March 29, 2018

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PUBLIC UTILITIES COMMISSION

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

Dear Commissioners:

Subject: Transmittal No. 13-07
For Approval to Establish Schedule EV-F – Commercial Public Electric Vehicle Charging Facility Service Pilot, and Schedule EV-U – Commercial Public Electric Vehicle Charging Service Pilot
Hawaiian Electric Companies' Annual Report

Attached is the Hawaiian Electric Companies'[1] Annual Report on the Progress and Status of the Commercial Public Electric Vehicle Charging Pilot rates.[2]

The attached Annual Report provides year ending December 31, 2017 information on the status of implementing pilot rates for commercial charging of electric vehicles.

Sincerely,

Daniel G. Brown
Manager, Regulatory Non-Rate Proceedings

Attachment

cc: Division of Consumer Advocacy
Department of Business, Economic Development, and Tourism (courtesy copy)
OpConnect, LLC (courtesy copy)

[1] The Hawaiian Electric Companies are: Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited.
[2] The Annual Report is submitted in accordance with Ordering Paragraph 1 in the Commission's Decision and Order No. 31338, filed on July 1, 2013, for Transmittal Nos. 13-07 and 13-08 (consolidated), as explicitly modified by Decision and Order No. 34592, filed June 2, 2017 in Docket No. 2016-0168.

Hawaiian Electric Companies
Electric Vehicle Pilot Rates Report

Annual Report on the Progress and Status of the
Commercial Public Electric Vehicle Charging
Service Pilot Rates
Transmittal No. 13-07

March 29, 2018

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Executive Summary

2017 was an important year for the Hawaiian Electric Companies'[1] efforts in electric vehicles ("EVs"). The Companies formally established an Electrification of Transportation department to provide greater resources, emphasis, and development in this transformative market, and received Commission approval to continue this pilot program for another five years. Adoption of EVs continued to grow, with new vehicle models becoming available for sale for the first time and electrification efforts being explored for mass transit systems Statewide. The Companies expanded their fast charger network, by opening three new charging stations on O'ahu and one station on Hawai'i Island. In addition, the Companies received Commission approval to extend the pilot programs to June 30, 2023 and to change the tariff rate structure from a flat fee to a per kilowatt-hour ("kWh") basis for the pilot, which went into effect on December 12, 2017. The new rates are also priced to encourage charging during the mid-day period between 9 a.m. and 5 p.m. when excess solar energy exported to the grid is at its highest. The Companies are refining their siting analysis to include indicators of high utilization and have conducted several customer surveys regarding EV charging behavior and preferences, which are included in this report.

Background

In accordance with Ordering Paragraph 1.C. of Decision and Order No. 31338, filed July 1, 2013 in Transmittal Nos. 13-07 and 13-08 (consolidated), as explicitly modified by Decision and Order No. 34592 ("D&O 34592"), filed June 2, 2017 in Docket No. 2016-0168, this 2017 report provides year ending December 31, 2017 information on the status of implementing

[1] The "Hawaiian Electric Companies" or "Companies" are: Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited.

Schedule EV-F: Commercial Public Electric Vehicle Facility Charging Service Pilot, and Schedule EV- U: Commercial Public Electric Vehicle Charging Service .

On July 3, 2013, in accordance with Decision and Order No. 31338, the Hawaiian Electric Companies filed their commercial rates Schedule EV-F and Schedule EV-U to be effective July 4, 2013. Schedule EV-F supports clean energy goals by encouraging "the development of public EV charging facilities by pricing electricity at levels that are lower than Schedule EV-C and Schedule J at lower energy consumption levels for start-up EV public charging operators."[2] Schedule EV-F incorporates specific terms, including:

1. The rate is applicable only to separately-metered commercial public EV charging facilities providing charging services with demand no greater than 100 kW. The facility is limited to no more than 5 kW for ancillary load, such as area lighting.

2. Time-of-use ("TOU") rate periods include Priority-Peak, Mid-Peak, and Off-Peak periods.

Priority-Peak	5:00 p.m.-9:00 p.m., Monday-Friday
Mid-Peak	7:00 a.m.-5:00 p.m., Monday-Friday
	7:00 a.m.-9:00 p.m., Saturday-Sunday
Off-Peak	9:00 p.m.-7:00 a.m., Daily

3. The maximum number of accounts is limited to: (A) 100 meters within Hawaiian Electric's service territory; (B) 40 meters within Hawai‘i Electric Light's service territory; and (C) 40 meters within Maui Electric's service territory, consisting of its Lana‘i, Maui, and Moloka‘i Divisions.

4. The five year pilot is effective through June 30, 2018.

Schedule EV-U is intended to support the EV market by allowing the Companies to install and operate public EV charging facilities in strategic locations to address range anxiety, support the rental EV market, and increase EV acceptance by residents in multi-unit dwellings ("MUDs"). The terms for Schedule EV-U include:

1. Company-operated public charging facilities are based upon a fee-per-charge session.

[2] Transmittal No. 13-07 at 22.

2. Per session fees during the Priority-Peak and Off-Peak periods are set no more than $0.50 above and $0.50 below the Mid-Peak fee, respectively.

3. The maximum, aggregate amount of Company accounts will be 25.

4. The Company may curtail charging of EVs under certain circumstances.

5. The five year pilot is effective through June 30, 2018.

By Decision and Order No. 33165 issued on September 25, 2015, the Commission approved "the Companies' request to terminate Schedule EV-C, as of October 1, 2015" and "suspend[ed] the Companies' request to establish their proposed Schedules TOU EVD, EV-RD, and EV-CD."[3] Therefore, as of October 1, 2015 Schedule EV-F is the only commercial EV rate available for EV charging services.

On June 27, 2016, the Companies filed a request to extend the termination date for Schedule EV-F and Schedule EV-U from June 30, 2018 to June 30, 2028. On July 5, 2016, the Commission filed Order No. 33783 and opened Docket No. 2016-0168 for the purpose of reviewing the Companies' request. On September 15, 2016, the Commission filed Order No. 33918, establishing the procedural schedule. On November 18, 2016, the Companies filed their Reply Statement of Position thereby completing the procedural schedule.

On June 2, 2017, the Commission issued D&O 34592, approving a five-year extension of the pilot, on the condition that the Companies submit revised rate structures for Schedule EV-F and Schedule EV-U within ninety days and comply with applicable requirements. The Commission provided further guidance that the revised rate structures for Schedule EV-F and Schedule EV-U should (1) align Schedule EV-F and Schedule EV-U to TOU rates developed

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[3] Docket No. 2015-0342, Decision and Order No. 33165, issued on September 25, 2015, at 36. The Commission subsequently closed Docket No. 2015-0342 with Order No. 33279, filed October 23, 2015, stating "the commission's review and adjudication of the Companies' proposed electric vehicle time-of-use tariff schedules will be undertaken in Docket No. 2014-0192, as part of the commission's consideration of all of the Companies' proposed time-of-use tariff proposal as a whole."

within Docket No. 2014-0192, (2) "incorporate lessons learned from time of use rates and demand response initiatives"[4] into the revised rate structures, (3) contemplate various business and EV charging models that may be facilitated through various technologies, and (4) be "proactive in proposing revised rate structures and tariffs as research, technology, and market-related changes occur."[5] The Commission also required the Companies to include discussion on efforts to forecast anticipated utilization in subsequent EV charging deployments and how costs for EV charging deployments have been and are anticipated to be recovered from customers.[6] On September 5, 2017, the Companies submitted revised rate structures and accompanying tariff sheets for Schedules EV-F and EV-U. On October 13, 2017, the Commission issued Decision and Order No. 34867, approving the Companies' revised tariff sheets for Schedules EV-F and EV-U, to be implemented within sixty (60) days. On December 12, 2017, the Companies implemented the revised rate structure for Schedules EV-F and EV-U for all participating accounts. Rate Schedules EV-F and EV-U currently align to the guidance provided by the Commission in D&O 34592 by providing the lower energy cost during the Mid-Day period. The time of use periods are currently:

On-Peak	5:00 p.m.-10:00 p.m., Daily
Mid-Day	9:00 a.m.-5:00 p.m., Daily
Off-Peak	10:00 p.m.-9:00 a.m., Daily

The revised rate for Schedule EV-U incorporates additional guidance from the Commission. Schedule EV-U is currently a variable rate based on electricity consumption instead of the previous flat fee structure, and includes incremental costs for network fees, non-labor O&M and customer surcharges.[7] The intent of the revised rate structure is to equitably

[4] Docket No. 2016-0168, D&O 34592 at 52-53
[5] Id. at 53
[6] Docket No. 2016-0168, D&O 34592 at 68.
[7] See *Revised Rate Structures for Schedules EV-F and EV-U*, filed on September 5, 2017 Attachment 1 at 8-9.

charge customers based on their actual electricity consumption, while aligning to a TOU structure that reflects system needs and incorporating additional pilot costs to alleviate some of the cost shift between participating EV customers and all ratepayers.

I. Schedule EV-F Tariff

A. Adoption and Status of Schedule EV-F

Schedule EV-F was implemented as an economic development rate whereby "the absence of a demand charge and the inclusion of time-of-use rates serve to encourage the development of public EV charging facilities by keeping electricity costs low for new, start-up public EV charging facilities."[8] Public EV charging facilities, particularly direct-current fast charging ("DCFC") facilities, are still in an early stage of development, and typically incur high upfront costs relative to prospective ongoing revenue.

The difficult business prospects discussed above have limited the development of non-utility fast charging facilities in the State, with the notable exception of the JUMPSmart Maui program (branded as the "EV Ohana" Program as of September 1, 2017), which was funded by the New Energy and Industrial Technology Development Organization ("NEDO") of Japan. A recent study by the U.S. Department of Energy examining the level of EV charging infrastructure required to support the proliferation of EVs, offers an explanation for the low level of private investment in fast charging services in general, which may also explain the results seen in Hawai'i. The study notes the existence of a "utilization gap" at low levels of EV adoption, at which the need for an initial level of infrastructure is required to provide basic charging coverage but exceeds market demand. As EV adoption increases, market demand for charging services fill the "utilization gap" and eventually leads to the deployment of new infrastructure to meet

[8] Transmittal No. 12-05 at 23.

incremental demand.[9] While EV adoption continues to increase in Hawai'i, overall ownership remains less than 1% of total passenger cars registered.[10] Continued growth in EV ownership can improve market demand for EV charging and pave the way for increased participation by third-party developers. Lowering costs for businesses to operate EV charging, such as providing relief from high demand billing charges through Schedule EV-F, helps support the development of charging resources as the nascent EV market continues to grow in Hawai'i.

Table 1, below, provides a breakdown of the number of customer accounts billed for each month in 2017 on the Schedule EV-F pilot rate for all the three Companies. The data in this section of the Report is provided up to and after the rate changed implemented on December 12, 2017 to reflect the change in TOU periods. Aside from changes in customer counts, variance from month to month in total customers billed may also be attributed to the timing of EV-F meters being read at each Company. On O'ahu, no customers were added to Schedule EV-F in 2017, one customer remains on Hawai'i Island, and nine customers remain on Maui. While participation in Schedule EV-F is currently low, this may be the result of a limited business case for private development of fast charging services in Hawai'i rather than the rate design. During this stage of early EV adoption, many third-party developers and private businesses may not deploy charging services due to the cost of infrastructure. As EV adoption continues to increase in the State, a more attractive business case for installing multiple Level 2 charging stations or a DCFC station may emerge and lead to increased adoption of Schedule EV-F.

[9] *National Plug-In Electric Vehicle Infrastructure Analysis*. U.S. Department of Energy. September 2017 at 4

[10] Statewide EV Ownership ranged from 0.51% in January, 2017 to 0.65% in December, 2017. Per DBEDT Datawarehouse: Available at http://dbedt.hawaii.gov/economic/datawarehouse/.

Table 1
Schedule EV-F Customers Billed
January-December 2017

Month	Hawaiian Electric	Hawai‘i Electric Light	Maui Electric	Total
January	0	1	8	9
February	0	1	6	7
March	0	1	9	10
April	0	1	6	7
May	0	2	9	11
June	0	1	9	10
July	0	1	7	8
August	0	1	9	10
September	0	1	8	9
October	0	1	9	10
November	0	1	9	10
December 1-11	0	1	9	10
December 12-31	0	0	4	4

As reflected in Table 2, below, approximately 251 MWh were billed under Schedule EV-F in the year 2017. The larger consumption at Maui Electric is attributed to the EV Ohana program.

Table 2
Schedule EV-F kWh Billed
January-December 2017

Month	Hawaiian Electric	Hawai‘i Electric Light	Maui Electric	Total
January	0	192	21,857	22,049
February	0	116	16,657	16,773
March	0	229	22,801	23,030
April	0	245	19,453	19,698
May	0	267	25,778	26,045
June	0	11	23,445	23,456
July	0	206	20,656	20,862
August	0	300	21,795	22,095
September	0	490	21,247	21,737
October	0	487	19,654	20,141
November	0	400	18,717	19,117
December 1-11	0	318	13,960	14,278
December 12-31	0	0	1,828	1,828
TOTAL	0	3,261	247,848	251,109

The average billed kWh per customer account is provided in Table 3, below. On Maui, the EV Ohana program implemented four new rate plans for their DC fast charging sites on September 1, 2017 to adjust for the loss of NEDO funding which subsidized the charging costs for JUMPSmart Maui participants.[11] While the average consumption per billed account at Maui Electric remains the highest among all three companies, the new rate plans under EV Ohana may have contributed to the drop in average consumption under Schedule EV-F at Maui Electric. The average consumption per Maui Electric account billed in the months of January through August 2017 was 2,766 kWh, which dropped to 2,169 kWh (by 21.6%) in the months of September through December 2017.

[11] Available at http://evohana.com/phase2-volunteer/

Table 3
Schedule EV-F Average kWh Billed per Account
January-December 2017

Month	Hawaiian Electric	Hawai'i Electric Light	Maui Electric	Company Average
January	0	192	2,732	2,450
February	0	116	2,776	2,396
March	0	229	2,533	2,303
April	0	245	3,242	2,814
May	0	134	2,864	2,368
June	0	11	2,605	2,346
July	0	206	2,951	2,608
August	0	300	2,422	2,210
September	0	490	2,656	2,415
October	0	487	2,184	2,014
November	0	400	2,080	1,912
December 1-11	0	318	1,551	1,428
December 12-31	0	0	203	183
ANNUAL AVERAGE	0	261	2,543	2,266

The Companies designed rate Schedule EV-F such that "[w]hen monthly consumption exceeds around 5,000 kWh on a regular basis, the public EV charging facility may be considered large enough such that it no longer needs rate tariff support."[12] As EV ownership remains below 1% of all passenger vehicles in Hawaii, Schedule EV-F is able to support the development of third-party EV charging facilities and significantly mitigate the risk of high demand charges coupled with low utilization for third party developers. The Companies will continue to monitor the utilization of the EV-F rate as the market matures and demand for EV charging grows.

While additional data needs to be collected to determine any change in consumption as a result of the revised rate for Schedule EV-F, the Companies have found that utilization by time-of-use period in the entirety of 2017 remains essentially unchanged from 2016. Tables 4a and 4b, below, provides a breakdown of Schedule EV-F consumption in each TOU period for each

[12] Transmittal No. 12-05, filed October 26, 2012 at 22.

service territory in 2017. Throughout the Companies' service territories for the year of 2017, 17.7% of the energy was consumed during the tariff's Priority-Peak, 68.0% during the Mid-Peak, and 14.3% during the Off-Peak. Currently, the Companies are aware of only one billed Schedule EV-F account, which extends a TOU fee to their EV driving customers.

Table 4a
Schedule EV-F Billed kWh Consumption by TOU Period
January-December 11, 2017

Territory	Priority-Peak	Mid-Peak	Off-Peak	Total
Hawaiian Electric	0	0	0	0
Hawai‘i Electric Light	363	2,423	475	3,261
Maui Electric	42,838	164,115	39,067	246,020
TOTAL	43,201	166,538	39,542	249,281
PERCENTAGE	17.3%	66.8%	15.9%	100.0%

Table 4b
Schedule EV-F Billed kWh Consumption by TOU Period
December 12-December 31, 2017

Territory	On-Peak	Mid-Day	Off-Peak	Total
Hawaiian Electric	0	0	0	0
Hawai‘i Electric Light	0	0	0	0
Maui Electric	329	1,343	156	1,828
TOTAL	329	1,343	156	1,828
PERCENTAGE	18.0%	73.5%	8.5%	100.0%

Charging Impact of Rate Change

On December 12, 2017, the Companies implemented a new rate structure for Schedule EV-F which revised the TOU periods to align with "periods from TOU-RI, an outcome of Docket 2014-0192, which reflects system needs resulting from increased penetration of [distributed energy resources], especially during the Mid-Day period."[13]

[13] See *Revised Rate Structures for Schedules EV-F and EV-U*, filed on September 5, 2017, Attachment 1 at 7.

Up until December 12, 2017, under the prior rate structure for Schedule EV-F, the following TOU periods applied:

Priority-Peak	5:00 p.m.-9:00 p.m., Monday-Friday
Mid-Peak	7:00 a.m.-5:00 p.m., Monday-Friday
	7:00 a.m.-9:00 p.m., Saturday-Sunday
Off-Peak	9:00 p.m.-7:00 a.m., Daily

As of December 12, 2017, Schedule EV-F was revised to reflect the following TOU periods:

On-Peak	5:00 p.m.-10:00 p.m., Daily
Mid-Day	9:00 a.m.-5:00 p.m., Daily
Off-Peak	10:00 p.m.-9:00 a.m., Daily

Due to the late date of implementing the new TOU periods in 2017, there is insufficient data to draw conclusions regarding changes in consumption for the 20 days after the rates were changed. Such an analysis will be conducted for the next annual report.

B. Summary of Cost and Revenue

Table 5, below, presents a breakdown of the revenue generated each month from Schedule EV-F for the three Companies. In 2017, $88,034.59 in revenue was generated from customers under the Schedule EV-F Pilot rate.

Table 5
Schedule EV-F Revenues
January-December 2017

Month	Hawaiian Electric	Hawai'i Electric Light	Maui Electric	Total
January	$ -	$ 96.26	$ 7,325.62	$ 7,421.88
February	$ -	$ 70.75	$ 5,678.12	$ 5,748.87
March	$ -	$ 111.91	$ 7,823.52	$ 7,935.43
April	$ -	$ 118.82	$ 6,870.19	$ 6,989.01
May	$ -	$ 145.40	$ 9,058.73	$ 9,204.13
June	$ -	$ 12.55	$ 8,311.02	$ 8,323.57
July	$ -	$ 103.95	$ 7,539.87	$ 7,643.82
August	$ -	$ 134.92	$ 7,709.18	$ 7,844.10
September	$ -	$ 205.00	$ 7,121.18	$ 7,326.18
October	$ -	$ 214.48	$ 6,670.90	$ 6,885.38
November	$ -	$ 184.08	$ 6,750.76	$ 6,934.84
December 1-11	$ -	$ 153.91	$ 5,023.63	$ 5,177.54
December 12-31	$ -	$ -	$ 599.84	$ 599.84
TOTAL	$ -	$ 1,552.03	$ 86,482.56	$ 88,034.59

Incremental costs to support Schedule EV-F, including cost to enroll and bill customers, are *de minimis*. The labor to support the participation of this rate is similar to other rates and participation is currently limited.

C. Subsidization by non-participating customers

Schedule EV-F is an economic development rate intended to reduce the financial risk for startup EV charging providers, which may otherwise be confronted with significant demand charges combined with low utilization. A report prepared by Idaho National Laboratory ("INL") supports the need to provide an economic development rate for third-party EV charging facilities, stating that "[d]emand charges associated with 50 to 60-kW high power charging . . . can have a significant impact on a business' monthly electric utility bill."[14] The Companies

[14] Idaho National Laboratory, "What is the Impact of Utility Demand Charges on a DCFC Host?" June 2015.

maintain that Schedule EV-F can help to reduce initial cost barriers for prospective third-party infrastructure providers and incentivize greater investment in infrastructure.

Table 6, below, summarizes the total monthly revenue generated from Schedule EV-F compared to the potential revenue generated if the charging facility were billed under each Company's respective Schedule J.[15, 16] As utilization of third-party facilities under Schedule EV-F increases, the difference between revenues collected and the potential revenues collected under Schedule J will decline. The potential Schedule J revenue provided in Table 6 is calculated based on an assumed monthly billing demand of 47.5 kW.[17] The total potential revenue under Schedule EV-J for the year 2017 was $36,880.87 above revenues from Schedule EV-F.

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[15] General Service Demand rate applicable to general light and/or power loads that exceed 5,000 kWh per month or exceed 25 kW three times within a twelve month period but are less than 300 kW per month, and supplied through a single meter.

[16] In response to CA-IR-13, filed on October 14, 2016, the Companies provided an analysis of projected revenues under Schedule EV-F and Schedule EV-U compared to Schedule J, and committed to providing an updated analysis as revised EV forecasts are made available. The Companies have available a revised EV forecast for the island of Oahu, but do not yet have revised EV forecasts for Maui, Lanai, Molokai or Hawai`i Island. When revised EV forecasts for all islands in the Companies' service territory are made available, the analysis conducted for CA-IR-13 will be updated accordingly and included in the subsequent annual report.

[17] A typical EV will fast charge at power up to 50 kW, but will reduce power as the battery state of charge increases.

Table 6
Schedule EV-F to Potential Schedule J Revenue Comparison
January-December 2017

Month	Total Schedule EV-F	Potential Schedule J	Difference
January	$ 7,421.88	$ 10,365.04	$ 2,943.16
February	$ 5,748.87	$ 8,068.57	$ 2,319.70
March	$ 7,935.43	$ 11,339.75	$ 3,404.32
April	$ 6,989.01	$ 9,040.66	$ 2,051.65
May	$ 9,204.13	$ 12,719.78	$ 3,515.65
June	$ 8,323.57	$ 11,324.00	$ 3,000.43
July	$ 7,643.82	$ 10,167.49	$ 2,523.67
August	$ 7,844.10	$ 11,337.60	$ 3,493.50
September	$ 7,326.18	$ 10,296.24	$ 2,970.06
October	$ 6,885.38	$ 10,424.80	$ 3,539.42
November	$ 6,934.84	$ 10,704.69	$ 3,769.85
December 1-11	$ 5,177.54	$ 8,300.78	$ 3,123.24
December 12-31	$ 599.84	$ 826.06	$ 226.22
TOTAL	$ 88,034.59	$ 124,915.46	$ 36,880.87

D. Recommendation of revisions to rate structures

On September 5, 2017, the Companies submitted a revised rate structure for Schedule EV-F, which was approved by the Commission on October 13, 2017. On December 12, 2017, the Companies implemented the revised rate structure for all accounts under Schedules EV-F. As the Companies are in the initial stages of gathering meter data under the revised rate structure, there are no recommendations for revisions at this time. However, as mentioned in their September 5, 2017 tariff filing for Schedules EV-F and EV-U, the Companies will continue to monitor both adoption and utilization under the current rate structures and provide recommendations, as appropriate.[18]

[18] Docket No. 2016-0168, EV-F and EV-U Pilot Extension, filed September 5, 2018, at 11.

II. Schedule EV-U Tariff

A. Describe and Review the Adoption and Status of Schedule EV-U

The Companies filed their request for the extension of Schedules EV-F and EV-U on June 27, 2016. Among the justifications to extend the pilot, the Companies discussed how potential site hosts had voiced concerns regarding the approaching termination date in June of 2018, and were not comfortable initiating an agreement to host charging facilities for a short period of time, after which the continued availability of the charging infrastructure was uncertain. The Companies were also concerned with the prospect of expending ratepayer funds to deploy infrastructure that may not be available for customer use beyond June, 2018. As a result, Companies did not actively seek new potential sites following its agreement to own and operate a DCFC unit at 801 Dillingham Blvd., which was executed on October 12, 2016. Once the Commission issued D&O 34592 on June 5, 2017, approving the pilot extension for five years, the Companies resumed the search for additional sites and anticipate the commissioning of additional DC fast charging locations in 2018.

Hawaiian Electric New Site Installation

In 2017, Hawaiian Electric opened DC fast charging facilities at three locations, increasing the total number of Company-owned stations on O‘ahu from five to eight.:

- A second DCFC station was opened at the Companies’ Ward Avenue location on January 1, 2017. Prior to deployment of the second unit, the Companies noted that the Ward Avenue location represented the highest utilization among all of its existing locations in last year’s report. The Companies had observed, and confirmed with utilization data, that customers at the Ward Avenue location were often queueing for extended periods of time to utilize the charging station.
- A DCFC station was opened at Waianae Shopping Center on January 11, 2017. The Waianae charging station is located 22 miles from the nearest fast charging station at

Kapolei Commons, helping to extend electric driving range along the leeward coast of O‘ahu.

- A DCFC station was opened at a shopping center located at 801 Dillingham Blvd., in Honolulu, on April 13, 2017. After the opening it was discovered that the station exhibited intermittent issues which interrupted or restricted charging sessions. After extensive diagnostics, the vendor provided a new charge station at no cost to the Company, which was installed and re-opened on August 4, 2017.

As stated in the jointly signed Transmittal No. 13-07, the "Companies will competitively bid for Schedule EV-U EV fast charging system[s]."[19] The Companies have also initiated a process to analyze data for potential locations that may indicate higher levels of utilization. Once a potential site host expresses interest for a specific address, the Companies will utilize Geographic Information Systems (GIS) software to provide a more detailed analysis of these data points with respect to the site. This process will be discussed in further detail in this report.

Hawai‘i Electric Light New Site Installation

In March of 2017, Hawai‘i Electric Light opened a DCFC station at KTA Super Stores in Waimea. With the largest land area in the state, Hawai‘i Island will require significant charging infrastructure to extend electric driving range throughout the island and help alleviate "range anxiety." The Waimea location is located between two major population centers on Hawai‘i, and can serve as a recharging point for EVs travelling between Hilo and Kailua-Kona, as well as serving the population in and around Waimea.[20] In addition, Hawai‘i Electric Light has been in discussion with another site host along the Kohala coast to transfer an existing fast charger to the Companies' fleet. David Bliss, founder and CEO of Charge Bliss and the owner of the charge station, has stated, "Charge Bliss Inc. began its foray into the energy marketplace with a plan to contribute to transportation electrification in Hawai‘i. Through its pilot DC fast EV charger

[19] Transmittal No. 13-07, filed June 3, 2013, at 14.
[20] Waimea KTA Super Stores is approximately 56 miles from the company-owned DC fast charging station in Hilo and 40 miles from the company-owned station in Kailua-Kona.

project at the Shops at Mauna Lani on the Island of Hawaiʻi, Charge Bliss determined that charging system ownership and operation is best administered through Utilities, non-profits, or EV manufacturer networks."[21] The Companies assert the continued operations of this charge station and the deployment of additional fast charging services to provide a minimal backbone of charging infrastructure will be instrumental to extend driving range and support EV adoption on Hawaiʻi Island.

Maui Electric New Site Installation

Maui Electric did not install additional charging infrastructure in 2017, however it has been engaged in various discussions regarding siting fast charging facilities on the islands of Molokaʻi and Lanaʻi These efforts have been conducted in conjunction with various stakeholders in an attempt to leverage partnerships to address costs impacts. Such deployments, although serving a small community, show the Companies' commitment and leadership in providing EV charging services across its service territory.

On Molokaʻi, system reliability issues can be caused by excess energy generated from the continued installation of residential and commercial photovoltaics. EVs can potentially benefit all customers through additional load during solar peaks, and may also offer grid support services. With time of use pricing mechanisms embedded within the EV-F and EV-U rates, incremental EV charging during the middle of the day will help alleviate potential system-wide excess energy and promote utilizing renewable energy for transportation. The Molokaʻi DCFC is planned to be installed and operational by the end of the third Quarter of 2018.

[21] Personal communication between David Bliss and Hawaiian Electric's Director of Transportation via email on March 13, 2018.

Combined Adoption

The deployment of Company-owned and operated DCFC stations, each of which are operated under Schedule EV-U, throughout 2017 is summarized in Table 7, below.

Table 7
Total DC Fast Charger Under Schedule EV-U
January-December 2017

Month	Hawaiian Electric	Hawai'i Electric Light	Maui Electric
January	7	2	1
February	7	2	1
March	7	3	1
April	8	3	1
May	8	3	1
June	8	3	1
July	8	3	1
August	8	3	1
September	8	3	1
October	8	3	1
November	8	3	1
December	8	3	1

Hawaiian Electric Adoption and Status

Through December 2017, Company-owned DCFC stations on O'ahu experienced increased utilization in aggregate. The addition of three additional stations in 2017, two of which are located in urban Honolulu, increased the fast charging capacity available to customers and significantly contributed to the large increase in utilization. While EV registrations increased by 31% between December 2016 and December 2017 on O'ahu, total charging sessions at Company-owned O'ahu stations increased by 110%. The Ward Avenue location continues to be the most heavily utilized charging location on O'ahu, while the recently commissioned station at 801 Dillingham Blvd. was the second-most utilized location in

December. While the Companies will continue to utilize the pilot to help extend electric driving range for EV customers, locations that are anticipated to experience high utilization will also factor into the strategic deployment of fast charging stations. The total number of paid charging sessions and revenue earned for each DCFC station owned and operated by Hawaiian Electric is shown in Figures 1 through 8, below.

Figure 1
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Dole Plantation

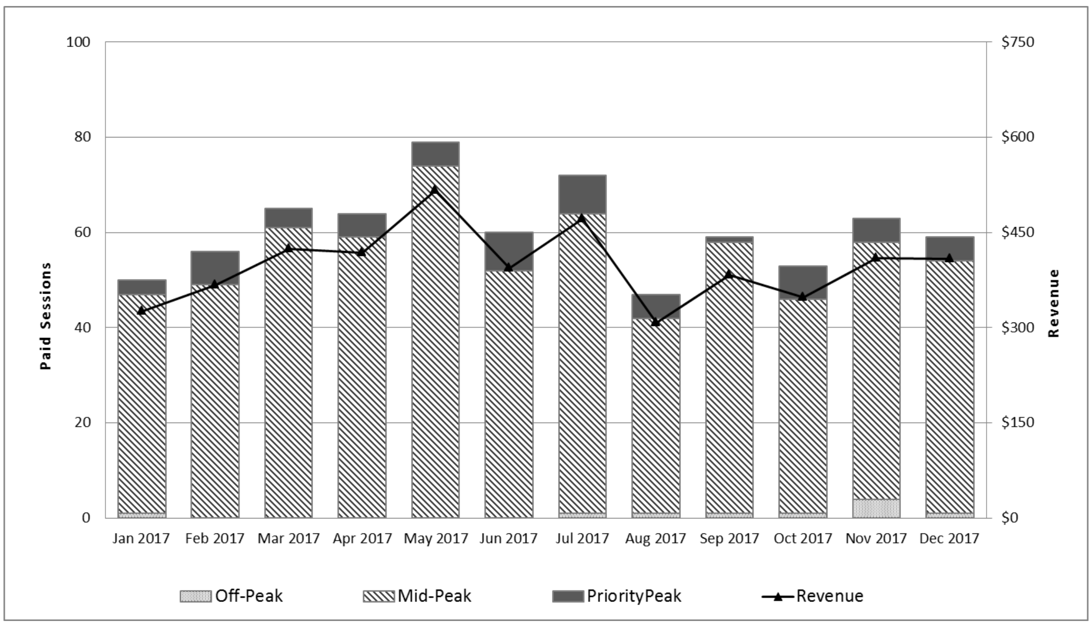

Figure 2
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Ko'olau Center

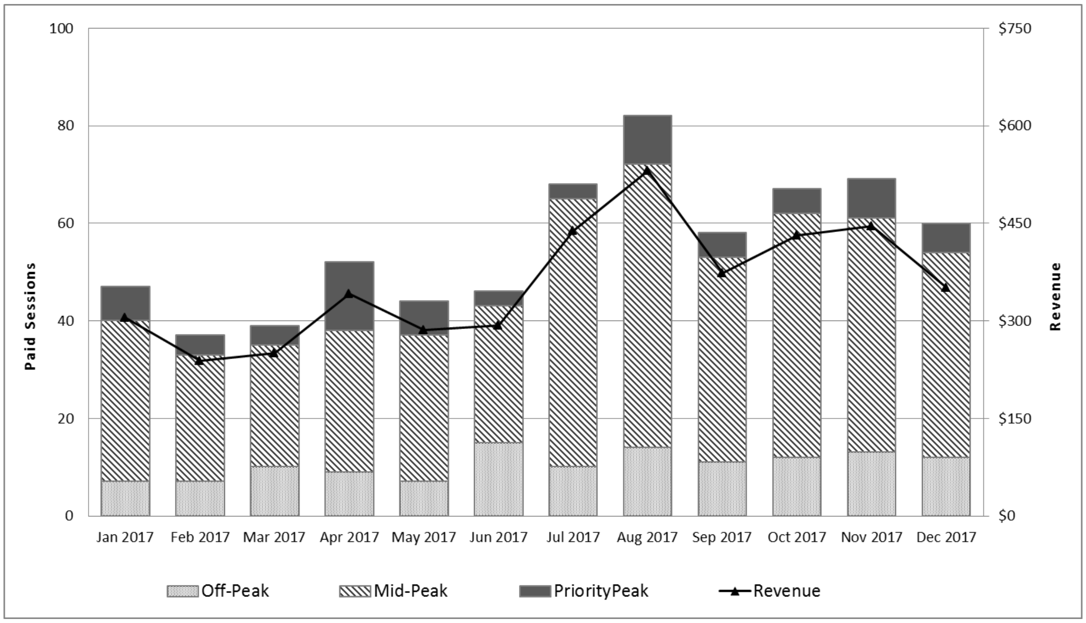

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Figure 3
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Kapolei Commons[22]

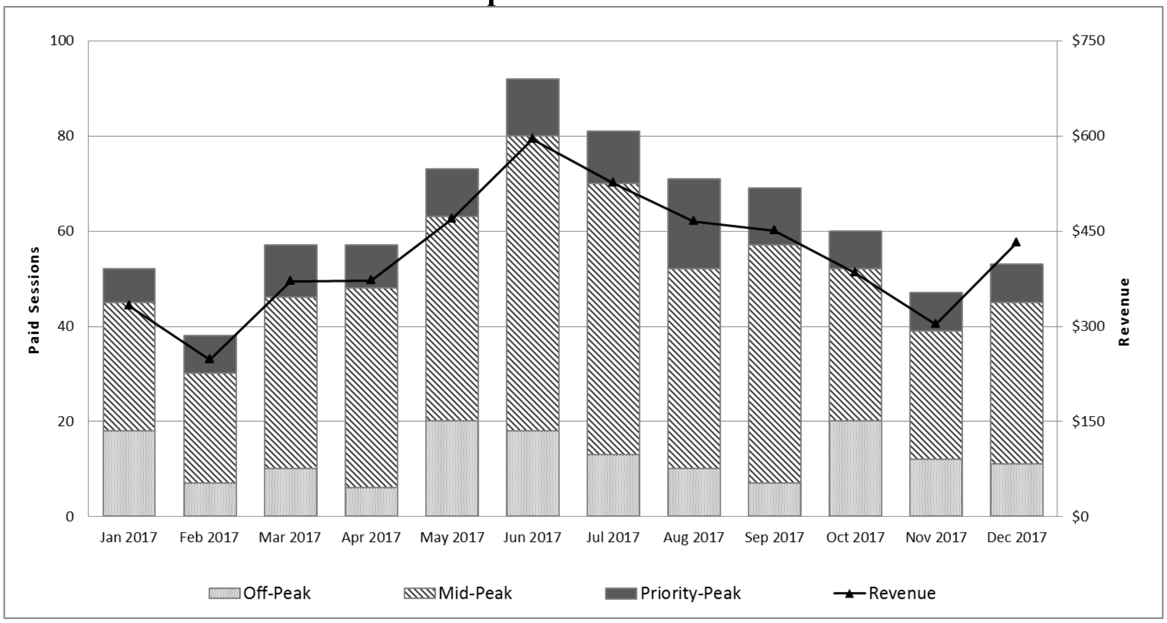
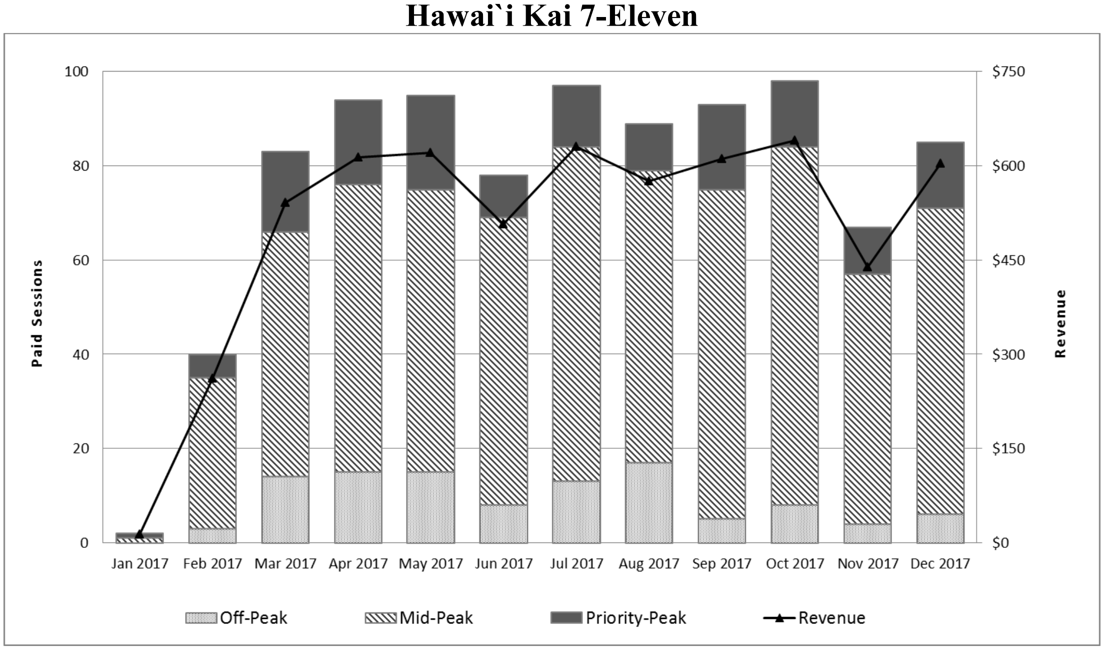


Figure 4
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Hawai`i Kai 7-Eleven



[22] The overall utilization patterns for Kapolei Commons did not significantly decrease in 2017, in spite of various nearby level 2 charging options (including a free charger).

