F0Zm5rK0R5c1FBUG90OGFEOWlVQ1E1YjZsZ0dFZVhpXC9cL05CSzhGa29WMEtUMHRPOW5rT1NmY1wvZEFpRXM2THRpZ1lqM3A4dHZDdmlJbDA5WXFuMiJ9 for latest news on financing electric buses.

working to overcome split incentives between building owners and occupants, and supporting permitting agencies to identify and implement needed changes to building codes

- Providing make-readies for Level 1 and/or Level 2 charging in workplaces, and potentially in MUDs

- Engaging hotels to host and invest in Level 2 charging solutions for guests with rental cars, and

- Providing drivers with opportunities to earn financial incentives for grid services from EV charging

Finally, Hawaiian Electric plans to provide opportunities and management fees to third-party EVSPs to contribute grid services from charging, including

- Opportunities to participate as aggregators that provide grid services from EVs under Grid Services Purchase Agreements and

- Incentives for installing public charging at locations on the utility's distribution network that are not highly constrained, through location-dependent prices for interconnection or subsidies to install at sites that are lowest cost for utility customers (potentially by providing make-readies)

We plan to support open standards and interoperability

Hawaiian Electric is committed to supporting open standards wherever we can to enable a seamless experience for EV drivers. This support may take many forms. For example, in situations where Hawaiian Electric owns physical or informational EoT infrastructure, the companies are committed to the adoption of open standards. In situations where we partner with third-party providers, Hawaiian Electric will, to the extent practicable, encourage if not require the use of standards. For example, if an EoT third-party provider were interested in engaging with Hawaiian Electric as an aggregator via a Grid Services Purchase Agreement (GSPA), the third party would be obligated to interact with the company's DRMS via a modified version of OpenADR 2.0b protocol. Similarly, if a third-party EoT provider were engaged to facilitate the participation of customers in Hawaiian Electric-administered programs under the grid services tariff structure, we would require interoperability via standard protocols either from the DRMS to the third-party head-end system, or directly to the charger or car level.

Overcoming Hawai'i's EoT barriers will require a joint effort

Ultimately, a successful EoT industry in Hawai'i will require a concerted and cooperative effort by many parties. Our objective is for each proposed initiative to be implemented with input and cooperation from a number of partners. Proposed partners are listed on each initiative summary (see Chapters 6 – 8), and include our customers, Drive Electric Hawai'i members, policymakers and planners, third-party EVSPs, automakers and dealerships.

Our investigation also revealed some EoT solutions that do not fit easily into the utility's purview. These will require leadership from others. Most significantly, our research suggests that action is needed to

- Ensure enforcement of HRS § 291-71, which requires EV charging to be installed in structures with 100+ public parking spaces

- Develop and support legislation or other policy that promotes EV adoption goals and/or reduces upfront vehicle costs, and

- Work with automakers to promote on-island job training programs to fill the need for EV service technicians

- The following chapters provide details on each of our proposed initiatives and the justification for our selection of each through the funnel process outlined above.

6. Hawaiian Electric's proposed role in enabling electrification of light-duty vehicles

The 'Action Funnel' approach outlined in Chapter 5 results in eight proposed Hawaiian Electric initiatives on LDVs:

Table 5. Proposed Hawaiian Electric initiatives targeted at light-duty vehicles

Initiative #1:	Work with partners to deliver education and outreach to drivers, dealerships, fleet managers, and taxi and TNCs
Initiative #2:	Continue to electrify Hawaiian Electric fleets as availability of electrified vehicle technologies expands and total cost of ownership comes down
Initiative #3:	Work with partners to find ways to lower EV purchase costs
Initiative #4:	Investigate and develop opportunities to lower customer bills in return for 'smart' charging of vehicles and provision of grid services.
Initiative #5:	Expand access to charging for customers living in multi-unit dwellings (MUDs), i.e. condominiums and apartment buildings
Initiative #6:	Expand availability of workplace charging
Initiative #7:	Expand availability of public charging
Initiative #8:	Engage the tourism industry

Below we have provide a summary of each LDV initiative that describes Hawaiian Electric's proposed actions, identifies potential partners, and details how the actions proposed meet the funnel criteria above. Chapters 7 and 8 provide similar summaries for our proposed actions on buses and other vehicle types, respectively. Where further Commission approval is needed for these initiatives, Hawaiian Electric intends to provide additional details in subsequent programmatic filings. The first action that we intend to bring before the Commission is the e-bus pilot tariff in initiative #9, which we are prioritizing to support our bus customers in meeting their planned electrification timelines.

Hawaiian Electric Initiative #1

Work with partners to deliver education and outreach to potential EV buyers and sellers. Key messages are the availability and range of EV models, benefits to drivers, available incentives, charging options, and smart charging opportunities.

Technology: LDVs and Personal Mobility Solutions

Segment: All

Near term Hawaiian Electric Actions (Initiate in 1-3 years)

- Participate in Ride and Drive events, to give potential buyers the opportunity to test drive multiple vehicle models and provide information on available incentives and programs
- Work with partners to create education materials targeted separately for drivers, dealerships, fleet managers, and taxi and TNC drivers. Disseminate through:
  - Hawaiian Electric and partner websites
  - Ride and Drive events
  - Mailouts
  - Workshops, training and info sessions
- Engage TNC and taxi drivers with EVs as ambassadors to educate passengers

Medium term Hawaiian Electric Actions (Initiate in 3-5 years)

- Continue education and outreach efforts

Long term Hawaiian Electric Actions (Initiate in 6-10 years)

- Continue education and outreach efforts, as needed

Need Addressed:

Limited awareness, understanding, and enthusiasm for EVs among fleet operators, auto dealerships, and the public. Also provides an information channel to generate driver and dealer participation in all other proposed initiatives.

Potential Partners:

- Drive Electric Hawai‘i
- Hawai‘i Energy
- NGOs
- Automakers
- Electrify America
- Dealerships and Hawai‘i Automobile Dealers Association (HADA)

Rationale for Hawaiian Electric Role:

Hawaiian Electric proposes this initiative as a partnership with others who have shared clean transportation objectives and who are willing to contribute their knowledge and expertise. The utility plans to leverage the unique abilities of each partner and is hopeful that partners will contribute financial and/or in-kind resources to this effort. Ultimately, the extent of utility action needed on outreach and education will depend on the ability of partners to assist.

Hawaiian Electric is uniquely qualified to contribute to the EV education and outreach effort in the following ways:

- The Hawaiian Electric Companies websites are a go-to resource for many customers seeking information about electric transportation

• Regular Hawaiian Electric customer mailings provide a wide-reaching communications channel to reach prospective EV purchasers

• Hawaiian Electric can leverage the relationships of utility customer service representatives with medium and large customers with vehicle fleets

• Hawaiian Electric is best qualified to educate customers, dealers, TNCs and fleets about its own rates, and has a clear line of sight into all available smart charging programs available through DR aggregators

• Hawaiian Electric can provide electric vehicles from its own fleet for display and participation at Ride and Drive events, and can contribute experiences and lessons learned by employees to engage and educate the broader public

• Hawaiian Electric is invested in providing electrified transportation solutions for the long haul, and can therefore commit to updating materials over time and providing a consistent source of contact and knowledge for dealerships and fleet managers as the market evolves and technologies change

Value Proposition for Customers:
This education and outreach initiative will fill an identified barrier to EV adoption. As discussed in Chapter 3, increased EV adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil.

These efforts will further add to customer benefits by increasing enrollment in smart charging rates and programs, allowing more EVs to provide 'good' load that increases use of Hawai'i's renewables while lowering costs.

Finally, providing information to customers about the availability and benefits of EVs expands their mobility choices. Customers looking to purchase an EV often look to the electric utility to help them understand their options and to provide advice on vehicle charging.

Utility Precedent:
In the U.S., customer education and outreach programs on EVs are typically delivered through partnerships between utilities, local and national NGOs, and state and local governments. The U.S. Department of Energy has developed resources to support these efforts but is not currently actively engaged in promoting EV adoption, as are national governments are in Europe and Asia.[1]

Hawaiian Electric's proposed actions are consistent with those of utilities in other states. The websites of California's three large investor owned utilities (IOUs) all provide extensive content on choosing an EV, rates and charging options, location of public chargers, rebates and incentives, and utility programs. This material complements and reinforces information disseminated through the state's DriveClean website. For example, Southern California Edison's website offers information tailored to individual customers as well as employers, fleet operators, MUD owners and parking providers (e.g. retailers, garage operators). The California utilities have also joined automakers in supporting the state's new broad-based outreach program, Veloz, which sponsors Ride and Drive events and plans to implement a paid media promotional campaign.[2]

[1] Jin, Lingzhi, Slowick, Peter, 2017. "Literature review of electric vehicle consumer awareness and outreach activities" https://www.theicct.org/sites/default/files/publications/Consumer-EV-Awareness_ICCT_Working-Paper_23032017_vF.pdf

[2] http://www.veloz.org/

In Oregon, Portland General Electric's website offers information similar to that posted on the California utilities' websites, while state agencies provide considerably less information than in California. The utility also partnered with Forth, a national NGO focused on innovative partnership approaches to spurring EV adoption. This partnership is an example of how an innovative non-profit can join forces with an energized utility and other stakeholders to drive market transformation. The partnership resulted in the Northwest Electric Vehicle Showcase in downtown Portland. EVs are typically one of only many offerings at a conventional dealership, and salespeople are often uninformed about them and unmotivated to sell them. In contrast, the EV showroom has trained staff, and multiple makes and types of plug-in electric vehicles are displayed to show the range of options available. Prospective buyers and interested members of the public are able to test drive the vehicles. The program is funded by a $1 million, three-year federal grant awarded in 2016.[3] Forth also holds monthly networking events to spread the latest industry news and best practices. It worked with environmental justice advocates to learn how underserved communities can benefit from electric and shared mobility, and worked with partners to launch a community-based electric car sharing program at an affordable housing complex in Portland. Forth partnered with a Nissan dealer to secure a $7,500 discount on a new LEAF, on top of the $7,500 federal tax credit. In concert with employers and manufacturers, Forth also created the nation's first workplace e-bike demonstration.

Utilities in many states (including Hawai'i) also participate in Ride and Drive programs. For several years, the national non-profit organization Plug In America has organized National Drive Electric Week to boost awareness of EVs and connect potential drivers with resources. Examples of local initiatives include the Mass Drive Clean campaign, jointly sponsored by the Massachusetts Department of Environmental Protection and National Grid, who partner with interested businesses and organizations to hold free ride-and-drive events. The campaign strives to increase consumer exposure to electric vehicles by reaching targeted audiences and providing resources and information about available vehicles. Participant surveys have found that the events increase interest in EV ownership.[4] Alabama Power has focused education activities on dealerships.[5]

Hawaiian Electric's proposal to use TNC and taxi drivers who drive EVs as education ambassadors is based on Portland General Electric's plan to provide a stipend to TNC drivers in return for their handing out educational materials on EVs to passengers.[6] The Oregon PUC recently approved a stipulation agreement with stakeholders, allowing PGE to go ahead with its education and outreach programs.[7]

Local Hawai'i Implementation Considerations:

Care will need to be taken to target educational materials to each island to reflect differences in rates, smart charging programs, charging infrastructure locations, vehicle preferences, etc.

There are currently limited EV dealerships and models on islands other than O'ahu. Efforts should focus on expanding dealership support on neighbor islands in addition to offering educational support.

[3] Voelcker, John, 2016. "Federal funds to back Portland storefront for electric-car marketing, pop-up roadshows" https://www.greencarreports.com/news/1105902_federal-funds-to-back-portland-storefront-for-electric-car-marketing-pop-up-roadshows

[4] MJB&A, 2017.""Accelerating the Electric Vehicle Market: Potential Roles of Electric Utilities in the Northeast and Mid-Atlantic States" https://www.mjbradley.com/sites/default/files/MJBA_Accelerating_the_Electric_Vehicle_Market_FINAL.pdf

[5] GTM Research, 2016, "Electric Vehicles as a Grid Resource: Market Size, Initiatives and Resource Potential."

[6] Portland General Electric, March 2017. "Transportation Electrification Plan" https://www.portlandgeneral.com/-/media/public/residential/electric-vehicles-charging-stations/documents/pge-ev-plan.pdf?la=en

[7] Oregon Public Utilities Commission, Feb. 2018, Order No. 18-054.

There are limited taxi and TNC vehicles on islands other than O'ahu, so for now the educational efforts for these vehicle types should be focused mostly on that island.

Intersection with other Hawaiian Electric Initiatives/Processes:
This initiative will communicate opportunities for drivers to participate in smart charging opportunities developed by aggregators that participate in the Hawaiian Electric DR program. These opportunities could be offered at home, at work, and/or in public. Aggregators could include, for example, automakers, charging companies, and other technology companies.

Hawaiian Electric Initiative #2

Continue to electrify Hawaiian Electric fleets as availability of electrified vehicle technologies expands and total cost of ownership (TCO) comes down

Technology: light-, medium-, and heavy-duty vehicles

Segment: All

Near term Hawaiian Electric Actions (Initiate in 1-3 years)
• Current focus is mainly sedans
• Demonstrate electrified bucket trucks
• Use experiences to inform rate design, programs and educational efforts.
• Disseminate best practices and use experiences to serve as a practical resource for fleet operators interested in electrifying, through one-on-one discussions with customers, providing written whitepapers and case studies, and participating in workshops and training sessions (for example, the fleet conversion workshop hosted by Honolulu City on March 8 and 9, 2018)
Medium term Hawaiian Electric Actions (Initiate in 3-5 years)
• Continue fleet conversion efforts. Begin adding electric vans, SUVs as availability and TCO improve
Long term Hawaiian Electric Actions (Initiate in 6-10 years)
• Begin adding HD vehicles, provided availability and TCO advance as expected

Need Addressed:
Limited awareness, understanding, and enthusiasm for EVs among fleet operators and the public

Potential Partners:
- Automakers

Rationale for Hawaiian Electric Role:
Hawaiian Electric currently leads the state in electrified vehicle fleet conversions, with 14 percent (204) of its fleet vehicles already being converted to hybrid or battery electric vehicles as of January 2018. This includes electrification of sedans, bucket trucks, forklifts, man-lifts, carts and other equipment. Continuing to convert Hawaiian Electric vehicles to electric will help the utility to support and advise customers seeking to electrify their own fleets. The utility needs to remain well-informed on the availability and capabilities of electric drive cars and trucks. Continual incorporation of these vehicles into its own operations enables Hawaiian Electric to provide advice grounded in our employees' experience using them in the daily course of business. Hawaiian Electric's in-house expertise on vehicles and chargers will also inform rates, programs and educational efforts.

Hawaiian Electric is also positioned to lead by example. With its large and widely deployed fleet, Hawaiian Electric will showcase EVs to the public, demonstrating that they are a practical and affordable option. While sedans account for most of the EVs in the companies' fleet today, the increasing availability of MD and HD vehicles in the coming years will grow both the opportunity and the audience.

Value Proposition for Customers:
Electrifying the Hawaiian Electric fleet offers savings to its customers. On a TCO basis, EVs are an increasingly cost-effective alternative to conventional vehicles as price points fall and range increases. Also, electrified bucket trucks are quieter than diesel trucks and do not expose our employees and nearby people to their toxic diesel emissions.

Providing best practices and serving as a practical resource to other fleets can help them transition to electric vehicles, capturing the financial benefits to all customers described in Chapter 3.

Utility Precedent:
At a 2014 White House event, officials from the U.S. Department of Energy and the Edison Electric Institute announced a utility fleet electrification initiative.[8] Over 70 utility holding and operating companies, including Hawaiian Electric Industries, committed to spend at least 5 percent of fleet acquisition budgets to purchasing plug-in electric vehicles and technologies. Other participants included Duke Energy, American Electric Power, Eversource Energy and Exelon Corporation.[9]

Local Hawai'i Implementation Considerations:
With only a small population of electric medium-duty and heavy-duty vehicles on the islands, securing access to qualified service technicians may pose additional challenges. We can help seed the development of well-trained service technicians to serve our own fleet needs, in particular through our adoption of medium- and heavy-duty vehicles. This technician development can be leveraged to benefit other electric vehicle customers on the islands.

Intersection with other Hawaiian Electric Initiatives/Processes:
N/A

[8] Edison Electric Institute, 2014. "EEI Announces Industry Commitment to Fleet Electrification at White House Roundtable" http://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20Announces%20Industry%20Commitment%20to%20Fleet%20Electrification%20at%20White%20House%20Roundtable.aspx

[9] Edison Electric Institute, 2015. "EEI Fleet Electrification Commitment List as of July 2015" http://www.eei.org/issuesandpolicy/electrictransportation/FleetVehicles/Documents/EEI%20Fleet%20Electrification%20Commitment%20List.pdf

Hawaiian Electric Initiative #3

Work with partners to find ways to lower upfront EV purchase costs

Technology: LDVs

Segment: All

Near term Hawaiian Electric Actions (Initiate in 1-3 years)
• Continue engaging automakers to provide discounts on EVs, and publicizing these to employees and customers
• Evaluate and pilot EV programs to make EVs affordable or accessible to low- and middle-income residents
• Support partners' efforts to develop and implement policy that reduces EV costs to drivers
Medium term Hawaiian Electric Actions (Initiate in 3-5 years)
• Expand successful pilot programs, as needed, and continue publicizing
Long term Hawaiian Electric Actions (Initiate in 6-10 years)
• Continue programs as needed

Need Addressed:

The upfront cost of EVs is currently higher than that of comparable conventional vehicles, even with federal tax incentives. Until price party is reached and EV range matches that of conventional vehicles, purchase incentives and/or discounts will be needed to overcome this barrier. Individual purchasers are especially sensitive to upfront cost and are less likely than fleet operators to fully factor savings in fuel cost and maintenance costs into their vehicle purchase decision. EVs' higher purchase price also puts them beyond the reach of low and many moderate-income customers.

Potential Partners

- Drive Electric Hawai'i
- Automakers
- Dealerships
- Economic development organizations and others focused on low-income residents

Rationale for Hawaiian Electric Role:

Hawaiian Electric will help ensure that its customers benefit as much as possible from price discounts and other opportunities to reduce the upfront cost of EVs by publicizing these programs to its customers and employees. As a utility that is dedicated to all its customers, Hawaiian Electric wants to ensure broad access to the increasing range of mobility options that is becoming available to Hawai'i's residents.

Value Proposition for Customers:

Bringing down the upfront cost of electric vehicles will help to boost EV adoption. As discussed in Chapter 3, increased adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil.

Lowering upfront costs will also ensure that more of Hawai'i's residents are able to access electric mobility options.

Utility Precedent:
As discussed in Chapter 2, Hawaiian Electric has already had some experience engaging with automakers to offer discounts to employees and customers. This initiative is envisaged as an extension of these existing efforts.

Legislators and regulators in many of the leading states for EV adoption have sought to ensure that low- and moderate-income residents share in the benefits of electrification, especially the opportunity to reduce their transportation costs. Tax credits offered by the federal government and some states are most valuable to high earners. To level the playing field, several states, including California, Massachusetts and New York, offer rebates, and New Jersey exempts EVs from its sales tax. In California qualifying low income households and residents of disadvantaged communities may be eligible for additional purchase incentives as well as payments for retiring and replacing high emitting vehicles.[10]

Several NGOs and public agencies around the U.S. have piloted e-car sharing programs for low income customers. Since disadvantaged communities are often underserved by public transportation and exposed to more air pollution (e.g. from freeways, airports, seaports, and diesel trucks and equipment), these programs provide their residents clean transportation options. Utilities may play a supporting role in launching these efforts. For example, the BlueLA program plans to place 100 EVs and 200 chargers in central Los Angeles.[11] The Los Angeles Department of Water and Power is helping to site and install the charging stations and contributed $888,000 in rebates for them.

Local Hawai'i Implementation Considerations:
Due to tourism's significant role in our economy, Hawai'i has large rental car fleets, which are a major source of used cars. As car rental enterprises include or expand the share of EVs in their fleets, more second-hand EVs will become available, providing the opportunity to own an EV for Hawai'i residents who lack the means to buy a new vehicle.

Intersection with other Hawaiian Electric Initiatives/Processes:
N/A

[10] Plug In America, "State & Federal Incentives" https://pluginamerica.org/why-go-plug-in/state-federal-incentives/
[11] https://www.bluela.com/about-bluela and LA Thrives, 2016, "3 Ways LA's Electric Car Sharing Pilot is Setting the Urban Sustainability Agenda" http://www.lathrives.org/3_ways_la

Hawaiian Electric Initiative #4

Investigate and develop opportunities to lower customer bills in return for 'smart' charging of vehicles and provision of grid services.

Technology: LDVs

Segment: All

Near term Hawaiian Electric Actions (Initiate in 1-3 years):

- Investigate and develop more advanced rates –
  - For residential customers: currently filed and emerging DR and DER rates, such as TOU and location-based, dynamic residential rates
  - For commercial fleets and TNC/taxi vehicles: investigate bulk discounts for off-peak purchase of electricity at public chargers and depots
- Work through proposed Demand Response Grid Services Purchase Agreements (GSPA) to engage aggregators to offer "smart charging" incentives to drivers and fleet managers
  - Based on preliminary observations, Hawaiian Electric believes that EVs will be capable of delivering each of the four currently filed grid service tariffs in the companies' DR program: capacity, replacement reserves, regulating reserves and fast frequency response. As the companies move toward defining and valuing locational distribution services, EVs are expected to play a significant role in delivering these services as well, although testing has not yet been performed to demonstrate this capability.
  - As the EV infrastructure continues to flourish, aggregators who help manage portfolios of vehicles - and track their mobility – will serve an important role in bridging control and service delivery by guiding EV owners towards specific behavioral patterns, inspired by variable pricing.
- Design data collection protocol to collect information from aggregators. Use this information for continual improvement of programs to enhance customer experience and increase the value that EoT provides to the grid.
- Undertake additional pilots on the ability of vehicles to provide additional grid and customer services via vehicle-to-grid, vehicle-to-home, and vehicle-to-business flows. These will build on the learnings from the JUMPSmart Maui and OATI pilots (see Chapter 2) to answer key remaining questions, for example:
  - How does the mobility of these vehicles present challenges to tracking individual customer participation in the delivery of services if the charging manipulations occur at a location that is not the customer's home or an otherwise dedicated charging location?
  - Given the large size of commercial loads, what is the minimum size of commercial fleet that can reliably contribute to delivery of grid services?
  - Is load shifting a real option for portfolios of EVs? How does Hawaiian Electric measure a baseline charging profile to assess effective load? Are there predictable patterns over large portfolios?
  - Is it possible to support all kinds of cars and chargers without significant calibration of the gateway device for each type of car or charger?
  - How many vehicles can realistically be expected to be reliably available during DR events?
  - What is needed to ensure that vehicles can reliably provide Fast Frequency Response?
- Educate customers about the availability of rates and programs that can save them money while providing benefits to the grid.

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Further publicize programs and rates
- Continue to refine and expand offerings to reflect ongoing lessons learned, fill remaining grid needs and meet customer demands

Long term Hawaiian Electric Actions (initiate in 6-10 years):

- Further publicize programs and rates
- Continue to refine and expand offerings to reflect ongoing lessons learned, fill remaining grid needs and meet customer demands

Need Addressed:
These actions help to offset the effect of the EV cost premium on drivers' purchase decisions, by reducing refueling costs to customers willing to charge in a manner that supports renewable integration and reduces impacts on Hawaiian Electric's distribution grid. These opportunities for cost offsetting may be increased by V2G, V2H and V2B opportunities.

Potential Partners:
- Individual vehicle owners
- Fleet managers
- Charger hosts
- DR aggregators (incl. third-party charging providers, smart charging technology providers, automakers)

Rationale for Hawaiian Electric Role:
This initiative is envisaged as a partnership between three parties. Hawaiian Electric will offer rates that incentivize drivers and fleet managers to charge when most valuable to the grid, define the value of grid services, and offer incentives for their provision. Drivers will enjoy savings on their electricity bill in return for shifting their charging to hours with lower rates, and/or for enrolling in DR programs offered by aggregators. Aggregators will be relied on to combine fleets of vehicles to provide these services, and to offer compensation to drivers and fleet managers.

Hawaiian Electric is best qualified to quantify the value of grid services to the utility and its customers, and to understand how DR services can meet the changing hourly needs of the grid. Rate design and development of DR programs are core utility functions. Finally, data collection and program evaluation from these programs are integral aspects of program administration: the companies' collection of this information will provide system operators with more refined operational tools to manage the grid more efficiently and reliability and integrate additional renewable resources.

