July 30, 2019

FILED

2019 JUL 30 P 3:24

PUBLIC UTILITIES COMMISSION

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

Dear Commissioners:

Subject: Docket No. 2018-0135 – Electrification of Transportation
Electric Vehicle Critical Backbone Study: Planning Methodology

In February 2019, the Hawaiian Electric Companies[1] informed the Commission of their plan to evaluate the overall electric vehicle charging needs in their service territories by undertaking an EV backbone study.[2] Accordingly, the Companies respectfully submit herewith their *Electric Vehicle Critical Backbone Study: Planning Methodology* ("Study").

In connection with the Study, the Companies commissioned Navigant Consulting, Inc. ("Navigant") to analyze data from the Companies' service territories by developing an *EV Critical Backbone Study: Selection Tool* ("Backbone Tool"). The analyzed data, which is contained in a Microsoft Excel file, is voluminous, and does not lend itself well to printing. Therefore, the Excel file is being provided to the Commission and Consumer Advocate on the enclosed compact disc.

To facilitate further analysis, Navigant has offered to provide the Commission and Consumer Advocate with online access to the Backbone Tool. Any member of the Commission or Consumer Advocate's staff who wishes obtain access to this tool may contact Michael Colón, Hawaiian Electric's Manager of Electrification of Transportation and Program Development, at (808) 543-4620 or email at michael.colon@hawaiianelectric.com.

Sincerely,

Kevin M. Katsura
Director
Regulatory Non-Rate Proceedings

cc: Division of Consumer Advocacy

[1] The "Hawaiian Electric Companies" or "Companies" are Hawaiian Electric Company, Inc., Maui Electric Company, Limited ("Mai Electric") and Hawaii Electric Light Company, Inc.

[2] See, e.g., Maui Electric's response to PUC-MECO-IR-107, filed February 4, 2019 in the EV-MAUI Tariff proceeding, Docket No. 2018-0422 ("In the future, the Companies plan to revisit the overall charging needs on Maui as part of its EV charging backbone study.").

Electric Vehicle Critical Backbone Study: Planning Methodology

Prepared by:
Hawaiian Electric Company,
Maui Electric Company, and
Hawai'i Electric Light Company

July 30, 2019

Analysis conducted by:
Navigant Consulting, Inc.
101 California Street
Suite 4100
San Francisco, CA 94111
415.356.7100

Docket No.: 2018 0135

Table of Contents

Executive Summary 3

1. Introduction 5

2. Policy Background and Regulatory Context 8

2.1 Policy Background 8
2.2 Regulatory Context 9

3. Project Overview 11

3.1 Project Purpose and Objectives 11
3.2 Stakeholder Value 12
3.3 Project Process 12
3.4 Stakeholder Engagement 13

4. Planning Methodology Development 14

4.1 Activity 1: PEV Forecast Disaggregation 15
4.2 Activity 2: EV Charging Baseline Analysis 18
4.3 Activity 3: EV Charging Universe Forecast 20
4.4 Activity 4: EV Charging Universe Grid Impact Analysis 22
4.5 Activity 5: Critical Backbone Methodology and Tool Development 23

5. EV Charging Universe Results 27

5.1 EV Charging Universe: A Brief History 27
5.2 EV Charging Universe Results: Reference Case 27
5.3 Public Universe Results 29

6. Planning Tool Sensitivity Test 33

6.1 Sensitivity Test Approach 33
6.2 Sensitivity Test Results 33
6.2.1 Multi-unit Dwelling 34
6.2.2 Low Income 35
6.2.3 Utilization 36
6.2.4 Range Support 37
6.2.5 Development Cost 38
6.2.6 Grid Support 39
6.3 Sensitivity Test Takeaways 40

7. Summary of Key Stakeholder Feedback 41

7.1 June 4 Workshop and Follow-up 41
7.2 July 12 Workshop and Follow-up 42
7.3 Stakeholder Questions and Answers 42

8. Road Ahead 44

Appendices A-G A1

List of Figures

Figure 1. Critical Backbone Methodology and Tool Development Overview..3
Figure 2. EV Charging Universe – Public and Private Infrastructure..4
Figure 3. EV Charging Universe – Public and Private Infrastructure..6
Figure 4. Project Steps and Schedule 12
Figure 5. The Companies' EoT Roadmap PEV Forecast (Reference Case by County)...........................15
Figure 6. Adapted Forecast – PEV Forecast Disaggregation 2030 by County 17
Figure 7. The EV Charging Universe – Private, Public, Critical Backbone..21
Figure 8. Backbone Tool EV Charging Load Shapes..23
Figure 9. 2030 Public Universe Results by Island – Reference Case 29
Figure 10. 2019 to 2030 Public Universe Results by Island – High & Low Scenario Growth....................32
Figure 11. Selection Filter Sensitivity Test Result – Multi-unit Dwelling 34
Figure 12. Selection Filter Sensitivity Test Result – Low Income 35
Figure 13. Selection Filter Sensitivity Test Result – Utilization...36
Figure 14. Selection Filter Sensitivity Test Result – Range Support 37
Figure 15. Selection Filter Sensitivity Test Result – Development Cost..38
Figure 16. Selection Filter Sensitivity Test Result – Grid Support 39
Figure 17. Draft Backbone Tool Design – June 4, 2019..41
Figure 18. Selection Filter Stakeholder Feedback Template...42

List of Tables

Table 1. Final Use Cases...19
Table 2. Selection Filter Descriptions 24
Table 3. 2030 EV Charging Universe Results by Island, Technology Type and Use Case –Reference Case 28
Table 4. 2030 EV Charging Port Universe by Technology Type – Reference Case.................................28
Table 5. 2030 Public Universe Results by Island, Technology Type and Use Case – High & Low Scenarios 30
Table 6. 2030 Public Universe Results by Technology Type and Use Case – High & Low Scenarios.....31
Table 7. Backbone Tool Sensitivity Test Results...40

Executive Summary

The first motorized vehicle to arrive in Hawai'i in 1899 was an electric vehicle (EV).[1] With the recent advances in EV technology, the Hawaiian Electric Companies (the Companies) have continued to support electrification of transportation (EoT) efforts. Today, the EV industry is positioned to disrupt the global transportation landscape with billions of dollars invested in technology platforms and value chains across the world. The transition to EoT is underway across all vehicle classes—light, medium, and heavy duty—and the future of transportation in Hawai'i will require investment in charging infrastructure to meet the growing energy needs of those vehicles and their drivers.

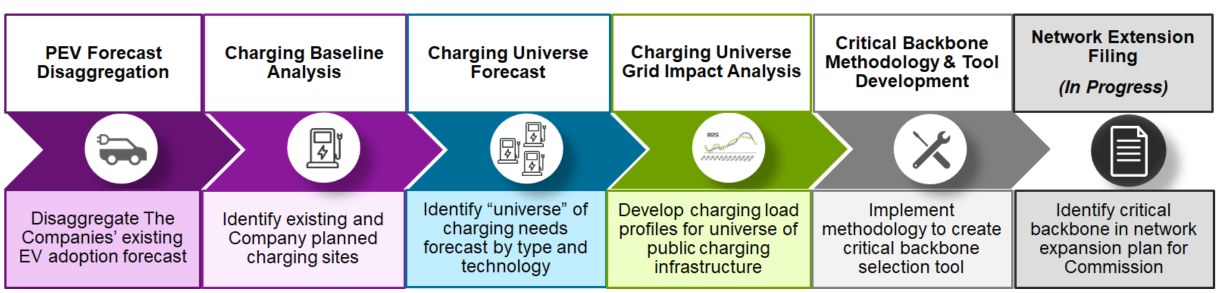
Hawai'i has long been a leader in clean energy initiatives, such as its decision to become the first state in the country to establish a 100% renewable energy portfolio standard for electricity generation. The transition to clean transportation in Hawai'i shares a close nexus with renewable energy generation. Since 2014, the Companies have steadily expanded their role in EV charging infrastructure development, with the support of the Hawai'i Public Utilities Commission (Commission), to establish pilot public charging resources for early adopters of electrified transportation.

The Companies' *Electrification of Transportation Strategic Roadmap* (*EoT Roadmap)* outlines their proposed role in the EoT in Hawaiʻi to optimize, facilitate, accommodate, and integrate EoT within its service area.[2] Initiative 7 of the EoT Roadmap seeks to "[e]xpand [the] availability of reliable public charging," and describes the need to identify a "critical backbone" of EV charging infrastructure to support ongoing growth in EV adoption and to reduce barriers to the adoption of EVs.[3]

As a first step in support of this initiative, this informational report summarizes recent analysis by the Companies to better understand how the global EV market transition will manifest for their customers by forecasting the need for EV charging infrastructure in the Companies' territories in 2025 and 2030.

Figure 1 provides a synthesized view of the three-month process that the Companies and Navigant Consulting, Inc. (Navigant) undertook to develop the forecasts and planning methodology described in this *Electric Vehicle Critical Backbone Study: Planning Methodology Report*.

Figure 1. Critical Backbone Methodology and Tool Development Overview



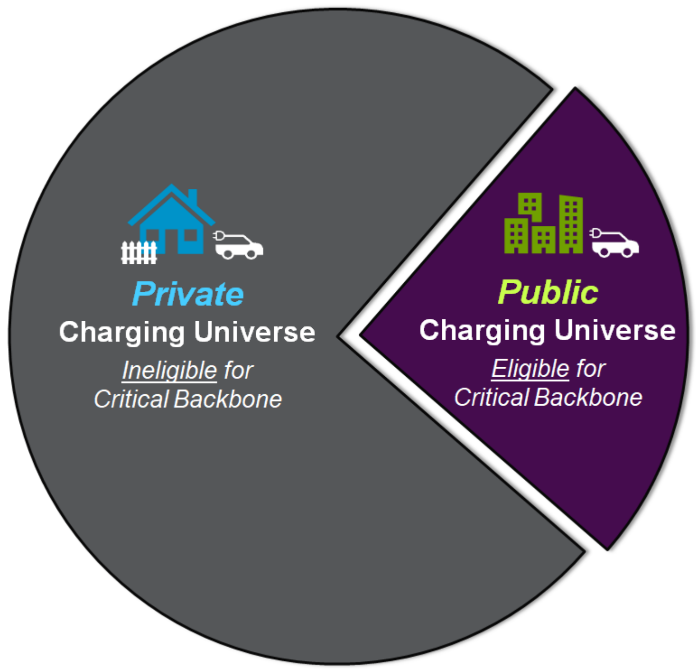
[1] See State of Hawai'i, Energy Office, available at https://energy.hawaii.gov/wp-content/uploads/2016/11/FF_Nov2016_EV-only.pdf.

[2] See Docket No. 2016-0168, Electrification of Transportation Strategic Roadmap, filed March 29, 2018.

[3] Id. at 86

This process included disaggregating the Companies' EV adoption forecast from the EoT Roadmap to develop a commensurate "EV Charging Universe" (the Universe) of private (Private Universe) and public (Public Universe) charging needs, which Navigant implemented through a web-based tool. This tool can use stakeholder-reviewed selection filters that reflect EoT priorities to help identify a critical backbone of eligible public charging infrastructure (Critical Backbone) from within the Public Universe—as depicted in Figure 2—for development by the Companies.

Figure 2. EV Charging Universe – Public and Private Infrastructure



(Source: Navigant)

As discussed in the Companies' EoT Roadmap, 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" is instrumental to optimize, facilitate, accommodate, and integrate EoT within its service area.[4]

To that end, the Companies intend to use the methodology and tool to identify a Critical Backbone as defined in the EoT Roadmap for development as part of its charging network expansion plans in a filing request to the Commission anticipated by the end of the first quarter of 2020.

Thus, the intent of this report is to provide the Commission with an informational update on the Companies' progress on Initiative 7 of the EoT Roadmap.

---

[4] Id. at 86

1. Introduction

Electrification of transportation (EoT) will play a prominent role as Hawai'i transitions to a clean energy future and drastically reduces its petroleum imports. In March 2018, the Hawaiian Electric Companies (the Companies) filed their *Electrification of Transportation Strategic Roadmap* (EoT Roadmap). As the EoT Roadmap explains, the Companies' efforts to replace fossil fuel-powered vehicles with cleaner and more efficient electric vehicles (EVs) will:

- Facilitate reduced fossil fuel use and the corresponding reduction in the state's reliance on imported fossil fuels) for transportation;
- Reduce greenhouse gas emissions and overall air pollution;
- Provide public health benefits including reduced medical costs; and
- Support the integration of renewable energy, which contributes to lowering and stabilizing rates for all customers).[5]

These benefits grow incrementally over time with each additional EV that replaces a fossil fueled vehicle as a result, in whole or part, of the Companies' EoT efforts. These efforts can grow exponentially once the penetration of EVs reaches a critical mass.[6] Achieving these benefits requires an initial investment of resources, both time and capital, to establish the regulatory and physical frameworks upon which meaningful EoT efforts can succeed.

The Companies' EoT Roadmap outlines their proposed role in the EoT in Hawai'i to optimize, facilitate, accommodate, and integrate EoT within their service territories. The Companies have specifically identified the buildout of charging infrastructure as one of their five key short-term steps that will build on the momentum and accelerate the transition in their strategy:

> *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.*[7]

Furthermore, the EoT Roadmap identifies the continued development and expansion of public charging as one of the Companies' primary strategic initiatives beyond the current public charging infrastructure pilot under tariff Schedule EV-U, initiated in 2013. Under EV-U, the Hawai'i Public Utilities Commission (Commission) authorized the Companies to own and operate direct current fast charging (DCFC) stations for EVs at up to 25 metered sites across their service territories. As of June 2019, the Companies have installed 17 50 kW publicly accessible charging stations. In addition, the Companies provide a commercial rate for high demand charging with a separate meter, called Schedule EV-F. Initiative 7 of the EoT Roadmap seeks to "[e]xpand [the] availability of reliable public charging," and describes the need to

[5] See Docket No. 2016-0168, Electrification of Transportation Strategic Roadmap, filed March 29, 2018.

[6] As of mid-2019, there are approximately 9,450 passenger EVs in the State.

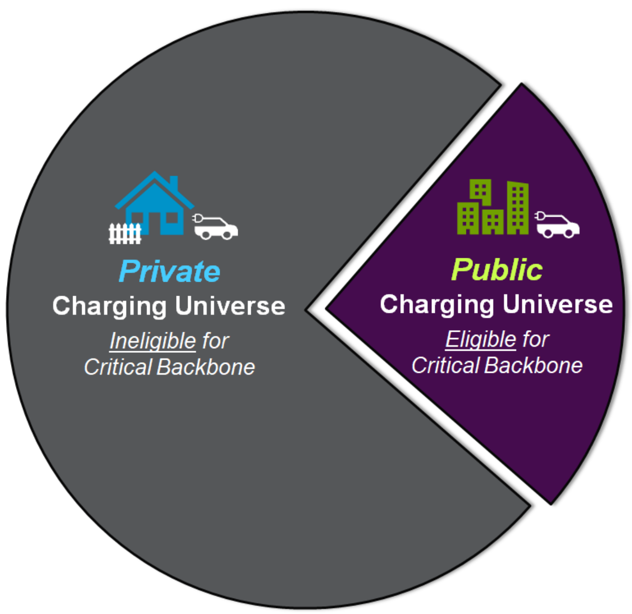
[7] Id. at 86.

identify a "critical backbone" of EV charging infrastructure to support ongoing growth in EV adoption and to reduce barriers to the adoption of EVs. As set forth in the EoT Roadmap, the Companies' primary objective role for public charging infrastructure is to begin:

> *. . . 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 ("LD 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 . . . . The Companies' initiative will also foster opportunities for third parties in the EV charging market and expects this "critical backbone" to represent a very small fraction of the public infrastructure ultimately needed to support EVs in Hawai'i.*[8]

In March 2019, the Companies issued an RFP and engaged a consultant to disaggregate the Companies' EV adoption forecast from the EoT Roadmap to develop a commensurate "EV Charging Universe" (the Universe) of private (Private Universe) and public (Public Universe) charging needs within a web-based tool. This tool can use stakeholder-reviewed selection filters that reflect EoT priorities to help identify a critical backbone of eligible public charging infrastructure (Critical Backbone) from within the Public Universe—as depicted in Figure 3—for development by the Companies.

Figure 3. EV Charging Universe – Public and Private Infrastructure



(Source: Navigant)

[8] Id. at 66.

The resulting Public Universe and Critical Backbone Planning Methodology (Backbone Methodology) implemented through the web-based Critical Backbone Tool (Backbone Tool) will serve as the basis for the Companies’ expanded role in charging infrastructure deployment. The Companies anticipate filing a network expansion filing (Network Expansion filing) by the end of the first quarter of 2020 that will draw upon the forecast results and will identify a Critical Backbone subset of the Public Universe as part of the request to expand, make permanent, and diversify the technology for the Companies’ public charging infrastructure program. The Companies intend to conduct a business case analysis, including evaluating the existing tariff rates to determine the overall cost recovery request and to develop other program details to present and review in that future filing. The Network Expansion filing will also outline the parameters for a permanent infrastructure program, including rates, administration, operation and maintenance (O&M), and outreach.

Since the Companies have not yet identified their proposed Critical Backbone subset of the Public Universe, they request that the Commission and Consumer Advocate evaluate the merits of future Critical Backbone results and proposed infrastructure program as part of the Network Expansion filing instead of the current report filing that is rather intended as an informational progress update.

Thus, the intent of this report is to provide the Commission with an informational update on the Companies’ progress on Initiative 7 of the EoT Roadmap.

2. Policy Background and Regulatory Context

2.1 Policy Background

The Companies' efforts to expand public charging infrastructure draw from the initiatives outlined in the Companies' EoT Roadmap, which support numerous state and county policies to reduce Hawai'i's dependence on fossil fuels. Furthermore, such efforts are intended to reduce barriers to EV adoption, provide long-term customer benefits, and lower customer bills in the long-run. In 2008, the state executed the Hawai'i Clean Energy Initiative (HCEI), which identified the need to transition the state to clean energy in part by integrating transportation and the electrical grid. In 2009, Act 156 stipulated state policy to aggressively promote and develop alternatives to fossil fuel modes of transportation. The HCEI Road Map (2011 Edition) laid out four strategies to achieve a 70% reduction in petroleum use from ground transportation:

- Reduction in vehicle miles traveled (VMT);
- Expansion of renewable fuels;
- Improved vehicle fleet efficiencies; and
- Expanded market share of EVs.

In 2012, the state enacted HRS § 291-71, requiring that public parking facilities with at least 100 parking spaces have at least one space dedicated for EV use and EV charging. This law also established that EVs with an EV license plate may use high occupancy highway lanes regardless of the number of passengers and exempted EV drivers from certain parking fees. In 2013, HRS § 291-72 established an Anti-ICEing law that institutes fines for conventional internal combustion engine (ICE) vehicles that park in spaces reserved for EVs. In 2015, Act 164 established 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 EV charging infrastructure in multi-family communities. A key conclusion of that report was that utilities are well positioned to help multi-family developments overcome barriers to EV infrastructure development. In 2017, each of the county mayors issued a joint proclamation to convert all public and private ground transportation to 100% renewable sources by 2045 as well as pledge to transition all of their county fleet vehicles to 100% renewable power by 2035. Earlier this year, the state passed HB 1585 (Act 142) 2019, establishing, among other things, a rebate program for the installation of eligible new or upgraded multi-user EV charging systems. Looking forward, growth in EV market share is expected to play a much larger role in achieving Hawai'i's clean energy goals and the Companies will continue to support this transition into the future.

2.2 Regulatory Context

In 2012, the Companies filed their initial request to own and operate public DCFC stations to:

- Reduce the use of fossil fuel for transportation;
- Reduce greenhouse gas emissions and overall air pollution;
- Provide public health benefits; and
- Support the integration of renewable energy.

In 2013, the Commission approved the Companies' request to own and operate public DCFC stations, establishing tariffs EV-F and EV-U. In Docket No. 2016-0168 in response to the Companies' request to extend the public DCFC pilot, the Commission acknowledged that the pilot continues to "align with clear State policy objectives related to supporting EV adoption and reducing fossil fuel use in transportation."[9] In Docket No. 2016-0168, the Commission also directed the Companies to file their Electrification of Transportation strategy.[10] In response, the Companies filed their EoT Roadmap outlining 10 key initiatives, three of which address the need to install and maintain charging infrastructure. Specifically, the evaluation of future EV demand for public charging and planning methodology supporting the expanded role of the Companies in serving demand aligns with State policy.

On December 21, 2018, Maui Electric filed an application proposing, among other things, to own and operate eight EV charging stations that are currently part of the EV DCFC EVohana network.[11] In its decision and order, the Commission noted the Companies' intent to conduct an EV charging backbone study to support their ongoing infrastructure siting efforts as well as the Companies' intent to include the existing EVohana network as part of the baseline of existing charging infrastructure on Maui. However, the Commission indicated that:

> *. . . the assumption that the eight selected EVohana stations are maintained should be removed from the backbone study. By removing this assumption, a backbone study would reflect a more accurate assessment of charging needs on Maui and better assist MECO in*

[9] Docket No. 2016-0168, Decision and Order No. 34592 filed June 5, 2017.

[10] "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; (2) how the Companies can foster opportunities within the Companies' service territory for third parties in the EV charging market; (3) how the Companies' 'Electrification of Transportation' strategy and efforts will interface with the Companies' efforts related to demand response software, programs, and planning; (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 (5) how the Companies can ensure that tariffs provide for adequate flexibility as technology, the market, and other factors evolve within the EV landscape." Id.

[11] The EVohana network consisted of 26 DCFCs and three Level 2 chargers at 13 charging stations on the island of Maui. The Maui Economic Development Board (MEDB) owns the EVohana network, which is operated and maintained by Hitachi Advanced Clean Energy Corporation (HIACE) . The EVohana network was initially operated as the "Japan-U. S. Maui Project or JUMPSmartMaui ('JUMPSmart'), funded by the New Energy and Industrial Technology Development Organization ('NEDO'), with numerous partnerships including MEDB, HIACE, the County [of Maui] and Maui Electric from 2011-2017." In 2017, NEDO transferred the network to MEDB; MEDB then contracted with HIACE to operate and maintain the network, rebranding it as EVohana. The existing contract with HIACE expired on March 31, 2019. Specifically, Maui Electric's application sought approval (1) of MECO's proposed Schedule EV-MAUI EV fast charging service tariff (Schedule EV-MAUI) and (2) to defer certain O&M expenses relating to offering such services until rates that reflect these amounts take effect in MECO's next general rate case. See Docket No. 2018-0422.

> *determining which charging stations should reasonably be maintained to provide the referenced critical backbone network. As such, the commission instructs MECO to remove from the backbone study the assumption that the eight selected EVohana network stations are maintained.*[12]

As such, the analysis contained in this report has removed the EVohana network stations from the baseline of existing charging stations. The resulting charging infrastructure forecast will provide validation for siting selections made in future planning efforts.

[12] See Docket No. 2018-0422, Decision and Order No. 36229, at 38.

3. Project Overview

3.1 Project Purpose and Objectives

The Companies commissioned Navigant Consulting, Inc. (Navigant) to perform the analysis contained in this report using its Vehicle Adoption Simulation Tool (VAST)™ Analytics Suite.[13] The VAST™ suite leverages an enhanced systems dynamics innovation diffusion model to forecast adoption of various powertrain-fuel configurations in the plug-in electric vehicle (PEV) market at the local level to inform projected EV charging equipment deployment over a specified time horizon.[14] Notably, the EoT market is still nascent within the context of the broader transportation landscape, yet market dynamics are evolving rapidly on a day-to-day basis. Recognizing the uncertainty inherent in forecasting such a nascent, tumultuous market, the analysis produced projections for 2025 and 2030 recognizing that a forecast time horizon beyond 10 years would exacerbate its inherent uncertainty, and commensurately diminish its value to the Companies' objectives.

Specifically, the Companies sought to advance the following objectives through the analysis:

- Understand the need for public charging required to support PEV adoption as provided in the Companies' forecast;
- Identify the total universe of forecast charging infrastructure needed in 2025 and 2030 in the Companies' service territories;
- Inform potential to increase the electric driving range;
- Support increased PEV charging opportunities near or at multi-unit dwellings (MUD) and workplaces;
- Develop a planning methodology that will help identify a Critical Backbone subset of public EV charging infrastructure;
- Increase use of Company-owned charging locations as well as the potential increase in stations;
- Enable grid impact or upgrade analysis; and
- Inform potential to enable grid support services.

[13] By modelling vehicle adoption based on inputs specific to a particular jurisdiction, the forecast more closely reflects local market conditions compared to national level forecasts. See Appendix E for details on the VAST™ Analytics Suite

[14] PEV includes plug-in hybrid electric vehicles (PHEVs) that include combined internal combustion engine and battery-based powertrains, as well as battery electric vehicles (BEVs) that only contain battery powertrains.

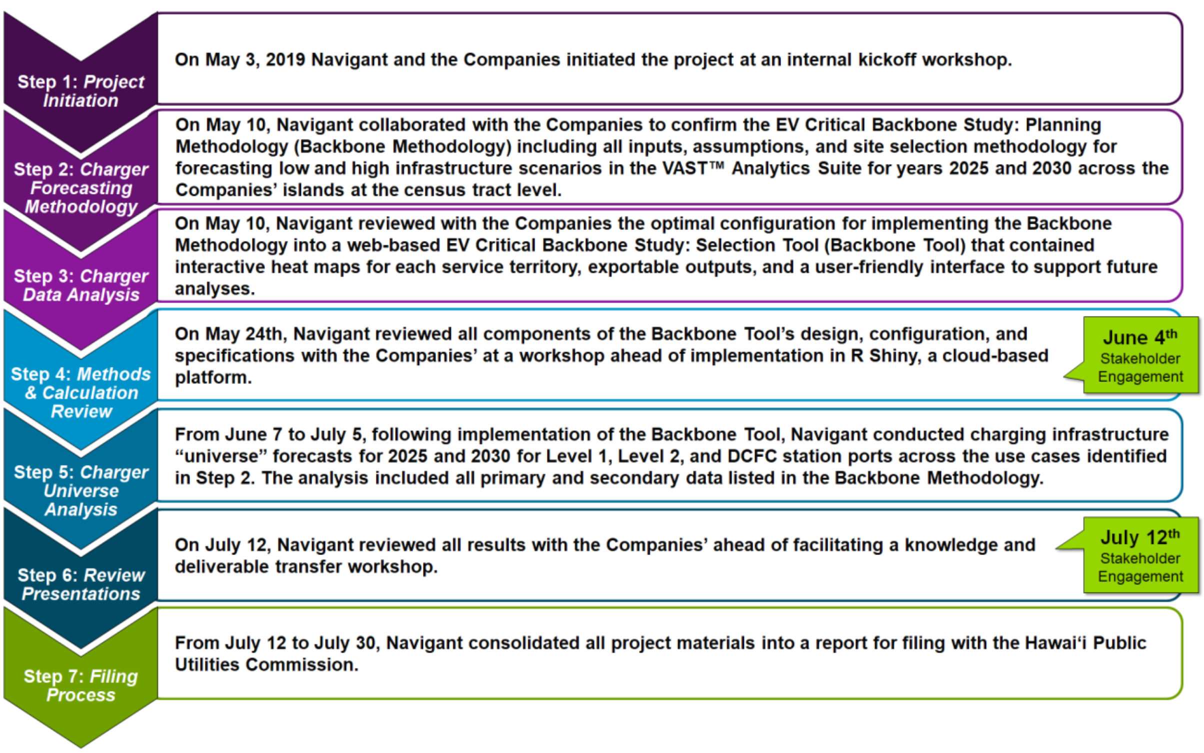
3.2 Stakeholder Value

The Companies have engaged with key external stakeholders from the onset of their participation in EV charging infrastructure planning and development. Multiple stakeholders participated in the creation of the Companies' EoT strategy, set forth in the EoT Roadmap, and have continued that participation in the development of the Backbone Methodology herein. This diverse stakeholder group has provided invaluable insight and impartial perspective in this process, creating a more robust and representative set of priorities and considerations in the development of the Backbone Methodology. In particular, the Companies incorporated stakeholder feedback on the methodology inputs and assumptions before finalizing analysis results. In addition, the stakeholders' participation provided insight that would help address near-term needs for the Companies future infrastructure filings by enabling greater community collaboration on utility planning efforts. The Companies will continue to engage with external stakeholders as part of the next phase of program development, wherein the Companies will identify a Critical Backbone in support of their public EV charging infrastructure Network Expansion request. Appendix B provides details on stakeholder engagement meetings, participation, and feedback

3.3 Project Process

Navigant performed seven key project process steps over three months to complete the analysis and reporting for the *EV Critical Backbone Study: Planning Methodology*. Figure 4 provides a project timeline with high level descriptions of each key step.

Figure 4. Project Steps and Schedule



(Source: Navigant)

3.4 Stakeholder Engagement

The Companies conducted two in-person stakeholder engagement workshops to support the project steps on June 4 (Step 4) and July 12, 2019 (Step 6). The workshops were available to off-site attendees through a web conference. Presentation materials were delivered via email to all attendees following workshop completion. The Companies held the first workshop so stakeholders could learn about the project approach and Backbone Methodology, ahead of reviewing the analysis results in the second workshop.

The process for each workshop was to report project progress, review stakeholder feedback, and refine project activities and outputs to incorporate feedback into this *EV Critical Backbone Study: Planning Methodology Report* and for consideration in a subsequent Network Expansion filing.

The June 4 workshop provided an opportunity for stakeholders to:

- Better understand the proposed methodological process (Step 2);
- Ask questions and seek clarifications; and
- Propose modifications to the Backbone Methodology.

Subsequently, the July 12 workshop provided an opportunity for stakeholders to:

- Review the finalized Backbone Methodology (Steps 3 and 4);
- Review the EV Charging Universe analysis results (Step 5); and
- Provide input on relative importance of each selection filter for the Companies' consideration in the future development of a Critical Backbone for inclusion in a Network Expansion filing (Step 6).

Following the workshops, the Companies collected stakeholder feedback on the progress reported at each workshop, reviewed data and supporting rationales provided by stakeholders, and refined relevant analytical methods or data sources. The details of that feedback, invited stakeholders, workshop attendees, and other stakeholder engagement details are included in Appendix B to this report.

4. Planning Methodology Development

In Project Steps 2, 3, and 4 of the analysis, Navigant undertook a series of activities to develop and implement a Backbone Methodology that used its VAST™ Analytics Suite and the PEV adoption forecasts from the EoT Roadmap to produce results in an interactive web-based Backbone Tool for the Companies.

This section describes the activities Navigant undertook to model the Companies' existing and planned charging ports into an EV Charging Universe necessary to support forecasted PEV usage. The Universe provides the Companies with flexibility to model a "critical backbone" using key selection filters that reflect priorities for the Companies and other stakeholders. This information is displayed in a web-based tool that allows the utility to determine which set of charging sites will comprise a "critical backbone" in the Companies' five-island service territory.

Table 1 provides an overview of the activities, by Project Process step, associated with development of the Backbone Methodology.

Table 1. Backbone Methodology Development Activities

Step	Description	Activities
Step 2: *Charger Forecasting Methodology*	On May 10, Navigant collaborated with the Companies to confirm the EV Critical Backbone Study: Planning Methodology (Backbone Methodology) including all inputs, assumptions, and site selection methodology for forecasting low and high infrastructure scenarios in the VAST™ Analytics Suite for years 2025 and 2030 across the Companies' islands at the census tract level.	1. PEV Forecast Disaggregation 2. EVSE Baseline Analysis 3. EVSE Universe Forecast 4. EVSE Universe Grid Impact Analysis
Step 3: *Charger Data Analysis*	On May 10, Navigant reviewed with the Companies the optimal configuration for implementing the Backbone Methodology into a web-based EV Critical Backbone Study: Selection Tool (Backbone Tool) that contained interactive heat maps for each service territory, exportable outputs, and a user-friendly interface to support future analyses.	5. Critical Backbone Methodology and Tool Development
Step 4: *Methods & Calculation Review*	On May 24th, Navigant reviewed all components of the Backbone Tool's design, configuration, and specifications with the Companies' at a workshop ahead of implementation in R Shiny, a cloud-based platform.	

(Source: Navigant)

Appendix B provides additional supporting detail on how Navigant and the Companies collaborated to develop the Backbone Methodology with stakeholder input for the *EV Critical Backbone Study*.

4.1 Activity 1: PEV Forecast Disaggregation

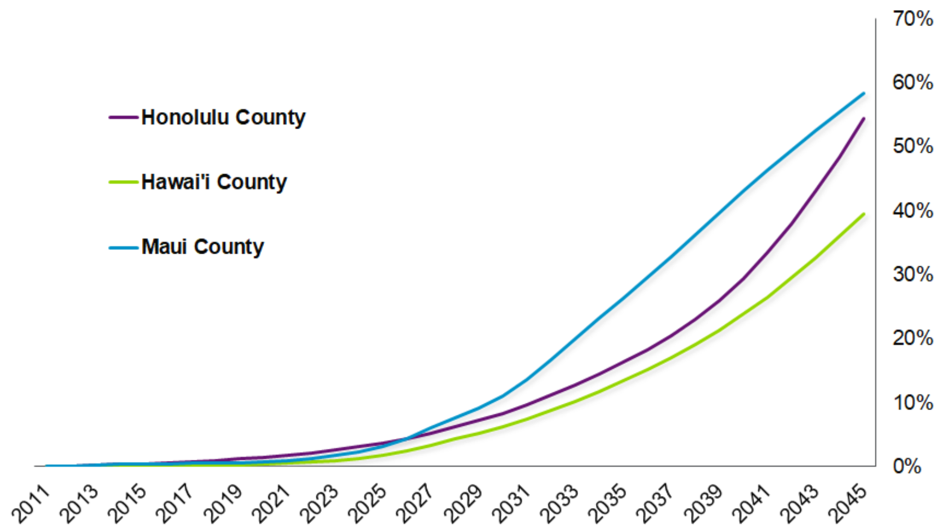
Objective

The objective of Activity 1 was for Navigant to coordinate with the Companies to adapt their existing EoT Roadmap light duty (LD) PEV adoption forecasts for use in the VAST™ suite. Specifically, Navigant needed to disaggregate the Companies' forecast to align with VAST™ data granularity requirements for forecasting locational charging needs across the islands.[15] Census tract was the selected level of granularity because any larger measurement unit than census tract does not provide sufficient granularity by island relative to population density and trip distance. Moreover, any smaller measurement unit does not align with Department of Motor Vehicle (DMV) data for PEV registrations or US Census demographic data that are key inputs to VAST™. Consequently, no larger or smaller unit of measurement was viable for completing the analysis.

Approach

To complete this activity the Companies provided Navigant with the LD PEV forecast by island that included reference, low, and high scenario projections through 2045 from the EoT Roadmap. Figure 5 reflects the reference case developed by the Companies for the EoT Roadmap.

Figure 5. The Companies' EoT Roadmap PEV Forecast (Reference Case by County)



(Source: The Companies)

Importantly, this forecast did not distinguish between PEV powertrains, vehicle ownership (individual or fleet), or vehicle class (passenger car or light truck)—all requirements for VAST™ to develop charger counts and estimate energy impacts. For compatibility with VAST™, Navigant needed to disaggregate the EoT Roadmap PEV forecast to produce an Adapted Forecast.[16]

---

[15] See Docket No. 2016-0168, Electrification of Transportation Strategic Roadmap, filed March 29, 2018.

[16] Navigant-adapted EoT Roadmap PEV adoption projections including reference, high, and low forecasts for 2025 and 2030.

To produce this forecast, Navigant and the Companies aligned on the dimensions, or data requirements, for the VAST™ model inputs—including geography granularity, PEV powertrains, vehicle ownership, and vehicle class—to produce outputs at the island and census tract levels.[17] Navigant then used the VAST™ model to calculate adoption forecasts across the PEV powertrain, vehicle ownership, and vehicle class dimensions at the island level. Navigant applied the VAST™ projections by dimension to the EoT Roadmap's Lānaʻi, Maui, Moloka'i, O'ahu, and Hawai'i Island PEV forecasts to determine the disaggregated number of registrations by vehicle type at the census tract level.[18] Navigant then disaggregated this forecast by census tract based on income, education, and historic PEV penetration in each census tract.[19] The resulting Adapted Forecast was used as an input for subsequent activities. As a quality control measure, Navigant and the Companies examined heatmaps of the Adapted Forecast to ensure the vehicles were correctly distributed among the islands.