Figure 5
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Hawaiian Electric Main Office, "Ward 1"

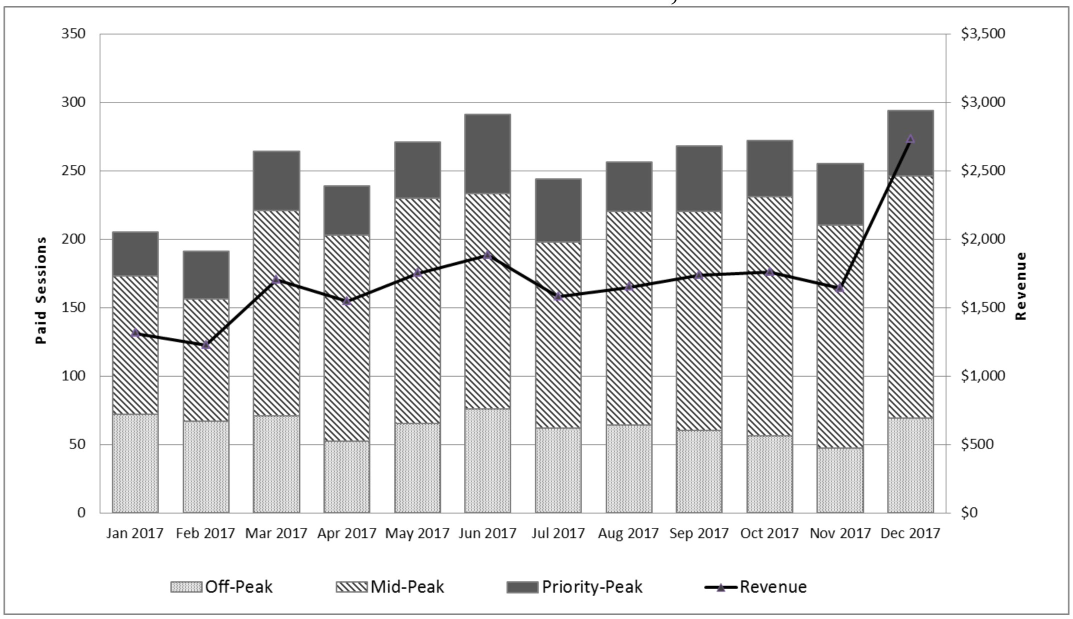


Figure 6
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Hawaiian Electric Main Office, "Ward 2"

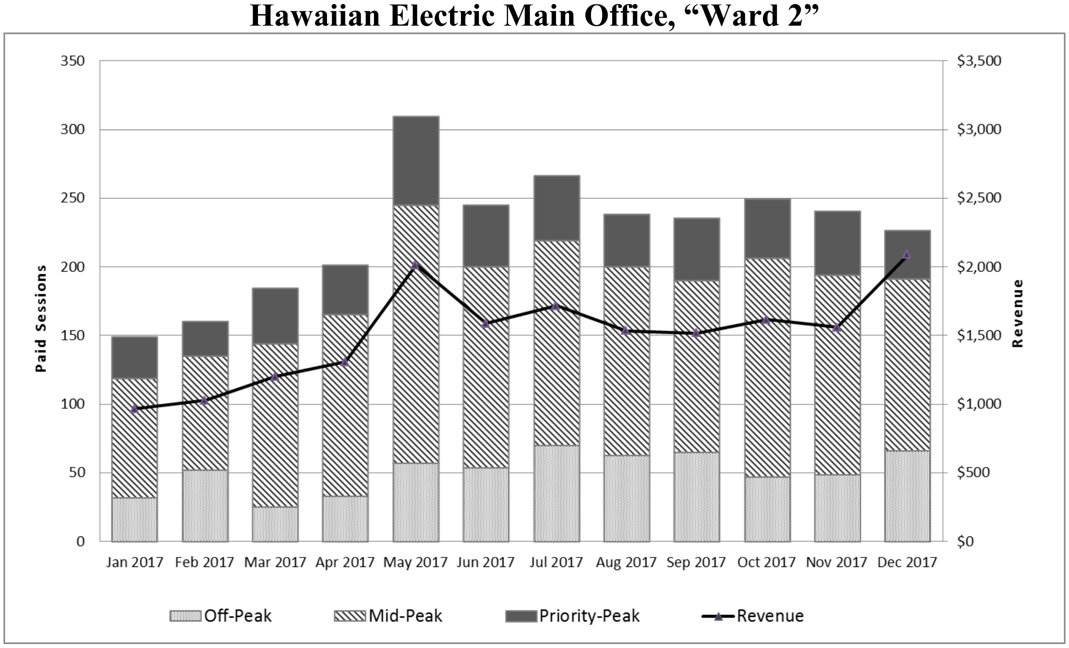


Figure 7
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Waianae Mall

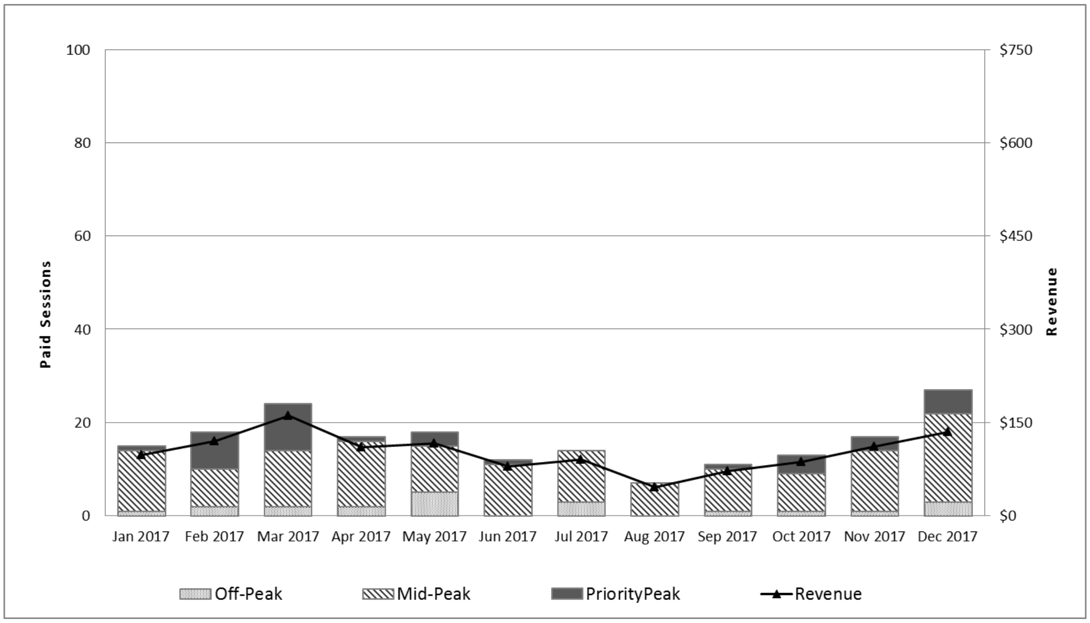
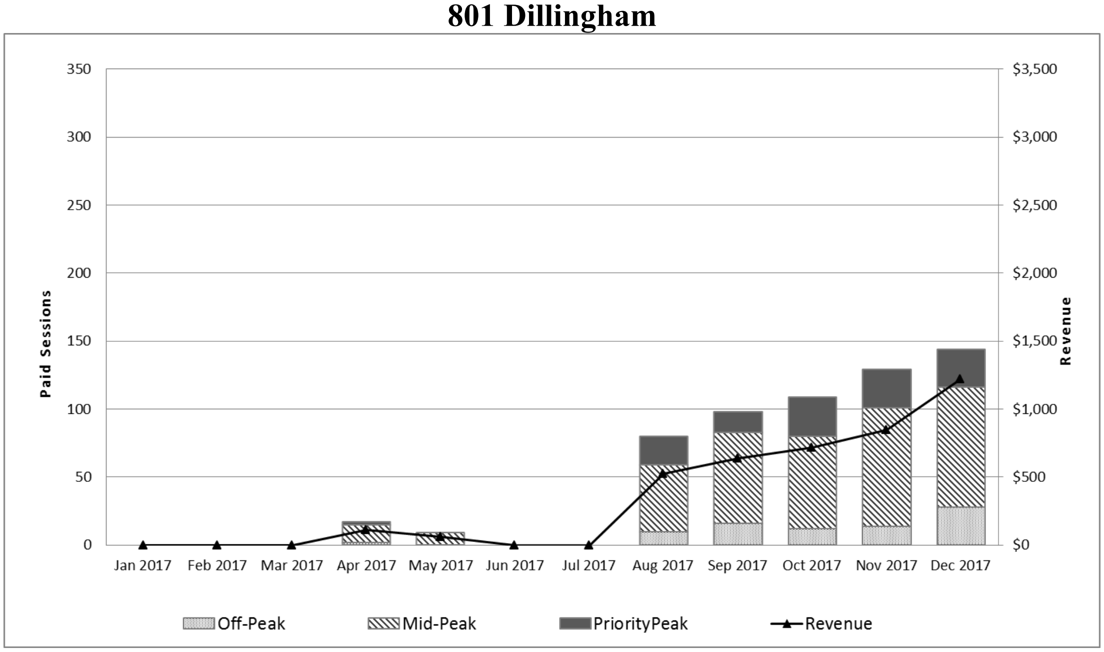


Figure 8
Monthly Charge Sessions, TOU Periods, and Gross Revenue
801 Dillingham



Hawai‘i Electric Light Adoption and Status

Through December 2017, Company-owned DCFC stations on Hawai‘i Island experienced increased utilization in aggregate. While EV registrations increased by 45% from December 2016 to December 2017 on Hawai‘i Island, total charging sessions increased by over 400%. The 2017 addition of the location in Waimea increased the fast charging capacity available to customers and provided an additional charging location between the two population centers of Hilo and Kailua-Kona. As the largest island in the State, the Companies expect increased electric driving range to be a key strategic driver to new fast charger deployment on Hawai‘i Island. In a recent survey conducted by the Companies, included as attachment A, respondents in Hawai‘i County identify increased battery range and additional public charging locations as more likely to influence their decision to purchase an EV compared to respondents in Honolulu and Maui Counties. The total number of charging sessions and revenue earned for each DCFC station owned and operated by Hawai‘i Electric Light is displayed in Figures 9 through 11, below.

Figure 9
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Hawai‘i Electric Light Hilo Office

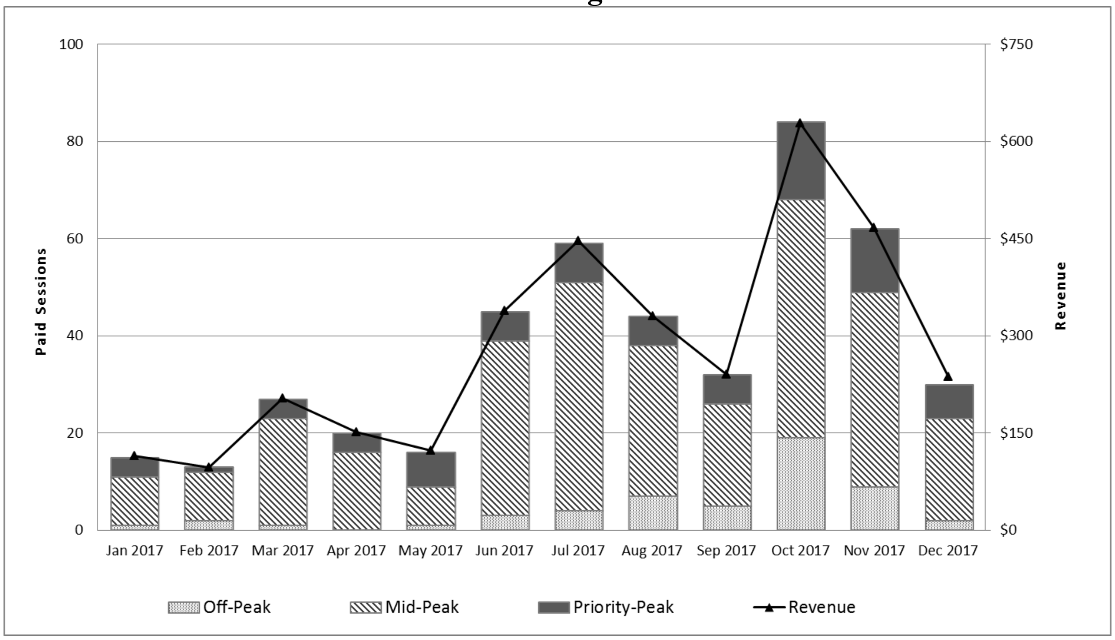


Figure 10
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Hawai‘i Electric Light Kona Office

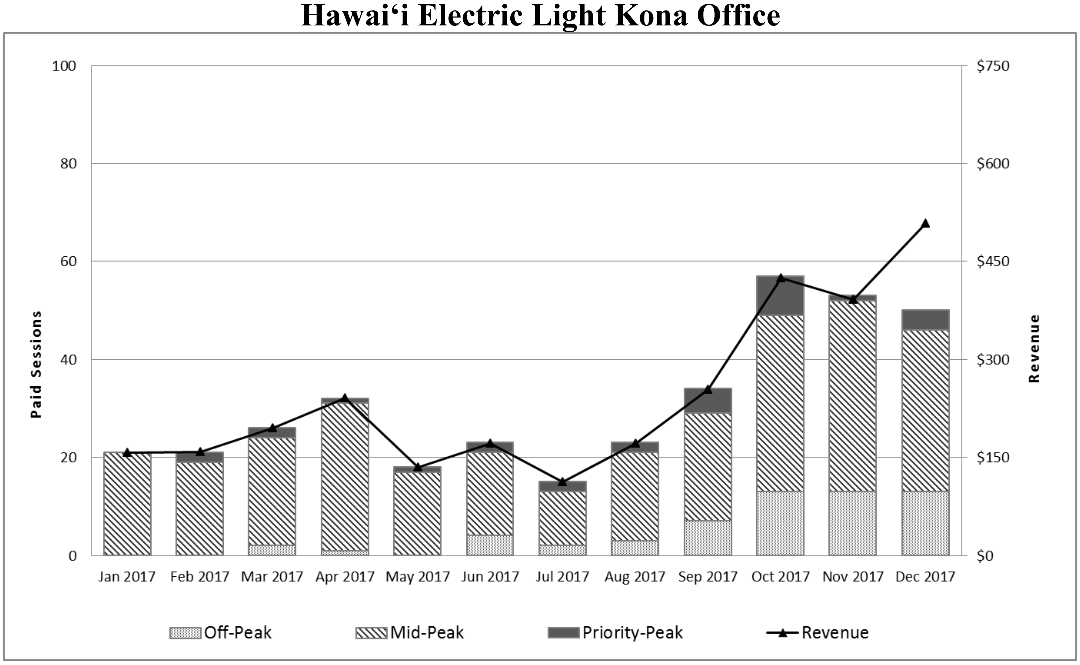
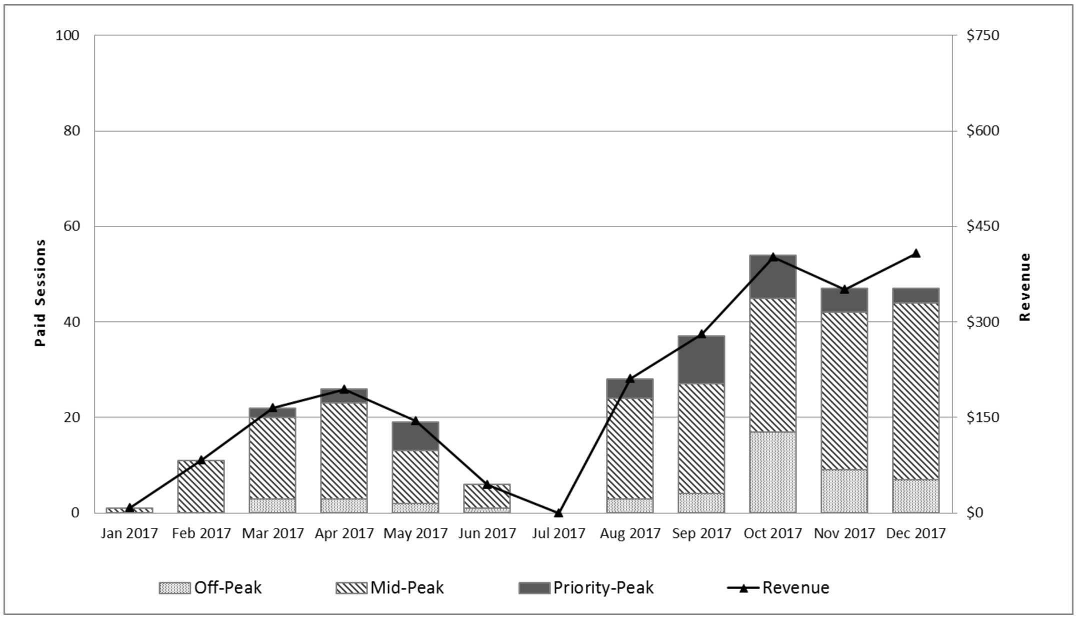


Figure 11
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Waimea KTA

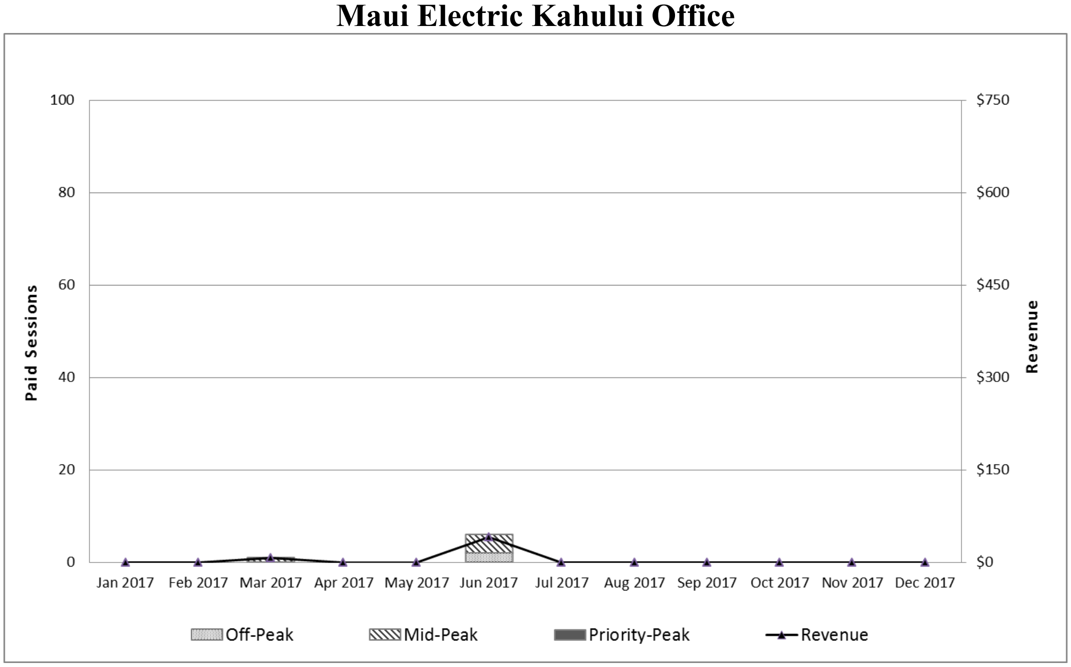


Maui Electric Adoption and Status

The Maui Electric DCFC station, located at the Maui Electric main office in Kahului, was in and out of service in the first half of 2017, and has been out of service since July 6, 2017. Negotiations are being completed with the vendor to provide a replacement station, which is anticipated to be installed in 2018. As discussed in previous reports, the EV Ohana program (previously "JUMPSmart Maui") provides DC fast charging membership plans for 13 locations throughout Maui for $15-$50 per month depending on the plan chosen by the member, which is more cost competitive in comparison to Schedule EV-U. One of these locations is approximately one-half mile from the Maui Electric main office and offers four fast charging stalls. As the Companies consider new deployments in Maui County, the existence of charging alternatives will be considered. While a significant network of DCFC stations operated by EV Ohana have been established on Maui Island, all facilities offer only the CHAdeMO standard, which is not applicable to certain EV models. The deployment of Schedule EV-U facilities on

Maui Island may support EV adoption and increase electric driving range for EVs operating under the Combined Charging System ("CCS") standard. As of this report, there remains no fast charging service and overall no public charging options on both Lana'i and Moloka'i. The deployment of charging services on these islands may help support additional EV adoption for these communities, and can be leveraged to integrate increasing levels of renewable energy by adding additional load to these small island grids during the middle of the day when excess solar energy exported to the grid is at its highest. If the additional load from the charging EVs were to be sustained during the mid-day solar peak, e.g., the EV charging stations were regularly in use during daylight hours, this could help balance system load and generation and enable more renewable energy systems to connect to the grid and produce electricity while maintaining system security and reliability. Figure 12, below, depicts the total number of charging sessions and revenue earned at the Maui Electric Kahului location in 2017.

Figure 12
Monthly Charge Sessions, TOU Periods, and Gross Revenue
Maui Electric Kahului Office



Aggregate Utilization Details

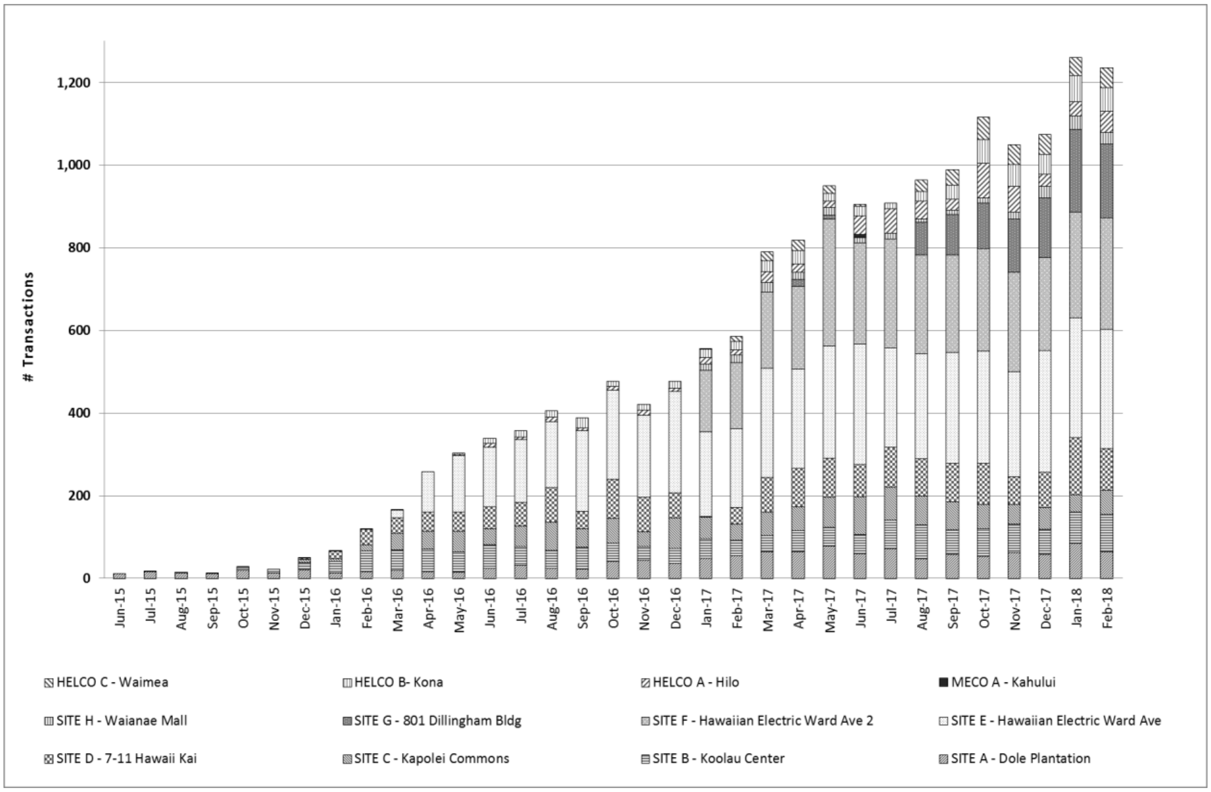
Through December 2017, Company-owned DCFC stations on O‘ahu experienced increased utilization in aggregate. While EV registrations increased by 30% between December 2016 and December 2017 in the Companies’ service territories, total charge sessions at Company-owned stations increased by 183%. The Companies also note that Company-owned charge stations continue to receive patronage despite the availability of lower-cost or free charging alternatives, as exemplified by the charge station at Kapolei Commons which is in the same retail shopping center as free Level 2 EV charging stations. The Companies acknowledge the value in increased utilization at its EV charging stations, but also recognize the value in providing a broad network of charging locations to EV customers, including locations in remote areas that increase electric driving range but may experience the lower levels of utilization. As will be discussed below, both utilization and range extension are important components of the Companies’ EV charging deployment strategy to provide a backbone of charging infrastructure. Table 8, below, provides details of monthly charging sessions for each service territory. All data reflects paid sessions and does not include any sessions used for testing or Company purposes.

Table 8
Schedule EV-U Aggregate Charging Detail
January-December 2017

Month	Hawaiian Electric		Hawai'i Electric Light		Maui Electric		Total	
	Sessions	kWh	Sessions	kWh	Sessions	kWh	Sessions	kWh
January	520	10,614	37	482	0	0	557	11,096
February	540	10,816	45	521	0	0	585	11,337
March	716	14,298	75	871	1	1	792	15,170
April	741	14,723	78	969	0	0	819	15,692
May	898	17,211	53	852	0	0	951	18,063
June	824	18,581	74	949	6	223	904	19,754
July	842	17,667	74	1,073	0	0	916	18,739
August	870	20,382	95	1,416	0	0	965	21,797
September	891	20,628	103	1,716	0	0	994	22,344
October	921	21,926	195	4,667	0	0	1,116	26,593
November	887	20,339	162	3,989	0	0	1,049	24,329
December 1-11	304	7383	49	1347	0	0	353	8,730
December 12-31	644	11445	78	1480	0	0	722	12,924
TOTAL	9,598	206,012	1,118	20,332	7	224	10,723	226,569

Figure 13, below, illustrates the combined usage and gross revenues of the twelve charging stations for each month in 2017, and the first two months of 2018.

Figure 13
Monthly Charge Sessions
All Sites



Tables 9 and 10, below, provide the breakdown of charging sessions by TOU period for each service territory in 2017.[23] Table 9 provides kWh consumption for each TOU period while Table 10 provides sessions per TOU period. The TOU period of a charge session is based upon its start time.

Table 9
Schedule EV-U kWh Consumption by TOU Period
January-December 2017

Period	Territory	Priority-Peak	Mid-Peak	Off-Peak	Total
Jan 1	O'ahu	32,524	121,600	40,444	194,568
-	Hawai'i	2,801	12,399	3,652	18,852
Dec 11	Maui	0	125	99	224
		On-Peak	**Mid-Day**	**Off-Peak**	**Total**
Dec 12	O'ahu	2,682	6,434	2,328	11,445
-	Hawai'i	110	1,057	312	1,480
Dec 31	Maui	0	0	0	0
	TOTAL	38,118	141,616	46,835	226,569
	% TOTAL	16.8%	62.5%	20.7%	100.0%

[23] Prior to December 12, Schedule EV-U TOU periods were: Priority-Peak (5:00 p.m.-9:00 p.m., Monday-Friday); Mid-Peak (7:00 a.m.-5:00 p.m., Monday-Friday, 7:00 a.m.-9:00 p.m., Saturday-Sunday); Off-Peak (9:00 p.m.-7:00 a.m., daily). Schedule EV-U TOU periods on and after December 12 are: On-Peak (5:00 p.m.-10:00 p.m., daily); Mid-Day (9:00 a.m.-5:00 p.m., daily); Off-Peak (10:00 p.m.-9:00 a.m.).

Table 10
Schedule EV-U Charge Sessions by TOU Period
January-December 2017

Period	Territory	Priority-Peak	Mid-Peak	Off-Peak	Total
Jan 1	O‘ahu	1,463	5,751	1,740	8,954
-	Hawai‘i	148	740	152	1,040
Dec 11	Maui	0	5	2	7
		On-Peak	**Mid-Day**	**Off-Peak**	**Total**
Dec 12	O‘ahu	153	353	138	644
-	Hawai‘i	8	61	9	78
Dec 31	Maui	0	0	0	0
	TOTAL	1,772	6,910	2,041	10,723
	% TOTAL	16.5%	64.4%	19.0%	100.0%

Figure 14, below, depicts the aggregated charge sessions for all Companies in each TOU period, by month.

Figure 14
Monthly Charge Sessions, TOU Periods
All Sites

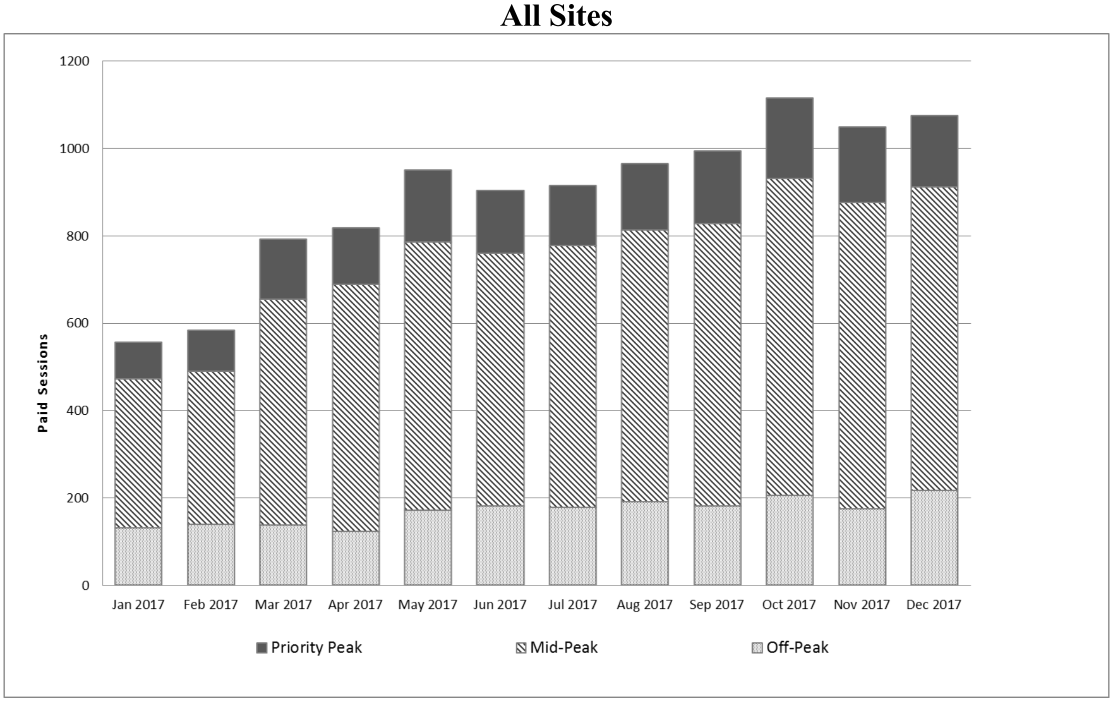


Figure 15, below, shows the variance in total charging sessions by each day of the week.

Figure 15
Charge Session by Day of Week
All Sites, 2017

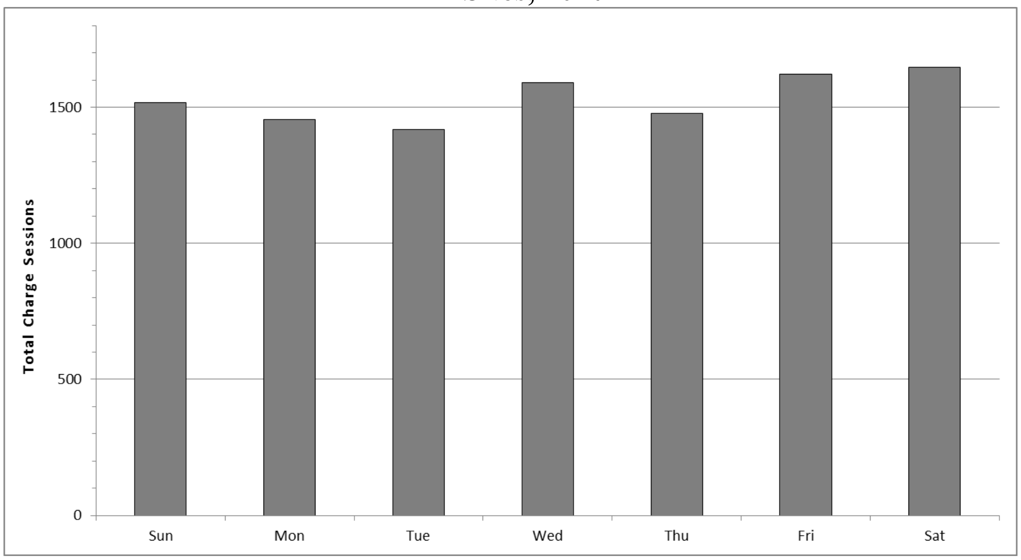
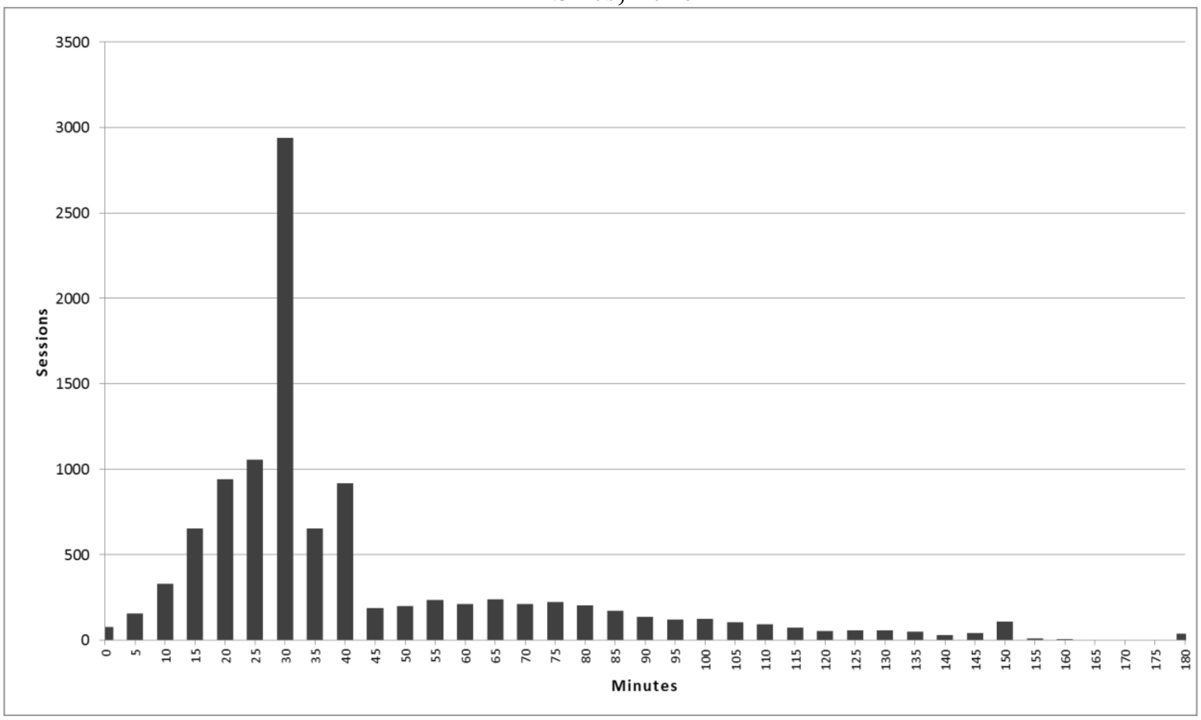


Figure 16, below, provides the number of charge sessions by connection time for all sessions in 2017.[24]

Figure 16
Charge Session by Average Charge Time[25]
All Sites, 2017



Charging Impact of Rate Change

On December 12, 2017, a revised rate structure was implemented for Schedule EV-U. The revised rate is based on electricity consumption, incorporates a TOU structure that incentivizes daytime consumption, and includes incremental costs for network fees, non-labor O&M and customer surcharges.[26] The intent of the revised rate structure is to provide a pricing structure that equitably charges customers based on their actual electricity consumption,

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[24] There were five recorded charge sessions over 180 minutes. This data is assumed to be in error due to data communication issues and were not used for this calculation.
[25] Connection time is represented in 5-minute bins, starting from 0-5 minutes.
[26] See Revised Rate Structures for Schedules EV-F and EV-U, filed on September 5, 2017 at 8-9.

facilitates potentially quicker charge sessions, while aligning to a TOU structure that reflects system needs and incorporating additional pilot costs to alleviate some of the cost shift between participating EV customers and all ratepayers.