Value Proposition for Customers:
This initiative is projected to maximize the value that utility customers derive from EVs, by

- Shifting charging load away from peak system load hours, deferring distribution grid upgrades that might otherwise be needed to accommodate EV charging loads

- Increasing the utility's ability to cost-effectively integrate renewable resources, by incentivizing customers to shift charging loads into low-cost, high-renewables hours. For residential customers, this will be achieved through emerging DR and DER rates, such as Time of Use (TOU) and location-based, dynamic residential rates. For fleets and TNC vehicles, we will investigate bulk discounts for off-peak purchase of electricity at public chargers and depots. An advantage of directly engaging and incentivizing TNC and taxi drivers is that these vehicles tend to drive most consistently during peak system hours, and are often available to charge during mid-day and very late-night hours, when system costs are lowest. These vehicles are also likely to rely on DC fast charging: getting a sufficient number of these vehicles to electrify may be the key to unlocking the business model for DCFC and attracting future private investment in a broader network of public DC fast charging

- Allowing the utility to access EVs as an additional resource that can provide DR services (capacity, replacement reserves, regulating reserves and fast frequency response). This will provide cost benefits to the companies' customers wherever EVs can provide these at lower cost than other resources, and

- Affording customers opportunities to save on their electricity bills in return for shifting load and/or providing DR services

Utility Precedent:

Utilities around the country are piloting various smart charging approaches that employ a variety of hardware, software and network services. Approaches include including TOU and dynamic rates, as well as V1G and V2G managed charging approaches. Table 6 provides several examples.

Table 6. Examples of U.S. Utility Smart Charging Programs

Application	Utility	Approach
Peak Shaving	Con Edison (NY)	Con Edison's pilot program uses FleetCarma's technology to tap into EVs' on-board diagnostics to monitor battery state of charge and control charging. This approach enables Con Edison to effectively implement critical peak pricing for EV charging without deploying a dedicated smart meter for the vehicle.
	Eversource (MA)	Eversource managed the impact of EV charging on peak demand by throttling Level 2 charging down to Level 1 as needed.
V1G solutions to shift load to integrate solar power and manage distribution grid impacts	Southern California Edison (CA)	The CPUC is currently considering SCE's proposal for "Matinee" TOU Rates that offer commercial customers discounts for charging during peak solar generation hours, especially in the winter and shoulder months. The rates also include temporary demand charge relief.
	San Diego Gas and Electric (CA)	SDG&E is piloting a day ahead dynamic rate that encourages participants to charge their vehicles when and where grid benefits are greatest. The program aims to minimize impacts of EV charging on SDG&E's distribution system and encourage charging when solar power is abundant.
	Pacific Gas and Electric (in partnership with BMW) (CA)	This pilot provided conventional DR services to the grid operator while ensuring that customers' mobility needs are always met. BMW acted as an aggregator, curtailing home charging in response to program calls. Customers had the option to opt out, while BMW was able to use a bank of second use batteries to augment customers' response as needed to fulfill its obligation to the California ISO (CAISO).
V2G to provide ancillary services to grid using vehicle's battery	Southern California Edison (in partnership with the U.S. Air Force) (CA)	The U.S. Air Force partnered with SCE to demonstrate the potential for its fleet of EVs to bid frequency regulation into the CAISO ancillary services market. The pilot employed two-way chargers using Open ADR, and bid into CAISO ancillary service markets protocol.

Local Hawai'i Implementation Considerations:

Hawai'i's aggressive renewable energy goals, high penetration of distributed generation, and diverse, isolated island grids make it imperative that we harness the flexibility in EV charging loads. Suitable approaches are likely to differ across our operating companies, reflecting variations in the islands' resource mix. Multiple rate and program offerings will likely be necessary to secure participation of different customer segments. For example, in mainland pilots residential TOU rates have proven highly effective in encouraging customers to charge during low cost overnight hours. A challenge for Hawaiian Electric is that thus far a high percentage of customers with EVs have also installed rooftop solar PV and prefer our flat rate Schedule R to TOU-RI. These customers, as well as others who are unable to charge at home, may best be served by workplace charging combined with price-based incentives or direct management.

Intersection with other Hawaiian Electric Initiatives/Processes:

The Hawaiian Electric DR filing proposed four Grid Service Rules for which EVs are a significant potential resource: capacity, fast frequency response, regulating reserve and replacement reserve. Electrified vehicles will be eligible to enroll, though convenient aggregator services, in Grid Services Purchase Agreements to provide and be compensated for these grid services. The DR portfolio as filed also creates opportunities for customers to participate in programs aimed at delivering these same services by way of direct enrollment with the companies. The initial GSPA engagements are expected to be contracted in June of 2018. A final version of the tariff rules, rates and riders that serve as the basis for the GSPAs – and through which EVs can also participate is expected to be filed for Commission approval around the same time. Hawaiian Electric was granted approval of its application for a Demand Response Management System (DRMS)12, which is intended to manage customer-cited energy resources, including EVs. As Hawaiian Electric rolls out its DRMS, control of EVs will fit squarely into the architecture and functionality sets currently contemplated by Hawaiian Electric's DR program.

A final point of overlap between our DR programs and our EoT strategy occurs with forecasting efforts. Future DR plans will make use of the EV adoption forecast described in Chapter 3 and Appendix E: Electric vehicle forecast methodology and assumptions of this EoT Roadmap as an input to our long-term sales and peak forecast and the assessment of DR potential. This forecast will be used in all Hawaiian Electric's planning processes, including the Integrated Grid Planning (IGP) process, ensuring consistency and alignment across the board.

See Chapter 9 for additional details.

[12] See D&O No. 34884 issued on October 18, 2017, in Docket No. 2015-0411 "For Approval to defer certain computer software development costs for a Demand Response Management System, to accumulate an allowance for funds used during construction during the deferral period, to amortize the deferred costs, and to recover deferred, amortized costs through the Renewable Energy Infrastructure Surcharge"

Hawaiian Electric Initiative #5

Expand access to charging infrastructure for residents of multi-unit dwellings (MUDs)

Technology: LDVs

Segment: Personal Transportation

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Design and implement 1-3 pilots to test MUD charging approaches and investigate solutions to common MUD charging barriers, informed by:
  - Report by DBEDT-led Working Group to the HI State Legislature on MUD charging
  - Mainland pilots
  - Site assessments
  - Customer and stakeholder research

  These pilots could involve installation of make-readies or full charging solutions for Level 1 and/or Level 2 charging in MUDs, and/or a centrally-located, publicly-available DCFC plaza in a location with high MUD density. Hawaiian Electric plans to investigate a requirement that pilot participants enroll in smart charging programs and/or rates (as available) and will also investigate further the issue of submetering.
- Design data collection protocols to gather information from pilot participants that can be used for continual improvement
- Support permitting agencies to identify and implement changes to building codes needed to ease installation of charging infrastructure in MUDs
- Outreach to existing MUDs as well as developers of new buildings to provide information and best practices on the potential value of providing EV charging, streamlining installation processes, and opportunities to participate in DR programs and/or rates

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Continue implementing and evaluating pilots as needed. Potentially expand successful pilot(s)
- Continue outreach and permitting efforts

Long term Hawaiian Electric Actions (Initiate in 6-10 years):

- Continue programs as needed

Need Addressed:

Lack of access to home charging in apartment buildings, condominiums and other multi-family housing severely limits the feasibility of EV ownership for customers living in MUDs.

Potential Partners:

- MUD developers, owners, managers, and renters
- Third-party charging providers
- Drive Electric Hawai‘i
- Hawai‘i Energy
- County building permitting agencies

Rationale for Hawaiian Electric Role:

As discussed in Chapter 4, the MUD market segment is underserved because deploying Level 1 and Level 2 chargers in existing MUDs is complicated and costly. In the absence of public funding, utility investment is needed to fill this market gap and deploy charging infrastructure in MUDs. Further, by contributing its expertise and experience to initiatives to streamline planning and permitting, Hawaiian Electric will help lower the cost of serving

MUDs. Finally, Hawaiian Electric can use its existing customer relationships with building developers and customers to provide advice and information to this segment on the potential value of providing EV charging, streamlining installation processes, and opportunities to participate in smart charging programs and/or rates.

Value Proposition for Customers:
Enabling EV charging for multi-unit dwellings will expand electric mobility choices for those living in the estimated 38 percent of Hawai'i's housing units that are MUDs.[13]
Further, supporting MUD charging will help to boost EV adoption. As discussed in Chapter 3, increased adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil. Finally, Hawaiian Electric plans to require that participants in MUD programs participate in smart charging programs and/or rates in exchange for investment of utility funds. This will yield cost savings for all customers by deferring distribution grid upgrades and enabling more cost-effective integration of renewables.

Utility Precedent:
Level 2 chargers in MUDs have been included in virtually every major utility infrastructure program approved by commissions to date, including the initial pilot programs of California's three IOUs, Eversource in Massachusetts, and Washington's Avista.

In a series of decisions in which it has worked out the role of utilities in deploying charging infrastructure, the California Public Utilities Commission (CPUC) has increasingly relied upon utilities to deliver charging services to customers living in MUDs. In its order on SCE's Charge Ready Pilot program, which provides hosts with make-readies and partial rebates for charging, the CPUC set the rebate amount for MUDs at 50 percent of the equipment cost (compared to 25 percent for other charging locations).[14] In its order approving SDG&E's Power Your Drive pilot program, the CPUC assessed the relative difficulty of serving workplaces and MUDs; it concluded that "the targeting of MUDs remains a priority," and directed the utility to install 40 – 60 percent of charging stations in MUDs, with a target of 50 percent.[15] Finally, in approving a modified version of PG&E's original proposal for a utility owned and operated network, the CPUC ruled that utility ownership would only be permissible in MUDs and disadvantaged communities (elsewhere PG&E may only provide make-readies and rebates). As in the SCE order, the CPUC required smaller host contributions for MUD owners than for other types of sites.[16]

SCE's and SDG&E's experiences implementing their infrastructure pilots have underscored the cost and complexity of reaching the MUD market.[17] In the most recent round of applications to the CPUC, SCE proposed to pilot an alternative approach in densely populated areas – DCFC plazas that would operate more like conventional gas stations. The CPUC authorized the pilot in a January 2018 decision.[18] Electrify America plans to develop similar facilities in several urban markets around the country, potentially using ultra-high-speed chargers.[19]

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[13] Ibid

[14] Decision 16-01-023, January 14, 2016.

[15] Decision 16-01-045 January 28, 2016 p. 133-4.

[16] Decision 16-12-065 December 15, 2016

[17] E. Gregory, 2017. "Electric Vehicle-Grid Integration Pilot Program ("Power Your Drive") Third Semi-Annual Report of San Diego Gas & Electric Company (U902-E)" https://www.sdge.com/sites/default/files/documents/1926712231/PYD_Semi-Annual_Rpt_with_attchmnt.pdf?nid=22191 p. 23 and
SCE, 2017. "Charge Ready Pilot Program Q3/2017 Report, November 30, 2017" https://www.sce.com/wps/wcm/connect/f5e63a64-a369-4e56-be02-1b3469c6ec89/5227_SCE_CReadyQuarterlyReport_2017Q3_r5.pdf?MOD=AJPERES&attachment=false&id=1506624100270 p. 20 and p. 24

[18] CPUC Decision 18-01-024, 2018. "Decision on the Transportation Electrification Priority Review Projects" http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M204/K670/204670548.PDF

[19] https://www.electrifyamerica.com/our-plan

Washington State and California are starting to incorporate EV charging infrastructure into their energy building codes.[20] Beginning in 2015, the California Building Code requires new construction to be wired for EV charging.[21] The Washington State Building Code requires new MUDs, hotels, and businesses to include EV charging infrastructure for at least 5 percent of parking spaces, and build the electrical rooms necessary to accommodate a minimum of 20 percent of the total parking spaces with 208/240 V 40-amp EV charging infrastructure. [22]

Local Hawai'i Implementation Considerations:

A high percentage of Hawai'i's housing is multi-unit dwellings, especially on O'ahu. This makes this initiative particularly crucial for the state if it is to reach its EoT and clean energy goals and create customer value from EoT.

Intersection with other Hawaiian Electric Initiatives/Processes:

This initiative will communicate opportunities for drivers to participate in smart charging opportunities developed by aggregators that participate in the Hawaiian Electric DR program. These aggregators could include, for example, automakers, charging companies, and other technology companies.

[20] WXY Architecture + Urban Design, Spiewack, Bruce J., Energetics Incorporated, 2012. "EV-Ready Codes for the Built Environment, Electric Vehicle Supply Equipment Support Study". https://www.nyserda.ny.gov/- /media/Files/Programs/ChargeNY/EV-Ready-Codes-for-the-Built-Environment.pdf

[21] http://www.hcd.ca.gov/codes/calgreen/docs/calgreen-report-to-legislature-2014.pdf

[22] Washington State Legislature Chapter 51-50 Section 427 Electric Vehicle Charging Infrastructure. http://apps.leg.wa.gov/wac/default.aspx?cite=51-50-0427 accessed February 28, 2018

Hawaiian Electric Initiative #6

Expand access to workplace charging

Technology: LDVs

Segment: Personal Transportation

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Lead by example and investigate key challenges by installing charging at HawaiianElectric workplaces:
  - In 2018, Hawaiian Electric will install a workplace charging system providing access for employees to Level 1 charging at the Ward office. The initial rollout will include infrastructure for five Level 1 charging systems and equipment to control access and monitor usage. This data will allow the companies to better understand employees' acceptance of Level 1 charging and whether it provides sufficient charging opportunities for the average commute.
  - Hawai'i Electric Light will also embark on providing Level 1 charging for employees as a pilot project in its employee lot in Hilo in 2018.
  - The companies also plan to provide Level 2 charging to employees at the Waiau Power Plant and Maui Electric's main office in 2018. The Waiau Power Plant will utilize an existing Level 2 charge station and Maui Electric will install two charging stations in its employee parking lot.
- Investigate alternative workplace charging such as mobile charging and other innovative technologies
- Outreach to workplaces to provide charging 'package,' including:
  - Education on employee benefits, vendors, streamlining installation processes, and smart charging opportunities
  - Based on learnings from Hawaiian Electric pilots described above, provide make-readies for Level 1 and/or Level 2 charging

  in exchange for anonymized charging session data and participation in smart charging programs and/or rates.
- Design data collection protocol to collect information from participating workplaces.
- Support permitting agencies to identify and implement changes to building codes needed to ease installation of charging infrastructure in workplaces and parking garages

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Use data from pilot phase of workplace program to improve package to enhance customer experience and increase the value that EoT provides to the grid
- Expand program

Long term Hawaiian Electric Actions (Initiate in 6-10 years):

- Continue if needed

Need Addressed:

- Compensates for MUD residents' lack of access to home charging by providing the opportunity to charge at work
- Alleviates range anxiety for customers with lengthy commutes by enabling them to top-off before driving home in the evening
- Promotes adoption by creating convenience and flexibility in charging
- Supports renewable integration and lowers distribution grid impacts by increasing the share of the vehicle population available to charge during periods of peak solar generation, and moving commuters' charging out of the peak system hours in the evening.

Potential Partners:

- Employers
- Parking management companies, and building owners with public-access parking
- Building Owners and Managers Association (BOMA), Hawai‘i
- Third-party charging providers and DR aggregators
- Drive Electric Hawai‘i
- County building permitting agencies
- Hawai‘i Energy
- NGOs

Rationale for Hawaiian Electric Role:

Workplace charging will align charging loads with peak solar generation hours, increasing the ability of the state to use its renewable resources and increasing value to all customers. As described in Chapter 4, installing workplace charging is challenging due to the many players involved, the cost to the parking owner, and a lack of knowledge and information about the process. Employers need education and incentives to host chargers and go through this involved process, at least while EV adoption in the early stages and best practices are still being investigated and shared. Utility investment is needed to fill these gaps in the absence of public funds.

Further, by contributing its expertise and experience with initiatives to streamline planning and permitting, Hawaiian Electric will help lower the cost of serving workplaces. Finally, Hawaiian Electric can use its existing customer relationships with building developers and customers to provide advice and information to this segment on the potential value of providing EV charging, streamlining installation processes, and opportunities to participate in smart charging programs and/or rates.

Value Proposition for Customers:

Enabling charging in workplaces will expand electric mobility choices by increasing the convenience and flexibility of EV charging and creating charging options for those without access to home charging. It will also enable drivers to align charging loads with low-cost solar generation hours and move charging away from evening system peaks, increasing the ability of the state to use its renewable resources and increasing value to all customers. Hawaiian Electric plans to investigate a requirement that participants in Level 2 workplace charging programs participate in DR programs and/or rates in exchange for investment of utility funds. Such DR programs can extract even further value from workplace charging vehicles by enabling them to provide additional DR services.

Further, Hawaiian Electric’s support of workplace charging will help to boost EV adoption at lowest cost, by using the utility’s expertise and experience with planning and permitting. As discussed in Chapter 3, increased adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil.

Utility Precedent:

Many utilities offer workplace charging to encourage EV ownership among their employees. Examples include Duke Power, Consolidated Edison, Kansas City Power & Light, and Arizona Public Service.[23]

Deploying charging in workplaces has been a major early focus for utility programs. While not as costly and complex as MUDs, workplaces do present many challenges and have been included in virtually every major utility infrastructure program approved by regulatory commissions to date. These include the initial pilot programs of California’s three IOUs,

[23] Department of Energy, 2016. “Workplace Charging Challenge: Progress Update 2016: A New Sustainable Commute” https://energy.gov/sites/prod/files/2017/01/f34/WPCC_2016%20Annual%20Progress%20Report.pdf

Eversource in Massachusetts, and Washington's Avista. The make-ready approach has been more common in workplaces, but SDG&E is installing utility-owned chargers in its current pilot. Utility programs for employers typically include a significant educational component to help gain their cooperation, promote smooth integration into parking operations and encourage participation in smart charging.[24]

Local Hawai'i Implementation Considerations:
On the mainland, campus-style workplaces with expansive, outdoor parking lots have proven relatively inexpensive to serve. In Hawai'i, many employees park in commercial garages that are not owned by their employer. This is likely to increase the cost and complexity of workplace solutions relative to the mainland, increasing the importance of learnings from early pilots and the need to work closely with partners like BOMA which understand the complexities of the relationships and incentives involved, as well as NGOs that have successfully implemented workplace solutions in the past.

Intersection with other Hawaiian Electric Initiatives/Processes:
Workplaces are ideal sites for aggregators to engage EV owners in providing demand response services because they provide both a) a concentration of parked vehicles during peak solar generation hours, and b) vehicles that are plugged in many more hours than necessary to replenish a battery.

[24] For example: https://www.sce.com/wps/portal/home/business/electric-cars/Workplace-Charging

Hawaiian Electric Initiative #7

Expand availability of reliable public charging

Technology: LDVs

Segment: All

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Hawaiian Electric proposes to site, install, own, and operate a reliable, uncongested "critical backbone" of public charging infrastructure on the islands in its service territory. This critical backbone will be a network that consists of the DCFC and Level 2 public chargers needed to eliminate existing range anxiety, where these are not already being provided by third-party charging providers.

  The initial focus for this critical backbone will be the 25 DCFC sites already authorized by the Commission for installation. Hawaiian Electric will continue to work with data and industry partners (HDoT, DEH, fleet operators, shared mobility operators, etc.) to site authorized DCFCs in locations where they provide maximum impact on range anxiety.

  Hawaiian Electric will continue to assess the need for any critical backbone sites beyond these 25 DCFCs as the EV market in Hawai'i grows. The companies will request authorization for additional critical backbone sites if and when needed. As an example, key Level 2 public charging locations that have not been addressed by the private sector are:
  - On O'ahu: locations on the Leeward Coast and North Shore
  - On Maui: Hana and Haleakalā
  - On the islands of Moloka'i and Lāna'i. Moloka'i currently has no public Level 2 or DC fast charging, Lāna'i has one Level 2 EVSE.
  - On Hawai'i Island: Saddle Road and Volcano

  Hawaiian Electric also plans to include in a subsequent filing a request for future ownership of the 25 stations currently authorized

- In addition, Hawaiian Electric proposes to incentivize third-party charging providers to install charging at locations on the utility's distribution network that are not highly constrained. Approaches to this effort will be further investigated and put forward in a future filing, but could include charging third-party EVSPs location-dependent prices for interconnection, or subsidizing them to install at sites that are low cost for utility customers (potentially by providing make-readies).

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Own and operate critical backbone of public charging infrastructure
- Continue to incentivize third-party charging providers to install charging at locations on the utility's distribution network that are not highly constrained.

Long term Hawaiian Electric Actions (Initiate in 6-10 years):

- Continue as needed

Need Addressed:

Promotes EV adoption by reducing range anxiety, creating an alternative to home charging, and providing a primary source of charging for rental cars and TNCs/taxis.
Leverages the utility's existing distribution network to create maximum customer value at lowest cost.

Potential Partners:

- Charger hosts, including airports, tourist attractions, parking management companies and building owners
- Third-party charging providers
- TNC, taxi, and rental car fleet owners (to provide trip data for siting)
- Drive Electric Hawai'i

Rationale for Hawaiian Electric Role:

Despite Hawaiian Electric's offering a development rate for high capacity EV charging (Schedule EV-F), there has been minimal private investment in DC fast charging infrastruc-

ture. As documented in the companies' 2016 annual report, capital costs for DCFCs can well exceed $100,000 and operation and maintenance costs can be substantial. While Hawai'i currently has the second highest EV adoption rate per capita, the total number of EVs in Hawai'i is still relatively low, which translates into a limited market for DCFC services. Additionally, since most EV drivers can charge at home, fees for using public DCFC are in direct competition with residential rates for most current EV drivers.[25] This combination of high ownership costs, low anticipated utilization, and competition from home charging makes the development of a sustainable DCFC business model difficult for third parties in Hawai'i.

This difficulty is evident in Hawai'i. The majority of EV-F accounts and associated charging stations were developed under JUMPSmart Maui, a research project subsidized by the New Energy and Industrial Technology Development Organization (NEDO) of Japan. Hawaiian Electric is currently supporting conversations with stakeholders in this project to ensure that these crucial Maui charging assets remain in place beyond the expiration of that project. In 2013, there were three customer accounts on Schedule EV-F on O'ahu for third-party operated DC fast charging. In 2016, all three accounts were closed, and the charging stations were removed. As of January 2018, the companies were in the process of acquiring a DCFC station at the Shops at Mauna Lani from a third-party that no longer wishes to be involved in the EV infrastructure business.

Hawaiian Electric appreciates that technology, markets, and business models for EVs and charging services are evolving rapidly. Less costly and more energy dense batteries, far faster rates of charging, and affordable inductive chargers are all realistic possibilities within the ten-year planning horizon of this Roadmap. For novel solutions to emerge and succeed, others must fail. This process of creative destruction is essential to realizing technical progress and is ultimately beneficial to our customers. It is also inherently disruptive: technologies may fail and charging providers may go bankrupt. Against this backdrop of constant flux, Hawaiian Electric will maintain a critical backbone of EV charging infrastructure to ensure the steady growth in EV adoption essential to sustain demand for innovative technologies and meet policy goals.

Ensuring that charging assets installed by the utility will remain in the ground is also crucial to the utility's ability to continue to site DCFCs and build out the critical backbone. As stated in Hawaiian Electric's DCFC Extension filing,[26] some potential site hosts are concerned that the companies will terminate the pilot program and are reluctant to make future investments if a resource may not be available in the future. Full utility-ownership provides greater certainty and opens up additional potential sites for DCFCs, ultimately improving the utilities' ability to site in areas that achieve the goals of the pilot (utilization, range extension, grid support).

Finally, operation of public charging infrastructure enables the utility to provide valuable data that can inform policymakers. Pursuant to Decision & Order No. 31338, by March 31 of each year, the companies file an annual report for the preceding year covering, among other things, adoption rates, costs, revenues, and other metrics. This information may be used to assess public policies and private investment related to EVs and EV charging. Further, the usage profiles of the DCFC stations provide insight into overall customer demand and can aid in the development of policies to encourage greater adoption and utilization of EVs. Unlike third-party developers, the companies are required to provide this information through the existing reporting requirements.

[25] Hawaiian Electric survey efforts indicate that the majority of current EV owners reside in a single-family home, approximately 81 percent.

[26] Docket No. 2016-0168 "For Approval to Extend Schedule EV-F, Commercial Public Electric Vehicle Charging Facility Service Pilot, and Schedule EV-U, Commercial Public Electric Vehicle Charging Service," Transmittal No. 13-07 filed June 27, 2016 Attachment 1 at 2.