Outputs

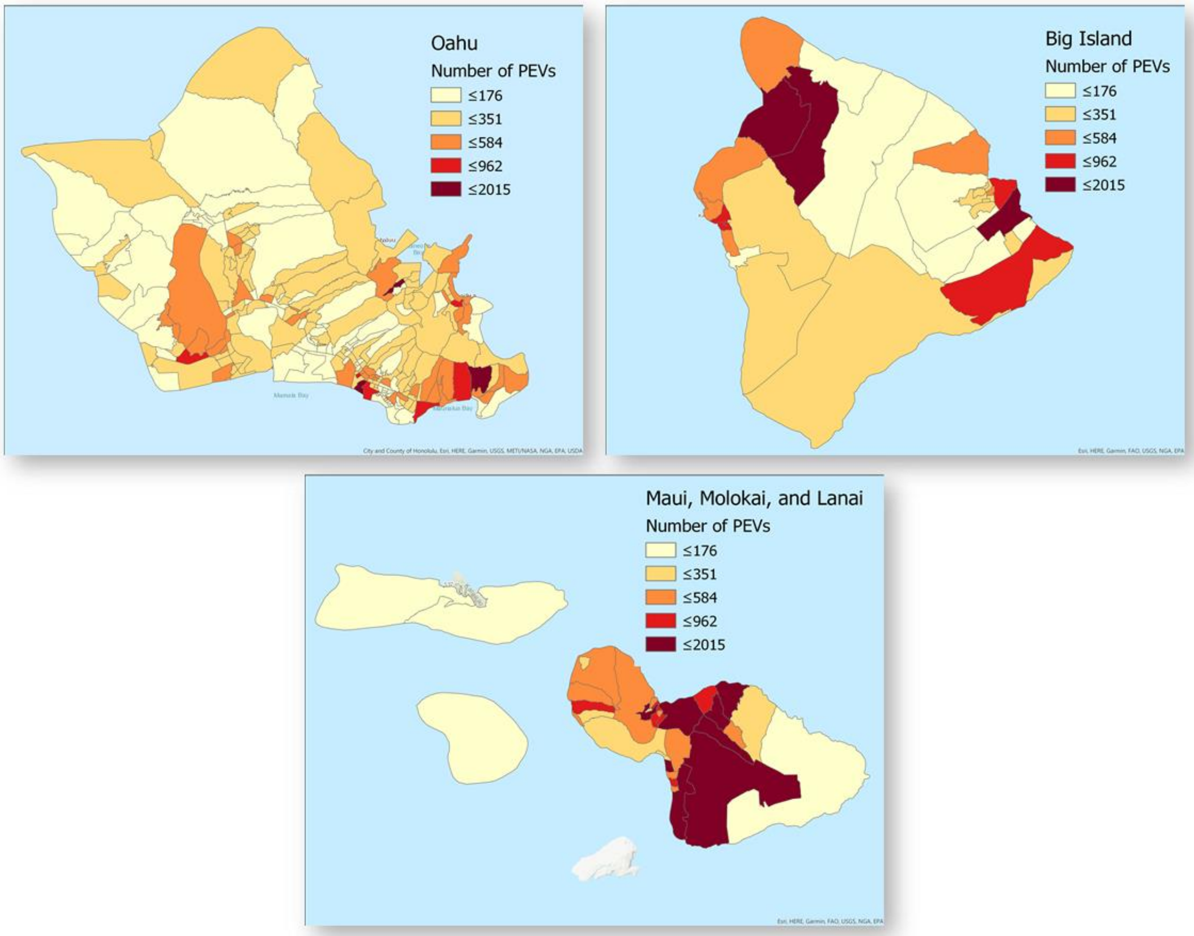
The Adapted Forecast heatmaps in Figure 6 represent census tract-level data for each county for the reference scenario in the year 2030. The color of each census tract indicates the number of PEVs registered in that tract in 2030. These outputs were subsequently used in Activity 2.

[17] The Companies provided a shape file with island, census tract, and operating Company geographic boundaries.

[18] Navigant determined the proportion of vehicle type combinations (powertrain, owner, and class) associated with each island's census tracts, with these proportions summing to 1.

[19] To check these disaggregated figures, Navigant ensured the number of PEV registrations matched expectations by reviewing demographics such as income and population for randomly selected census tracts. To adapt Navigant's census tract-level forecast to the Companies' adoption figures, Navigant multiplied VAST™ breakout values (between 0 and 1) by the Companies' PEV forecast for each island. This resulted in census tract registrations by vehicle-type which, summed to the island level, matched the Companies' PEV forecast for each scenario.

Figure 6. Adapted Forecast – PEV Forecast Disaggregation 2030 by County



(Source: Navigant)

For Adapted Forecast PEV disaggregation results in 2030 by county on a per-capita basis, see Appendix A.

4.2 Activity 2: EV Charging Baseline Analysis

Objective

The objective of Activity 2 was to develop a baseline of existing EV charging sites—i.e., existing[20] and Company-planned[21] charger sites[22]—for comparative analysis relative to those that would be forecast in Activity 3 according to island, charger ownership,[23] and charging technology type—i.e., Level 1, Level 2, and DCFC. Navigant's VAST™ model provided charger estimates and sites by technology type. These charging types have distinct inputs in the utilization and load forecasting analysis, such as charging time, power usage, and expected charger-to-vehicle ratios.

Approach

Navigant examined data from the Alternative Fuels Data Center (AFDC) along with input from the Companies to curate a database of existing public charging infrastructure to analyze in VAST™. This data at the latitude/longitude level along with VMT data were key inputs into VAST™, which was used in Activity 3 to locate new chargers among existing gaps. Yearly VMT estimates were leveraged from the Federal Highway Administration (FHWA) as were data from FHWA for average annual daily traffic (AADT). These values provide a discrete locational estimate of VMT, which VAST™ uses as an input for charging demand. VMT was also an input to the grid impact analysis to calculate vehicle annual energy consumption. Notably, the legacy JUMPSmart Maui program sites on Maui were excluded from the baseline of existing sites to test their value within the total Universe of forecast charging infrastructure needed in 2025 and 2030 in the Companies' service territory.[24]

In the baseline analysis, the VAST™ model indicated additional charging sites were needed to satisfy current EV charging demand for several islands and scenarios. In those situations, Navigant determined the potential locations for additional charging sites based on use cases and the hybrid objective function described in Activity 3. Specifically, home charging locations were based on registration locations, workplace charging incorporated employee counts, and market charging included traffic flow.[25] In addition, parking lots of greater than 100 spaces include a charging site based on direction from the Companies.

After establishing the baseline of existing and Company-planned EV charging sites, Navigant then collaborated with the Companies to formulate charging use cases to address the Companies' charging infrastructure network gaps by charging type and location. Use case refers to the type of charging location included in the model, as well as the availability of that location to public access, as defined in Table 1.

---

[20] See Alternative Fuels Data Center, US Department of Energy, available at https://afdc.energy.gov/.

[21] See Docket No. 2016-0168, Electrification of Transportation Strategic Roadmap, filed March 29, 2018.

[22] Charging sites refer to the locations where individual ports connect to the grid, whereas ports describe the part of a charger that plugs into a PEV. A single charging site can have multiple ports.

[23] Navigant categorized charger ownership as either public or private. Public chargers were accessible to all PEV drivers, while private chargers were considered behind the fence, and only available to certain individuals, such as workplace employees and MUD tenants.

[24] See Docket No. 2018-0422, Decision and Order No. 36229, at 38.

[25] Navigant assumed that a portion of PEVs registered to single-unit dwellings possessed Level 1 charging at their residence, along with a portion of multi-unit dwellings.

Using information on the existing public charging network from Activity 1 and input from stakeholders during and following a workshop on June 4, Navigant and the Companies identified expected use cases that would be incremental to the baseline charging use cases in VAST™.[26] These incremental use cases included tourist destinations, Honolulu Authority for Rapid Transportation (HART) rail stations, shared single-family, and LD fleet chargers. During this activity, Navigant collected data from the Companies and other external sources for use in Activity 3 to project potential charging station locations for the incremental use cases.

Outputs

The key output from this activity was the existing EV charging baseline in the tri-Company service territories and a finalized set of use cases to include in Activity 3. Table 1 provides the final list of use cases including definitions and examples, with additional data and sources available in Appendix C.

Table 1. Final Use Cases

Use Case	Definition	Example
Market	Public chargers that are driven by traffic demand, sited in public areas where PEV drivers are likely to be driving frequently.	A charger installed in the parking lot of a grocery store in a busy area of town.
Tourist Destinations	Public EV charging sites that allow for travel between major destination areas, and not based strictly on vehicle traffic.	A charger at a public beach parking that is off the beaten track where tourists take longer than average trips to reach.
Rail Station	Public EVSE sites located in the parking lots of HART rail stations. This use case is only present on the island of Oʻahu.	A charger installed in the public parking lot where commuters park to catch the train to work.
Light-Duty Fleet	Depot chargers used by light-duty fleet vehicles, including government and rental car fleets.	A charger located in the private parking lot where a fleet of vehicles is parked overnight.
Single-Unit Dwelling	Home chargers installed in the driveway or garage of a single-unit dwelling and used only by the occupant of that dwelling.	A charger installed in the garage of a residential single-family home.
Shared Single-Unit Dwelling	Shared home chargers located in residential areas where homes are not likely to be able to install their own charger.	A curbside charger installed in a neighborhood of older homes that do not have garages.
Multi-Unit Dwelling	Home chargers installed in the garage of a multi-unit dwelling and used only by the occupants of that dwelling.	A charger installed in a private garage of an apartment building where only tenants are allowed to park.
Workplace	Chargers sited at a workplace and only available to employees of that workplace.	A charger installed in a private garage of an office building where only employees are allowed to park.

(Source: Navigant)

[26] The baseline set of VAST™ use cases is public, workplace, multi-family, and single-family. These use cases were expanded based on stakeholder feedback to provide the basis for charger siting across the islands. See Appendix C for details on each use case.

4.3 Activity 3: EV Charging Universe Forecast

Objective

The objective of Activity 3 was to use VAST™ to map charging locations based on use cases for 2018, 2025, and 2030.

Approach

To complete this activity, Navigant modeled 2025 and 2030 charger counts by census tract for the use cases developed in Activity 2 based on charger-to-vehicle ratios from the National Renewable Energy Laboratory's (NREL) Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite and the Adapted Forecast from Activity 1.[27]

EVI-Pro Lite provided state-level estimates for the number of ports needed to support the expected number of EVs from the Adapted Forecast. Navigant used EVI-Pro Lite to calculate the ratio of chargers to vehicles for Workplace Level 2, Public Level 2, and Public DCFC chargers in 2030.[28] Inputs included the following:

- Vehicle count to support with charging infrastructure (sourced from the Adapted Forecast)
- Vehicle mix (PHEVs vs. BEVs, sourced from the Adapted Forecast)
- Assumption of full support or partial support for PHEVs (Navigant used full support)
- Ratio of drivers that have access to home charging (assumed 85% based on Hawaiian Electric Company customer survey data)[29]

Navigant subsequently calculated charger-to-vehicle ratios for each year by interpolating an S-curve between the initial ratios (from vehicle registration data and AFDC existing charger data) and final ratios (from NREL EVI-Pro Lite). Charger-to-vehicle ratios were used to calculate the number of ports expected to meet the vehicle demand on each island.

The analysis then relied on GIS Network Analysis functions within VAST™ to optimally place the estimated population of chargers throughout the islands. To place charging sites to meet the expected number of EVs, Navigant and the Companies aligned on a hybrid approach using two types of objective functions (depending on the island): either target market share[30] or minimize facilities.[31] This hybrid

[27] See Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite, National Renewable Energy Laboratory, available at https://afdc.energy.gov/evi-pro-lite.

[28] Navigant assumed that a portion of PEVs registered to single-unit dwellings possessed Level 1 charging at their residence, along with a portion of multi-unit dwellings. The EVI-Pro Lite analysis did not include Level 1 charging as the low charging rate and commensurately low energy sales is not widely considered viable for public charging: https://www.energy.gov/eere/electricvehicles/vehicle-charging.

[29] Trans No. 13-07, Attachment A at 24, filed March 29, 2018

[30] The first objective function, target market share, chooses location and minimum number of facilities to reach a specified target market share; this translates to choosing the minimum number of EV charging sites to meet a specified share of EVMT (electric vehicle miles traveled) demand. This objective function solves the competitive facility location problem and uses gravity model concepts to determine demand allocation to each facility. Appendix C includes further detail.

[31] The second objective function, minimize facilities, chooses facilities such that as many traffic data points as possible are within the road network distance cutoff defined are allocated to charging sites. For example, a cutoff distance of two miles would result in EV traffic demand within two miles of a site being allocated to that site. In addition, the number of sites required to cover all traffic data points is minimized. The objective function operates under the assumption that EV traffic at any specific point on the road network is assumed to charge from its nearest charging site only. Appendix C includes further detail.

objective function approach aimed to balance the need across islands to maximize both utilization and coverage to support market development and geographical space constraints.

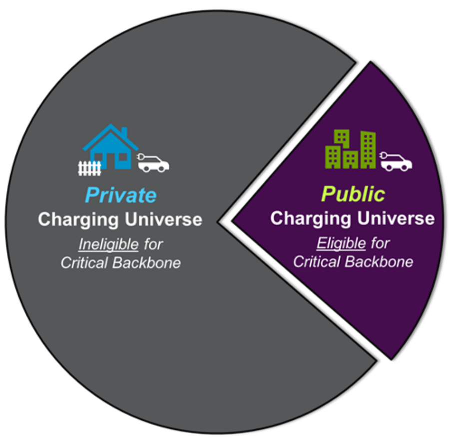
Finally, VAST™ allocated charging ports to census tracts based on the total weight of sites located by census tract described in Activity 1—that is, vehicle registrations for home charging, employee counts for workplace charging, and traffic demand weight for public charging. The resulting EV charging sites were aggregated to the census tract level to be used to develop the Backbone Tool in Activity 5.

Outputs

The resulting forecast from this activity constitutes the Universe of private and public chargers. Universe refers to all of the charging ports Navigant modeled based on the Adapted Forecast, and the VAST™ census tract-level charging output. These ports were categorized according to use case, technology, and ownership (public or private).[32] Thus, the Critical Backbone is a selected portion of the public charging ports within the full Universe, as depicted in Figure 7.

Figure 7. The EV Charging Universe – Private, Public, Critical Backbone

EV Charging "Universe"



Private & Public Accessibility

Private	Public
Description	
Private chargers are considered ***"behind the fence"*** and only accessible by certain groups of PEV drivers	Public chargers are accessible to all PEV drivers, i.e. ***"not behind the fence"***
Examples	
• Residential home charging • Workplace employees charging on private lots • MUD tenants charging in underground parking lots • Fleet charging	• Curbside charging • Charging at retail parking lots (i.e. grocery stories; • Tourist destinations • Rail stations

(Source: Navigant)

Section 5 provides a comprehensive view of the Universe by island, scenario, and technology type through 2030. Notably, the Universe outputs from Activity 3 illustrated differences between current and projected EV charger counts at the island level, providing comparative insights into gaps in potential network size relative to current coverage for inclusion in Activities 4 and 5.

[32] The EV Charging Universe of ports is used in the Backbone Tool that allows the utility to select a Critical Backbone based on specific criteria as described in Appendix C.

4.4 Activity 4: EV Charging Universe Grid Impact Analysis

Objective

The objective of Activity 4 was to develop estimated charging load profiles segmented by use case and charging technology type to produce rated kilowatt (kW)—or electrical peak loading—for each charger in the Public Universe only (as the Private Universe is not in scope for Critical Backbone calculations) using VAST™ for inclusion in the Backbone Tool.[33]

Approach

To complete this activity, Navigant blended load profiles from the Companies, NREL, and an EV supply equipment (EVSE) manufacturer to develop hourly charging profiles by day type and month, normalized according to expected utilization, for the following dimensions:

- Technology type (Level 1, Level 2, or DCFC);
- Use case (market, tourist destinations, rail station, LD fleet, single-unit dwelling, shared single-unit dwelling, multi-unit dwelling, workplace);
- Ownership (public or private); and
- Day type (weekday or weekend).

Navigant forecasted load shapes for the Public Universe in 2025 and 2030 using DCFC charging load profiles from existing chargers in the Companies’ service areas and other normalized load profiles. Expected vehicle annual energy consumption determined the forecast scale of final load profiles.

Navigant then modeled overall grid impacts associated with future PEV registrations and use cases based on expected rated kW increases for charging technology, port counts, and a blend of load profiles.

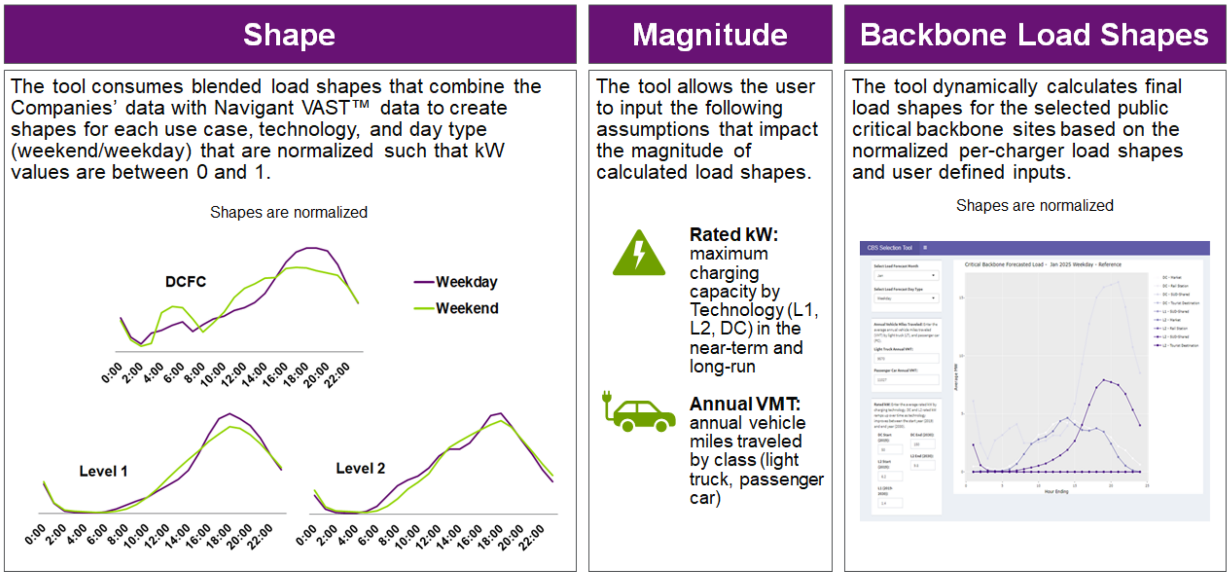
Additionally, Navigant added functionality to the Backbone Tool to display load profile forecasts that are dynamically calculated for any Critical Backbone selection. See Appendix C for further detail on the load shapes.

Outputs

The key output from this activity was estimated charging load profiles segmented by use case and charging technology type as depicted in Figure 8 to include in the Backbone Tool during Activity 5.

[33] Rated kW is the maximum demand (kW) of a given charger. Rated kW varies by technology level (L1, L2, DCFC), and is assumed to increase over time as charging technology progresses and new chargers are installed, or old chargers are replaced (assuming a 10-year measure life). Rated kW is a dynamic assumption in the Backbone Tool that the utility can adjust and impacts the resulting load profiles.

Figure 8. Backbone Tool EV Charging Load Shapes



4.5 Activity 5: Critical Backbone Methodology and Tool Development

Objective

The objective of Activity 5 was to deploy a planning methodology for identifying the Critical Backbone from the Public Universe using selection filters in a web-based Backbone Tool.[34]

Approach

In this activity, Navigant, the Companies, and stakeholders collaborated on key priorities for selecting, or filtering, Critical Backbone chargers among the Public Universe.

Selection Filters

Navigant developed selection filters at the census tract level to allow the utility flexibility in selecting which subset of chargers from the Public Universe could make up a Critical Backbone in either 2025 or 2030. Each selection filter uses a quintile-based scale to indicate the threshold for inclusion of a census tract in the Critical Backbone. The scale for each filter is based on the units being measured by the filter. For example, a Multi-unit Dwelling percentile of 20% indicates inclusion of the census tracts with lowest MUD density. The utility can adjust each selection filter to select desired segments along each scale to reflect desired priorities when choosing the Critical Backbone. Calculation of selection filters at the census tract level enables a given census tract to be entirely included or entirely excluded based on the quintiles chosen for each selection filter. Notably, it would not be possible to select only a portion of a census tract. Navigant collected and aggregated data for each of the priority selection filters listed in Table 2 that allow the Companies to filter the Public Universe of chargers down to the Critical Backbone.

[34] Selection filters enable the utility to screen out EV charging from a geographic region (i.e., census tract) from the Universe based on an area's unique characteristics. Navigant and the Companies determined the criteria described in Table 2 would comprise selection filters to identify the Critical Backbone; for further detail on these selection filters please refer to Appendix C.

Table 2. Selection Filter Descriptions

Selection Filter	Definition	Data Point (Source)
Multi-Unit Dwelling	Indicates the level of public charging supporting access for multi-unit dwellings .	MUD household concentrations (American Community Survey 2017)
Low Income	Indicates a given census tract's proportion of low-income residents	Income categories (American Community Survey 2017)
Utilization	Indicates the level of public charging supporting market making, population density, revenue potential	Average annual daily traffic by road segment (Federal Highway Administration)
Range Support	Indicates the level of public charging supporting longer distance trips	Distance between chargers (Navigant VAST™ Analytics Suite)
Development Cost	Indicates the expected level of investment required to install an EVSE in a given census tract due to required updates to the grid (inverse of Grid Support concept)	Grid excess capacity (the Companies forecasted capacity and peak demand for 2025 and 2030)
Grid Support	Indicates the opportunity for resiliency support through managed charging potential (inverse of Development Cost concept) .	Grid constraints (the Companies forecasted capacity and peak demand for 2025 and 2030)

(Source: Navigant)

For additional detail on selection filters, see Appendix C.

<u>Stakeholder Input and Data Collection</u>

Navigant collaborated with the Companies to incorporate stakeholder feedback in developing the final Backbone Methodology. Navigant provided a summary of the draft Backbone Methodology, including draft selection filters, for input at a July 12 external stakeholder workshop. Navigant collaborated with the Companies to collect supporting data from internal and external stakeholders for use in implementing the Backbone Methodology through a web-based Backbone Tool.

<u>Tool Design</u>

The final Backbone Methodology was implemented in a web-based Backbone Tool to enable the Companies to iteratively explore many possibilities for the final Critical Backbone. Design requirements included the following:

- Web-based tool with interactive heatmap of each of the Companies' service territory locations;
- Exportable outputs with dimensions aligned to the Companies' reporting and planning needs;
- User-friendly interface with the ability to support the Companies' future analyses; and
- Set of adjustable filters the Companies can use to determine the Critical Backbone.

Tool Development

Navigant implemented the Backbone Tool design in R Shiny. R Shiny was chosen based on the following attributes:

- **Secure and accessible:** Credentialed users can view the tool on any web browser through a custom URL.
- **Hosted in the cloud:** RStudio provides cloud hosting services so there is no need for hosting on the Companies' servers.
- **Compatible with R analysis:** The dashboard is powered by R, the software performing the VAST™ calculations.

Reporting

Navigant collaborated with the Companies on compiling the Backbone Methodology and Tool inputs, assumptions, methods, results, and stakeholder feedback into the *EV Critical Backbone Study: Planning Methodology Report* for filing with the Commission. Navigant provided the Companies with access to the Backbone Tool and a User Guide for conducting Critical Backbone selection analysis in the Backbone Tool.[35]

Outputs

The key outputs from this activity included the following:

- **EV Critical Backbone Study: Planning Methodology (Backbone Methodology)**
  - The Backbone Methodology helps identify a subset of the Public Universe to be owned and operated by the Companies. Only public chargers are candidates for inclusion in the Critical Backbone.
- **EV Critical Backbone Study: Selection Tool (Backbone Tool)**
  - The Backbone Tool is a web-based tool that allows the utility to select the subset of the Public Universe that makes up the Critical Backbone. The Backbone Tool features six selection filters that are used to prioritize the characteristics of chargers selected into the Critical Backbone. Furthermore, the Backbone Tool provides data and insights into the entire Universe, both public and private chargers, by allowing the utility to access and download the entire forecast dataset.
- **EV Critical Backbone Study: Selection Tool User Guide (User Guide)**
  - The User Guide is intended as a standalone document to assist the utility in understanding and using the Backbone Tool. It includes background information on the

[35] See Appendix C for the User Guide.

forecast dimensions and Backbone Methodology, along with the selection filters available in the tool. More details on the User Guide can be found in Appendix C.

- **EV Critical Backbone Study: Planning Methodology Report (Report)**
  - The report is an external-facing written description of all finalized forecasting methodologies, key inputs, stakeholder feedback, output results, and conclusions, including citations and key assumptions and commensurate rationale.

5. EV Charging Universe Results

In Step 5 of the analysis, following implementation of the Backbone Tool, Navigant produced a reference EV Charging Universe forecast for 2025 and 2030 for Level 1, Level 2, and DCFC station ports across the selected use cases. As discussed in Section 4, the Adapted Forecast included high and low forecasts through 2030. Consequently, Navigant also calculated high and low Universe scenarios through 2030 based on the Adapted Forecast. The resulting Universe of forecast charging ports reflects the latest stage of the Companies' iterative forecasting process, which will continue to evolve over time.

5.1 EV Charging Universe: A Brief History

The following is a brief history of the Universe described in Section 4 to provide context for interpreting the results in this section:

- The Universe consists of public and private charging ports through 2030 based on the Adapted Forecast, as described in Section 4.1.
- This latest enhanced approach taken by the Companies enables increased granularity across EV charging geographic and energy/demand dimensions, as described in Section 4.2.
- The Critical Backbone is a selected portion of the public charging ports within the full Universe, as described in Section 4.5.
- This approach also supports the Companies' ability to select a subset of the total Universe using criteria based on six selection filters, as described in Section 4.5.
- Selection filters screen out EV charging from a geographic region (i.e., census tract) from the full universe based on the particular area's unique characteristics, as described in Section 4.5.
- Further, this approach enables the Companies' collection of input from stakeholders on priorities for consideration in a future Network Expansion filing, as described in Section 1.

5.2 EV Charging Universe Results: Reference Case

This section provides a comprehensive view of the Private and Public Universe results by island, scenario, and technology type—i.e., Level 1, Level 2, direct current fast charge— through 2030.

In addition to private and public accessibility, the forecast includes deeper granularity by technology type and use case as described in Section 4.2.

Table 3 provides the granular 2030 Universe by island, technology type and use case.

Table 3. 2030 EV Charging Universe Results by Island, Technology Type and Use Case –Reference Case [36]

Island	Technology /Use Case	Private Universe				Total Private Universe	Public Universe				Total Public Universe
		Light-Duty Fleet	Multi-Unit Dwelling (MUD)	Single-Unit Dwelling (SUD)	Workplace		Market	Rail Station	Shared-SUD	Tourist Destination	
Hawaiʻi Island	Level 1	-	8	707	-	715	-	-	3	-	3
	Level 2	42	197	6,370	390	6,999	431	-	103	2	536
	DCFC	46	41	-	-	87	71	-	25	-	96
Lānaʻi	Level 1	-	-	5	-	5	-	-	-	-	-
	Level 2	3	2	41	10	56	2	-	2	1	5
	DCFC	3	1	-	-	4	-	-	-	-	-
Maui	Level 1	-	21	1,010	-	1,031	-	-	6	-	6
	Level 2	82	525	9,126	444	10,177	315	-	145	6	466
	DCFC	92	111	-	-	203	52	-	30	1	83
Molokaʻi	Level 1	-	-	10	-	10	-	-	-	-	-
	Level 2	1	3	85	9	98	11	-	2	1	14
	DCFC	-	-	-	-	-	2	-	1	-	3
Oʻahu	Level 1	-	66	2,217	-	2,283	-	-	17	-	17
	Level 2	234	1,715	19,907	2,571	24,427	1,389	46	612	-	2,047
	DCFC	263	362	-	-	625	238	9	128	-	375
Total Ports		766	3,052	39,478	3,424	46,720	2,511	55	1,074	11	3,651
Percent of Total Ports		2%	6%	78%	7%	93%	5%	0%	2%	0%	7%

Table 3 demonstrates that the clear majority of charging ports in 2030 appear in the privately-accessible portion of the universe (46,720 or 93%) relative to the Public Universe (3,651 or 7%). The table also indicates that Single-unit Dwelling comprises the largest share of charging ports among the use cases (78%) in 2030, followed by Workplace (7%) and Multi-unit Dwelling (6%), with Rail Station and Tourist Destination accruing the smallest shares of ports (<1%). EV Charging Universe results for 2025 are available in Appendix G.

Table 4 provides a different view of the granular 2030 Universe by technology type and use case.

Table 4. 2030 EV Charging Port Universe by Technology Type – Reference Case

Technology /Use Case	Private Universe				Total Private Universe	Public Universe				Total Public Universe	Percent of Total
	Light-Duty Fleet	Multi-Unit Dwelling (MUD)	Single-Unit Dwelling (SUD)	Workplace		Market	Rail Station	Shared-SUD	Tourist Destination		
Level 1	-	95	3,949	-	4,044	-	-	26	-	26	8%
Level 2	362	2,442	35,529	3,424	41,757	2,148	46	864	10	3,068	89%
DCFC	404	515	-	-	919	363	9	184	1	557	3%

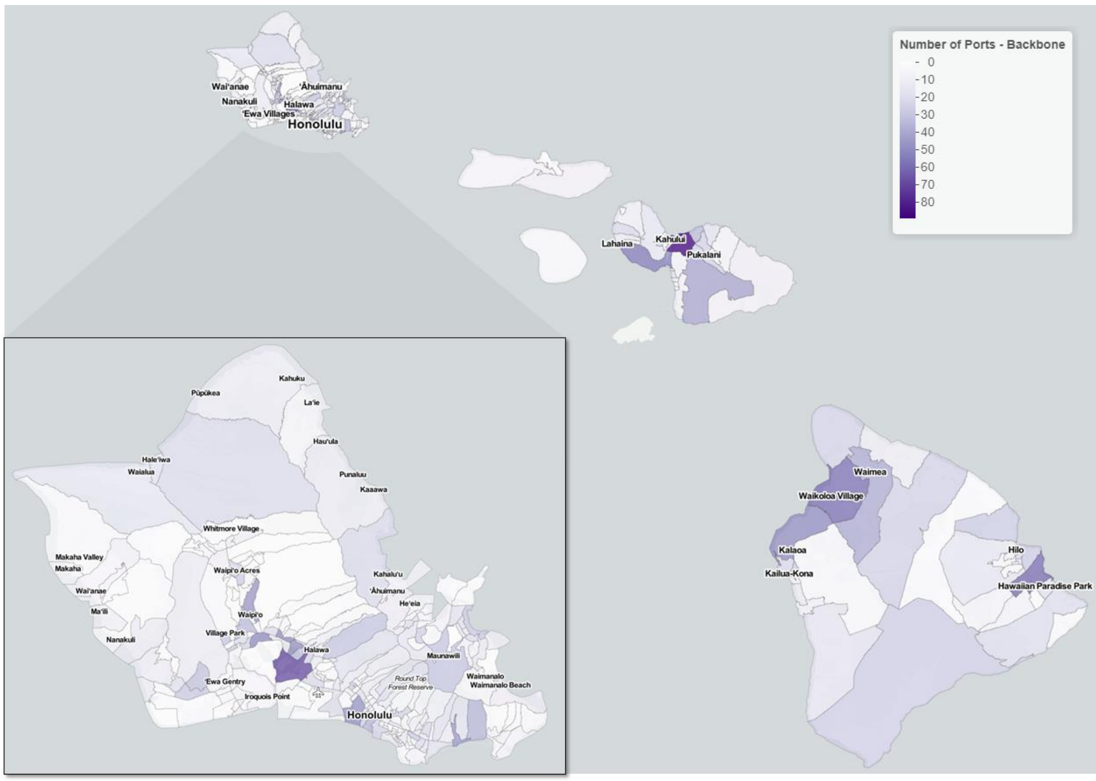
By technology type, in 2030 over 97% of charging ports are projected to be Level 1 and Level 2, while less than 3% are DCFC.

[36] A full data extract of the EV Charging Universe can be found in Appendix F.

5.3 Public Universe Results

As discussed in Section 4.5, and depicted in Figure 7, the Public Universe would be the focus of a Critical Backbone analysis. Figure 9 depicts total 2030 public charging port needs, by census tract, based on the Adapted Forecast reference case. The figure provides charging port counts based on variances in projected PEV adoption, demographics, and traffic patterns.

Figure 9. 2030 Public Universe Results by Island – Reference Case



Within the 2030 Public Universe, Table 5 depicts charging port needs, by island and technology type, for high and low scenarios, across use cases based on the Adapted Forecast high and low cases for PEV adoption.

Table 5. 2030 Public Universe Results by Island, Technology Type and Use Case – High & Low Scenarios

Public Univese											
Island	Technology /Use Case	2030 High Scenario				Total High Scenario Ports	2030 Low Scenario				Total Low Scenario Ports
		Market	Rail Station	SUD-Shared	Tourist Destination		Market	Rail Station	SUD-Shared	Tourist Destination	
Hawai'i Island	Level 1	-	-	4	-	4	-	-	1	-	1
	Level 2	621	-	133	2	756	234	-	49	2	285
	DCFC	101	-	31	-	132	42	-	10	-	52
Lāna'i	Level 1	-	-	-	-	-	-	-	-	-	-
	Level 2	4	-	2	1	7	1	-	1	1	3
	DCFC	1	-	1	-	2	-	-	-	-	-
Maui	Level 1	-	-	6	-	6	-	-	1	-	1
	Level 2	451	-	195	6	652	173	-	80	6	259
	DCFC	76	-	41	1	118	29	-	19	1	49
Moloka'i	Level 1	-	-	-	-	-	-	-	-	-	-
	Level 2	17	-	3	1	21	6	-	1	1	8
	DCFC	3	-	1	-	4	2	-	-	-	2
O'ahu	Level 1	-	-	31	-	31	-	-	4	-	4
	Level 2	2,004	69	920	-	2,993	768	28	356	-	1,152
	DCFC	341	12	197	-	550	130	4	72	-	206
Total Ports		3,619	81	1,565	11	5,276	1,385	32	594	11	2,022
Percent of Total Ports		69%	2%	30%	0.2%	100%	68%	2%	29%	1%	100%

The Public Universe results suggest the most dramatic public charging needs for the Market (up to 69% of ports) and Shared Single-unit Dwelling (up to 30% of ports) use cases in 2030, particularly on O'ahu. Maui and Hawai'i Island show similar needs—albeit at lower port counts than O'ahu—while Lāna'i and Moloka'i are projected to have limited charging needs at all technology types and use cases through 2030.

Public Universe results for 2025 are available in Appendix G.

Table 6 provides a granular view of the Public Universe by technology type and use case in both high and low scenarios for 2030.