Primarily a result of the transition from a flat fee structure to a price per kWh consumed, the revised rate structure for Schedule EV-U typically results in decreased costs for customers that consume less electricity per session and increased costs for customers that consume more electricity per session. In its Revised Rate Structure filing, the Companies note the discrepancy between "long-range" EV consumption compared to "conventional" EV consumption, where "'long range' EV drivers consumed an average of 48.2 kWh while 'conventional' EV drivers consumed an average of only 11.2 kWh in 2016" under the previous rate structure for Schedule EV-U.[27] To make this comparison, the Companies assume that any charging session that consumes less than 20 kWh to be attributed to "conventional" EVs and any session above 20 kWh to be attributed to "long-range" EVs. As the revised rate structure no longer financially incentivizes longer charging per session, and new EV models offer a variety of driving ranges and battery capacities, the Companies will continue to analyze customer behavior based on total consumption but will not speculate which sessions can be attributed to "conventional" or "long-range" EVs.

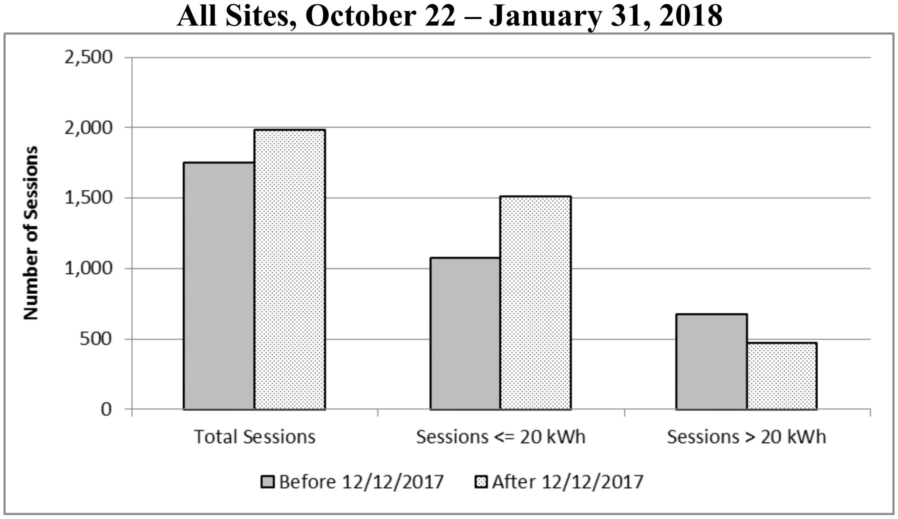
While the transactional data that is available after the revised rate was implemented is limited, in this section, the Companies compare consumption data at all Company-owned DC fast charging stations for 50 days before the rate change and 50 days after the rate change. While more data will be required to refine and better understand customers' behavioral response to the revised rate, this provides an early indication of the rate revision impact.

[27] Id. at 12

Total Charge Sessions

In Figure 17, below, the Companies note a net increase in total charge sessions of 13% in the 50 days after the rate change. This increase was largely driven by charging sessions that consumed less than 20 kWh, which increased by 41%, while charging sessions that consumed more than 20 kWh decreased by 30%. This finding is consistent with the Companies' position to change from a flat fee structure to a price per kWh consumed, which no longer provides a financial advantage for longer charging sessions. If this trend continues, the revised rate structure is likely to increase charger availability for all customers.

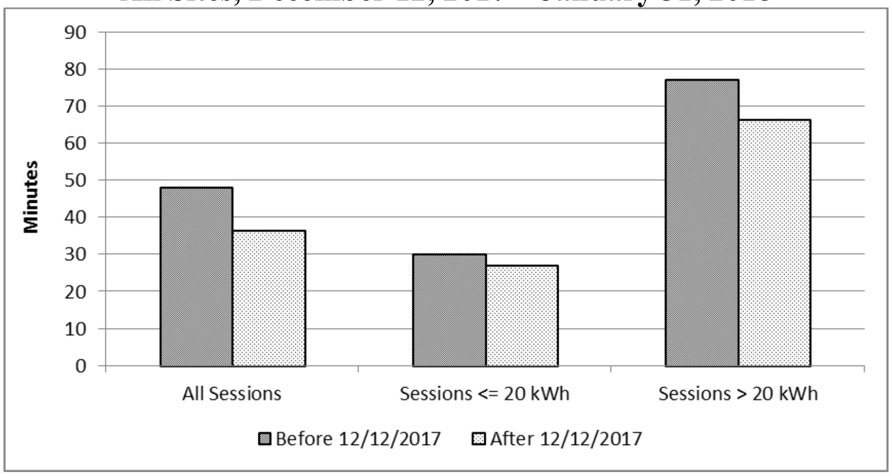
Figure 17
Comparison Total Sessions
All Sites, October 22 – January 31, 2018



Duration per Charge Session

In Figure 18, below, the Companies find that the total duration per average charging session decreased by 24% across all charging sessions in the 50 days following the rate change. The drop in charge session duration is most notable among sessions consuming more than 20 kWh per session.

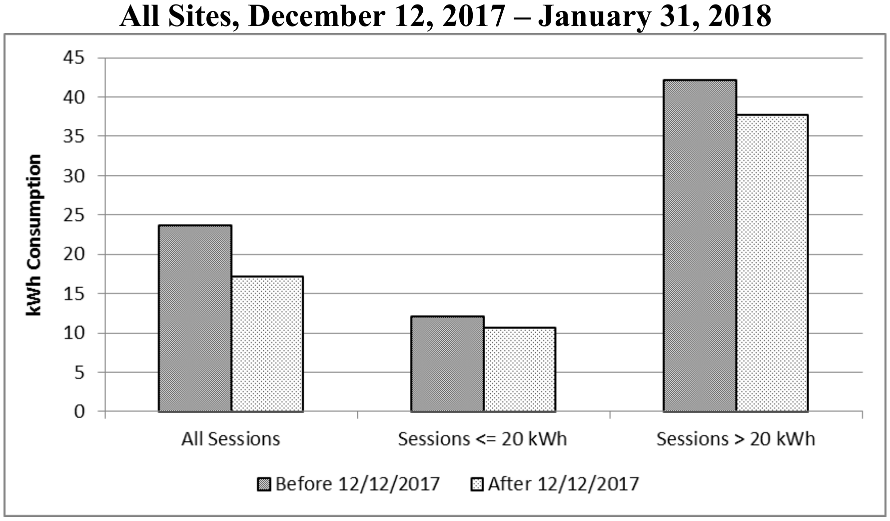
Figure 18
Comparison Average Duration per Session
All Sites, December 12, 2017 – January 31, 2018



Consumption per Charge Session

Figure 19, below, compares electricity consumption per session before and after the rate change. Closely aligned to duration, the Companies find that average consumption per charging session decreased by 27% in the 50 days following the rate change, with the largest decrease among the customers who consume the most electricity per session.

Figure 19
Comparison Average kWh Consumption per Session
All Sites, December 12, 2017 – January 31, 2018



Net Revenue

Figures 20 and 21, below, show a significant increase in both average revenue generated by each charge session and total revenue collected across all Company-owned charge stations. Average revenue per session increased by 38%, while total revenue increased by 57% in the 50 days following the rate change. This finding suggests that the revised rate structures succeed in allocating more pilot costs to participating EV customers and alleviating some of the costs borne by nonparticipating customers.

Figure 20
Comparison Average Net Revenue per Session
All Sites, December 12, 2017 – January 31, 2018

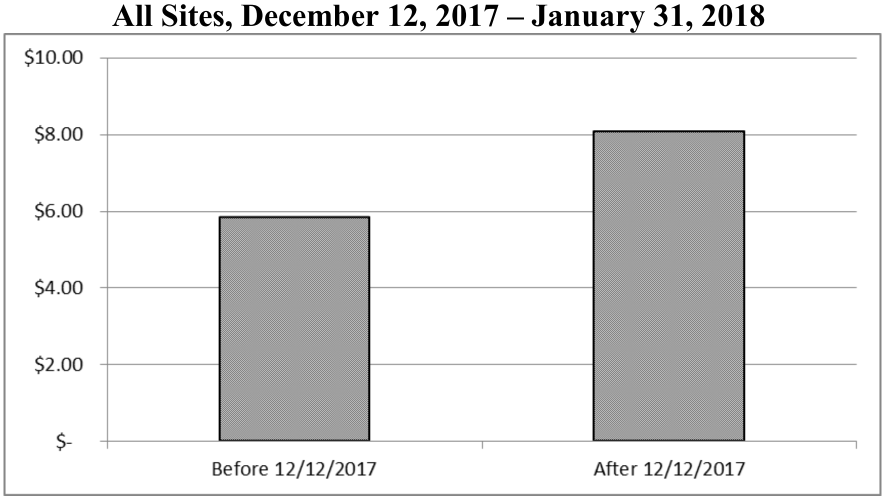
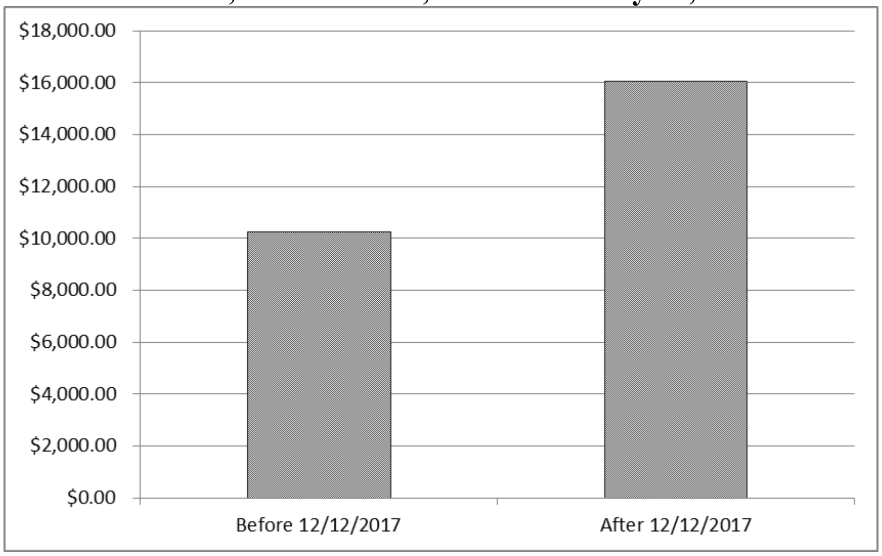


Figure 21
Comparison Total Net Revenue
All Sites, December 12, 2017 – January 31, 2018



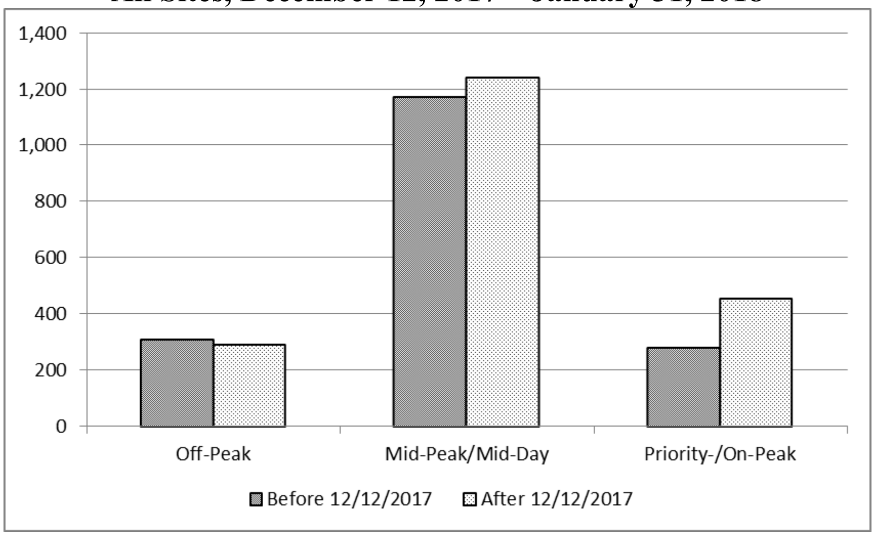
Charge Sessions by Time-of-use Period

The revised rate for Schedule EV-U lowers the relative cost to charge an EV during the Mid-Day period when compared to the prior flat fee structure. The Off-Peak period is the second-most expensive time to charge an EV, while the On-Peak period remains the highest cost period. The TOU periods adopted under the revised rate also reduces the total hours per week attributed to the Mid-Day period and increase the hours assigned to the Off-Peak and On-Peak (formerly "Priority-Peak") periods when compared to the previous Schedule EV-U tariff.[28] Figure 22, below, indicates very little movement in charge sessions by TOU period for the Mid-Day and Off-Peak periods, but does indicate an increase in charge sessions during the On-Peak period of 64%. This may largely be influenced by the expansion of the On-Peak period in the revised rates by one hour, now ending at 10:00 PM, and also the inclusion of weekends. The

[28] Total hours per week assigned to the Mid-Day period decrease by 22 hours, while hours assigned to the On-Peak and Off-Peak periods increase by 15 and 7 hours, respectively.

slight increase in charge sessions during the Mid-Day is also notable, given the significant reduction (28%) in total hours assigned to that period.

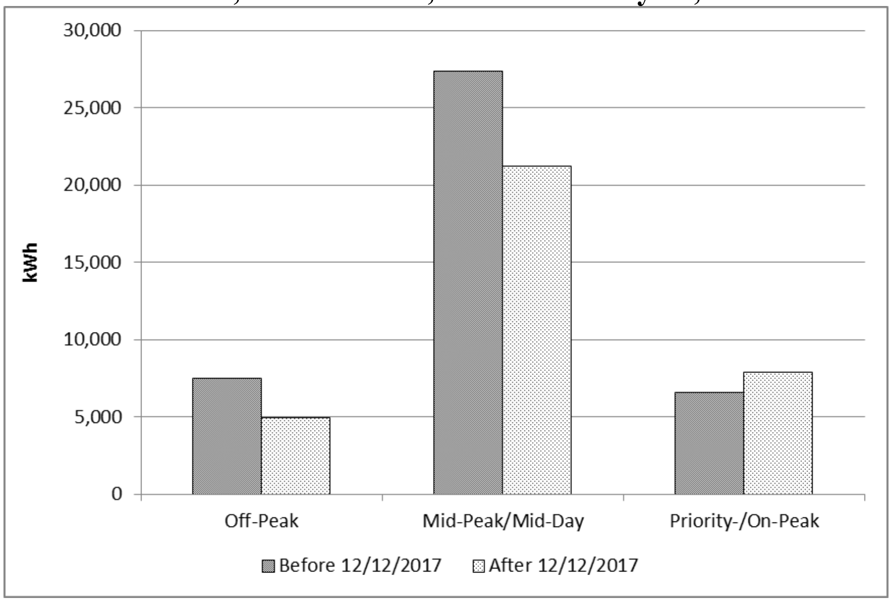
Figure 22
Charge Sessions by TOU Period
All Sites, December 12, 2017 – January 31, 2018



Total Consumption by Time-of-Use Period

Figure 23, below, depicts the change in consumption by TOU period in the 50 days following the rate change. As noted, above, the modified assignment of hours to each TOU period under the revised rate is a significant factor in both the drop in consumption during the Mid-Day period and the increase during the On-Peak period. The Companies will continue to monitor utilization data to determine the behavioral response to the revised rate for Schedule EV-U.

Figure 23
Total Consumption by TOU Period
All Sites, December 12, 2017 – January 31, 2018



Hawaiian Electric's Demonstration Projects and Data Analytics

The Companies requested approval of Schedule EV-U, in part, to enable opportunities "to conduct research, development, and demonstration activities to … address load control and other technologies, and collect data for analyses."[1] In its demonstration project at Kapolei Commons, Hawaiian Electric installed a DC fast charging system with an integrated 12 kWh battery energy storage system ("BESS"). The system is configured to draw up to 23 kW from the grid, while the BESS provides the incremental power to charge an EV at up to 50 kW. The BESS has enough storage capacity to sequentially charge up to three Nissan Leafs.

This charge station was opened to the public at the end of 2015. While several issues were discovered in the following year, most were minor and did not result in significant unavailability. However, longer-range EVs with large batteries were often able to deplete the usable storage in the DCFC system during a single charge session resulting in a terminated charge session before the battery was fully recharged. The vendor's engineers implemented a software fix in early 2017 and the charge station has since remained in operation with few issues.

This research and demonstration is now being conducted in conjunction with the Electric Power Research Institute ("EPRI"). The research objective is to determine viability of this system to alleviate customer billing demand charges and potential utility system upgrades. EPRI has published an interim report of initial findings (reference Attachment B). Hawaiian Electric and EPRI will continue to collect and analyze data for a final EPRI report target for draft by the end of this year.

Hawaiian Electric, Greenlots, and EPRI are also developing demand response ("DR") capability on a DCFC fast charging station at the Ward avenue location. This technology will allow the utility to initiate a curtailment event restricting the maximum power output of a CHAdeMO DC fast charging session from 50 kW to 25 kW. This project defines four use cases to demonstrate this capability. In 2017, the project team demonstrated most of the baseline use case as well as parts of the other three use cases. While some of the basic curtailment function has been demonstrated, more development is required to complete the demonstration of all use cases.

B. Summary of Costs and Revenue

The Companies strive to minimize operations and maintenance ("O&M") expense of DC fast charging stations under Schedule EV-U, while also ensuring reliable service for EV customers.[29] In D&O 34592, the Commission ordered the Companies to provide "a discussion of how and to what extent the costs for each DCFC facility have been and/or are proposed to be

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[29] Under agreement with its equipment providers, periodic inspection and maintenance of the DC fast charging stations is performed. Hawaiian Electric keeps an inventory of spare parts such as extra CHAdeMO and CCS plugsets and fuses which facilitates timely resolution of operational issues. Twice in 2017, trouble-shooting and replacement of the fuses were quickly carried out by Company resources using parts stocked on island.

recovered from ratepayers."[30] The recovery of capital and O&M costs for company-owned and operated DCFC stations are discussed, below.

Capital Costs

Hawaiian Electric, from its 2017 test year rate case,[31] and Hawai'i Electric Light,[32] from its 2016 test year rate case, currently recover the costs for EV charging plant additions, net of any applicable contributions in aid of construction ("CIAC"), through their base electric rates. Maui Electric currently recovers the costs for EV charging plant additions, net of any applicable CIAC, through its revenue adjustment mechanism ("RAM"). When rates from its currently ongoing 2018 test year rate case[33] become effective Maui Electric anticipates recovery of prior year capital costs as well as costs for 2018 EV charging plant additions, net of any applicable CIAC, through its 2018 base electric rates.

O&M Expenses

For each of the Companies, the costs for internal labor for the EV pilot program are generally recovered through existing base electric rates. Hawaiian Electric, in its 2017 test year rate case, and Hawai'i Electric Light, in its 2016 test year rate case, included in test year revenue requirements EV charging O&M non-labor expenses of $34,278[34] and $20,748,[35] respectively.

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[30] Docket 2016-0168, D&O 34592 at 68

[31] In Docket No. 2016-0328, Hawaiian Electric's 2017 test year rate case, Hawaiian Electric included in test year estimates for 2016 and 2017 plant additions $641,312 and $94,436, respectively, for a total of $735,478 for DC Fast Charging Infrastructure projects. See Docket No. 2016-0328, HECO-WP-1625, page 1, projects P0003286-P0003293.

[32] In Docket No. 2015-0170, Hawaii Electric Light's 2016 test year rate case, Hawaii Electric Light included in test year estimates for 2016 plant additions $721,637 for EV charging facilities. See Docket No. 2015-0170, CA-IR-224, Attachment 1, page 2, projects H0002972, H0003218, and H0003219.

[33] In Docket No. 2017-0150, Maui Electric's 2018 test year rate case, Maui Electric included in test year estimates for 2018 plant additions $150,454 for EV Charger #2. See Docket No. 2017-0150, MECO-WP-1908B, page 2, line 39, and CA-IR-83 (Supplement 3/2/2018), Attachment 2, page 3, line 36.

[34] See Docket No. 2016-0328, Parties' Stipulated Settlement Letter filed November 15, 2017, Exhibit 1, at 57.

[35] See Docket No. 2015-0170, HELCO-WP-1002, page 2, line 33.

Maui Electric does not currently recover the relatively small amount of incremental non-labor O&M expenses for its EV charging station.

The Companies anticipate the recovery of future capital costs and O&M expenses, to the extent over and above existing recoveries, will be through either future rate cases or their respective RAMs, as appropriate. The Companies are also in discussions to potentially partner with third parties in the deployment of charging infrastructure, which could reduce overall pilot costs. As those partnerships are executed, the Companies will provide analysis and commentary regarding the cost-impact to customers.

Tables 12 and 13, below, provide overall program costs and revenues related to Schedule EV-U. Table 12 reflects costs and revenues incurred during 2017, and Table 13 reflects costs and revenues for the pilot from inception through December 2017. Included in the table are Capital costs (for purchase of equipment and labor for design and installation of the project site), O&M labor (for project management and research), O&M non-labor (for operations and maintenance), and other costs (for revenue and reimbursements,) for each company.

Other costs also reflect overall pilot adjustments due to reporting the expense of electric service. Stated in Transmittal No. 13-07, "[a] project accounting framework will be set up and key departments will create workorders to track expenses and capital expenditures associated with tariff implementation."[36] As such, the Companies are tracking operating expenses including the cost of electric service, which are metered, calculated, and subsequently tracked by workorders for each charging facility. Since the Companies cannot report revenue of electric sales to itself, the Companies are required to reverse these costs. The reversal of costs for electric sales are included as "Reverse energy charge" in Tables 12 and 13.

[36] Transmittal No. 13-07 at 20.

Table 12
Program Costs
January – December 2017

	Hawaiian Electric	Hawaii Electric Light	Maui Electric	Totals
Revenue	$ (64,053)	$ (8,610)	$ (41)	$ (72,703)
Expenses				
Energy charge	$ 63,265	$ 10,118	$ 2,322	$ 75,705
Reverse energy charge	$ (63,265)	$ (10,118)	$ (2,322)	$ (75,705)
O&M				
Labor	$ 227,782	$ 2,139	$ 11,748	$ 241,669
Non-labor	$ 52,545	$ 1,164	$ 372	$ 54,080
Total Expenses	$ 280,327	$ 3,303	$ 12,120	$ 295,749
Capital costs, net of CIAC	$ 110,608	$ -	$ -	$ 110,608

Table 13
Program Costs
Pilot Inception Through December 2017

	Hawaiian Electric	Hawaii Electric Light	Maui Electric	Totals
Revenue	$ (88,415)	$ (9,960)	$ (125)	$ (98,500)
Expenses				
Energy charge	$ 80,090	$ 11,664	$ 8,559	$ 100,313
Reverse energy charge	$ (80,090)	$ (11,664)	$ (8,559)	$ (100,313)
O&M				
Labor	$ 481,938	$ 3,893	$ 113,970	$ 599,800
Non-labor	$ 84,291	$ 1,707	$ 10,002	$ 63,832
Total Expenses	$ 566,229	$ 5,600	$ 123,972	$ 663,632
Capital costs, net of CIAC	$ 1,174,738	$ 721,637	$ 86,776	$ 1,983,151

Table 14, below, details expenses related to Schedule EV-U for each site in service as of December 31, 2017. The capital cost of the Kapolei site was offset by funds through the joint EPRI project. In Table 14, costs for sites not yet in service, as well as project administration, energy reversals, and overall research are aggregated as "Other" costs. Therefore, Table 14 reflects energy costs as an O&M expense to each operating site.

Table 14
Costs Per Available Site
Pilot Inception Through December 2017

Territory	Site	Cost Element	Cost
O'ahu	Kapolei Commons	Capital	$ 218,687
		O&M	$ 47,118
		CIAC	$ (163,486)
		Revenue	$ (8,414)
		TOTAL	$ 93,905
	Dole Plantation	Capital	$ 128,094
		O&M	$ 29,983
		Revenue	$ (7,483)
		TOTAL	$ 150,594
	Ko`olau Center	Capital	$ 178,329
		O&M	$ 31,316
		Revenue	$ (8,043)
		TOTAL	$ 201,602
	Hawaii Kai 7-Eleven	Capital	$ 164,967
		O&M	$ 40,452
		Revenue	$ (10,356)
		TOTAL	$ 195,062
	Hawaiian Electric Ward Ave #1	Capital	$ 163,312
		O&M	$ 67,082
		Revenue	$ (30,647)
		TOTAL	$ 199,747
	Hawaiian Electric Ward Ave #2	Capital	$ 143,667
		O&M	$ 39,300
		Revenue	$ (18,137)
		TOTAL	$ 164,829
	Waianae Shopping Mall	Capital	$ 159,841
		O&M	$ 9,656
		Revenue	$ (1,222)
		TOTAL	$ 168,275
	801 Dillingham	Capital	$ 181,328
		O&M	$ 11,012
		Revenue	$ (4,114)
		TOTAL	$ 188,227
	Other	Capital	$ -
		O&M	$ 370,401
		Rev Energy Charge	$ (88,415)
		TOTAL	$ 281,985

Hawai'i	Hawaii Electric Light Hilo	Capital	$ 261,437
		O&M	$ 6,744
		Revenue	$ (3,894)
		TOTAL	$ 264,287
	Hawaii Electric Light Kona	Capital	$ 266,666
		O&M	$ 6,830
		Revenue	$ (3,777)
		TOTAL	$ 269,719
	Waimea KTA	Capital	$ 193,534
		O&M	$ 3,690
		Revenue	$ (2,289)
		TOTAL	$ 194,935
	Other	Capital	$ -
		O&M	$ -
		Rev Energy Charge	$ (11,664)
		TOTAL	$ (11,664)
Maui	Maui Electric Kahului	Capital	$ 86,776
		O&M	$ 45,357
		Revenue	$ (125)
		TOTAL	$ 132,008
	Other	Capital	$ -
		O&M	$ 87,173
		Rev Energy Charge	$ (8,559)
		TOTAL	$ 78,615

Table 15, below, provides charging fees billed for Schedule EV-U between January 1 and December 31, 2017. Due to lags in processing transactions, some of these revenues are reported by the charging network, but may not yet be remitted to the Companies.

Table 15
Schedule EV-U Charging Fees
January-December 2017

Month	Hawaiian Electric	Hawai'i Electric Light	Maui Electric
January	$3,355.00	$279.00	$-
February	$3,486.50	$338.00	$-
March	$4,652.00	$562.50	$7.00
April	$4,819.00	$587.00	$-
May	$5,827.50	$402.00	$-
June	$5,338.50	$554.50	$41.00
July	$5,451.00	$558.50	$-
August	$5,635.50	$713.00	$-
September	$5,781.00	$775.00	$-
October	$5,983.50	$1,455.00	$-
November	$5,754.47	$1,209.00	$-
December	$7,967.84	$1,152.97	$-
TOTAL	$64,051.81	$8,586.47	$48.00

C. Identify and Describe the Level and Extent of Subsidization by Non-Participating Ratepayers

The Companies maintain that a key criterion in developing EV rates and programs is to encourage the adoption of EVs by customers. Because the EV market is still nascent in Hawai'i and EV proliferation is regarded as a State policy goal, it is prudent to provide rate support for the development of public EV charging infrastructure. As stated herein, the Companies contend that EV customers using Company chargers should not necessarily be characterized as benefitting from a subsidy *per se*, but viewed within the context of the customer's entire load increased by EV charging, an increment that would not otherwise exist on the system.

To the extent that the provision of the EV tariffs incentivize or enable customers to purchase or lease a new EV, the subsidization of the EV charging should not be viewed in isolation, but as part of package of incentives to adopt clean transportation as a technology that is still in the nascent stages. Therefore, Schedule EV-F and EV-U rates that support this incremental load should not completely be considered to be subsidized by other ratepayers. Further, the revenues collected by the incremental discretionary load of EV charging would not contribute to overall Company profits, but instead would constitute contributions to fixed costs and support the State's transition to cleaner transportation.

That said, the difference between revenues collected is provided in Table 16, below, summarizing the total monthly revenue generated from Schedule EV-U compared to the potential revenue generated if the charging facility were billed under each Companies' respective Schedule J, representing potential revenue that may have been generated if similar fast charging services were provided by a private commercial entity.[37] As previously discussed, the revised rate structure coincides with an increase in average revenue per charge session under Schedule EV-U in the 50 days following implementation. The impact of this increase in average revenue can also be found in the December comparison, where the difference between Schedule EV-U and potential Schedule J revenue drops significantly. The potential Schedule J revenues were based upon the reported monthly kWh energy provided to charge EVs under Schedule EV-U and 47.5 kW billing demand. Months in which existing charging stations had no usage are reflected with the minimum charge for Schedule J.

[37] In response to CA-IR-13, filed on October 14, 2016, the Companies provide an analysis of projected revenues under Schedule EV-F and Schedule EV-U compared to Schedule J, and commit to providing an updated analysis as revised EV forecasts are made available. The Companies have available a revised EV forecast for the island of O‘ahu, but do not yet have revised EV forecasts for Maui, Lana‘i, Moloka‘i or Hawai`i Island. When revised EV forecasts for all islands in the Companies' service territory are made available, the analysis conducted for CA-IR-13 will be updated accordingly and included in the subsequent annual report.

Table 16
Schedule EV-U to Potential Schedule J Revenue Comparison
January-December 2017

Month	Total EV-U Revenues	Potential Schedule J Revenue	Difference
January	$3,634.00	$9,461.47	$5,827.47
February	$3,824.50	$9,855.84	$6,031.34
March	$5,221.50	$10,061.38	$4,839.88
April	$5,406.00	$12,217.79	$6,811.79
May	$6,229.50	$11,694.53	$5,465.03
June	$5,934.00	$12,426.68	$6,492.68
July	$6,009.50	$12,333.15	$6,323.65
August	$6,348.50	$12,299.57	$5,951.07
September	$6,556.00	$12,715.39	$6,159.39
October	$7,438.50	$13,579.57	$6,141.07
November	$6,963.47	$13,835.22	$6,871.75
December	$9,120.82	$12,379.47	$3,258.65
TOTAL	$72,686.29	$142,860.06	$70,173.77

D. Data Collection

In its D&O 34592, the Commission provides guidance to the Companies that the DC fast charging pilot is an opportunity to collect data and feedback from customers to support the development of EV charging services.[38] Specifically, the Commission recommends that the Companies collect data and identify potential grid services that may be derived from pilot infrastructure deployment and that any data collection systems should support demand response initiatives.[39] Furthermore, the Commission notes that the Companies should work with Network Providers to improve data collection capabilities and enhance customer experience, and should consider the recommendations made by both the Consumer Advocate and Department of Business, Economic Development & Tourism ("DBEDT") in Docket 2016-0168.

[38] D&O 34592 at 61-62.
[39] Id. at 62-63.

In its statement of position, the Consumer Advocate discusses the role of data collection as a tool to better understand the grid services that may be derived from fast charging resources.[40] The Consumer Advocate also recommends developing an "EV DCFC station infrastructure deployment plan that links the number of stations deployed to current EV adoption trends, current DCFC station utilization, and localized factors affecting potential demand,"[41] and that the Companies consider "demographic data, transportation patterns, geographic density and distribution, and the availability of other charging alternatives" to analyze the prospective utilization at potential sites.[42]

In its statement of position, DBEDT recommends that pilot EV charging infrastructure be sited in locations that support the integration of renewable energy, citing this is a key role for electric utilities in the EV market.[43] DBEDT also suggests that the Companies conduct customer surveys[44] and collect data to identify underserved markets[45] and develop "robust data sets specific to Hawaii."[46]

In response to the guidance provided by the Commission, the Consumer Advocate and DBEDT, the Companies have undertaken several initiatives to enhance data collection and usage with respect to the pilot. An EV survey was implemented in 2017 to identify customer insights that can improve existing EV charging pilots and programs. The Companies also utilize the survey to measure the willingness of DCFC customers to provide demand response services, and are investigating new technologies that can leverage charging locations to provide grid support services. Finally, the Companies have initiated a process to examine potential indicators or

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[40] CA SOP, at 15-16.
[41] Id. at 17.
[42] Id. at 11.
[43] DBEDT SOP, at 3.
[44] Id. at 9-10.
[45] Id. at 3-4.
[46] Id. at 11.

higher utilization for EV charging services, and incorporate those indicators into its existing deployment strategy.

EV Survey

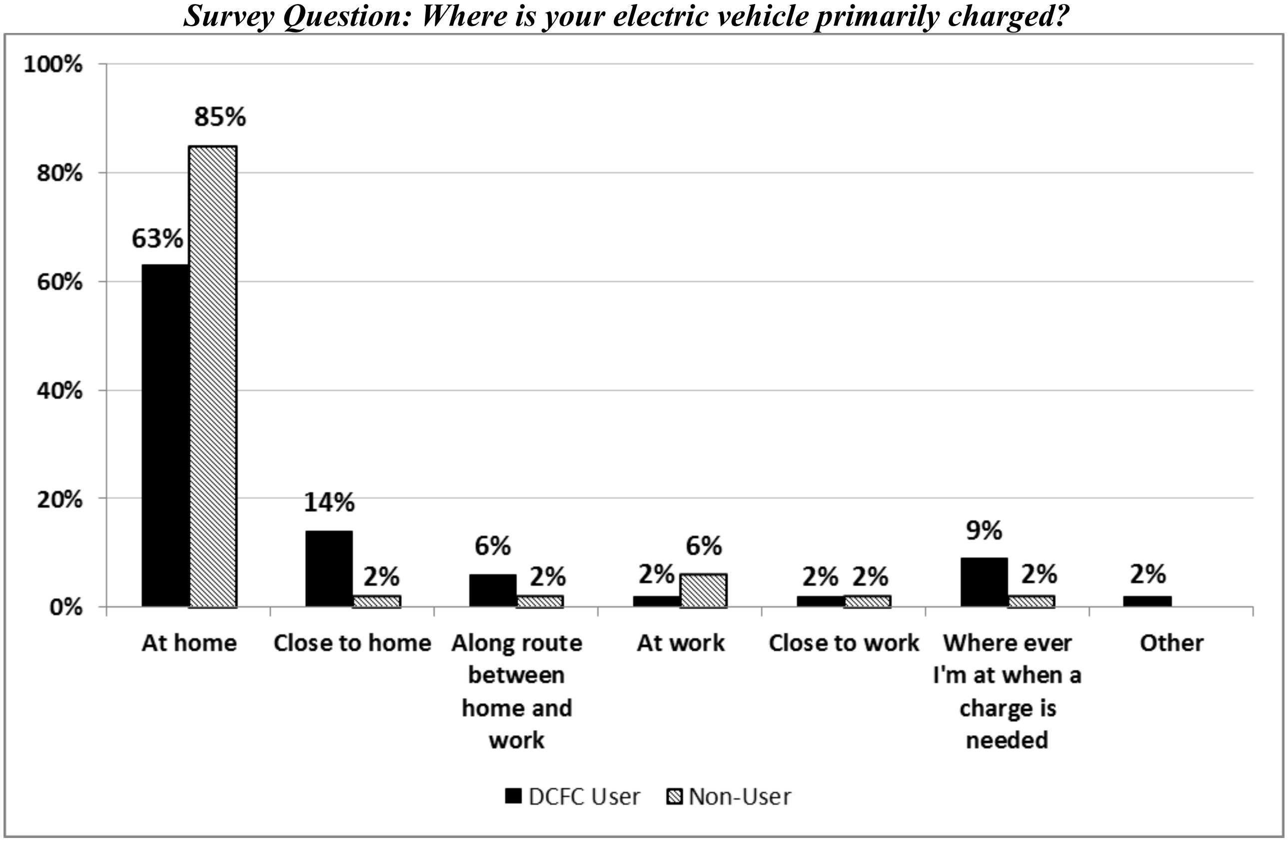
In D&O 34592, the Commission notes that data collection should be used to assess the achievement of pilot objectives and identify "areas for improvement."[47] The Companies began a survey effort in 2017 to determine demographic and behavioral dispositions of Hawai‘i residents related to EVs and EV charging infrastructure, among both EV owners and non-EV owners. While EV adoption continues to increase in Hawaii, overall ownership remains less than 1% of total passenger cars registered.[48] To obtain a representative sample of EV owners among all survey respondents, the Companies pursued several avenues to accumulate survey responses, leveraging customer research panels, in-person intercept surveys and subscriber networks. More than 2,200 responses were received from this survey, over 300 of which came from plug-in hybrid EV ("PHEV") owners and battery-only EV ("BEV") owners, collectively referred to as plug-in electric vehicles ("PEVs"). The results of these survey efforts are included in this report, as Attachment A. While the number of responses received is significant and offers valuable insights into customer demographics and disposition, further surveys are anticipated to refine customer profiles. The current results have been used to improve upon pilot strategy, and can provide useful information for future EV infrastructure projects and for the private EV charging market in Hawai‘i. The following are examples of insights from the survey efforts that may be leveraged to improve upon existing and future EV pilots and programs.