Value Proposition for Customers:

Range anxiety still remains a key barrier to EV adoption. Hawaiian Electric's support of public charging infrastructure will expand electric mobility choices by eliminating range anxiety and creating charging options for those without access to home charging. It will also create benefits for non-EV customers: as discussed in Chapter 3, increased adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil.

Utility Precedent:

SCE's ChargeReady pilot program, which the CPUC approved in January 2016, provides make-readies and 25 percent rebates for Level 2 chargers at destination centers such as parks, beaches and retail establishments.[27] Under the pilot program authorized by the Washington Utilities and Transportation Commission, Avista is installing both Level 2 and DCFC at publicly accessible locations in Washington state. These chargers will be owned and operated by the utility.[28] In a November 2016 decision, the Massachusetts Department of Public Utilities allowed Eversource to rate-base make-readies for both Level 2 and DCFC in public locations.[29] Georgia Power's Will-It-Work program has sponsored 37 new public EV charging locations across the state to serve fleet vehicles, including electric taxis for Checker Cab.[30] The Oregon PUC recently approved a stipulation allowing Portland General Electric to proceed with its proposal to install, own and operate six new public charging stations that will each contain up to four DCFC and one Level 2 charger.[31]

Additionally, in U.S. states and Canadian provinces where significant public funds have been committed to deploying EV infrastructure, building out a backbone of DC fast charging along the principal travel corridors has been a funding priority. British Columbia, Washington, Oregon and California have banded together in the Pacific Coast Collaborative to fund the West Coast Electric Highway that provides DCFCs approximately every 30 miles from Vancouver, BC to San Diego, CA.[32] British Columbia has provided $6 million in funding for the deployment of 30 DCFC.[33] The Ontario provincial government has allocated $20 million to deploy 500 charging stations at 250 locations.[34] Quebec's 2030 Energy Action Plan calls for the Circuit électrique network to expand to include 2,500 DCFC by 2030.[35]

Local Hawai'i Implementation Considerations:

Fortunately, the needed critical backbone for Hawai'i may include fewer charging sites than would be needed for many mainland utility service territories, due to the limited size of the islands and the limited number of major traffic thoroughfares. This smaller geographic area also allows for more strategic clustering or development of plaza-type charging options to ensure reliability and avoid charger congestion. On the other hand, the large number

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[27] Application of Southern California Edison Company for Approval of its 2017 Transportation Electrification Proposals. California Public Utility Commission Proceeding Number A1701021. https://apps.cpuc.ca.gov/apex-/f?p=401:56:0::NO:RP,57,RIR:P5_PROCEEDING_SELECT:A1701021

[28] Docket Number: UE-160082, https://www.utc.wa.gov/docs/Pages/recordsCenter.aspx

[29] Massachusetts Department of Public Utilities, 2017. "Order Establishing Eversource's Revenue Requirement" P.P.U 17-05: http://170.63.40.34/DPU/FileRoomAPI/api/Attachments/Get/?path=17-05%2f1705_Final_Order_Revenue_Requi.pdf

[30] Taxicab Limousine & Paratransit Association, 2017. "Atlanta Checker Cab's Electric Taxis Hit the Road" https://www.tlpa.org/Atlanta-Checker-Cab-s-Electric-Taxis-Hit-the-Road

[31] Oregon Public Utility Commission, Order No. 18-054, http://apps.puc.state.or.us/orders/2018ords/18-054.pdf

[32] Washington State Department of Transportation, 2014. "West Coast Electric Highway" http://www.westcoastgreenhighway.com/electrichighway.htm

[33] British Columbia Utilities Commission, 2016. Document No. G-71-16 https://www.ordersdecisions.bcuc.com/bcuc/orders/en/item/144369/index.do

[34] Docket: EB-2010-0142, Partial D&O No. 07-07-2011, https://www.oeb.ca/industry/tools-resources-and-links/regulatory-document-search

[35] Ministere de l'Energie et des Ressources Naturelles. "2030 Energy Policy Action Plan" https://politiqueenergetique.gouv.qc.ca/wp-content/uploads/Tableau-PA-PE2030_ANG.pdf

of O‘ahu residents living in MUDs means that the need for DCFCs as a primary charging source may be significant.

Intersection with other Hawaiian Electric Initiatives/Processes:
As discussed in Docket No. 2016-0168, the companies are investigating the ability of DCFC resources to provide grid services and support the integration of additional renewable resources. The DCFC station at Kapolei Commons employs a 12 kWh battery to research how energy storage can minimize the grid impact of high-capacity EV charging. It is unclear to what extent and at what cost third-parties would be willing to deploy new technologies or manage customer EV charging to provide grid support services. As the Demand Response program begins to take shape, it will be easier to define the potential value of DCFCs to provide particular grid services.
The companies are also currently developing the ability to curtail DC fast charging sessions. This project with EPRI could demonstrate the ability to curtail 50kW fast charging to provide some grid services.

Hawaiian Electric Initiative #8

Engage the **tourism industry**

Technology: LDVs

Segment: Personal Transportation

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Encourage automakers to offer vehicle discounts aimed at placing EVs in rental, TNC and taxi fleets in Hawai‘i by demonstrating the attractiveness of Hawai‘i as a place to showcase EVs to likely new car buyers
- Site public DCFC at destinations that support tourists, TNC and taxi drivers, and rental car agencies
- Engage hotels to host and invest in “valet” and/or Level 2 charging solutions for guests with rental cars

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Continue as needed

Long term Hawaiian Electric Actions (Initiate in 6-10 years):

- Continue as needed

Need Addressed:
- Helps overcome limited awareness and enthusiasm by making EVs visible to the public and accessible to tourists
- Counters upfront cost premium of EVs for use in rental, TNC and taxi fleets, and for personal drivers by making second-hand vehicles available as rental fleets turn over

Potential Partners:
- Tourism industry (resorts, rental car agencies, travel agencies)
- Hawai‘i Tourism Authority
- Governor’s Office
- HDOT
- Drive Electric Hawai‘i, especially DBEDT through their Volkswagen Settlement discussions
- Automakers
- Hawai‘i Energy

Rationale for Hawaiian Electric Role:
Hawaiian Electric proposes partnering with another lead agency on this initiative. Hawaiian Electric is well positioned to support tourism efforts because its account representatives have ongoing engagement with major resort operators and participate in long-term planning for Hawai'i's major airports. Hawaiian Electric also has ongoing relationships with rental car agencies, having supported their efforts to date on incorporating EVs into their fleets. This initiative is a natural extension of our existing outreach to automakers and the work that we aim to do with them as part of the other proposed initiative.

Value Proposition for Customers:
This initiative will expand electric mobility choices for customers by increasing the availability of second-hand EVs as they are retired from rental car fleets.

It will also increase EV adoption by creating awareness and excitement about EVs. Hawai'i's residents will gain significant exposure to EVs through their use of electrified taxis and TNCs, as tourists themselves across the islands, and in regular visits to the destinations (e.g. beaches) where chargers would be placed to serve mainland and international tourists. As discussed in Chapter 3, increased adoption provides financial benefits to all utility customers, as EV drivers pay more in electric bills than it costs the utility to serve the additional load. This increased adoption will also provide the broader benefits of improving local air quality and lowering reliance on foreign oil.

Utility Precedent:
Portland General Electric is currently proposing a significant focus on TNC vehicles, aimed at incentivizing and educating drivers to make the switch to an EV given the advantageous economics of this high-miles use case.[36]

Though not a utility, Drive Electric Orlando has rolled out a program focused on tourists that could provide inspiration for Hawaiian Electric and its partners. The program, titled Plug-in Perks, offers drivers benefits when they rent an EV, including free EV charging and parking at hotels, and preferred parking and free charging at Disney and Universal Studios.[37]

Local Hawai'i Implementation Considerations:
Hawai'i's significant tourism industry should make the state a particularly attractive market for automakers because of the "showroom effect" of having tourists from Hawai'i and from other locations "test drive" electric vehicle models as rental cars or see them at key destinations around the islands.

Kahului Airport rents the most cars of all the airports in the state, with an average of 2,200 cars rented daily (more than twice the amount at Honolulu). Maui may therefore be a natural first focus for this initiative.[38]

Intersection with other Hawaiian Electric Initiatives/Processes:
N/A

[36] Portland General Electric, March 2017. "Transportation Electrification Plan" https://www.portlandgeneral.com/-/media/public/residential/electric-vehicles-charging-stations/documents/pge-ev-plan.pdf?la=en
[37] http://pluginperks.com/
[38] Hawai'i Department of Transportation, 2016. "Construction Begins on New Earth Friendly Facility at Kahului Airport" http://hidot.hawaii.gov/blog/2016/04/15/construction-begins-on-new-earth-friendly-facility-at-kahului-airport/

7. Hawaiian Electric's proposed role in enabling electrification of buses

As described in Chapter 4, electric buses are a commercial technology that is ready to deploy on the islands. Hawaiian Electric seeks to support the adoption and smart charging of these vehicles to create financial, clean air and noise pollution benefits for its customers. To define the utility's role, we applied the Funnel approach described in Chapter 5. This resulted in a number of proposed utility actions packaged into a "Bus Initiative." Below we provide details, identify potential partners, and describe how our proposed actions meet the funnel criteria.

Hawaiian Electric Initiative #9

Encourage and enable electrification of smart charging of buses

Technology: Buses

Segments: Transit Operators, School Districts, School Bus Contractors, Tour Bus Operators

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Continue education and outreach to transit operators throughout Hawaiian Electric utilities' service territory on vehicle availability and benefits, infrastructure deployment and vendors, and available rates, incentives and battery service agreements
- Enable access to 1-2 e-school buses for short term user demonstration and test drives
- Continue to provide technical support to smooth e-bus adoption and provide for cost-effective grid integration of bus charging
- Design and make available a battery service agreement that will make the upfront purchase price of an electric bus equal to the upfront purchase price of a diesel bus
- Investigate reuse and servicing of bus batteries
- Develop e-bus pilot tariff
- Explore the possibility of make-ready and rebate program for charging infrastructure to further lower cost of adoption

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Continue outreach efforts
- Provide ongoing technical assistance as bus operators continue to add e-buses to their fleets
- Continue to offer the bus battery service agreement until the upfront purchase cost differential closes between a diesel bus and an electric bus
- Pilot demand response programs for buses and explore V2G, as well as opportunities to deploy used vehicle batteries for stationary storage

Long term Hawaiian Electric Actions (initiate in 6-10 years):

- Continue outreach efforts
- Provide ongoing technical assistance as bus operators continue to add e-buses to their fleets
- Expand DR programs

Need Addressed:

- Education, outreach, and technology demonstration programs aim to overcome limited awareness
- Reduce cost premium over diesel vehicles via bus battery service agreement
- Partially offset cost premium over diesel buses through e-bus tariffs, and DR, V2G and battery second-life program. Explore the possibility of further offsetting cost premium through make-readies and rebates

Potential Partners:

- County Transit agencies (e.g., OTS, The Bus, Hele On, Maui Bus)
- State agencies (e.g., Department of Transportation, DAGS, etc...)
- Private schools
- Public school districts
- School bus contractors (Roberts, Ground Transport Inc., Akina Bus Service, Gomes, etc.)
- Bus Manufacturers and Service Providers
- Drive Electric Hawai‘i

Rationale for Hawaiian Electric Role:

With chargers that are 50 – 60 kW each and increasing in power, electric bus depots will represent significant additions to Hawaiian Electric's distribution system. Engaging bus fleet operators and electric bus providers early on in the electrification transition will allow the utility to plan for cost-effective integration of this new load. Hawaiian Electric can leverage its existing relationships with bus operator customers to learn how they plan to deploy e-buses, and to help shape operators' expectations and plans. Understanding bus fleet operators' needs and plans will also inform Hawaiian Electric's development of tariffs to maximize contributions to renewable integration from this load. Finally, Hawaiian Electric can help ensure positive experience for early adopters by supporting them through the process of installing and interconnecting chargers, and by providing a single point of contact as they encounter concerns and issues in electrifying.

Value Proposition for Customers:

Electric buses, like personal EVs, can create value for all customers by paying more in utility bills than they cost to serve. Hawaiian Electric's proactive engagement with bus operators will maximize this value by ensuring cost-effective grid integration of these vehicles and maximizing their support of renewable integration. School buses, for example, can be encouraged to charge in the middle of the day when low-cost solar is most available. Other buses can be incentivized to move their charging away from system peaks.

Another significant benefit to customers is reduced exposure to diesel emissions in areas where e-buses operate, including for children that ride e-school buses. And a significant decrease in noise pollution: electric buses are almost silent.

Utility Precedent:

The proposed technical support is an extension of the work that Hawaiian Electric has already begun doing with bus operators including The Bus.[1]

[1] AP, 2018. "Honolulu Puts Electric Bus on the Road for Pilot Program" https://www.usnews.com/news/best-states/hawaii/articles/2018-01-31/honolulu-puts-electric-bus-on-the-road-for-pilot-program

California IOUs received CPUC approval in January 2018 for "priority review" transportation electrification pilots, including several related to transit and school buses.[2] SCE will deploy make-ready infrastructure at bus depots and along bus routes and provide a rebate to participating customers to cover the cost of the charging equipment and installation for up to 20 electric charge ports (accommodating 60-120 buses). The transit agencies must take service under an applicable TOU rate to be eligible for the program. Portland General Electric recently secured approval from the Oregon Public Utility Commission to install, own, and manage six electric bus charging stations (five depot chargers and one on-route charger) for use by Portland's TriMet transit agency.[3] In April 2017, Consolidated Edison in New York issued a request for information for smart technology that manages charger use to determine which buses to charge and when so as to minimize new grid investment.[4]

Utilities are also supporting deployment of electric school buses. In California, Pacific Gas and Electric (PG&E) will deploy make-ready infrastructure to serve two to five school buses. PG&E will explore opportunities to manage the charging of the buses so they charge during times with excess renewable energy mid-day, including testing the value of incentives that could be provided for shifting the time of vehicle charging or throttling demand. SCE proposed offering electric school buses at reduced prices in return for being able to use the buses as grid batteries during the summer months. Dakota Electric Association and Great River Energy launched a program that will demonstrate the technology of a battery electric school bus in a cold-weather climate that began operation in November 2017 in Minnesota.[5]

Local Hawai'i Implementation Considerations:
The mayors' recent clean transportation pledge signals significant county-level support for electrifying transit buses, and Honolulu Mayor Kirk Caldwell has stated that the county's fleet of over 500 electric buses should be converted to electric by 2035.[6]

Some school buses in Hawai'i are owned and operated by schools or school districts, while others are operated by private contractors. We plan to engage both groups in order to support this market.

Intersection with other Hawaiian Electric Programs/Initiatives:
Forecasting the impacts of these assets will be an important input to future Integrated Grid Planning efforts. Hawaiian Electric plans to explore the ability of electric buses to participate in the companies' demand response programs.

[2] CPUC, 2018. "Decision on the Transportation Electrification Priority Review Projects". CPUC D. 18-01-024, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M204/K670/204670548.PDF

[3] Oregon Public Utility Commission, Order No. 18-054, http://apps.puc.state.or.us/orders/2018ords/18-054.pdf

[4] ConEdison, 2017. "Electrification of Transportation" https://www.coned.com/-/media/files/coned/documents/business-partners/electric-vehicle-project-partners/con-ed-electric-vehicle-rfi.pdf?la=en

[5] Dakota Electric Association, 2017. "CIRCUITS: News for Dakota Electric Members" https://www.dakotaelectric.com/wp-content/uploads/2017/11/Circ1017_lores.pdf

[6] Mai, HJ, 2017. "Hawai'i counties pledge to eliminate fossil fuels from ground transportation by 2045" https://www.bizjournals.com/pacific/news/2017/12/12/hawaii-counties-pledge-to-eliminate-fossil-fuels.html

8. Hawaiian Electric's proposed role in enabling electrification of other vehicle types

For vehicle types and customers beyond light-duty vehicles and buses, Hawaiian Electric aims to lay the foundation in the near-term with customer engagement and small-scale electrification pilots, with a view to more wide-scale electrification in the medium- and long-terms.

Based on the technology assessment presented in Chapter 4, the following vehicles could start electrifying in the medium term (3-5 years from now):

- Airport ground services and support, including electric ground service equipment and preconditioned air
- Harbor operations, including electric cranes and shore power capabilities (especially for cruise ships)
- Medium-duty vans and trucks
- Military vehicles
- First and last mile tie-ins with the Honolulu Authority for Rapid Transportation (HART) system to enable electrified modes from end to end of a commuter's journey, including stops and charging stations at HART locations for electric buses, taxis, TNCs, car share, or and/or bikes
- Hydrogen fuel-cell technologies

In the longer term, we further expect more movement on electrified and autonomous vehicles.

Below, we have summarized our Hawaiian Electric initiative on these other vehicle types, including potential partners and details on how this initiative meets the Funnel criteria outlined in chapter 5.

Hawaiian Electric Initiative #10

Encourage and enable electrification of medium and heavy-duty vehicles and off-road equipment as technologies mature and become commercially available at reasonable cost.

Technology: Medium and Heavy-duty vans, trucks, and off-road equipment

Segments: Goods movement, construction, military bases, first and last-mile tie-ins to HART

Near term Hawaiian Electric Actions (initiate in 1-3 years):

- Targeted outreach and engagement with customers and partners, including:
  - Continue and expand individualized conversations with military, airports, ports, and large customers with fleets of vans and trucks to educate, support, and enable forward-looking distribution planning for these vehicles
  - Hold working groups to solicit input on customer plans, issues, and needs, and disseminate information and best practices from the mainland
  - Provide a dedicated point of contact at Hawaiian Electric for these customers
- Continue to support customers as they undertake near-term pilots for commercially-available technologies, including:
  - Cranes and forklifts at ports and other commercial and industrial locations
  - Use of preconditioned air units at airport jet-bridges
- Continue incorporating electrified vans and trucks into Hawaiian Electric fleets
- Monitor development of medium-duty, heavy-duty and off-road electric vehicle technologies and mainland pilot programs
- Explore targeted demand response applications

Medium term Hawaiian Electric Actions (initiate in 3-5 years):

- Support wider-scale electrification of these vehicle types based on experiences and information collected through near term efforts
- Continue to provide technical support to customers as customers electrify vehicles and equipment
- Enroll customers in demand response programs

Long term Hawaiian Electric Actions (initiate in 6-10 years):

- Continue all medium term efforts

Need Addressed:

- Education, outreach, and technical support aim to overcome **limited awareness**

- Partially offset **cost premium** over comparable diesel equipment through rates designed to support **renewable integration** by passing along some of the savings that result from charging during periods of peak renewable generation.

Potential Partners:

- Hawai‘i Department of Transportation
- Airlines and shipping companies
- Army and Navy
- HART
- Automakers
- Drive Electric Hawai‘i
- NGOs

Rationale for Hawaiian Electric Role:

The potential adopters of these electrified vehicles and equipment comprise a large and diverse group of customers. Hawaiian Electric customer service representatives are already a trusted energy advisor to many, so the utility is well positioned to provide education and technical support via existing communication channels. Hawaiian Electric can leverage these existing relationships to learn how they plan to deploy electrified vehicles, and to help shape their expectations and plans. Engaging these customers early on in the electrification transition will allow the utility to plan for the cost-effective integration of these new

loads as they come online down the road. Understanding customers' needs and plans will also inform Hawaiian Electric's development of tariffs and demand response programs to maximize contributions to renewable integration from this load. Finally, Hawaiian Electric can help ensure positive experience for early adopters by supporting them through the process of installing and interconnecting chargers, and by providing a single point of contact as they encounter concerns and issues in electrifying.

Value Proposition for Customers:
Hawaiian Electric's proactive engagement with customers as they begin to electrify will maximize value to all customers by planning for cost-effective grid integration of these vehicles and maximizing their support of renewable integration. Another significant benefit to customers is reduced exposure to diesel emissions at ports, airports and industrial areas.

Utility Precedent:
The California IOU programs approved in January 2018 include several pilots for medium-, heavy-duty and off-road vehicles. San Diego Gas and Electric (SDG&E) will support the expansion of electric ground support equipment at the San Diego Airport, offering to upgrade and own existing charging infrastructure that needs retrofitting. SDG&E will also install and own approximately 30 EVSE and supporting infrastructure at the San Diego Unified Port to support charging for medium- and heavy-duty vehicles and forklifts. SDG&E also plans to partner with local delivery service businesses to support the electrification of their fleet delivery vehicles by installing, owning, operating, and maintaining the electric charging infrastructure for up to 90 new medium-duty electric delivery vehicles. SDG&E also proposed a dynamic, hourly Commercial Grid-Integration Rate for fleet EV charging that will be considered by the CPUC in a subsequent decision. SCE will deploy make-ready infrastructure to serve nine cranes and 24 EVSE for electric yard tractors at the Port of Long Beach. PG&E will partner with one fleet customer who is currently operating a fleet of MD or HD vehicles to deploy make-ready infrastructure, offer a rebate for the EVSE, and provide technical assistance, including employing managed charging strategies to reduce demand charges.

Georgia Power's Will-It-Work program has also supported the deployment of electric terminal tractors and gantry cranes at the Port of Savannah and electric ground support equipment at Atlanta's Hartsfield-Jackson airport.[1]

Local Hawai'i Implementation Considerations:
State ownership of major airports and seaports in Hawai'i simplifies the electrification transition relative to other locations, where split ownership and incentives can cause significant issues.

Intersection with other Hawaiian Electric Programs/Initiatives:
Hawaiian Electric plans to explore the ability of these vehicles to participate in the companies' demand response programs. Forecasting the impacts of these assets will also be an important input to future Integrated Grid Planning efforts.

[1] Edison Electric Institute. "Southern Company Driving Transportation Electrification" http://www.eei.org/future/Pages/story.aspx?sid=14_Southern%20Company%20Driving%20Transportation%20Electrification and Atlanta Business Chronicle, 2017. "Ports, Ikea to test electric tractor" https://www.bizjournals.com/atlanta/news/2017/02/22/ports-ikea-to-test-electric-tractor.html

9. EoT Strategic Roadmap alignment with Hawaiian Electric programs and filings

As described in Chapter 2, Hawaiian Electric's EoT strategy aligns with and builds on the work that the companies are doing in several existing programs and filings. EoT will integrate with and support programs that facilitate integration of renewable energy, enable greater customer engagement and empowerment as "prosumers" of energy, and enhance grid efficiency and reliability by leveraging the flexibility of electrified vehicles.

To support these objectives and provide customer value, Hawaiian Electric's EoT plans will align with and leverage existing Hawaiian Electric planning processes and programs, including the Integrated Grid Planning (IGP) process (which continues the work done in the Power Supply Improvement Plan, or PSIP), Grid Modernization Strategy (GMS), Demand Response (DR) and Distributed Energy Resources (DER) programs. Specifically, Hawaiian Electric plans to:

- Leverage the proposed Hawaiian Electric DR program to offer drivers and fleet operators incentives for "smart" charging and provision of other grid services,

- Leverage technologies and data collection proposed in the Hawaiian Electric GMS and DER dockets to enable EV drivers as "prosumers" who support DER adoption and broader grid reliability, and

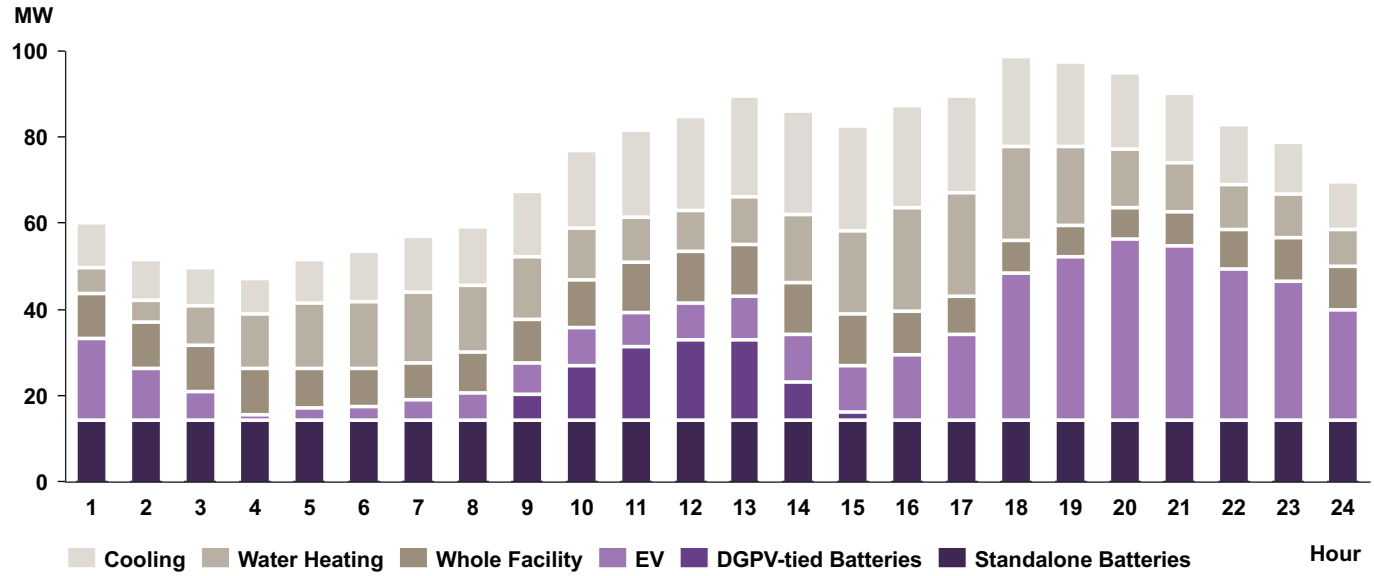
- Use IGP to cost-effectively plan for forecast EV adoption and seek new opportunities to maximize the value of EVs to customers and as a resource to the grid.