Table 6. 2030 Public Universe Results by Technology Type and Use Case – High & Low Scenarios

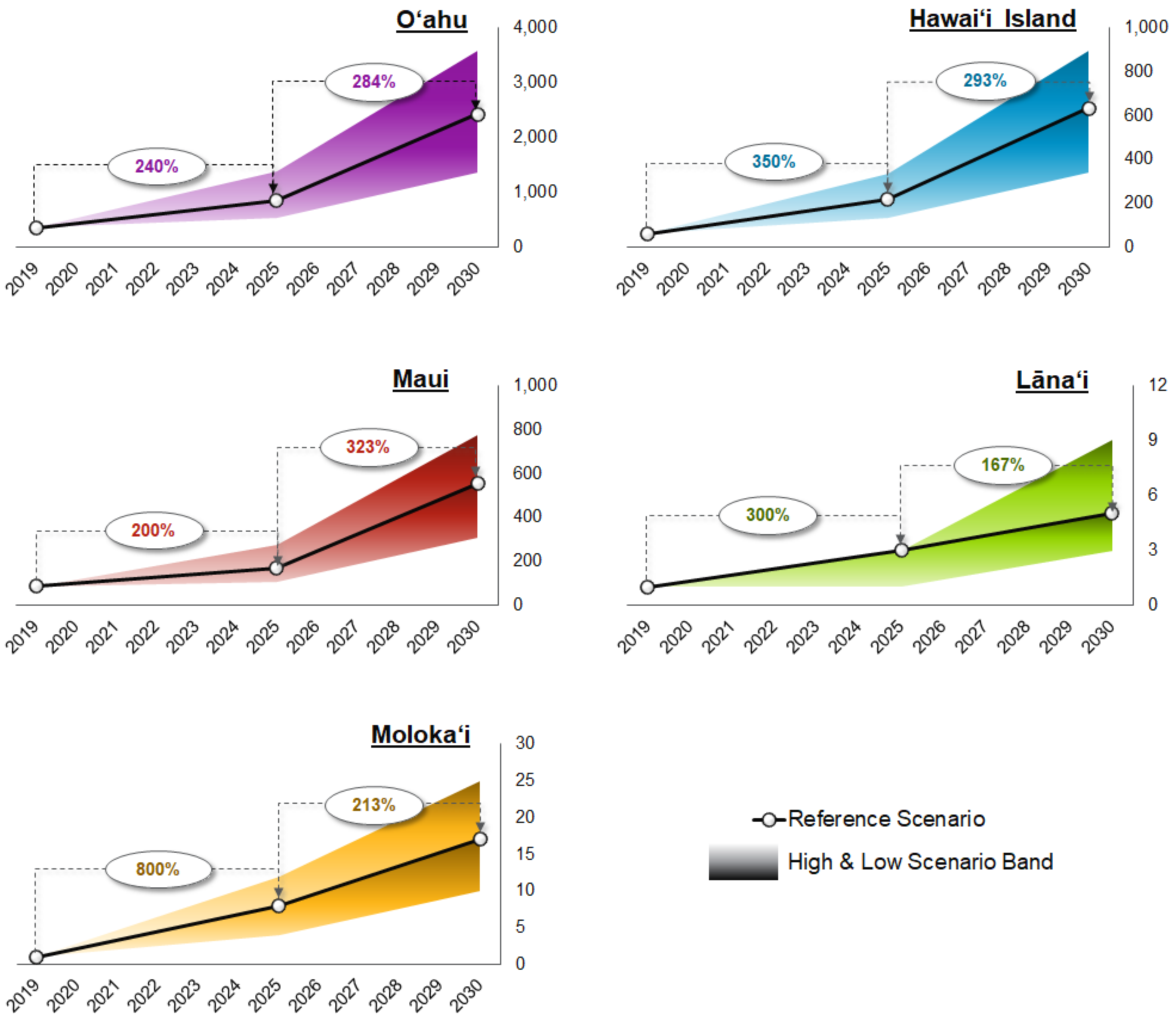
Technology /Use Case	2030 High Scenario				Total High Scenario Ports	Percent of Total
	Market	Rail Station	SUD-Shared	Tourist Destination		
Level 1	-	-	41	-	41	0.8%
Level 2	3,097	69	1,253	10	4,429	84%
DCFC	522	12	271	1	806	15%

Technology /Use Case	2030 Low Scenario				Total Low Scenario Ports	Percent of Total
	Market	Rail Station	SUD-Shared	Tourist Destination		
Level 1	-	-	6	-	6	0.3%
Level 2	1,182	28	487	10	1,707	84%
DCFC	203	4	101	1	309	15%

The technology type results indicate that approximately 85% of Public Universe charging port needs are Level 1 and Level 2, while roughly 15% of port needs are DCFC.

Figure 10 provides a time-segmented view of the Public Universe for 2025 and 2030. From this perspective Moloka'i and Hawai'i Island see the largest percentage gains in ports by 2025 due to low port populations in 2019, with Maui seeing the largest gains after 2025.

Figure 10. 2019 to 2030 Public Universe Results by Island – High & Low Scenario Growth



6. Planning Tool Sensitivity Test

During Step 5 Navigant developed a set of sensitivity tests leveraging the selection filters to support the stakeholder feedback process.

6.1 Sensitivity Test Approach

The objectives of the sensitivity tests were to:

- Provide example outputs from the Backbone Tool to support stakeholder understanding of its capabilities;
- Identify degrees in sensitivities across selection filters to inform stakeholder feedback on perceived importance of one filter relative to another; and
- Set a potential range within the Public Universe that a Critical Backbone could comprise in a future Network Expansion filing by the Companies.

To complete the test, Navigant utilized the Backbone Tool. For each selection filter, the test consisted of adjusting the filter to select only census tracts in the top quintile (80th percentile or higher) according to the given filter (e.g., MUD percentile). Navigant repeated this process for each of the selection filters and compared the sizes of the Critical Backbone selections to demonstrate the sensitivity of each selection filter.

6.2 Sensitivity Test Results

The following subsections provide results in heatmap form to illustrate the census tract-level results by selection filter using the 2025 reference scenario. Note the following key points for interpreting the sensitivity test results:

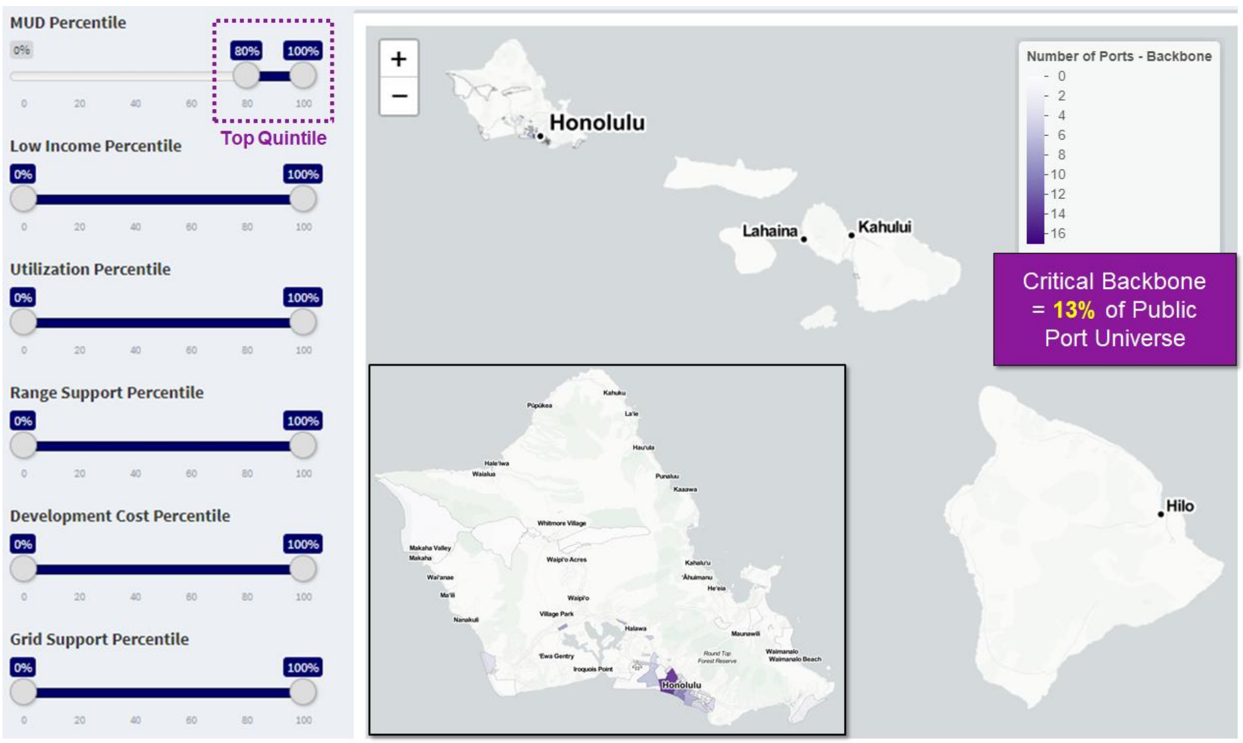
- Test results are intended to visually illustrate how the selection filters can individually parse out census tracts when each filter is limited to the top quintile (80% to 100%)
- Selection filters will have overlapping filtering effects when the utility uses more than one filter in selecting a Critical Backbone in the tool.
- Scoring by selection filter has been implemented on a tri-Company basis such that quintile scaling is not specific to one island, but rather to all islands in the tri-company service territory.

6.2.1 Multi-unit Dwelling

The MUD selection filter indicates the level of access to public charging for MUDs as described in Table 2. Census tracts with higher scores have a higher proportion of households living in MUDs.

Figure 11 provides a snapshot of the Backbone Tool, illustrating the results when the MUD filter is prioritized at the top quintile (top 20% of high MUD tracts) while keeping all census tracts for the other filters. In this test, which assumes that MUD is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 13% of the Public Universe. Notably, because O'ahu has the highest MUD density, and scoring is implemented on a tri-Company basis, the Critical Backbone prioritizes census tracts on O'ahu.

Figure 11. Selection Filter Sensitivity Test Result – Multi-unit Dwelling

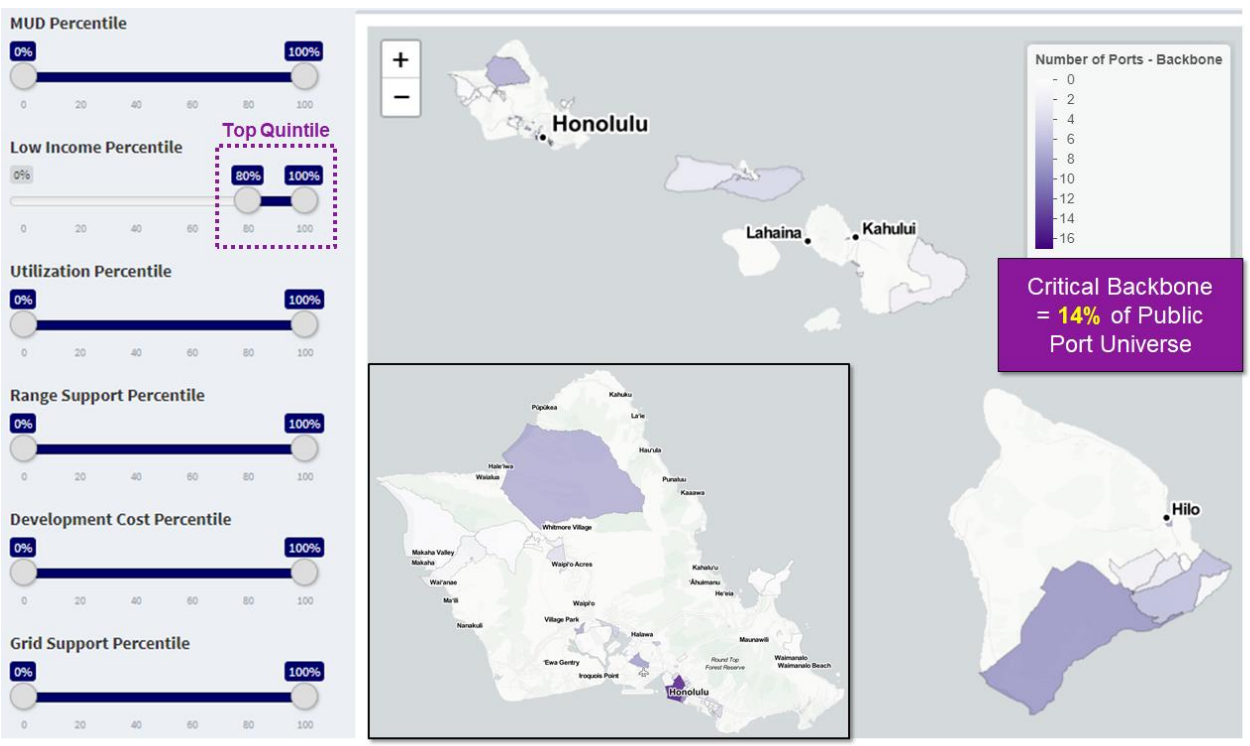


6.2.2 Low Income

The Low Income selection filter reflects the proportion of residents with an annual household income less than the defined threshold in each census tract as described in Table 2. For Hawai'i Island, the low-income threshold was $65,000 / year, and for all other islands the threshold was $75,000 / year. Census tracts with a high Low Income score have higher proportions of households that are considered low income.

Figure 12 provides a snapshot of the Backbone Tool, illustrating the results when the Low Income filter is prioritized at the top quintile (i.e., top 20% of low-income census tracts) while keeping all census tracts for the other filters. In this test, which assumes that Low Income is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 14% of the Public Universe.

Figure 12. Selection Filter Sensitivity Test Result – Low Income

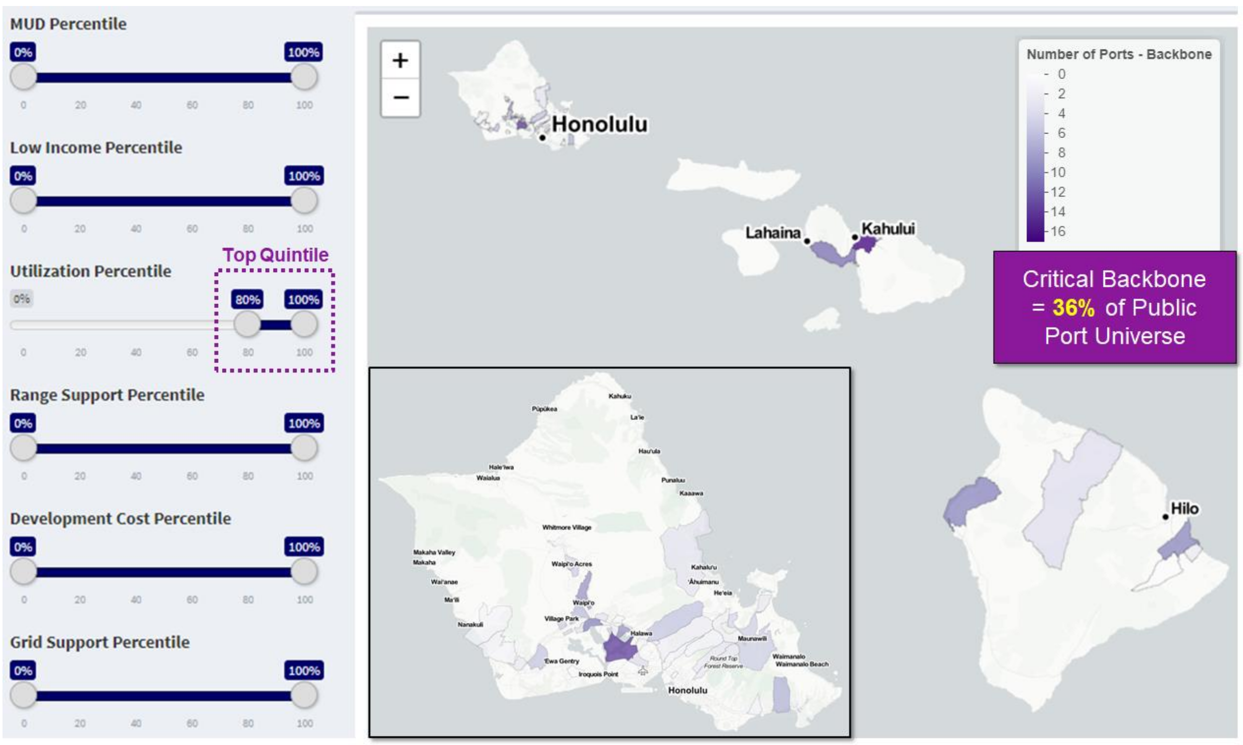


6.2.3 Utilization

The Utilization selection filter indicates the level of support for areas with dense populations and opportunities to serve high levels of traffic demand for charging based on VMT as described in Table 2. Census tracts with high utilization scores support more demand and a larger population.

Figure 13 provides a snapshot of the Backbone Tool, illustrating the results when the Utilization filter is prioritized at the top quintile (top 20% of high utilization tracts) while keeping all census tracts for the other filters. In this test, which assumes that Utilization is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 36% of the Public Universe. Notably, the high utilization areas are located near dense urban centers across the five islands.

Figure 13. Selection Filter Sensitivity Test Result – Utilization

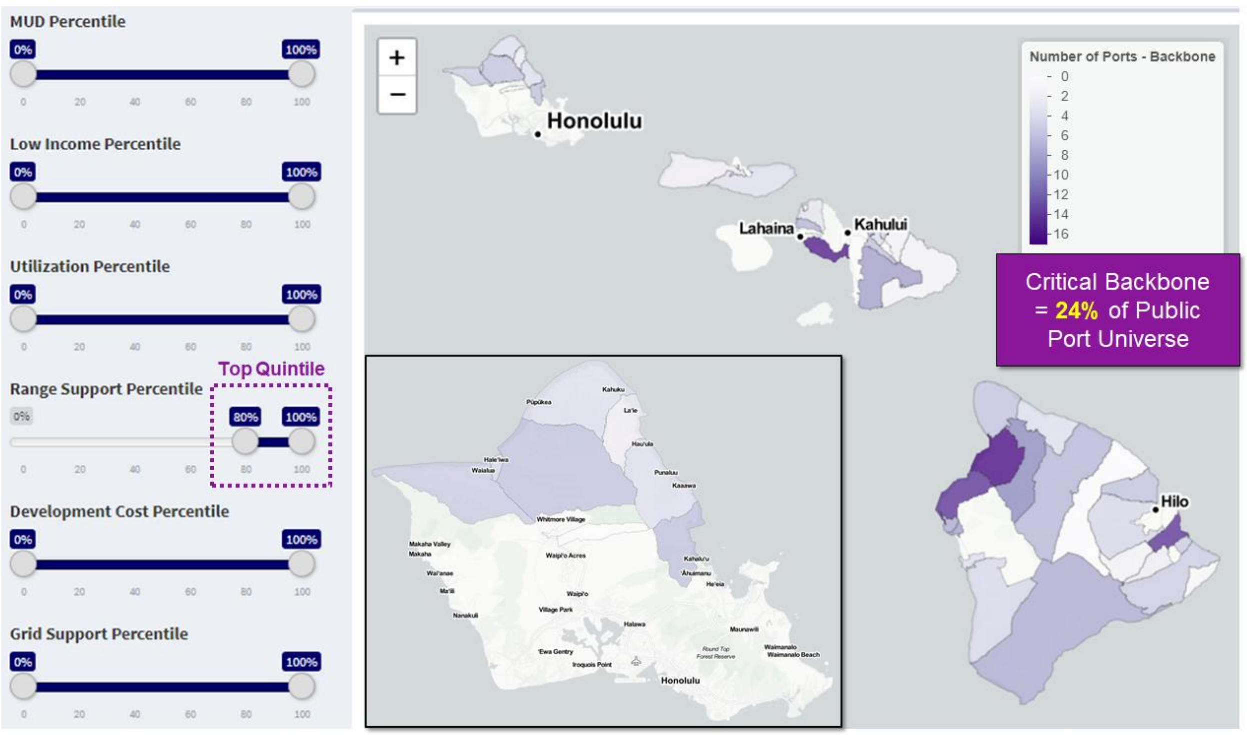


6.2.4 Range Support

The Range Support selection filter indicates the opportunity to enable longer-distance trips as described in Table 2. This is based on the average distance between one EV charging site and the next nearest site.

Figure 14 provides a snapshot of the Backbone Tool, illustrating the results when the Range Support filter is prioritized at the top quintile (i.e., top 20% of range supporting census tracts) while keeping all census tracts for the other filters. In this test, which assumes that Range Support is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 24% of the Public Universe. Notably, the high range supporting areas are located away from urban centers in more rural areas of each island.

Figure 14. Selection Filter Sensitivity Test Result – Range Support

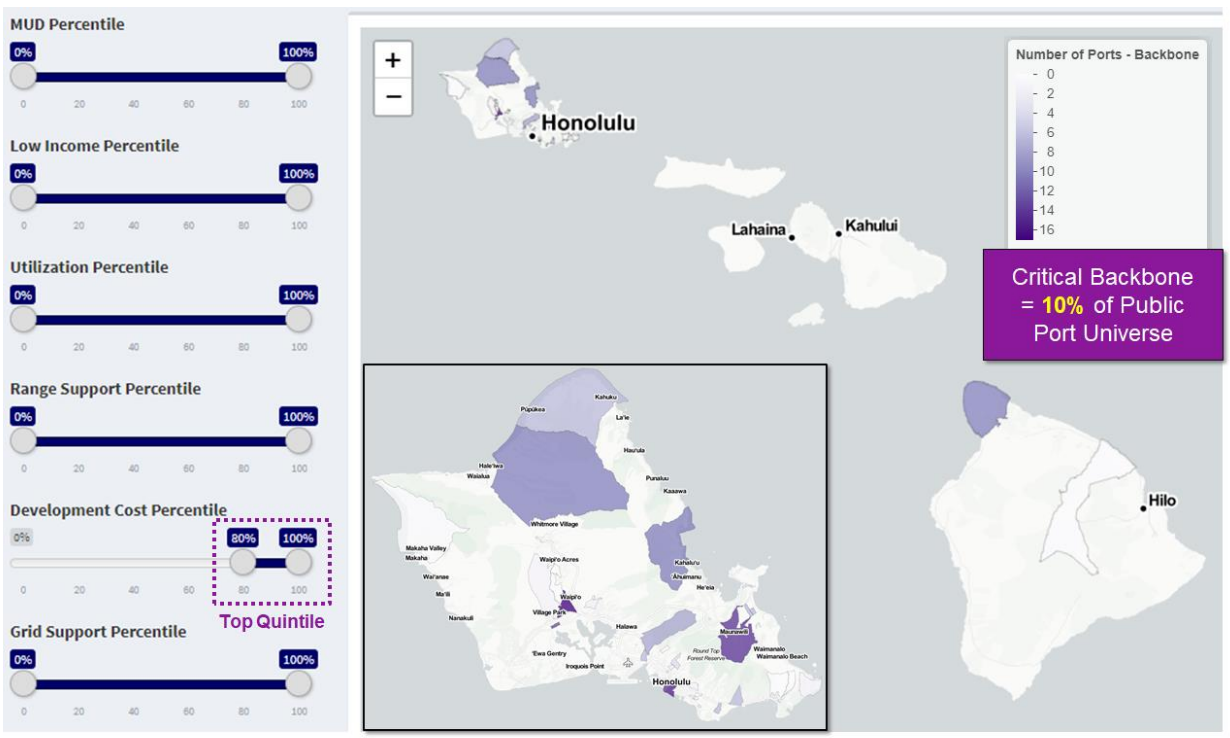


6.2.5 Development Cost

The Development Cost selection filter considers the required grid updates and the impact on the level of investment required to install an EV charger as described in Table 2. A higher Development Cost score identifies areas with fewer updates, which results in lower costs.

Figure 15 provides a snapshot of the Backbone Tool, illustrating the results when the Development Cost filter is prioritized at the top quintile (top 20% of low Development Cost tracts) while keeping all census tracts for the other filters. In this test, which assumes that Development Cost is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 10% of the Public Universe.

Figure 15. Selection Filter Sensitivity Test Result – Development Cost

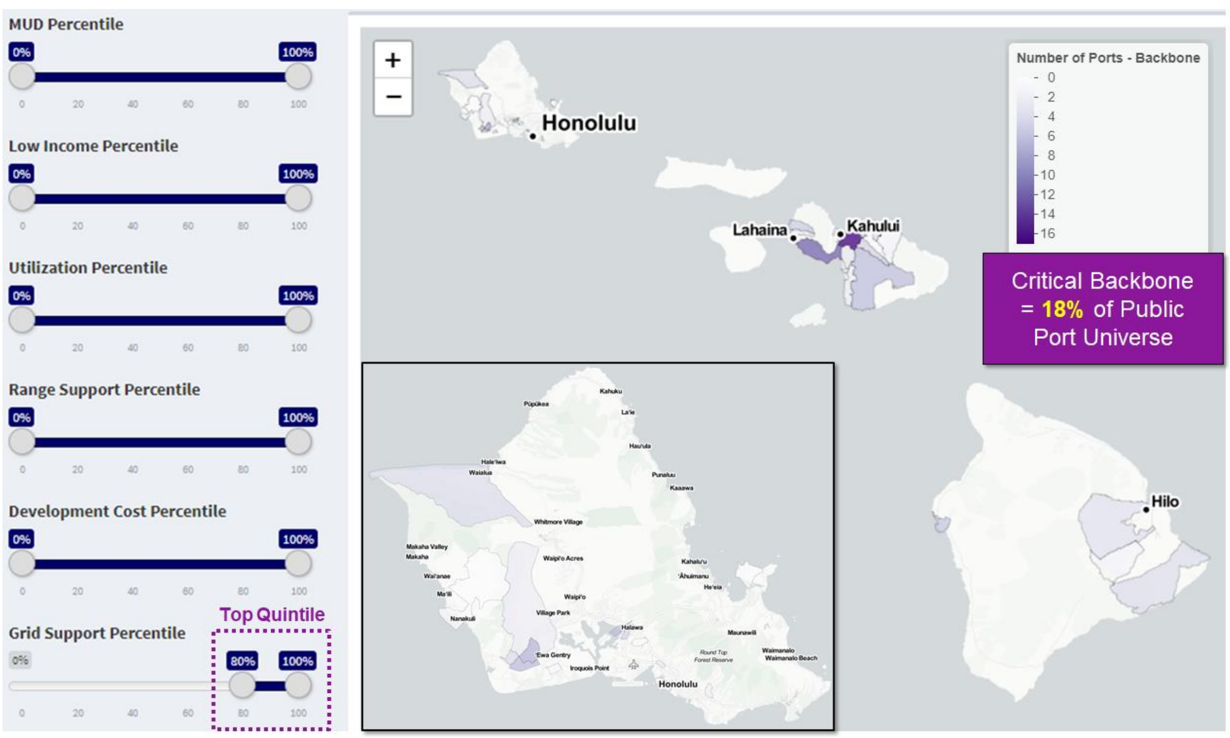


6.2.6 Grid Support

The Grid Support selection filter indicates the level of opportunity to utilize managed charging to enable grid resiliency as described in Table 2. This is based on the amount of headroom identified in the Companies' load forecast. The greatest opportunities are in census tracts with the least headroom.

Figure 16 provides a snapshot of the Backbone Tool, illustrating the results when the Grid Support filter is prioritized at the top quintile (top 20% of tracts with the least headroom) while keeping all census tracts for the other filters. In this test, which assumes that Grid Support is the most critical selection filter, the resulting hypothetical Critical Backbone reflects 18% of the Public Universe.

Figure 16. Selection Filter Sensitivity Test Result – Grid Support



6.3 Sensitivity Test Takeaways

- Test results indicated a Critical Backbone ranging from ***10% to 36%*** of the Public Universe, as summarized in Table 7.

Table 7. Backbone Tool Sensitivity Test Results

Selection Filter	Result Description	Test Result
Multi-Unit Dwelling	When the MUD filter is prioritized at the top quintile (top 20% of high MUD tracts) while keeping all census tracts for the other filters, the critical backbone reflects 13% of the Public EVSE Universe.	**13%**
Low Income	When the Low Income filter is prioritized at the top quintile (top 20% of low-income tracts) while keeping all census tracts for the other filters, the critical backbone reflects 14% of the Public EVSE Universe.	**14%**
Utilization	When the Utilization filter is prioritized at the top quintile (top 20% of high utilization tracts) while keeping all census tracts for the other filters, the critical backbone reflects 36% of the Public EVSE Universe.	**36%**
Range Support	When the Range Support filter is prioritized at the top quintile (top 20% of range supporting tracts) while keeping all census tracts for the other filters, the critical backbone reflects 24% of the Public EVSE Universe.	**24%**
Development Cost	When the Development Cost filter is prioritized at the top quintile (top 20% of low development cost tracts) while keeping all census tracts for the other filters, the critical backbone reflects 10% of the Public EVSE Universe.	**10%**
Grid Support	When the Grid Support filter is prioritized at the top quintile (top 20% of tracts with the least headroom) while keeping all census tracts for the other filters, the critical backbone reflects 18% of the Public EVSE Universe.	**18%**

- Breadth of range ***warrants additional input*** for the Companies' consideration in developing a Critical Backbone ahead of a future Network Expansion filing
- Range of results also demonstrates importance of the values selected for filters in any Critical Backbone configuration, further highlighting the need to ***root filter selections*** in ***best available empirical data*** collected by the Companies and stakeholders
- Finally, the results demonstrate the value of stakeholder engagement, as the process of estimating charging port needs iteratively over time will need to ***leverage newer, better data*** as they become available in the market and among stakeholders

7. Summary of Key Stakeholder Feedback

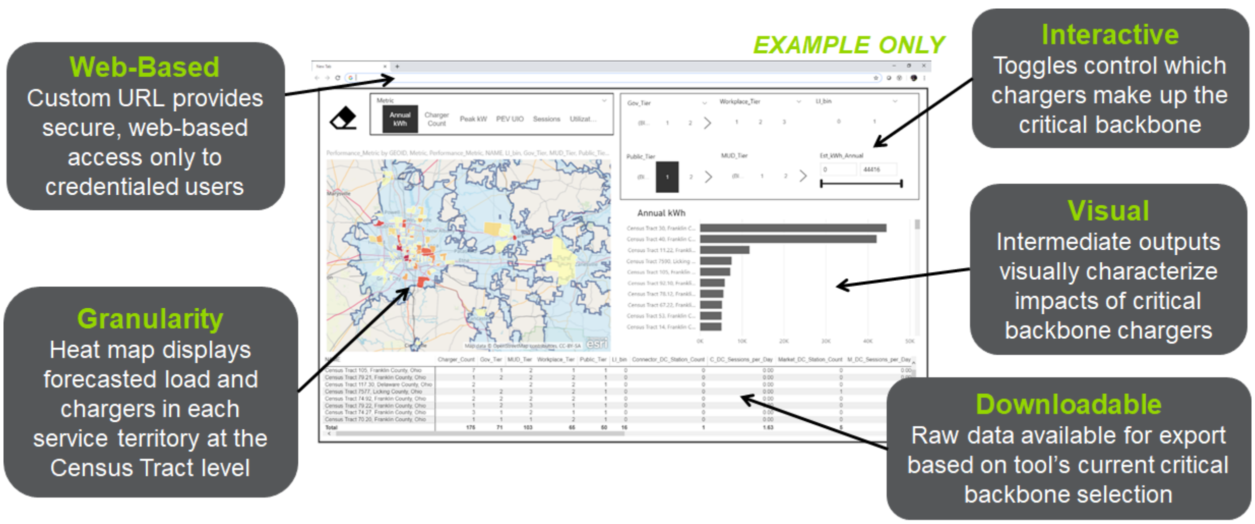
The Companies received stakeholder feedback in response to each workshop on the Backbone Methodology for incorporation in this *EV Critical Backbone Study: Planning Methodology Report* and for consideration in a subsequent Network Expansion filing. This section includes key feedback points as well as critical stakeholder questions and answers provided by the Companies and Navigant.

7.1 June 4 Workshop and Follow-up

The Companies sought stakeholder feedback on the proposed methodological process for incorporation into refinement of the Backbone Methodology and Tool design.

Figure 17 provides the preliminary tool features presented to stakeholders for feedback.

Figure 17. Draft Backbone Tool Design – June 4, 2019



Key feedback incorporated into the Backbone Methodology included adding tourist destinations to the analyzed use cases and including a household income data metric based on locally-sourced data.[37]

Appendix B contains all stakeholder responses received by the Companies as of the writing of this report for consideration in developing a Critical Backbone infrastructure for inclusion in a future Network Expansion filing.

[37] See Appendix B for further details.

7.2 July 12 Workshop and Follow-up

The Companies sought stakeholder feedback on the relative importance of each selection filter for consideration in development of a future Critical Backbone infrastructure.

Stakeholders received the template depicted in Figure 18 for completion and return to the Companies. The Companies will continue to conduct stakeholder engagement throughout 2019 in preparation for a subsequent filing.

Figure 18. Selection Filter Stakeholder Feedback Template

Selection Filter ***(check one)***	**Rationale for Consideration in Critical Backbone** ***(per island if more than one selected)***	**Supporting Data** ***(if available include links or attachments with template)***	**Needed Data** ***(describe if not available)***
❑ Multi-Unit Dwelling			
❑ Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
❑ Grid Support			

Select Applicable Island(s) ❑ Oahu ❑ Maui ❑ Molokai ❑ Lanai ❑ Big Island

Appendix B contains all stakeholder responses received by the Companies as of the writing of this report for consideration in developing a Critical Backbone infrastructure for inclusion in a future Network Expansion filing.

7.3 Stakeholder Questions and Answers

- **Granularity: Why choose census tract over island, county, or ZIP code level?**
    - *Rationale: Census tract was the selected level of granularity because any larger measurement unit than census tract does not provide sufficient granularity by island relative to population density and trip distance. Moreover, any smaller measurement unit does not align with Department of Motor Vehicle (DMV) data for PEV registrations or US Census demographic data that are key inputs to VAST™. Consequently, no larger or smaller unit of measurement was viable for completing the analysis.*
- **Universe: How is the Critical Backbone reflected in the universe of private and public charging ports?**
    - *Rationale: The Critical Backbone is a selected portion of the Public charging ports within the full EV Charging Universe as described in Section 4.3.*

- **Approach: Why did Navigant not recommend a Critical Backbone in the analysis?**
    - *Rationale: Provided an EV Charging Universe from which to extract a prioritized Critical Backbone in a future filing. Backbone Methodology implemented provides high degree of granularity, requiring time to incorporate additional analysis and stakeholder feedback.*
- **Workplace Charging: Why was workplace charging not included as a selection filter?**
    - *Rationale: Traffic flow data (AADT) captures market effects needed to serve public workplace charging. The inclusion of an 85% home charging assumption in the Backbone Methodology (sourced from the Companies' survey data) directionally increased the quantity of charging estimated for the Public Universe relative to other market assumption of greater than 90% home charging.[38] Relatedly, the future Network Expansion filing development process will provide a logical venue to discuss opportunities for exploring workplace charging to support grid needs, i.e., Grid Support selection filter.*
- **Renters: How are renters considered in the analysis?**
    - *Rationale: The Low Income Selection Filter seeks to capture multiple market effects for renters and multi-generational residents. See Appendix C for further detail.*
- **Origin-to-Destination Trip: Was origin-to-destination trip data included in the Backbone Methodology?**
    - *Rationale: AADT data were leveraged in the minimize facilities objective function to account for origin-to-destination considerations. In addition, the Tourist Destination and Rail Station use cases addressed origin-to-destination considerations from a qualitative analysis perspective. Point estimate traffic data (e.g., StreetLight Data) are making gains in precision and representativeness, while protecting data privacy. These data types could be considered for incorporation in future Critical Backbone analyses seeking to include origin-to-destination calculations.*
- **Building Code: How are building codes considered in the analysis?**
    - *Rationale: Building code considerations are relevant to site acquisition process, whereas the EV Critical Backbone Study: Planning Methodology Report is a policy planning snapshot that will inform site acquisition processes.*
- **Flood Zones: How were flood zones treated in the Backbone Methodology?**
    - *Rationale: Flood zones were not explicitly treated in the Backbone Methodology because the methodology focuses on census tract-level forecasts for planning purposes. Flood zones should be considered when selecting specific sites to host Critical Backbone chargers, but site selection is not an objective of the Backbone Methodology.*
- **Selection Filters: Can selection filters function on an intra-island basis?**
    - *Rationale: Scoring by selection filter has been implemented on a tri-Company basis such that quintile scaling is not specific to one island, but rather to all islands in the tri-company service territory. This approach allows for "apples-to-apples" comparisons of the selection filter effects in the Public EV Charging Universe to inform forthcoming business case, cost recovery, and other tri-company analyses for the Network Expansion filing.*

[38] Trans 13-07, Attachment A at 24, filed March 29, 2018

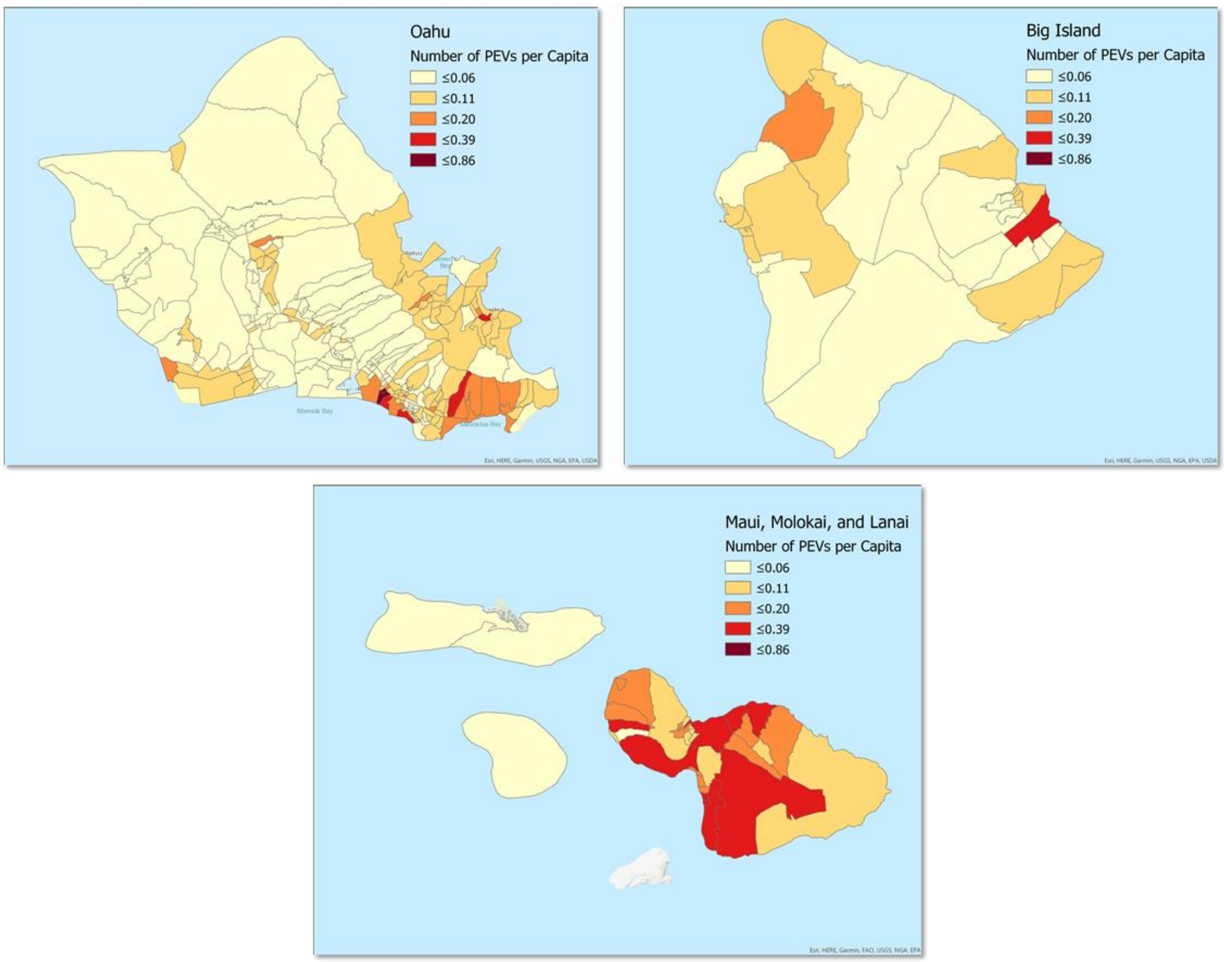
8. Road Ahead

This filing is the first of several steps establishing the Companies' expanded role in EV charging infrastructure deployment. The Backbone Methodology identified herein, along with ongoing stakeholder input, will support upcoming requests to expand and make permanent, the existing public charging infrastructure pilot (Schedule EV-U); validate the site selections made in the EV-Maui filing; and support a request to pilot a behind-the-meter EV infrastructure make-ready program for multiple-unit dwellings and workplaces. The Companies are currently in preliminary development of an EV-U Network Expansion filing and anticipate filing a request by the end of the first quarter of 2020.