[47] D&O 34592 at 63.
[48] Statewide EV Ownership ranged from 0.51% in January, 2017 to 0.65% in December, 2017. DBEDT Datawarehouse: Available at http://dbedt.hawaii.gov/economic/datawarehouse/.

EV drivers value charging infrastructure in remote locations

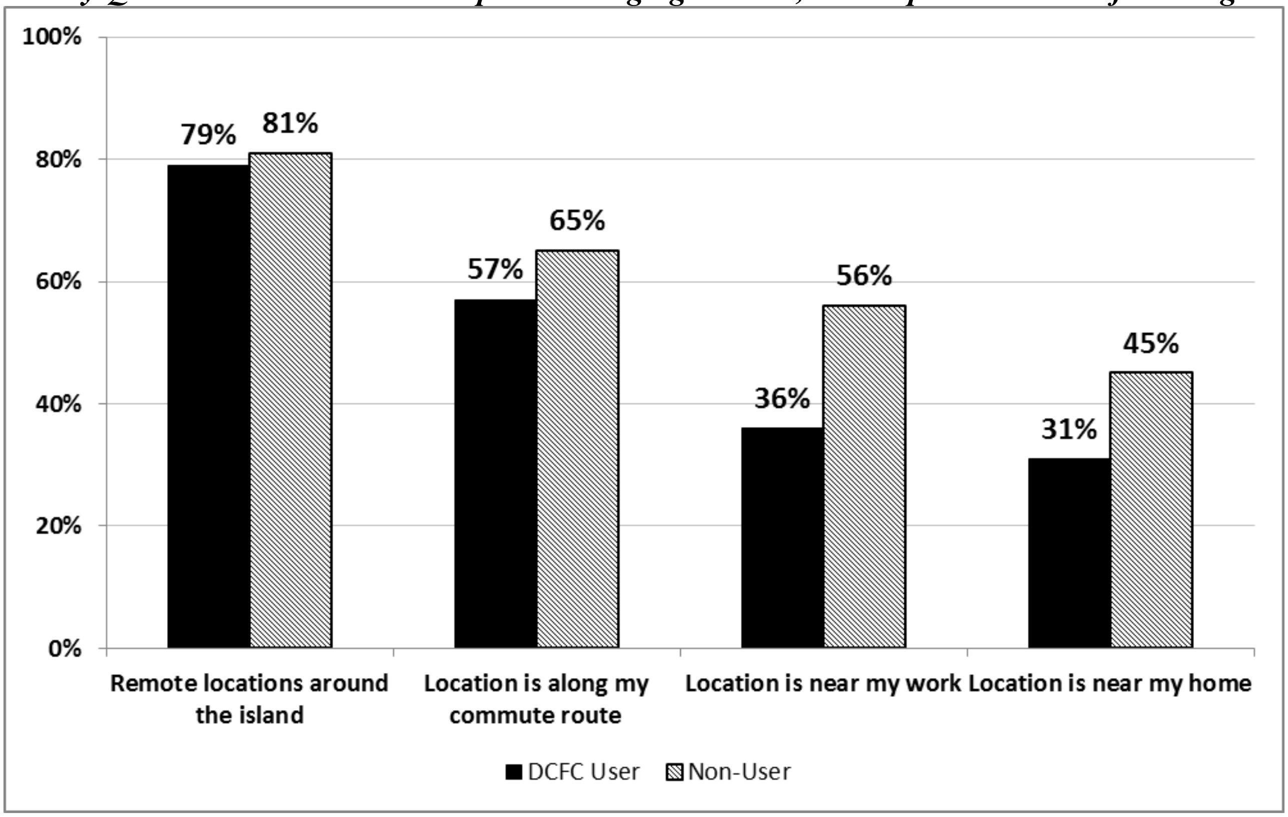
To date, the Companies' deployment strategy for DC Fast Charging stations has included installations in remote areas, under the assumption that a minimum backbone of public charging stations is needed to support the adoption of EVs among customers. The Companies' surveys indicate that, among customers with PEVs capable of fast charging,[49] the primary charging locations for EV drivers is typically at or near their place of residence, as illustrated in Figure 24, below. However, Figure 25 indicates that those same EV drivers specify a higher level of importance for charging locations in "remote locations around the island," when compared to locations near their home, work, or along a commuting route.

Figure 24
Primary Charging Location of BEVs Capable of Fast Charging
Survey Question: Where is your electric vehicle primarily charged?



[49] BEVs, such as the BMW i3, Kia Soul, Nissan Leaf, are capable of fast charging with standard or optional equipment upgrades. Tesla BEVs may use the Companies' fast charging stations with an optional adaptor. Almost all models of PHEVs are not capable of fast charging.

Figure 25
Station Location Importance for BEVs Capable of Fast Charging
Survey Question: When it comes to public charging stations, how important are the following:



Although customers are more likely to utilize charging stations located at or near their home, the survey results support the proposition that stations in remote locations can provide significant value to EV owners. While the Companies plan to include indicators of high utilization in its siting strategy, the development of a broad EV charging network will continue to be a priority to support EV adoption. As discussed in its application for the extension of this pilot, the proliferation of EVs can benefit all customers through reduced emissions from ground transportation, the integration of incremental renewable energy, lower electricity rates, and a reduced dependence on imported petroleum.[50]

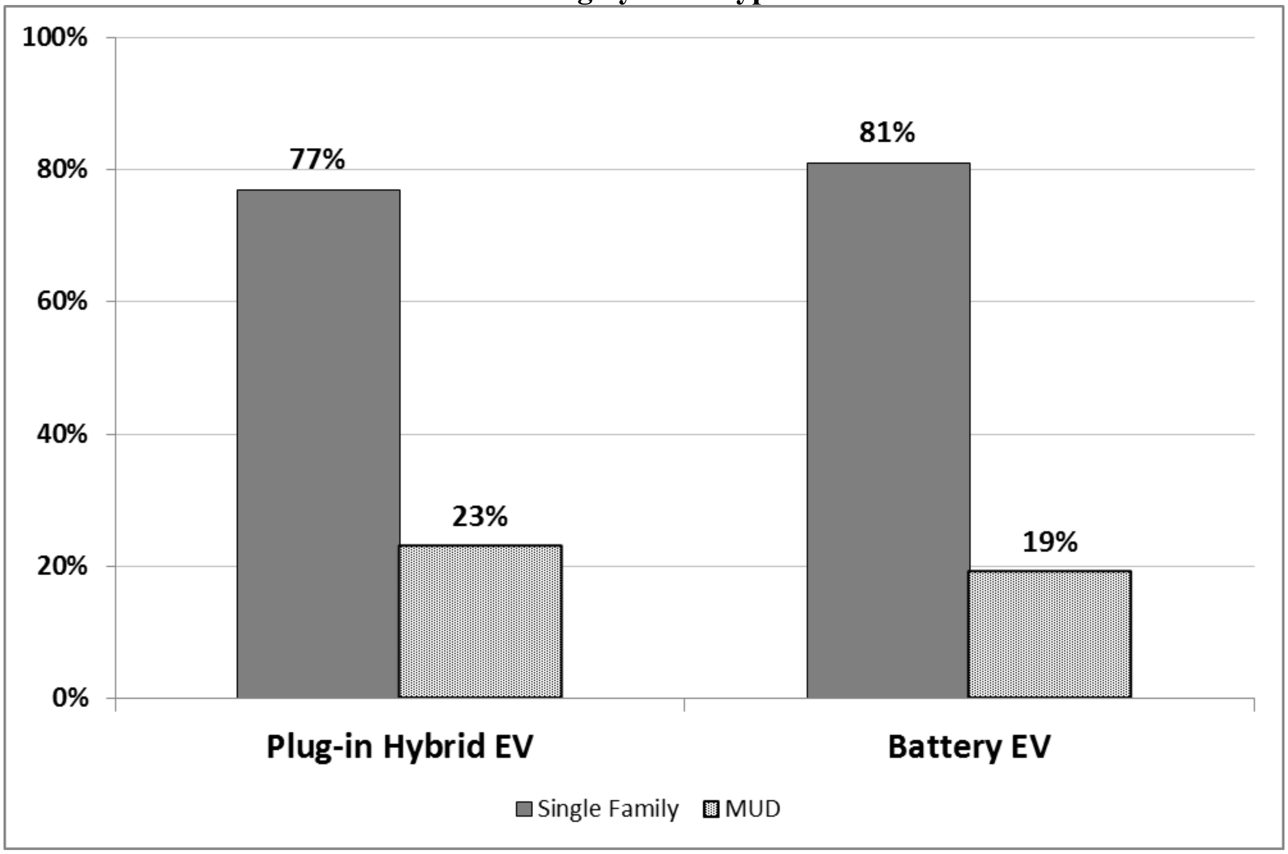
[50] Transmittal 13-07, filed June 27, 2016, at 17-20.

Higher EV adoption among customers in single-family residences

The results of the Companies' 2017 survey efforts illustrate a significant difference in EV ownership between residents of single family homes when compared to those in MUDs. According to the U.S. Census 2012-2016 American Community Survey, approximately 38% of residents within the Companies' service territory live in an MUD.[51] However, as illustrated in Figure 26 below, the Companies' survey results show that only 23% of respondents with PHEVs reside in an MUD. Even more pronounced, only 19% of respondents with BEVs capable of fast charging reside in an MUD. The survey results indicate that as dependence on electricity for fuel increases, EV ownership among MUD residents declines relative to single family residents. While there may be multiple drivers to lower PHEV and BEV adoption among MUDs, including level of income, limited access to charging options among is likely a significant concern and indicates a greater need for MUD infrastructure support.

[51] MUD defined as any housing unit in a structure with two or more total units. Source: ACS 5-year estimate selected housing characteristics (DP04). Available at https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?.

Figure 26
Dwelling by PEV Type



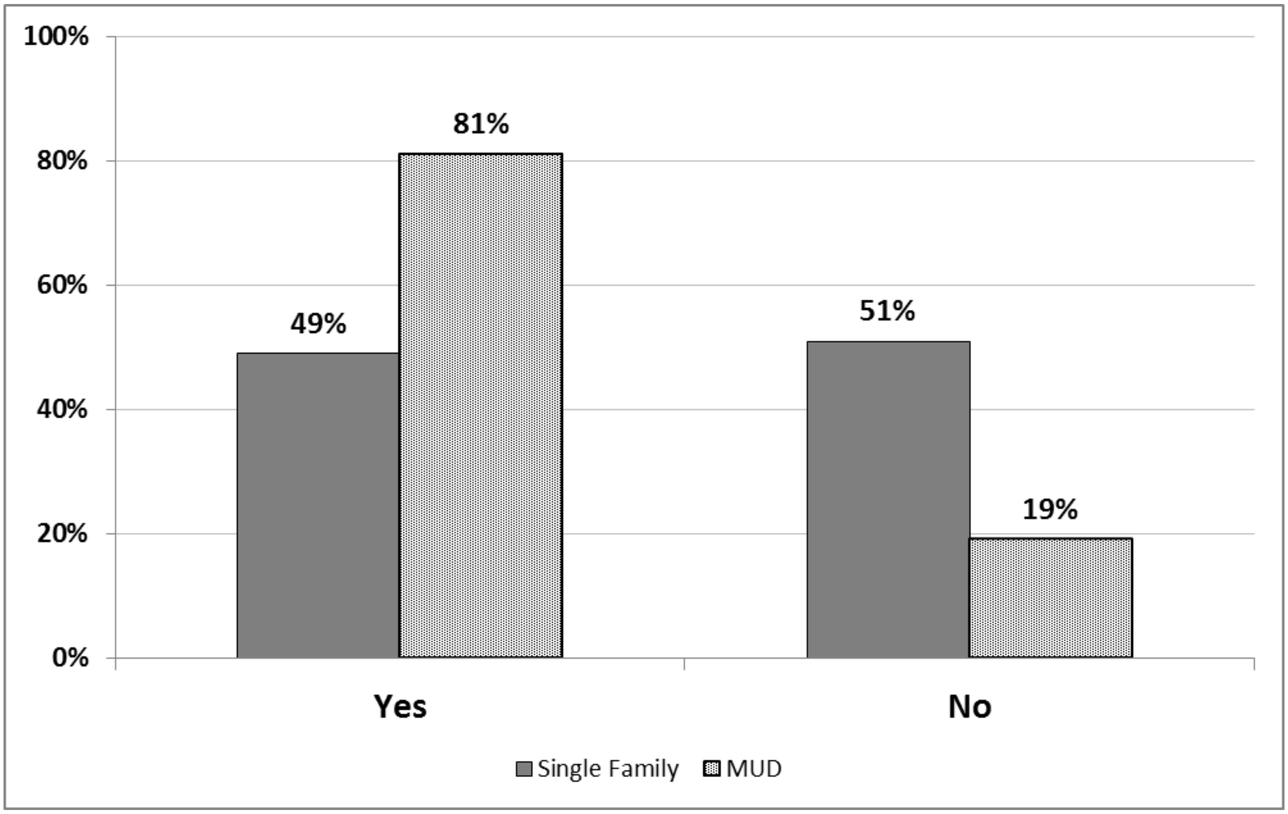
Greater utilization of public fast charging among residents of multi-units dwellings

In their application for the extension of Schedules EV-F and EV-U, the Companies contend that MUD residents "will … benefit from reliable, fast charging options if they are unable to procure charging services at their residence."[52] In its D&O 34592, the Commission notes that data collection efforts should be employed to support the benefits of the pilot, citing the benefit to MUD residents of public fast charging as an example.[53] The results of the Companies' 2017 survey efforts illustrate an increased propensity to utilize public fast charging stations by MUD residents when compared to single family residents. Figure 27, below,

[52] Companies' extension request at 25-26.
[53] D&O 34592 at 63-64.

illustrates that among surveyed customers with EVs capable of fast charging, about 81% of those who live in MUDs utilize fast charging services, compared to 49% for single family residents.

Figure 27
Propensity to Fast Charge by Dwelling Type among BEVs Capable of Fast Charging
Survey Question: Have you ever used a DC Fast Charger on your BEV?



DCFC Siting Methodology

As stated in Transmittal 12-05 on October 26, 2012, one of the Companies' main objectives for public EV charging facilities is to "enable public charging of electric vehicles during the daytime, away from residences and businesses."[54] The Companies discuss how public charging options can be strategically deployed to extend electric driving range, also characterizing Schedule EV-U as an opportunity to install utility-owned charging facilities at strategic locations that "may not be initially marketable, profitable, or attractive" to private

[54] Transmittal 12-05 at 6.

development.[55] This objective is supported by the results of the Companies' 2017 EV survey, which indicates a significant value derived from remote charging, as discussed above. As additional charging locations are considered to support the backbone of charging infrastructure, the Companies intend to continue to seek out locations that extend electric driving range in their service territory. However, as the EV charging market matures, EV battery capacities increase and additional charging locations are deployed by both the Companies and private developers, alternative pilot objectives may emerge. In future deployments of public EV charging facilities, the Companies will consider alternative pilot objectives, including maximizing utilization and providing grid services, in its deployment strategy.

In D&O 34592, the Commission orders the Companies to include in subsequent annual reports "a description of the analysis that the Companies are undertaking to assess expected utilization for DCFC facilities … including the impacts of geographical location, existing charging infrastructure, population density, and other demographic factors and system needs."[56] The Companies have begun analyzing locational data related to population, jobs, MUD residents, average daily traffic, EV ownership and charging alternatives with respect to communities and prospective locations within its service territories, and are in the process of standardizing collected data at the census tract level. Once a potential site host expresses interest, the Companies utilize GIS software to provide a more detailed analysis of these data points with respect to a particular address.

While the Companies assume that particular drivers may influence utilization, further data will need to be collected and analyzed to interpret the relationship between the various data points. Surveys of EV owners and potential EV owners will help the Companies better

[55] Id. at 8.
[56] Docket 2016-0168, D&O 34592 at 68.

understand and leverage data to enhance site utilization. For example, in its recent survey efforts, the Companies have found a significantly higher utilization rate of its DC fast charger facilities from surveyed residents of MUDs compared to residents of single family homes. As a result of this finding, localized estimates of MUD residents will likely outweigh total population estimates as an indicator of high utilization. The Companies are in the initial stages of developing these analytical capabilities with respect to projected utilization. Once fully developed, they plan on sharing and collaborating with local stakeholders, including the CA and DBEDT, to communicate and help refine this analysis.

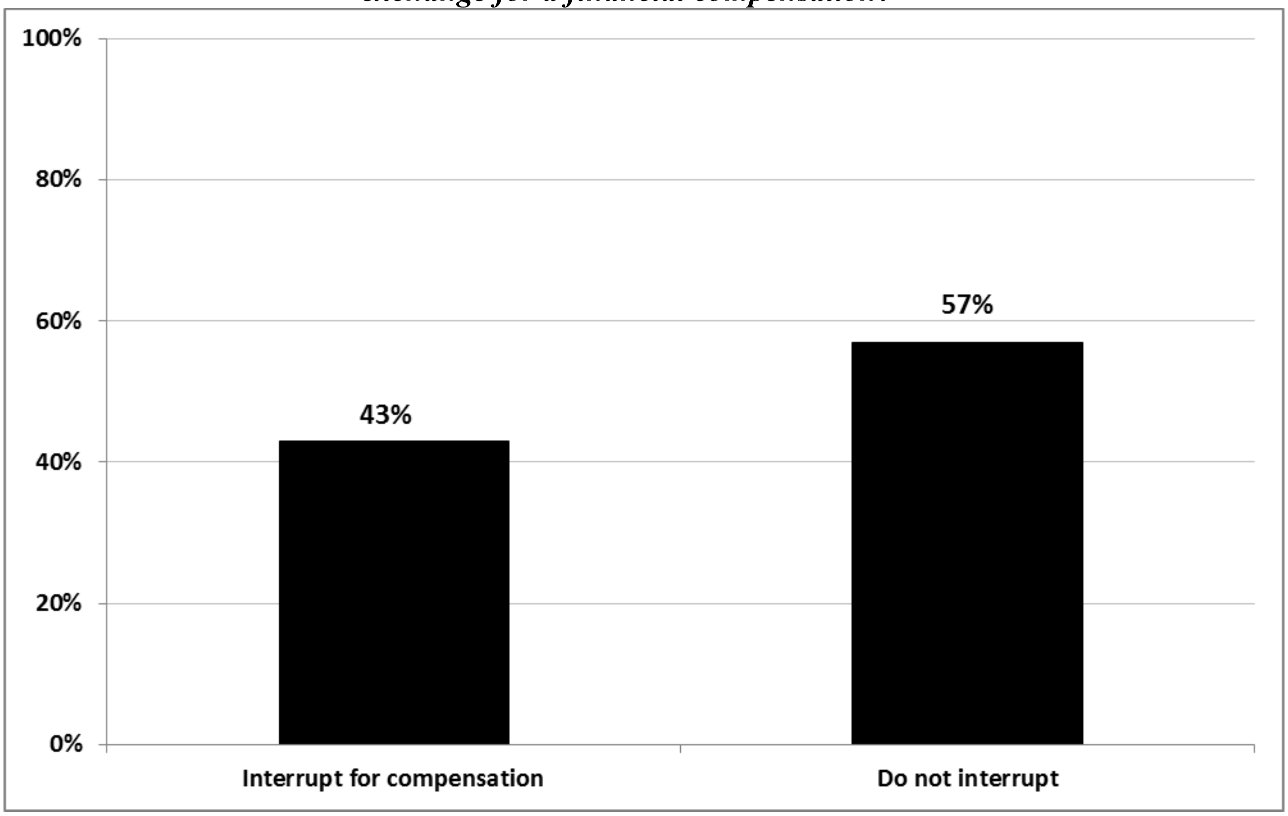
Grid Support Services

As discussed, the Companies have deployed demonstration projects at both Kapolei Commons and its Ward avenue facilities to test the ability of DCFC stations, coupled with BESS, to limit the power drawn from the electric grid for fast EV charging service. In addition to limiting demand charges incurred by EV charging providers, coupling EV charging with BESS may also be deployed in areas with high saturation of distributed generation to support grid reliability. The Companies have had and continue to be open to discussions with third-party developers regarding options to deploy DC fast charging stations coupled with BESS to provide grid support services. Further analysis will be required to determine the cost-effectiveness of these solutions compared with alternative grid technologies. As new and innovative grid services are made available for DC fast charging services, the Companies' deployment strategy will also contemplate the value of those grid services.

The Companies included a question in its survey efforts related to the utilization of DCFC stations for DR services. As shown in Figure 28, below, a slight majority of BEV owners with fast charging capability indicated that they would not be willing to interrupt a charging session in exchange for financial compensation. However, a substantial number of customers

(43%) did express a willingness to participate. The Companies intend to continue the exploration of how DC fast charging stations, or other types of charging infrastructure, may be cost-effectively leveraged to provide grid services.

Figure 28
Customer Willingness to Provide DCFC DR Services
Survey Question: Would you be willing to have your DC Fast Charger session interrupted in exchange for a financial compensation?



E. Recommendation of revisions to rate structures

On September 5, 2017, the Companies submitted a revised rate structure for Schedule EV-U, which was approved by the Commission on October 13, 2017. On December 12, 2017, the Companies implemented the revised rate structure for all accounts under Schedules EV-U. As the Companies are in the initial stages of gathering consumption data under the revised rate structure, there are no recommendations for revisions at this time. However, as mentioned in their tariff filing for Schedules EV-F and EV-U, the Companies will continue to monitor both adoption and utilization under the current rate structures and provide recommendations, as appropriate.[57]

[57] Docket No. 2016-0168, EV-F and EV-U Pilot Extension,filed September 5, 2018, at 11.

Attachment A

2017 Electric Vehicle Market Research

Electric Vehicle Market

Residential Customer Study in Hawaiian Electric Companies' Service Territories

Prepared by

Hawaiian Electric Companies

February 2018

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Contents

- Residential Customers (Non-EV)
- Hybrid Vehicle Drivers (HEV)
- Plug-in Vehicle Drivers (PEV)
- DCFC User Comparison – BEV Segment
- Appendix – Supplemental Results

Panel Survey Overview

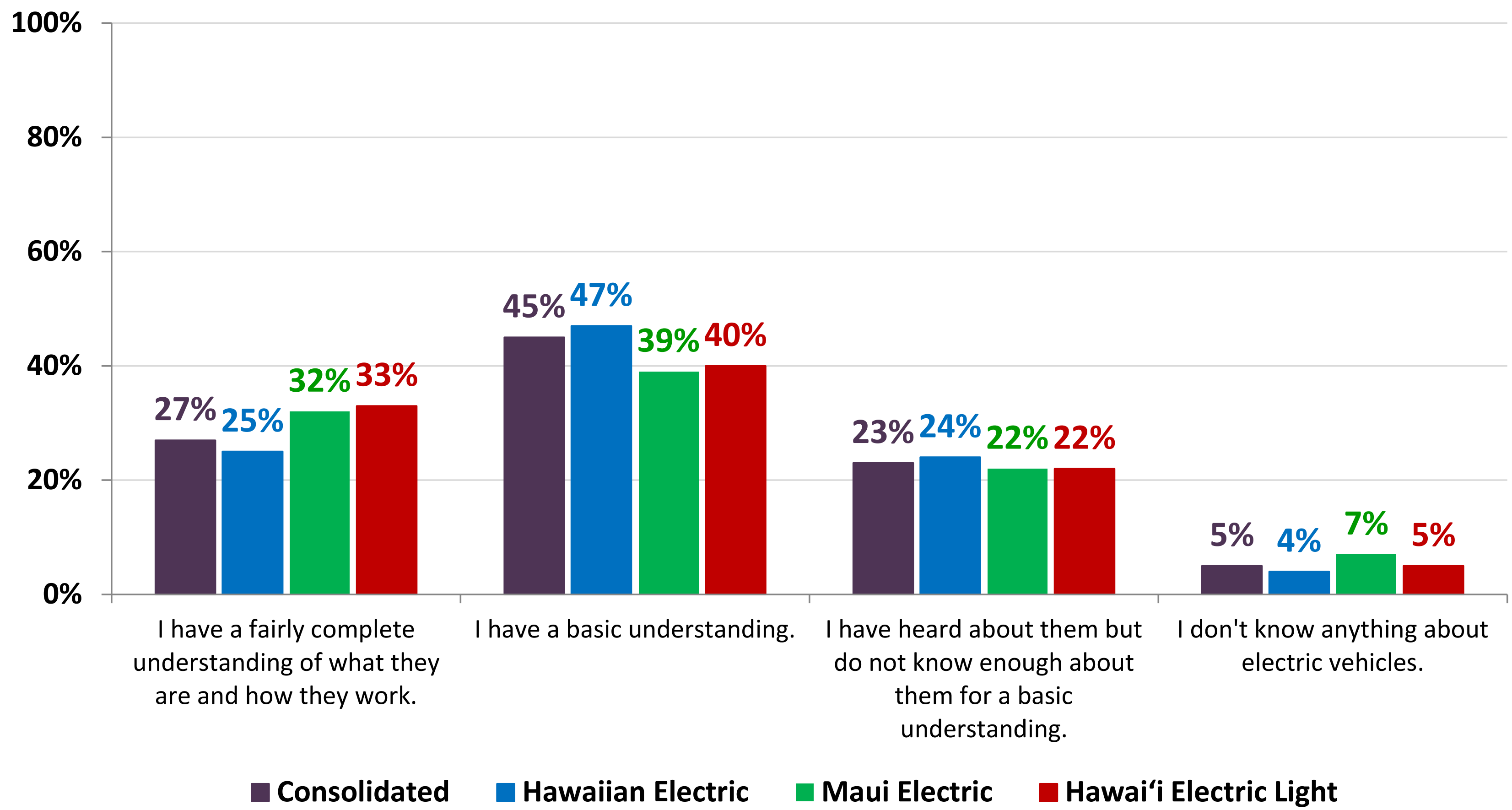
- Online panel conducted with randomly selected Hawaiian Electric, Maui Electric, and Hawai‘i Electric Light residential customers.
  - [Non-EV subset] The objective of the research is to better understand general knowledge of EVs, future purchasing likelihood, and purchasing influences or preventions.

- Survey fielding: **July 26, - November 30, 2017**
  - Invite sent to 5,651 panel members
    - **2,247 responses** (40 percent response)

    - **Non-EV subset:** **1,905**
      - Oahu: **904**
      - Maui County: **426**
      - Hawai‘i Island: **575**

  - Data was weighted by ***ages*** within ***genders*** across each ***utility’s*** residential service areas for reporting

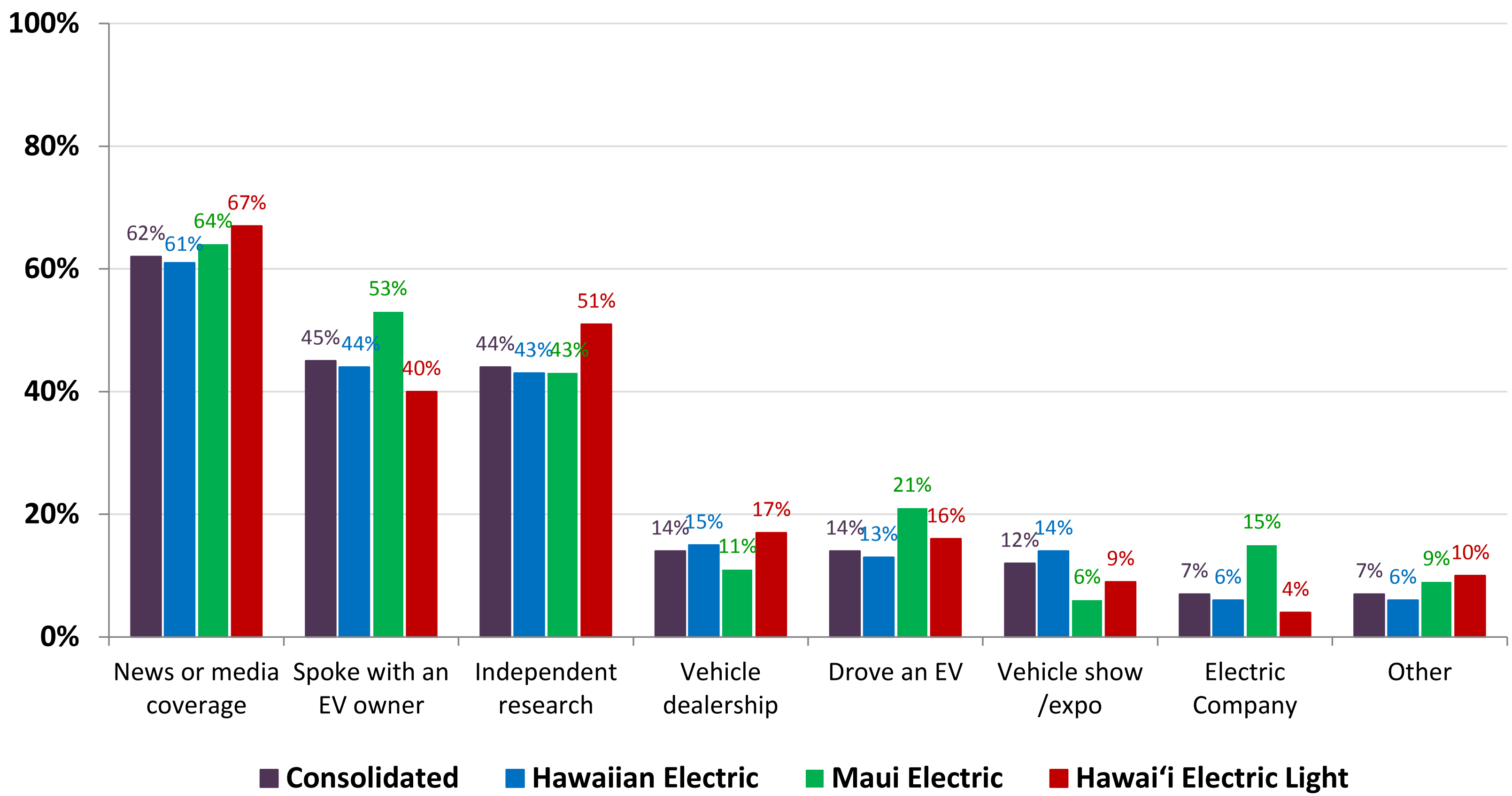
More education is necessary to support EV adoption



Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Which of the following statements comes closest to describing your level of knowledge about electric vehicles?

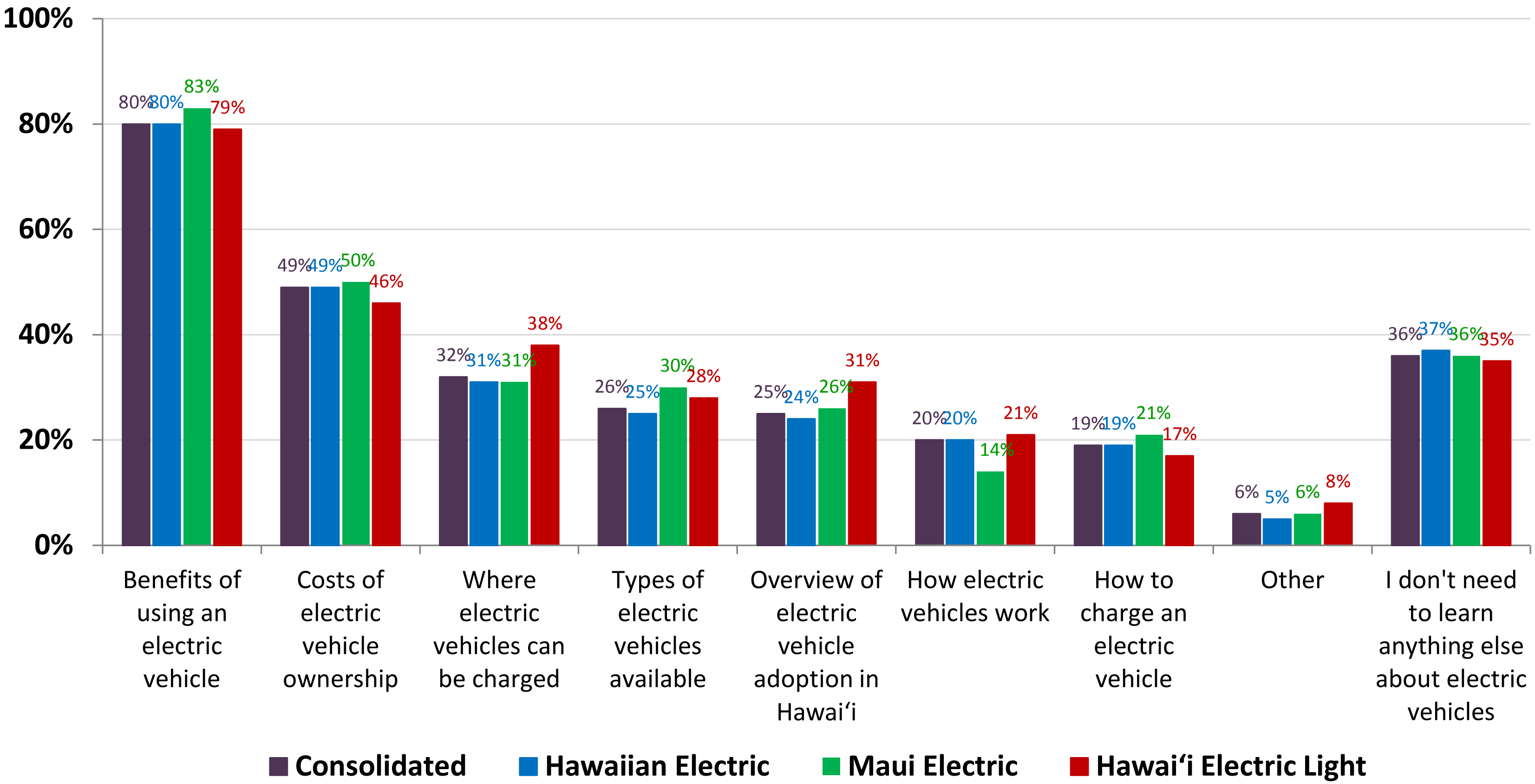
Most have learned about EVs through news sources, current drivers, and independent research



Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

From what sources have you learned about electric vehicles? Please select all that apply.