The remainder of this chapter provides additional detail on these crucial points of alignment between Hawaiian Electric's EoT Strategic Roadmap and existing or proposed Hawaiian Electric programs.

Hawaiian Electric's Demand Response program will enable EVs to be grid assets

The goal of the proposed Hawaiian Electric DR portfolio is to provide cost-effective dispatch options for each island's system operations and, correspondingly, to help provide all customers with lower bills, while giving individual customers an additional option to help reduce their energy bills further by participating in a DR program. Hawaiian Electric filed its original DR Portfolio application on December 30, 2015. A revised DR Portfolio that updated the DR potential and its cost effectiveness was filed to the Public Utilities Commission on February 10, 2017. In addition, on December 18, 2017 Hawaiian Electric filed the draft Grid Service Purchase Agreement, a proposed contract mechanism for the aggregators for Commission consideration and review. Furthermore, in tandem with this docket, Hawaiian Electric also filed an application for a Demand Response Management System (DRMS), which is intended to manage customer-sited energy resources, including EVs. This application was approved in October of 2017, with a go-live date slated for December of 2018. On January 25, 2018, the Commission issued D&O No. 35238 approving the DR Portfolio tariff structure framework,

Figure 31. O'ahu Fast Frequency Response Load Reduction Potential from DR Filing



Source: Docket 2015-0412, "Revised DR Portfolio Filing" filed on February 10, 2017, Attachment A "Potential Study" at 26.

which includes the four grid service tariffs and the rate schedules and riders upon which the DR programs are to be deployed, and directed the companies to begin immediate implementation of rate schedules and riders for the islands of O'ahu and Maui, and staged implementation of additional rate schedules and riders by island.[1] The expectation is that the companies will proceed with implementation and customer acquisition beginning by third quarter of 2018.

The DR filing proposed four Grid Service Rules for which EVs are a significant potential resource: capacity, fast frequency response, regulating reserve and replacement reserve. As an example, Figure 31 shows the forecast potential availability of EVs to contribute fast frequency response services in 2025. Electric vehicles will be eligible to enroll, though convenient aggregator services, in Grid Services Purchase Agreements to provide and be compensated for these grid services. The DR portfolio as filed also creates opportunities for customers to participate in programs aimed at delivering these same services by way of direct enrollment with the companies. The initial GSPA engagements are expected to be contracted in June of 2018. A final version of the tariff rules, rates and riders that serve as the basis for the GSPAs – and through which EVs can also participate is expected to be filed for Commission review and approval around the same time.

The companies' planned approach will enable electrified vehicles to participate in DR programs that facilitate increased use of renewables on the grid while also supporting grid stability and reliability. DR opportunities will empower customers with expanded energy options and economic opportunity, by providing near-term opportunities to fuel their sustainable transportation with locally-produced renewable generation, and to be compensated for managing their charging.

Hawaiian Electric is in the process of using learning from ongoing DR pilots to drill down on the specifics of the DR services that can be provided by EoT. Results collected so far from JUMPSmart Maui, the OATI pilot, and the Kapolei and Ward DC fast charger pilots (described in Chapter 2) suggest that the near-term focus should be on one-way "smart charging" to provide capacity, regulating reserve and fast frequency response grid services. In the near-term, Hawaiian

[1] See D&O 35238.

Electric therefore proposes that the following one-way EoT "smart charging" initiatives be administered under the DR program:

1. Educating and enabling commercial electric vehicle fleets to be compensated for one-way smart charging

- By enrolling in Critical Peak Incentive programs
- By enrolling in Day-Ahead Load Shift programs, and
- As self-aggregators under Grid Service Purchase Agreements (GSPAs)

2. Enabling vehicle aggregators to provide grid services from residential, workplace, fleet and public charging stations under GSPAs. These aggregators could include charging providers, automakers, and technology companies, who would provide incentives to individual drivers for participation

"The companies' planned approach will enable electrified vehicles to participate in DR programs that facilitate increased use of renewables on the grid while also supporting grid stability and reliability."

The ultimate size of the EoT resource included in the companies' DR portfolio will be determined by a) the quantity of DR services the vehicles can provide, and b) the cost at which they can provide them relative to other sources of DR. Prior experience suggests that electrified vehicles will be able and willing to provide these one-way smart charging services at relatively low cost: since electrified vehicles are often parked at a single location (home, work, depot or work site) for several hours at a time, their charging can often be shifted or modulated without a noticeable impact to the driver.

So long as the vehicle is ready to depart when needed, the marginal cost to the driver of altering the vehicle's charging pattern can be fairly low. In the JUMPSmart Maui demand response demonstration, the participants responded to a customer survey (n= 30 respondents) that showed strong willingness to participate in programs where EVs charging was altered by the utility for grid stability. On the mainland, TOU rates have been shown to reliably shift EV charging load to off-peak periods. For example SDG&E's EV TOU Rate pilot showed that participating customers shifted 78 percent or more of their charging load to off-peak periods.[2] BMW and PG&E's iChargeForward pilot was over-subscribed, and enrolled 96 customers that allowed their BMW i3s to be dispatched to reduce charging and provide reserves in the California Independent System Operator's (CAISO) ancillary services market.[3] Toronto Hydro and FleetCarma ran the ChargeTO pilot in which 97 percent of customers reported a neutral or positive impact on their vehicle usage while reducing peak loads by 50 percent over 150 days of active curtailment.[4]

It will also be important for Hawaiian Electric to investigate in the near term additional EoT grid services and pricing structures for medium- and long-term implementation. We are therefore proposing to undertake vehicle-to-grid, vehicle-to-business, and vehicle-to-home pilots that seek to identify additional services that can be provided and develop valuation schemes or real-time and location-based pricing for residential and commercial EoT customers (see Chapter 6).

The currently-filed grid services tariff structure provides an extensible foundation to evolve grid services as EoT technologies and markets change and additional grid needs emerge. This is not limited to bulk system needs, but also anticipates an evolution to locational distribution grid service needs. Within this framework, Hawaiian Electric can continue to evolve existing rates and programs that support the delivery of

[2] Nexant, 2014, "Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle TOU Pricing and Technology Study, https://www.sdge.com/sites/default/files/documents/1681437983/SDGE%20EV%20%20Pricing%20%26%20Tech%20Study.pdf

[3] "BMW iChargeForward: PG&E's Electric Vehicle Smart Charging Pilot". 2017. http://www.pgecurrents.com/wp-content/uploads/2017/06/PGE-BMW-iChargeForward-Final-Report.pdf

[4] FleetCarma. Residential Smart Charging Pilot in Toronto. 2017. https://www.fleetcarma.com/docs/ChargeTO FleetCarma.pdf

the existing DR services, or introduce new, technology-agnostic rates or riders. These are expected to include near real-time, dynamic rates to support either locational needs or bulk system needs, and other customer or service specific riders.

EV-related opportunities are expected to continue to grow and evolve through this framework as the technology evolves and the market becomes more experienced in delivering a wider range of grid services. Furthermore, this framework serves as the cornerstone to the Grid Services Purchase Agreements, which will also afford EV-centric or EV-oriented aggregators the opportunity to enroll and enable various customer classes into agreements to deliver grid services.

To enable Hawaiian Electric to take full advantage of flexible resources, including EVs, the companies are currently implementing a DRMS. Initially intended to serve as a bulk system Distributed Energy Resource Management System (DERMS), the platform will eventually deliver locational services once Hawaiian Electric evolves its Grid Modernization vision. The system is designed to enable grid services from all end use technologies, including EVs, by way of direct connection and control or by way of third-party aggregators.

The current work around the immediate implementation of the DRMS will continue to be leveraged by innumerable initiatives within Hawaiian Electric, including those proposed for EoT. The DRMS will collect information on enrollment and enablement of EVs, among other devices, and make the forecasted availability of the corresponding services these EVs can provide available to system operators.

A final point of overlap between DR and our EoT strategy occurs with forecasting efforts. Future DR plans will make use of the EV adoption forecast described in Chapter 3 and Appendix E: Electric vehicle forecast methodology and assumptions of this EoT Roadmap as an input to the assessment of DR potential. This forecast will be used in all Hawaiian Electric's planning processes, ensuring consistency and alignment across the board.

EVs are well positioned to become cost-effective Distributed Energy Resources

The companies are currently engaged in Phase II of the Commission's investigative proceeding on DER (Docket No. 2014-0192). DER Phase II is focused on developing a longer term, competitive market structure for maximizing the benefits of DER in Hawai'i. The Commission divided Phase II into Technical and Market Track issues. The DER Parties focused on Technical Track issues in 2017, collaborating through various working groups, which culminated in the filing of several stipulations and statements of position. In October 2017, the Commission ruled on the various positions, and approved two new DER Programs -- Customer Grid Supply Plus ("CGS+") and Smart Export -- and two new advanced inverter functions -- Volt-Var and Frequency-Watt. The companies filed tariffs implementing the new programs and officially launched the programs on February 20, 2018.

The Market Track of the proceeding is expected to start next in 2018. The Commission has identified multiple issues for evaluation during the Market Track, including alternative rate designs, rate unbundling, improved DER integration and aggregation, cost allocation for upgrades related to DER integration, and sunset dates for existing DER tariffs.

The objectives of the DER proceeding are to support reliability, safety and power quality and to meet the 100 percent RPS goal in a fair and cost-effective manner. An additional objective is to provide visibility to the "end game" where all DER customers will be "prosumers" of energy assisting with support of the grid. EoT supports the use of renewable fuel in place of gasoline and shifting EV load to maximize utilization of renewable generation. EVs will be enrolled in tariffs and programs developed for all DER to provide value-based compensation for grid services without cost shift to other customers. This will harness the potential for EVs to reduce costs of achieving 100 percent RPS and

to reduce distribution costs in constrained areas.

EVs are well positioned to become cost-effective DER. Our EoT vision is to enable EVs as highly visible and attractive positive touchpoints to engage customers as 'prosumers' who can choose to manage their energy bill using convenient solutions provided by aggregators and automated technologies. In the future, EVs will be able to be employed as controllable resources able to support the Smart Export Program, reducing energy exports to the grid during less beneficial times and supporting system reliability and stability.

EoT will leverage Hawaiian Electric's vision for an innovative and integrated grid platform, as outlined in our Grid Modernization Strategy

The overall goal of the GMS is to deploy modern grid investments at an appropriate priority, sequence and pace to cost-effectively maximize flexibility, minimize the risk of redundancy and obsolescence, deliver customer benefits and enable greater DER and renewable energy integration. On June 30, 2017, Hawaiian Electric filed an initial draft GMS describing how new technology will help triple private rooftop solar and make use of rapidly evolving products including storage and advanced inverters. The final Grid Modernization Strategy was filed on August 29, 2017. On February 8, 2018 the Commission issued an order setting forth next steps and directives to implement the GMS. Hawaiian Electric has begun work to implement the GMS by issuing solicitations for advanced meters, a meter data management system, and a communications network; Hawaiian Electric is working toward filing its first application with the Commission for the first implementation phase in Q2 2018.

The GMS provides a vision for investment in a grid platform that will enable greater customer engagement, empowerment, and options for utilizing and providing energy services. EoT represents a perfect opportunity to further leverage this platform to create additional customer value. EoT will enable customers to use EVs as a readily-available, advanced, flexible distributed resource to manage their bill and engage in providing services that support the grid. The groundwork laid by the GMS is flexible, allowing the grid to accommodate future EoT technology and market conditions. Customer-purchased EVs will be connected to grid management software and technology as a foundational, integrated network, enabling the EVs to provide a broad range of cost-effective grid services.

Hawaiian Electric's modernized grid will allow the companies to integrate the technology inside vehicles, solutions from smart charging providers and aggregators, DRMS, and advanced metering infrastructure. This will enable the sending of price signals to customers (including future dynamic rates and location-based incentives), receiving grid services from EVs (including through two-way flows in the future), and provide visibility into customer loads and behaviors. Advanced meter data will support accurate forecasts of EV load growth and help Hawaiian Electric understand how to motivate managed and daytime charging to facilitate integrated planning with renewable generation and distribution planning.

This will create value for EV drivers and non-EV drivers alike by enabling improved customer engagement and experience with the grid, supporting efficient and reliable distribution planning, enabling the design and targeting of smart charging programs, and using EVs to more fully integrate renewable generation.

The vision for a fully flexible grid also benefits third-party technology providers and aggregators by allowing them to send pricing signals to drivers, which will allow them to demonstrate a variety of new and innovative solutions and business models. Flexible GMS platforms will enable utilization of automaker, EVSP and aggregator technologies for EVs to provide valuable grid services.

Planning for EoT in the Integrated Grid Planning (IGP) process will maximize customer value and reliability

The companies' Power Supply Improvement Plan (PSIP), filed December 23, 2016,[5] adhered to several key Renewable Energy Planning Principles[6] that will help guide the companies through the grid transformation to 100 percent renewable energy. Our EoT strategy supports the first planning principle that renewable energy is the first option and will replace the use of gasoline, by shifting EV load to maximize utilization of renewable generation. It also supports integration of EVs with DRMS, advanced meters, traditional grid infrastructure, and other smart grid platforms. This will enable EVs to be effectively utilized in providing local and system grid services.

For the cost-benefit analysis in Chapter 2, Hawaiian Electric leveraged the extensive work done to model grid planning and operation for the December 2016 PSIP filing to understand the potential impacts of EoT. This included using the same E3 model (RESOLVE) and input data. Chapter 2 and Appendix E: Electric vehicle forecast methodology and assumptions also described the work done as part of this EoT strategy to forecast EV adoption and load, and to predict its geographic distribution on the islands. This forecasting work will be an important input to allow granular, forward-looking planning.

The companies filed their Integrated Grid Planning update on March 1, 2018 in accordance with the Commission's Decision and Order No. 34696 issued on July 14, 2017 in Docket No. 2014-0183. Integrated grid planning will combine customer-centric resource, transmission, and distribution planning to holistically assess the physical, operational, technological, and behavioral changes to the electric grid necessary to enable safe, reliable, and affordable service that satisfies customers' evolving service expectations and use of distributed resources. This new IGP process will consider a full range of options and more effectively evaluate the final set of short-term solutions to meet Hawai'i's resource, transmission, and distribution needs defined in technology neutral terms. This approach avoids the need to conduct transmission and distribution analysis outside of the resource planning process, as is the case with most locational benefits methods currently being employed in other states. IGP will need to learn from and inform other ongoing activities and relevant proceedings, including DER, DR, Community Based Renewable Energy (CBRE), Electrification of Transportation (EoT), and ongoing grid modernization projects.

[5] Docket No. 2014-0183, Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited, PSIP Update Report: December 2016 filed December 23, 2016.

[6] Hawaiian Electric Renewable Energy Planning Principles available at https://www.hawaiianelectric.com/Documents/about_us/our_vision/RE_planning_principles.pdf

10. Hawaiian Electric's EoT Strategic Roadmap responds to Commission requirements in D&O No. 34592

Table 7 provides a cross-reference of (a) the five requests made by the Commission in D&O No. 34592 regarding the companies' electrification of transportation strategy with (b) the remainder of Hawaiian Electric's EoT Strategic Roadmap.

Table 7. Commission guidance in D&O No. 34592 regarding Hawaiian Electric's EoT Strategic Roadmap

Commission Guidance	Hawaiian Electric EoT Strategic Roadmap Cross-Reference
In the programmatic filing, the Companies shall include a discussion of the following issues: *(1) the intended extent of the Companies' participation in 'Electrification of Transportation' efforts in the Companies' service territory;*	Hawaiian Electric is proposing to undertake ten EoT *Initiatives* (see Table 4). Each involves partnership with and enabling of other organizations and industry players. We propose to take the lead in addressing some adoption and integration challenges, while playing a supporting role for others. An overview of Hawaiian Electric's proposed role in EoT is provided in *Chapter 5: Defining Hawaiian Electric's role in EoT* Additional details are provided in *Chapter 6: Hawaiian Electric's Proposed Role in Enabling Electrification of Light-Duty Vehicles,* *Chapter 7: Hawaiian Electric's proposed role in enabling electrification of Buses, and* *Chapter 8: Hawaiian Electric's proposed role in enabling electrification of Other Vehicle Types.*
(2) how the Companies can foster opportunities within the Companies' service territory for third parties in the EV charging market;	Hawaiian Electric seeks to support the market for third-party electric vehicle service providers (EVSPs) in the state. Our proposed initiatives aim to maximize customer value from EoT by taking on roles that the utility is best equipped to fill, while leveraging maximum private investment from the third-party charging market. Our proposed initiatives will foster opportunities for third-party EVSPs by: a) jumpstarting a larger and broader electric vehicle market, b) directly influencing customers to install charging from EVSPs, and c) providing opportunities and incentives to EVSPs to supply grid services from charging. A more detailed description of Hawaiian Electric's proposed role in EoT and our interaction with third parties EV charging providers is presented in *Chapter 5: Defining Hawaiian Electric's role in EoT.* Additional details are provided in *Chapter 6: Hawaiian Electric's Proposed Role in Enabling Electrification of Light-Duty Vehicles,* *Chapter 7: Hawaiian Electric's proposed role in enabling electrification of Buses, and* *Chapter 8: Hawaiian Electric's proposed role in enabling electrification of Other Vehicle Types.*

Continued on next page.

Commission Guidance	Hawaiian Electric EoT Strategic Roadmap Cross-Reference
(3) how the Companies' 'Electrification of Transportation' strategy and efforts will interface with the Companies' efforts related to demand response software, programs, and planning;	Hawaiian Electric intends to leverage its existing efforts related to DR software, programs, and planning to ensure maximum customer value from EoT. *As shown in Chapter 6 ('Defining Hawaiian Electric's role in EoT')*, we include 'Harmonizes with companies other programs' as one of the filters applied to select proposed Hawaiian Electric actions on EoT. That chapter also includes a statement on open standards. Initiative #4 - investigate and develop opportunities to lower customer bills in return for 'smart' charging of vehicles and provision of grid services – is particularly significant in the extent to which it leverages the companies' DR programs. Details of the alignment between each proposed EoT initiative and the companies' DR software, programs and panning are provided in *Chapter 6: Hawaiian Electric's Proposed Role in Enabling Electrification of Light-Duty Vehicles,* *Chapter 7: Hawaiian Electric's proposed role in enabling electrification of Buses, and* *Chapter 8: Hawaiian Electric's proposed role in enabling electrification of Other Vehicle Types.* A cross-cutting exploration of the interactions between the companies' DR efforts and our EoT strategy is provided in *Chapter 10: Alignment of EoT Strategic Roadmap with Hawaiian Electric's Existing Programs and Filings.*
(4) how the Companies' 'Electrification of Transportation' strategy fits in with other dockets and related efforts, including dockets examining demand response (e.g., Docket No. 2015-0412) and distributed energy resources (Docket No. 2014-0192); and	As shown in *Chapter 6 ('Defining Hawaiian Electric's role in EoT')*, we include 'Harmonizes with companies other programs' as one of the filters applied to select proposed Hawaiian Electric actions on EoT. Details of the alignment between each proposed EoT initiative and the companies' other dockets and related efforts are provided in *Chapter 6: Hawaiian Electric's Proposed Role in Enabling Electrification of Light-Duty Vehicles,* *Chapter 7: Hawaiian Electric's proposed role in enabling electrification of Buses, and* *Chapter 8: Hawaiian Electric's proposed role in enabling electrification of Other Vehicle Types.* A cross-cutting exploration of the interactions between the companies' other dockets and our EoT strategy is provided in *Chapter 9: Alignment of EoT Strategic Roadmap with Hawaiian Electric's Existing Programs and Filings.*
(5) how the Companies can ensure that tariffs provide for adequate flexibility as technology, the market, and other factors evolve within the EV landscape.	This discussion is found in *Chapter 9: Alignment of EoT Strategic Roadmap with Hawaiian Electric's Existing Programs and Filings:* *"The currently-filed grid services tariff structure [approved in D&O No. 35238] provides an extensible foundation to evolve grid services as EoT technologies and markets change and additional grid needs emerge. This is not limited to bulk system needs, but also anticipates an evolution to locational distribution grid service needs. Within this framework, Hawaiian Electric can continue to evolve existing rates and programs that support the delivery of the existing DR services, or introduce new, technology-agnostic rates or riders. These are expected to include near real-time, dynamic rates to support either locational needs or bulk system needs, and other customer or service specific riders. EV-related opportunities are expected to continue to grow and evolve through this framework as the technology evolves and the market becomes more experiences in delivering a wider range of grid services. Furthermore, this framework serves as the cornerstone to the Grid Services Purchase Agreements, which will also afford EV-centric or EV-oriented aggregators the opportunity to enroll and enable various customer classes into agreements to deliver grid services."*

Appendix A:
Stakeholder letters of support

Alliance for Transportation Electrification

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+1 (206) 335-5451
https://evtransportationalliance.org

March 19, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanao'a Building
Honolulu, HI 96813

Docket No. 2016-0168: EV-F/EV-U Extension: EoT Strategic Roadmap

Dear Commissioners:
The Alliance for Transportation Electrification is a newly established industry trade association that is seeking to engage with State Commissions, utilities, environmental NGO's, and many stakeholders about EV adoption and deployment of EV infrastructure in over 20 priority States, including Hawaii. The Alliance is a multi-sector trade association, including 18 utilities, 7 EV infrastructure firms, 3 auto OEM's such as GM and American Honda, and other related national trade associations.

We have had a chance to discuss informally with Hawaiian Electric Company (HECO) and some stakeholders in Hawaii during the development of the draft Roadmap, although since we are newly established, we have not had the chance to discuss the broad elements of the Roadmap with our Policy-Regulatory Committee and all Members. However, the Alliance is quite familiar with the consultants who assisted HECO with this Roadmap and the assumptions, modelling, and scenario planning that were included, and believe they are credible. We believe that the stakeholder process used by HECO was robust, and resulted in a feedback loop that improved the final report.

We believe the Roadmap to be balanced and comprehensive in its approach, and it includes several sensible recommendations, including the five short-term steps, as well as for the necessary robust role for HECO for the longer-term as EV penetration increases across the distribution grid. The Alliance believes the Roadmap is a credible document on which the Commission can set guidance for HECO, EVSE, and the multiple stakeholders involved in this proceeding, and allow HECO to move forward quickly to implement the near-term action items. The Alliance stands ready and willing to assist the Commission in this Docket and the process going forward.

Sincerely,

Philip B. Jones, Executive Director
Alliance for Transportation Electrification: https://evtransportation.org
1402 Third Avenue, Ste. 1315
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Alliance for Transportation Electrification

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MEMBERS

Utilities
Ameren
American Electric Power (AEP)
Avista Corporation
Consumers Energy (CMS)
Detroit Edison (DTE Energy)
Duke Energy
Fortis Inc.
National Grid
New York Power Authority (NYPA)
Oncor
PacifiCorp
Pacific Power/Rocky Mountain Power
Pacific Gas and Electric (PG&E)
PNM Resources
Portland General Electric
Seattle City Light
Southern California Edison (SCE)
Southern Company
Xcel Energy

EV Infrastructure Firms
Greenlots
Sema Connect
Efacec
EV-Box
OpConnect
ABB
EV-Connect

Automotive
General Motors
American Honda

Engineering/Consultant
Burns McDonnell
Affiliated Trade Organizations: regional, national, international
CalETC
Edison Electric Institute (EEI)
Institute for Electric Innovation (IEI)
Open Charge Alliance (OCA), the Netherlands

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

As a nonprofit committed to clearing the path for 100% clean energy, Blue Planet Foundation supports many of the key strategies that have been identified in Hawaiian Electric's Electrification of Transportation (EoT) Strategic Roadmap for enabling Hawaii's transition to electrified transportation. This EoT Strategic Roadmap outlines a number of ways to improve electric vehicle charging options, integrate low-cost renewable energy, and create new opportunities for industry partnerships that could help the state increase the speed, ease, and cost-effectiveness of electric vehicle adoption.