Appendix A. PEV Forecast Disaggregation 2030 by County (Per Capita)

The heatmaps in Figure A-1 represent 2030 census tract-level data in the tri-Company counties Navigant developed in Activity 1 for the reference scenario; these were used in Activity 2. The color of each census tract indicates the number of PEVs per capita in that tract in 2030.

Figure A-1. 2030 PEV Forecast Disaggregation – Tri-Company Service Territory Counties



Appendix B. Stakeholder Engagement and Feedback Summary

B.1 Invitees to Stakeholder Engagement Meetings

Advocacy Groups

- Alliance for Transportation Electrification (ATE)
- Blue Planet Foundation
- Elemental Excelerator
- Ulupono Initiative

Automakers/Dealerships

- Tesla

Charging Solution Providers

- Aloha Charge
- Greenlots
- OpConnect
- Hitachi

Transportation Network Company

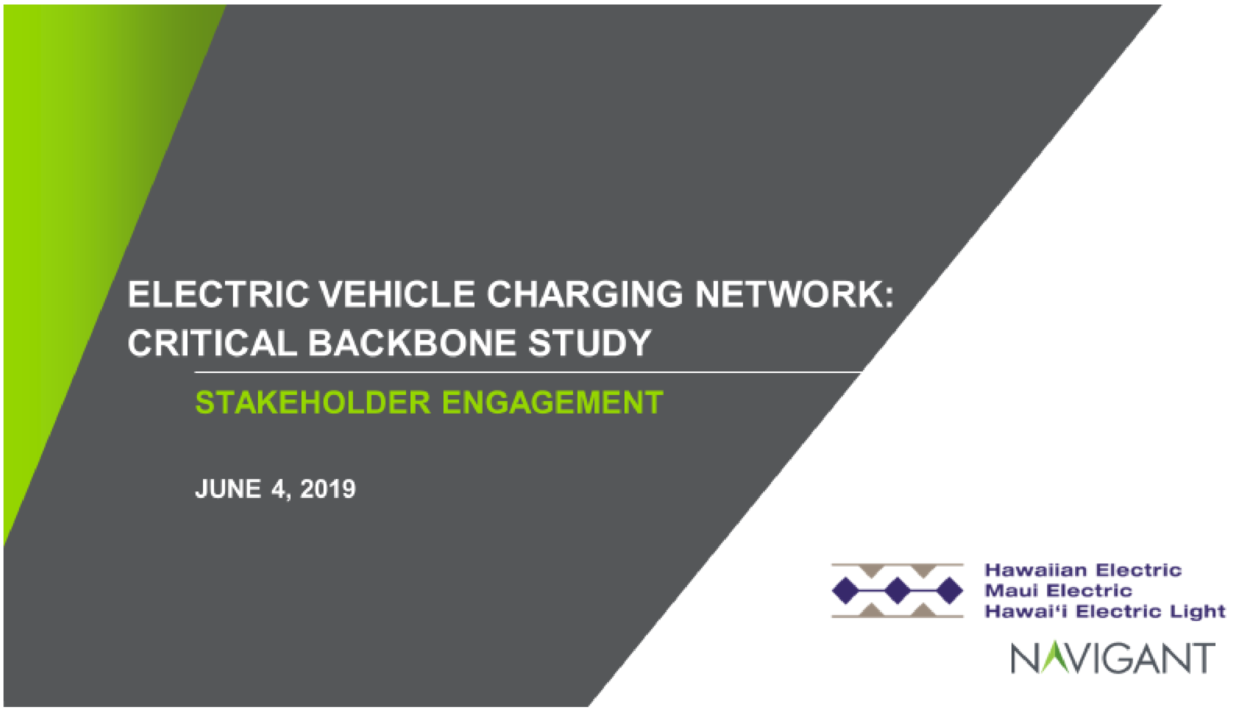
- Lyft
- Uber

Public Agencies, Offices, and Representatives

- City and County of Honolulu – Department of Transportation Services
- City and County of Honolulu – Office of Climate Change, Sustainability and Resiliency
- Hawai'i County – Department of Research and Development
- Maui County – Energy Commissioner
- Department of Business, Economic Development and Tourism – Energy Office
- Hawai'i Department of Transportation
- Honolulu Authority for Rapid Transportation

B.2 June 4, 2019 Meeting Presentation

The Companies presented the following material to stakeholders during the meeting and delivered an electronic copy via email after the meeting to support stakeholder feedback responses.



AGENDA OVERVIEW

	Agenda Topic
1	Welcome and Introductions
2	Objectives & Goals
3	Backbone Study Methodology Overview
4	Identification of Critical Backbone
5	Tool Overview
6	Next Steps
7	Q&A

INTRODUCTIONS

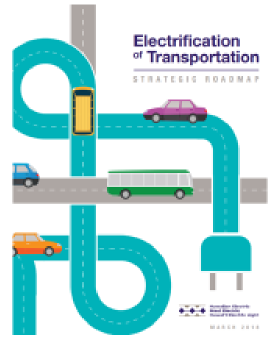
Please introduce yourselves and be sure to cover:

- ► Name
- ► Organization
- ► Interest in the EV Backbone Study

OBJECTIVES & GOALS

Objectives

Develop a comprehensive EV public charging infrastructure study, **including a method to identify a subset of "critical backbone" infrastructure**.



Goals

- Support EV adoption & Increase driving range
- Support EV charging near or at MUD and workplaces
- **Identification of a subset of "critical backbone" infrastructure**
- Increase utilization
- Enable grid impact

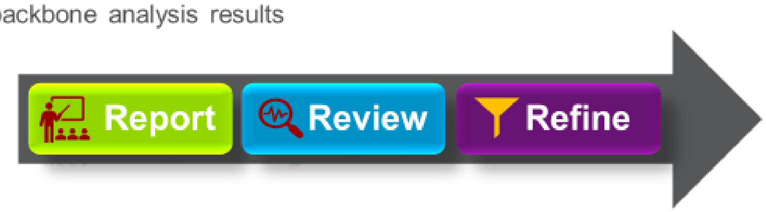
WORKSHOP OBJECTIVE STATEMENT

Purpose

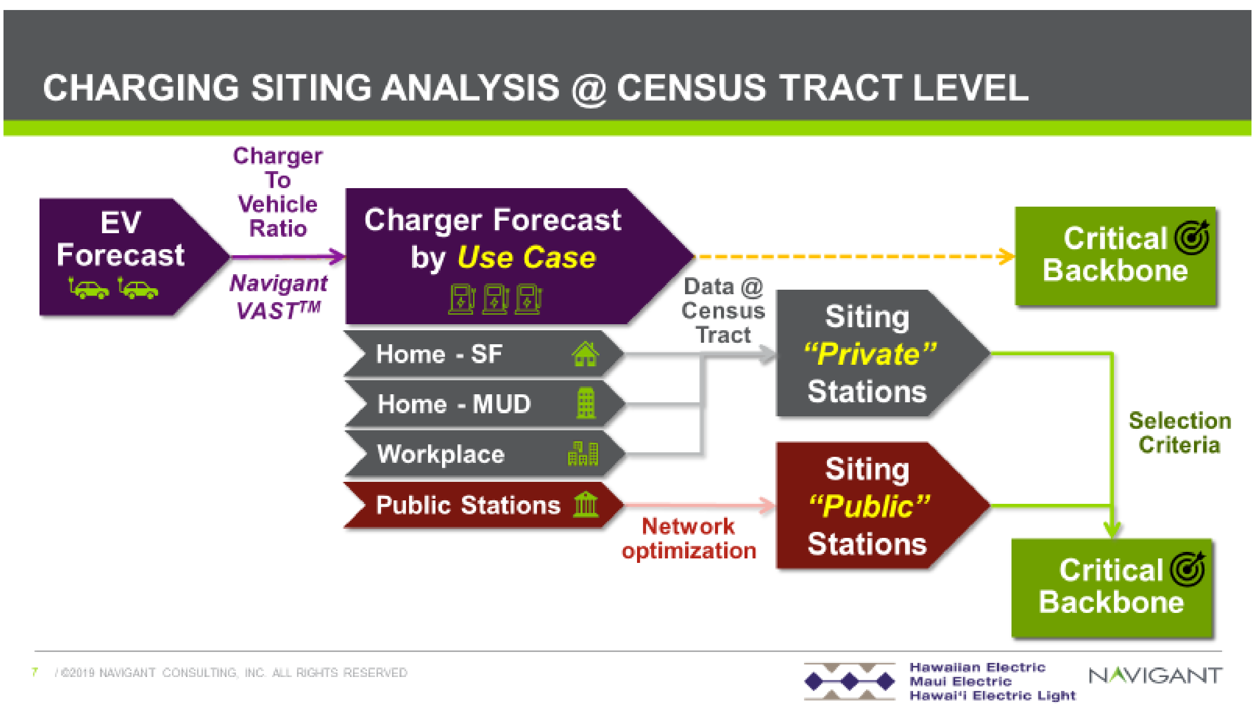
- To **better understand the proposed methodological process**
- To **ask questions, seek clarifications, and propose changes**
- To collect and confirm **proposed modifications** to the current **methodology**

Next Steps

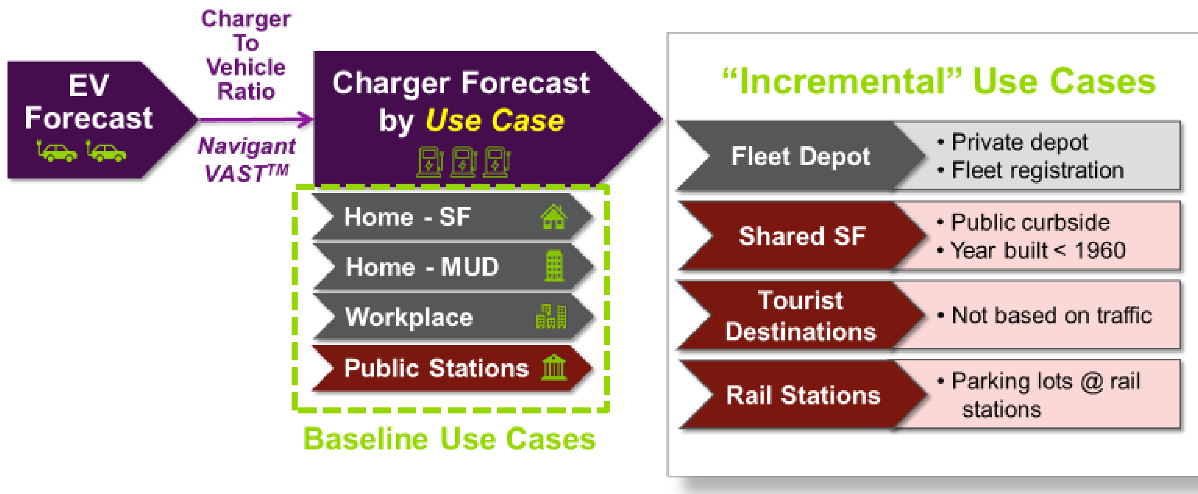
- Backbone Study team to **incorporate feedback into methods refinement** and review of preliminary backbone analysis results



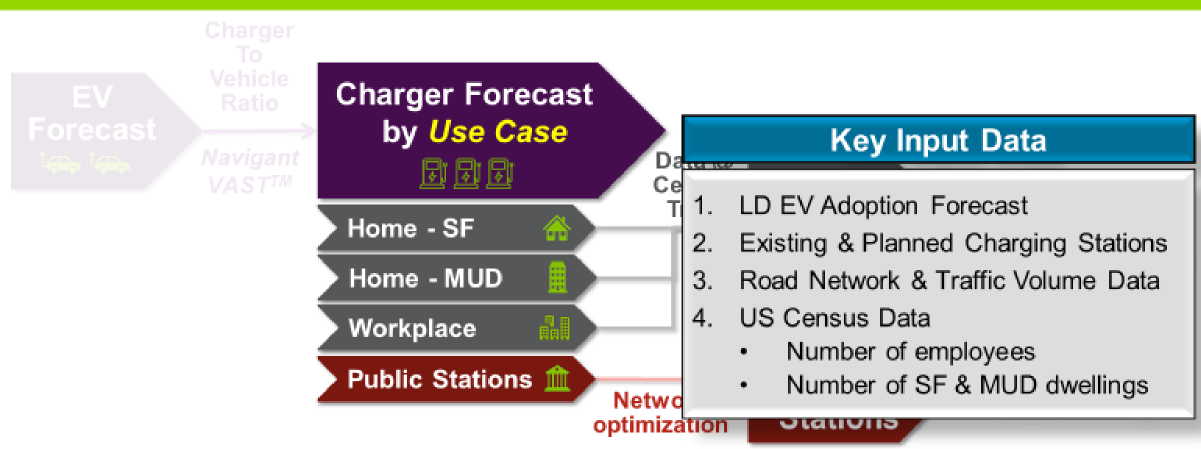

METHODOLOGY
OVERVIEW
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT


CHARGING SITING ANALYSIS @ CENSUS TRACT LEVEL
EV Forecast
Charger To Vehicle Ratio
Navigant VAST™
Charger Forecast by Use Case
Critical Backbone
Data @ Census Tract
Home - SF
Home - MUD
Workplace
Public Stations
Siting "Private" Stations
Siting "Public" Stations
Network optimization
Selection Criteria
Critical Backbone
7 / ©2019 NAVIGANT CONSULTING, INC. ALL RIGHTS RESERVED
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

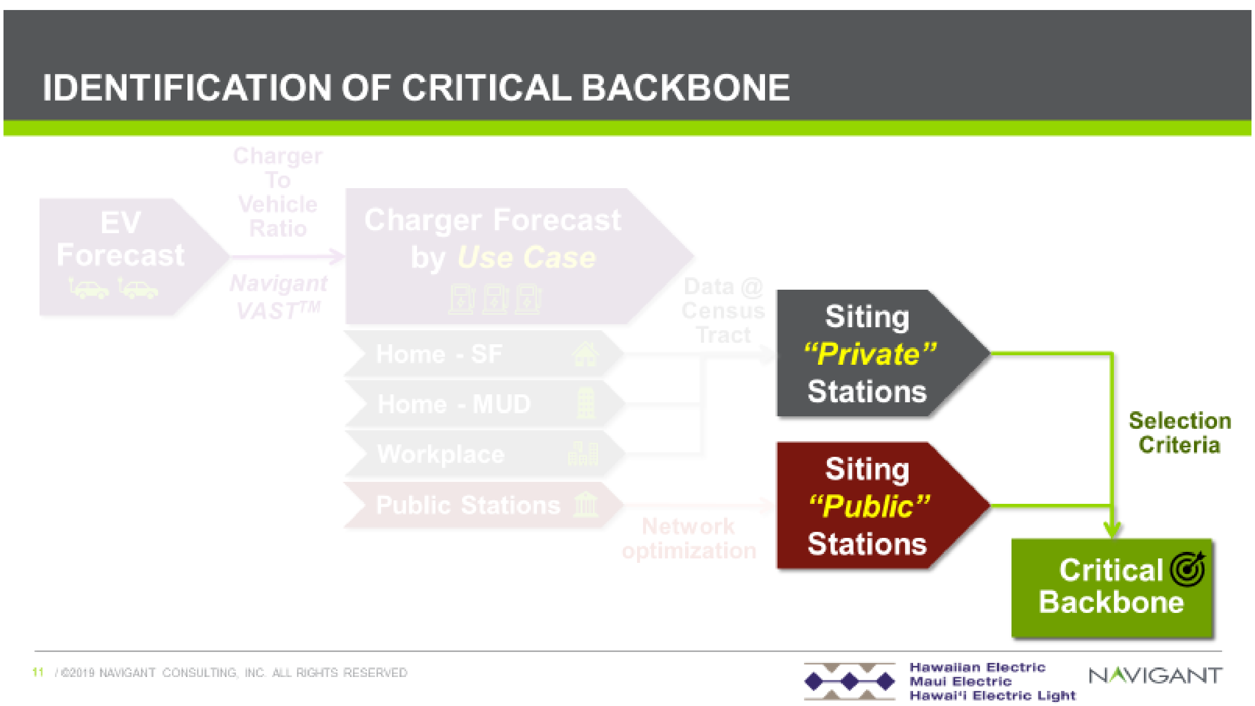
NAVIGANT'S VAST™ SUITE CONNECTS EVS TO DIFFERENT TYPES OF CHARGING STATIONS, KNOWN AS *USE CASES*



CHARGING SITING ANALYSIS @ CENSUS TRACT LEVEL




IDENTIFICATION
OF
CRITICAL
BACKBONE
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT


IDENTIFICATION OF CRITICAL BACKBONE
EV Forecast
Charger To Vehicle Ratio
Navigant VAST™
Charger Forecast by Use Case
Home - SF
Home - MUD
Workplace
Public Stations
Data @ Census Tract
Network optimization
Siting "Private" Stations
Siting "Public" Stations
Selection Criteria
Critical Backbone
11 / ©2019 NAVIGANT CONSULTING, INC. ALL RIGHTS RESERVED
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

MULTIPLE SELECTION CRITERIA WILL BE CONSIDERED WHEN OPTIMIZING THE CRITICAL BACKBONE SITING LOCATIONS.

Selection Criteria	Description
Multi-Unit Dwellings	Support charging access for MUD
Utilization	Support demand, population density, revenue potential
Range Support	Support longer distance travel
Income	Support charging access for low income, rural areas
Development Costs	Avoid congested feeder to minimize development cost
Grid Support	Support resiliency through managed charging

MULTIPLE SELECTION CRITERIA WILL BE CONSIDERED WHEN OPTIMIZING THE CRITICAL BACKBONE SITING LOCATIONS.

Selection Criteria	Metric	Data Source
Multi-Unit Dwellings	MUD Concentration	2017 ACS
Utilization	Usage intensity	EV Adoption
Range Support	Distance between chargers	Island-level GIS map
Income	Median income	2017 ACS
Development Costs	Excess grid capacity	HECO
Grid Support	Constrained grid capacity	HECO

USER-FRIENDLY TOGGLES NARROW DOWN TO CRITICAL BACKBONE CHARGERS

Universe

All chargers forecasted to meet LD EV charging needs

Interactive Selection Criteria

Set of key criteria used to select backbone chargers

- Multi-Unit Dwelling
- Utilization
- Range Support
- Income
- Development Costs
- Grid Support

Critical Backbone

Subset of chargers that make up “critical backbone”

NAVIGANT

TOOL OVERVIEW

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

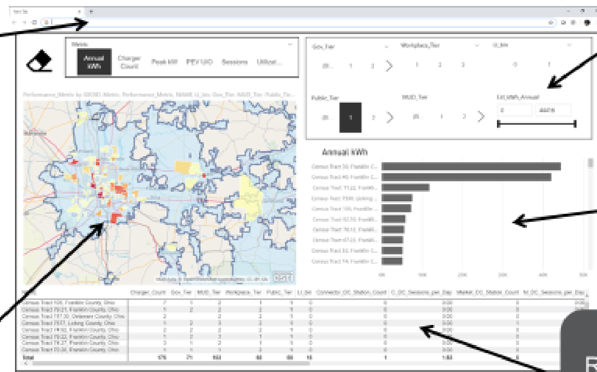
NAVIGANT

DRAFT TOOL DESIGN

EXAMPLE ONLY

Web-Based
Custom URL provides secure, web-based access only to credentialed users

Granularity
Heat map displays forecasted load and chargers in each service territory at the Census Tract level



Interactive
Toggles control which chargers make up the critical backbone

Visual
Intermediate outputs visually characterize impacts of critical backbone chargers

Downloadable
Raw data available for export based on tool's current critical backbone selection

NEXT STEPS

- Collect stakeholder onsite and offline feedback – *By June 11th*
- Consider feedback for refinements to methodology
- Perform critical backbone analysis
- Report draft results at stakeholder webinar for additional feedback


CONTACTS
MICHAEL COLÓN
Manager (HECO)
808.543.4620
michael.colon@hawaiianelectric.com
PAM CHASUTA ANUKOOLTHAMCHOTE
SR Program Manager (HECO)
808.543.4934
pam.anukoolthamchote@hawaiianelectric.com
DEREK JONES
Director (NAVIGANT)
415.356.7187
derek.jones@navigant.com
HECTOR ARTZE
Managing Director (NAVIGANT)
786.239.1292
artze@navigant.com
ROBIN MASLOWSKI
Director (NAVIGANT)
303.728.2518
robin.maslowski@navigant.com
GREG MANDELMAN
Associate Director (NAVIGANT)
925.818.7084
gregory.mandelman@navigant.com
SCOTT ROBINSON
Associate Director (NAVIGANT)
303.728.2529
scott.robinson@navigant.com
REBECCA KUSS
Senior Consultant (NAVIGANT)
303.954.8565
rebecca.kuss@navigant.com
Mahalo!
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

B.3 June 4, 2019 Meeting Feedback

Invitees included 34 stakeholders from 17 organizations. Attendees included 17 participants from 13 organizations. The Companies received the information contained in this subsection from stakeholders during and after the meeting.

The Companies received the information contained in this subsection from stakeholders during and after the meeting.

Low Income Metric Selection

Based on stakeholder feedback, the metrics in Table B-1. were considered as options for the Low Income selection filter.

Table B-1. Low Income Metric Description

Low Income Metric	Brief Description
Department of Housing and Urban Development **(HUD)**[1]	The department of Housing and Urban Development (HUD) sets income limits that determine eligibility for assisted housing programs including the Public Housing, Section 8 project-based, Section 8 Housing Choice Voucher, Section 202 housing for the elderly, and Section 811 housing for persons with disabilities programs.
Low Income Home Energy Assistance Program **(LIHEAP)**[2]	The Low Income Home Energy Assistance Program (LIHEAP) is a federal program that provides qualifying low-income households with a 1-time credit to offset household energy costs.
Federal Poverty Level **(FPL)**[3]	The Federal Poverty Level (FPL), or the "poverty line" is an economic measure that is used to decide whether the income level of an individual or family qualifies them for certain federal benefits and programs. The FPL is the set minimum amount of income that a family needs for food, clothing, transportation, shelter, and other necessities.
Asset Limited, Income, Constrained, Employed **(ALICE)**[4]	ALICE (Asset Limited, Income, Constrained, Employed) families have income above the Federal Poverty Level (FPL), but not high enough to afford a basic household budget that includes housing, child care, food, transportation and health care.

1 https://www.huduser.gov/portal/datasets/il//il19/IncomeLimitsMethodology-FY19.pdf
2 https://www.hcapweb.org/wp-content/uploads/2018/11/2019-liheap-application.pdf
3 https://aspe.hhs.gov/poverty-guidelines
4 https://www.unitedforalice.org/hawaii

The low income thresholds defined by Department of Housing and Urban Development (HUD) and depicted in Table B-2 and Table B-3 were selected because they provide granularity at the county level, aligning with the Backbone Methodology granularity. Annual updates provide an ongoing data source for inclusion in future Backbone Tool data refreshes.

Table B-2. Data and Calculation for Low Income Metric

Low Income Metric	Data & Calculation	Metric Update & Granularity
Department of Housing and Urban Development **(HUD)**	• HUD uses 2012-2016 5-year ACS data as the basis for calculating HUD's FY2019 Median Family Income (MFI).	• Data updated annually • Data at county level
Low Income Home Energy Assistance Program **(LIHEAP)**	• Income must be below 150% of the FPL.	• Data updated annually • Data at state level
Federal Poverty Level **(FPL)**	• To calculate percentage of poverty level, divide income by the poverty guideline and multiply by 100. • Household survival budget is calculated based off of the true cost of living, reflecting a family's need for support – ACS 2015 data.	• Data updated annually • Data at state level
Asset Limited, Income, Constrained, Employed **(ALICE)**	• Household survival budget is calculated based off of the true cost of living, reflecting a family's need for support – ACS 2015 data.	• Bi-annual publication (latest report was issued in 2016.) • Data at county level

Table B-3. Comparison of 2019 Income Threshold of a Four-Person Household

County	HUD	LIHEAP	FPL	ALICE
Maui County	Low Limits = $78,100 Very Low Limits = $48,800			$69,792
Hawai'i County	Low Limits = $62,800 Very Low Limits = $39,250	$43,305 (State-wide)	$29,620 (State-wide)	$71,472
Honolulu County	Low Limits = $96,400 Very Low Limits = $60,250			$75,204

List of Tourist Destinations

The following lists and maps of tourist destinations were compiled with stakeholder input. The lists were used to identify sites for the Tourist Destinations use case.

Figure B-1. O'ahu Tourist Destinations Map

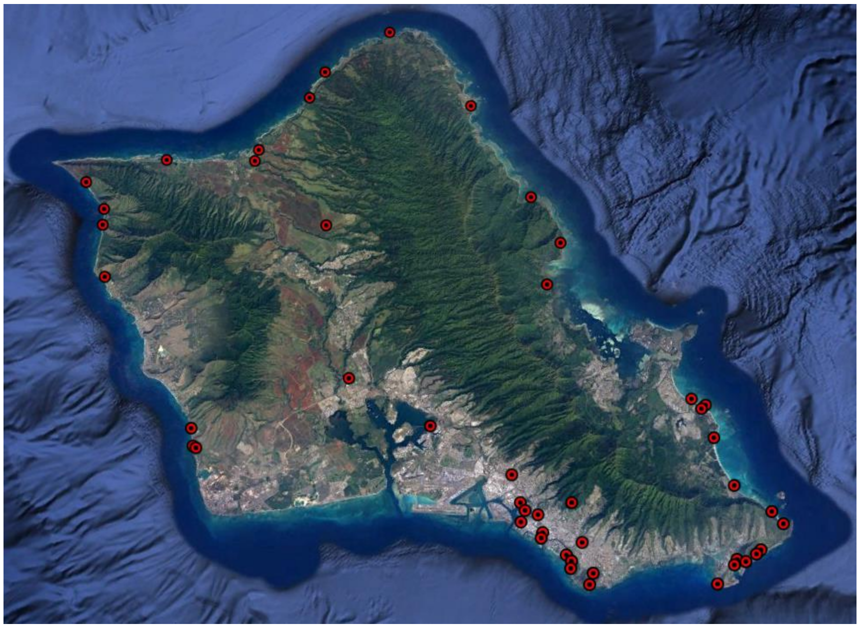


Table B-4. Tourist Destinations and Latitude/Longitude – O'ahu

Destinations	Latitude, Longitude	Destinations	Latitude, Longitude
Ala Moana Shopping Center	21.290854, -157.844483	Laie Shopping Center	21.646745, -157.921655
Banzai Pipeline	21.664910, -158.051760	Lanai Lookout	21.276575, -157.685475
Bellows Field Beach Park	21.367894, -157.709175	Lanikai Beach	21.392940, -157.715622
Bishop Museum	21.332781, -157.870598	Lanikai Pillbox Hike	21.389998, -157.718943
Chinatown	21.312242, -157.862908	Leonard's Bakery	21.285033, -157.813352
Crouching Lion Hike	21.558986, -157.863779	Magic Island, Ala Moana Beach Park	21.286835, -157.845492
Diamond Head Beach Park	21.254899, -157.806877	Makaha Beach Park	21.475379, -158.219890
Diamond Head State Monument	21.263098, -157.804238	Makapuu Point Lighthouse Trail	21.305405, -157.655306
Dole Plantation	21.527051, -158.037614	Makua Beach	21.533127, -158.229702
Giovanni's Shrimp Truck	21.580833, -158.105006	Paradise Cove Luau	21.343631, -158.127705
Haleiwa Town	21.590892, -158.102737	Pearl Harbor National Memorial	21.367190, -157.937905
Halona Blowhole Lookout	21.282354, -157.677053	Polynesian Cultural Center	21.638932, -157.919904
Hanauma Bay Parking	21.273766, -157.694434	Sandy Beach Park	21.285563, -157.673480
Hawaiian Electric Beach Park	21.357181, -158.130843	Sea Life Park Hawaii	21.314051, -157.664168
Honolulu Museum of Art	21.303876, -157.848660	Skydive Hawaii	21.578581, -158.181927
Honolulu Zoo	21.271126, -157.821387	Splitting Cave	21.259498, -157.707754
Iolani Palace	21.306595, -157.859003	Tantalus Lookout	21.313984, -157.822285
Kaena Point	21.555999, -158.248971	Waiāhole Beach Park	21.484880, -157.847485
Kahuku Sugar Mill	21.678280, -157.950000	Waiahole Poi Factory	21.482018, -157.845182
Kailua Beach Park	21.397331, -157.726995	Waialua Sugar Mill	21.572766, -158.124277
Kakaako	21.297949, -157.861889	Waikele Premium Outlets	21.401673, -158.006973
Kaneana Cave (Makua Cave)	21.519453, -158.228693	Waikiki	21.275399, -157.825515
King Kamehameha Statue	21.306595, -157.859003	Waikiki Aquarium	21.265837, -157.821789
Ko Olina Resort	21.342322, -158.125146	Waimanalo Beach	21.332251, -157.693500
Koko Crater Railway Trailhead	21.277795, -157.692342	Waimea Bay Beach Park	21.640417, -158.063221
Kualoa Ranch & Zipline	21.520581, -157.837281	Waimea Valley	21.636026, -158.054024
Kuilima Cove Snorkeling - Turtle Bay	21.705207, -157.997118	White Plains Beach	21.303647, -158.045046

Figure B-2. Hawai'i Island Tourist Destinations Map

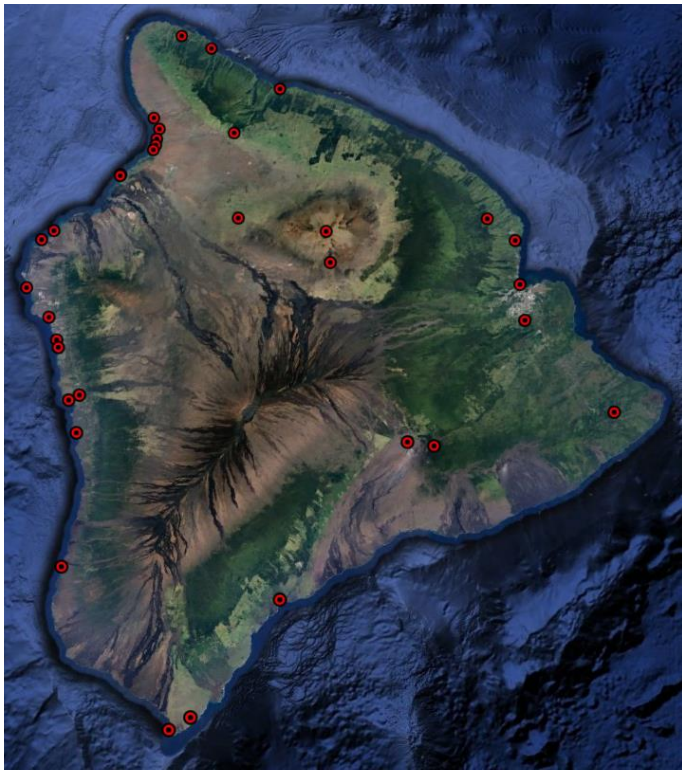


Table B-5. Tourist Destinations and Latitude/Longitude – Hawai'i Island

Destinations	Latitude, Longitude	Destinations	Latitude, Longitude
Akaka Falls State Park	19.853593, -155.152110	Mauna Kea Recreation Area	19.748838, -155.526634
Alii Drive	19.637733, -155.992868	Miloli'i Beach Park	19.181898, -155.907273
Buddha Point	19.928195, -155.888778	Nāhuku - Thurston Lava Tube	19.413498, -155.238519
Captain James Cook Monument	19.481129, -155.933366	Onizuka Center - Mid-Level Facility	19.758328, -155.456017
Dolphin Quest Hawaii	19.925471, -155.889272	Panaewa Rainforest Zoo	19.653753, -155.073840
Hamakua Macadamia Nut Co Inc	20.049040, -155.835587	Papakōlea Green Sand Beach	18.935978, -155.646634
Hapuna Beach	19.991303, -155.825113	Pine Trees Surfing Beach	19.694674, -156.044539
Hawaii Tropical Botanical Garden	19.810895, -155.096111	Pololu Valley Lookout	20.203633, -155.733681
Hawai'i Volcanoes National Park	19.419327, -155.288386	Punalu'u Black Sand Beach	19.135636, -155.504820
Hilo	19.723418, -155.084840	Puuhonua O Honaunau Park	19.420930, -155.910895
Kahaluu Beach Park	19.580075, -155.966674	Pu'ukohola Heiau Historic Site	20.025583, -155.821759
Kauna'oa (Mauna Kea) Beach	20.004429, -155.824748	Saddle Road	19.843494, -155.644283
Kona Coffee Living History Farm	19.491000, -155.914242	South Point Cliff Dive	18.914833, -155.682978
Lava Tree State Monument	19.483675, -154.902313	Statue of King Kamehameha	20.230328, -155.798376
Magic Sand Beach Park	19.594342, -155.971711	Waialea Beach	19.981280, -155.828911
Makalawena Beach	19.790950, -156.028747	Waimea Town	20.020540, -155.669031
Manini Owali Beach (Kua Bay)	19.809797, -156.006817	Waipio Valley Park	20.117620, -155.584263
Mauna Kea	19.820530, -155.468548		