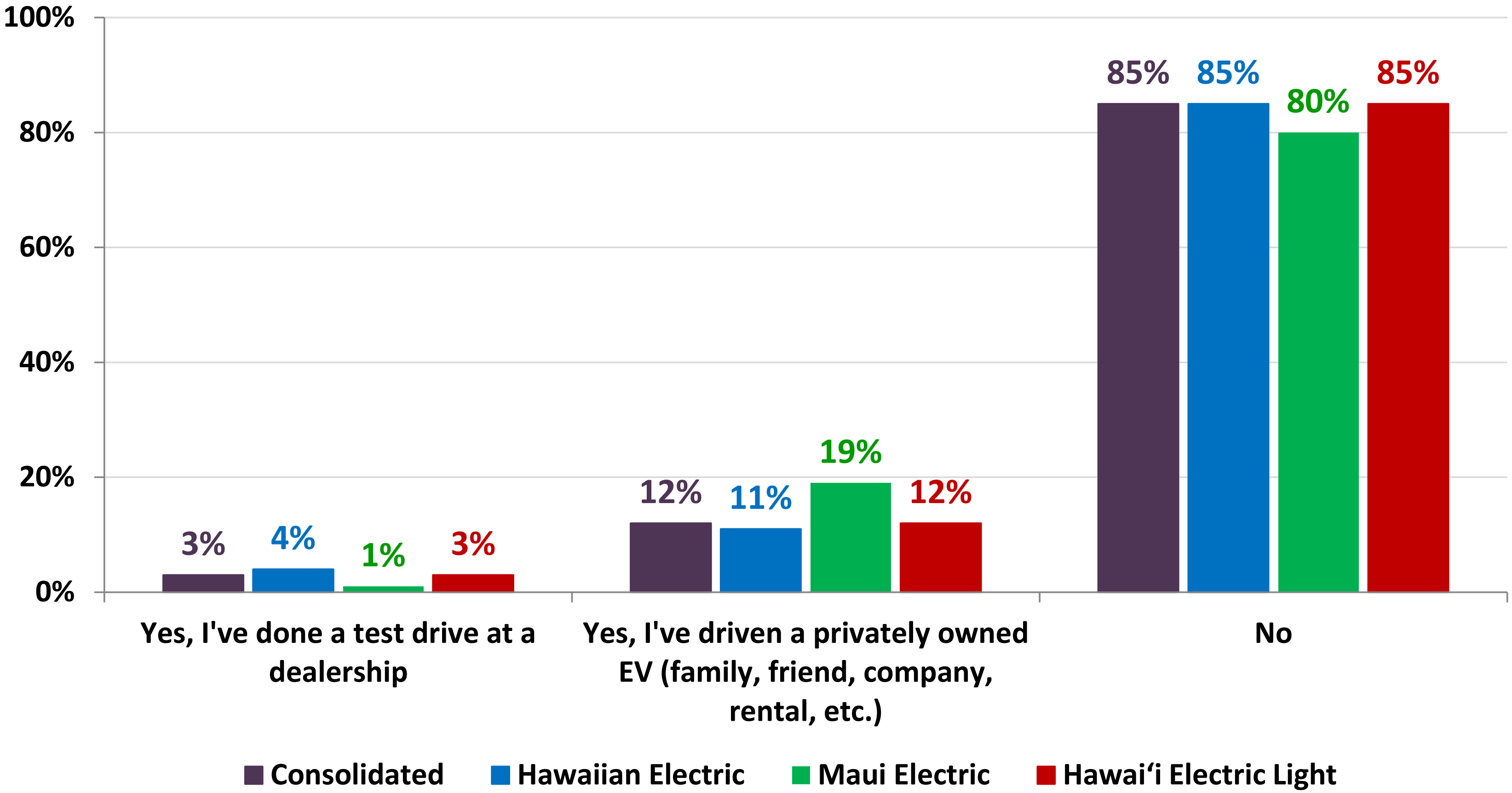
Largest knowledge gaps exist for benefits and cost of ownership



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Is there any additional information you would like to learn about electric vehicles? Please select all that apply.

Most respondents have not driven an EV

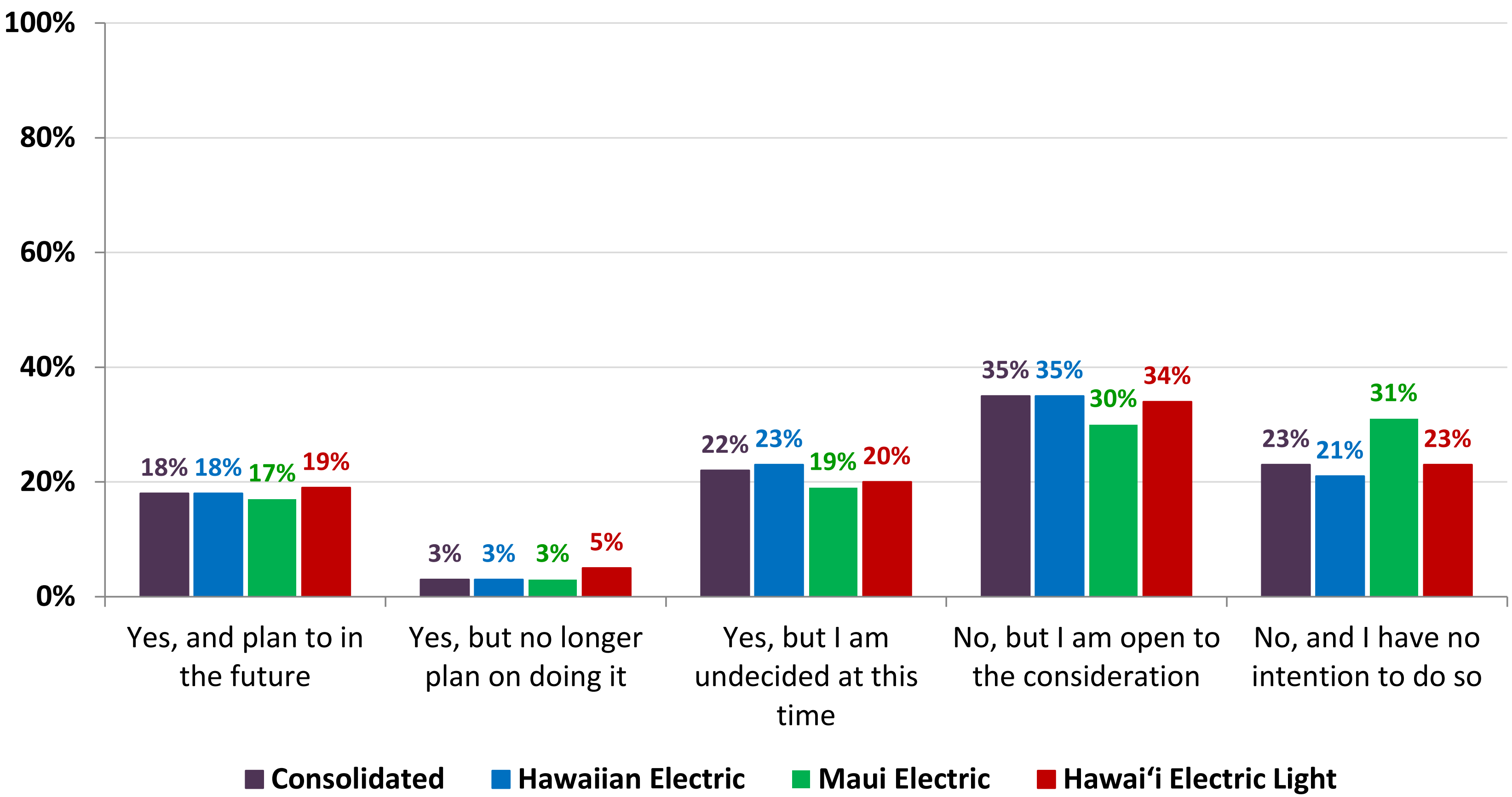


Exceeds 100% due to multiple response

Have you ever driven an electric vehicle? [multiple response]

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

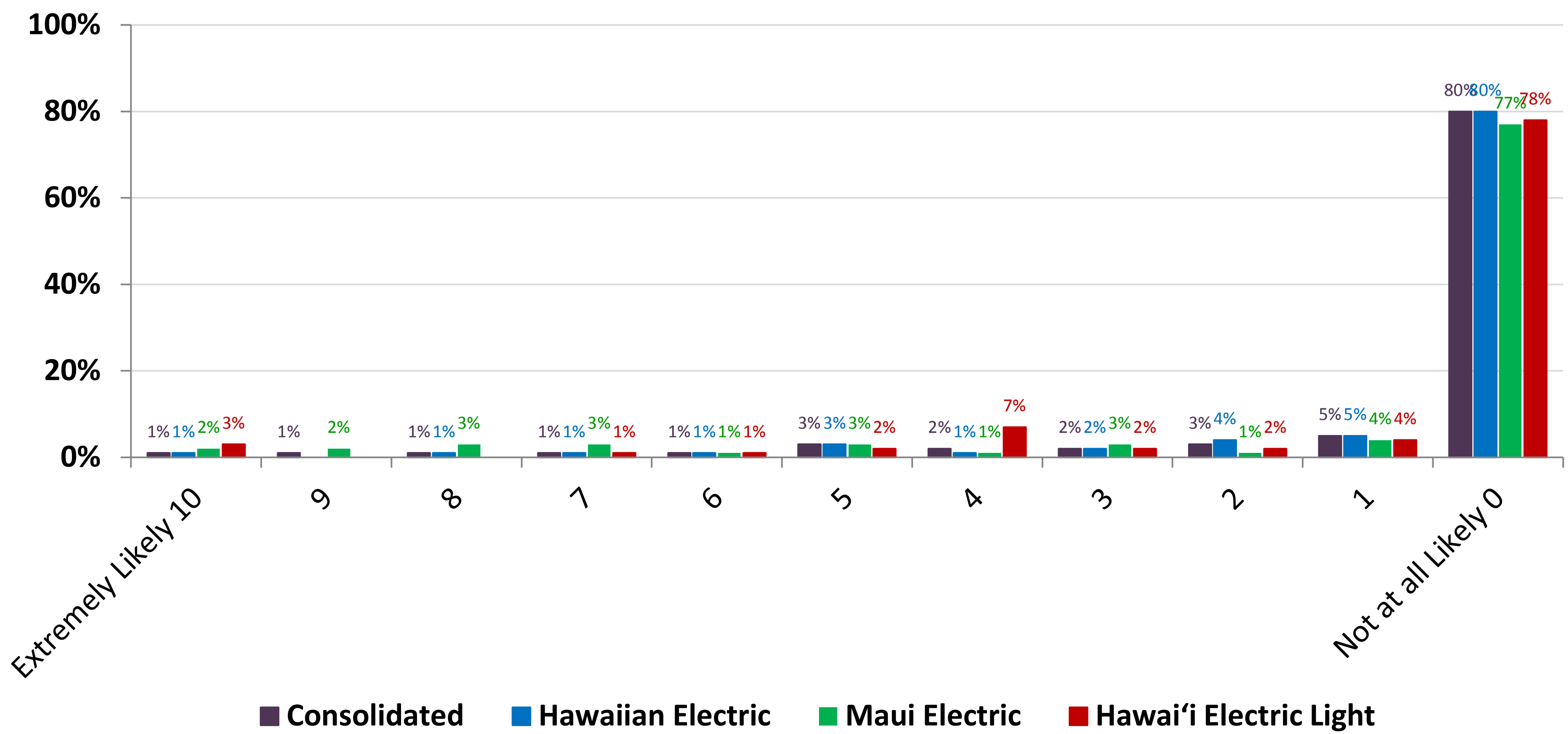
Three quarters are open to considering an EV in the future



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Have you considered purchasing or leasing an electric vehicle?

Most respondents are unlikely to purchase or lease an EV in the next 12 months

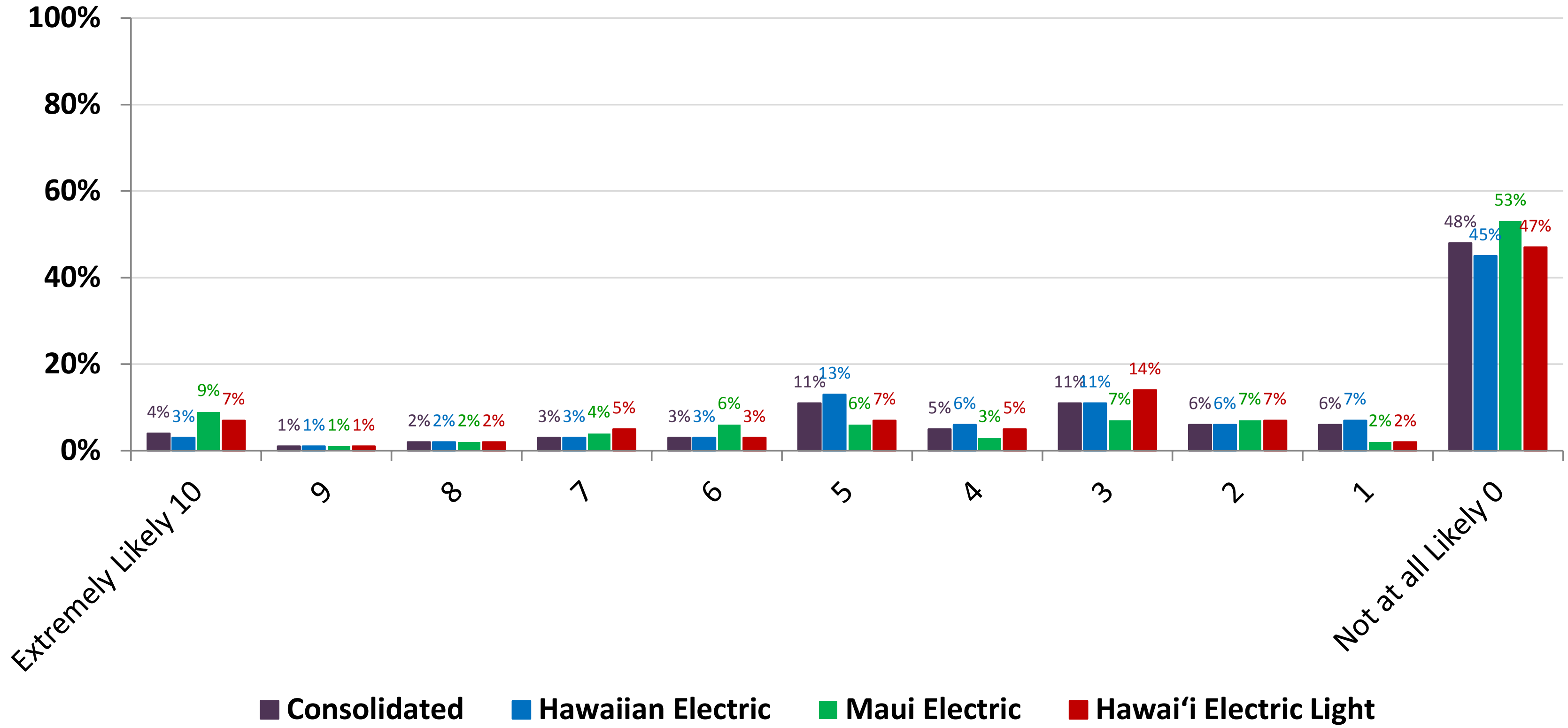


How likely are you to purchase or lease an electric vehicle in the future? For each of the timeframes, please use a scale of 0 to 10 with 10 meaning "Extremely Likely" and 0 meaning "Not at All Likely." Within the next 12 months

- Analysis adds the "No, and I have no intention to do so" and "Yes, but no longer plan on do it" responses to "0 – Not at all Likely"

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

EV purchase or lease likelihood increases in the next three years

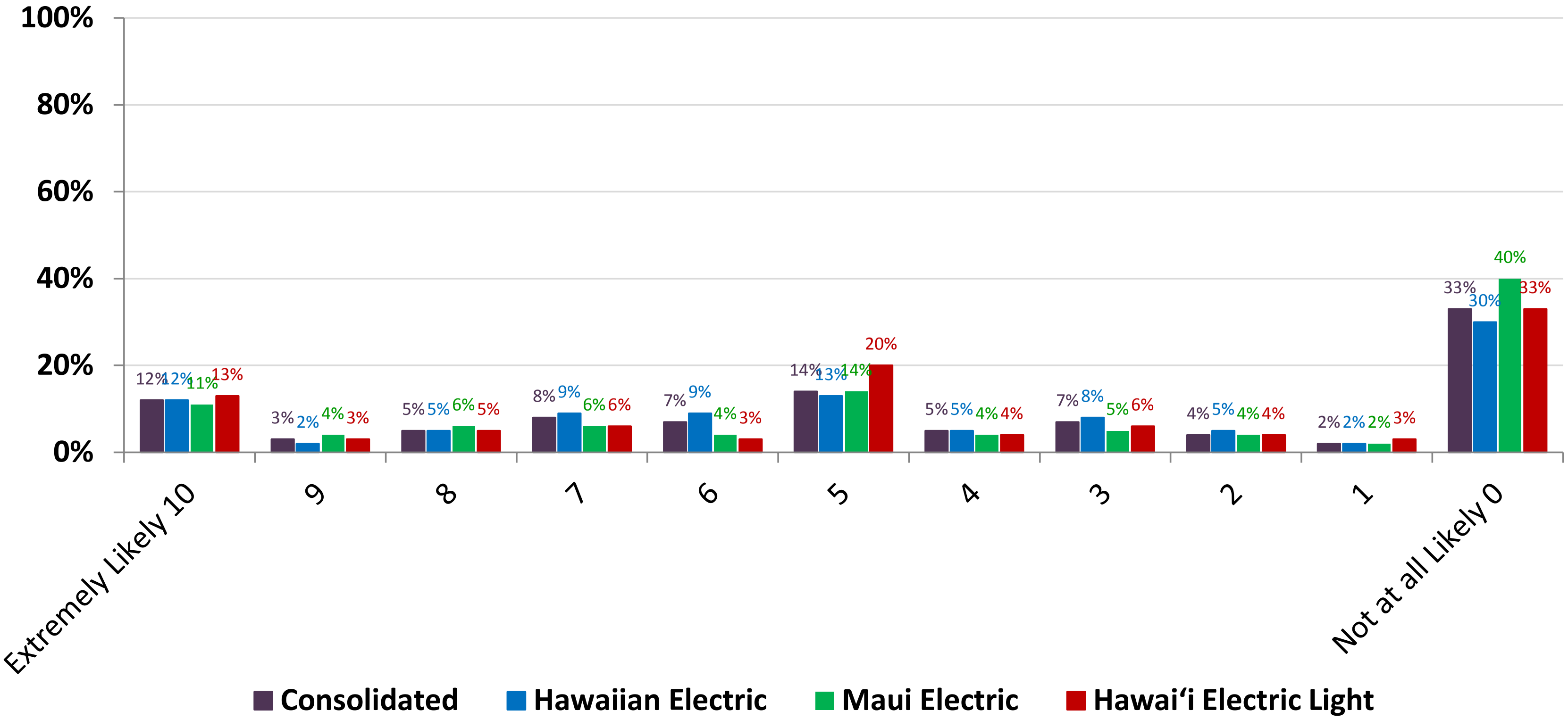


How likely are you to purchase or lease an electric vehicle in the future? For each of the timeframes, please use a scale of 0 to 10 with 10 meaning "Extremely Likely" and 0 meaning "Not at All Likely." Within the next 3 years

- Analysis adds the "No, and I have no intention to do so" and "Yes, but no longer plan on do it" responses to "0 – Not at all Likely"
- Analysis adds "10 – Extremely Likely" from "next 12 months" to the current timeframe

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

With a five year outlook, respondents are even more likely to purchase or lease an EV

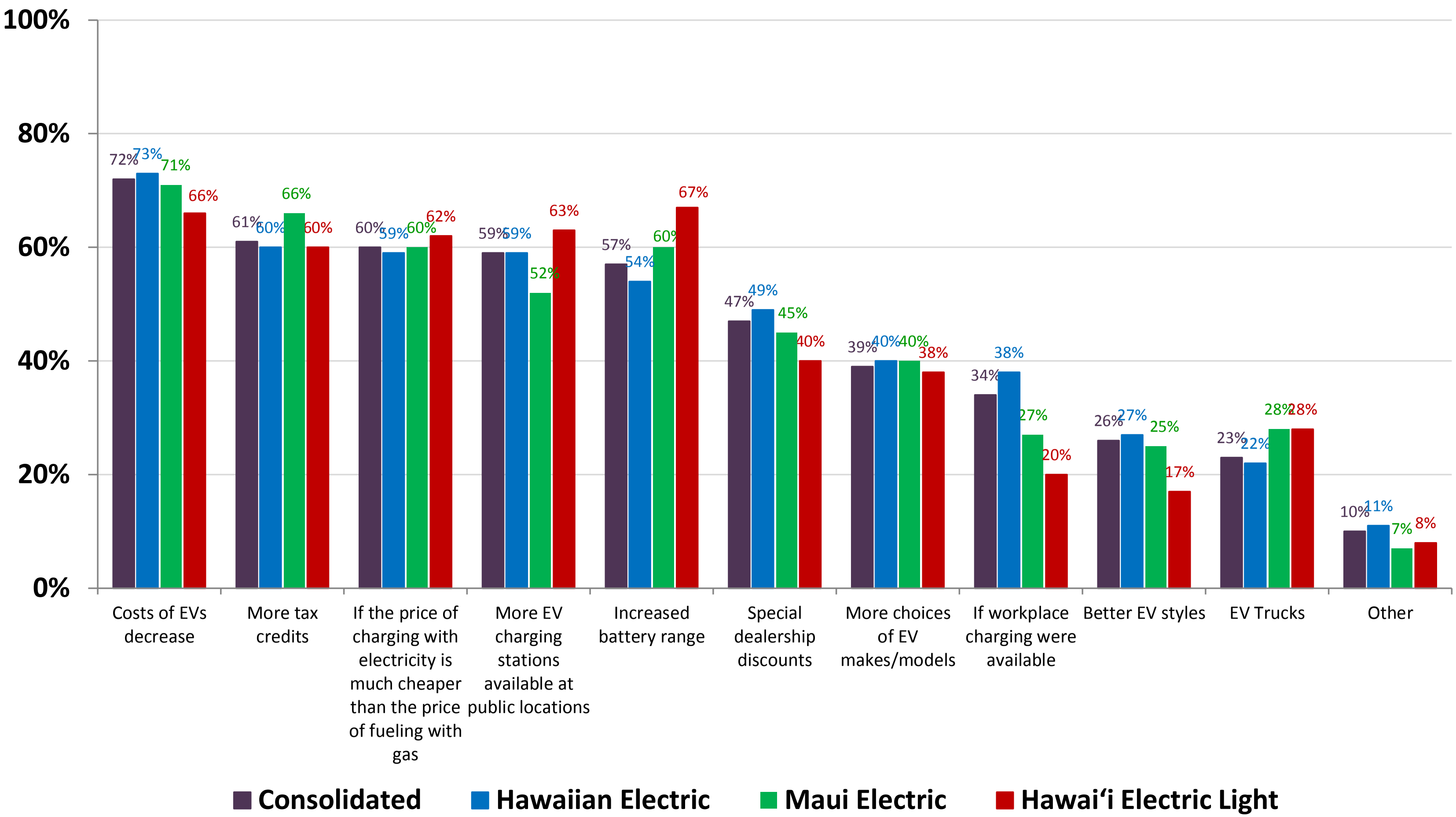


How likely are you to purchase or lease an electric vehicle in the future? For each of the timeframes, please use a scale of 0 to 10 with 10 meaning "Extremely Likely" and 0 meaning "Not at All Likely." Within the next 5 years

- Analysis adds the "No, and I have no intention to do so" and "Yes, but no longer plan on do it" responses to "0 – Not at all Likely"
- Analysis adds "10 – Extremely Likely" from "next 12 months" and "next three years" to the current timeframe

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

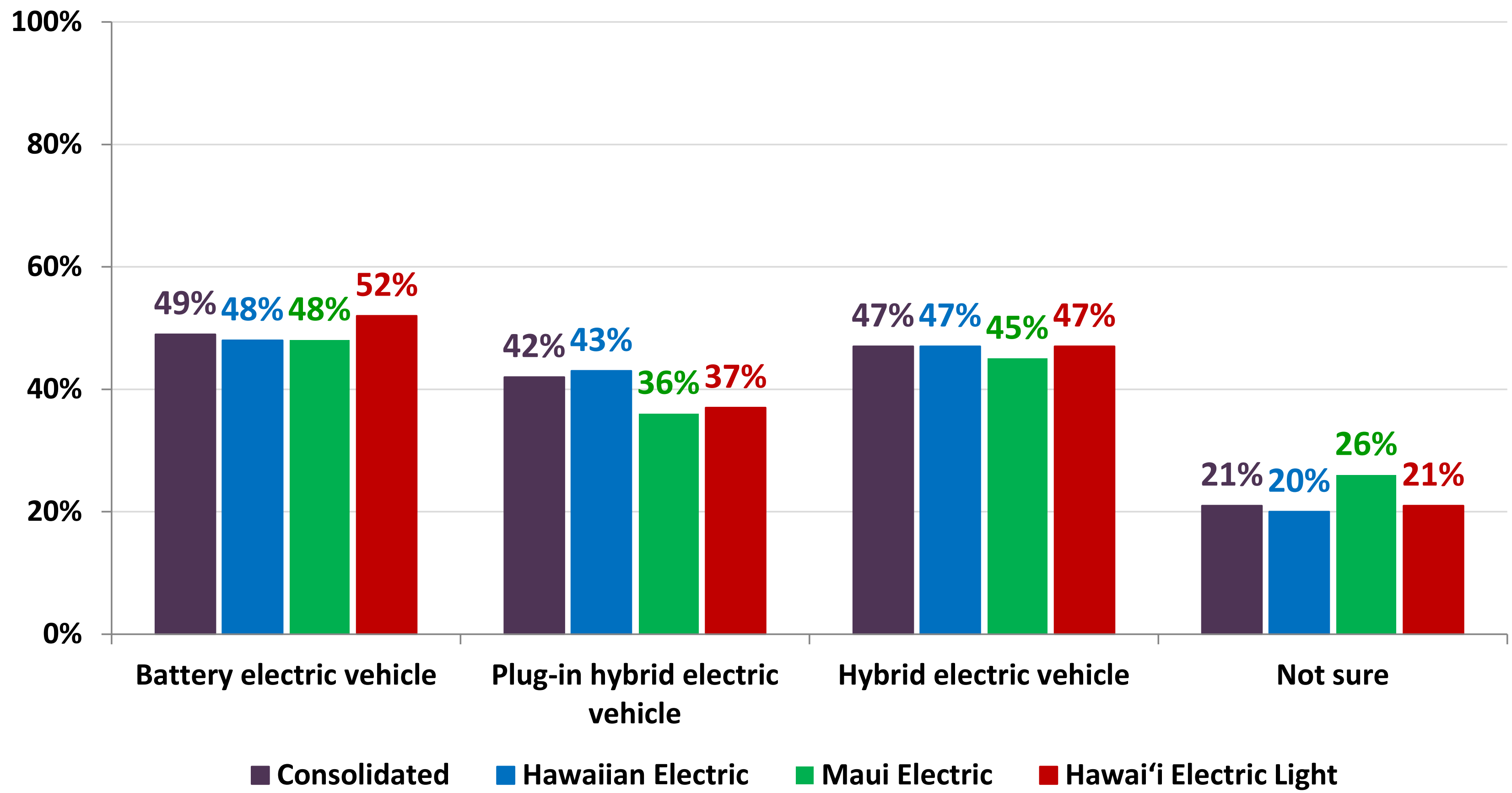
Financial considerations, charge station availability, and driving range are among the top influences for EV adoption



Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

What would make you more likely to purchase or lease an electric vehicle? Please select all that apply.

For those considering an EV in the future, BEVs have a slight lead among their choices



Exceeds 100% due to multiple response

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

What type of EV would you consider? Please select all that apply.

Contents

- Residential Customers (Non-EV)
- Hybrid Vehicle Drivers (HEV)
- Plug-in Vehicle Drivers (PEV)
- DCFC User Comparison – BEV Segment
- Appendix – Supplemental Results

Panel Survey Overview

- Online panel conducted with randomly selected Hawaiian Electric, Maui Electric, and Hawai‘i Electric Light residential customers.
  - [Hybrid driver subset] The objective of the research is to better understand their motivations to purchase a hybrid as well as their likelihood to purchase a plug-in or battery electric vehicle in the future.

- Survey fielding: **July 26 – November 30, 2017**
  - Invite sent to 5,651 panel members
    - **2,247 responses** (40 percent response)

    - **Hybrid driver subset:** **200** **(unidentified hybrid makes and models excluded)**
      - Oahu: **110**
      - Maui County: **32**
      - Hawai‘i Island: **58**

    - Results are reported unweighted and in aggregate.

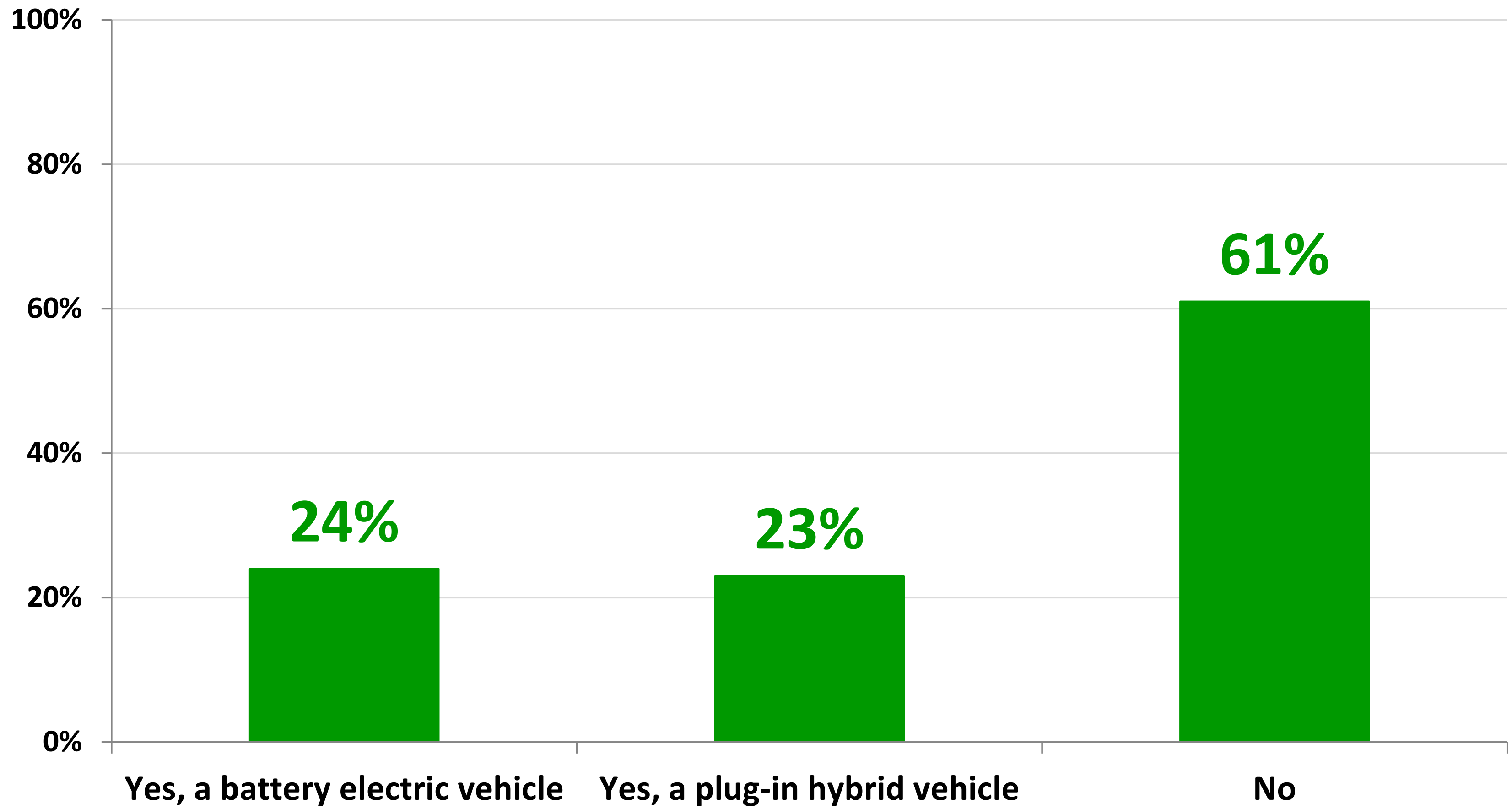
Overview of Unweighted Hybrid Distribution: TOP 10

Panelists' Hybrid type		Research Panel	IHS Markit (Hawai'i Subset* from June 2017)
Toyota Prius (+ C & V)	n=103+11+6	60%	49%
Toyota Camry Hybrid	n=12	6%	7%
Lexus RX400h + RX450h	n=8+2	5%	3%
Honda Civic Hybrid	n=8	4%	6%
Lexus CT200H	n=7	4%	4%
Toyota Highlander Hybrid	n=6	3%	3%
Toyota Rav4	n=6	3%	1%
Ford C-MAX Hybrid	n=5	3%	2%
Ford Escape Hybrid	n=4	2%	2%
Honda Insight	n=4	2%	3%
ALL OTHER HYBRIDS	*n=18*	*9%*	*20%*

*Excludes Kaua'i

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Nearly equal proportion considered a plug-in and/or battery EV before deciding to get a hybrid



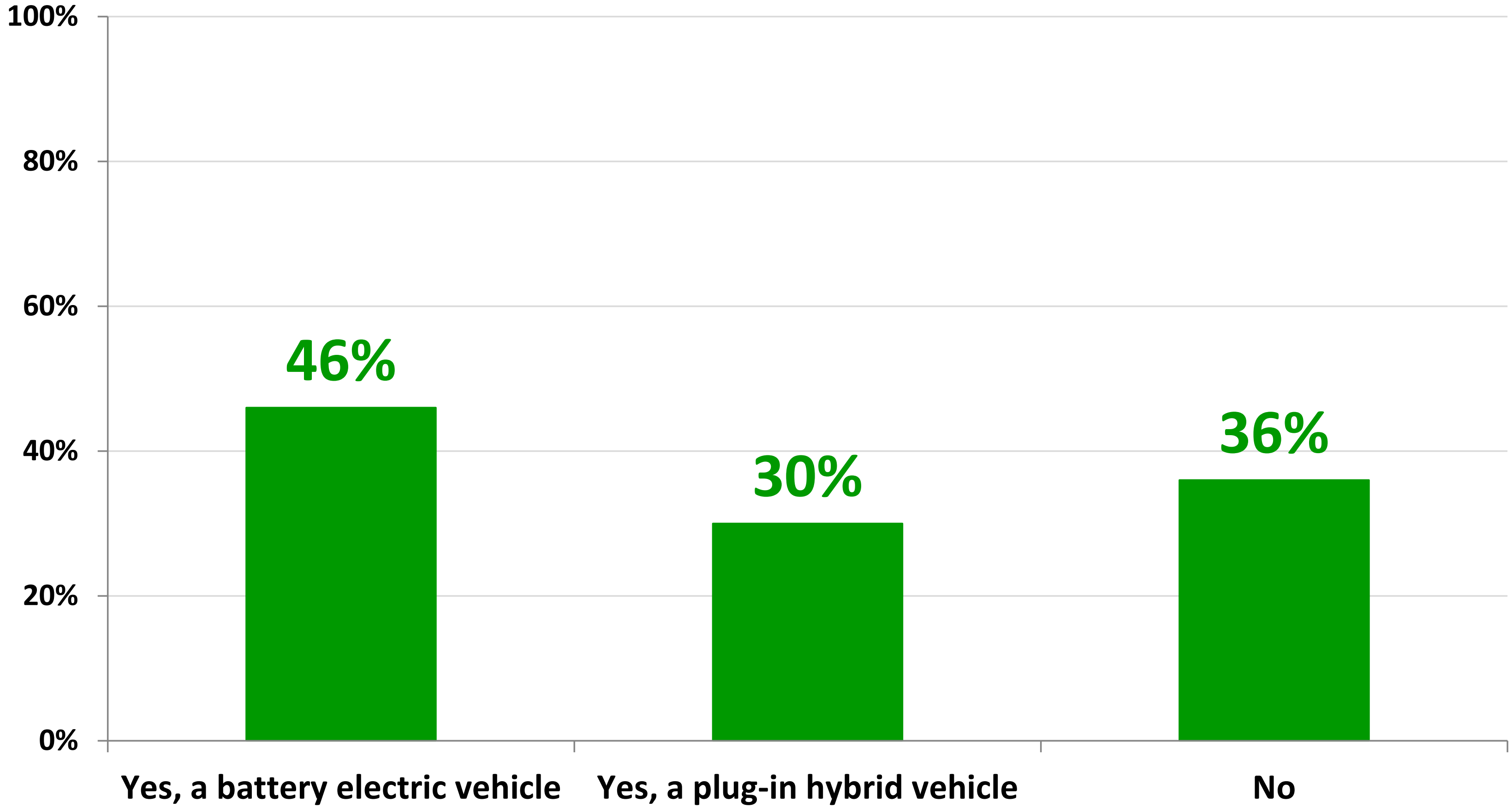
Exceeds 100% due to multiple response

Did you consider any other types of electric vehicles before buying or leasing your hybrid electric vehicle?