In its EoT Strategic Roadmap, and through its stakeholder engagement and coordination, Hawaiian Electric has demonstrated that it recognizes the potential for electrified transportation and its alignment with Hawaii's clean energy goals. In 2017, the mayors of all four counties in Hawaii set a goal of achieving 100% renewable ground transportation by 2045, while the counties of Honolulu, Maui, and Kauai committed to 100% renewable county fleets by 2035. Hawaiian Electric's vision for the future of clean transportation will play a critical role in setting us on track to achieving those ambitious commitments.

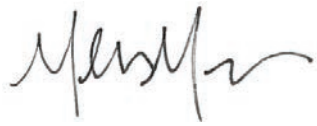
The EoT Strategic Roadmap is an important step toward realizing a cleaner, brighter future for Hawaii. The commitment of local utilities to expand electric vehicle charging infrastructure can help provide fast and reliable charging to the continuously increasing number of Hawaii residents that choose the environmental and economic benefits of electric vehicles. We also support and encourage partnerships between the utilities and public and private fleets, which can allow for steady, reliable, and affordable charging of electric light duty fleets and busses. These strategies will not only make it easier for the electrified transportation system to grow, but will also help to balance the electrical grid and ensure better utilization of variable renewable energy resources.

info@blueplanetfoundation.org
55 Merchant Street 17th Floor • Honolulu, Hawai'i 96813 • 808-954-6161 • blueplanetfoundation.org

For these reasons, Blue Planet Foundation is writing in support of Hawaiian Electric's EoT Strategic Roadmap. We look forward to continued collaboration with Hawaiian Electric on accelerating our transition away from fossil fuels and towards 100% clean energy.

If you have any questions or would like to discuss further, please contact me at melissa@blueplanetfoundation.org.

Respectfully,



Melissa Miyashiro
Chief of Staff
Blue Planet Foundation

March 15, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

It is our distinct pleasure to rise in support of the Hawaiian Electric Companies efforts to foster transportation electrification in the State of Hawaii. As experienced members of the community of providers of electric vehicle charging equipment, Charge Bliss is well-positioned to understand the challenges with this space. We installed, own and operate the first DC fast charger on the Island of Hawaii at the Shops at Mauna Lani and have learned valuable information about device function, use, and value. We strongly believe the Utility is best suited to foster the growth of EV adoption in Hawaii through the build-out of charging infrastructure and wholeheartedly support your consideration of the Strategic Roadmap.

Specifically, the Utility's participation in transportation electrification is essential to achieve the following, crucial goals:

- providing rates which support the operation, charging, and/or ownership of electric vehicles, ground support, port shipping equipment, and other forms
- deployment and ownership of charging infrastructure in the public, workplace, multi-unit dwelling spaces
- support of transition to fleet conversions of vehicles including heavy duty and bus fleets
- education to support the adoption and conversation to electric fleets and charging infrastructure
- programs supporting strategic charging and ancillary services to best support the grid
- Company Fleet conversation

Thank you for your consideration of these comments.

Respectfully,

David Bliss
Founder and CEO
Charge Bliss, Inc.
8 Argonaut, Suite 160
Aliso Viejo, CA

ELEMENTAL EXCELERATOR

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

Thank you for providing Elemental Excelerator (EEx) with the opportunity to comment on Hawaiian Electric's Electrification of Transportation (EoT) Strategic Roadmap. We appreciate Hawaiian Electric's efforts to collect and incorporate broad stakeholder input.

EEx innovation companies partner with Hawaiian Electric to provide solutions that enhance electric vehicle (EV) infrastructure interconnection, EV adoption & awareness, grid voltage regulation, load shifting, distributed energy interconnection, energy storage, and system mapping and visualization. We are particularly interested in what the proposed approach would mean for **innovation, new ideas, and new technologies.** We are also keenly interested in how Hawaiian Electric, in their various jurisdictions, will coordinate with Hawaii's counties to meet their 100% clean transportation commitments. From our experience with our portfolio companies and other innovators, we support a plan that can incorporate the following initiatives:

1. Assist public and private fleets in electrification conversions of light-duty vehicles

   From our experience working with government and private businesses, we anticipate that they will make capital and operational decisions based on market signals. We encourage Hawaiian Electric to work early and closely with these entities to develop programs that allow public & private organizations to gain access & insight into rate programs and charging infrastructure that will further Hawaii in meeting its clean transportation goals.

2. Assist in increased electric bus adoption for public transit agencies, private bus service providers, and schools.

   Widespread adoption of electric buses will present a new paradigm for electric service & infrastructure. Specific bus tariffs as well as implementing innovative charging methods are necessary for successful adoption.

3. Institute transparent rate structures that incentivize multifamily and workplace charging in concert with grid needs.

   Existing rate structures provide insufficient incentives for multifamily and workplace charging, which is a significant barrier to EV adoption. Transparent, flexible,

technology-enabled pricing will give customers more options and give more residents access to EVs.

EVs are a valuable flexible load that can increase the amount of renewable energy on the grid and reduce grid integration costs for renewables if rate programs are designed to be dynamic and drive behavior, and technology is leveraged to prioritize this.

4. Deploy charging networks beyond Level 3 and DC Fast Charging.

   Drivers are in need of a reliable charging network to further adoption of electric vehicles. This plan should include Level 2 chargers that can intelligently interact with the grid where appropriate.

5. Engage stakeholders and innovators, and educate the public about EVs and electrification.

   We suggest engaging stakeholders and innovators in planning processes, such as the EoT Strategic Roadmap, to obtain real-time feedback on what the community wants and needs, what is possible, and how new technology will change and can improve Hawaiian Electric's investment strategy and the mobility landscape.

Finally, we see a critical need for programs that provide access to EV technology for all community members, not just wealthier residents who have access to economic resources.

We see public awareness as one of the largest gaps in the community and a significant barrier to EV adoption.

Thank you for your consideration of these comments.

Respectfully,

Aki Marceau
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Elemental Excelerator
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March 19, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
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Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

I am writing to this letter to be included in the EoT roadmap to support HECO's efforts in your next policy discussions. The specific request we have is to encourage for consideration in the commissions filings the ability for the utility to play a larger role in facilitating EV adoption. This is important for the following reasons:

- A consistent message from the utility increases general regarding EVs and the electrification of transportation. Triangulating and validating the EV market via the utility, along with the other key stakeholders interests in reducing the barriers to adoption, will provide significant benefits;
- An active utility role will further enable the electrification of public transportation such as electric buses and medium-duty trucks.
- Utility support for more DCFC and Level-2 charging in key areas such as workplace and MDU locations will be crucial to the installations and long term success of the deployments.
- The active or passive assistance in the upfront financing of electric infrastructure will ensure that proper installations are available in relevant locations. This includes higher power needs such as the advent of more DCFC's and the associated network and placement of these charging stations. We'd like to ensure there is authorization beyond the 25 fast charger locations, and would like to build a minimum backbone network needed to satisfy customer driving needs that will ensure reliability.

Thank you for your consideration of these comments.

Respectfully,

Alan Z White
Chief Business Officer
Electric MotorWerks, Inc

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S., King Street, Room 103
Kekuanoaa Building
Honolulu, HI 96813

RE: Docket No. 2016-0168
EV-F/EV-U Extensions
Electrification of Transportation Strategic Roadmap

Dear Commissioners;

Vehicle electrification is core to Ford Motor Company. We introduced the Escape Hybrid nearly 20 years ago; our Hybrid and Plug-in vehicles are among the best sellers in the industry, and we recently announced plans to invest more than $11 billion in electrification by 2022. Ford believes that the future of transportation is electrified, and this future will benefit both our customers and the environment.

Substantial challenges must be overcome before this future can be realized. A principal challenge is the significant shortfall in publicly available EV charging[1]. We believe that both Public Utility and Private Company participation is needed to fully address this challenge. Public and Private entities bring unique skillsets and focus, and participation by both is necessary to address all of the distinct, varied needs of the charging market.

On February 15, Ford submitted comment (copy attached) to Hawaii State Energy Office on use of Environmental Mitigation Trust Funds (VW Settlement Appendix D). The recommendations made in our letter include expanded public charging infrastructure, DC Fast Charging in targeted, critical locations, and a focus on public and workplace charging.

Hawaii has exhibited great leadership in fostering the installation of innovative EV charging solutions, and we are glad to see that plans are being made to further expand public EV charging infrastructure in Hawaii.

If you have any questions, please feel free to contact me at shenders@ford.com, or at 313 322 4475.

Sincerely,

Steve Henderson
Manager, Vehicle Electrification Infrastructure, Programs and Policy
Ford Motor Company

1 US DOE. National Plug-In Electric Vehicle Infrastructure Analysis (https://www.nrel.gov/docs/fy17osti/69031.pdf).

Attachment: February 15, 2018 Ford Motor Company letter to Hawaii State Energy Office re: use of VW Mitigation Trust funds

Kim Pittel
Group Vice President
Sustainability, Environment & Safety Engineering
Ford Motor Company

Ford World Headquarters
One American Road
Dearborn, MI 48126-2738 USA

February 15, 2018

Department of Business, Economic Development & Tourism
Hawaii State Energy Office
P.O. Box 2359
Honolulu, Hawaii 96804

Subject: Ford Motor Company's Input on VW Draft Beneficiary Mitigation Plan Appendix D

Dear Sir or Madam:

Thank you for this opportunity for Ford Motor Company to provide input on the use of your state's Environmental Mitigation Trust (EMT) funds.

Vehicle electrification is core to Ford Motor Company. We introduced the Escape Hybrid nearly 20 years ago; our Hybrid and Plug-in vehicles are among the best sellers in the industry, and we recently announced plans to invest more than $11 billion in electrification by 2022. Ford believes that the future of transportation is electrified, and this future will benefit both our customers and the environment.

Substantial challenges must be overcome before this future can be realized. A principal challenge is the significant shortfall in publicly available EV charging.[1] For this reason, **we encourage Hawaii to utilize the maximum allowable 15% toward light duty electric vehicle charging infrastructure.**

CHARGER SITING RECOMMENDATIONS

Charging infrastructure must meet both daily driving and long distance travel needs.

Daily Driving: Charge While Parked

While high-speed DC Fast Charging (DCFC) is essential for EVs driving long distance, this 'while you wait' model is a poor solution for day-to-day EV usage. A common 50 kW DC Fast Charger requires **nearly 45 minutes** to add 100 miles of range, significantly affecting the driver's daily routine. Meanwhile, the average vehicle is parked for 22 hours a day.[2] **Charging while parked** is the superior solution.

Charging while parked at home, work, or destinations conveniently incorporates charging into daily routines. It also allows use of lower power Level 2 (L2) AC chargers, which, compared to DCFC, are cheaper to install and operate[3] and provide lower priced electricity to consumers.

Ford recommends that Hawaii fund L2 charging **where vehicles park on a routine basis**. While there are several options for more L2 charging, such as on-street charging (e.g., lamppost retrofits) in high density neighborhoods, Ford believes that chargers at workplaces will provide the greatest impact. Therefore, funding of **workplace charging** should be prioritized.

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[1] US DOE. National Plug-In Electric Vehicle Infrastructure Analysis (https://www.nrel.gov/docs/fy17osti/69031.pdf).
[2] Source: AAA and Ford Analytics.
[3] https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf

The unique benefits of **workplace charging** include the following:

- **Increased EV adoption.** Workplaces become EV showcases. US DOE data suggests that employees with workplace charging are 6 times more likely to purchase an EV. Ford's own experience installing over 200 L2 chargers at our offices and manufacturing plants demonstrated a clear increase in EV adoption and increased electric vehicle miles driven for plug-in hybrids.[4]
- **Routine.** The majority of drivers park at their workplace for 4-10 hours on Monday through Friday. This parking time is sufficient to meet most drivers' range needs with L2 chargers.
- **Alternative for Multi-Unit Dwelling (MUD) Residents.** Workplace charging gives those with limited 'home charging' options an affordable place to charge, expanding the EV market.

Long Distance Travel: Highway Corridor Charging

While there are several solutions for routine charging, long distance travel is impossible without a 'while you wait' model of DCFC along major highway corridors. A complete intercity DCFC network is required for most drivers to adopt an EV as their only vehicle. Therefore, EMT funds should also be directed towards **highway DCFC fast chargers**. To prevent long lines and impractical charge times, highway DCFC stations should have 100-150 kW capability or greater.

POLICY RECOMMENDATIONS

In addition to our funding allocation recommendations, Ford recommends the following policy items.

Coordinate Efforts

In order to ensure the most cost effective and grid responsible build out of charging infrastructure, Ford encourages Hawaii to coordinate with local utilities and other key stakeholders in strategic planning efforts. We encourage Hawaii to consider related programs like the VW National ZEV Investment Plan.

Hawaii is also in a unique position to increase the impact of EMT funds through concurrent development of EV-friendly policy, including:

- **Building Code** modifications to require new or modified residential and commercial parking be charger 'make ready,' including conduit installation and service panel upgrades.
- **Complementary Incentives** like utility charger installation support (e.g., transformer upgrades) or free permitting.

Ensure a Positive Consumer Experience

In addition to intelligent siting, deploying easy-to-use equipment maximizes the impact of new public chargers. As such, projects should meet the following customer protection principles[5]:

- **Payment Interoperability.** Public chargers should accept a standard method of payment (credit card or mobile app like ApplePay) rather than a dedicated card or key, which can leave drivers stranded.
- **Transparency.** The price of a charge should be clear to the driver, both at the point of sale and also via any charger locator apps.

[4] https://www.slideshare.net/emmaline742/stephanie-janczakcharging-up-at-work-november-2017
[5] Similar comments were provided to Connecticut DEEP by Plug-In America, a non-profit organization that bills itself as the "national consumer voice for plug-in electric vehicles."

- **Mapping Data.** All electric vehicle service providers (EVSPs) should make mapping data for charging locations readily available, including, as noted above, charging costs.
- **Signage.** Even when shown in a mapping app, chargers can be difficult to locate. Charging stations should have adequate signage, from highway visibility down to the last few feet. Signage provides the additional benefit of increasing charger visibility for non-EV drivers considering EV adoption.
- **Accessibility.** Charger installation projects should be designed in accordance with Title III of the Americans with Disabilities Act (ADA), giving people with disabilities the option to 'go electric.'[6]

Provide Competitive Bidding

Hawaii can best accelerate sustainable growth of public charging infrastructure by funding a diverse cross-section of the charging industry. To this end, the state should support competition and allow multiple vendors and business models to participate.

In summary, Ford recommends that a **full 15%** of EMT funds be allocated towards light duty charging and be spent primarily on **workplaces** and **highway** corridors. Ford also recommends a number of policy items to support the coordination of efforts to deploy chargers. If you would like to discuss further, please contact Melanie Wiegner, Ford's Government Relations Representative for Hawaii, at mwiegner@ford.com or 916-442-0111.

Sincerely,

Kimberly L. Pittel

Kim Pittel
Group Vice President
Sustainability, Environment & Safety Engineering
Ford Motor Company

[6] Resource: *ADA Requirements to Consider for Workplace Charging Installation* (http://vwclearinghouse.org/resource/ada-requirements-for-workplace-charging-installation/).

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

My name is Arcady Sosinov, and I am writing to show my support for the EoT Roadmap created by Hawaiian Electric to facilitate the electric vehicle transition in the Aloha state. As CEO of FreeWire Technologies, a startup whose mobile energy storage units deliver electric vehicle charging, I've seen first-hand how public charging services can improve grid reliability and flexibility while supporting innovators in deploying new business models and technologies in the field. In 2016, FreeWire Technologies partnered with Hawaiian Electric and Elemental Excelerator to pilot two DC fast chargers at Honolulu's Airport Trade Center. This deployment allowed our team to showcase how mobile EV charging services can be quickly implemented to offer value streams to both utilities and end customers in the place of traditional charging infrastructure, which is time-intensive and expensive to upgrade.

Electric vehicles match Hawaii's commitment to a renewable energy future. I firmly believe that the DC fast charging (DCFC) network should be expanded to offer distributed and reliable power to drivers across the state. Improved access to a variety of fast charging options, including Level 2 and mobile charging, can reduce range anxiety for drivers and drive the EV conversion process. For example, mobile EV charging services better utilize charging assets and can be easily scaled and adjusted based on demand without incurring significant permitting and installation costs. As more EVs hit the road in Hawaii, new areas like workplaces and multi-unit dwellings (MUDs) will begin to upgrade facilities to provide EV charging. Neighboring MUDs — e.g., the new buildings rising up in Honolulu — could pool their efforts and offer electric vehicle charging services amongst a group of MUDs without building permanent infrastructure.

As the traditional electricity provider, utilities are key for building a path to diverse, accessible charging infrastructure that also supports the grids they manage. Utilities are also uniquely equipped to educate the public on electrification within their expansive existing customer networks. When it comes to EVs, utilities have the financial stability to fund ongoing energy transactions by recouping costs over the lifetime of long-term assets. As the transportation sector moves beyond conventional ownership models, Hawaiian Electric's roadmap will provide substantial assistance to both public and private entities looking to electrify fleets and transit systems. With an impressive commitment to the state's cleaner and more resilient energy

future, Hawaiian Electric is a leader in accommodating both the impact of mass vehicle electrification and fluxes in renewable energy to ensure a reliable grid.

Thank you for your consideration of these comments.

Respectfully,

Arcady Sosinov
Chief Executive Officer
FreeWire Technologies
1933 Davis Street
San Leandro, California
94577, USA

GENERAL MOTORS

Britta K. Gross Director
Advanced Vehicle Commercialization Policy
Environment, Energy & Safety Policy

General Motors Global Headquarters
MC: 482-C30-C76
300 Renaissance Center
Detroit, MI 48265-3000

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Re: GM Support for Hawaiian Electric's proposed Electrification of Transportation Strategic Roadmap

Dear Commissioners:

General Motors LLC (GM) would like to encourage the PUC of Hawaii to support Hawaiian Electric's efforts to actively engage in the critically-needed development of the early EV market. Electric utilities, and Hawaiian Electric in particular, are uniquely qualified to address 2 key EV market barriers we are currently facing: a lack of compelling EV charging infrastructure and a general lack of EV awareness.

GM has invested billions of dollars to develop electrification technologies, including the state-of-the-art Chevrolet Volt and Chevrolet Bolt EV, which has swept the industry's most prestigious car awards, including North America Car of the Year, Motor Trend's® 2017 Car of the Year, MotorWeek's 2017 Drivers' Choice "Best of the Year" Award, and Green Car Journal's Green Car of the Year. The Bolt EV is the industry's first affordable, long-range EV with an EPA estimated range of 238 miles-per-charge, and is now available at Chevrolet dealers across all 50 states, including Hawaii. This advanced technology will require more widespread charging infrastructure to convince consumers that EVs can be driven anywhere they need to go. Consumer-friendly home (including MUD), workplace, and public EV charging infrastructure is vital to the growth of the EV market. Thus, the urgency to rapidly expand EV charging infrastructure in Hawaii.

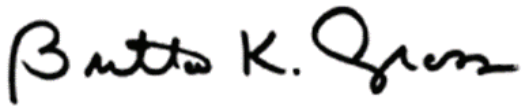
EV charging infrastructure today has not attracted sufficient investment to establish a compelling foundation of EV charging stations. This market will become more viable and competitive over time, but this early market currently requires additional investment to close the infrastructure gap and establish a network of charging stations that is highly visible to consumers and drives consumer-confidence in the ability to drive EVs anywhere on the islands. EV infrastructure is also key to attracting innovative and advanced mobility solutions to Hawaii, such as car-sharing, ride-hailing, and autonomous vehicles. The ability to introduce and grow these advanced mobility services relies on a robust foundation of EV charging infrastructure, especially DC fast-charging. And Hawaiian Electric is uniquely positioned to reach every consumer in its service territory with programs that grow consumer awareness of EVs through education

and outreach. Both EV infrastructure and EV outreach are critically important to the successful growth of EV-adoption in Hawaii.

Importantly, utilities are able to target infrastructure where it will be most beneficial to consumers and this can be used to inform subsequent infrastructure programs in the state. And the direct engagement of utilities in the strategic planning and execution of EV charging solutions will ensure the most cost-effective and grid-responsible EV charging solutions. Electric companies are central to managing charging in a manner that captures benefits for the grid and all customers. Thus, electric company programs, informed by automakers and other stakeholders, can help lay the groundwork for intelligent charging solutions that will help EV drivers save money and help ensure a smooth transition to widespread transportation electrification.

GM greatly appreciates Hawaii's commitment to accelerate the strategic transition to transportation electrification and all efforts to help drive this emerging market. The speed with which EV charging infrastructure and EV awareness can be expanded will determine the pace of EV adoption in Hawaii as well as the ability to drive towards even more advanced transportation technologies.

Sincerely,



Britta K. Gross, Director
Advanced Vehicle Commercialization Policy
britta.gross@gm.com
(586) 596-0382

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

Greenlots is pleased to provide support for the Hawaiian Electric Companies' Electrification of Transportation Strategic Roadmap.

Greenlots is a leading provider of electric vehicle charging software and services. The Greenlots network supports a significant percentage of the DC fast charging infrastructure in North America, including deployments in Hawaii with Hawaiian Electric, Maui Electric, Hawaii Electric Light, and Nissan. Greenlots' smart charging solutions are built around an open standards-based focus on future-proofing while helping site hosts, utilities, and grid operators manage dynamic electric vehicle charging loads and respond to local and system conditions.

Greenlots recognizes the need for a strong utility role in supporting and accelerating transportation electrification, and is encouraged by the roadmap process. However, in supporting the roadmap, we acknowledge that a deeper utility role than that envisioned in the roadmap may well be necessary to meet Hawaii's goals both in the near term and over time.

Greenlots looks forward to engaging with the Commission, the Hawaiian Electric Companies, and the spectrum of stakeholders to see and evolve the roadmap forward. Please do not hesitate to contact me should you have any questions.

Sincerely,

Thomas Ashley
Vice President, Policy

Hawaii Automobile Dealers' Association

Brian Kitagawa, President
Dave Rolf, Executive Director

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

The members of the Hawaii Automobile Dealers Association, Hawaii's franchised new car dealers, appreciate the opportunity to offer strong support for the favorable consideration of the EV-F/EV-U Extension under Docket No. 2016-0168 relating to the Electrification of Transportation Strategic Roadmap.

Introduction

HADA dealers are much appreciative of the leadership roles accepted by Hawaiian Electric Company and other utility companies, the PUC, elected officials, and customers, in the electrification of ground transportation and the transition to renewable fuels for electric power production .

HADA dealers were represented at the press conference in 2008 when Governor Linda Lingle, accompanied by U.S. Senator Daniel K. Inouye, announced the Hawaii Clean Energy Initiative, and subsequently, HADA dealers ardently pursued the HCEI goals. It has been a collaborative effort with HECO and all the other stakeholders.

No one has summed things better, however, than Alan Oshima, President and CEO, Hawaiian Electric company, who stated in one of the company's earlier reports, **"HCEI was an historic clean energy agreement that provided all of us with a holistic framework of specific actionable goals. It memorialized our good faith commitment to work collaboratively to achieve the very aggressive clean energy goals of the state. We recognized we're all in this together."**

HADA Comments

Now, this year, at the ten-year anniversary of the HCEI, which had a 2030 horizon, Hawaii is involved in new clean energy goals with benchmarks extending through the year 2045.

The electrification factor in the auto industry has become a focus of much discussion this year.

Governor David Ige issued an executive order (EO 07-17) November 22, 2017, involving HADA and the UH Engineering Department in the development of a driverless bus as a shuttle to the new rental car facility at the Daniel K. Inouye International Airport. Self-driving technology involves much electrification in transportation.

On December 12, 2017, Hawaii's four county mayors issued a joint proclamation, with the Hokule'a as the background, which set a goal of 100% renewable energy in ground transportation in Hawaii by 2045—making Hawaii as the first state in the nation with all its counties having set such a 100% goal.