Figure B-3. Maui Island Tourist Destinations Map

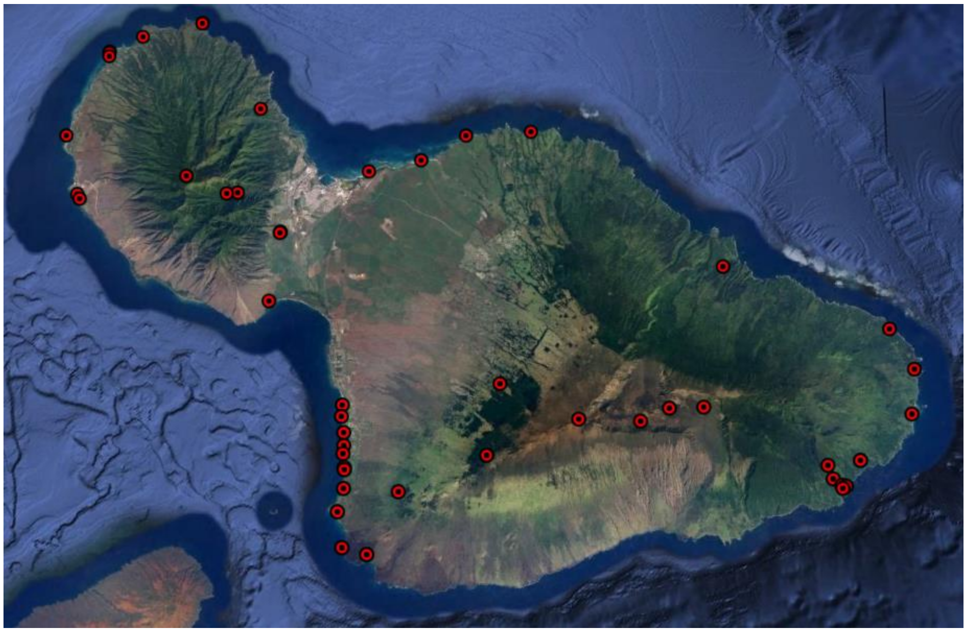


Table B-6. Tourist Destinations and Latitude/Longitude – Maui Island

Destinations	Latitude, Longitude	Destinations	Latitude, Longitude
Ahihi-Kinau Natural Area Reserve	20.605210, -156.439463	Makena State Park	20.665012, -156.441519
Alii Kula Lavender	20.733249, -156.319766	Maluaka Beach	20.649212, -156.441090
Baldwin Beach Park	20.913013, -156.392544	Maui Ocean Center	20.792758, -156.511827
Front Street - Lahaina	20.875451, -156.679968	Maui Tropical Plantation	20.849426, -156.506660
Haleakala Crater	20.718576, -156.182784	Maui Zipline Company	20.848566, -156.507073
Haleakala National Park	20.720212, -156.155156	MauiWine	20.648123, -156.397424
Haleakala Observatory	20.707807, -156.255577	Nakalele Blowhole	21.027126, -156.588556
Hamoa Beach	20.720048, -155.987692	Napili Place	20.994934, -156.666447
Heart-Shaped Rock	21.027126, -156.588556	Oheo Gulch	20.664030, -156.045736
Honolua Bay	21.013058, -156.639162	Peahi - Jaws Lookout	20.940192, -156.300544
Hookipa Beach Park	20.935231, -156.355510	Pipiwai Trail	20.668630, -156.052594
Iao Valley	20.879881, -156.554399	Polipoli Spring State Recreation Area	20.677882, -156.328471
Iao Valley State Park	20.880817, -156.545179	Polo Beach	20.675405, -156.443177
Kaanapali Beach	20.924796, -156.695144	Poolenalena Beach	20.663324, -156.441374
Kamaole Beach Park III	20.712675, -156.446125	Red Sand and Hana Bay Beach	20.755111, -155.984090
Kanaha Beach Park	20.902114, -156.436077	Seven Sacred Pools at Oheo	20.663387, -156.042466
Kapalua Beach	20.999259, -156.666421	Ulua Beach	20.691560, -156.443644
Kapalua Coastal Trail	20.998006, -156.666705	Upper Waikani Falls	20.832437, -156.138532
Keawakapu Beach	20.703896, -156.446302	Waianapanapa State Park	20.786405, -156.002916
Keoneheehee - Sliding Sands Trail	20.707810, -156.205866	Waihee Ridge Trail	20.952892, -156.531708
Kipahulu Visitor Center	20.661726, -156.045141	Wailea Beach	20.681593, -156.442947
La Perouse Bay and Makena Stables	20.600813, -156.419708	Wailua Falls	20.683286, -156.030434
Lahaina Banyan Court	20.871650, -156.677552	Waimoku Falls	20.678686, -156.056526
Makena Beach	20.631587, -156.444771	West Maui Mountains	20.893581, -156.589701

Figure B-4. Moloka'i Tourist Destinations Map

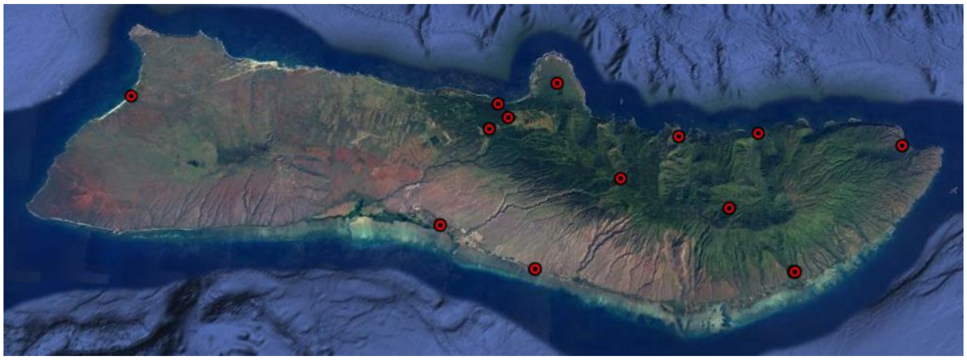


Table B-7. Tourist Destinations and Latitude/Longitude – Moloka'i

Destinations	Latitude, Longitude
Papohaku Beach Park	21.173840, -157.251473
Molokai Museum & Cultural Center	21.160163, -157.010031
Palaau State Park	21.168087, -156.997843
Kalaupapa Lookout	21.176971, -157.005139
Kalaupapa National Historical park	21.192119, -156.966435
Pelekunu Preserve	21.159404, -156.883952
Waikolu Valley Lookout	21.130606, -156.921460
Molokai Forest Reserve	21.113952, -156.849877
Wailau Valley	21.163341, -156.831284
Halawa Beach Park	21.158524, -156.735894
Iliiliopae Heiau	21.075161, -156.807728
Wailau Trail	21.075146, -156.806832
One Alii Park	21.071175, -156.974569
Kapuaiwa Coconut Grove	21.096673, -157.037777

Figure B-5. Lānaʻi Tourist Destinations Map

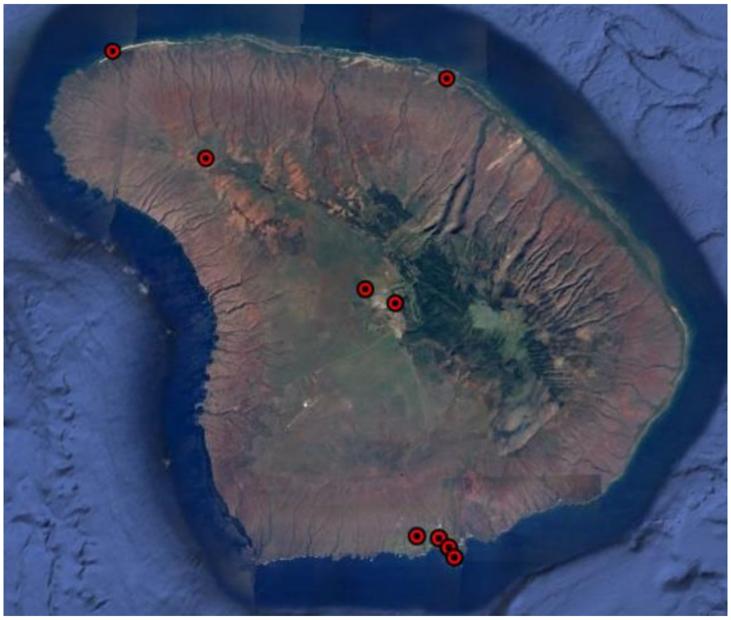
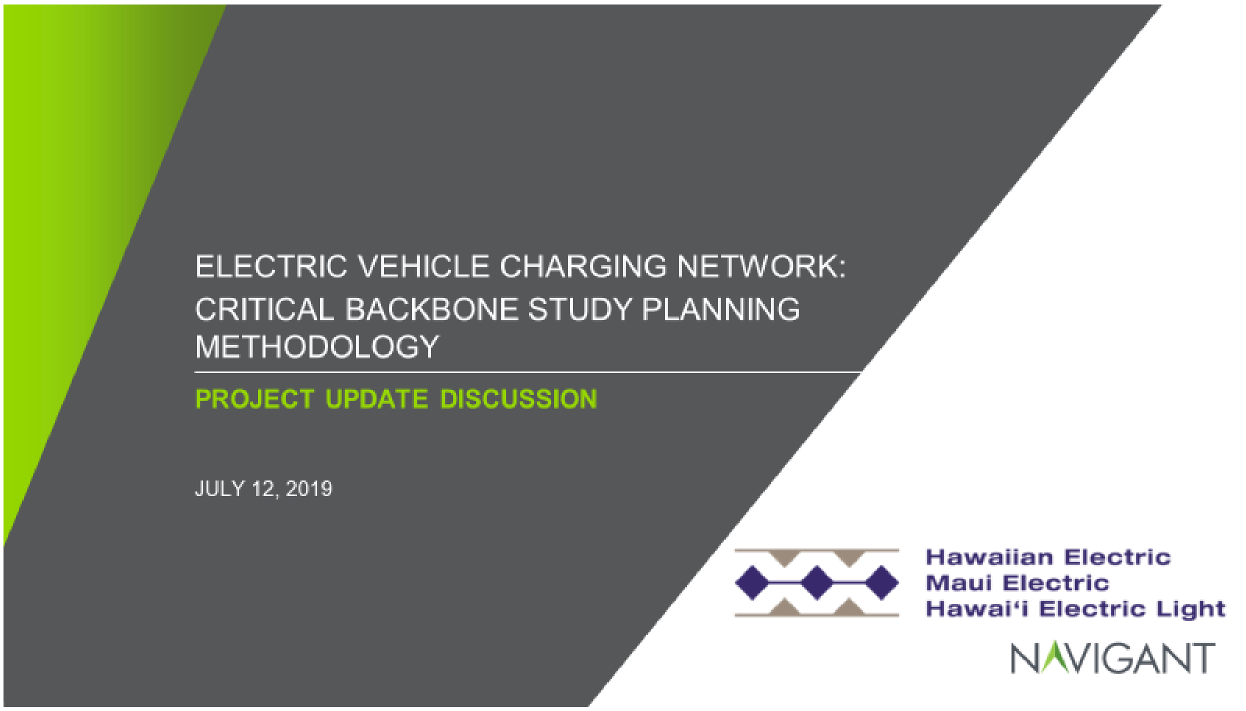


Table B-8**. Tourist Destinations and Latitude/Longitude – Lānaʻi**

Destinations	Latitude, Longitude
Four Seasons Resort Lanai	20.741753, -156.896561
Heritage Center	20.826078, -156.917977
Hulopo Beach Park	20.738652, -156.892667
Keahiakawelo - Garden of the Gods	20.878959, -156.996514
Lanai Airport	20.785692, -156.952803
Lanai City	20.830921, -156.929932
Lanai Petroglyphs	20.913903, -156.902587
Manele Golf Course	20.742194, -156.904822
Polihua Beach	20.920354, -157.038088
Puu Pehe Sweetheart Rock	20.735301, -156.890446

B.4 July 12, 2019 Meeting Presentation

The Companies presented the following material to stakeholders during the meeting and delivered an electronic copy via email after the meeting to support stakeholder feedback responses.



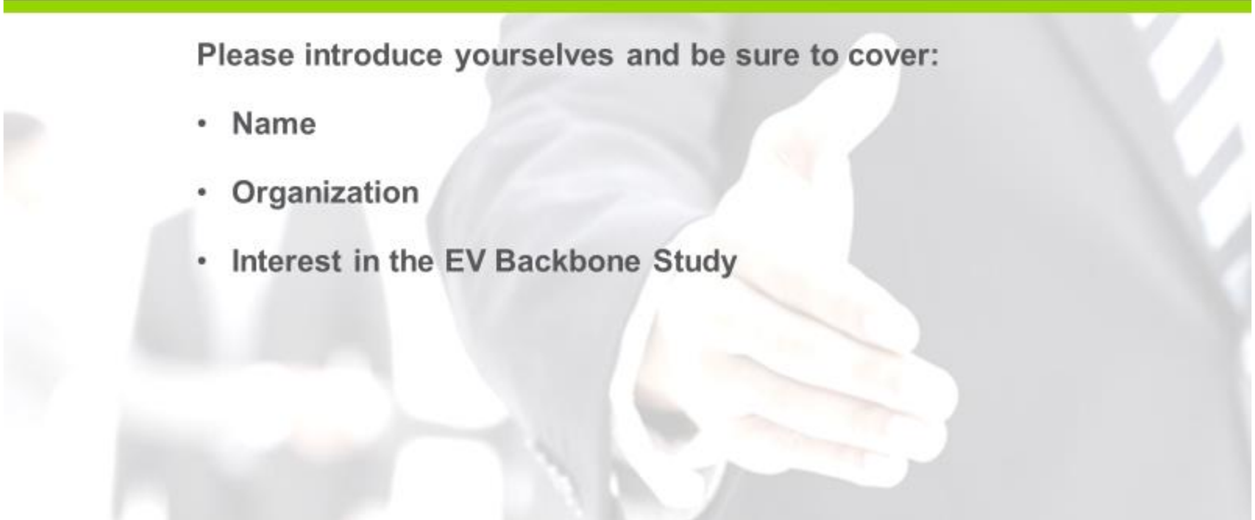
PROJECT UPDATE DISCUSSION

AGENDA OVERVIEW

Section	Agenda Topic	Time	Length
1	Introduction	2:00 – 2:10 pm	10 mins
2	Review Project Schedule & Key Deliverables	2:10 – 2:20 pm	10 mins
3	Review Critical Backbone Study Overview / Methodology	2:20 – 2:30 pm	10 mins
4	EV Forecast and Forecasted "Universe" of Charging Ports	2:30 – 3:00 pm	30 mins
5	Review Study Analysis	3:00 – 3:30 pm	30 mins
6	Discussion / Next Steps	3:30 – 4:00 pm	30 mins

PROJECT UPDATE REVIEW

INTRODUCTIONS



Please introduce yourselves and be sure to cover:

- Name
- Organization
- Interest in the EV Backbone Study

PROJECT UPDATE:
QUICK PROJECT REVIEW
(SECTION 1)

Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

PROJECT REVIEW

PROGRESS TO DATE

Regulatory Context and Progress

- **EoT Roadmap** filed in March 2018 and subsequent **Update to include neighbor island forecast** filed in November 2018
  - **Initiative # 7** guides this project's current efforts
- **EVSE Planning Report** filing expected July 30th, 2019
- **EVMaui** filing expected
- "**Network Expansion**" application targeting Q4 2019 filing date

Critical Backbone Study: Planning Methodology

- Initiated project April 2019
- Hosted **initial stakeholder webinar** June 4th, 2019
- Incorporated stakeholder **feedback**
  - **Tourist Destination** sites included
  - Incorporated feedback on **household income** data metric
- Hosting stakeholder **project update webinar** today
  - **Seeking feedback** on Selection Filtering considerations

PROJECT REVIEW

OUR UNDERSTANDING OF THE COMPANIES' NEED

The Need

The Companies require a comprehensive electric vehicle public charging infrastructure study and a tool that enables the evaluation of current and future EV charging needs across their service territories, **including a planning methodology to identify a subset of "critical backbone" infrastructure**.

Specifically, the Companies are seeking to achieve and optimize the following:

- Support EV adoption as provided in the Companies' forecast
- Increase the electric driving range
- Support increased EV charging opportunities near or at multi-unit dwellings and workplaces
- **Identification of a subset of "critical backbone" infrastructure**
- Increase the utilization of company-owned charging locations as well as the potential increase in stations
- Enable grid impact and/or upgrade analysis
- Potentially enable grid support services

PROJECT REVIEW

VEHICLE ADOPTION SIMULATION TOOL (VAST™) SUITE OVERVIEW

- The project approach uses our proven ***Vehicle Adoption Simulation Tool™ (VAST) Analytics Suite*** and leverages the EV adoption forecasts from the Electrification of Transportation Strategic Roadmap to produce results in an interactive tool for the Companies'.

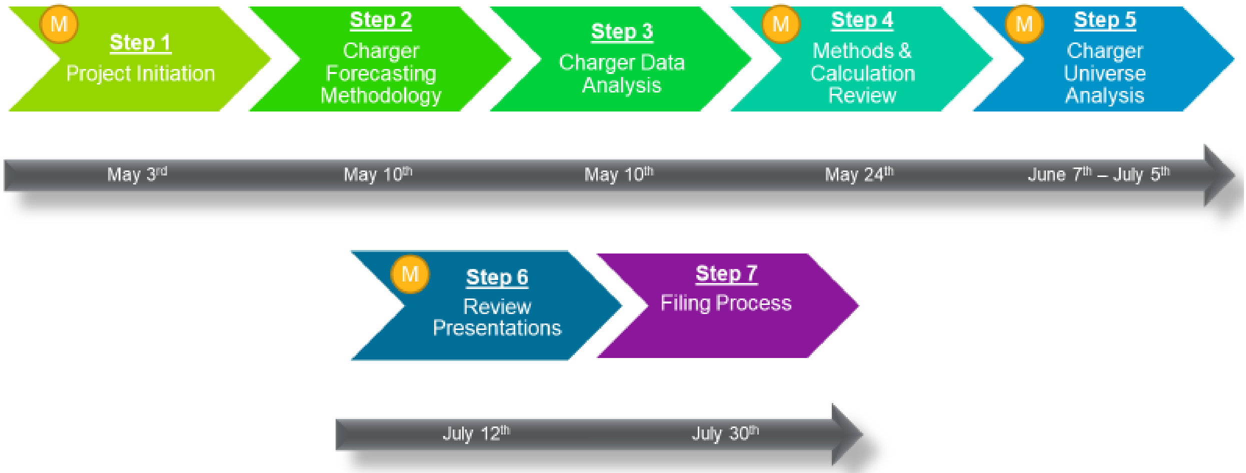
- VAST™ leverages an **enhanced systems dynamics innovation diffusion model** to forecast adoption of various powertrain-fuel configurations in the PEV market at the local level. By modeling vehicle adoption based on inputs specific to a particular jurisdiction, the forecast more closely reflects local market conditions compared to similar national level forecasts.

VAST™ Analytics Suite Module Synergies

(Source: Navigant)

PROJECT REVIEW

PROJECT SCHEDULE & DELIVERABLES



 M = *Meeting or Workshop*

CHARGER UNIVERSE REVIEW

EVSE UNIVERSE FORECAST

Updated EVSE charging port forecast "universe" enables *flexibility* to model the *adoption of specific policy and grid support objectives and outcomes*

EVSE Forecast Key Points

- Updated EVSE charging port forecast "**universe**" reflects latest stage of The Companies' **iterative forecasting process that will continue to evolve over time**
- Latest enhanced approach enables **increased granularity** across EVSE geographic and energy/demand dimensions
- Supports **ability to select a subset of the total EVSE universe** using criteria based on six (6) Selection Filters
  - **Selection Filters** screen out EVSE from a geographic region (i.e. census tract) from the full universe based on the areas unique characteristics
- Enables collection of input from stakeholders on priorities for consideration in future "**Network Expansion**" filing

EVSE Forecast Key Questions

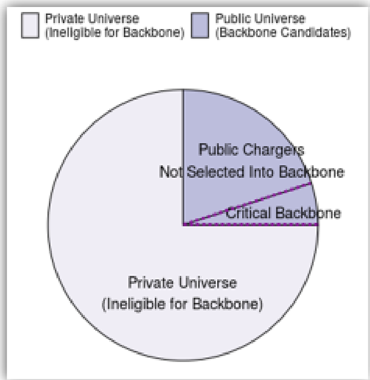
- **Granularity Rationale**: why choose census tract over island, county, or zip code level?
  - Anything **larger** than census tract does not provide sufficient granularity by island relative to population density and trip distance
  - Anything **smaller** does not align with DMV data for EV registrations or NREL EVIPro Lite that is a key input to VAST™, i.e. not technically feasible
- **Approach Rationale**: why didn't Navigant recommend a "critical backbone" in the study?
  - Provide an **EVSE universe** from which to extract a prioritized critical backbone in a future filing
  - Methodology implemented provides **high degree of granularity**, requiring time to incorporate additional preparatory analysis and stakeholder feedback

CHARGER UNIVERSE REVIEW

THE CHARGER PORT UNIVERSE – PRIVATE, PUBLIC, CRITICAL BACKBONE

The *Critical Backbone* is a *selected portion* of the Public charging ports within the full EVSE Universe

EVSE Charging "Universe"*



Private vs. Public Ownership

Private

- **Description**: Private chargers are considered "behind the fence" and only accessible by certain groups of PEV drivers
- **Examples**: Residential home charging, workplace employees charging on private lots, MUD tenants charging in underground parking lots, and fleet charging

Public

- **Description**: Public chargers are accessible to all PEV drivers, i.e. *not* "behind the fence"
- **Examples**: Curbside charging, charging retail parking lots (i.e. grocery stories), tourist destinations and rail stations

PROJECT UPDATE:

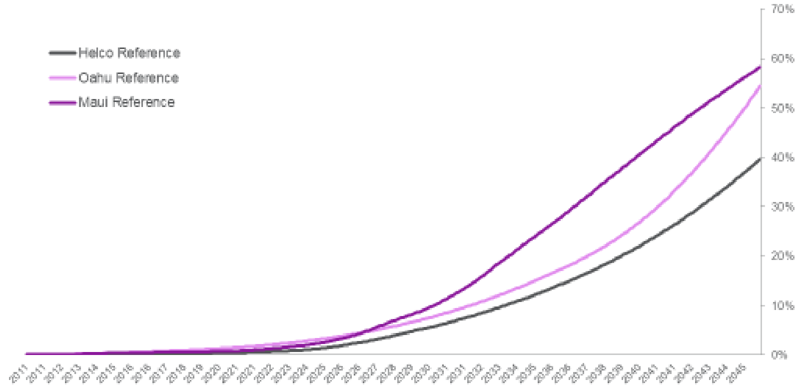
REVIEW OF ELECTRIC VEHICLE FORECAST

(SECTION 2)

Hawaiian Electric Maui Electric Hawai'i Electric Light NAVIGANT

EV FORECAST REVIEW

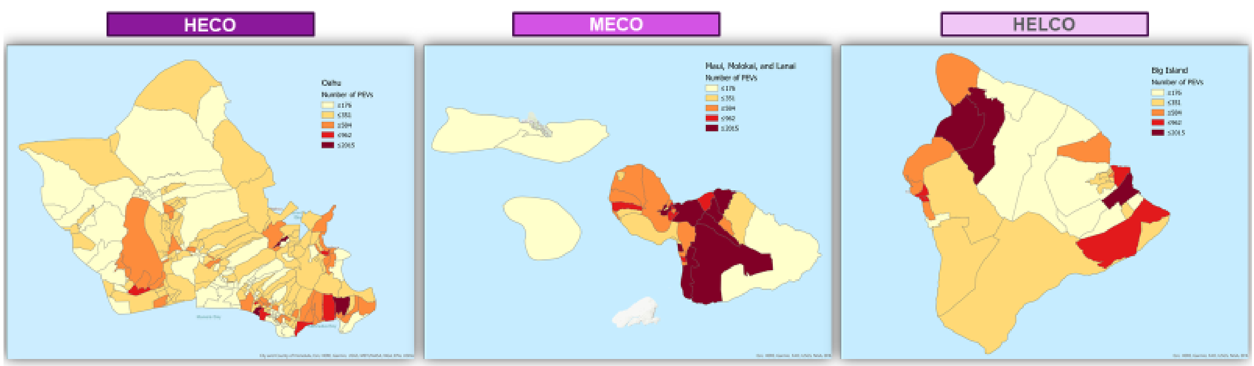
ADAPTING THE COMPANIES' EOT ROADMAP FORECAST



To meet the Critical Backbone Study Planning Methodology ***requirements for locational and energy usage granularity****, The Companies' EV adoption forecast from the EoT Roadmap was adapted for use by* ***Navigant's VAST™ forecasting software***

EV FORECAST REVIEW

EV FORECAST BY ISLAND – CENSUS-TRACT LEVEL SUMMARY (# OF PEVS)



Forecast Notes

- **Over the forecast period, the relative level of adoption by census-tract can vary over time**
- **However, across the three scenarios, the relative level of adoption by census-tract remains constant, but the number of vehicles scales proportionally**
- **The heatmaps shown here represent the reference scenario in the year 2030**

PROJECT UPDATE:
REVIEW OF CHARGER RESULTS
(SECTION 3)

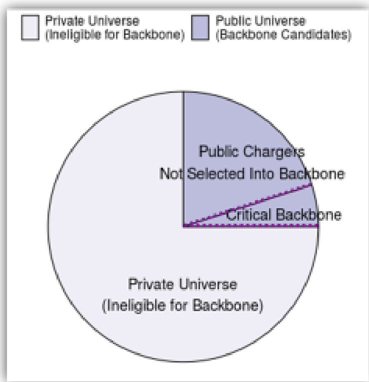
Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

CHARGER UNIVERSE REVIEW

THE CHARGER PORT UNIVERSE – PRIVATE, PUBLIC, CRITICAL BACKBONE

The *Critical Backbone* is a *selected portion* of the Public charging ports within the full EVSE Universe

EVSE Charging "Universe"*



Private vs. Public Ownership

Private

- **Description**: Private chargers are considered "behind the fence" and only accessible by certain groups of PEV drivers
- **Examples**: Residential home charging, workplace employees charging on private lots, MUD tenants charging in underground parking lots, and fleet charging

Public

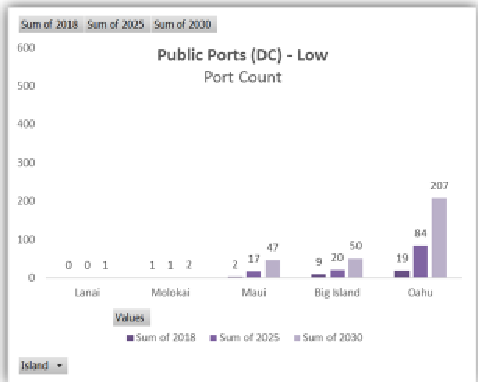
- **Description**: Public chargers are accessible to all PEV drivers, i.e. *not* "behind the fence"
- **Examples**: Curbside charging, charging retail parking lots (i.e. grocery stories), tourist destinations and rail stations

CHARGER UNIVERSE REVIEW

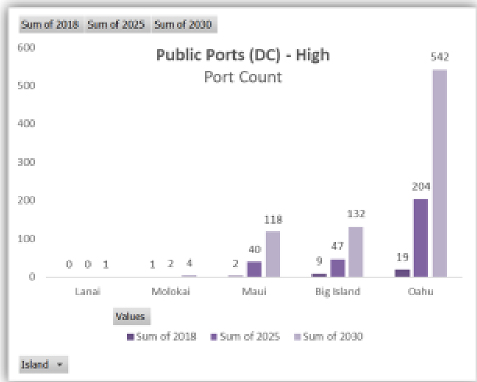
EXISTING (2018) AND FORECASTED (2025, 2030) PORT COUNT, BY SCENARIO

Charging needs (e.g., direct current [DC]) reflect *high, low* scenarios for *electricity* and *gasoline* costs over time based on EoT Roadmap reference case.

Low Scenario



High Scenario

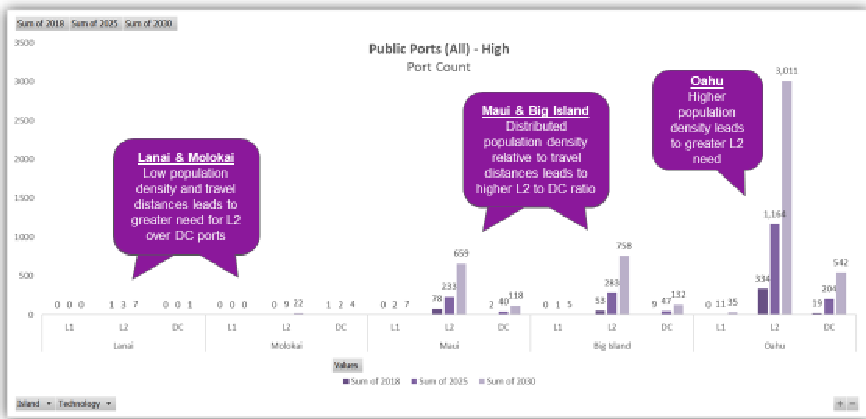


CHARGER UNIVERSE REVIEW

ISLAND-LEVEL CHARGING PORT UNIVERSE, BY TECHNOLOGY – HIGH SCENARIO

***Key Takeaway*: Due to variances in *population density* and *travel distance*, most dramatic public charging needs in Oahu; Maui & Big Island see similar Level 2, DC needs; Lanai & Molokai needs limited at all levels.**

Row Labels	Sum of 2018	Sum of 2025	Sum of 2030
Lanai	**1**	**3**	**8**
L1	0	0	0
L2	1	3	7
DC	0	0	1
Molokai	**1**	**10**	**26**
L1	0	0	0
L2	0	9	22
DC	1	2	4
Maui	**80**	**275**	**784**
L1	0	2	7
L2	78	233	659
DC	2	40	118
Big Island	**62**	**332**	**895**
L1	0	1	5
L2	53	283	758
DC	9	47	132
Oahu	**353**	**1,379**	**3,588**
L1	0	11	35
L2	334	1,164	3,011
DC	19	204	542
Grand Total	**497**	**1,999**	**5,301**

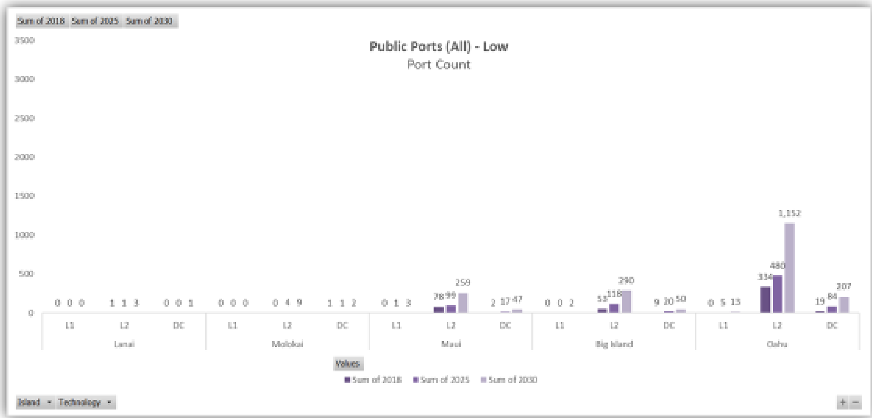


CHARGER UNIVERSE REVIEW

ISLAND-LEVEL CHARGING PORT UNIVERSE, BY TECHNOLOGY – LOW SCENARIO

Key Takeaway: Low electricity and gasoline price scenario sees ***lower overall charging needs*** across the islands, but ***similar trends*** in population density and travel distances.

Row Labels	Sum of 2018	Sum of 2025	Sum of 2030
Lanai	**1**	**2**	**4**
L1	0	0	0
L2	1	1	3
DC	0	0	1
Molokai	**1**	**5**	**11**
L1	0	0	0
L2	0	4	9
DC	1	1	2
Maui	**80**	**117**	**309**
L1	0	1	3
L2	78	99	259
DC	2	17	47
Big Island	**62**	**138**	**343**
L1	0	0	2
L2	53	118	290
DC	9	20	50
Oahu	**353**	**569**	**1,372**
L1	0	5	13
L2	334	480	1,152
DC	19	84	207
Grand Total	**497**	**830**	**2,038**



Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

PROJECT UPDATE:
BACKBONE FILTERING
(SECTION 4)

Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

BACKBONE FILTERING

SELECTION FILTERS

Updated EVSE charging port forecast can be prioritized based on filters that reflect key considerations for stakeholders

Selection Filters Key Points

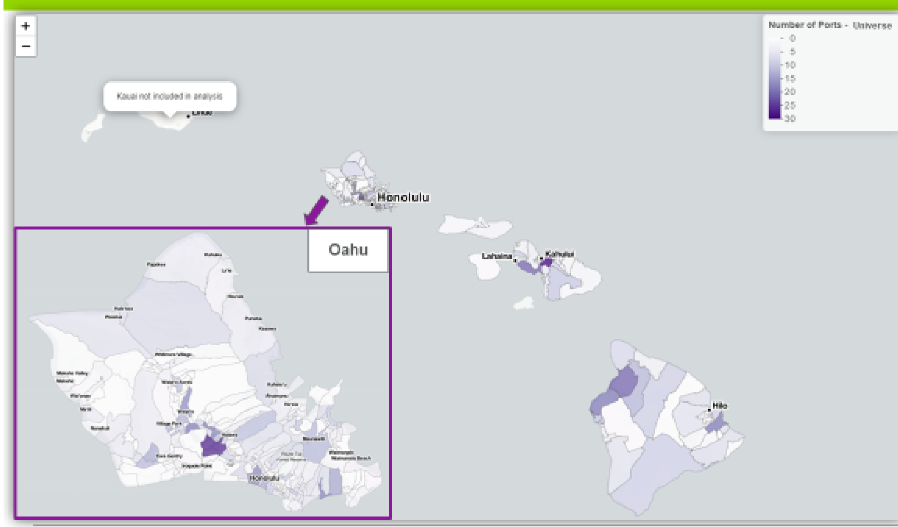
- Supports ***ability to select a subset of the total EVSE universe*** using criteria based on six (6) Selection Filters
  - **Selection Filters** screen out EVSE from a geographic region (i.e. census tract) from the full universe based on the areas unique characteristics
- The Companies ***seek stakeholder feedback*** on relative importance of ***each selection filter***
  - ***Feedback*** to be considered in The Companies' future development of a critical backbone infrastructure
- To support ***stakeholder feedback opportunity***, Navigant performed ***sensitivity test of selection filters***
  - *Test* results indicated a critical backbone ranging from ***10% to 37%*** of the Public EVSE Universe
  - Breadth of range ***warrants additional input*** for The Companies' consideration in developing backbone

Selection Filters Description

- **Multi-Unit Dwelling**
  - Indicates the level of public charging supporting access for multi-unit dwellings
- **Low Income**
  - Indicates a given census tract's proportion of low income residents
- **Utilization**
  - Census tracts with high Utilization Scores support market making, population density, revenue potential
- **Range Support**
  - Indicates the level of support for longer distance trips
- **Development Cost**
  - Indicates the expected level of investment required to install an EVSE in a given census tract due to required updates to the grid
- **Grid Support**
  - Indicates the opportunity for resiliency support through managed charging potential

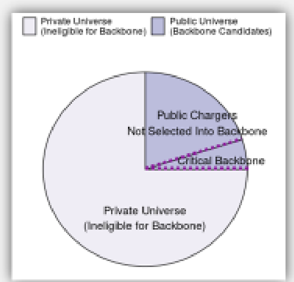
BACKBONE FILTERING

PUBLIC UNIVERSE (ALL BACKBONE CANDIDATES)



Public Universe

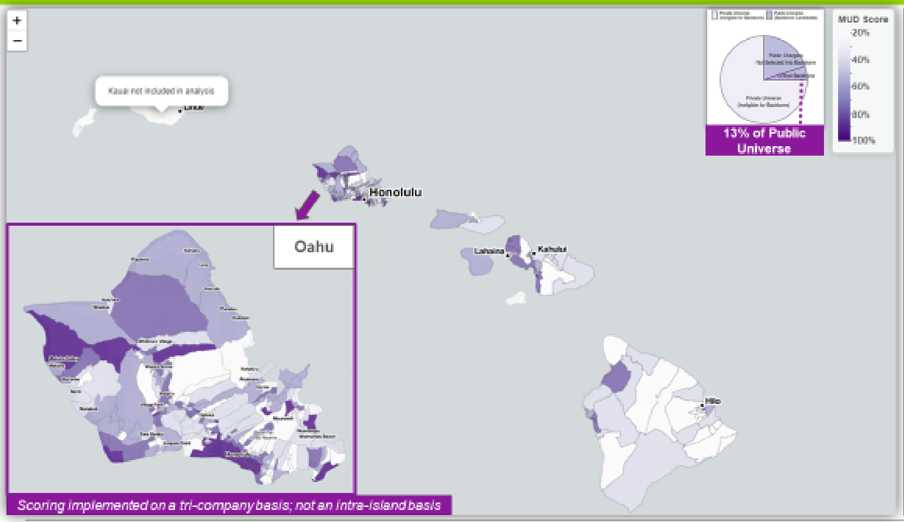
- Description: Public chargers are accessible to all PEV drivers, i.e. not "behind the fence"
- Examples: Curbside charging, charging retail parking lots (i.e. grocery stories), tourist destinations and rail stations



2025 - Reference Scenario

BACKBONE FILTERING

FULLY PRIORITIZE - **MULTI-UNIT DWELLING**



Multi-Unit Dwelling (MUD) Filter

- Description: Indicates the level of public charging supporting access for multi-unit dwellings
- Scale: A higher MUD score means a census tract has a higher proportion of MUD dwellings relative to other census tracts
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with highest MUD concentrations
- Takeaway: Focusing on MUD census tracts results in a critical backbone that reflects 13% of Public Universe