Data filtered for 2011 hybrids and newer

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Two thirds of current hybrid drivers are considering a plug-in and/or battery EV as their next vehicle

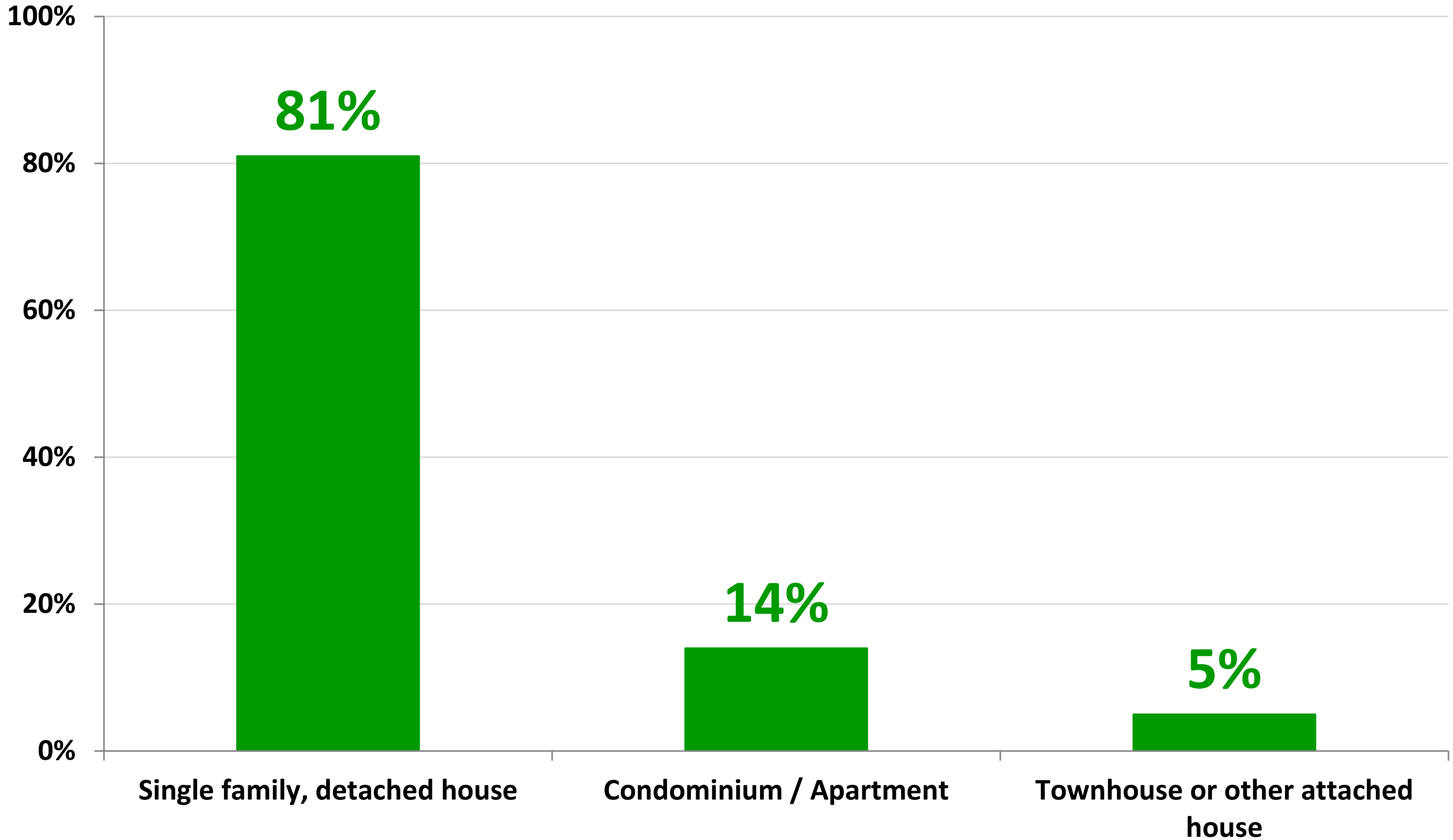


Are you considering the purchase of either a battery electric or plug-in hybrid as your next vehicle?

Exceeds 100% due to multiple response

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

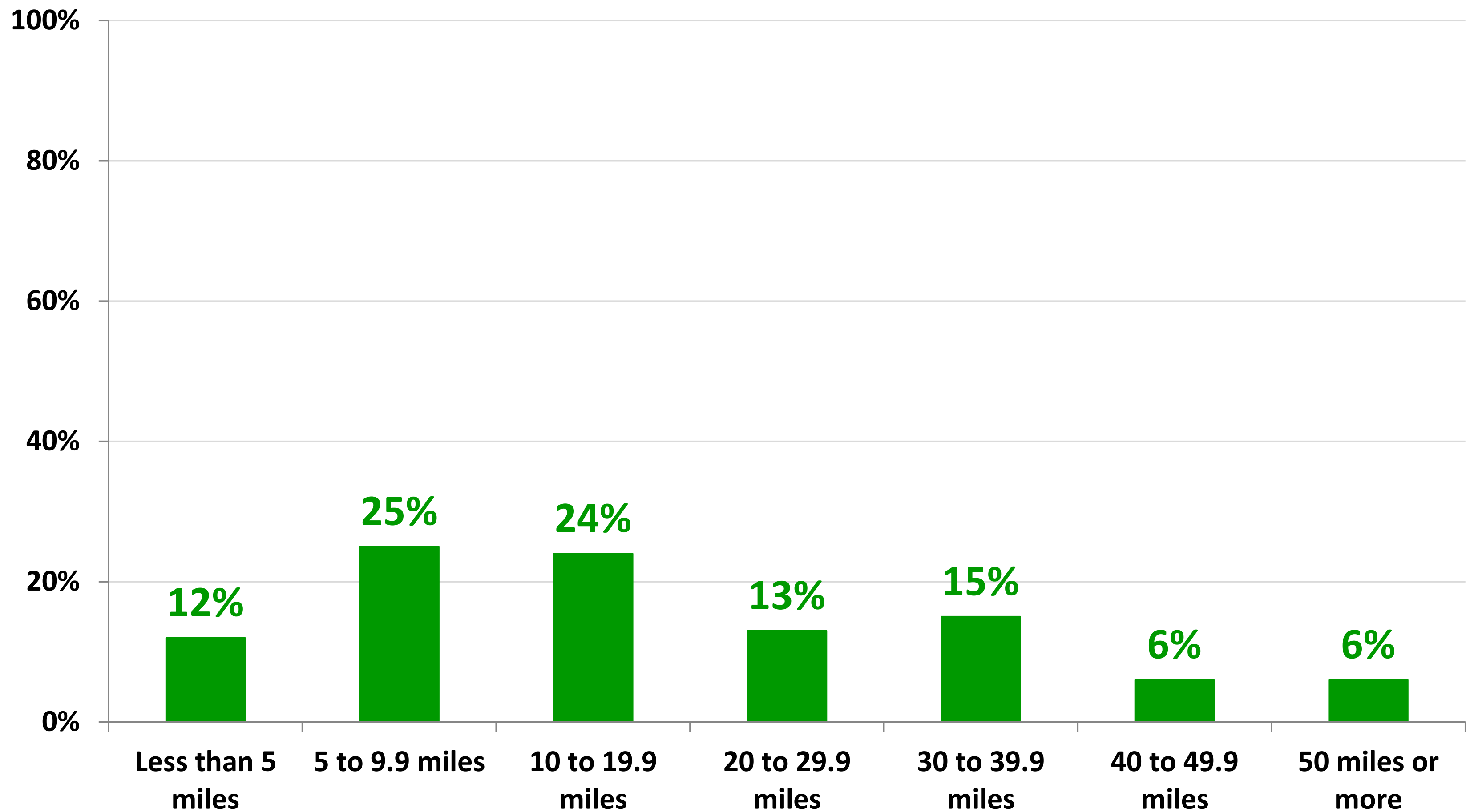
One out of five hybrid drivers live in a multi-unit dwelling



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Which best describes your primary residence?

A quarter of the hybrid drivers have commutes 30 miles or more in both directions



Approximately how far is your typical daily commute in both directions?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Contents

Panel Survey Overview

- Online panel conducted with randomly selected Hawaiian Electric, Maui Electric, and Hawai‘i Electric Light residential customers.
  - [EV owner subset] The objective of the research is to better understand the charging habits and preferences of plug-in hybrid and battery electric vehicle drivers.

- Survey fielding: **July 26, - November 30, 2017**
  - Invite sent to 5,651 panel members
    - **2,247 responses** (40 percent response)
    - **EV owner subset:** **142** **(unidentified EV makes and models excluded)**
      - Oahu: **75**
      - Maui County: **42**
      - Hawai‘i Island: **23**
    - Results are reported unweighted and in aggregate.

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

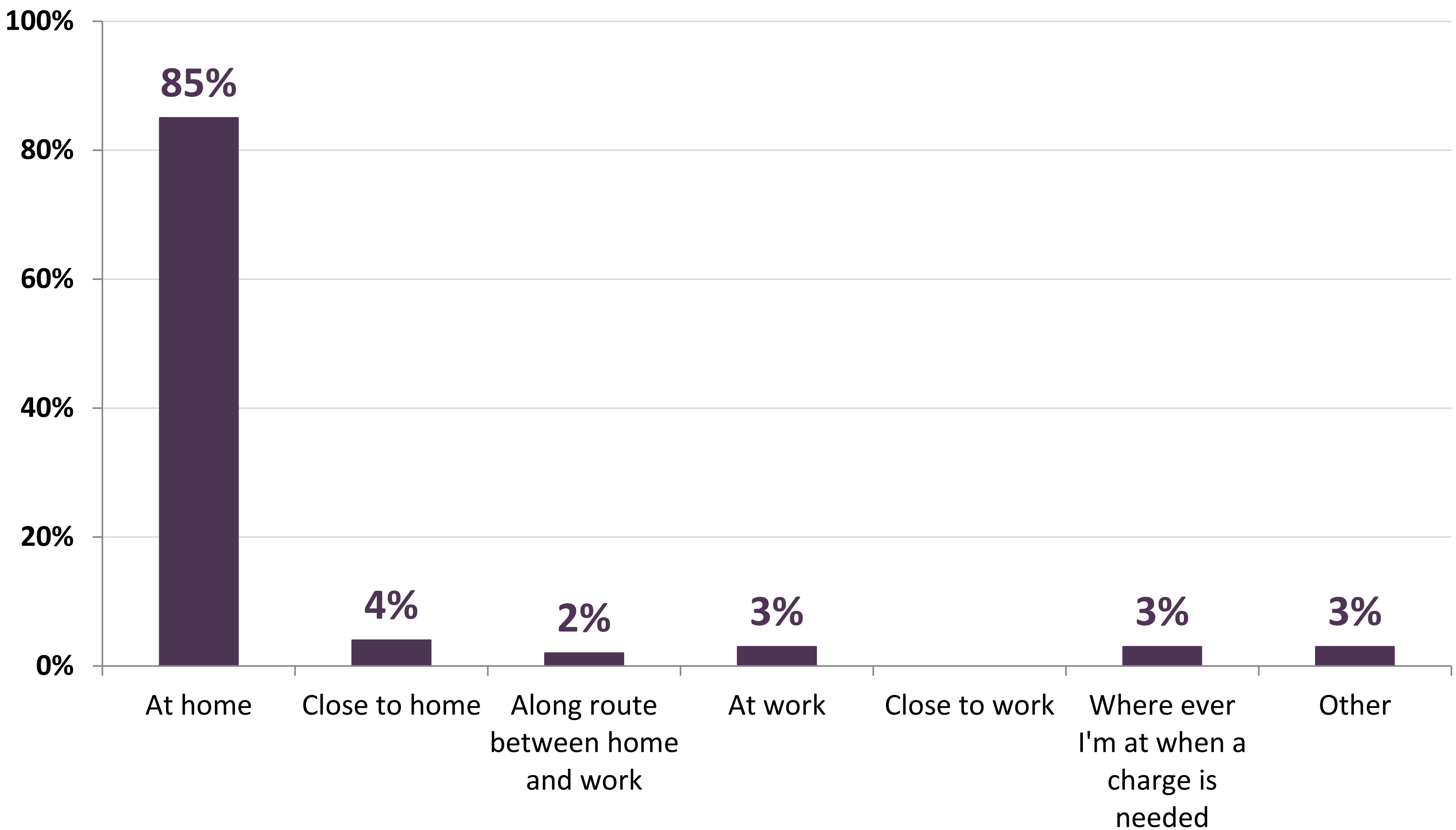
Overview of Unweighted EV Distribution: TOP 10

Panelists' EV type		Research Panel	IHS Markit (Hawai'i Subset* from June 2017)
Nissan Leaf (SL, SV)	n=76	54%	50%
Tesla Model S (40, 85D)	n=15	11%	12%
Toyota Prius Plug-in + Prime	n=7+2	6%	5%
Chevrolet Volt + Bolt	n=8+3	8%	7%
BMW i3 + REx	n=6+1	5%	6%
Kia Soul EV	n=4	3%	1%
Tesla Model X	n=4	3%	3%
Ford C-Max Energi	n=3	2%	4%
Ford Fusion Energi	n=2	1%	4%
BMW X5 xDrive40e	n=2	1%	1%
ALL OTHER EVs	*n=9*	*6%*	*7%*

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

*Excludes Kaua'i

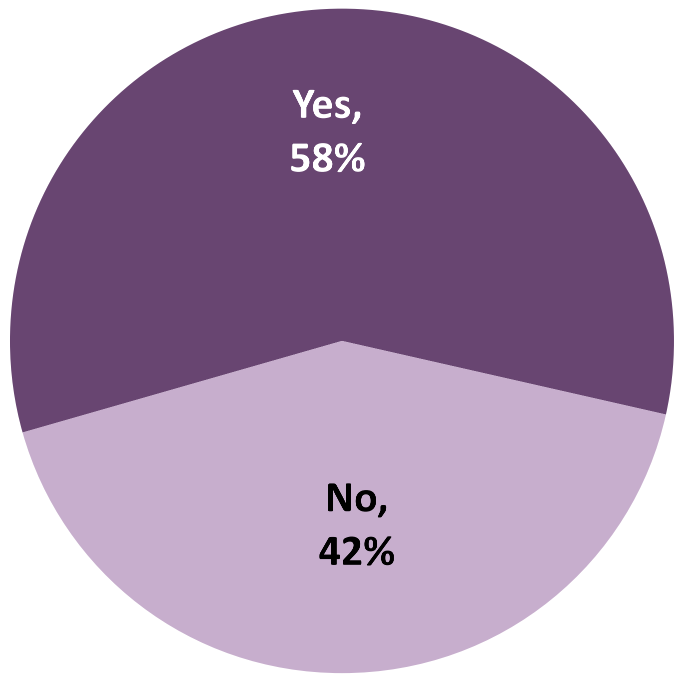
Most EV drivers primarily charge at home



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Where is your electric vehicle primarily charged?

Well over half have a Level 2 Charger at Home



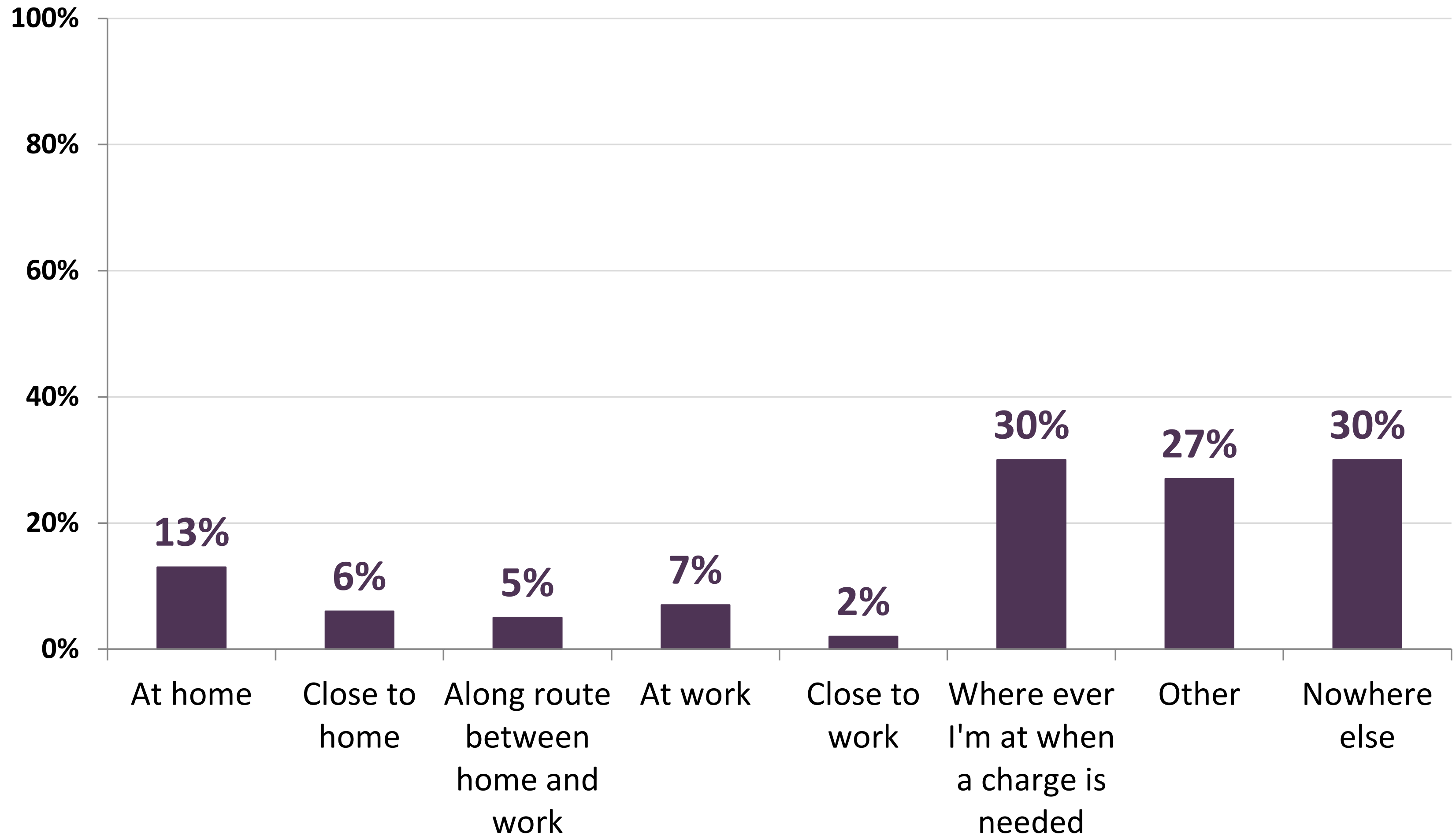
Yes: 98% primarily charge at home

No: 75% primarily charge at home
(close to home 5%, along route between home and work 2%, at work 5%, where ever a charge is needed 5%, other 8%)

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Do you have a Level 2 charger installed at your home?

When not at their primary charging location, nearly a third charge where ever they're at when it's needed

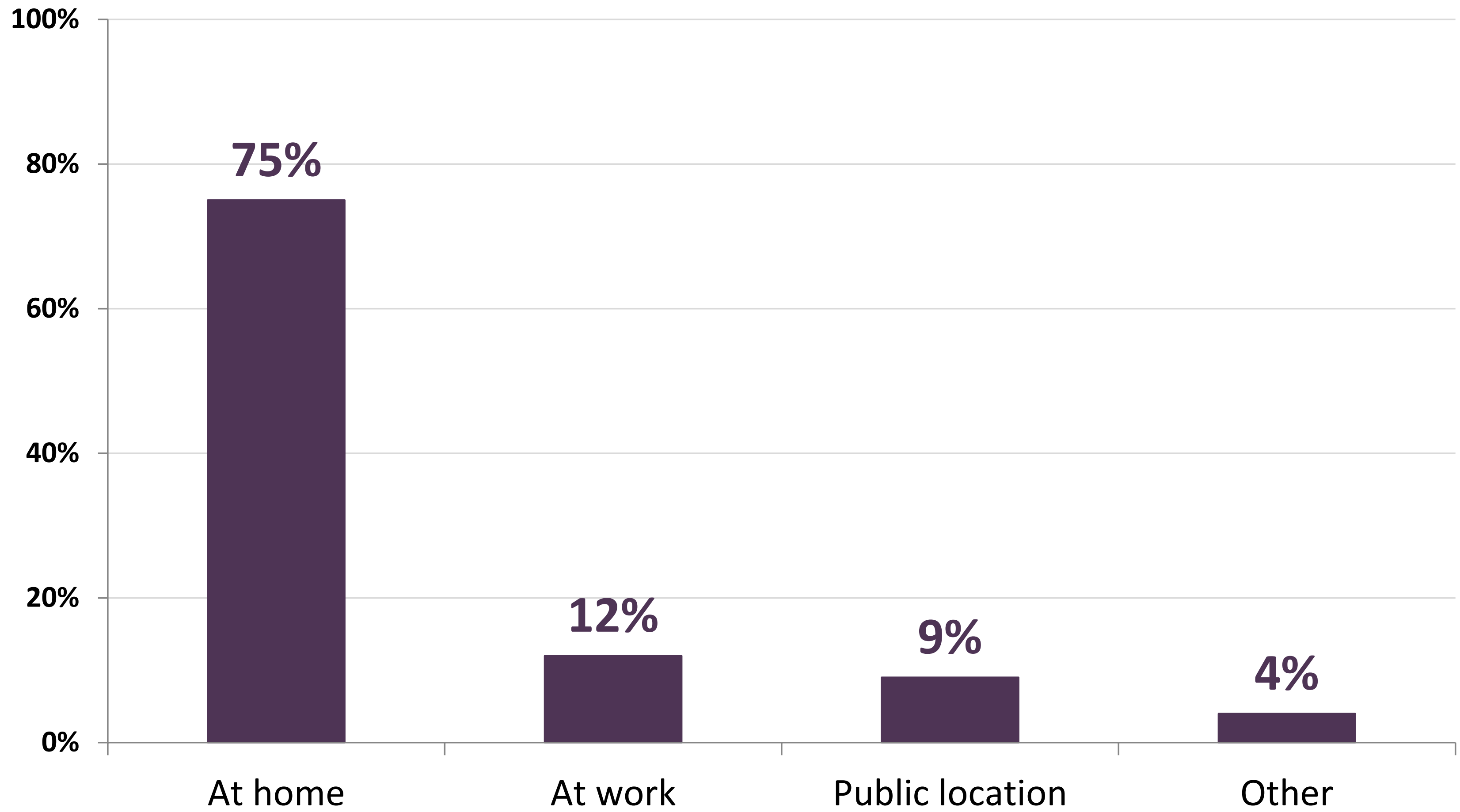


Percentages exceed 100% due to multiple response

Where else is your electric vehicle charged? Please select all that apply.

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

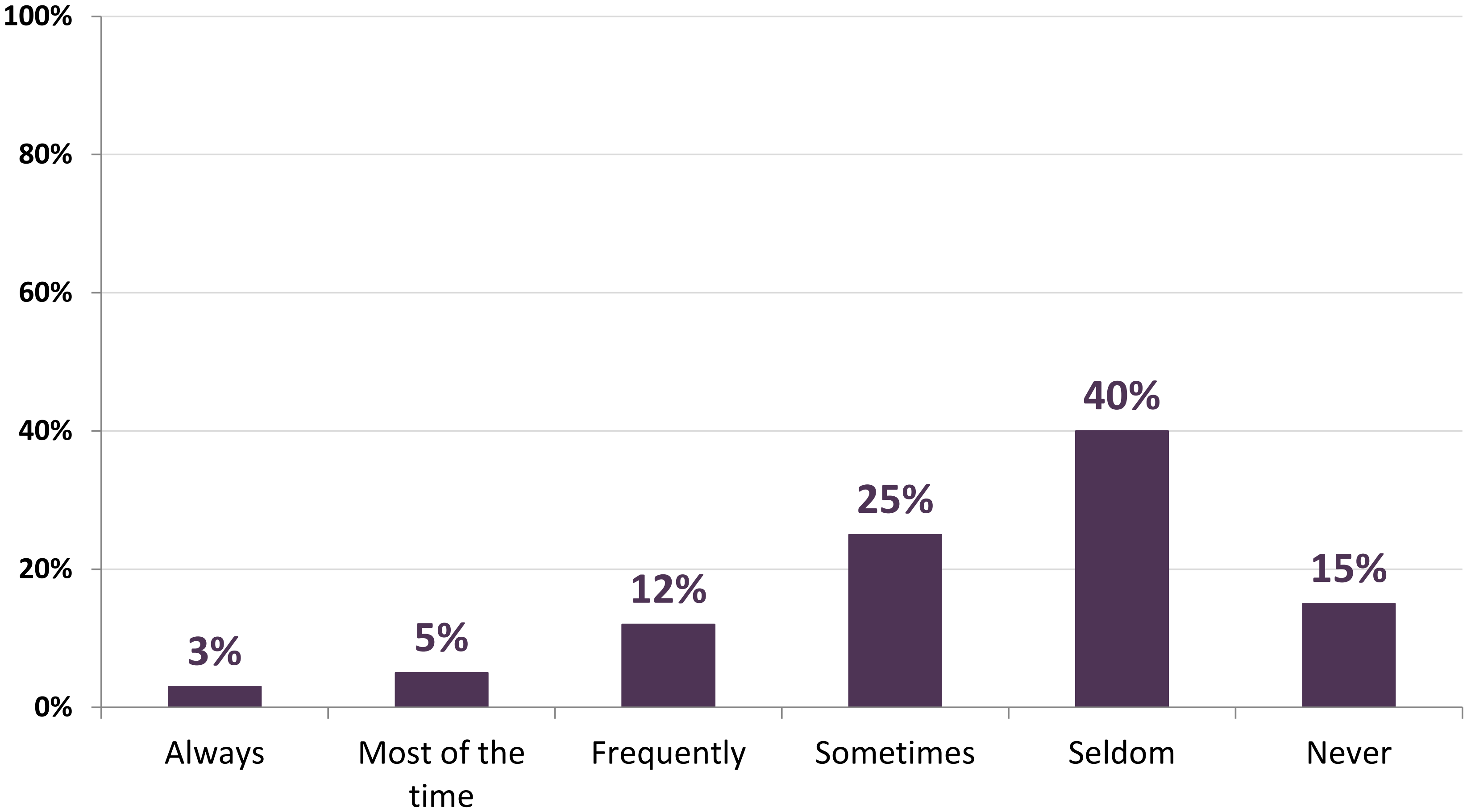
Respondents would most prefer to charge at home



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Where would you most prefer to charge?

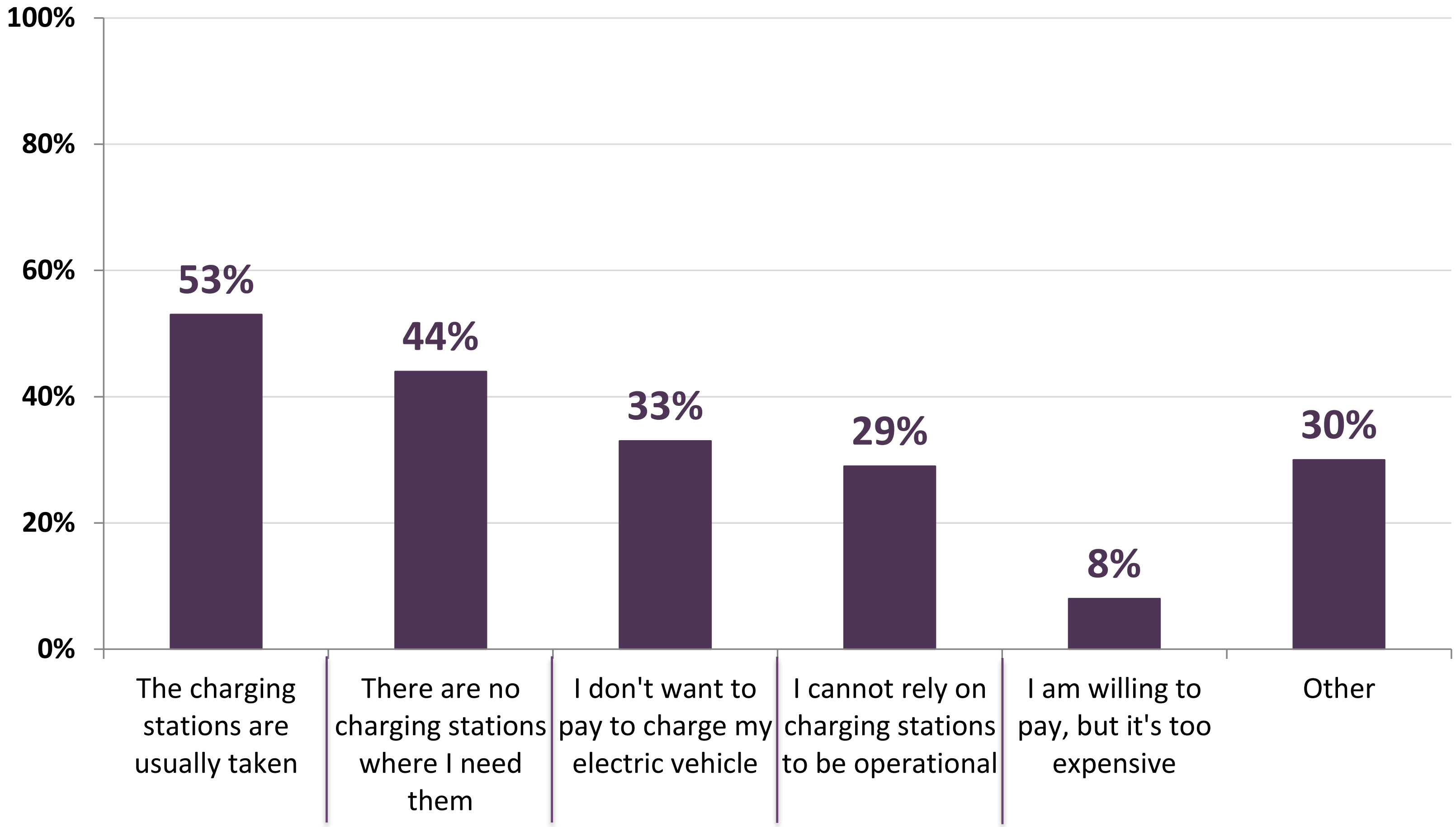
Nearly half have charged away from home at least sometimes



How often do you use a charging station away from your home to charge your electric vehicle?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Occupied and lack of charging stations are the top reasons that discourage charging away from home

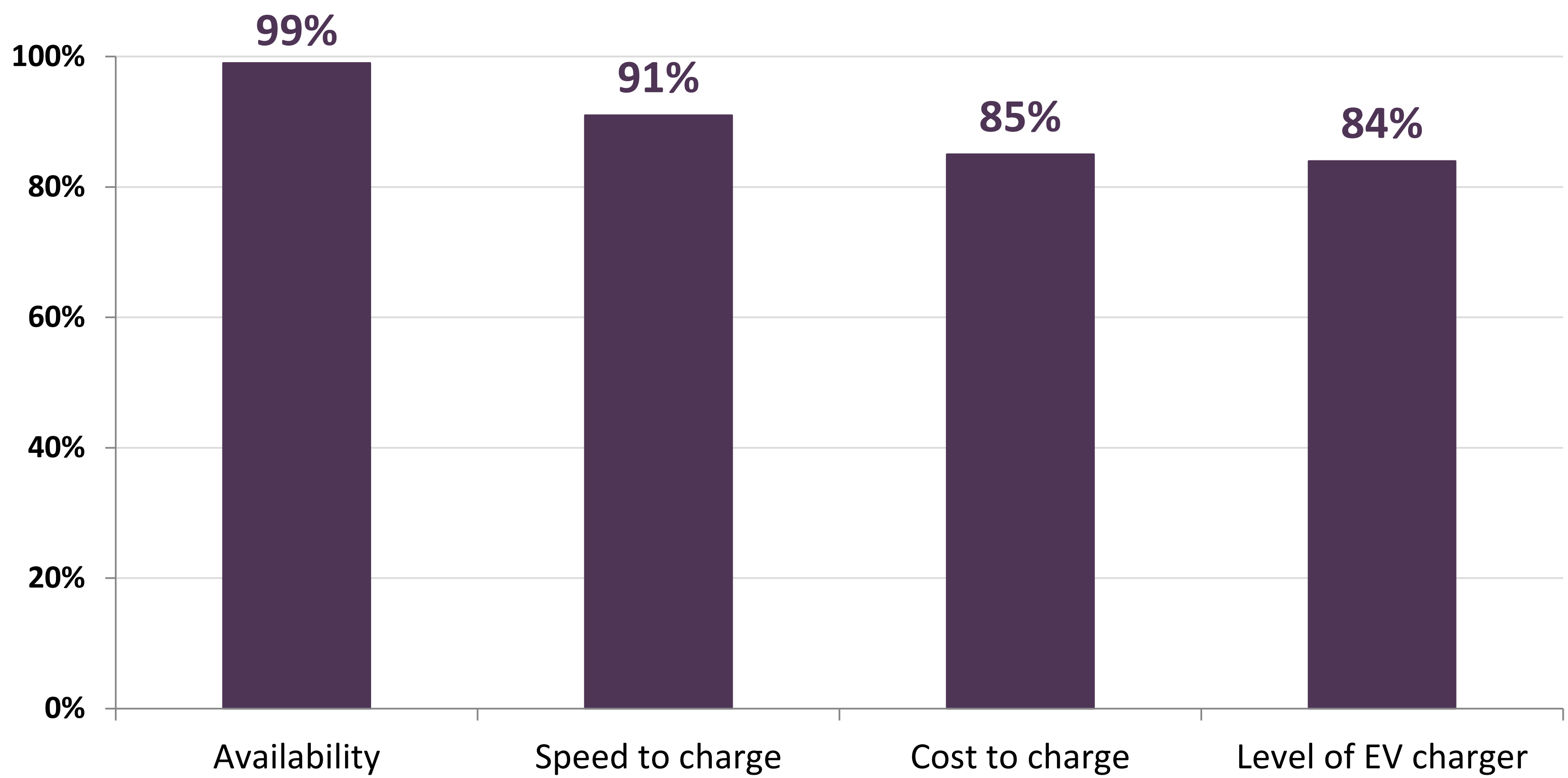


Sub-sample of "seldom" and "never" respondents for charging away from home

What are some of the reasons that discourage you from using a charging station away from your home? Please select all that apply.