This 2045 date for 100% renewable fuel use in ground transportation now coincides with the target date of 2045 set for utilities to use 100% renewable fuel for power production.

Interestingly, because of the backfill capabilities for the smoothing of the electric grid, provided by the electric batteries in hundreds of thousands of electric vehicles, during the daytime when the sun isn't shining, or the wind isn't blowing, electric cars can become the backup storage that allows more of the intermittent renewable energy resources to be utilized by the utilities.

At the present time, it appears that the roadmap to the achieving the two 2045 renewable energy goals --the ground transportation goal and the electric utility power goal—shows that the two are inextricably intertwined.

Auto industry projections, however, show that efficiencies produced by gasoline engines and gasoline-electric plug in hybrid vehicles will continue to play a role through 2045—while 100% renewable energy vehicles, with their sizable batteries capable of providing backfill for the grid, will comprise a large portion of the energy powering vehicles on the roadways in 2045.

There is no question, however, that the electrification factor, is proving to be a major influence affecting what we'll see in the auto industry over the next three decades.

HADA dealers anticipate that the uptake of electric vehicles and hydrogen fuel cell electric vehicles will accelerate as more of these renewable energy vehicles become available, and as China, the world's largest motor vehicle market, embraces this new technology.

Hawaii new car dealers have already worked to bring electric vehicles to the islands, installed charging infrastructure, and, at one point, helped to make Hawai'i second only to California in per-capita electric vehicle ownership.

While HADA dealers look forward to working with all stakeholders to make sure that both public and private infrastructure and favorable public policies are in place to allow every household to affordably own and operate a renewable fuel vehicle, HADA dealers still point out,

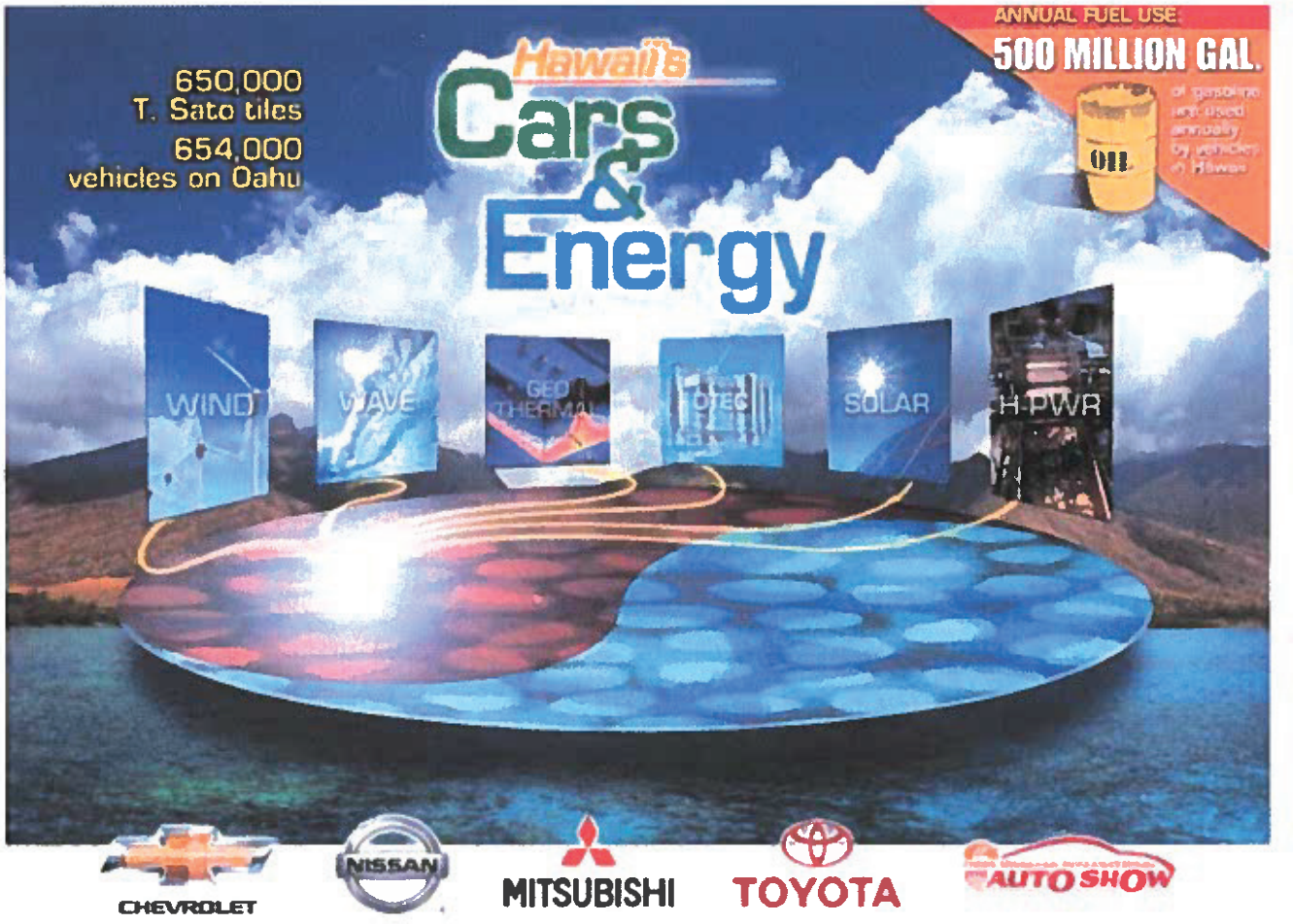
however, that they can sell only what the customers are willing to buy and the manufacturers are willing to make, and EVs will have to make economic sense for a broad-based customer uptake to take place.

Background

It has been written that to whom much is given, much is required.

Hawaii has been blessed with an abundance of renewable resources.

HADA erected a Cars & Energy exhibit at the First Hawaiian International Auto Show to illustrate this point. Note: The mosaic in the Capitol rotunda, happens to contain roughly the same number of tiles as the number of cars on Oahu. By showing graphically, how many private vehicles would need to transition to electric vehicles (40%) over the life of the Hawaii Clean Energy Initiative's goals (through 2030), and referencing the amount of fuel consumption reduction brought about by efficiencies created by the federal CAFE fuel standards (30%), the association showed how the current consumption of 500 million gallons of gasoline in ground transportation could be reduced to the reach the goal of 150 million gallons by 2030...illustrated by the draining oil barrel in the upper right hand corner of the exhibit.



As HECO notes, the electrification of delivery trucks, transit buses and specialty vehicles like shuttles and freight terminal tractors will be the next vehicle segment to see significant growth.

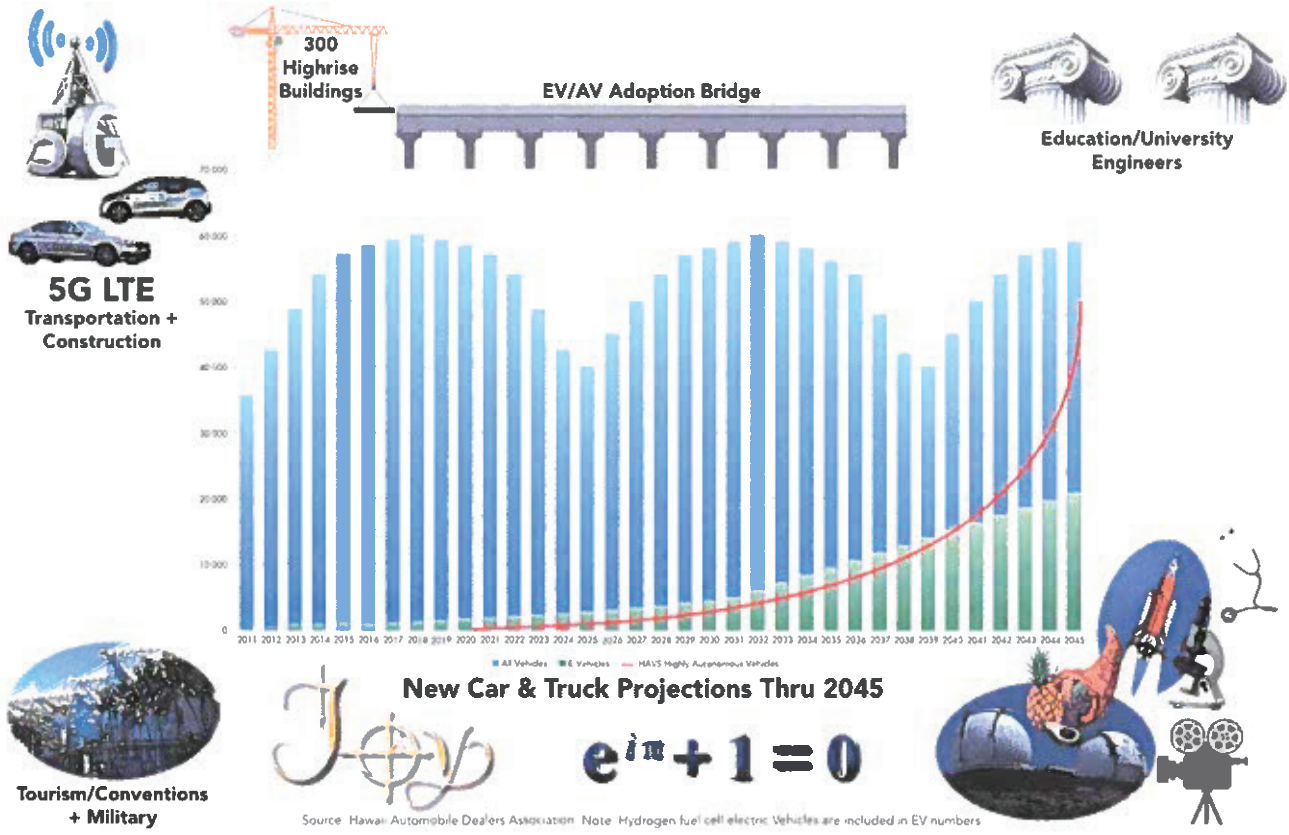
Some of the world's largest vehicle manufactures will be introducing dozens of all-electric models with extended battery range over the next decade. Right now, more than half of HADA's 70 dealerships sell a battery electric vehicle model.

Hurdles remain however, including:

1) EV price, for some customers, still remains an obstacle
2) EV range, remains as an obstacle for some drivers, especially on the island of Hawaii
3) EV charging time and charging station availability remains an obstacle, and finally
4) EV policies changing – like the airport parking policy for EVs—and federal policies changing

Many people anticipated a faster rate of electric vehicle adoption, but world economics played a greater role than was anticipated, especially the world price of petroleum which has allowed gasoline prices in the U.S. to remain relatively stable. Taking into account the price of oil which HADA anticipates will remain stable for quite some time, and factoring in the above obstacles to customer adoption, which are now being increasingly overcome by manufacturers, HADA dealers have made projections of anticipated electric vehicle uptake. Please see the graphic below.

Note: Since the transition to the new technology (renewable fuel technology and driverless car technology) will be hard, we thought it might as well be joyful. That thought is included on what HADA dealers call the Rosetta Stone graphic which is designed to help unlock some of the unknowns about anticipated adoption rates of the new technologies.



HADA supports HECO's general focus on:

1) An increased public outreach and education program to assist in overcoming barriers to EV adoption. This would include ride and drives, fairs and events like the auto show, on-line tools, as well as development of an outreach/education program to assist EV salespersons with tools necessary to sell and educate potential EV buyers.

2) Programs to assist fleet owners in EV conversions of their fleets with initial focus on public/government fleets.

3) Programs to assist bus service providers in acquiring electric buses by advising them on charging scenarios and charging infrastructure, creations of new bus tariffs, and offering battery service agreements to reduce upfront purchase prices of electric buses until price parity is achieved.

4) Programs to provide a *minimum* backbone network for charging infrastructure (both Level 3 and Level 2) owned by the utility. Much like the current DCFC pilot where the utility is authorized to own and operate 25 DCFCs across their service territories. This would allow focus on strategic siting of charging infrastructure like DC fast chargers in high density housing areas and tourist destinations.

4) Programs to provide make-readies for Level 2 public charging and Level 1 or Level 2 workplace charging and to provide opportunities for 3rd party electric vehicle charging service providers.

5) Laying the ground work for electrifying operations at harbors and airports, and finally,

6) Laying the ground work for electrification **of medium duty vehicles and heavy duty vehicles.**

In Summary

Commerce plays such a vital role in the health of our economy that is necessary to insure that it is smooth flowing. For the foregoing reasons outlined, the members of the Hawaii Automobile Dealers Association request that the Public Utilities Commission give favorable consideration to the EV-F/EV-U Extension in Docket No. 2016-0618 relating to The Electrification of Transportation Strategic Roadmap.

Respectfully submitted,

David H. Rolf

David H. Rolf

For the Members of the Hawaii Automobile Dealers Association

DAVID Y. IGE
GOVERNOR

JADE T. BUTAY
DIRECTOR

Deputy Directors
ROY CATALANI
ROSS M. HIGASHI
EDWIN H. SNIFFEN
DARRELL T. YOUNG

IN REPLY REFER TO:

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

March 19, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

As Deputy Director for Highways for the Hawaii Department of Transportation, I support the Hawaiian Electric Company's strategic roadmap for the Electrification of Transportation. The Hawaii Department of Transportation (HDOT) is charged with the responsibility to plan, design, construct, operate, and maintain State facilities in all modes of transportation, including air, water, and land. Given global climate change the proven detrimental effects of fossil fuel use, especially in the transportation sector, and the State's Sustainability initiatives, HDOT must support policies and initiatives that advance renewable energy and electrification for road users.

The Hawaiian Electric Electrification of Transportation Strategic Roadmap was developed with input from multiple stakeholders and I believe it effectively aligns the efforts of the various stakeholders, from governmental agencies to car manufactures, into a single vision for conversion to electric vehicles and reduction of carbon emissions.

The HDOT Highways Division has inventoried our fleets statewide to determine which gasoline-powered vehicles can be replaced with Electric Vehicles (EVs). We have planned to order two to three EVs this year and will replace the rest of our current fleet as they age out.

Our department also supports Hawaiian Electric and State Energy Office efforts to grow the State's alternative fuel corridors. In 2016, seven routes on Oahu and Maui were designated as "corridor-ready" alternative fuel corridors by the Federal Highway Administration and two additional routes received this designation in 2017. We plan to continue to support the strategic placement of EV charging stations statewide to move away from fossil fuel use in transportation and to meet Governor Ige's clean energy goals.

I respectfully submit my support for the Hawaiian Electric Electrification of Transportation Strategic Roadmap for the consideration of the commission.

Sincerely,

EDWIN H. SNIFFEN
Deputy Director, Highways Division

Hawai'i Energy
YOUR CONSERVATION & EFFICIENCY PROGRAM

1132 Bishop Street, Suite 1800 • Honolulu, Hawai'i 96813 • HawaiiEnergy.com • P: (808) 839-8880 • F: (808) 441-6068

March 21, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

Hawai'i Energy is working collaboratively with Hawaiian Electric Companies (HECO) to identify areas in which energy efficiency and the electrification of transportation intersect, either through technologies or through touch points with end use customer. Our current discussions have been focused on how Hawai'i Energy can best support HECO's electrification of transportation strategy. Our focus to date has been in the areas of energy efficient charging stations, workplace charging infrastructure and programs, multi-family charging infrastructure and programs, City and County of Honolulu initiatives, and consumer education.

On February 14 Hawai'i Energy hosted its first interactive stakeholder meeting to inform program design and Program Year 18 planning efforts. Attendees included representatives from the Aloha United Way, Blue Planet Foundation, Chamber of Commerce Small Business Program, City and County of Honolulu Consumer Advocate, Distributed Energy Resource Council, Environmental Protection Agency, Hawai'i Center for Advanced Transportation Technologies, Hawai'i Green Growth, Hawai'i Natural Energy Institute, Kamehameha Schools, Maui Economic Development Board, Oahu Economic Development Board, and Ulupono Initiative.

Facilitated in collaboration with the Elemental Excelerator, the meeting fostered meaningful dialogue around the ways the Hawai'i Energy Program can evolve in order to continue to play a pivotal role in Hawai'i's dynamic energy landscape. Through these efforts we were able to identify key initiatives that Hawai'i Energy can implement to drive energy efficiency and economic growth, improve resiliency, and enable a 100% clean energy future. The group work focused on defining the purpose of suggested initiatives, pinpointing specific actions that need to take place in order to enable them, and identifying the metrics that could be used to measure success.

One of the five areas the group selected to focus on was Energy Efficiency and Transportation. There was significant interest in having Hawai'i Energy work with the Hawaiian Electric Companies to provide incentives to support policy and plans that reduce fuel use and increase efficiency. Workplace charging has been identified as an area that would help with the duck curve while also facilitating increased electric vehicle (EV) ownership. One area we are collaboratively developing for our Program Year 2018 plan is a demonstration program which bundles incentives for energy efficiency measures with EV charging infrastructure for workplace charging. Additionally, educational workshops for employees that

we currently conduct could be expanded beyond efficiency to discuss the benefits of EV ownership as teaching owners about the best time of day to charge. The details are being flushed out and will be presented in our Annual Plan. This is one example of the ways HECO and Hawai'i Energy are working collaboratively to ensure our programs better address system needs, improve customer education, reduce confusion, and maximize our collective impact.

While we have not had a chance to review the strategic roadmap in its entirety, Hawai'i Energy is supportive and look forward to working with HECO in the aforementioned areas.

Thank you for your consideration of these comments.

Respectfully,

Brian Kealoha
Executive Director
Hawai'i Energy

March 19, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

I write in strong support of the Electrification of Transportation Strategic Roadmap as Proterra is committed to helping Hawaii transition to zero-emission, all-electric buses. Increased deployment of electric buses will make a significant contribution to the State of Hawaii's goal to reduce emissions and increase the environmental sustainability of its transit operations. In addition to the environmental benefit of zero emission, the new vehicles are more fuel efficient and have lower operation and maintenance costs than the older diesel buses currently operating in Hawaii.

As the leading U.S. manufacturer of zero-emission commercial transit solutions that provide the opportunity for all Americans to experience the benefits of an electric vehicle, Proterra designs and manufactures the world's most fuel-efficient battery-electric bus. Proterra's extended range battery-electric vehicle enables transit agencies to service transit routes with a nominal range of over 200 miles on a single charge. To date, Proterra's buses have logged over 4 million miles of revenue service in cities across the United States and expanded access to zero emission transit.

As part of Proterra's support of Electrification of Transportation Strategic Roadmap we look forward to helping educate customers on the value of electric bus operations and advising on certain charging scenarios to increase savings in their overall energy wallet. We also look forward to assisting customers who provide bus services in their planning for their charging network which suites their operations.

Proterra supports providing specific bus tariffs to incentivize more opportune charging that will benefit both the bus service providers and the grid itself which provides value to all electricity customers. Proterra also supports the use of battery service agreements and other ideas and programs that help reduce upfront capital costs for initial electric bus acquisitions.

Thank you for your consideration of these comments.

Respectfully,

Alan Westenskow

Alan Westenskow
Director of Business Development
Proterra
1815 Rollins Road, Burlingame, CA 94010

Roberts Hawaii

phone 808 523 7750
fax 808 522 7866

Roberts Hawaii, Inc.
680 Iwilei Road
Suite 700
Honolulu, Hawaii 96817

robertshawaii.com

March 19, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

We support Hawaiian Electric's Electrification of Transportation Strategic Roadmap that is meant to assist the transportation industry in its conversion toward electric mobility. Hawaiian Electric can play a big role in utilizing its experience and knowledge they have developed to educate customers in our industry on the value of electric bus operations and collaborating with the various operators on certain charging scenarios that would provide added value and increased savings for our operations.

Experiencing new electric bus technologies through pilots like the recent bus demonstration by the City with support from Hawaiian Electric, allowed Roberts Hawaii to learn and gain added comfort in these new buses.

As the state's largest operator of bus transportation services, we believe incentives like specific bus tariffs, especially if we charge during the middle of the day or late at night, and assistance in lowering up-front capital purchase costs for electric buses, that some of these initiatives will help in providing a business case that might allow for the adoption of electric buses into the various fleets in Hawaii.

Thank you for your consideration of these comments.

Respectfully,

Percy Higashi
President/CEO

Söderholm Sales & Leasing

March 10, 2018

Public Utilities Commission
State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, Hawaii 96813

RE: Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

We support HECO's Electrification of Transportation Strategic Roadmap to educate customers on the value of electric bus operations, assisting in the planning of an electric bus charging network, providing specific bus tariff incentives for more opportune charging tariffs and providing ways to reduce upfront capital costs for initial electric bus acquisitions thorough battery service agreements.

Soderholm Sales & Leasing, Inc. is the largest & oldest state licensed bus dealer. We have sold over 3,000 buses in Hawaii & the Pacific Islands including all the transit agencies in Hawaii, Guam & Saipan. We became the dealer two years ago for Hawaii & the Pacific islands for BYD. BYD is the largest electric bus and rechargeable battery manufacturer in the world. We became the dealer for BYD because we see the days of the internal combustion engine to be numbered. Our business has been relying on the sale of buses with internal combustion engines.

The adoption for electric vehicles has not met projections so far. That is going to turn around due to climate change, global warming, political change and the increase in range of batteries. It is already happening worldwide. I just got back from visiting BYD's headquarters in Shenzhen, China where they operate 16,000 electric buses in the city of Shenzhen. Their U.S. facility in Lancaster, CA recently expanded to 600,000 sqft building U.S. FMVSS & Buy America compliant buses. We need the PUC to create incentives to help jumpstart the adoption of electric buses.

Please call or email me any questions?

Sincerely,

R. Erik Soderholm
Vice President

Mailing Address: P.O. Box 19010 - Honolulu, Hawaii 96817
Delivery Address: 2044 Dillingham Blvd. - Honolulu, Hawaii 96819
Tel: (808) 834-1417 Fax: (808) 834-1070 • www.SoderholmMobility.com • www.SoderholmBus.com

March 20, 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

Tesla is pleased to submit this letter in support of HECO's plan to advance the electrification of transportation in Hawaii.

Tesla's mission is to accelerate the world' s transition to sustainable energy. Transportation electrification represents a critical element of an overall strategy to reduce the State of Hawaii's dependency on fossil fuels and facilitate this transition. Additionally, it provides a compelling opportunity to further support and leverage the State's nationally leading commitment to renewable energy and Hawaii's vast renewable resources.

The benefits of transitioning away from internal combustion engine vehicles are compelling and include reduced tailpipe emissions, reduced economic burden on the State and individual households through avoided fuel and maintenance costs, and improved air quality and associated public health benefits. Done correctly, transportation electrification can also serve to reduce electricity rates for all ratepayers by promoting greater asset utilization.

An area that we are particularly gratified to see recognized in HECO's plan is access to Level 1 and 2 charging infrastructure, particularly in multi-unit residential housing and workplaces. Access to charging is a key challenge that currently inhibits more widespread adoption of electric vehicles. This problem can be particularly acute in urban centers or other areas where, even in circumstances where end users have access to dedicated parking, they may have limited ability to invest in charging infrastructure, either due to financial barriers or because they do not own the parking structure or otherwise have rights to deploy charging equipment.

This challenge is not insurmountable. As HECO and other utilities throughout the country[1] [2] [3] recognize, utilities can play an important role by providing the necessary capital and technical support to expand the network of charging infrastructure. By building out make-ready infrastructure in locations where vehicles are parked for 4-8 hours at a time, like parking facilities serving multi-unit residential buildings and workplaces, HECO can help create the robust network that needs to be in place to make electric vehicles a more practical and viable choice for all customers.

[1] https://www.pge.com/en_US/business/solar-and-vehicles/your-options/clean-vehicles/charging-stations/program-participants/about-the-program.page
[2] https://chargeready.sce.com/(S(ywfnqel0clxjyxbsqhd5ayk3))/Default.aspx
[3] http://www.psc.state.md.us/wp-content/uploads/PC-44-Notice-Transforming-Marylands-Electric-Distribution-System.pdf

Tesla looks forward to working with the Commission, HECO, and other stakeholders to build on and implement HECO's Electrification of Transportation Plan.

Respectfully,

Andy Schwartz
Senior Policy Advisor
Tesla
3055 Clearview Way
San Mato, CA 94402

March 20, 2018

Public Utility Commission of the State of Hawaii
465 S. King Street, Room 103
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

The purpose of this letter is to express Uber Technologies' support for Hawaiian Electric's efforts to advance electrification of transportation in Hawaii.

Hawaiian Electric's EoT workshop on Nov. 9 allowed for thoughtful discussion between industry leaders and public officials on the future of transportation in Hawaii.