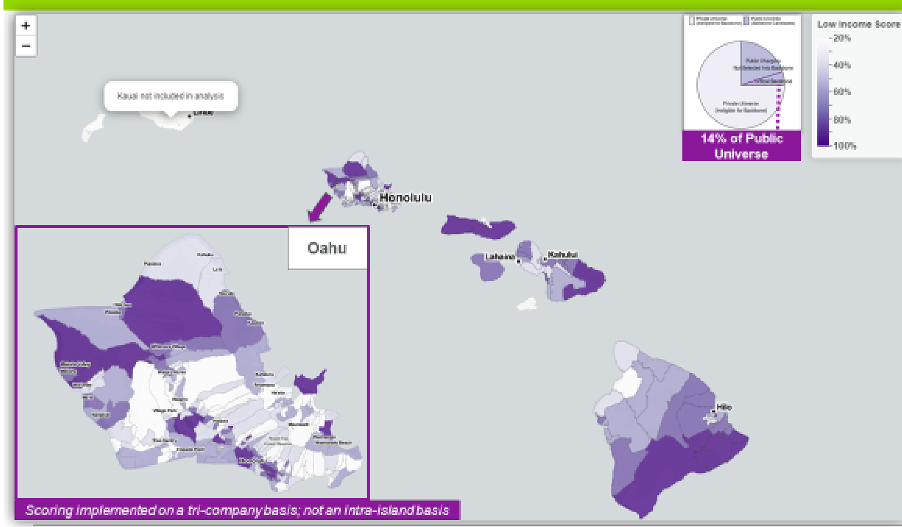
Critical Backbone: 13%

2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

BACKBONE FILTERING

FULLY PRIORITIZE - **LOW INCOME**



Low Income Filter

- Description: Indicates a given census tract's proportion of low income residents
- Scale: The proportion of households considered low income will be higher in census tracts with higher Low Income Scores
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with highest Low Income concentrations
- Takeaway: Focusing on Low Income census tracts results in a critical backbone that reflects 14% of Public Universe

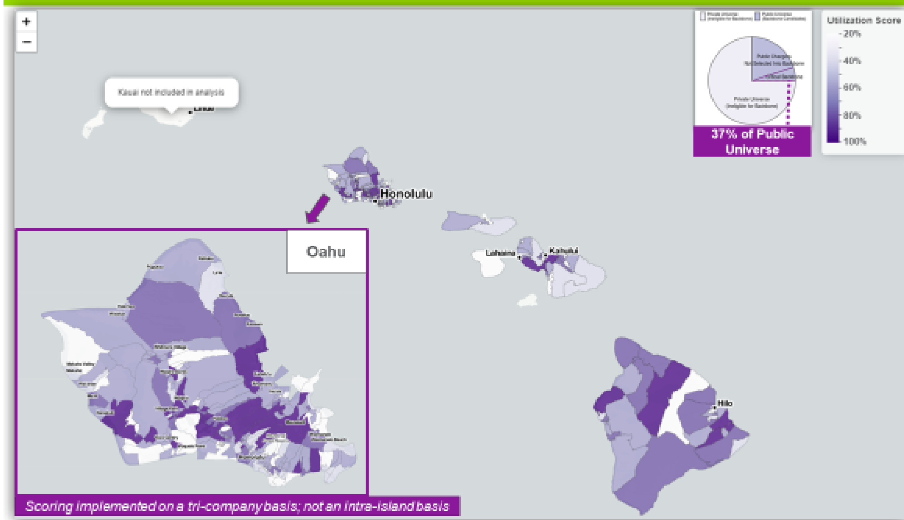
Critical Backbone: 14%

2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

BACKBONE FILTERING

FULLY PRIORITIZE - **UTILIZATION**



Utilization Filter

- Description: Indicates the level of public charging supporting market making, population density, revenue potential
- Scale: A higher Utilization score means a census tract serves more charging demand relative to other census tracts
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with highest Utilization
- Takeaway: Focusing on Utilization census tracts results in a critical backbone that reflects 37% of Public Universe

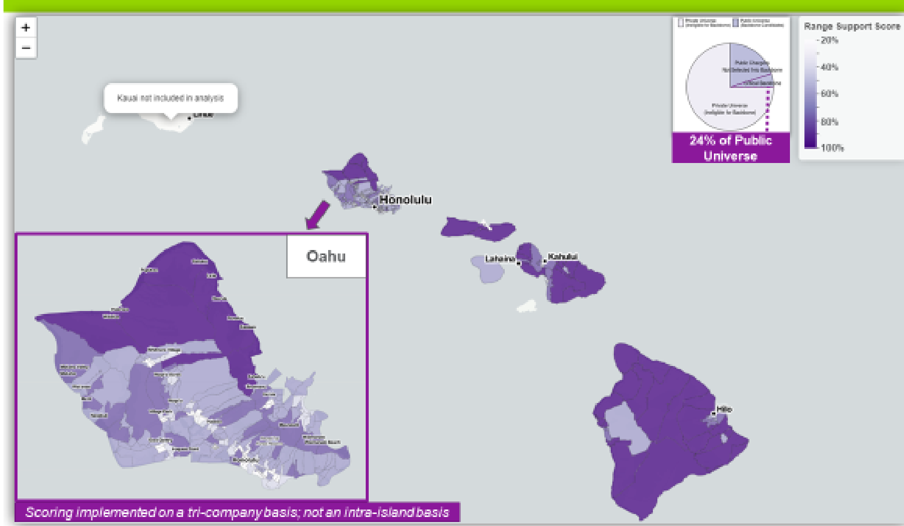
Critical Backbone: 37%

2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light
NAVIGANT

BACKBONE FILTERING

FULLY PRIORITIZE - **RANGE SUPPORT**



Range Support Filter

- Description: Indicates the level of public charging supporting longer distance trips
- Scale: A lower Range Support score reflecting shorter average trips and higher scores reflect areas with longer trips
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with higher Range Support
- Takeaway: Focusing on Range Support census tracts results in a critical backbone that reflects 24% of Public Universe

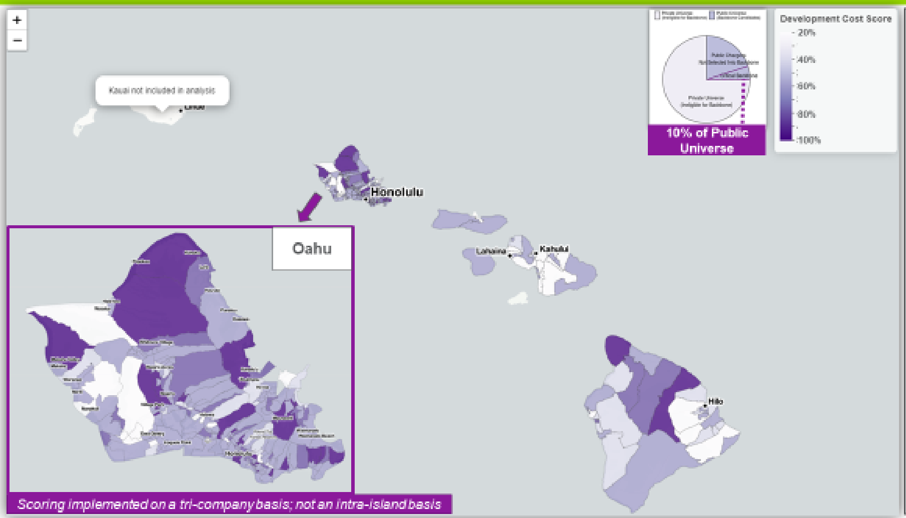
Critical Backbone: 24%

2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light
NAVIGANT

BACKBONE FILTERING

FULLY PRIORITIZE - **DEVELOPMENT COST**



Development Cost Filter

- Description: Indicates the expected level of investment required to install an EVSE in a given census tract due to required updates to the grid
- Scale: A low score indicates higher costs and a high score indicates lower costs
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with lower Development Cost
- Takeaway: Focusing on Development Cost census tracts results in a critical backbone that reflects 10% of Public Universe

Critical Backbone: 10%

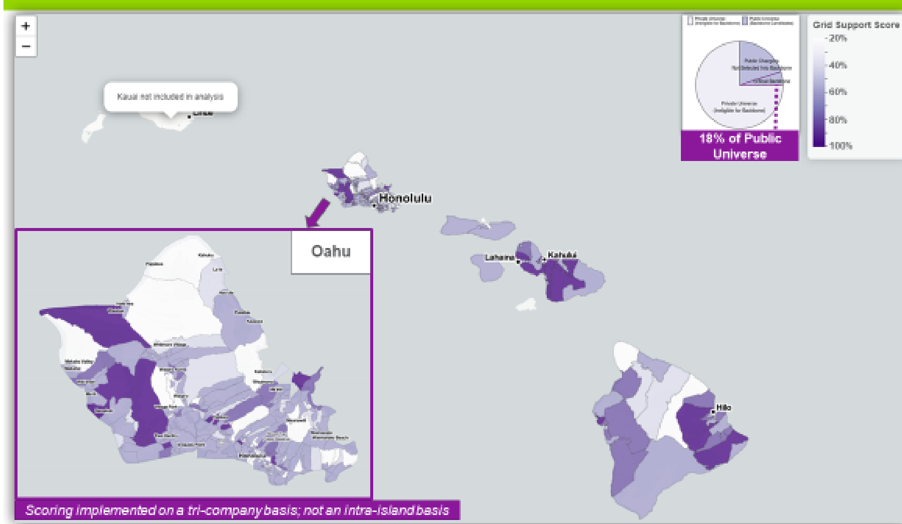
2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

NAVIGANT

BACKBONE FILTERING

FULLY PRIORITIZE - **GRID SUPPORT**



Grid Support Filter

- Description: Indicates the opportunity for resiliency support through managed charging potential
- Scale: A low score indicates less opportunity for grid support and high score indicates more opportunity for grid support
- Example Sensitivity Test: Critical backbone share (%) of Public Universe that only includes census tracts with highest Grid Support score
- Takeaway: Focusing on Grid Support census tracts results in a critical backbone that reflects 18% of Public Universe

Critical Backbone: 18%

2025 - Reference Scenario

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

NAVIGANT

PROJECT UPDATE:
FINAL FEEDBACK & NEXT STEPS
(SECTION 5)

Hawaiian Electric
Maui Electric
Hawai'i Electric Light
NAVIGANT

FEEDBACK TEMPLATE

EV CRITICAL BACKBONE STUDY PLANNING METHODOLOGY

The Companies seek *stakeholder feedback* on relative importance of each *selection filter* for *consideration* in development of a critical backbone infrastructure. Please fill out the following *template*

Selection Filter *(check one)*	**Rationale for Consideration in Critical Backbone** *(per island if more than one selected)*	**Supporting Data** *(if available include links or attachments with template)*	**Needed Data** *(describe if not available)*
☒ Multi-Unit Dwelling ☐ Low Income ☐ Utilization ☐ Range Support ☐ Development Cost ☐ Grid Support	Support large portion of population that live in MUD • Honolulu ranks as 36th densest populated incorporated place in the US • Hawaii ranks as 11th most densely populated state in the US	US Census (2010)	N/A

Select Applicable Island(s) ☒ Oahu ☐ Maui ☐ Molokai ☐ Lanai ☐ Big Island

Sample

FEEDBACK TEMPLATE

EV CRITICAL BACKBONE STUDY PLANNING METHODOLOGY

The Companies seek *stakeholder feedback* on relative importance of each *selection filter* for *consideration* in development of a critical backbone infrastructure. Please fill out the following *template*

Selection Filter *(check one)*	**Rationale for Consideration in Critical Backbone** *(per island if more than one selected)*	**Supporting Data** *(if available include links or attachments with template)*	**Needed Data** *(describe if not available)*
❑ Multi-Unit Dwelling			
❑ Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
❑ Grid Support			

Select Applicable Island(s) ❑ Oahu ❑ Maui ❑ Molokai ❑ Lanai ❑ Big Island

NEXT STEPS

EoT Stakeholders

1. Provide **feedback** via template on **filter prioritization** by **7/19/19**
   - One submission per organization emailed to michael.colon@hawaiianelectric.com
   - Submission may contain multiple templates
2. Communicate willingness to **provide (voluntary) letters of support** for **Critical Backbone Study methodology** by 07/25/19
3. Watch for **communication from The Companies** on timeline for next **opportunity to provide additional stakeholder feedback** on filing activities

Hawaiian Electric Maui Electric Hawai'i Electric Light

1. File **Critical Backbone Study Planning Methodology** on **7/30/19**
2. Communicate update on "**Network Expansion**" filing timeline
3. File "**Network Expansion**" application, targeting **2019 Q4**

THANK YOU!

Follow-up questions?
Feedback?

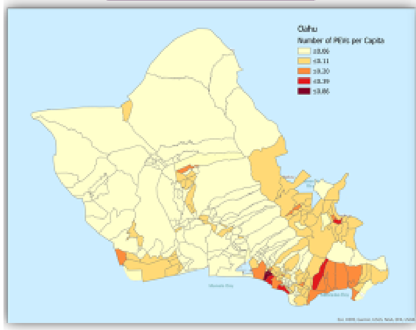
Contact Michael Colon
michael.colon@hawaiianelectric.com

APPENDIX MATERIAL

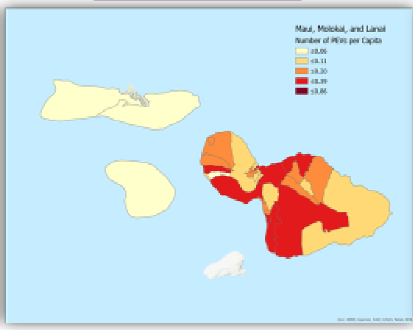
EV FORECAST REVIEW

EV FORECAST BY ISLAND – CENSUS-TRACT LEVEL SUMMARY (PEVS PER CAPITA)

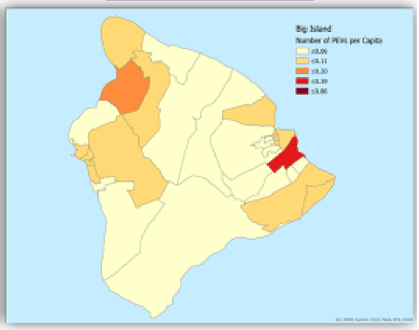
HECO



MECO



HELCO



Forecast Notes

- Over the forecast period, the relative level of adoption by census-tract can vary over time
- Across the three scenarios, the relative level of adoption by census-tract remains constant, but the number of vehicles, scales proportionally
- The heatmaps shown here represent the EoT Roadmap reference scenario in the year 2030

PROJECT REVIEW

EVSE FORECAST METHODOLOGY: OVERVIEW

1. LD EV Adoption Forecast
2. Comparative Analysis
3. Incremental Use Cases
4. Charging Siting Module Analysis
5. Analysis of Critical Backbone
6. Grid Impact / Upgrade Analysis
7. Summarize Methodology

- **Activity 1: Existing LD EV Adoption Forecast** - coordinate with the Companies to adapt the Companies' existing LD EV high and low adoption forecasts for use in Navigant's ***VAST™ Charging Siting Module***
- **Activity 2: Comparative Analysis** - Perform a comparative analysis of baseline chargers and chargers projected in future analysis years to identify key existing network gaps relative to coverage and usage for relevant use cases associated with the forecasted PEV adoption
- **Activity 3: Incremental Use Cases** – Formulate proposed incremental use cases to address the Companies' charging infrastructure network gaps (i.e., charging type, locations)
- **Activity 4: Charging Siting Module Analysis** – Populate module with use cases to map station locations and select siting **Objective Function**
- **Activity 5: Analysis of Critical Backbone** – Develop a methodology for identifying the "critical backbone" scenario based on collaboration with the Companies' and **Identify Selection Filters**
- **Activity 6: Grid Impact/Upgrade Analysis** – Provide an estimated charging load profile, electrical peak loading, and service voltage for each proposed critical backbone charger using the **VAST™ Load Forecasting Module**
- **Activity 7: Summarize Methodology** – Summarize the backbone siting inputs, assumptions, and methodology for review with the Companies' in a working session to refine and adjust the approach as needed to align with the Companies' needs.

B.5 July 12, 2019 Meeting Feedback

Invitees included 34 stakeholders from 17 organizations. Attendees included 13 participants from 9 organizations. The Companies received the information contained in this subsection from stakeholders during and after the meeting.

Selection Filter *(check one)*	**Rationale for Consideration in Critical Backbone**	**Supporting Data** *(if available include links or attachments with template)*	**Needed Data** *(describe if not available)*
❑ x (#1) Multi-Unit Dwelling	MUDs represent a market segment with some of the most challenging market barriers to overcome, while also being one of the most pressing to solve for from an equity standpoint. Access to home charging must not be limited to those in single family homes. While utility programs to provide charging within MUDs are critical, public charging, in particular fast charging around MUDs or along drivers' daily routines and at workplaces also help to solve for this challenge.		
❑ Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
❑ Grid Support			

Select Applicable Island(s): x All islands, but primarily urban centers. ❑ Molokai ❑ Lanai ❑ Big Island

Selection Filter *(check one)*	**Rationale for Consideration in Critical Backbone**	**Supporting Data** *(if available include links or attachments with template)*	**Needed Data** *(describe if not available)*
❑ Multi-Unit Dwelling	Fulfilling on the promise of transportation electrification is predicated upon providing for equitable access. This implicates an adequate level of public charging, including in disadvantaged communities, in addition to supporting to electrified transit and shared mobility. *[Respondent]* considers low income considerations to be part of broader equity demands, which also include urban-rural equity, ensuring charging is not only or principally provided in urban centers.		
❑ x (#2) Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
❑ Grid Support			

Select Applicable Island(s): ❑ x All islands ❑ Maui ❑ Molokai ❑ Lanai ❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling ❑ Low Income ❑ Utilization ❑ Range Support ❑ Development Cost ❑ x (#3) Grid Support	Many of the benefits of transportation electrification are predicated upon effective load management and grid support, something that is especially true and of value given the unique attributes of the state's grid. Ensuring that load management strategies, including smart charging, are used across the state's EVSE deployments in all market segments, including public and fast charging is essential to ensure EV charging is a grid asset rather than liability. While there should be some consideration for where charging is located to provide grid support, how that charging occurs should be of greater focus.		
Select Applicable Island(s)	❑ x All islands ❑ Maui	❑ Molokai ❑ Lanai	❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling ❑ Low Income ❑ Utilization ❑ x (#4) Range Support ❑ Development Cost ❑ Grid Support	While EV battery capacities are increasing, a focus should remain on ensuring there is sufficient charging infrastructure to facilitate A to B travel, and giving drivers confidence they will have adequate charging options in more rural parts of the state. For example, it will be critically important that EV drivers have confidence that they can get from urban centers to tourism locations and back. As part of this, a focus on developing destination charging at parks and beaches as California has done could be a valuable priority. Range support is also a key consideration for supporting fleet vehicles that may not cover large distances but instead cover many miles in a certain geography.	California AB 1083: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB1083	
Select Applicable Island(s)	❑ x All islands ❑ Maui	❑ Molokai ❑ Lanai	❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling ❑ Low Income ❑ Utilization ❑ Range Support ❑ x (#5) Development Cost ❑ Grid Support	While development costs should be a consideration, what is more critical is getting the necessary charging infrastructure in the right locations to drive adoption. Indeed, these market gaps exist due to market challenges, costs and risks that the private market is unable to bear, the reason why public funding is implicated in the first place.		
Select Applicable Island(s)	❑ x All islands ❑ Maui	❑ Molokai ❑ Lanai	❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling ❑ Low Income ❑ x (#6) Utilization ❑ Range Support ❑ Development Cost ❑ Grid Support	While opportunities to ensure a certain level of utilization should be a consideration, this should not be a limiting lens of analysis. Indeed, some of the most critically needed infrastructure in filling market gaps will likely be some of the least utilized, at least in the near term. Utilization and value have a very limited linkage, however utilization can have detrimental impacts to the driver experience very quickly when queuing occurs. Ensuring charging locations have multiple charging ports therefore should be a key consideration.	https://www.nytimes.com/2019/06/22/business/energy-environment/electric-cars-charging.html https://www.wired.com/2014/12/ev-charging-infrastructure-2/ https://www.latimes.com/business/la-fi-ev-charging-challenge-20181226-story.html	
Select Applicable Island(s)	❑ x All islands ❑ Maui	❑ Molokai ❑ Lanai	❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling ❑ Low Income ❑ Utilization ❑ Range Support ❑ Development Cost ✖ Grid Support	Range support is being met sufficiently via other chargers either current or planned. And while locating chargers near multi-unit dwellings will increase the convenience of EV ownership for the residents that live in them, those dwellings are often located near populated areas where other companies may find a business case to locate chargers on their own. Because of the need to maximize daytime charging to support Hawaii's clean energy goals, and the synergies with workplace charging that this might entail, I've selected grid support.		
Select Applicable Island(s)	✖ Oahu ✖ Maui	✖ Molokai ✖ Lanai	✖ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
X Multi-Unit Dwelling ❑ Low Income ❑ Utilization ❑ Range Support ❑ Development Cost ❑ Grid Support	Census data indicating large percentage of population living in MuD		Do we fully understand overlap of MuD and Low Income
Select Applicable Island(s)	X Oahu ❑ Maui	❑ Molokai ❑ Lanai	❑ Big Island

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
√ Multi-Unit Dwelling	• In general, *[Respondent]* strongly encourages investment in Level 2 charging in multi-unit dwellings – This supports convenient access to charging services as these locations coincide with where EV drivers would park their vehicle anyway for a sufficient period to achieve a meaningful charge. – Money will go much further if focused on Level 2 relative to focusing on Level 3 given high costs of deploying DCFCs. – Utility investment and support in MUD context can address the principal-agent issues and other challenges that limits investment in MUD charging facilities.		• Could validate approach via consumer study/survey to assess how propensity to purchase an EV changes as a function of charging location and level. • To support non-utility investments in charging infrastructure, might consider developing a map indicating where there is available capacity such that deployment of charging facilities wouldn't engender significant upgrade costs.
❑ Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
❑ Grid Support			
Select Applicable Island(s)	√ Oahu ❑ Maui ❑ Molokai ❑ Lanai ❑ Big Island		

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data	Needed Data
❑ 4) Multi-Unit Dwelling	These should be targeted to support EV adoption in areas with higher resident concentration and where household level deployment of EV infrastructure is more challenging		
❑ 3) Low Income	Although the cost of EVs is a major obstacle for adoption for LMI Households, we should make supporting LMI adoption a priority as they are those most negatively impacted by high price of fuel and least able to acquire EV infrastructure themselves	https://www.auw.org/alice	
❑ 2) Utilization	Infrastructure should first be placed in areas with highest estimated/projected use		
❑ 5) Range Support	Addressing range anxiety and providing a sense of security for EV adopters is critical in order to accelerate overall adoption.		
❑ 6) Development Cost	Although initial development cost is important, EV infrastructure should be considered a long term investment with many potential community benefits. Investment in EV infrastructure should not be viewed as one requiring short-term returns driven by quarterly profits.		
❑ 1) Grid Support	This is a critical need for overall grid resilience and stability		
Select Applicable Island(s)	❑ Oahu ❑ **X Maui** ❑ **X Molokai** ❑ **X Lanai** ❑ Big Island		

Selection Filter *(check one)*	Rationale for Consideration in Critical Backbone	Supporting Data *(if available include links or attachments with template)*	Needed Data *(describe if not available)*
❑ Multi-Unit Dwelling	Range Support aligns with designated routes on Oahu, Maui and Hawaii Island as signage ready alternative fuel corridors by the Federal Highway Administration. The rationale and/or consideration in the critical backbone ensures our highway infrastructures supports sustainable energy.	https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/all_corridors/	
❑ Low Income			
❑ Utilization			
❑ Range Support			
❑ Development Cost			
☒ Grid Support			
Select Applicable Island(s)	❑ Oahu ❑ Maui ❑ Molokai ❑ Lanai ❑ Big Island		

Appendix C. Electric Vehicle Critical Backbone Study: Planning Methodology Tool – User's Guide

The User's Guide is intended as a standalone document to assist the Companies' users in understanding and using the *Electric Vehicle Critical Backbone Study: Planning Methodology Tool (Backbone Tool)*. It first defines the forecast dimensions and provides information on the data used to define the dimensions. It includes a brief description of key methodologies used to forecast the EV Charging Universe required to support PEV adoption on the five islands. It then describes the six selection filters available to select the subset of chargers that make up the Critical Backbone. Finally, it provides tips on navigating and using the web tool.

C.1 Forecast Dimensions (Activity 2)

The EV Charging Universe forecast is dimensioned by Use Case, Ownership, and Technology for each census tract on the five islands. This section details the Use Cases and notes the Ownership and Technology dimensions included in each one.

- **Use Cases:** A Use Case is a category of EV charging that serves a similar charging purpose and can be forecasted using similar methodology. Use Cases vary by the type of charging location included in the model, as well as the availability of that location to public access. This study forecasted eight Use Cases: Market, Tourist Destination, Rail Station, Shared Single-Unit Dwelling, Single-Unit Dwelling, Multi-Unit Dwelling, Workplace, and Light-Duty Fleet.
- **Ownership:** Each Use Case is categorized as either Public or Private Ownership. Public chargers are accessible to all PEV drivers, while Private chargers are considered behind the fence and only accessible by certain groups of PEV drivers—for example, workplace employees or MUD tenants.
- **Technology:** Depending on the Use Case, a given site will have different Technology levels of ports: DC fast charging (DCFC), Level 2, or Level 1.

Table C-1 describes each Use Case in more detail.

Table C-1. Use Case Table

Use Case	Definition	Example	Dimensions	Data Source
Market	Public chargers that are driven by traffic demand, sited in public areas where PEV drivers are likely to be driving frequently.	A charger installed in the parking lot of a grocery store in a busy area of town.	Technologies: • DC • L2 Ownership: • Public	**National Highway System GIS Data (Federal Highway Administration)** • **Granularity**: Lat/Long • **Link:** https://www.fhwa.dot.gov/policyinformation/hpms/shapefiles.cfm
Tourist Destination	Public EV charging sites located that allow travel between major destination areas, not	A charger installed in the parking area at a public beach that is off the beaten track where	Technologies: • DC • L2 Ownership:	**The Companies' list of required Tourist Destination locations** • **Granularity**: Lat/Long

Use Case	Definition	Example	Dimensions	Data Source
	based strictly on vehicle traffic.	tourists take longer than average trips to reach.	• Public	*Note: Any location that appears on the Tourist Destination list but was selected as a Market site by the site optimization algorithm was included as a Market site. This means that all remaining Tourist Destination sites are not located based on traffic demand.*
Rail Station	Public EV charging sites located in the parking lots of HART rail stations. This Use Case is only present on the island of Oʼahu.	A charger installed in the public parking lot where commuters park to catch the train to work.	Technologies: • DC • L2 Ownership: • Public	**Honolulu Authority for Rapid Transit (HART) Rail Transit Route Map** • **Granularity**: Lat/Long • **Link:** http://www.honolulutransit.org/ride/route-map
Shared Single-Unit Dwelling	Shared home chargers located in residential areas where homes are not likely to be able to install their own charger.	A curbside charger installed in a neighborhood of older homes that do not have garages.	Technologies: • DC • L2 • L1 Ownership: • Public	**US Census Year Structure Built Data** • **Granularity**: Census Tract • **Units**: Number of households in each vintage category (e.g., built 1950 to 1959) • **Link:** https://factfinder.census.gov/bkmk/table/1.0/en/ACS/17_5YR/B25034 *Note: Homes built prior to 1960 are included in the SUD-Shared Use Case. Homes built in 1960 or later are included in the SUD Use Case.*
Single-Unit Dwelling	Home chargers installed in the driveway or garage of a single-unit dwelling and used only by the occupant of that dwelling.	A charger installed in the garage of a residential single-family home.	Technologies: • L2 • L1 Ownership: • Private	**US Census Units in Structure Data** • **Granularity**: Census Tract • **Units**: Number of households in each structure type category (e.g., single-unit detached) • **Link:** https://factfinder.census.gov/bkmk/table/1.0/en/ACS/17_5YR/B25024 *Note: Homes built prior to 1960 are included in the SUD-Shared Use Case. Homes built in 1960 or later are included in the SUD Use Case.*

Multi-Unit Dwelling	Home chargers installed in the garage of a multi-unit dwelling and used only by the occupants of that dwelling.	A charger installed in a private garage of an apartment building where only tenants are allowed to park.	Technologies: • DC • L2 • L1 Ownership: • Private	**US Census Units in Structure Data** • **Granularity**: Census Tract • **Units**: Number of households in each structure type category (e.g., single-unit detached) • **Link:** https://factfinder.census.gov/bkmk/table/1.0/en/ACS/17_5YR/B25024
Workplace	Chargers sited at a workplace and only available to employees of that workplace.	A charger installed in a private garage of an office building where only employees are allowed to park.	Technologies: • L2 Ownership: • Private	**US Census County Business Patterns Data** • **Granularity**: ZIP Code (Navigant transforms into Census Tract) • **Units**: Number of employees • **Link:** https://factfinder.census.gov/bkmk/table/1.0/en/BP/2016/00A1
Light-Duty Fleet	Private depot chargers serving fleets of light-duty vehicles	A charger located in a private government lot where the fleet of government vehicles charge.	Technologies: • DC • L2 Ownership: • Private	**Historic PEV Fleet Registrations** • **Granularity**: Census Tract • **Units**: Number of vehicles

C.2 EV Charging Universe Forecast Approach (Activities 3)

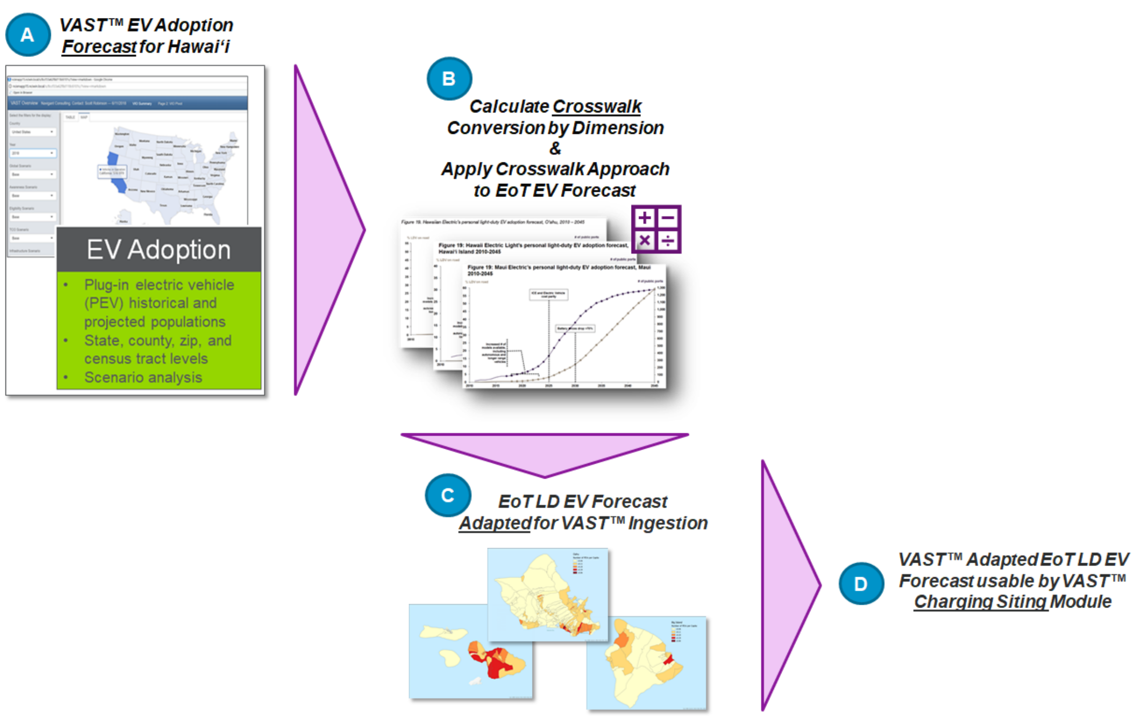
This section of the User's Guide outlines the methodology steps required to understand the EV Charging Universe forecast described in Section 4 of the *Electric Vehicle Critical Backbone Study: Planning Methodology Report*. As described in the report, the EV Charging Universe is grounded in the Electrification of Transportation (EoT) Roadmap's vehicle adoption forecast and relies on the following steps to arrive at the Public Universe forecast.

1. The Companies' Light Duty Electric Vehicle Adoption Forecast and Crosswalk
2. Vehicle Adoption Simulation Tool (VAST)™ EV Charging Site Optimization
3. Allocation of Ports to Sites and Public EV Charging Universe

1. The Companies' Light Duty Electric Vehicle Adoption Forecast and Crosswalk

Figure C-1 provides an overview of the process by which Navigant coordinated with the Companies to adapt, or crosswalk, their existing EoT Roadmap light duty (LD) PEV adoption forecasts for use in the VAST™ suite.

Figure C-1. Overview of Crosswalk Process



A: VAST™ EV Adoption Forecast

- Use the VAST™ tool to forecast EV adoption for the state of Hawai'i at the Powertrain (BEV/PHEV), Owner (Individual/Fleet), and Class (Passenger Car/Light Truck) level

- Disaggregate the VAST™ Hawai'i forecast to census tract level using the VAST™ EV Adoption Forecasting module, historic EV adoption by census tract, and income and education data from the US Census

B: Calculate Crosswalk Conversion by Powertrain, Owner, Class and Census Tract by Island

- Use the VAST™ forecast at the Powertrain, Owner, Class, and Census Tract level, to calculate a value between 0 and 1 for each Powertrain, Owner, Class, and Census Tract combination representing the portion of EV adoption on each island contained by each segment
- For each island, the breakout values will sum to 1

C: Apply breakouts to The Companies' LD EV Forecast by Island

- For each island, multiply the VAST™ breakout values by the Companies' LD EV island-level forecast

D: VAST™ Adapted EoT LD EV Forecast

- Powertrain, Owner, Class, Census Tract granularity makes the adapted forecast usable by the VAST™ Charging Siting Module

2. VAST™ EV Charging Site Optimization

VAST™ EV Charging Siting Module Hybrid Objective Functions

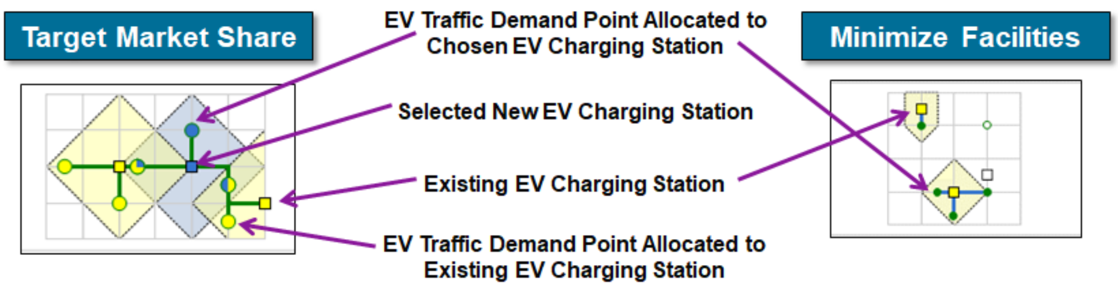
Navigant determined the potential locations for additional charging sites based on Use Cases and a hybrid approach using two objective functions.

First, the Target Market Share objective function located EV charging sites in areas with the highest demand. This objective function results in clusters of sites in areas with dense traffic. Target Market Share chooses location and minimum number of facilities to reach a specified target market share; this translates to choosing the minimum number of EV charging sites to meet a specified share of EVMT (electric vehicle miles traveled) demand. This objective function solves the competitive facility location problem and uses gravity model concepts to determine demand allocation to each facility

Next, the Minimize Facilities objective function filled in the gaps to locate the minimum number of sites required to cover the remaining traffic demand not covered by the Target Market Share function. This objective function results in sites spread more evenly over the islands to meet all demand. Minimize Facilities chooses facilities such that as many traffic data points as possible are within the road network distance cutoff defined are allocated to charging sites. For example, a cutoff distance of two miles would result in EV traffic demand within two miles of a site being allocated to that site. In addition, the number of sites required to cover all traffic data points is minimized. The objective function operates under the assumption that EV traffic at any specific point on the road network is assumed to charge from its nearest charging site only.

Figure C-2 provides an overview of the hybrid objective function approach.

Figure C-2. Hybrid Objective Function Approach Overview



Inputs

- Vehicle miles traveled (VMT) on each road segment from National Highway System (NHS) GIS data (Federal Highway Administration)
- VAST™-adapted EoT LD EV forecast at census tract level converts NHS VMT into VMT by battery electric VMT (BEVMT), which is the traffic demand input into the network analysis location allocation optimization problem

Outputs

- EV charging sites at lat/long level, which allows for required intermediate calculations but are aggregated to the census tract level when finalized
- BEVMT demand at each EV charging site

3. Location of Ports to Sites and Public EV Charging Universe

Allocation of Ports to Sites Analysis

This study relied on the National Renewable Energy Laboratory's (NREL's) Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite to calculate the overall number of public ports required to support the forecasted PEV adoption on the five islands based on the steps identified in Figure C-3.[1]

[1] See Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite, National Renewable Energy Laboratory, available at https://afdc.energy.gov/evi-pro-lite.