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Availability and charging speed rate highest in importance for public charges

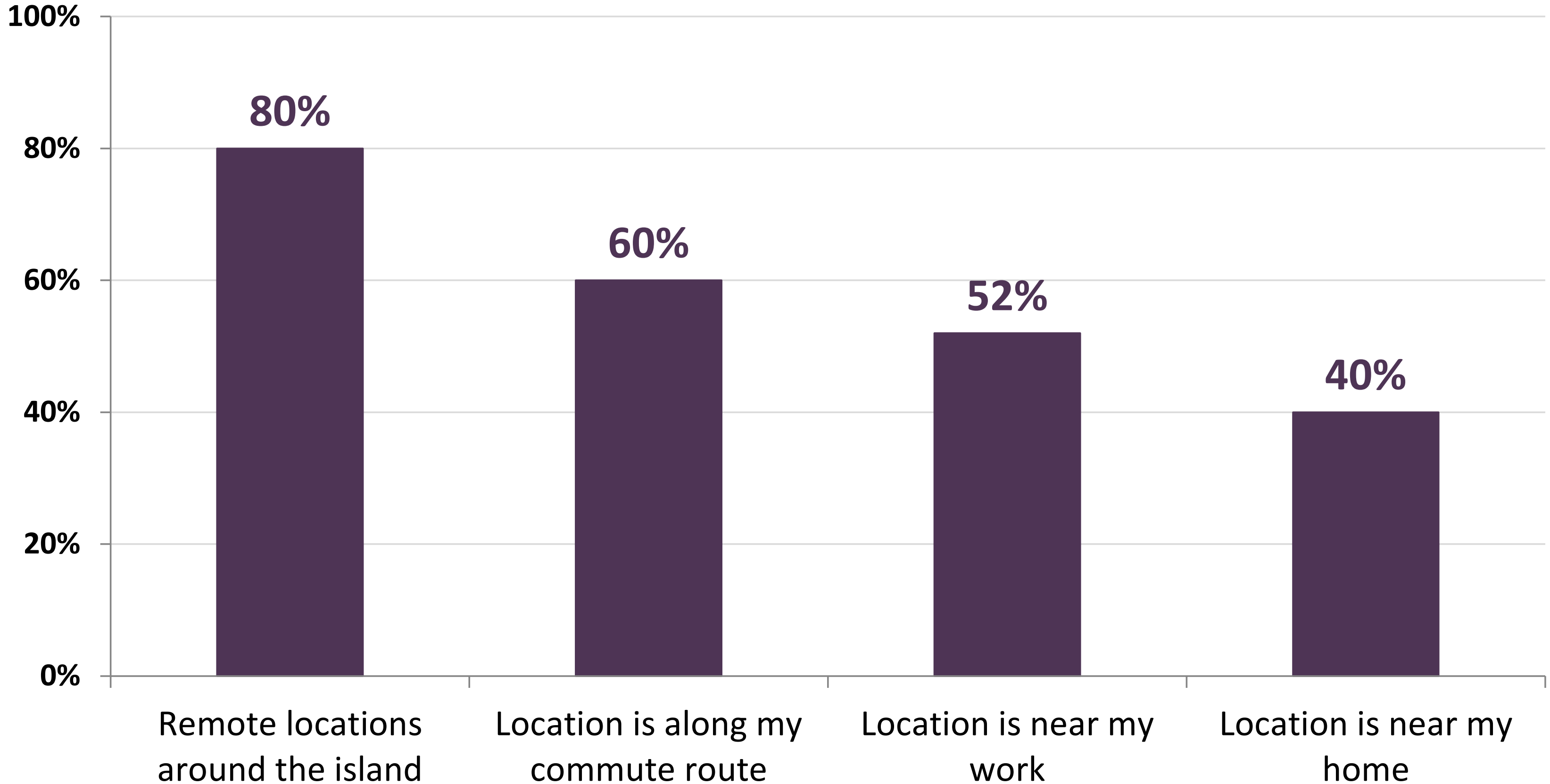


“Very Important” and “Somewhat Important” ratings combined from a four point scale

When it comes to public charging stations, how important are the following:

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Among the location-based attributes, remote siting rated highest in importance

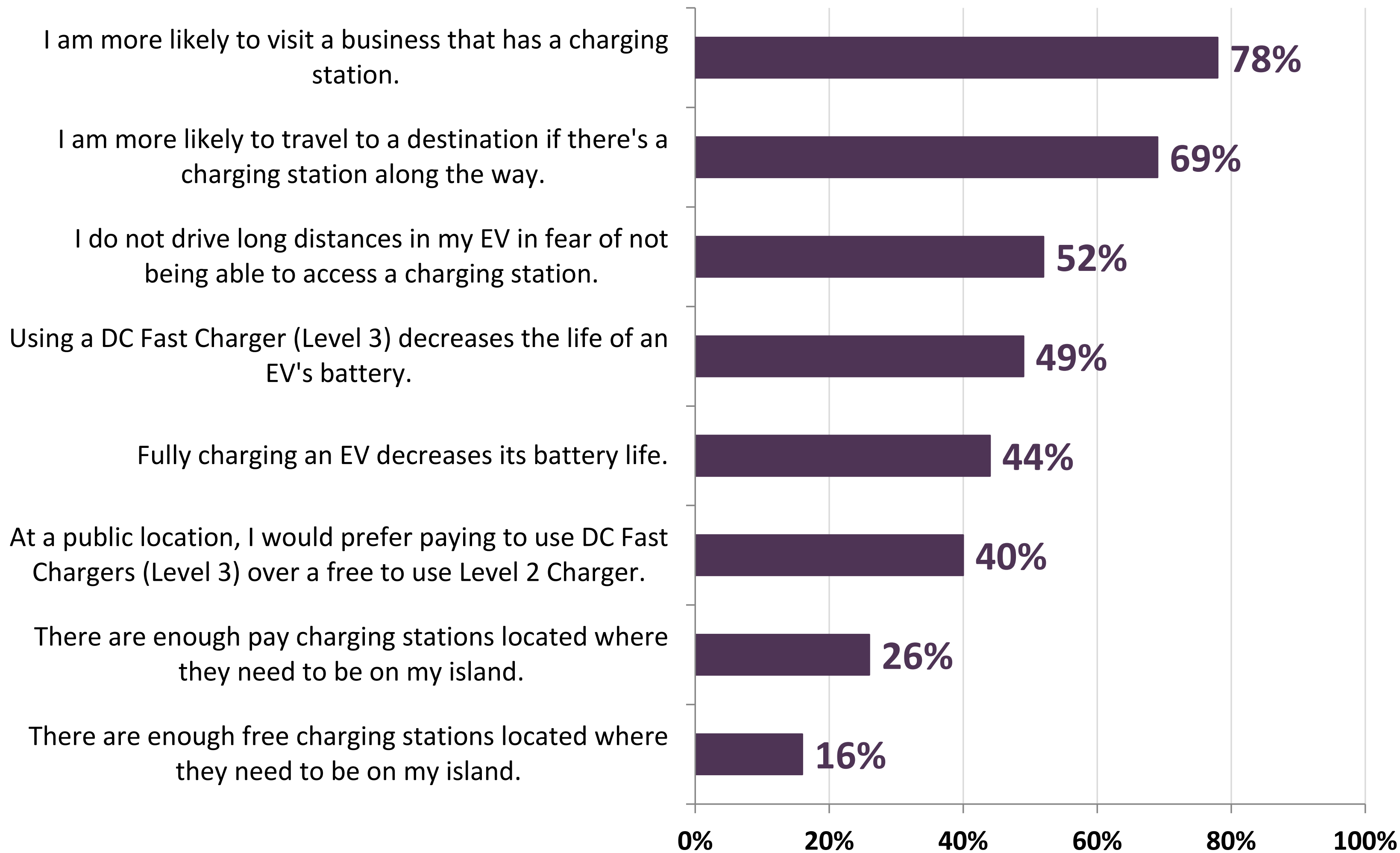


"Very Important" and "Somewhat Important" ratings combined from a four point scale

When it comes to public charging stations, how important are the following:

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Agreement Statements

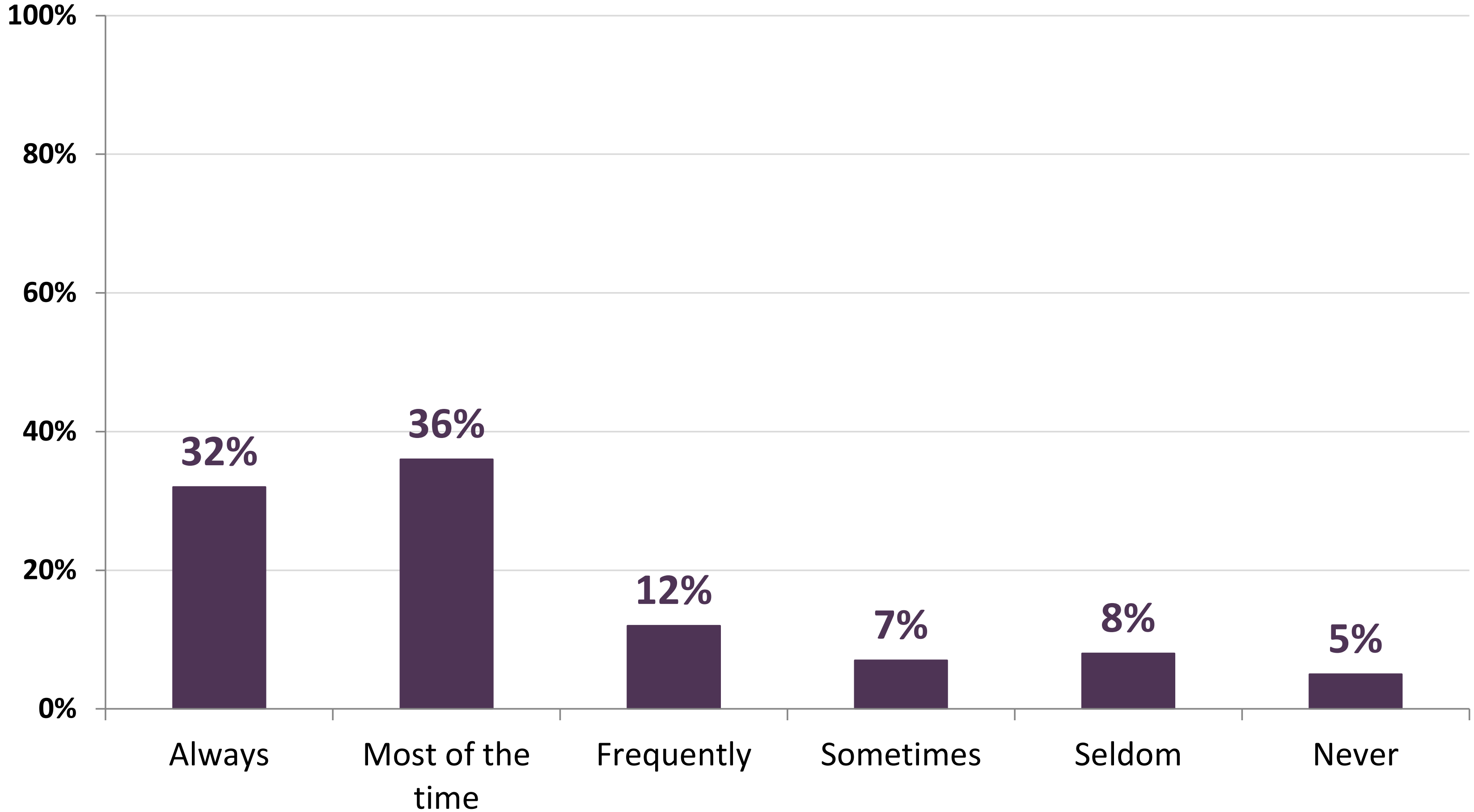


"Strongly Agree" and "Somewhat Agree" ratings combined from a four point scale

What is your level of agreement with the following statements?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

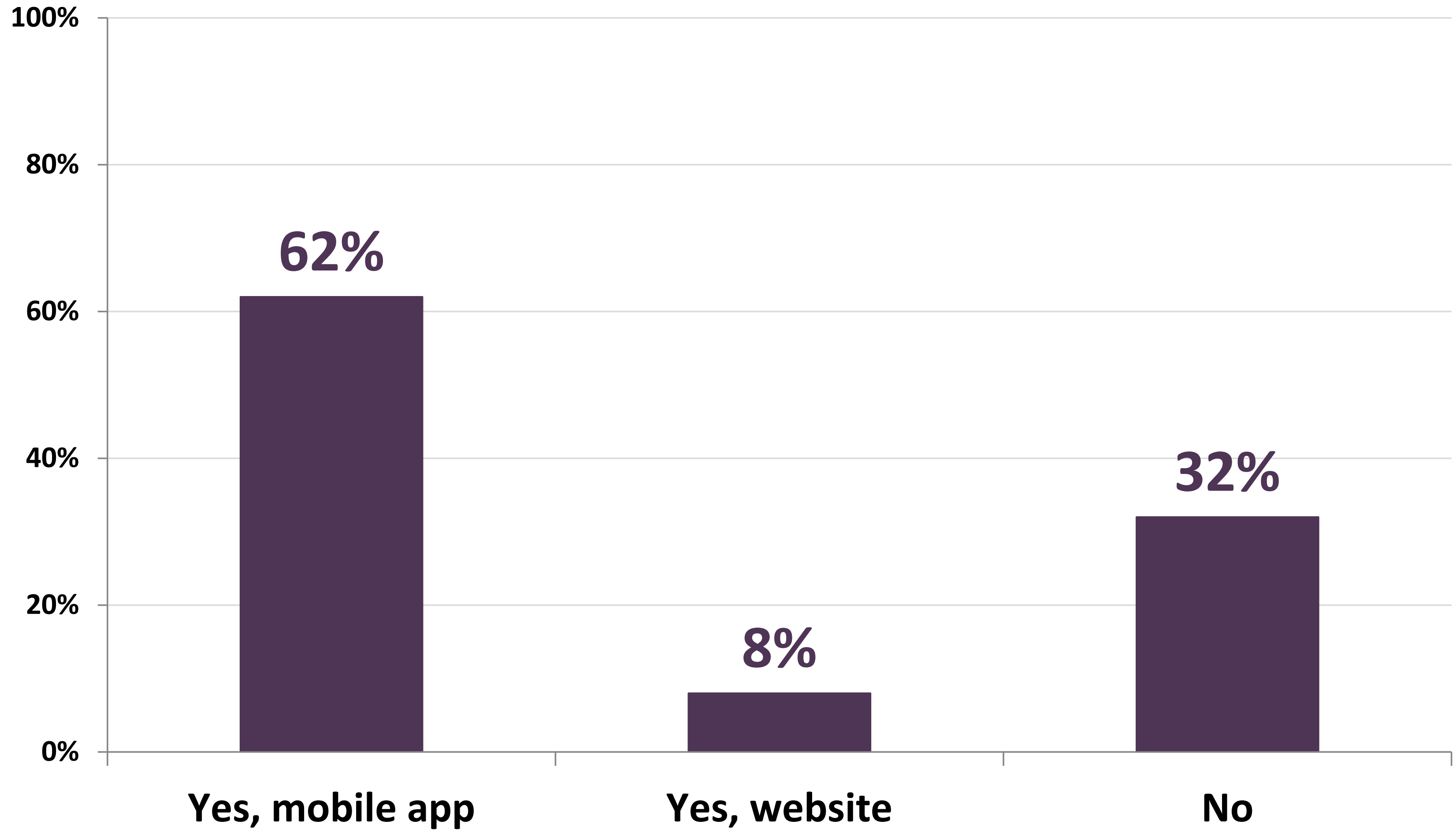
Two-thirds charge their battery to 100% always or most of the time



How often do you charge until your battery is full at 100%?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Two-thirds use a mobile app and/or website to locate charging stations

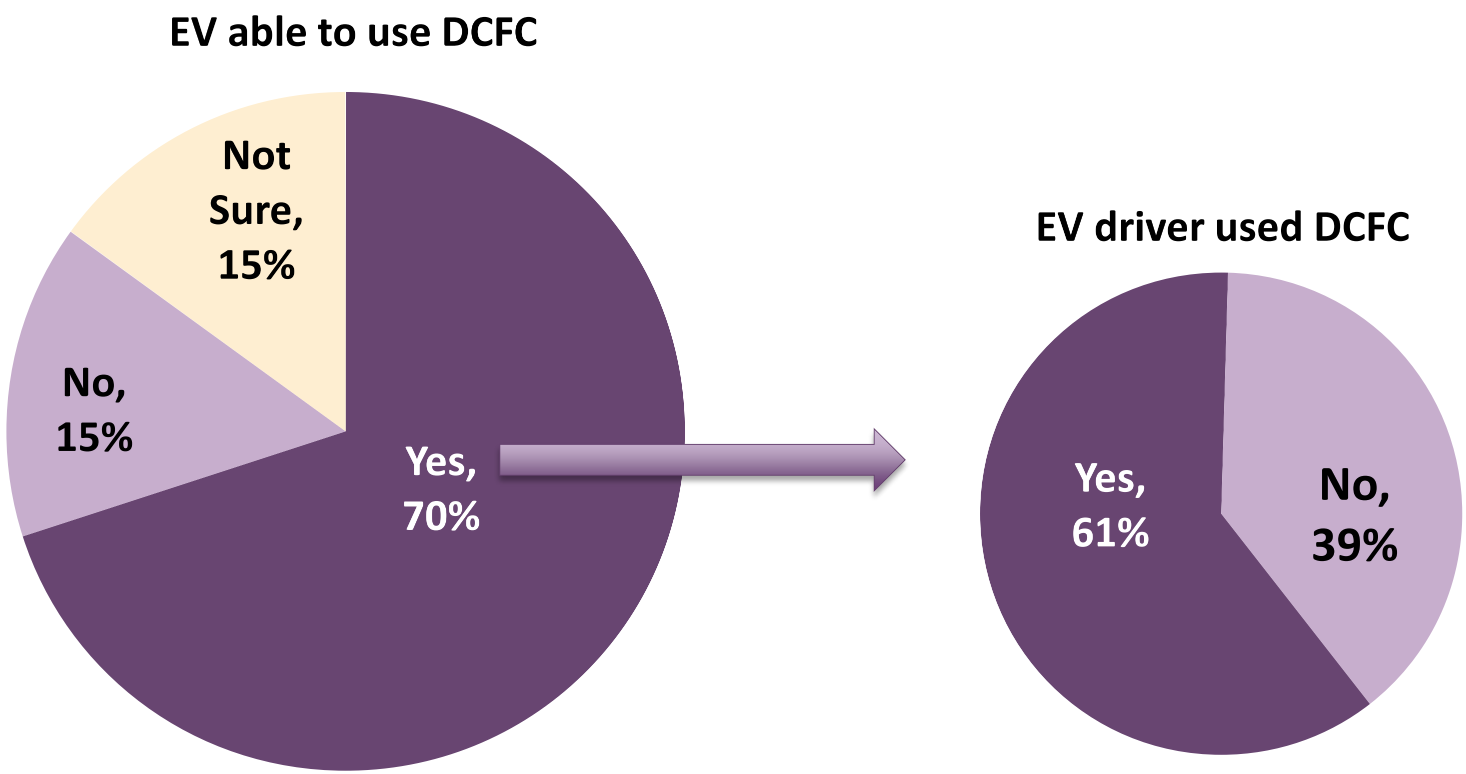


Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Percentages exceed 100% due to multiple response

Do you use a mobile app or website to locate EV charging stations?

Among those who are able to use a DCFC on their vehicle, well over half have used a DCFC



Can your EV use a DC Fast Charger (Level 3)?
[Yes] Have you ever used a DC Fast Charger on your EV?

Contents

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Multi-Survey Overview

Surveys conducted with residents throughout the Hawaiian Electric Companies' service territories.

- [BEV Drivers] The objective of the research is to do a comparison profile of battery electric vehicle drivers who have and have not used a DC Fast Charger.

All BEV makes and models included are able to fast charge.

Data collection from July 2017 – January 2018

Merged sample from multiple sources:

DCFC users: 207
Non-users: 164

Online Research Panel: 107
- randomly selected residential customers of the Hawaiian Electric Companies

EV charging app users: 240
- online survey sent to service provider app downloaders **(non-BEV drivers filtered out)**

DCFC Intercept Pilot: 24
- Ward and Kapolei locations for 16 hours each

Responses	
- Oahu	280
- Maui County	61
- Hawai'i Island	30
	371

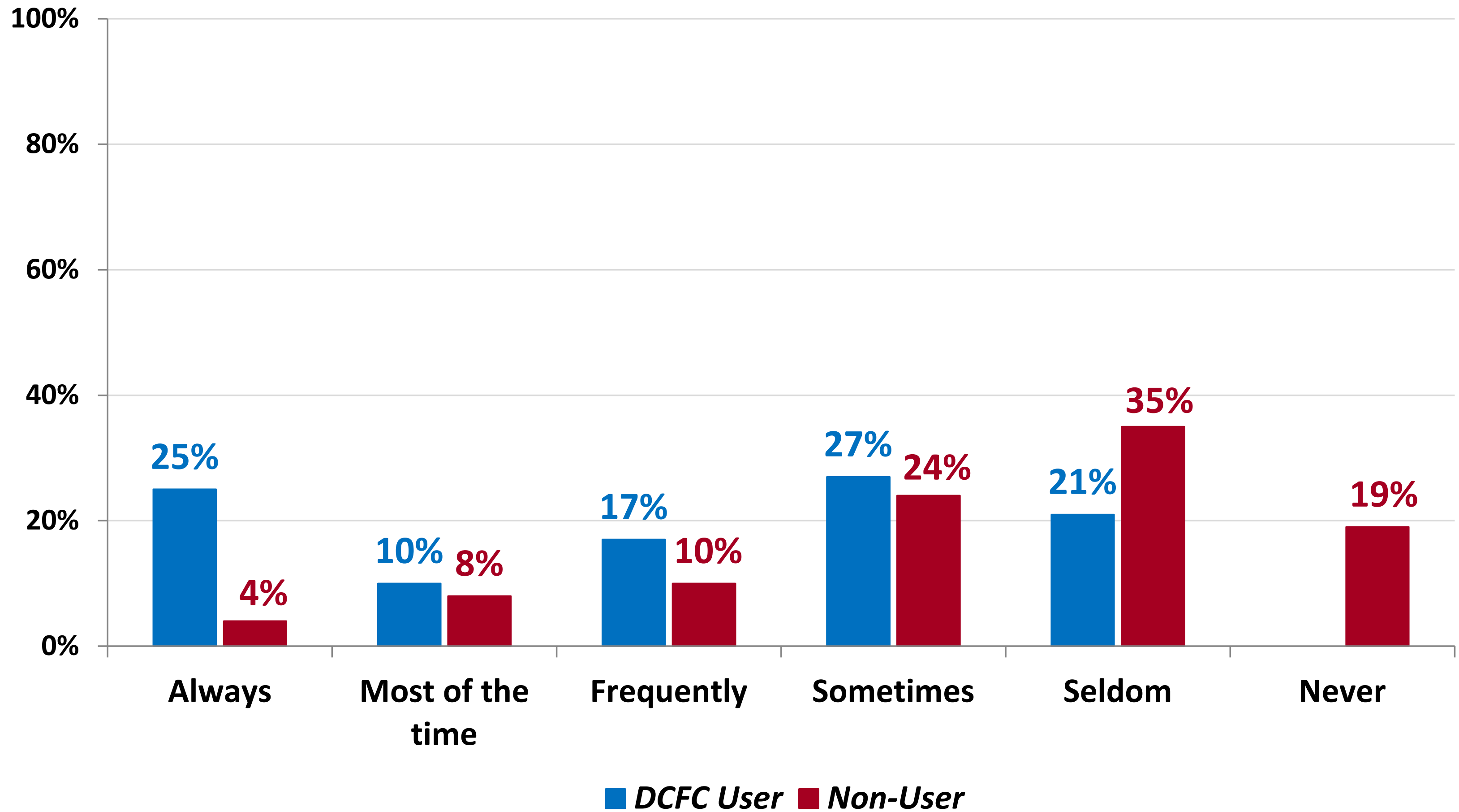
Overview of Unweighted BEV Distribution

Panelists' EV type		Combined Surveys		IHS Markit (Hawai'i Subset* from June 2017)
		DCFC User	Non-User	
Nissan Leaf	n=151 + n=97	73%	59%	68%
Tesla Model S	n=14 + n=26	7%	16%	16%
BMW i3	n=18 + n=19	9%	12%	9%
Kia Soul EV	n=11 + n=9	5%	6%	2%
Tesla Model X	n=10 + n=6	5%	4%	4%
Chevrolet Bolt	n=2 + n=4	1%	2%	<1%
Mitsubishi i-MiEV	n=0 + n=3	--	2%	1%
VW E-Golf	n=1 + n=0	1%	--	<1%
ALL OTHER BEVs		--	--	*<1%*

*Excludes Kaua'i

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

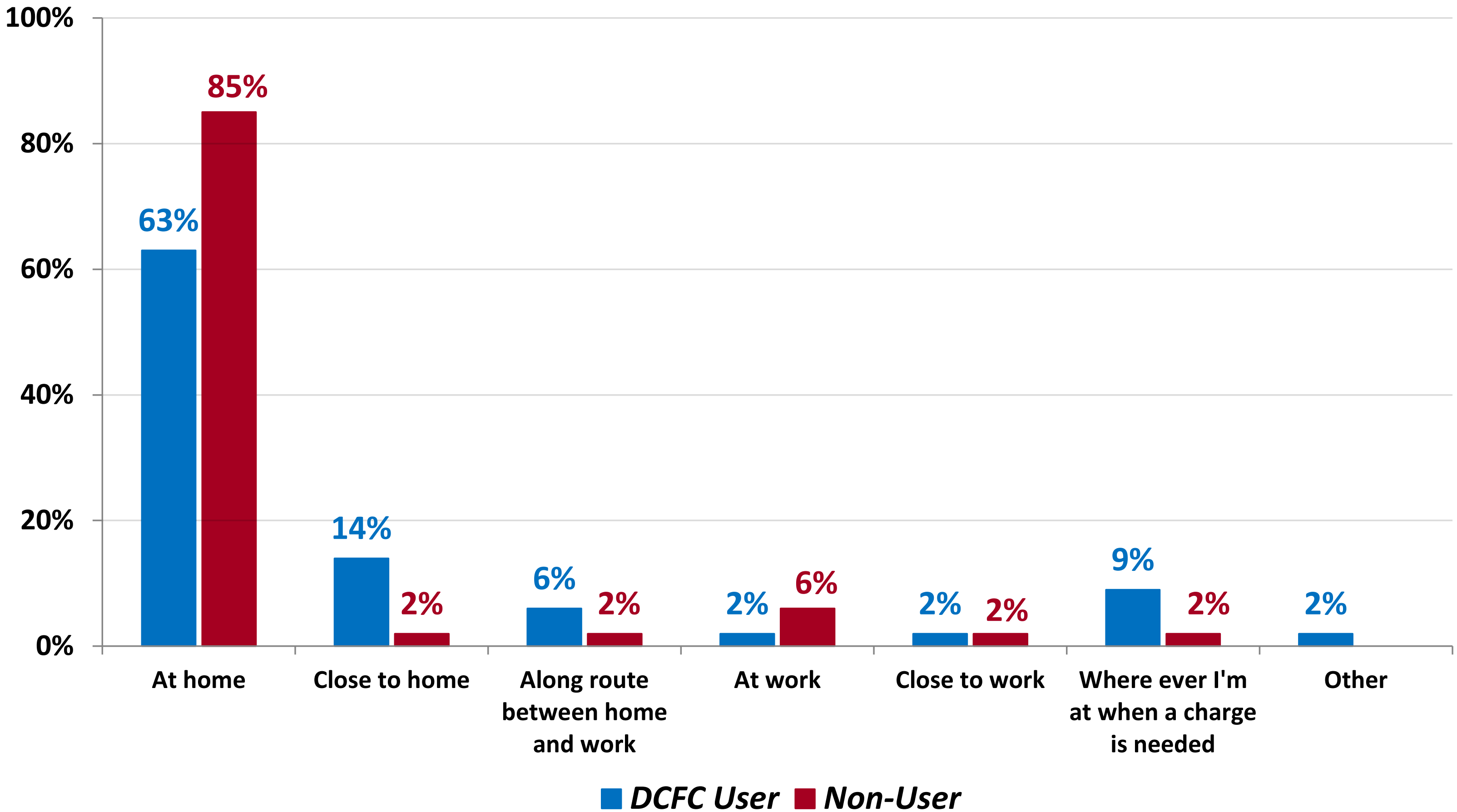
A quarter of the DCFC users always charge away from home



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

How often do you use a charging station away from your home to charge your electric vehicle?

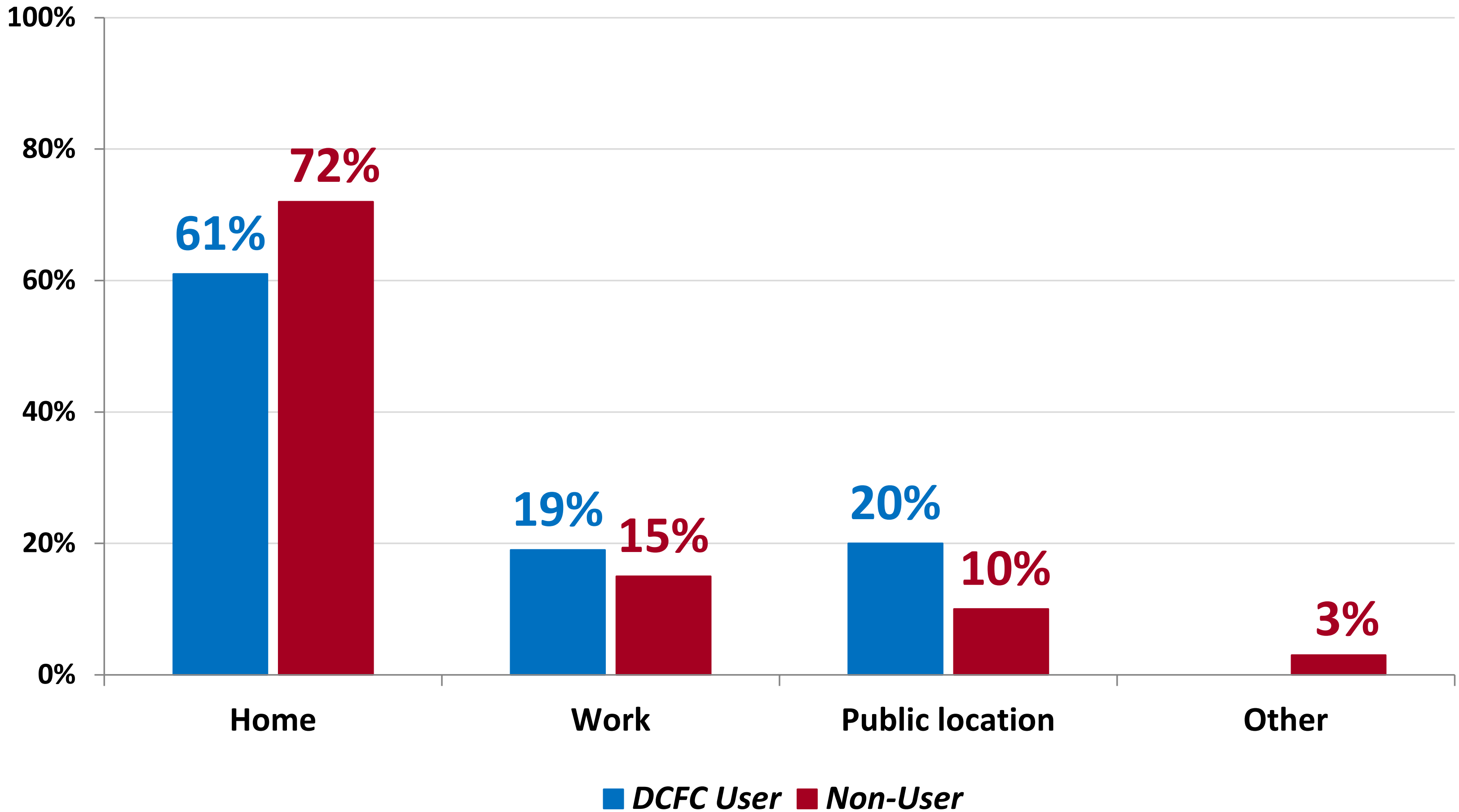
About a third of the DCFC users primarily charge away from home



Where is your electric vehicle primarily charged?

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

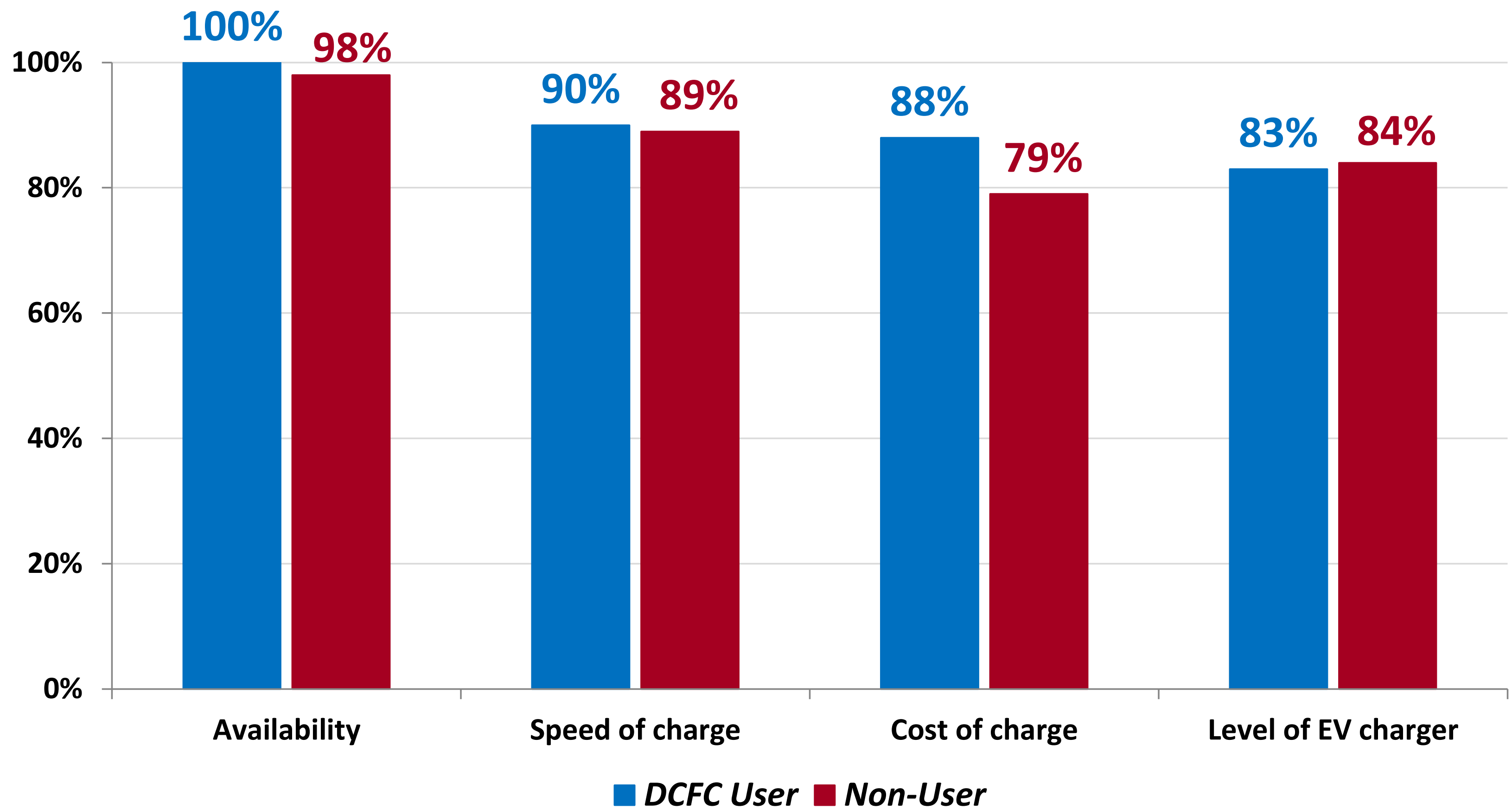
Two out of five DCFC users would most prefer to charge at work or a public location



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Where would you most prefer to charge?