One of the major barriers to EV adoption raised during this workshop- lack of infrastructure - is something we've also identified during interviews and focus groups with Uber EV drivers in other markets. While many drivers enjoy the cost-savings of an EV, many more fear they will not be able to provide as many trips due to limited charging infrastructure. Current drivers report a persistent fear of losing their charge while transporting a passenger or losing fare-time while charging, and therefore choose to limit the amount of time they spend on the network.

In several cities, Uber has launched initiatives to help drivers make the switch to electric vehicles. We believe with the right infrastructure and incentives in place, our efforts, along with community support, can enable a significant shift to electric mobility. More electric vehicles on the Uber app would give a personal EV experience to thousands of riders - many for the very first time. As an illustration, based on our experience piloting EVs in other markets, with just 100 additional electric vehicles operating on the Uber system, tens of thousands of Hawaii residents could be exposed to electric vehicles within the first year.

Uber supports Hawaiian Electric's efforts and is excited about the potential for increased EV adoption across the islands. Thank you for your consideration of these comments.

Respectfully,

Tabatha Chow
Senior Operations Manager
Uber Hawaii

March 22, 2018

Public Utilities Commission of the State of Hawai'i
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners:

My name is Murray Clay and I am Managing Partner of Ulupono Initiative. As you may know, Ulupono Initiative is a Hawai'i-based impact investment firm that strives to improve the quality of life for the people of Hawai'i by working toward solutions that create more locally produced food; increase affordable, clean, renewable energy; and improve management of waste and fresh water.

While Hawaii's electric power sector continues to make progress toward its 100 percent renewable portfolio standard goal, our transportation sector has received little attention. Ground transportation alone utilizes roughly a third of the state's imported fossil fuels.

Ulupono believes that clean multimodal transportation is a key component of Hawai'i's renewable energy future. Our efforts in transportation include supporting the acceleration of electric vehicles (EVs) through investments in public charging stations and helping lead coalitions such as Drive Electric Hawai'i (DEH). If you aren't familiar, DEH seeks to promote the use of EVs and cut fossil fuel usage in ground transportation. The Hawaiian Electric Companies (HECO) is a prominent partner in DEH along with us and several other organizations working toward the same goals.

Electrification of transportation (EOT) has the potential to offer a number of benefits for transportation and the electric grid. Along with being cheaper to maintain and operate, EVs produce zero emissions at the tailpipe and generate fewer lifecycle emissions than internal combustion and hybrid vehicles. As more renewable energy is integrated with the grid, EVs will become even cleaner. EVs, and their associated charging, are also potential resources to support the electric grid and the continued integration of renewable energy. That said, EVs can also impose costs on the system, not just in terms of enhancement to distribution circuits, but also depending on the behavior of customers, the costs of meeting new and different peak loads depending on the time-variant rates, the charging infrastructure, degree of control, and load flexibility. Thus, the integration of EVs into the electrical system at scale requires planning across both the electricity and transportation grids.

As the provider of electricity for 95 percent of Hawai'i, HECO is in a unique and important position to lead the EOT. Through intelligent planning and implementation, there is an opportunity to create great value for all ratepayers. We are encouraged by HECO's leading participation in DEH. We are also excited to see HECO looking ahead and planning to harness the opportunities that EOT presents.

While Ulupono strongly supports the intent of HECO's seven near-term opportunities/priorities identified, we also believe there is an even greater opportunity to garner widespread support, as well as leverage outside private capital to advance these initiatives. Similar to HECO bringing stakeholders together for DEH, by taking a leading role in EOT, the utility can convene, attract and leverage private capital and resources to help drive this transformation. In summary, these priorities are a good start to a long journey. We look forward to further collaborating and supporting HECO and others to create all the potential benefits that EOT offers.

Thank you for your consideration of these comments.

Sincerely,

Murray Clay
Managing Partner

UNIVERSITY of HAWAI'I MĀNOA

Office of Planning & Sustainability

6 March 2018

Public Utilities Commission of the State of Hawaii
465 S. King Street, Room 103
Kekuanaoa Building
Honolulu, HI 96813

RE: Docket No. 2016-0168
EV-F/EV-U Extension
Electrification of Transportation Strategic Roadmap

Dear Commissioners,

According to the US Environmental Protection Agency, the largest US sources of greenhouse gas emissions due to human activity are from burning fossil fuels for electricity, heat, and transportation. Of these figures, transportation and electricity accounts for almost 60% of annual emissions.

Green house gas emissions have been rising faster than we have been able to adjust our behavior to offset it, and we're already seeing its life threatening impacts to our communities and the loss of places we cherish. We now have the technology to generate and store electricity produced by renewable sources, and to power our vehicles and trucks using this clean energy.

Although your past support has been greatly appreciated, circumstances compel an exponential increase in efforts toward the electrification of our transportation sector – now -- while we have a chance to mitigate the change to our climate before our communities are irreparably lost. We need more charging infrastructure to enable increased EV driving; more public awareness and education along with incentives that favor EV driving over fossil fuel powered vehicles; increased support for renewable energy installations and battery storage. Would you please consider rising to this challenge – now – by increasing your support?

Respectfully,

Sharon Ching Williams, ArchD., AIA, LEED AP BD + C
Campus Planning Architect
University of Hawaii at Manoa
Office of Planning & Sustainability
2002 East-West Road
Honolulu, HI 96822

Appendix B: Agenda for Hawaiian Electric's EoT workshop, November 9, 2017

8:00am-8:05am

Welcome
Shelee Kimura, Hawaiian Electric

8:05am-9:05am

State of EV technology, markets, and policy
CALSTART- state of technology, key barriers, bellwether policies
E3 - state of the market and policy

9:05am-9:20am

EoT in Hawai'i
Brennon Morioka, Hawaiian Electric

9:20am-10:30am

Stakeholder Panel: Public Sector Perspective
By laying out a practical vision for how the electrification of transportation benefits individuals and the community, public policy plays a key role in encouraging its adoption. Speakers will discuss government goals, initiatives, and describe possible strategies for overcoming barriers.

Panelists:

- HDOT: Ford Fuchigami (ports, airports, ground transportation)
- Honolulu C&C: Jon Nouchi (transit buses)
- Honolulu C&C: Councilmember Joey Manahan
- US Army, Public Works: Keith Yamanaka

10:30am-10:45am

Break

10:45am-12:15pm

Stakeholder Panel: Private Sector Customer Perspectives
Beyond adoption of EV-friendly public policy, what will it take for electric vehicles to move from a niche to the mainstream for individuals and businesses? A look at how choice, convenience and cost influence buying decisions and how manufacturers, dealers and the utility can better align their marketing efforts and infrastructure to support the frictionless switch to electric vehicles.

Panelists:

- Mobile Charging: Torben Spitzer, FreeWire
- Infrastructure providers: Thomas Ashley, Greenlots
- Fleet Management: Kelvin Kohatsu, Hawaiian Electric
- Shared Mobility: Jon Walker, Lyft
- OEM: Jacob Mathews, Ford Motor Company
- OEM: Alan Westenskow, Proterra

12:15am-1:00pm

Working lunch - breakout groups

1:00pm-2:00pm

Report Out

Appendix C: Invitees to Hawaiian Electric's EoT workshop, November 9, 2017

Automakers/Dealerships
Proterra
BYD
Ford
Nissan
Tesla
BMW
New Flyer
Gillig
Honda
Hawai'i Auto Dealers Association
Fletcher Jones
JN Group
Chanje Energy

Charging Solution Providers
Greenlots
OpConnect
ChargePoint
Hitachi (JUMPSmart)
Mobi FreeWire
Driivz
FleetCarma
SemaConnect

Fleets
Uber
Lyft
Car rental companies

Bus Service Providers
Hawai'i Department of Education
JTB Hawai'i
O'ahu Transit Services
Roberts Hawai'i

Public Agencies, Offices, and Representatives
Office of the Governor
Department of Commerce and Consumer Affairs (DEH member)
Public Utilities Commission staff
Department of Business Economic Development and Tourism, Energy Office (DEH member)
Environmental Protection Agency - Hawai'i
University of Hawai'i
Hawai'i Natural Energy Institute
University of Hawai'i Maui
City and County of Honolulu - Office of Climate Change, Sustainability, and Resiliency
Office of Senator Lorraine Inouye
Office of House Speaker Scott Saiki
Department of Transportation Services
Councilmember Manahan
Honolulu City Council
U.S. Army
U.S. Navy
Hawai'i County Council
Hawai'i Sustainability Coordinator
Honolulu Board of Water Supply
Department of Commerce and Consumer Affairs
Department of Accounting and General Services
Hawai'i Dept. of Transportation (DEH member)
Dept. of Hawaiian Homelands
County of Maui – Energy Commissioner
County of Maui – Department of Transportation
County of Hawai'i – County Energy Office
County of Hawai'i – Department of Research and Development
County of Hawai'i – Office of the Mayor
Select State Senators
Select House Representatives
University of Hawai'i Economic Research Office

Other
Women in Renewable Energy
Kaua`i Island Utility Coop. (DEH member)

Consultants
Energy and Environmental Economics (E3)
CALSTART

Advocacy Groups
Blue Planet Foundation (DEH member)
Distributed Energy Resources Council
Elemental Excelerator
Maui Economic Development Board
Ulupono Initiative (DEH member)
Energy Freedom Coalition of America
Hawai'i Energy Policy Forum
Hawai'i Hotel and Lodging Association
American Assn. of Retired Persons
Hawai'i Tourism Authority
Hawai'i Solar Energy Association
Kanu Hawai'i
Land Use Research Foundation
Life of the Land
The Alliance for Solar Choice
Waikiki Improvement Association
HI Green Growth
IBEW 1260
Big Island EV Association
O'ahu Economic Development Board
Chamber of Commerce
Building Industry Association
Retail Merchants Association

Hawaiian Electric Company
Business Development & Strategic Planning
- EoT
- Demand Response
- Business Development

Public Affairs
- Government & Community Affairs
- Corporate Communications

Customer Service
- Customer Solutions
- Marketing

Planning & Technology
- Technical Planning Services (Forecasting)
- Distribution Planning
- Advanced Planning

Legal
Energy Delivery
- Fleet Services

Maui Electric Company
Hawai'i Electric Light Company
HEI
- Strategic Planning

Total # attended (red): 85
*some organizations were represented by multiple attendees

Appendix D: Follow-up online survey sent to invitees to Hawaiian Electric's EoT Workshop

1. Did you attend the workshop?

2. What are the interests or goals of your organization with respect to electrified transportation?

3. Who do you represent and/or serve?

4. Which vehicles are you focused on?
   a. Light-duty vehicles
   b. Buses
   c. Medium- or heavy-duty trucks, or truck refrigeration units
   d. Off-road equipment (please specify)
   e. All of the above
   f. Other

5. Which vehicles are you focused on?
   a. Off-road equipment and Other (open comments)

6. Which customer segments are you focused on?
   a. Personal transportation
   b. Shared passenger transport (public transit, taxi, car share, rideshare, van pool)
   c. Commercial fleets
   d. Airports
   e. Ports
   f. Other industrial customers
   g. All of the above
   h. Other (specify)

7. Which customer segments are you focused on? Other (open response)

8. What are the potential benefits to Hawai'i's residents and your constituents from electrifying this vehicle technology?

9. What do you see as the principle barriers to your organization's adoption of electrified transportation at scale?

10. What do you see as the principle barriers to wide-scale adoption of this electrified technology in Hawai'i?

11. Are there awareness or knowledge gaps that are preventing adoption?

12. Could you please identify what these awareness or knowledge gaps are?

13. What can Hawaiian Electric do to assist in overcoming these barriers and/or knowledge gaps?

14. Are there other parties with whom Hawaiian Electric should partner to help remove or address these barriers? Who and how?

15. How can electrification of this technology/segment potentially support attainment of Hawai'i's goals to reach 100 percent renewable electricity generation by 2045?

16. Are there other comments you'd like to submit?

Appendix E: Electric vehicle forecast methodology and assumptions

The development of the electric vehicle forecast was based on combining macro-level Bass Diffusion models with geospatial customer-level, agent-based models. These models are often used in forecasting new and innovative products. When past participation and locational information is available, these models can be trained to include the socio-economic and peer-effects that contribute to adoption, as well as but not limited to time-sensitive utility incentive, rebates, tax credits, electric and gasoline prices etc.

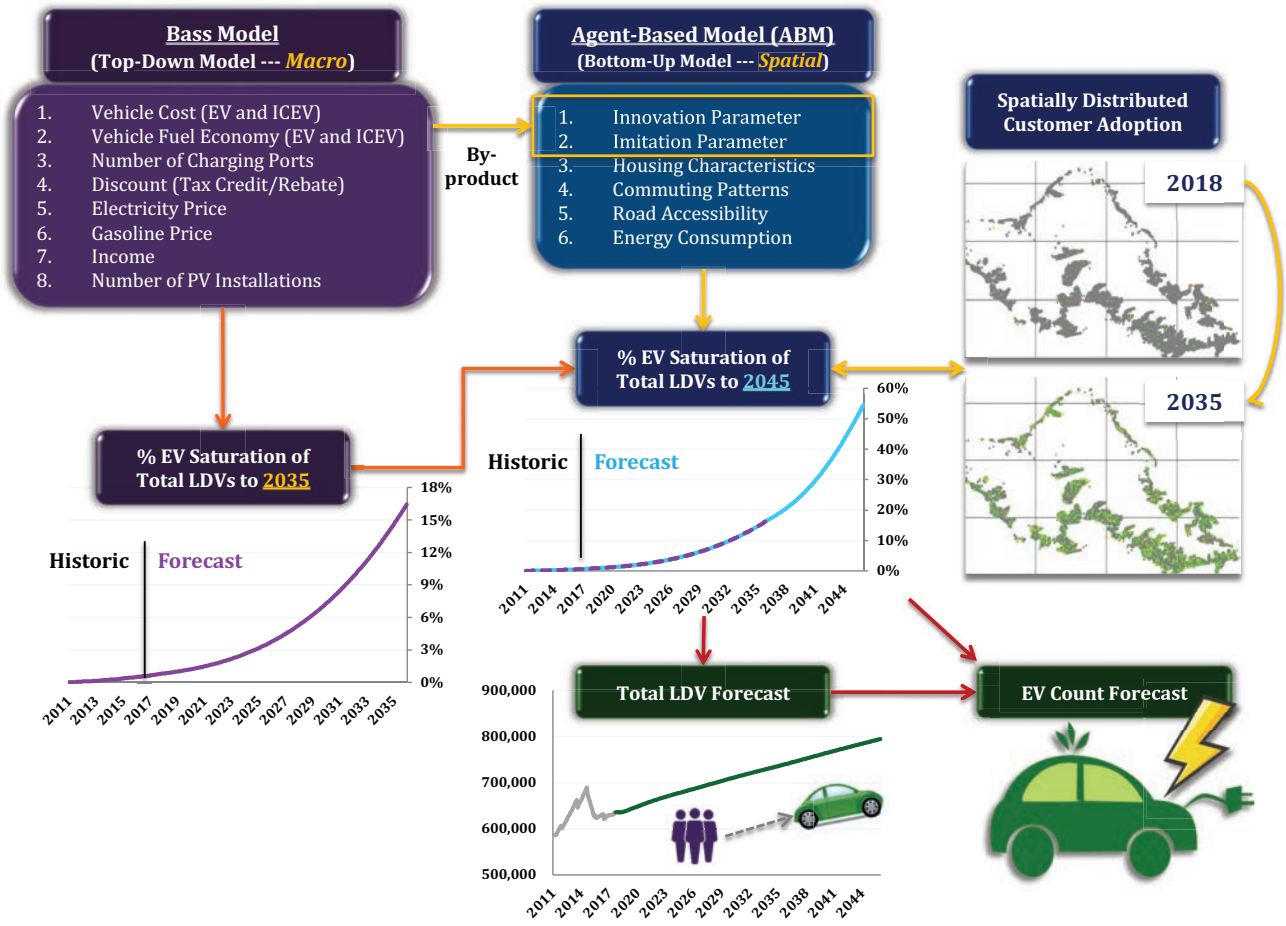
Multi-variate regression and other econometric methods such as polynomial distributed lag ("PDL") were employed to estimate how the macro-level Bass innovation (p) and imitation (q) parameters change as other factors change. Input variables considered in the macro-level models include vehicle costs (both electric and conventional), gasoline price, electricity price, fuel economies, PV installations and EV charging ports. Forecasts of charging ports are created based on historical growth and the assumption that such growth will eventually level out.

Forecast models for the islands within the companies' service territory were estimated using the past 6 years of observed EV adoption. The output of the macro-level models is EV percent penetration of total light-duty vehicles ("LDV"), as well as p and q parameters. These parameters are then used as inputs into the agent-based models. The macro-level Bass models are built to govern the agent-based models, with the macro-level Bass models having more influence on the forecast in the first 5-15 years and the agent models having more influence on the forecast in years 15-30.

The companies' consultant, Integral Analytics ("IA"), used its proprietary load forecasting analysis tool, LoadSEER, to develop a geospatial customer-level agent-based model. LoadSEER agents are defined as a utility customer, with 1 agent per premise/meter. Detailed premise-level attributes are required for agent simulations (i.e. energy consumption, utility rate, utility program participation, number of bedrooms, year built, market value etc.). Agents are geographically linked inside LoadSEER's spatial database, which includes parcel, transportation and satellite image data. LoadSEER's spatial database provides spatial context for each agent, based on location and nearby agents. The forecast models produce an electric LDV projection, which is converted to number of EVs using a forecast of total LDVs; the forecast of total LDVs was created using a model driven by population.

Figure 32 depicts the forecast methodology flow. (Next page)

Figure 32 . Hawaiian Electric's EV adoption and load forecast methodology



The next step was to segment the number of vehicles into charging profile segments such as but not limited to home, workplace, public and fleet charging. Hourly charging profiles were developed using third party and public charging station telemetry, load research conducted by several utilities in California, as well as Hawaiian Electric specific advanced metering infrastructure ("AMI") data. IA performed hourly load modeling and statistical sampling to develop a core set of EV charging profiles that were used as the building blocks of hourly charging behavior.

Appendix F: Cost-benefit analysis methodology and assumptions

Hawaiian Electric retained Energy and Environmental Economics, Inc. (E3) to perform an economic analysis of EoT in Hawai'i, using light-duty vehicle electrification on O'ahu as an initial case study and focusing on the 2018 – 2045 period. This timeframe was selected to coincide with the Company's long-range planning efforts accepted by the Commission[1] and the state's 100 percent RPS goal, which also includes the recent Mayors' Pledge on the decarbonization of Hawai'i's vehicles (see Chapter 2). The analysis builds directly from work performed by E3 for Hawaiian Electric's 2016 Power Supply Improvement Plan filing,[2] making use of the same grid modeling and data inputs for generating resource availability and costs, operating conditions, fuel costs, and discount rate.

Cost-benefit perspectives

E3's analysis considered two cost-benefit perspectives:

- The total "energy wallet" for the island. This considers the total amount spent on transportation in the state as ICE vehicles are replaced with EVs on retirement. In electricity economics, this is commonly referred to as the Total Resource Cost (TRC) test.

- The costs and benefits to Hawaiian Electric's customers. This compares the electricity bills paid by EV drivers to the marginal cost incurred by the utility to serve these drivers. In electricity economics, this is commonly referred to as the Ratepayer Impact Measure (RIM).

Table 8 indicates the costs and benefits included in each perspective. The remainder of this appendix describes our modeling inputs.

Table 8. Cost and benefit components included in each cost-benefit perspective

	Energy Wallet Perspective	Utility Customer Perspective
Incremental upfront vehicle cost	Cost	
Charging infrastructure cost	Cost	
Electricity supply cost to serve EVs	Cost	Cost
Federal EV tax credit	Benefit	
Vehicle operations and maintenance savings	Benefit	
Avoided vehicle gasoline	Benefit	
Utility bills paid by EV drivers		Benefit

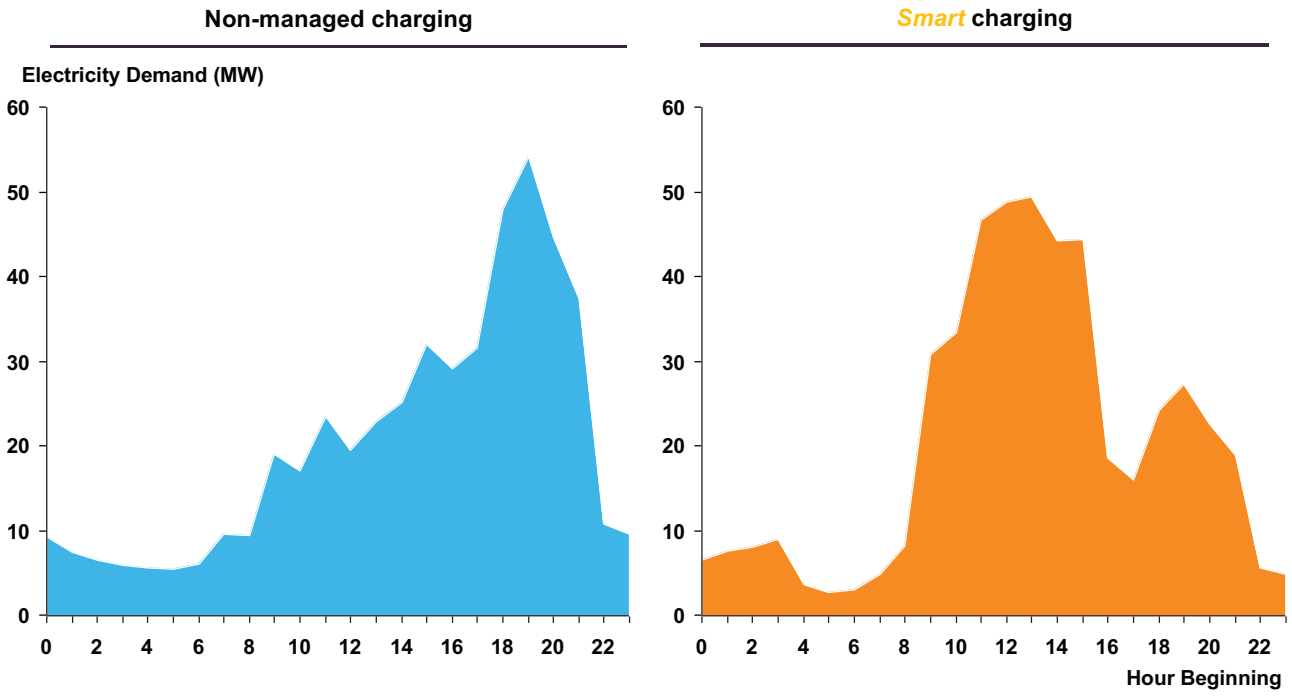
[1] Hawaiian Electric, July 2017, "Regulators Accept Hawaiian Electric Companies' Plan to Reach 100 percent Renewable Energy," https://www.hawaiianelectric.com/regulators-accept-hawaiian-electric-companies-plan-to-reach-100-renewable-energy

[2] Ibid.

Charging assumptions

E3 analyzed the two perspectives using two distinct charging profile cases. The first was a "Non-Managed Charging" case, which uses an hourly load forecast developed by Hawaiian Electric and Integral Analytics. This Non-Managed Charging load shape assumes that the majority of EV charging occurs at home.[3] It further assumes that most EV drivers are on Hawaiian Electric's flat "R" Residential rate for their home charging, with little incentive to charge their vehicle at any time other than right when they get home from work. It also includes a small amount of workplace and public charging. E3 also modeled an illustrative Smart Charging case. This case assumes that 50 percent of the kWh coming from charging at home can now occur at work, during hours when the electricity on O'ahu is producing its lowest-cost energy. The figure shows that even in this illustrative Smart Charging case, there remains a secondary evening peak from the 50 percent of home charging that was not moved to the workplace. Thus, there is potential to optimize behavior and increase benefits even further by incentivizing drivers to also move their home charging into the later hours of the night. See Figure 33.