Figure C-3. Steps for Allocations Ports to Sites

Existing Charger-to-Vehicle Ratios	The AFDC database of existing chargers and the Companies' data on existing PEV registrations were used to calculate the 2019 public charger-to-vehicle ratios by technology (L2 and DCFC).
EVI-Pro Lite Tool	The forecasted number of LD PEVs was input into the EVI-Pro Lite tool for the year 2028. The tool only functions up to 10% market share which is exceeded by the adoption forecast beginning in 2029.
Interpolated Charger-to-Vehicle Ratios	The number of public L2 and DCFC output based on the assumptions are used to calculate the long-run charger-to-vehicle ratio and an S-curve is used to interpolate between the existing and long-run ratios.
Forecasted Number of Chargers	The charger-to-vehicle ratios are used to calculate the total number of chargers needed at each year. Chargers are distributed among sites based on the demand weight of each site.

EVI-Pro Lite Assumptions

- Vehicle Mix[2]
  - PHEV with 20-mile range = 6%
  - PHEV with 50-mile range = 27%
  - BEV with 100-mile range = 18%
  - BEV with 250-mile range = 49%
- Full PHEV Support: Most PHEV drivers would not need to use gasoline on a typical day
- Access to Home Charging = 85%: This aligns with the Companies' survey data indicating 85% of charging needs are met at home[3]

C.3 Selection Filters (Planning Methodology Activity 5)

In the EV Charging Universe forecast, each census tract was assigned a percentile score in six categories: MUD Support, Low Income Support, Utilization, Range Support, Development Costs, and Grid Support. The 100th percentile prioritizes that category the most, and zero percentile the least. The selection filters are used to select the subset of chargers that make up the Critical Backbone. The Backbone Tool is designed to be dynamic and allow the user to see the impact of different prioritization schemes on the resulting Critical Backbone.

The series of figures in this section describe each selection filter in detail, including the data and calculations used to derive the score for each census tract and an example of the selection filter's use.

---

[2] Note: Vehicle mix of 33% PHEV and 67% BEV aligns with results of adapted LD EV Forecast.

[3] Trans 13-07, Attachment A at 24, filed March 29, 2018

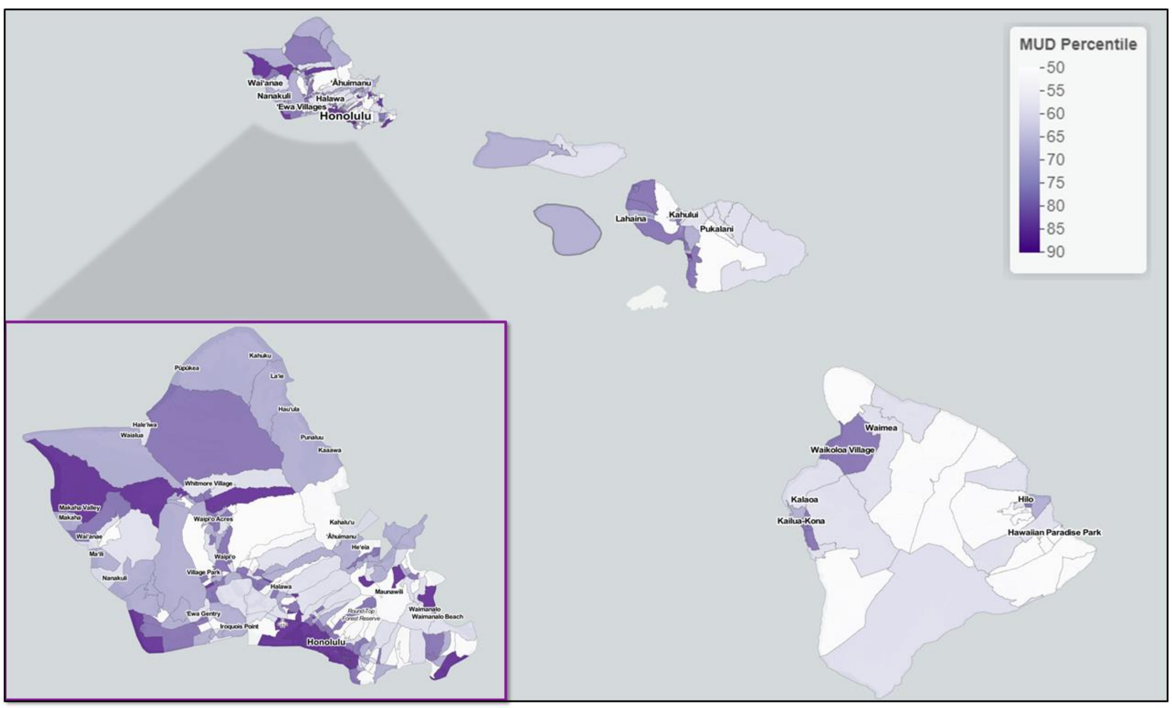
Multi Unit Dwelling (MUD) Support

MUD percentile indicates the level of public charging that supports access for MUDs. A higher MUD score means a census tract has a higher proportion of MUDs relative to other census tracts.

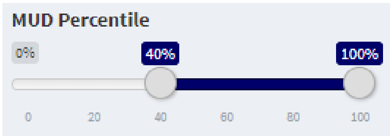
Calculation and Analysis

- **Label census categories as either SUD or MUD**
  - Single-family detached and single-family attached homes are considered SUD, all others are MUD.
- **Calculate MUD proportion for each census tract**
  - MUD proportion is the number of households categorized as MUD divided by the total number of households in the census tract
- **Rank-order census tracts by MUD proportion and assign percentile score**
  - Pool census tracts from all islands together into one rank-order, then split census tracts into five equal quintiles and assign percentile score where 100th percentile means highest MUD proportion and 0th percentile means lowest MUD proportion

Figure C-4. MUD Support Percentile



Interpretation Example



For example, to prioritize public chargers in areas near many MUDs, move the MUD slider toward the higher percentiles. In this selection, tracts in the 40th to 100th percentile will be included in the Critical Backbone. This means the percentage of dwellings that are MUDs will be average or higher than average.

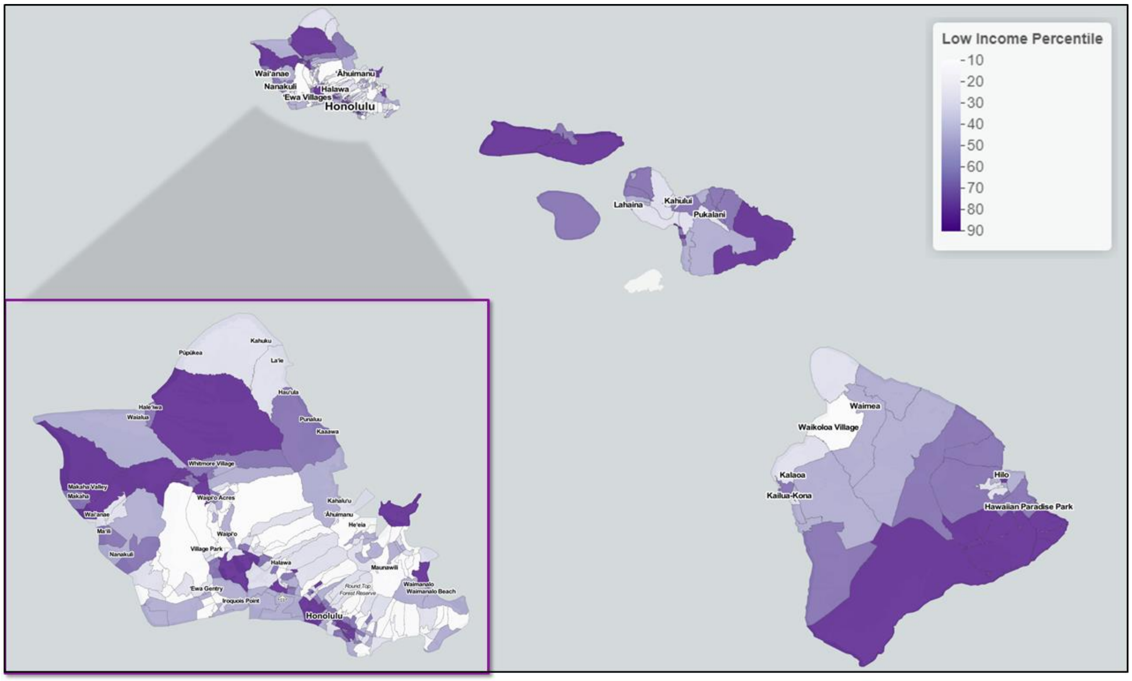
Low Income Support

Low Income percentile indicates a given census tract's proportion of low-income residents. The proportion of households considered low income will be higher in census tracts with higher low-income percentiles.

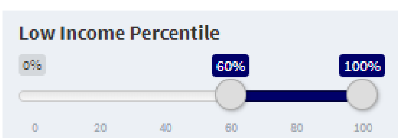
Calculation and Analysis

- **Label census income buckers as either low income or not low income**
  - To align with the Department of Housing and Urban Development (HUD) definition, low income is considered household income less than $75,000 per year on O'ahu, or less than $80,000 per year for all other islands.
- **Calculate low income percentage for each census tract**
  - Low income percentage is the number of households categorized as low income divided by the total number of households
- **Rank-order census tracts by low income proportion and assign percentile score**
  - Pool census tracts from all islands together into one rank-ordering, then split census tracts into five equal quintiles and assign percentile score where 100th percentile means highest low income proportion and 0th percentile means lowest low income proportion

Figure C-5. Low Income Support Percentile



Interpretation Example



For example, to prioritize public chargers in low income areas, slide the Low Income percentile slider toward the higher scores. In this selection, tracts in the 60th and 100th percentile will be included in the Critical Backbone. This means the percentage of households that are considered low income will be higher than average.

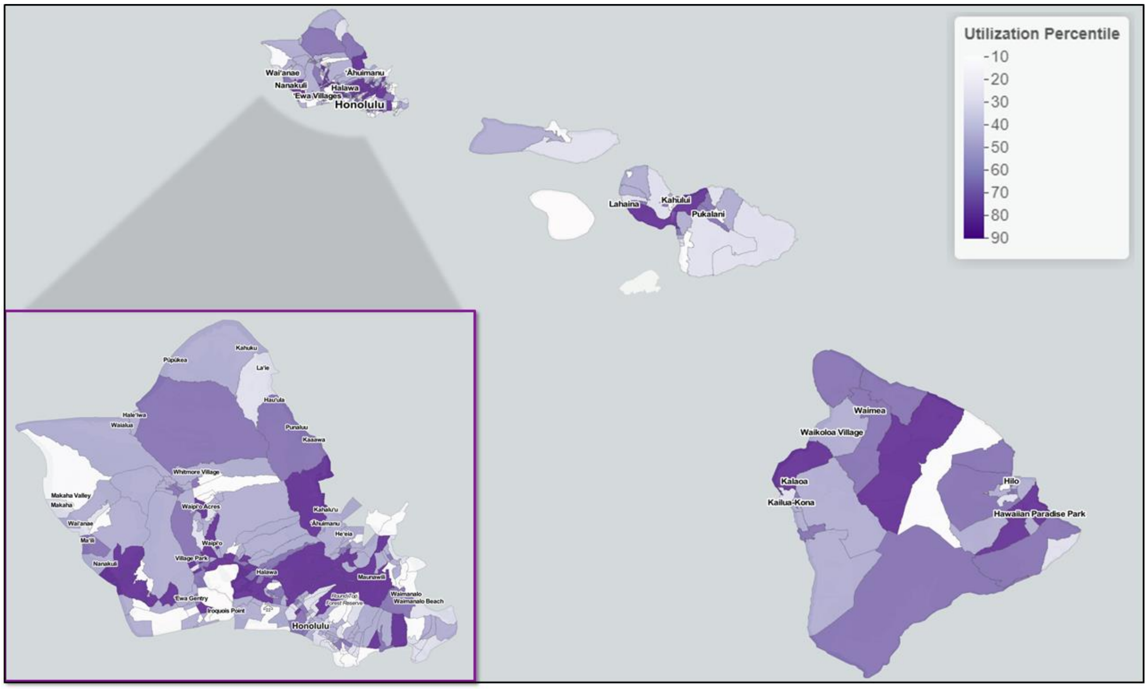
Utilization

Census tracts with high utilization percentiles support market making, population density, and revenue potential. Chargers in these census tracts will serve more charging demand relative to other census tracts.

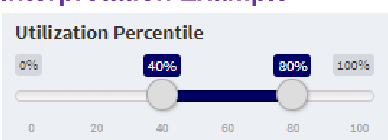
Calculation and Analysis

- **As part of the siting optimization, traffic demand is allocated to chosen sites**
  - Sites that serve higher BEVMT are given higher demand weights
- **Calculate average demand served at the census tract level**
  - Aggregate sites to the tract level by averaging their BEVMT demand weights
- **Rank-order tracts by average BEVMT served per site and assign percentile score**
  - Pool census tracts from all islands together into one rank-ordering, then split census tracts into five equal quintiles and assign percentile scores where 0th percentile means lowest BEVMT served and 100th percentile means highest BEVMT served.

Figure C-6. Utilization Percentile



Interpretation Example



For example, to prioritize public chargers that are expected to be highly utilized, move the Utilization percentile slider to the right. In this selection, tracts in the 40th to 80th percentile will be included in the Critical Backbone. This means the expected utilization of chargers in the backbone will be slightly above average but not the highest possible. Perhaps the most utilized chargers are expected to be installed by third parties and do not need to be included in the backbone.

Range Support

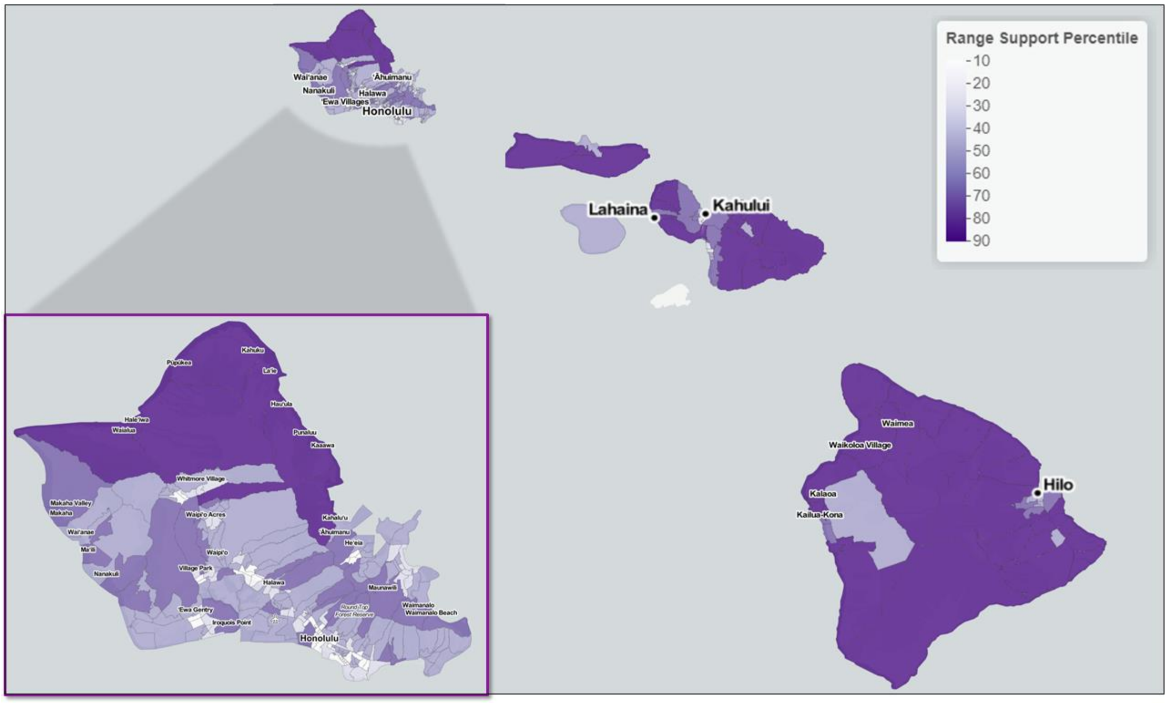
Range Support percentile indicates the level of support for longer distance trips.

Calculation and Analysis

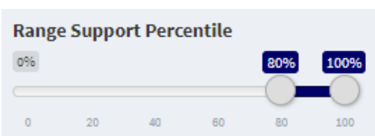
- **Identify next nearest site to each chosen EV charging site**
  - For each site at the lat/long level, calculate the network distance (i.e., distance along road network) to the next nearest site
- **Calculate average network distance at the census tract level**
  - Aggregate sites to the tract level by averaging their distances to next nearest sites
- **Rank-order tracts by average distance and assign percentile score**

- Pool census tracts from all islands together into one rank-ordering, then split census tracts into five equal quintiles and assign score where 100th percentile means longest average distance to next site and 0th percentile means shortest average distance to next site

Figure C-7. Range Support Percentile



Interpretation Example



For example, to prioritize public chargers that support longer range trips, slide the Range Support percentile slider toward the higher scores. In this selection, tracts in the 80th to 100th percentile will be included in the Critical Backbone. This means the chargers in the backbone will, on average, be sited further away from their nearest neighbors to enable longer trips to areas with less prevalent charging infrastructure.

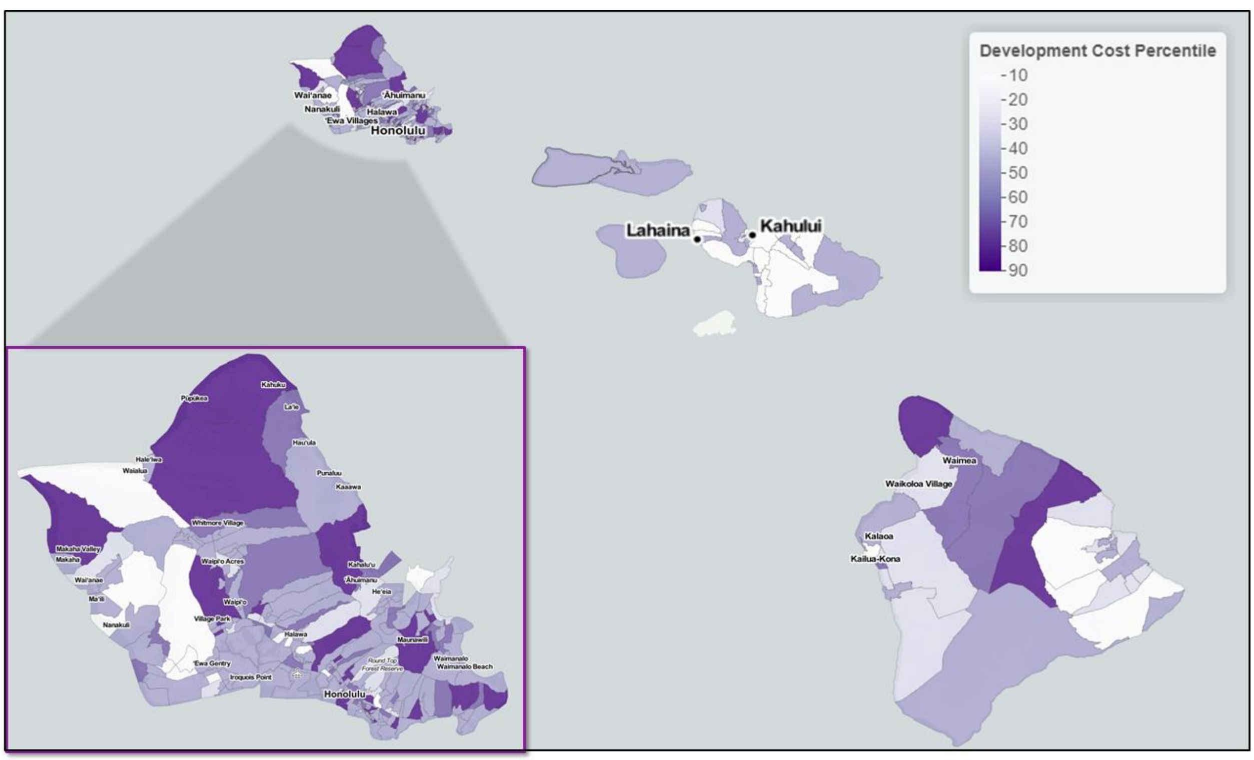
Development Cost

The Development Cost selection filter indicates the expected level of investment required to install an EV charger in a given census tract due to required upgrades to the grid. Note that this selection criterion is the inverse of Grid Support filter.

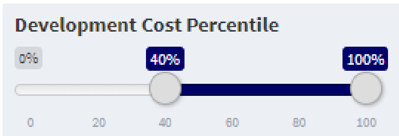
Calculation and Analysis

- **Aggregate data to the census tract level**
  - Spatially join circuit shapefiles to census tract shapefiles to develop circuit to census tract mappings for each island, then aggregate circuits, substations, or transformers to the tract level by summing their capacity and peak load forecasts
  - Note that this step is the same for calculating both Development Cost and Grid Support percentiles
- **Calculate headroom based on the Companies' load forecast data**
  - Headroom is calculated as capacity minus peak demand
  - Note that this step is the same for calculating both Development Cost and Grid Support percentiles
- **Rank-order tracts by *increasing* expected headroom and assign percentile score**
  - Pool census tracts from all islands together into one rank-ordering, then split census tracts into five equal quintiles and assign a score where 100th percentile means *most* headroom and 0th percentile means *least* headroom
  - Note that this step differs from the Grid Support percentile calculation because the rank-ordering of tracts is reversed

Figure C-8. Development Cost Percentile



Interpretation Example



For example, to prioritize public chargers that are in areas with lots of headroom on the grid, move the Development Cost slider toward the right. In this selection, tracts in the 40^{th} to 100^{th} percentile will be included in the Critical Backbone. This means the chargers in the backbone will likely require fewer grid upgrades and therefore the installation costs will likely be less. Note that since this criterion is the inverse of the Grid Support percentile, this selection is the same as selecting Grid Support percentile of 0^{th} to 60^{th} percentile.

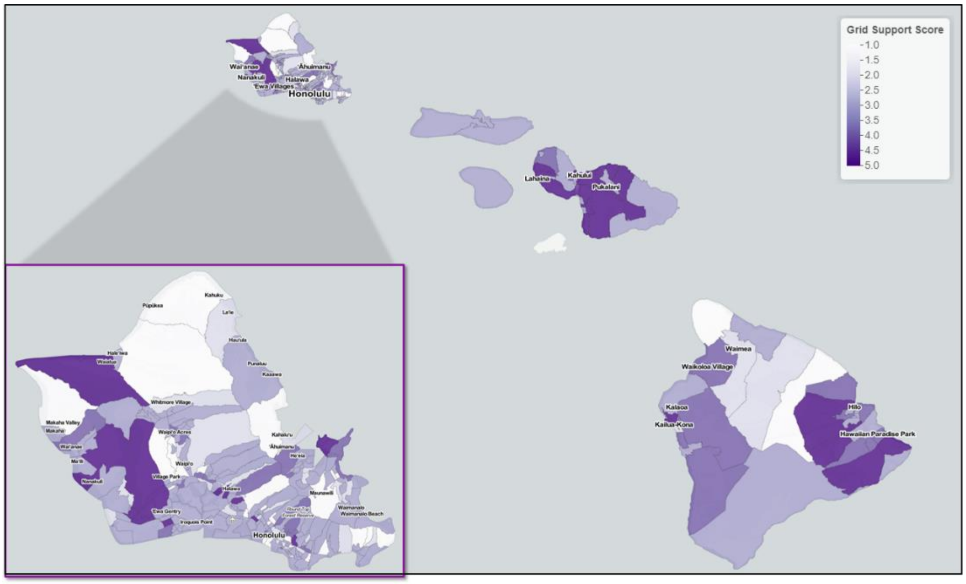
Grid Support

Grid Support percentile indicates the opportunity for resiliency support through managed charging potential. Note that this selection criterion is the inverse of Development Cost percentile.

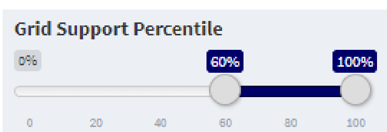
Calculation and Analysis

- **Aggregate data to the census tract level**
    - Spatially join circuit shapefiles to census tract shapefiles to develop circuit to census tract mappings for each island, then aggregate circuits, substations, or transformers to the tract level by summing their capacity and peak load forecasts
    - Note that this step is the same for calculating both Development Cost and Grid Support percentiles
- **Calculate headroom based on the Companies' load forecast data**
    - Headroom is calculated as capacity minus peak demand
    - Note that this step is the same for calculating both Development Cost and Grid Support percentiles
- **Rank-order tracts by *decreasing* expected headroom and assign percentile score**
    - Pool census tracts from all islands together into one rank-ordering, then split census tracts into five equal quintiles and assign score where 100^{th} percentile means *least* headroom and 0^{th} percentile means *most* headroom
    - Note that this step differs from the Grid Support percentile calculation because the rank-ordering of tracts is reversed

Figure C-9. Grid Support Percentile

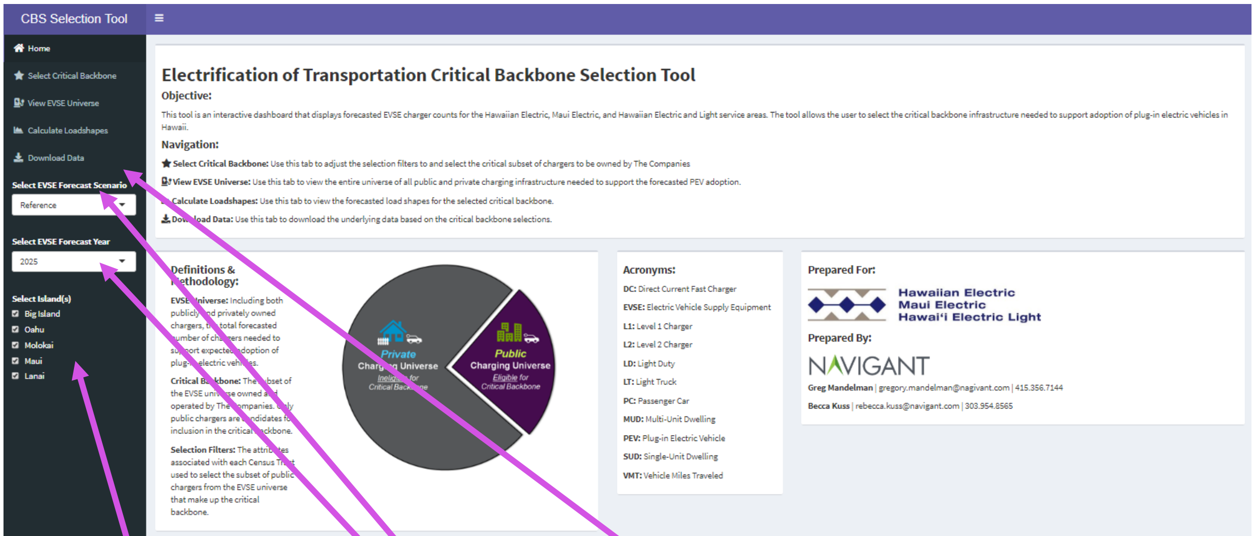


Interpretation Example



For example, to prioritize public chargers that are in areas with high estimated demand on the grid, slide the Grid Support percentile slider toward the higher scores. In this selection, tracts in the 60th to 100th percentile will be included in the Critical Backbone. This means the chargers in the backbone are more likely to be capacity constrained, and therefore benefit from managed charging opportunities. Note that since this criterion is the inverse of the Development Cost percentile, this selection is the same as selecting Development Cost percentile of 0th to 40th percentile.

C.4 Tool Tips 1: Landing Page, Critical Backbone Tab, Universe Tab

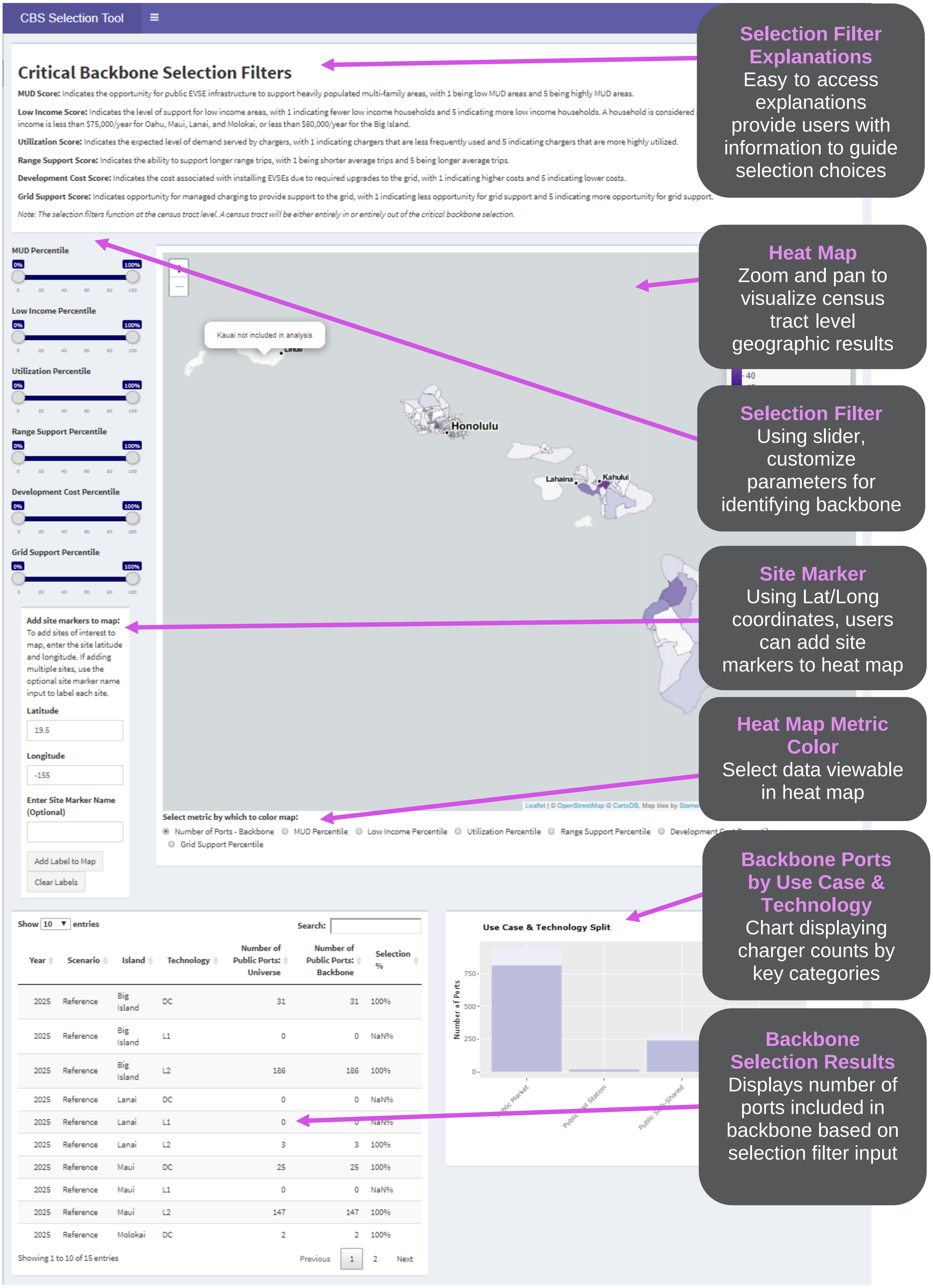


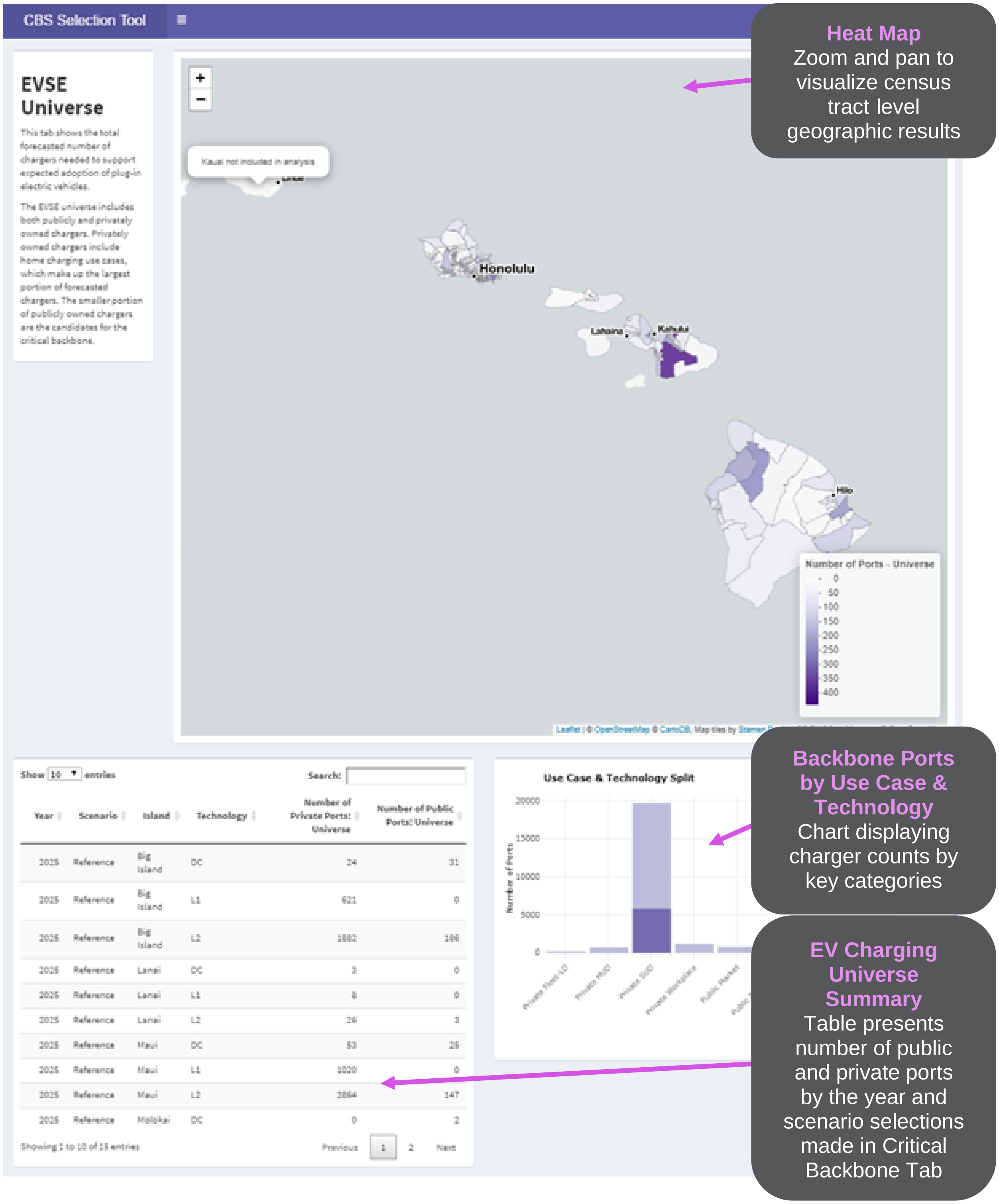
Island Selection
Select one, multiple or all islands for inclusion in heat map, data table, and data download