Figure 33. Average weekday charging load for personal, light-duty EVs, Non-Managed Charging case and Smart Charging case, 2030

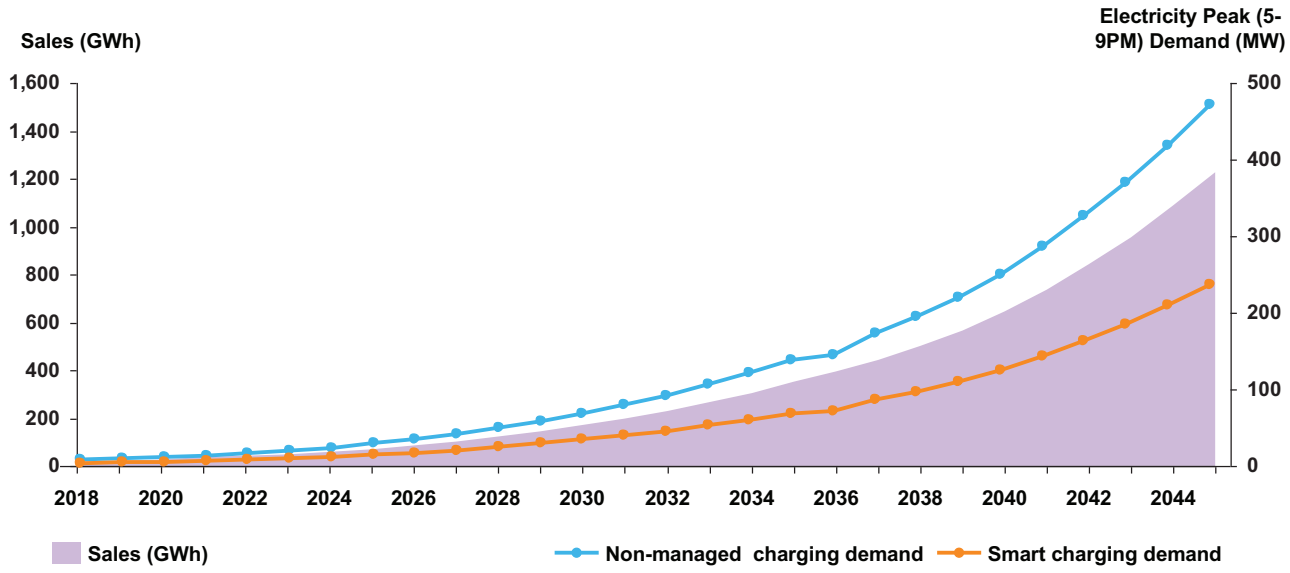


Source: E3 Analysis

Figure 19 is a forecast of the personal light-duty EV adoption for O'ahu. The estimated sales attributed to this adoption increases from approximately 20 GWh in 2018 to 1200 GWh in 2045. The electricity demand during the peak (5 PM to 9 PM) in the Non-Managed and Smart Charging cases also significantly increases over time. Figure 34 illustrates the growth in sales as well as the increased electricity demand during the peak hours.

[3] This assumption was based on: Ulupono Initiative, 2016, "Survey of Electric Vehicle Drivers in Hawai'i" and Hawaiian Electric, 2014, "Electric Vehicle Pilot Rates Final Evaluation Report."

Figure 34. Forecasted electricity sales and electricity demand for Non-Managed and Smart Charging cases during peak from 2018 to 2045



Vehicle and EVSE lifetime

EVs and EVSEs are assumed to have a useful life of 10 years. This is based on a literature review performed by ICF as part of a similar study done by ICF and E3 for California.[4]

The adoption forecasts referenced in "Appendix E: Electric vehicle forecast methodology and assumptions" are used in a "stock rollover" model that tracks the age of each PEV and EVSE. In each year, the model determines the number of new PEV or EVSE sales using equation (1). The sales in each year are the sales needed to meet population growth plus sales needed to replace equipment that has reached the end of its useful lifetime and must be replaced.

Equation 1: Annual Stock Rollover Equation

Sales[year]=Population[year] - Population[year-1] + Sales[year-lifetime]

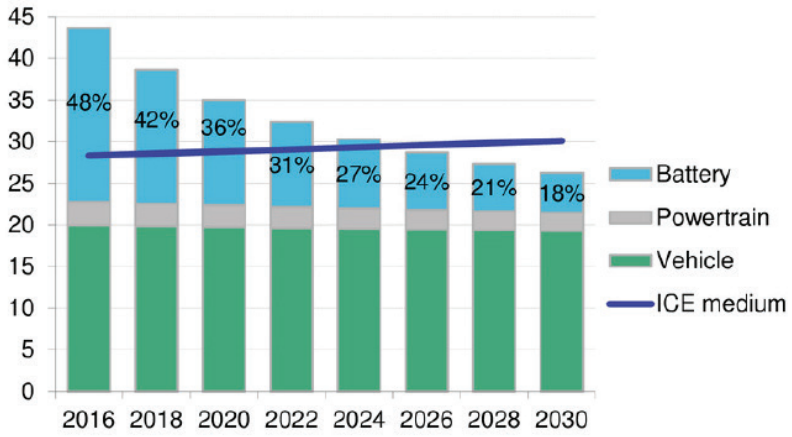
In our analysis we include all benefits and costs that accrue to these vehicles over their useful lifetimes. Since we assume a 10-year vehicle life, costs and benefits attributable to the vehicles adopted in 2045 are included in our analysis through 2054.

Incremental upfront vehicle cost

We use Bloomberg's analysis showing that EVs are expected to reach cost parity with ICE vehicles in 2025, and use the cost differential they provide for the 2018 – 2025 period. Although Bloomberg predicts that EVs will actually sell for less than ICE vehicles after 2025, we instead conservatively assume that EVs and ICE vehicles have the same upfront cost post-2025.

[4] ICF and E3, 2014, "California Transportation Electrification Assessment Phase 1: Final Report," http://www.caletc.com/wp-content/uploads/2016/08/CalETC_TEA_Phase_1-FINAL_Updated_092014.pdf

Figure 35. U.S. medium-size battery-electric vehicle price breakdown, ICE price and share of battery costs, 2016-30 (thousand 2016$ and %)



Source: Bloomberg New Energy Finance, April 2017, "When Will Electric Vehicles be Cheaper than Conventional Vehicles?"

Charging infrastructure cost

EV charging infrastructure cost includes the cost of purchasing and installing EVSEs at three types of locations: residential, workplace, and in public. Different assumptions are used to estimate the number of EVSEs in service at each location type. The number of residential EVSEs comes from the conservative assumption that a level 2 EVSE is purchased for use at home by each EV driver. A forecast for the number of non-residential charging ports was provided by Hawaiian Electric. The forecast of charging ports was divided into workplace, public, and DC fast charging ports (see Figure 19 for forecast). We assume that there is 1 DC fast charging port per DC fast charging EVSE and 2 charging ports per non-residential level 2 EVSE, which is typical today. In this study, we assume that the share of public charging ports that are DC fast charging ports is the same in the future as it is on O'ahu today: roughly 13 percent.[5] The remaining charging ports are assumed to be either workplace or publicly accessible level 2 charging ports. In the Non-Managed Charging case, the number of charging ports installed at workplaces is the minimum number required to satisfy the system-wide workplace EV charging load shape provided by Hawaiian Electric. In the illustrative Smart Charging case, the number of charging ports installed at workplaces is the minimum number required to satisfy the system-wide workplace EV charging load shape after 50 percent of residential charging has been moved to workplaces.[6] After accounting for the DC fast charging and workplace charging ports, the remaining charging ports in the forecast are assumed to be publicly available. Table 9: EVSE data gives other data about each EVSE type.

Table 9: EVSE data

EVSE Type	Charging Ports per EVSE	Purchase and installation cost ($)	Annual price reduction
Residential	1	$2,300	1.9 percent
Workplace Level 2	2	$8,000	1.9 percent
Public Level 2	2	$25,000	1.9 percent
DC Fast Charging	1	$128,094	1.9 percent

Source: Annual price reduction and Residential and Workplace Level 2 purchase and installation cost; Based on a literature review

[5] Estimated using data downloaded from https://www.afdc.energy.gov/locator/stations/
[6] Note that in this case, we continue to assume each EV has a Level 2 residential EVSE

performed by ICF as part of a similar study done by ICF and E3 for California. ICF and E3, 2014, "California Transportation Electrification Assessment Phase 1: Final Report," http://www.caletc.com/wp-content/uploads/2016/08/CalETC_TEA_Phase_1-FINAL_Updated_092014.pdf. Public Level 2 purchase and installation cost; Upper bound on installation cost estimates for public Level 2 EVSEs from the State Energy Office, in DBEDT, 2012, "Driving ECs Forward: A Case Study of the Market Introduction and Deployment of the EV in Hawai'i," http://energy.hawaii.gov/wp-content/uploads/2011/09/EVReportMauiElectricVehicleAlliance2012.pdf. DC Fast Charging purchase and installation cost; DCFC cost of $128,094 is the capital and installation cost of the Hawaiian Electric Dole Plantation DC Fast Charger. This is the lowest cost site that Hawaiian Electric has installed on non-company property. The assumption in using the lowest-cost site was that DCFC installation costs will fall over time as the utility gains experience and capital costs come down. See Hawaiian Electric Companies, "Electric Vehicle Pilot Rates Report," Filed with Hawaii Public Utilities Commission as Transmittal no. 13-07, March 31, 2017.

Electricity supply cost to serve EVs

Electricity supply cost is comprised of

- Fixed costs for electricity generation and generation capacity needed to serve EVs
- Operating costs for electricity generation and generation capacity needed to serve EVs
- Cost of distribution upgrades attributable to EVs

The first and second of these elements were calculated using E3's RESOLVE model. RESOLVE is an electric power system investment model that co-optimizes investment and operational decisions over a given time horizon. It was used in Hawaiian Electric's PSIP filing. For this analysis, E3 ran RESOLVE for 2018 to 2045 with and without the additional load attributed to electric vehicles. The incremental fixed and operating grid costs were then attributed to EVs. This analysis was performed using both the Non-Managed and Smart Charging cases (see Charging Assumptions section above). All other input data for these RESOLVE runs match those of the No-LNG, High DGPV case used for the companies' PSIP filing. For additional detail on the RESOLVE model and these inputs, see Hawaiian Electric's "PSIPs Update Report" from December 2016.[7]

E3 assessed the impact of future electric vehicle charging loads on the distribution network of O'ahu using a load threshold analysis for each substation. Three types of distribution costs were modeled: residential service transformer upgrades, new commercial service transformers for non-residential charging stations, and substation transformer upgrades needed to meet N-1 reliability requirements.

Hawaiian Electric provided detailed data about the O'ahu distribution network for E3's analysis. The data included the following for each substation:

- Peak day load shape
- Maximum power rating of substation circuits
- Annual growth rate of non-EV load
- Number of customers with PV
- Number of residential and commercial customers
- Data on all service transformers, including power rating and whether each was underground or overhead

Residential EV charging load was allocated to substations using the share of island-wide distributed PV installations located on each substation. Non-residential EV charging load was allocated to substations according to the share of all commercial customers located on each substation. Load was allocated in a discrete fashion, modeling the construction of new charging stations. Residential charging stations are assumed to comprise a single EVSE, while non-residential charging locations are assumed to consist of multiple EVSEs as shown in Table 10: Number of EVSEs per EV charging station.

[7] https://www.hawaiianelectric.com/about-us/our-vision

Table 10: Number of EVSEs per EV charging station

	EVSEs per Charging Location
Residential (Level 2)	1
Workplace (Level 2)	10
Level 2 Public	10
DC Fast Charger	3

he incremental substation upgrade cost attributable to EVs is calculated as the difference between upgrade costs with and without EVs. Substations are upgraded whenever the peak load exceeds the larger of 10MW or 50 percent of the sum of power ratings of a substation's circuits. Each substation upgrade adds 16.2 MW of capacity at a cost of $3.175 million -- the average upgrade size and cost on O'ahu.

E3 also estimated the cost of upgrading or installing new service transformers. For each substation, the price of installing a new service transformer was calculated as the weighted average of overhead or underground service transformer costs, using the share of service transformers that are either overhead or underground as the weights. Overhead service transformers are assumed to cost $13,500, while underground service transformers are assumed to cost $82,500. These are representative costs for capital expenditures and installation of service transformers according to Hawaiian Electric.

Service transformer upgrade costs were calculated separately for residential and non-residential locations. For non-residential locations, each new DC Fast Charger location is assumed to require a new service transformer and service drop, while 50 percent of workplace or Level 2 public charging stations are assumed to require a new service transformer for a new service drop. Residential service transformers are modeled with an upgrade threshold of 167 percent of the total installed service transformer capacity downstream of the substation (this is the threshold rating of a service transformer). When total load on a substation exceeds this threshold, then an upgrade adds capacity equal to the currently-installed service transformer capacity. The cost of this upgrade is the number of service transformers connected to the substation times the substation's service transformer price.

Federal EV tax credit

The U.S. Federal tax code grants a credit up to $7,500 credit per EV. Given the uncertainty regarding the future of this tax credit, as well as the associated quota applied to each vehicle manufacturer (200,000 vehicles), the federal tax credit is assumed to expire in 2021.

Vehicle operations and maintenance savings

Lifetime operations and maintenance savings from driving an EV instead of a conventional ICE vehicle are accrued for each EV sold. A lifetime O&M savings of $1,546 was taken from a recent report by the Union of Concerned Scientists.[8]

Avoided vehicle gasoline

The gasoline use avoided by EVs was estimated assuming that each EV displaces an ICE vehicle with average miles per gallon on O'ahu, accounting for improvements in the fuel efficiency of ICE vehicles over time. The average annual fuel consumption of an ICE vehicle on O'ahu was estimated using DBEDT LDV registration data[9] and ICCT's study[10] of transportation fuel use in Hawai'i. The average annual fuel consumption avoided per EV per year varies by vehicle vintage and falls over

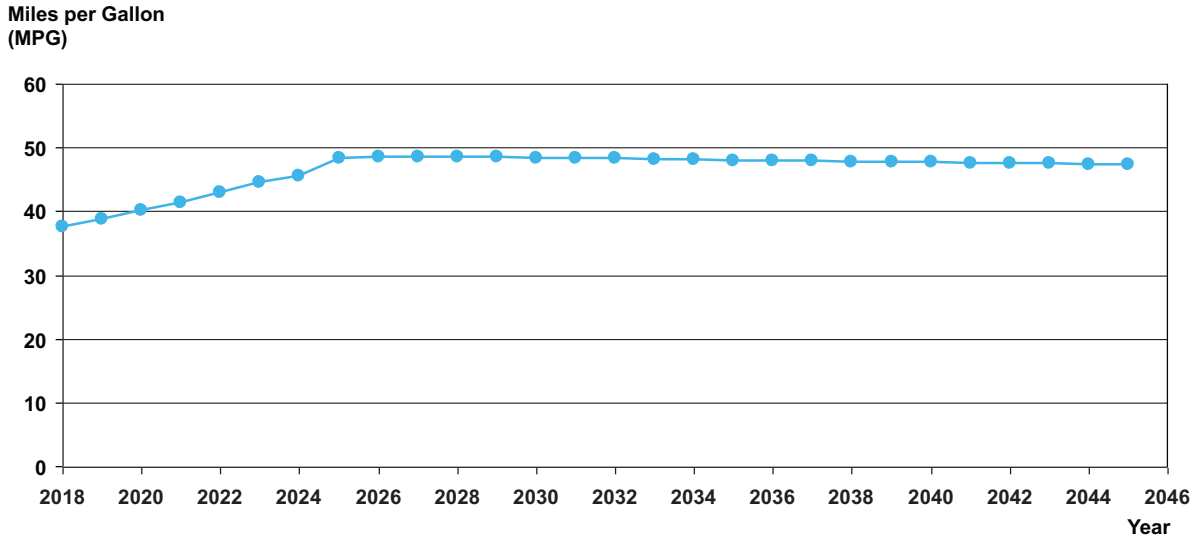
[8] Union of Concerned Scientists, 2017, "Going from Pump to Plug," https://www.ucsusa.org/sites/default/files/attach/2017/11/cv-report-ev-savings.pdf

[9] DBEDT Data Warehouse, "Registered vehicles, taxable—Gasoline, Passenger: 2017"

[10] ICCT, 2015, "Hawai'i Clean Energy Initiative Transportation Energy Analysis," https://energy.hawaii.gov/wp-content/uploads/2011/09/Final_TransEnergyAnalysis_8.19.15.pdf

time using the relative improvement in ICE vehicle fuel efficiency projected by the U.S. Energy Information Administration in their 2017 Annual Energy Outlook. [11]

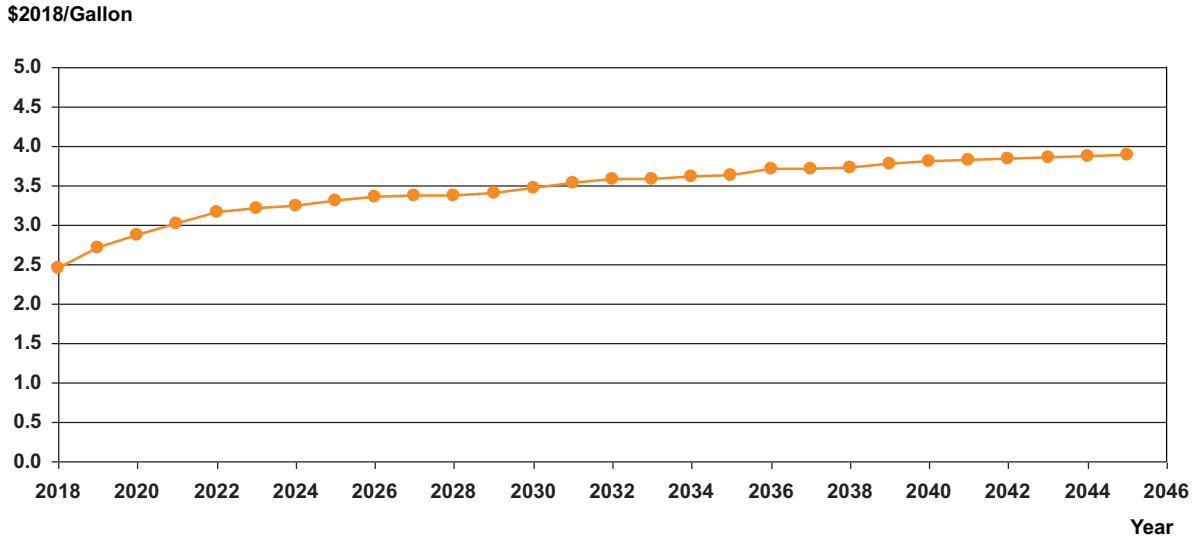
Figure 36. Forecast new internal combustion engine vehicle fuel economy



Source: E3 Analysis

The gasoline price used in E3's modeling is consistent with that used in Hawaiian Electric's PSIP filing. See Figure 37. Gasoline price forecast, net of state and local taxe. State and local taxes were removed from the avoided gasoline benefits, as these are considered transfers within Hawai'i (from drivers to government) and therefore are not considered "energy wallet" benefits to O'ahu.

Figure 37. Gasoline price forecast, net of state and local taxe



Source: E3 analysis

[11] Available at https://www.eia.gov/outlooks/aeo/data/browser

Utility bills paid by EV drivers

The rates used for calculating incremental utility bills from EV charging are shown below in Table 11: Hawaiian Electric rates applied to EV charging at different locations. We assumed that half of public Level 2 charging will be installed on commercial accounts and half will be at public garages, giving a 50/50 split of bills calculated using Schedule J and Schedule P, respectively. We chose to use these rates rather than EV-F, because that rate is limited to only 100 sites and we are forecasting significantly more than 100 public Level 2 sites in the 2045 timeframe. The analysis further assumes that rates escalate over time consistent with the companies' PSIP filing.

Table 11: Hawaiian Electric rates applied to EV charging at different locations

	Utility Rate
Residential	Schedule R
Workplace	Schedule J
Public Level 2	50/50 split Schedule P and Schedule J
DC Fast Charging	Schedule EV-U

Appendix G: Acronyms and Abbreviations

AGV	Automated Guided Vehicle
BNEF	Bloomberg New Energy Finance
BOMA	Hawai‘i Building Owners and Managers Association
CARB	California Air Resources Board
CAISO	California Independent System Operator
CAV	Connected Autonomous Vehicle
CBRE	Community-Based Renewable Energy
CCS	Combined Charging System – trade name of a quick charging method supported by major automobile manufacturers including Volkswagen, General Motors, BMW, Daimler, Ford, FCA, Tesla, and Hyundai
CGS+	Customer Grid Supply Plus Tariff approved by the Hawai‘i Public Utilities Commission in which owners of solar-only systems earn compensation for excess generation, and solar plus storage owners can choose to either earn compensation directly or store energy to offset usage at retail rates in future hours
Charging port	A single point of connection in a charger/EVSE. Also known as a plug.
CHAdeMo	“CHArge de MOve” – trade name of a quick charging method CHAdeMO was formed by Tokyo Electric Power Company, Nissan, Mi subishi, Fuji Heavy Industries, and later joined by Toyota
CONRACs	Consolidated Rental Car Facilities
Commission	Hawai‘i Public Utilities Commission
CPUC	California Public Utilities Commission
DBEDT	Hawai‘i Department of Business, Economic Development, and Tourism
DCFC	Direct Current Fast Charging. A type of EVSE that is designed to rapidly deliver direct current to a vehicle’s onboard battery DCFCs commonly have power ratings of 50kW or higher. Many fast chargers can restore an EV to 80 percent state of charge in 30 minutes or less
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management System
DOT	Department of Transportation
DPS	Hawai‘i Department of Public Safety
DR	Demand Response
DRMS	Demand Response Management System
E3	Energy and Environmental Economics, Inc
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EoT	Electrification of Transportation
EV	Electric Vehicle – In this document, ‘EV’ is used to mean a plug-in electric vehicle, i.e. a fully battery-electric vehicle or a plug-in hybrid vehicle
EVSE	Electric Vehicle Supply Equipment – Standalone equipment used to deliver charge safely into the battery inside an electric vehicle. Also referred to in this report as a charger.
EVSP	Electric Vehicle Service Provider Company which provides access and billing to multiple EVSEs Examples include ChargePoint, or Tesla with its Supercharger network
FAA	Federal Aviation Administration
GHG	Greenhouse Gas
GMS	Grid Modernization Strategy
GSE	Ground Support Equipment – equipment used in airports (examples include belt loaders, luggage tags, water trucks)
GSPA	Grid Services Purchase Agreement
HADA	Hawaiian Automobile Dealers Association
HART	Honolulu Authority for Rapid Transportation
Hawaiian Electric	‘Hawaiian Electric’ and ‘the companies’ are used interchangeably to refer collectively to the Hawaiian Electric Companies: Hawaiian Electric Company, Inc., Maui Electric Company, Limited, and Hawai‘i Electric Light Company, Inc.
HCEI	Hawai‘i Clean Energy Initiative

HD	Heavy-Duty
HDOT	Hawai'i Department of Transportation
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
IGP	Integrated Grid Planning
IOU	Investor-Owned Utility
LAX	Los Angeles International Airport
LDV	Light-Duty Vehicle
Level 1	Charging equipment using standard 120V household electricity
Level 2	Charging equipment using 208V or 240V electricity typically used in ovens and dryers
Make-ready	Electric company funds the installation and supply infrastructure costs up to the charging equipment. The customer procures and pays for the charging equipment.
MD	Medium-Duty
MUD	Multi-Unit Dwelling – type of residence in which multiple housing units are located within a single building or building complex (e.g. an apartment building)
NASA	National Aeronautics and Space Administration
NEDO	New Energy and Industrial Technology Development Organization
NGO	Non-Governmental Organization
NoMEPorts	Noise Management in European Ports EU project aimed to develop a good practices guide for noise mapping and management for industrial ports
NPV	Net Present Value
NRDC	Natural Resources Defense Council
NREL	National Renewable Energy Laboratory
OATI	Open Access Technology International, Inc
OEM	Original Equipment Manufacturer
PCA	Pre-Conditioned Air
PG&E	Pacific Gas and Electric
PSIP	Power Supply Improvement Plan
RESOLVE	Renewable Energy Solutions Model – E3 investment planning model used in PSIP
RPS	Renewable Portfolio Standard
RTG	Rubber Tired Gantry – Mobile gantry crane used to stack and transfer shipping containers
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
TCO	Total Cost of Ownership – Financial estimate that takes into account both purchase price and continued fuel and variable operating costs of an asset
TNC	Transportation Network Company
TOU	Time-of-use
TRL	Technology Readiness Level
TRU	Truck Refrigeration Unit
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
VALE	U.S. Department of Transportation's Voluntary Airport Low Emissions Program – National program, available to all commercial service airports, designed to reduce airport ground emissions
VMT	Vehicle Miles Travelled
ZEV	Zero Emission Vehicle – These include both light-duty plug-in electric vehicles and light-duty fuel-cell vehicles

Notes


Hawaiian Electric
GOEV
Hawaiian Electric
ELECTRIC VEHICLE
goev.heco.com

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light