Year & Scenario
Choose desired year and scenario for Critical Backbone selection

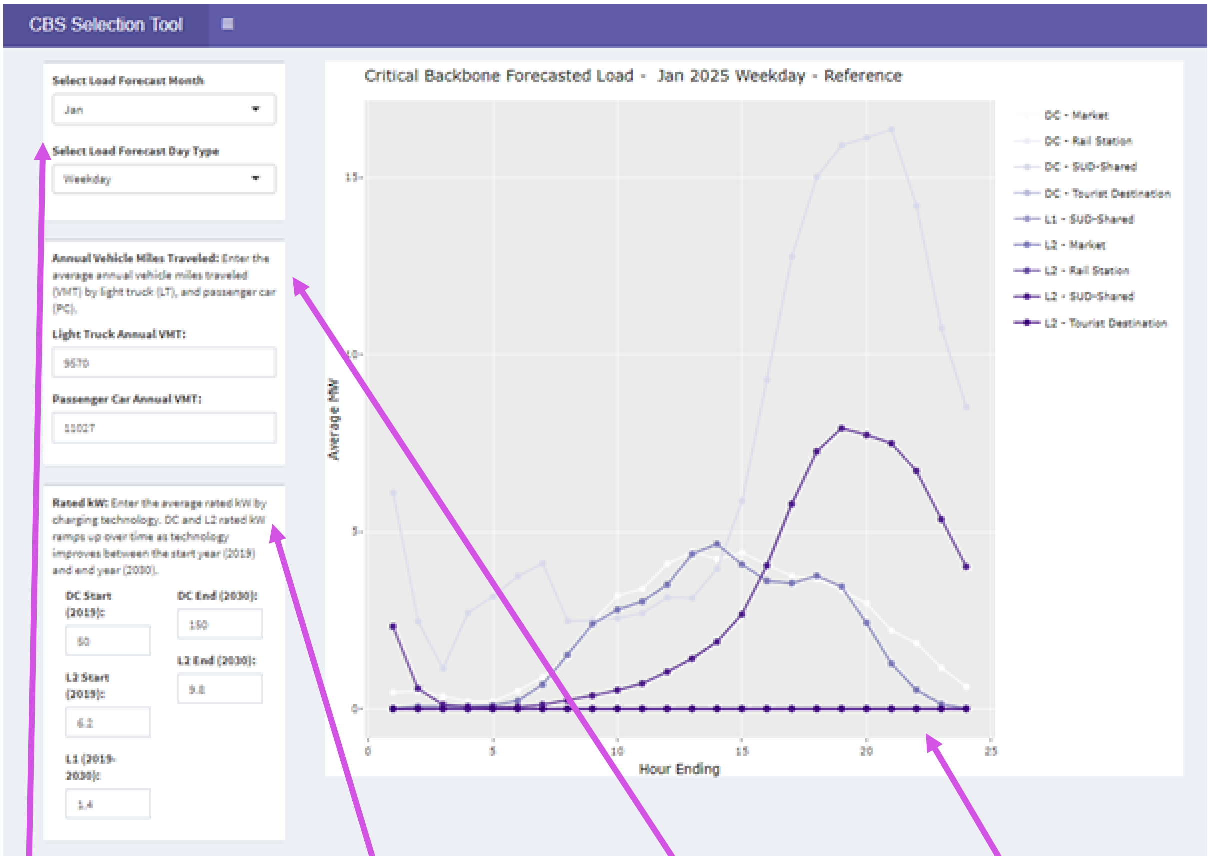
Downloadable
Raw data available for export based on tool’s current Critical Backbone selection

Web-Based
Custom URL provides secure, web based access only to credentialed users


CBS Selection Tool
Critical Backbone Selection Filters
MUD Score: Indicates the opportunity for public EVSE infrastructure to support heavily populated multi-family areas, with 1 being low MUD areas and 5 being highly MUD areas.
Low Income Score: Indicates the level of support for low income areas, with 1 indicating fewer low income households and 5 indicating more low income households. A household is considered
income is less than $75,000/year for Oahu, Maui, Lanai, and Molokai, or less than $60,000/year for the Big Island.
Utilization Score: Indicates the expected level of demand served by chargers, with 1 indicating chargers that are less frequently used and 5 indicating chargers that are more highly utilized.
Range Support Score: Indicates the ability to support longer range trips, with 1 being shorter average trips and 5 being longer average trips.
Development Cost Score: Indicates the cost associated with installing EVSEs due to required upgrades to the grid, with 1 indicating higher costs and 5 indicating lower costs.
Grid Support Score: Indicates opportunity for managed charging to provide support to the grid, with 1 indicating less opportunity for grid support and 5 indicating more opportunity for grid support.
Note: The selection filters function at the census tract level. A census tract will be either entirely in or entirely out of the critical backbone selection.
Selection Filter Explanations
Easy to access explanations provide users with information to guide selection choices
MUD Percentile
Low Income Percentile
Utilization Percentile
Range Support Percentile
Development Cost Percentile
Grid Support Percentile
Kauai not included in analysis
Honolulu
Lahaina
Kahului
Heat Map
Zoom and pan to visualize census tract level geographic results
Selection Filter
Using slider, customize parameters for identifying backbone
Add site markers to map:
To add sites of interest to map, enter the site latitude and longitude. If adding multiple sites, use the optional site marker name input to label each site.
Latitude
19.5
Longitude
-155
Enter Site Marker Name (Optional)
Add Label to Map
Clear Labels
Site Marker
Using Lat/Long coordinates, users can add site markers to heat map
Select metric by which to color map:
Number of Ports - Backbone
MUD Percentile
Low Income Percentile
Utilization Percentile
Range Support Percentile
Grid Support Percentile
Heat Map Metric Color
Select data viewable in heat map
Show 10 entries
Search:
Year | Scenario | Island | Technology | Number of Public Ports: Universe | Number of Public Ports: Backbone | Selection %
2025 | Reference | Big Island | DC | 31 | 31 | 100%
2025 | Reference | Big Island | L1 | 0 | 0 | NaN%
2025 | Reference | Big Island | L2 | 186 | 186 | 100%
2025 | Reference | Lanai | DC | 0 | 0 | NaN%
2025 | Reference | Lanai | L1 | 0
2025 | Reference | Lanai | L2 | 3 | 3 | 100%
2025 | Reference | Maui | DC | 25 | 25 | 100%
2025 | Reference | Maui | L1 | 0 | 0 | NaN%
2025 | Reference | Maui | L2 | 147 | 147 | 100%
2025 | Reference | Molokai | DC | 2 | 2 | 100%
Showing 1 to 10 of 15 entries
Previous 1 2 Next
Use Case & Technology Split
Number of Ports
Backbone Ports by Use Case & Technology
Chart displaying charger counts by key categories
Backbone Selection Results
Displays number of ports included in backbone based on selection filter input


CBS Selection Tool
EVSE Universe
This tab shows the total forecasted number of chargers needed to support expected adoption of plug-in electric vehicles.
The EVSE universe includes both publicly and privately owned chargers. Privately owned chargers include home charging use cases, which make up the largest portion of forecasted chargers. The smaller portion of publicly owned chargers are the candidates for the critical backbone.
Kauai not included in analysis
Honolulu
Lahaina
Kahului
Hilo
Number of Ports - Universe
0
50
100
150
200
250
300
350
400
Heat Map
Zoom and pan to visualize census tract level geographic results
Show 10 entries
Search:
Year | Scenario | Island | Technology | Number of Private Ports: Universe | Number of Public Ports: Universe
2025 | Reference | Big Island | DC | 24 | 31
2025 | Reference | Big Island | L1 | 621 | 0
2025 | Reference | Big Island | L2 | 1882 | 186
2025 | Reference | Lanai | DC | 3 | 0
2025 | Reference | Lanai | L1 | 8 | 0
2025 | Reference | Lanai | L2 | 26 | 3
2025 | Reference | Maui | DC | 53 | 25
2025 | Reference | Maui | L1 | 1020 | 0
2025 | Reference | Maui | L2 | 2864 | 147
2025 | Reference | Molokai | DC | 0 | 2
Showing 1 to 10 of 15 entries
Previous 1 2 Next
Use Case & Technology Split
Number of Ports
20000
15000
10000
5000
0
Private Fleet-LD
Private MUD
Private SUD
Private Workplace
Public Market
Backbone Ports by Use Case & Technology
Chart displaying charger counts by key categories
EV Charging Universe Summary
Table presents number of public and private ports by the year and scenario selections made in Critical Backbone Tab

C.5 Tool Tips 2: Load Shape Tab, Download Data Tab

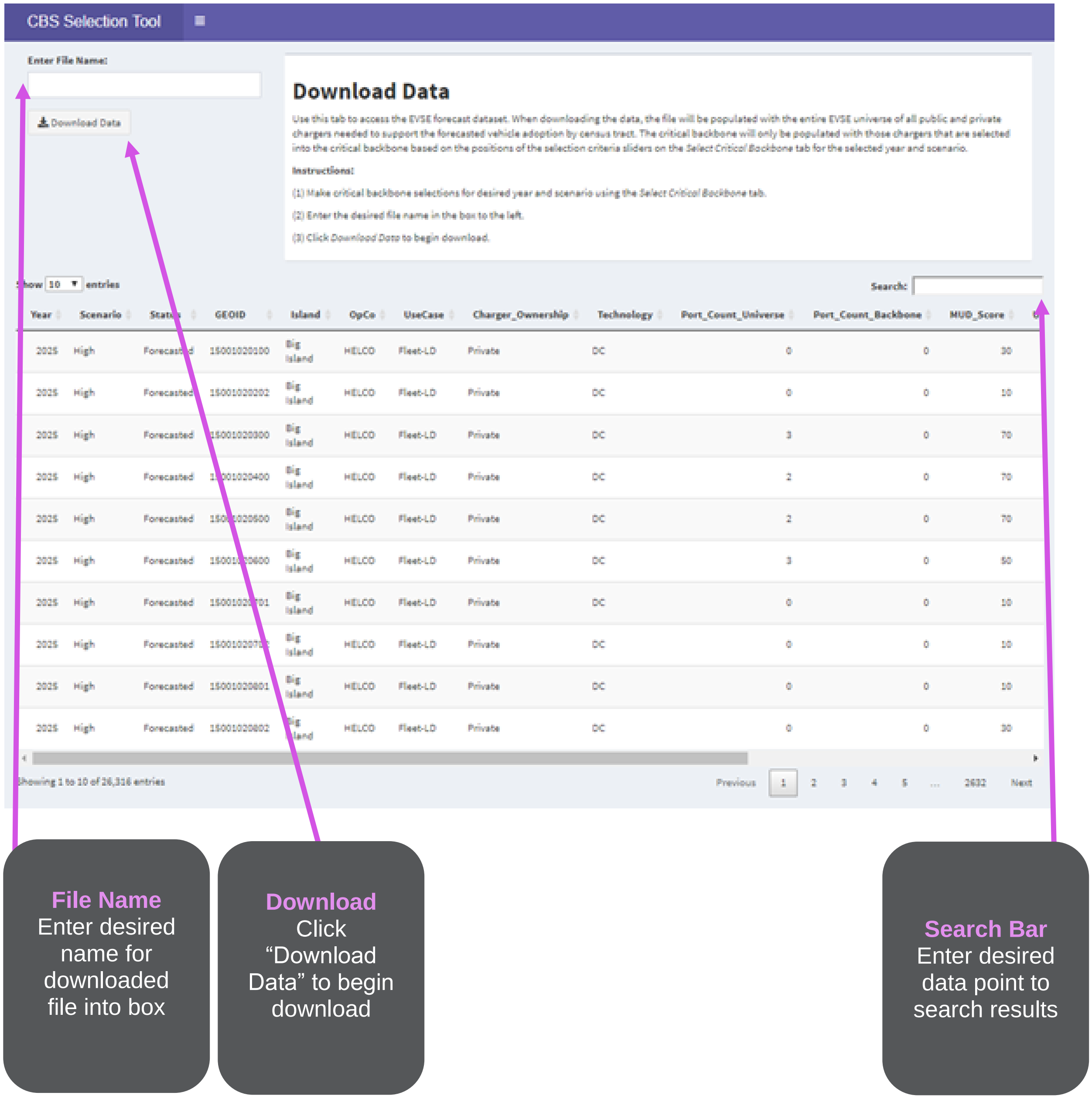


Select Month & Day-Type
Select the month and day type displayed

Modify Rated KW
Adjust the average rated charger kilowatts (kW) amount across the forecast horizon

Adjust VMT
Modify the average annual number of vehicle miles traveled (VMT) for light trucks and passenger cars

Charger Technology Load Shape
Displays the average hourly load for all charger technologies, by selected month and day type


CBS Selection Tool
Enter File Name:
Download Data
Download Data
Use this tab to access the EVSE forecast dataset. When downloading the data, the file will be populated with the entire EVSE universe of all public and private chargers needed to support the forecasted vehicle adoption by census tract. The critical backbone will only be populated with those chargers that are selected into the critical backbone based on the positions of the selection criteria sliders on the Select Critical Backbone tab for the selected year and scenario.
Instructions:
(1) Make critical backbone selections for desired year and scenario using the Select Critical Backbone tab.
(2) Enter the desired file name in the box to the left.
(3) Click Download Data to begin download.
Show 10 entries
Search:
Year
Scenario
GEOID
Island
OpCo
UseCase
Charger_Ownership
Technology
Port_Count_Universe
Port_Count_Backbone
MUD_Score
Previous
Next
File Name
Enter desired name for downloaded file into box
Download
Click “Download Data” to begin download
Search Bar
Enter desired data point to search results

Appendix D. Electric Vehicle Critical Backbone Study: Planning Methodology Tool – Access Request Instructions

To request access to the Critical Backbone Selection Tool, please submit the information identified in Table D-1.

Table D-1. Critical Backbone Tool Request Template

Item	Requestor Information
Name	
Organization	
Email	
Phone	

Appendix E. Vehicle Adoption Simulation Tool ™(VAST) Analytics Suite Documentation (Public)

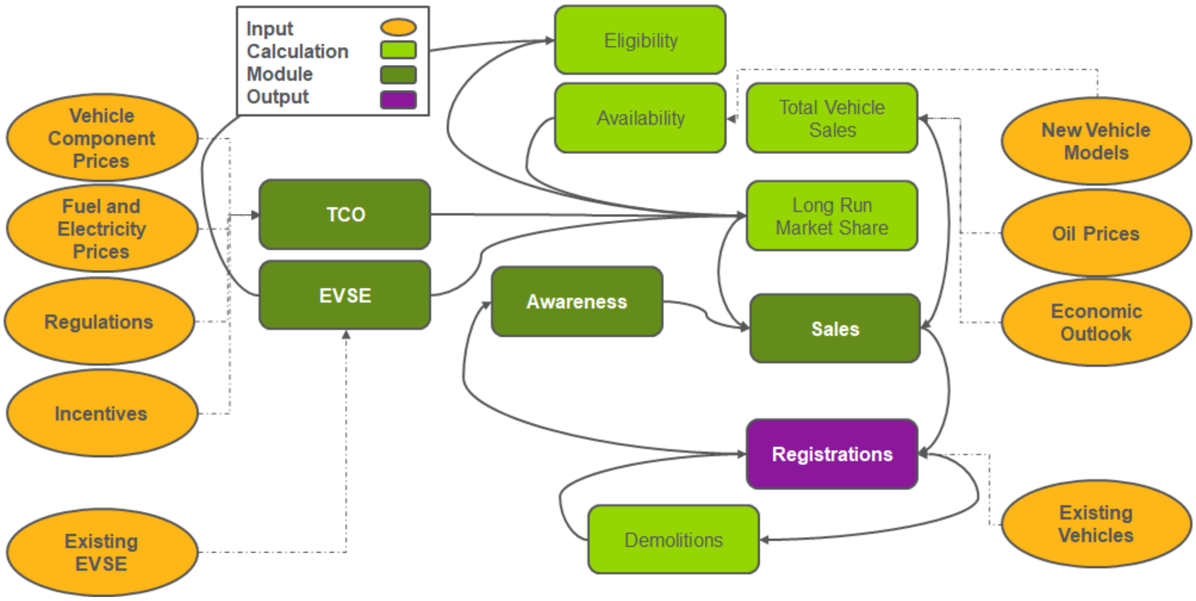
E.1 VAST™ Adoption Module Overview

Navigant's Vehicle Adoption Simulation Tool™ (VAST) Adoption Module uses a systems dynamics framework to forecast adoption of various powertrain-fuel configurations in the plug-in electric vehicle (PEV) market at the local level—usually ZIP code tabulation areas (ZCTAs) or census tracts.[4] By modeling vehicle adoption based on inputs specific to a particular jurisdiction, the forecast more closely reflects local market conditions compared to similar national level forecasts. Navigant uses an enhanced Bass diffusion model to forecast new vehicle sales split between competing powertrains and vehicle classes and fits the parameters of this model to seven years of historic localized data.

VAST™ is a systems dynamics model driven by enhanced Bass diffusion, conditioned on vehicle availability, customer ownership economics, and constraints on eligibility. The model determines the long-run technology adoption potential of vehicles based on changing dynamics of competing vehicle, infrastructure, and consumer attributes. The model explicitly accounts for supply-side dynamics driving vehicle production and availability as makes and models are rolled out to preferentially to specific geographies. If a vehicle is available, the economics of vehicle ownership, customer decision-making, and the impact of word-of-mouth effects and advertising all affect vehicle sales. This formulation is more accurate than strict time-series forecasts like GARCH or ARIMA models and outperforms econometric models because the system is fundamentally bounded by stocks and flows and can account for non-linear dynamics that arise from positive and negative feedback, balancing effects, and reinforcing trends. A high-level diagram explaining the relationships between the major model routines are shown in Figure E-1.

[4] PEV includes plug-in hybrid electric vehicles (PHEVs) that include combined internal combustion engine and battery-based powertrains, as well as battery electric vehicles (BEVs) that only contain battery powertrains.

Figure E-1. VAST™ Systems Dynamics Innovation Diffusion Approach



(Source: Navigant)

An important component to the model architecture is the relationship between refueling infrastructure and vehicle sales. Infrastructure is assumed to be driven by changes in PEV population. As infrastructure grows, the portion of the market that can consider purchasing a PEV increases and the economic disadvantage of PEV ownership decreases. The economic disadvantage reflects the vehicle's inability to satisfy all the driving requirements of its owner and is consequently modeled as a cost added to the TCO.[5] Navigant refers to this cost as the *consumer sacrifice penalty*.

The model produces a market share output for PEVs relative to the overall new vehicle market of a particular geography. PEV sales are determined by multiplying PEV market share by the overall eligible market projection, including internal combustion engine (ICE) vehicles, and the percentage of customers that are fully aware (enough to make an informed economic purchase decision) of the PEV option. The PEV population is then calculated as cumulative new vehicle sales minus vehicle retirements, which are a function of assumptions about average vehicle life.[6]

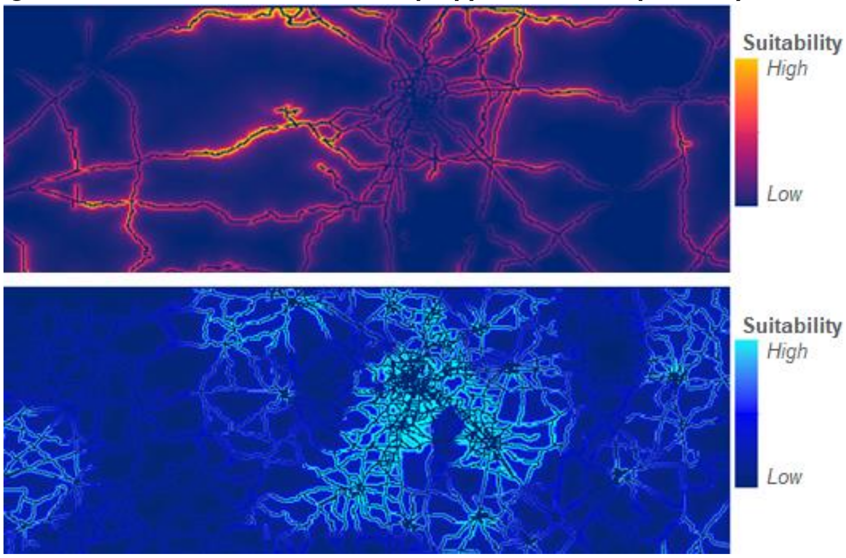
E.2 VAST™ Charging Siting Module Overview

The VAST™ Charging Siting Module uses a GIS model built in python, using the ArcPy library, to optimally site electric vehicle chargers based on local vehicle populations and vehicle miles travelled for a specified street network. As depicted in Figure E-2, the model is designed to site connector stations—needed to connect major cities and provide for intra-city commerce and tourism—and market stations, needed to meet local market demand generated by inter-city PEV traffic.

[5] There is no assumed infrastructure penalty associated with PHEVs, due to PHEVs ability to use gas and avoid the need for rental cars on long trips.

[6] The model assumes all vehicles sold in a given jurisdiction remain in the jurisdiction and does not consider used vehicle sales.

Figure E-2. Illustrative Connector (Top) and Market (Bottom) Station Suitability

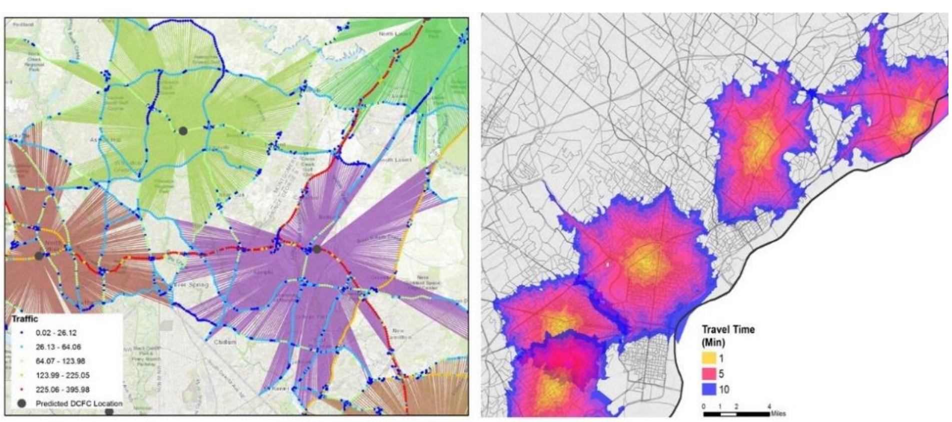


(Source: Navigant)

Additional key features depicted in Figure E-3 include:

- Roads are modeled as a network with explicit size, speed limits, navigation rules, travel times, and traffic volume.
- Stations are sited on nodes on the network.
- Station locations are determined discretely by network optimization to meet maximum demand for charging, subject to vehicle range, and network constraints.
- Each station has a service territory, defined by a drive-time isochrone.
- Stations are assigned chargers based on the total forecasted demand at a given location.

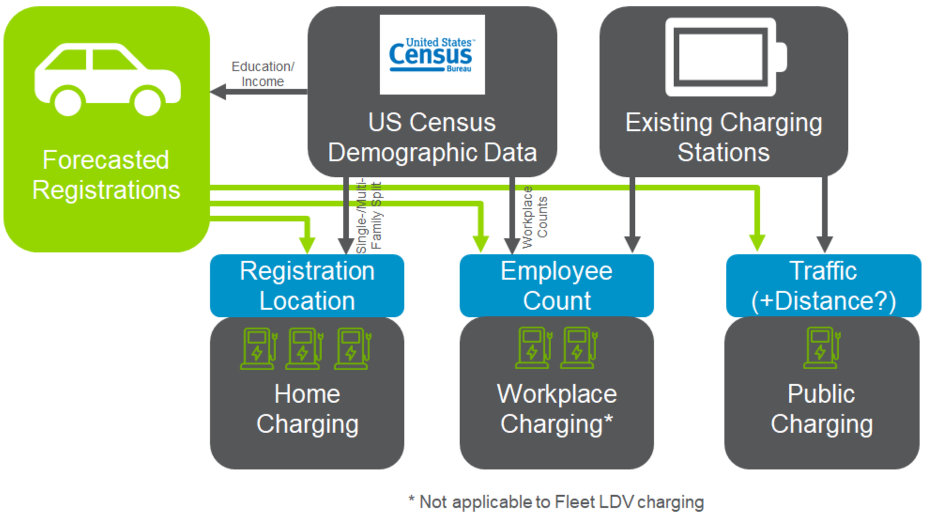
Figure E-3. Illustrative Traffic and Travel Time Outputs



(Source: Navigant)

Navigant has a discrete methodology for forecasting the required EV charging to support vehicle registrations in an area. Figure E-4 provides a high-level overview of the methodology.

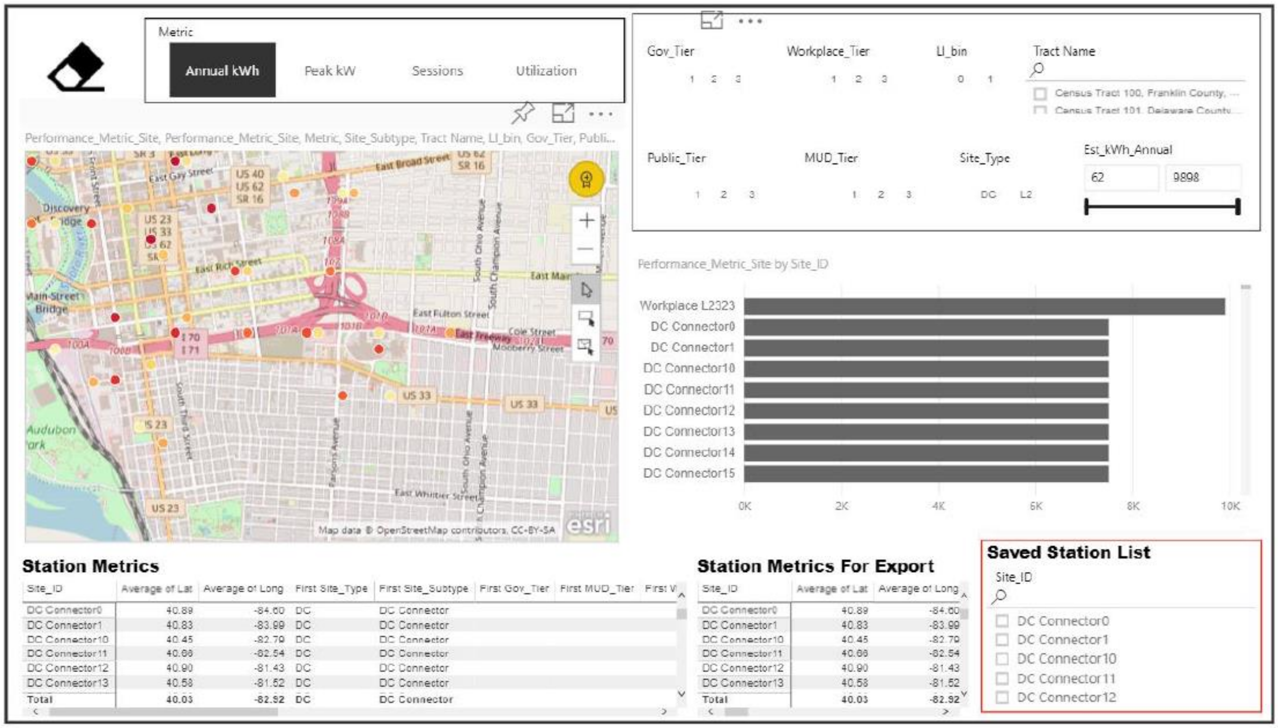
Figure E-4. Navigant Methodology for Connecting Charging Stations with Vehicle Registrations



(Source: Navigant)

Navigant's model allows for interactive site selection, real-time editing, and multi-criteria selection through a web-based tool. The web viewer is available in a variety of optional formats—developed in either Shiny R, PowerBI, Tableau, Spotfire, or ArcGIS vis ArcOnline—as appropriate. Figure E-5 provides an example in PowerBI. For this project, site selection was performed in a Shiny R platform, as described above.

Figure E-5. Illustrative Siting Tool Interface



(Source: Navigant)

E.3 VAST™ Load Forecasting Module Overview

The VAST™ Load Forecasting Module relies on the Adoption Module to determine the total volume of PEVs, and the charging siting module to determine the locations of supporting EV charging. Once these two factors have been forecast, the amount of load on the distribution system is calculated by modeling the VMT and seasonal efficiency for each vehicle, and the 8,760 load shape associated with each charger by technology and use case.

The model uses a top-down, allocation-based disaggregation approach that assigns ZIP code level PEV and charger data, including customer count by use case based on ***Navigant's Granular PEV Load Forecasting Framework*** depicted in Figure E-6, which illustrates the relationship between vehicles, chargers, and load for the light duty vehicle example. Medium and heavy duty vehicle loads are calculated in the same manner.

Figure E-6. VAST™ Granular PEV Load Forecasting Framework – Inputs & Outputs – EXAMPLE

FHWA Vehicle Class[1]	Vehicle Type	Ownership Type	Powertrain Type	Use Cases	VAST Vehicle Energy Calculation Methodology
Class 2	LDV – Passenger Car	Individual	PHEV	Individual – PHEV Individual – BEV	• Average annual VMT (miles) • Average efficiency per mile (kWh/mile)
Class 3	LDV – Light Truck	Fleet	BEV	Fleet – PHEV Fleet – BEV	

Charger Technology	Charging Station Type	Location Type[2]	Use Cases	VAST Charging Demand Calculation Methodology
Level 1 Level 2 DCFC	• Private – Home • Private – Workplace • Public – Corridor • Public – Market	• Urban • Suburban • Rural	• Private – Home • Private – Workplace • Public – Corridor • Public – Market	• Maximum charge rate per use case • Relative load per hour (kW)

VAST Charging Station Load Profiles

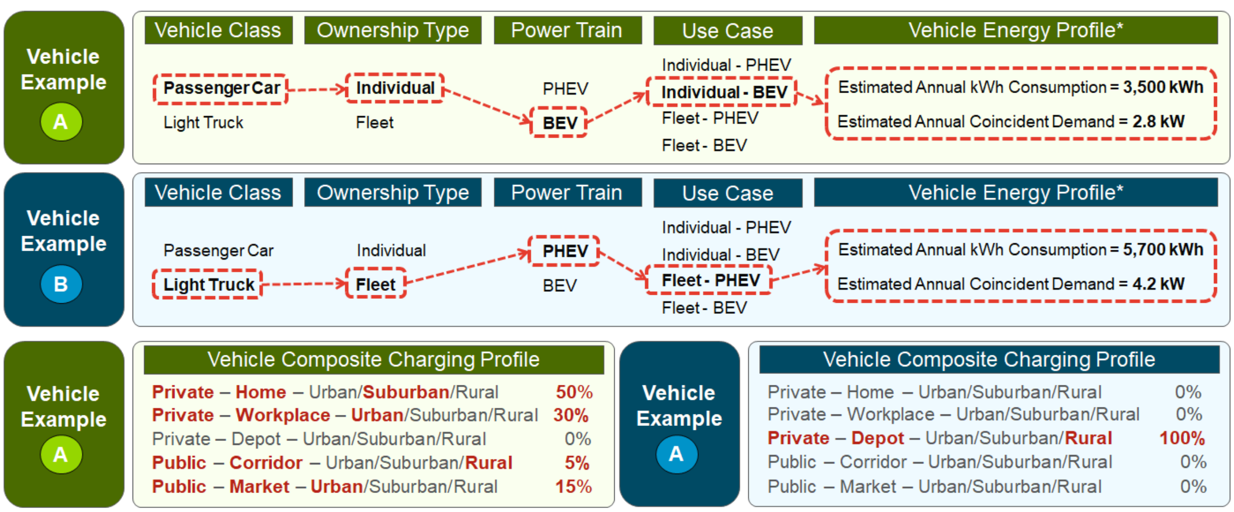
- VAST vehicle energy (kWh)
- VAST charging demand (kW)
- Profiles by weekday and weekend
- Allocation of vehicle use cases and charging station use cases by zip code according to distribution of customer segments
- Aggregated zip code loads to produce system level EV load

1 Source: Federal Highway Administration: https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm
2 Load weighted based on proximity to city center, local individual load profiles from actual vehicles, among other factors.

(Source: Navigant)

Figure E-7 provides examples A and B that illustrate the module's approach to estimating how a vehicle's energy and demand profile manifests on the grid based on the load it draws from the electric distribution system at multiple charging stations.

Figure E-7. Vehicle Energy Profile Forecast and Charger Profile Matching – EXAMPLE



* Consumption = Vehicle Average Annual VMT x kWh/mile, and Coincident Demand = Vehicle Average Annual VMT x kW/mile

(Source: Navigant)

Appendix F. Electric Vehicle Critical Backbone Study: Planning Methodology Tool: Data Extract – EV Charging Universe

A compact disc (CD) containing a full data extract of the EV Charging Universe is being submitted to the Commission and Consumer Advocate concurrently with this filing. Table F-1 defines each column included in the data extract.

Table F-1. Data Extract Column Definitions

Tab	Column Header	Definition
EVSE Data	Year	Forecast year; 2025 or 2030.
	Scenario	Forecast scenario; Reference, High, or Low.
	GEOID	Census tract unique identifier; 11-digit code indicating state, county, and tract.
	Island	Island identifier; O’ahu, Hawai’i Island, Maui, Moloka’i, or Lāna‘i.
	OpCo	Operating company; HECO, MECO, or HELCO.
	UseCase	Use case, as defined in Appendix C.1.
	Charger_Ownership	Charger accessibility; Public or Private.
	Technology	Charger technology; Level 1, Level 2, or DCFC.
	Port_Count_Universe	Number of ports forecasted in census tract.
	Port Count_Backbone	Number of ports eligible for selection into critical backbone. *Note that the critical backbone has not yet been selected, so this column is equal to Port_Count_Universe for all Public rows, and 0 for all Private rows.*
	MUD_Score	Multi-unit dwelling percentile; 0 – 100.
	Util_Score	Utilization percentile; 0 – 100.
	Income_Score	Low income percentile; 0 – 100.
	Range_Score	Range support percentile; 0 – 100.
	Dev_Score	Development Cost percentile; 0 – 100.
	Grid_Score	Grid Support percentile; 0 – 100.
Load Profile Data	Year	Forecast year; 2025 or 2030.
	Technology	Charger technology; Level 1, Level 2, or DCFC.
	UseCase	Use case, as defined in Appendix C.1.

	Charger_Ownership	Charger accessibility; Public or Private.
	Month	Month; e.g. Jan, Feb, …
	Day Type	Weekend or Weekday
	Hour Ending	Hour ending; 1 – 24.
	Average MW	Average MW demand across hour.
Settings	Setting	Tool setting; Year or Scenario.
	Value	Records the value of that setting when the data was downloaded.
	Selection Filter	Name of each of the six selection filters; MUD_Score, Income_Score, Util_Score, Range_Score, Dev_Score, Grid_Score.
	Lower Bound	Setting of the selection filter lower bound when the data was downloaded; 0 – 100.
	Upper Bound	Setting of the selection filter upper bound when the data was downloaded; 0 – 100.

Appendix G. 2025 Public Universe Results

Table G1. 2025 EV Charging Universe Results by Island, Technology Type and Use Case – Reference Case

Island	Technology /Use Case	Private Universe				Total Private Universe	Public Universe				Total Public Universe
		Light-Duty Fleet	Multi-Unit Dwelling (MUD)	Single-Unit Dwelling (SUD)	Workplace		Market	Rail Station	Shared-SUD	Tourist Destination	
Hawai'i Island	Level 1	-	2	619	-	621	-	-	-	-	-
	Level 2	16	40	1,686	140	1,882	164	-	21	1	186
	DCFC	17	7	-	-	24	28	-	3	-	31
Lāna'i	Level 1	-	-	8	-	8	-	-	-	-	-
	Level 2	3	1	19	3	26	1	-	1	1	3
	DCFC	3	-	-	-	3	-	-	-	-	-
Maui	Level 1	-	5	1,015	-	1,020	-	-	-	-	-
	Level 2	29	110	2,569	156	2,864	119	-	26	2	147
	DCFC	30	23	-	-	53	19	-	6	-	25
Moloka'i	Level 1	-	-	14	-	14	-	-	-	-	-
	Level 2	-	1	37	2	40	5	-	1	-	6
	DCFC	-	-	-	-	-	2	-	-	-	2
O'ahu	Level 1	-	16	4,191	-	4,207	-	-	3	-	3
	Level 2	126	549	9,531	917	11,123	525	18	187	-	730
	DCFC	136	122	-	-	258	87	2	38	-	127
Total Ports		360	876	19,689	1,218	22,143	950	20	286	4	1,260
Percent of Total Ports		2%	4%	84%	5%	95%	4%	0%	1%	0%	5%

Table G2. 2025 Public Universe Results by Island, Technology Type and Use Case – High & Low Scenarios

Public Univese											
Island	Technology /Use Case	2025 High Scenario				Total High Scenario Ports	2025 Low Scenario				Total Low Scenario Ports
		Market	Rail Station	SUD-Shared	Tourist Destination		Market	Rail Station	SUD-Shared	Tourist Destination	
Hawaiʻi Island	Level 1	-	-	1	-	1	-	-	-	-	-
	Level 2	256	-	28	2	286	102	-	10	2	114
	DCFC	45	-	3	-	48	19	-	1	-	20
Lānaʻi	Level 1	-	-	-	-	-	-	-	-	-	-
	Level 2	1	-	1	1	3	-	-	-	1	1
	DCFC	-	-	-	-	-	-	-	-	-	-
Maui	Level 1	-	-	1	-	1	-	-	-	-	-
	Level 2	192	-	41	2	235	75	-	19	2	96
	DCFC	31	-	7	-	38	10	-	3	-	13
Molokaʻi	Level 1	-	-	-	-	-	-	-	-	-	-
	Level 2	8	-	1	1	10	3	-	-	1	4
	DCFC	2	-	-	-	2	-	-	-	-	-
Oʻahu	Level 1	-	-	10	-	10	-	-	-	-	-
	Level 2	830	29	306	-	1,165	347	11	120	-	478
	DCFC	145	4	67	-	216	48	1	21	-	70
Total Ports		1,510	33	466	6	2,015	604	12	174	6	796
Percent of Total Ports		75%	2%	23%	0.3%	100%	76%	2%	22%	1%	100%