Availability and charging speed rate highest in importance in regard to public chargers

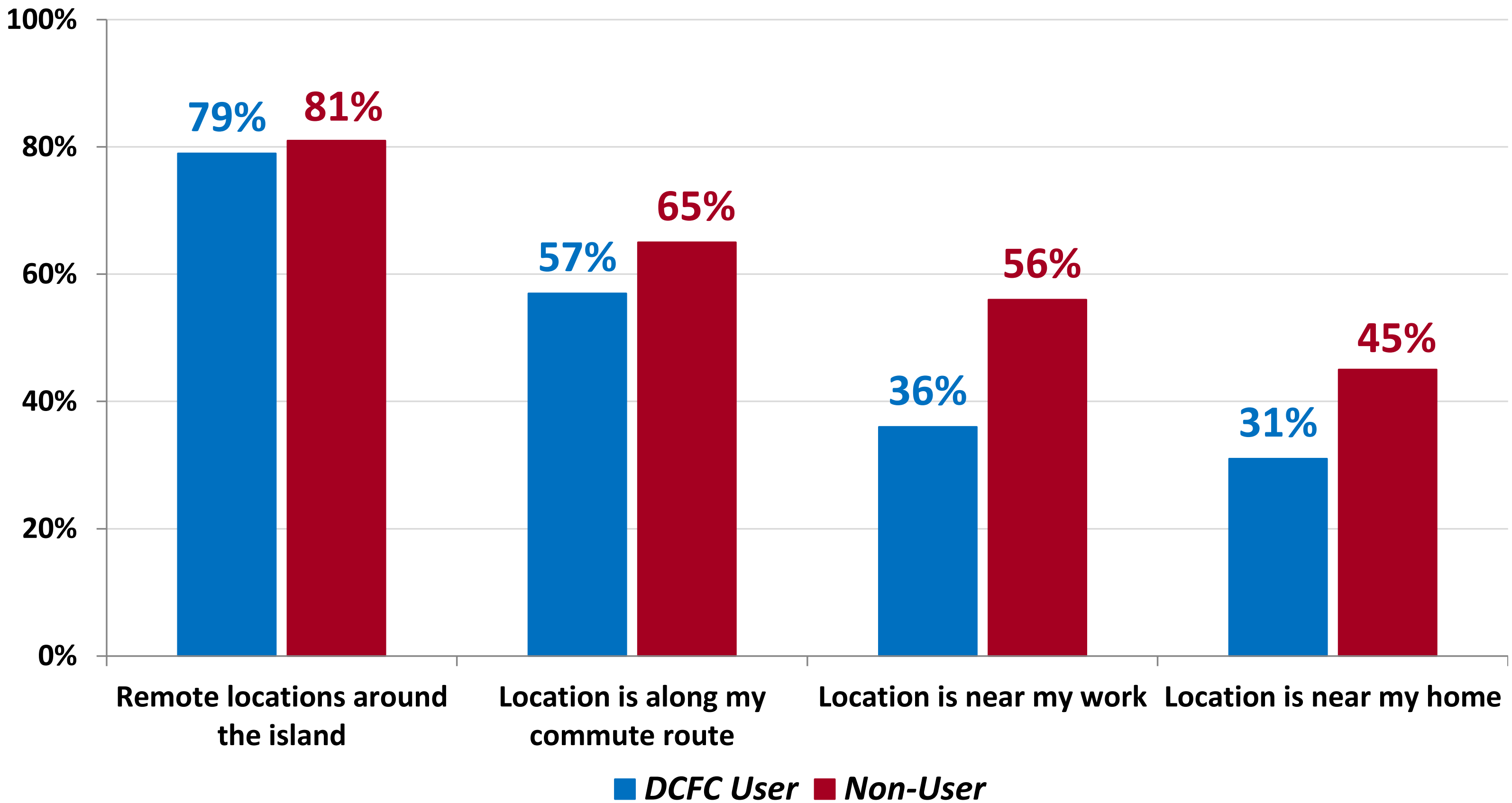


"Very Important" and "Somewhat Important" ratings combined from a four point scale

When it comes to public charging stations, how important are the following:

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Among the location-related attributes, remote placement rated highest in importance for both groups

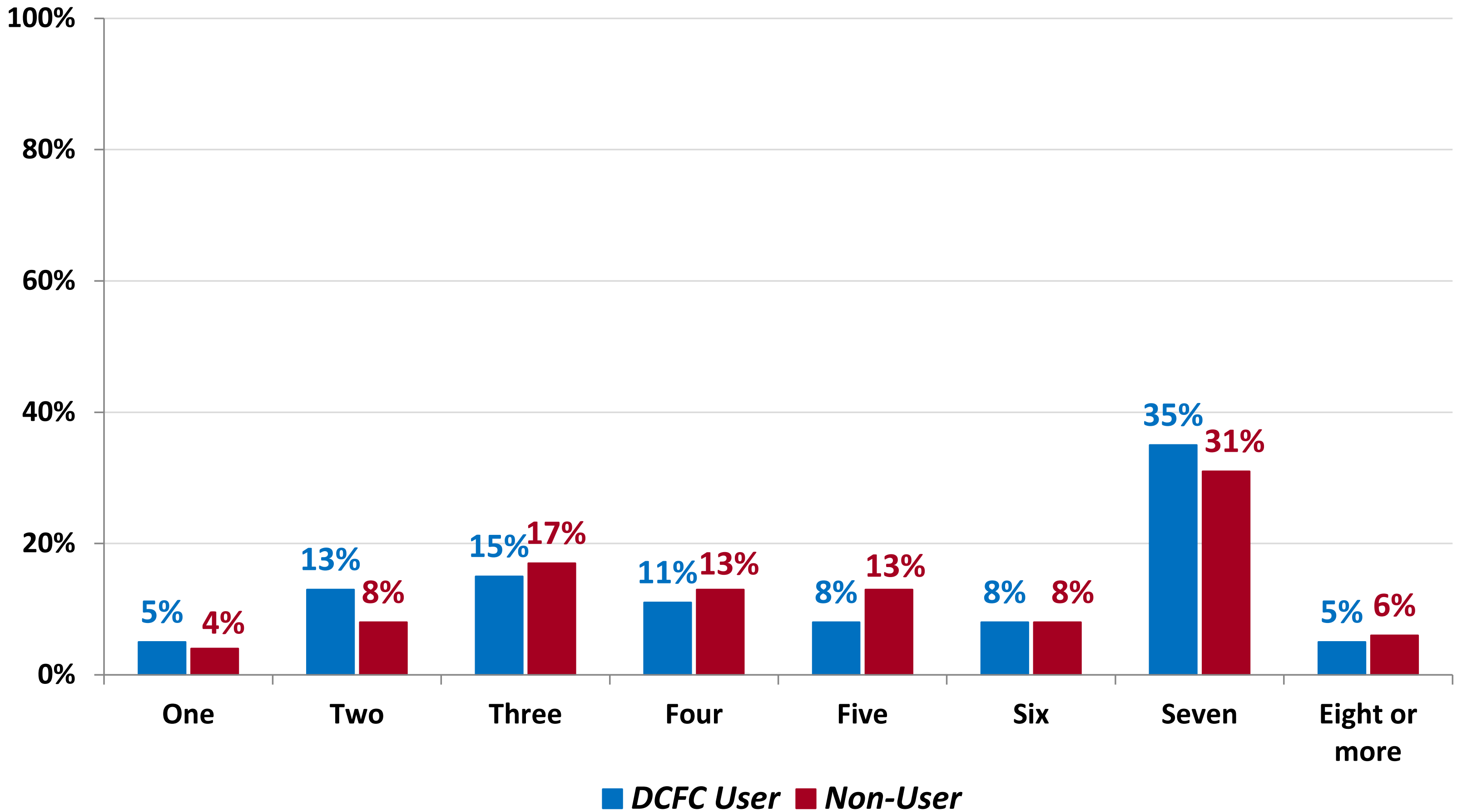


"Very Important" and "Somewhat Important" ratings combined from a four point scale

When it comes to public charging stations, how important are the following:

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

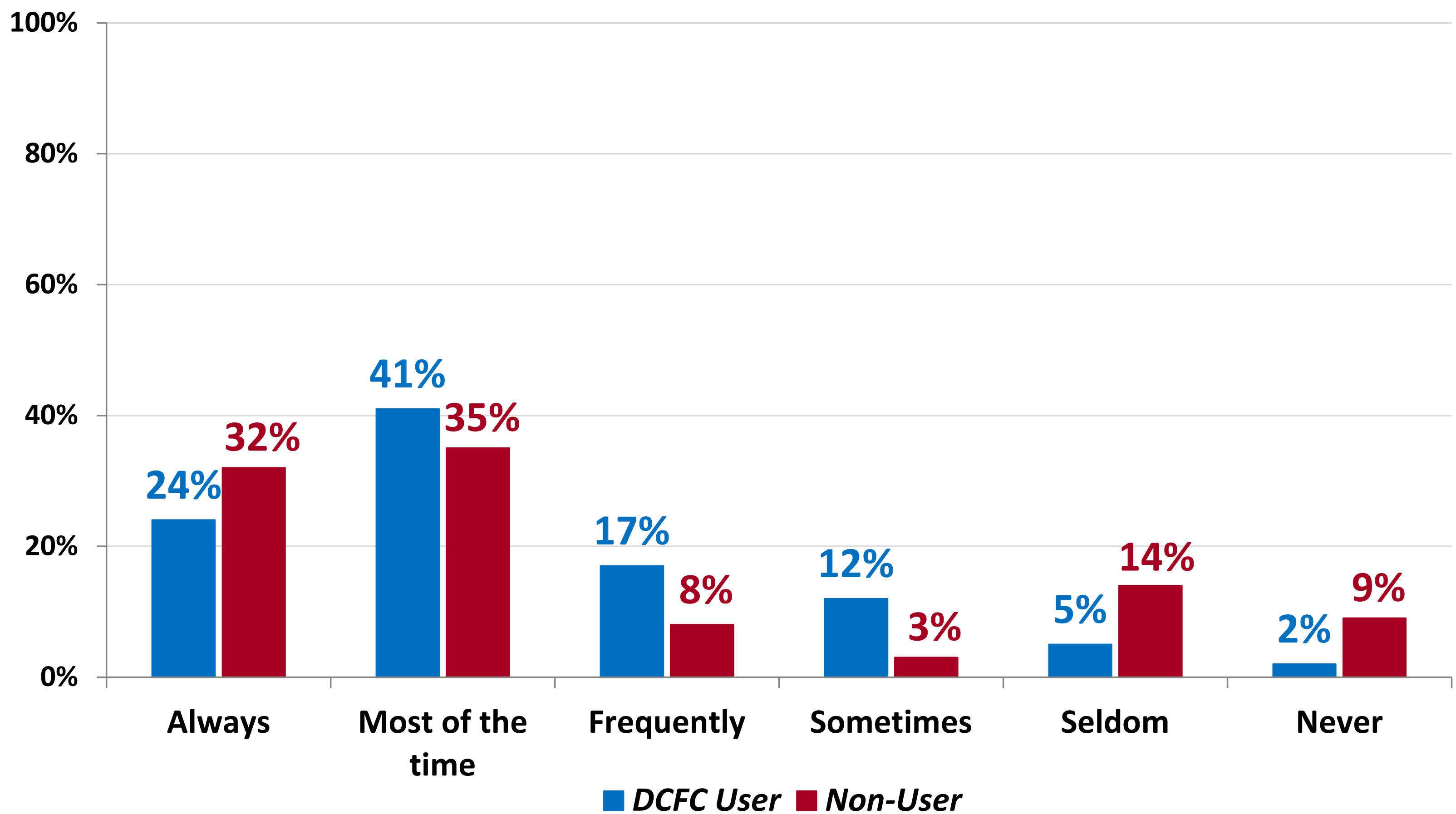
Weekly charging frequency is relatively the same between DCFC users and non-users



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

During a typical week, how many times is your electric vehicle charged?

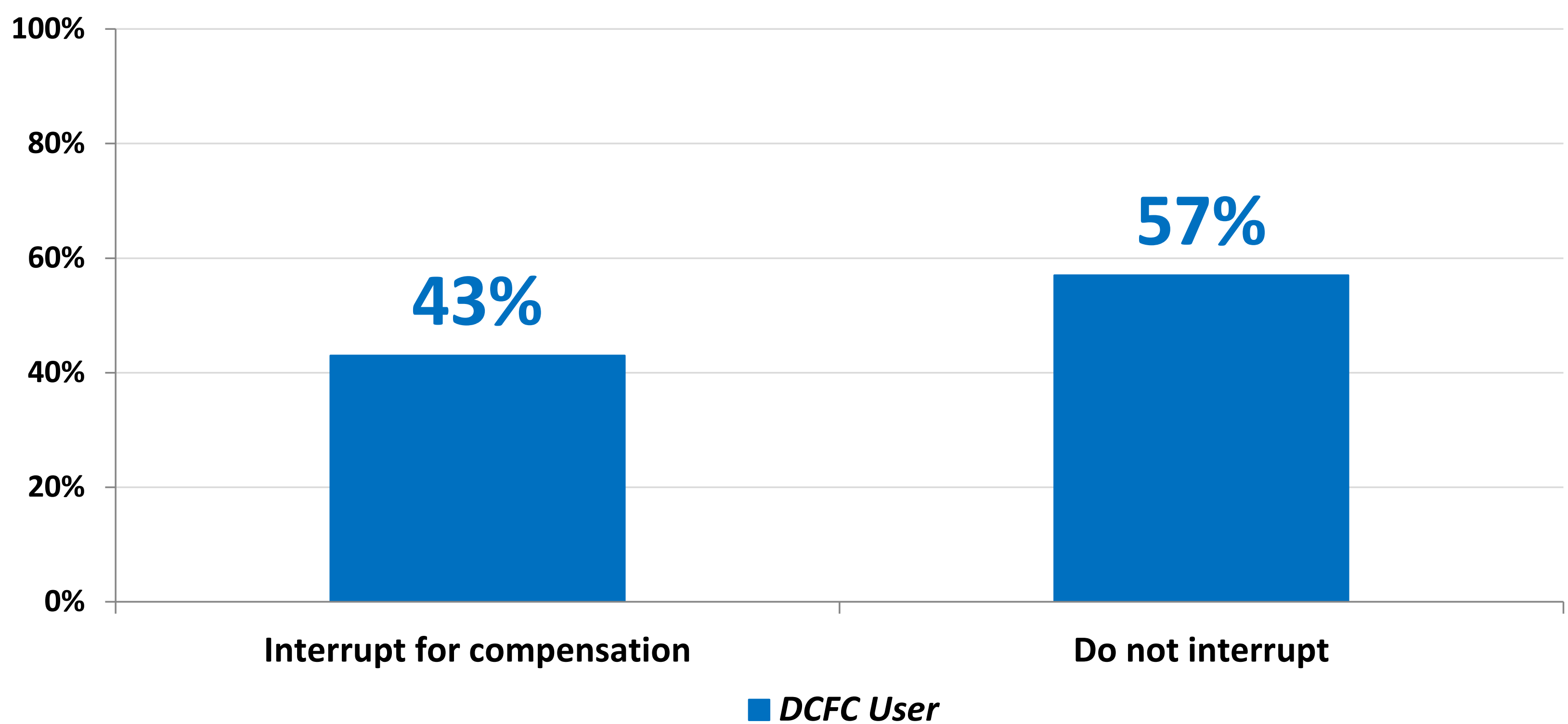
Fully charging a battery occurs more often than partial charges



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

How often do you charge until your battery is full at 100%?

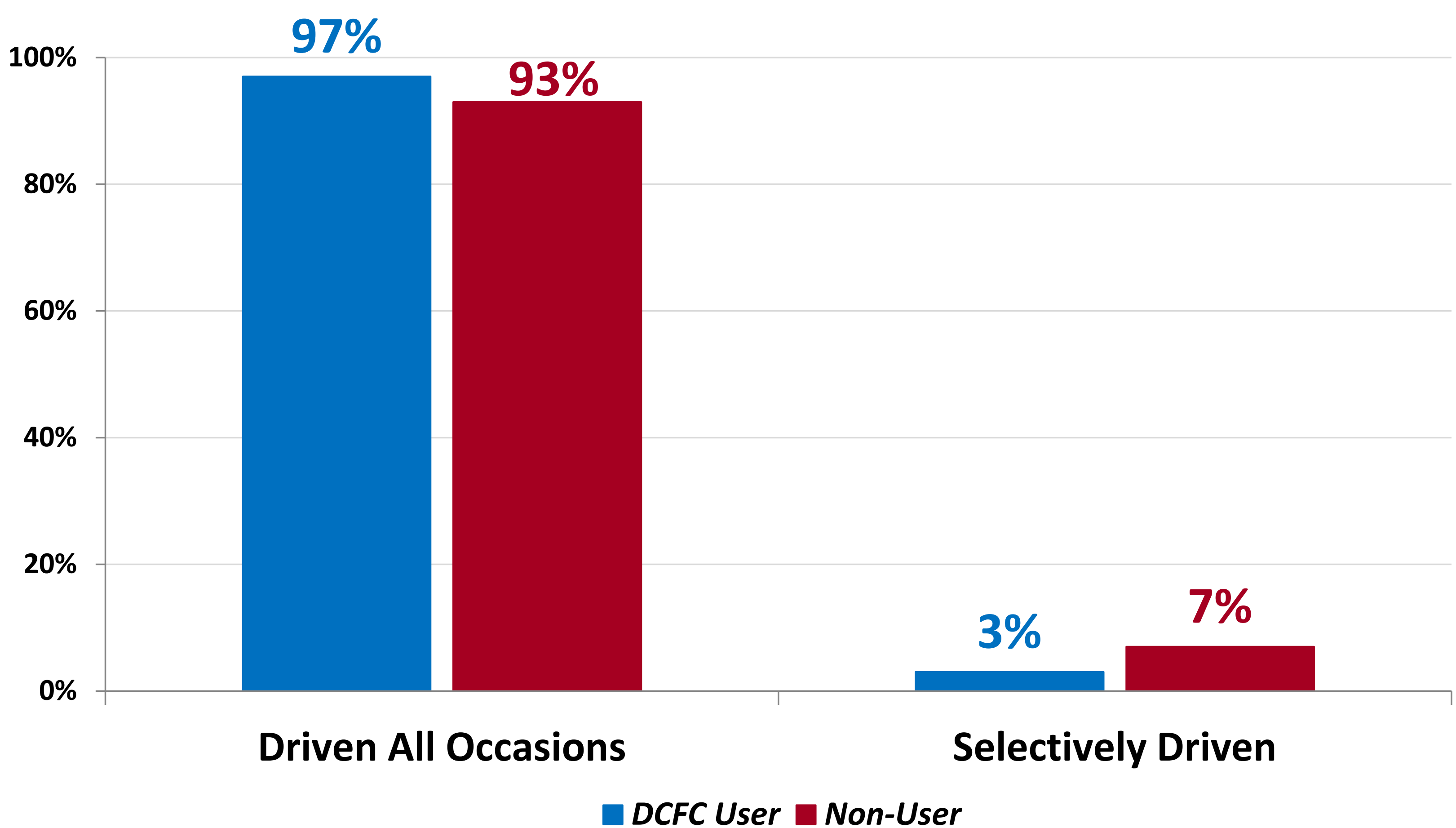
Just under half are willing to be interrupted for demand response during a DCFC session



Demand response is the change in electricity usage by customers from their normal day to day consumption in response to incentives provided to lower electricity usage for an individual during times when the electric grid is nearing its peak capacity. Your electric utility is considering similar control of its DC Fast Charger stations. Would you be willing to have your DC Fast Charger session interrupted in exchange for a financial compensation?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

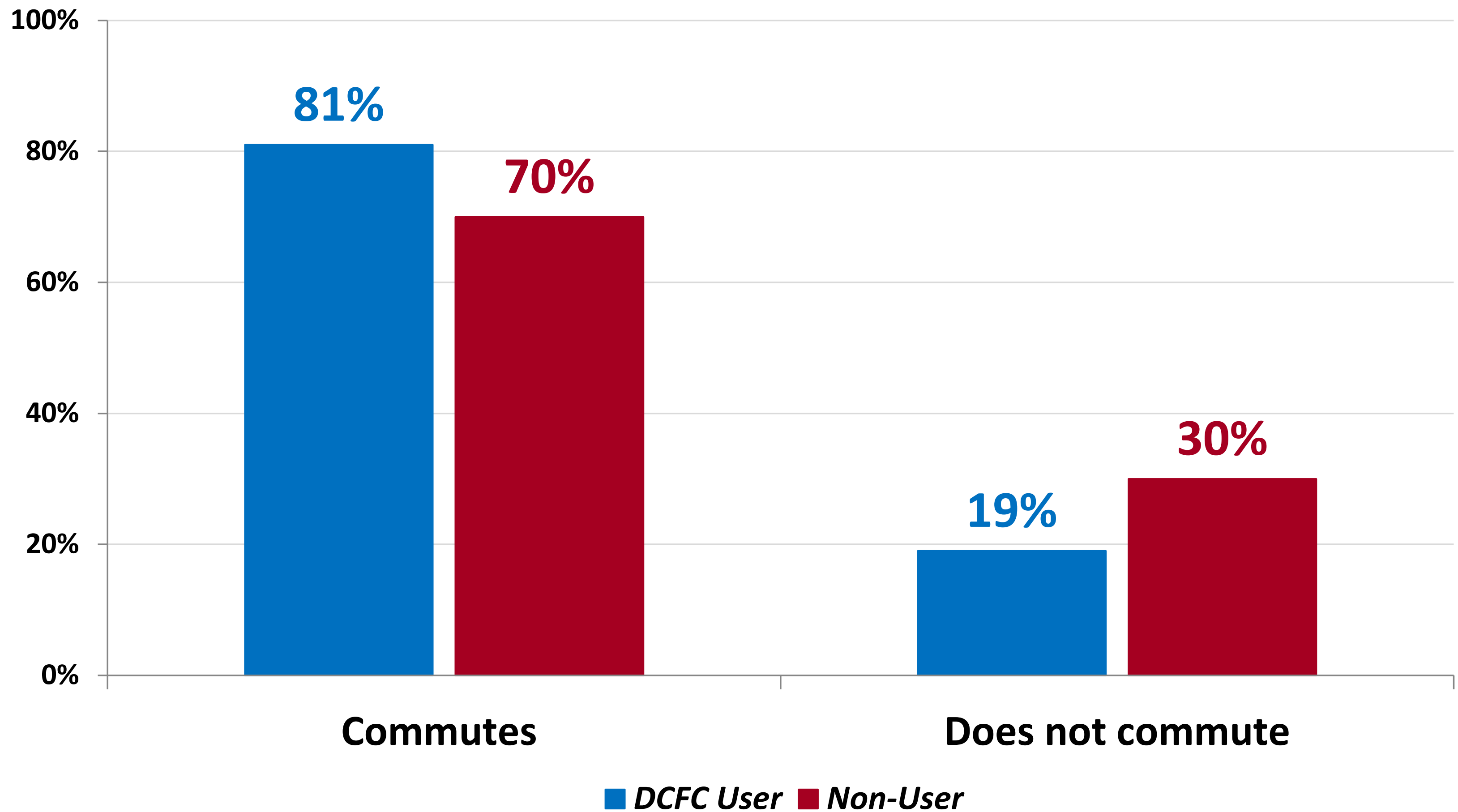
DCFC users are slightly more likely to use their BEV for all occasions



Is your household's electric vehicle used for all occasions (commutes, shopping, weekend outings, etc.)?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

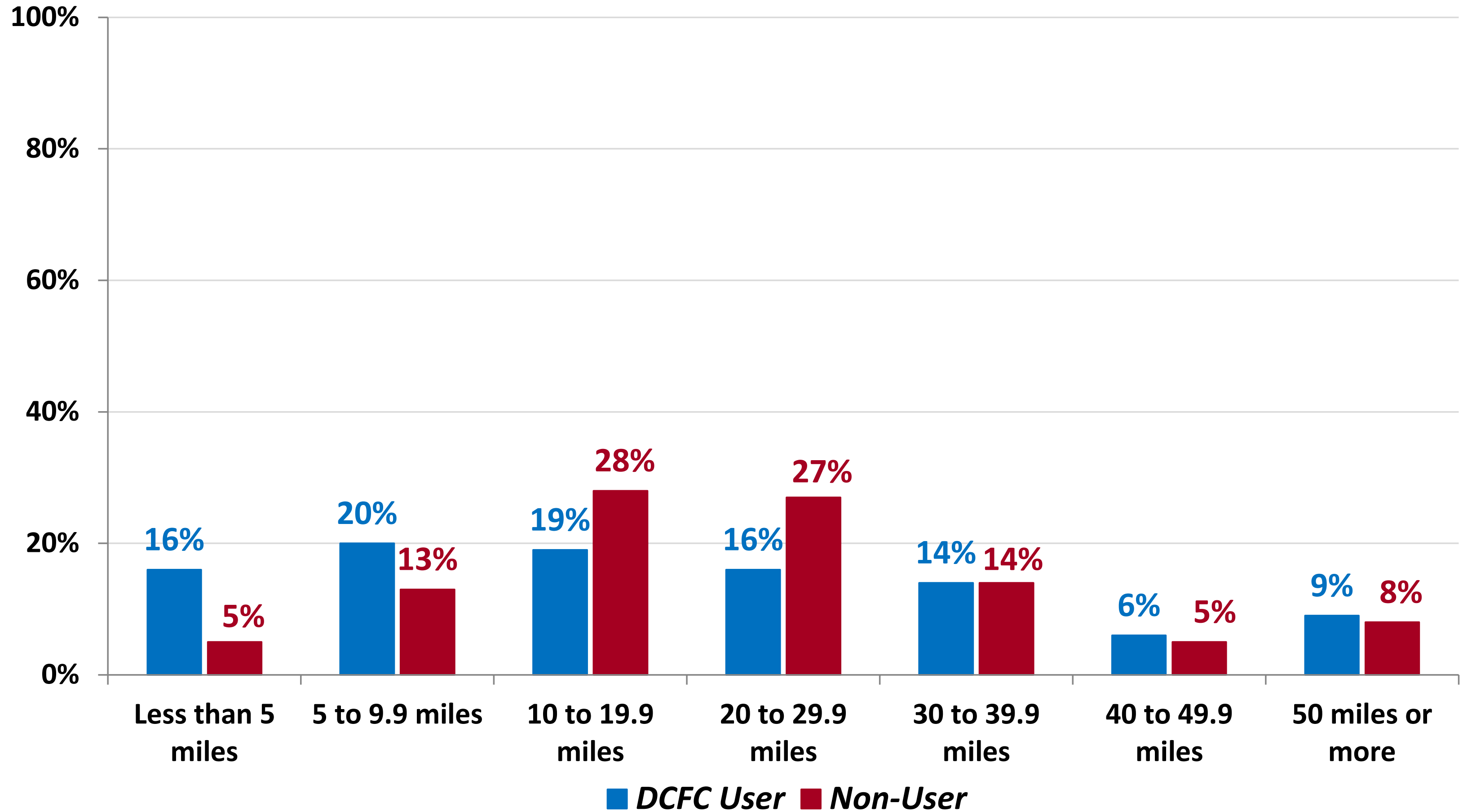
DCFC users include a larger proportion of commuters



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

How do you typically commute to work?

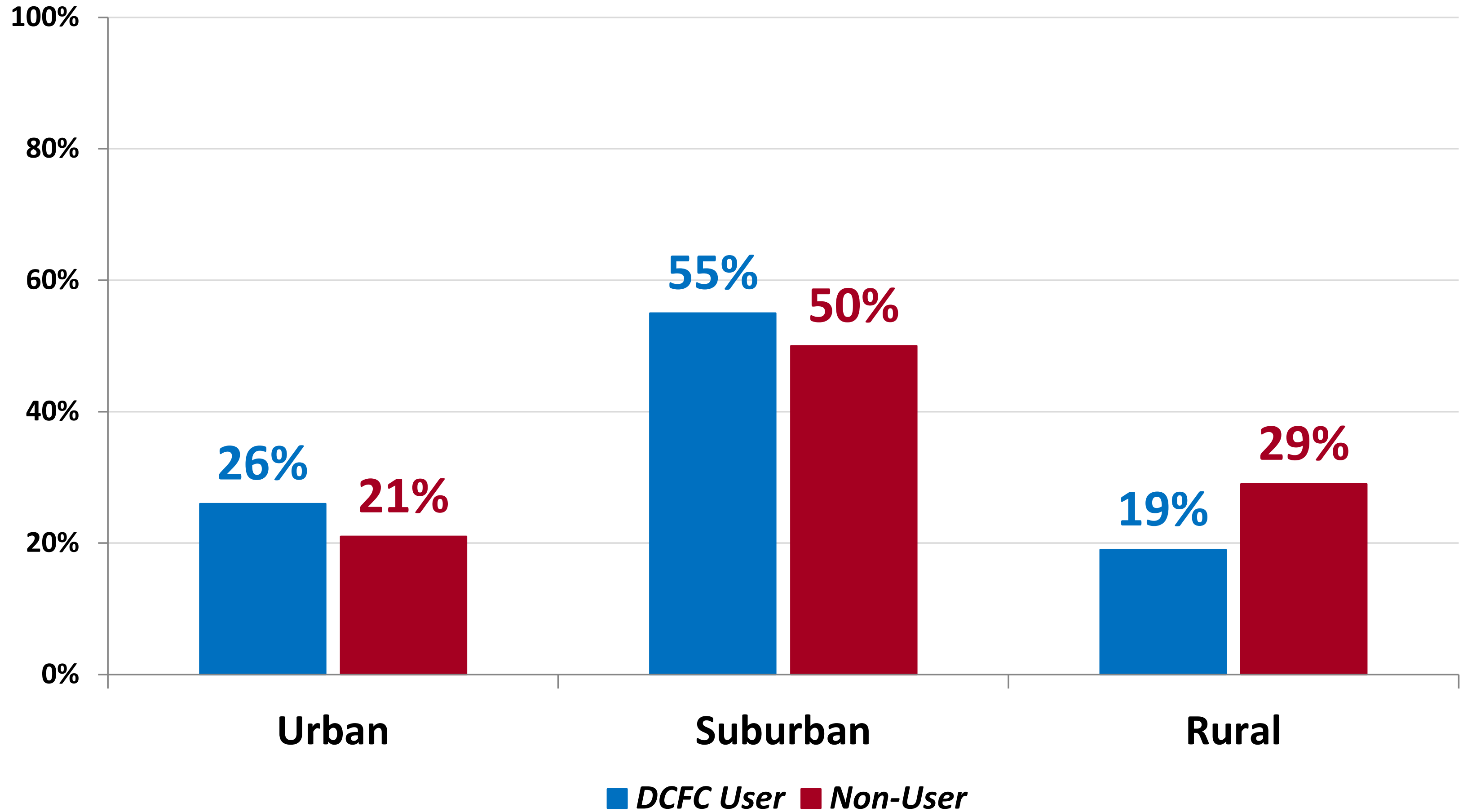
DCFC users tend to drive a shorter commute for work



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Approximately how far is your typical daily commute in both directions?

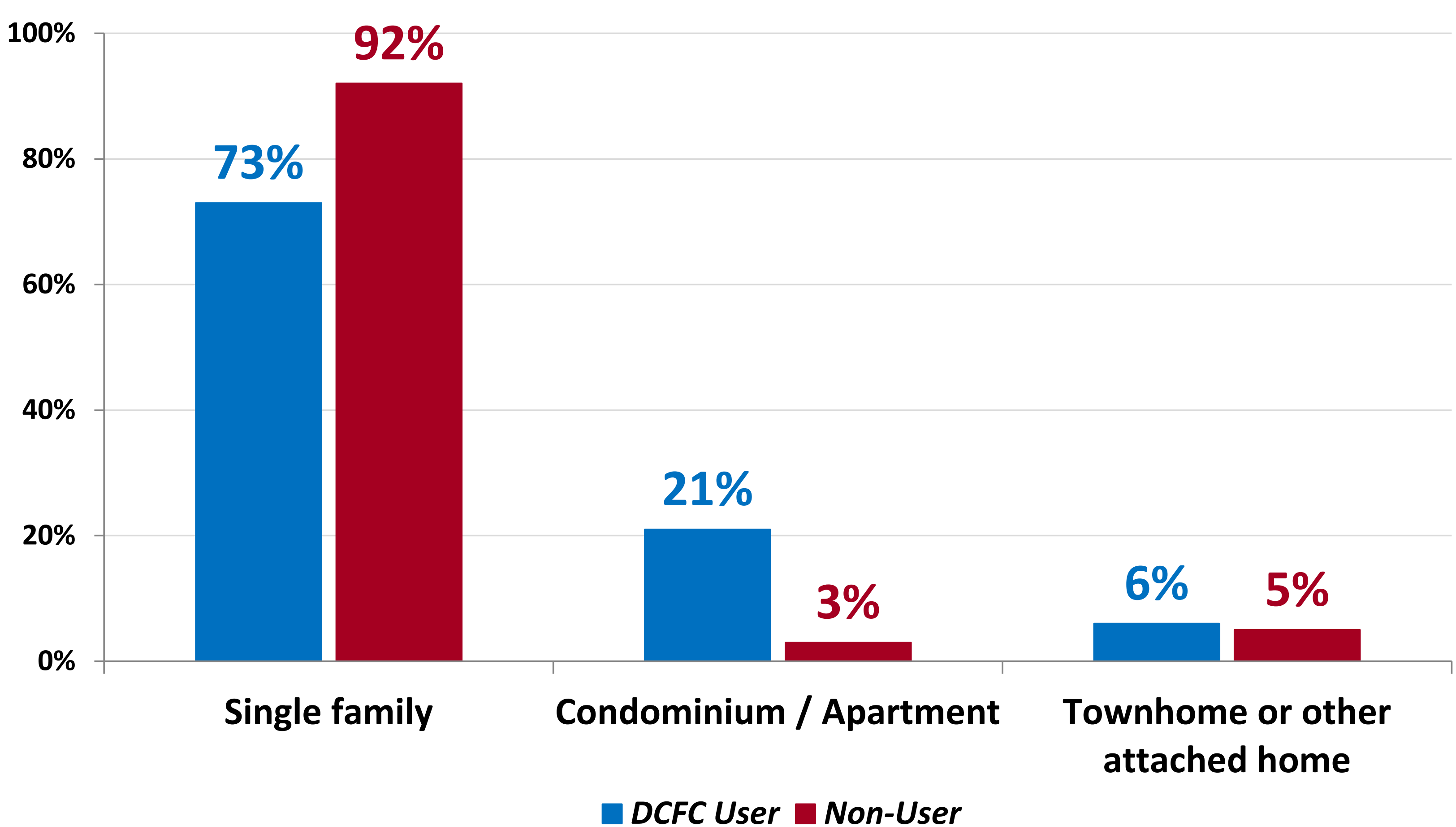
DCFC users are made up more of urban and suburban residences compared with non-users



Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Is the area where you live…?

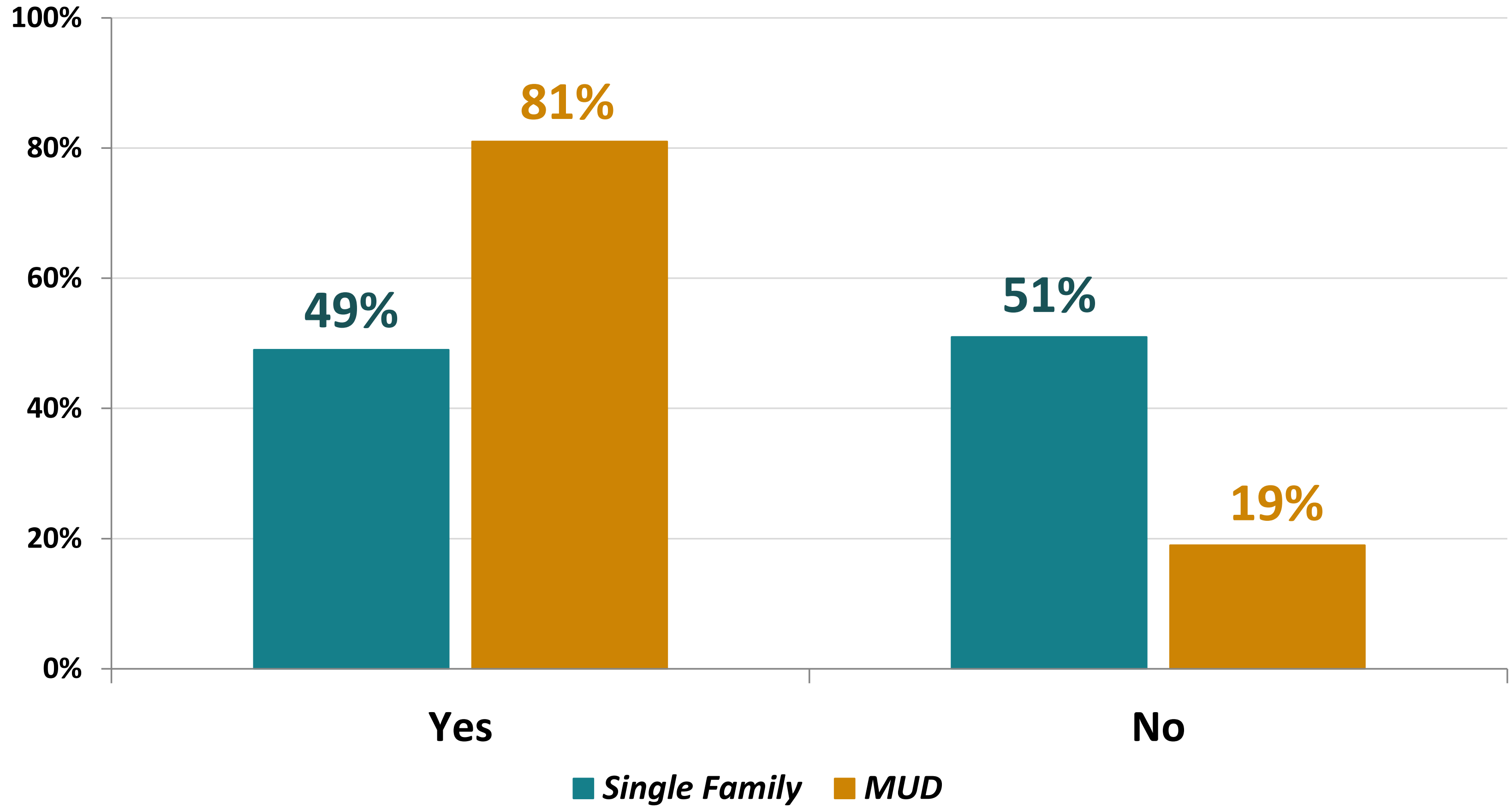
Higher representation of DCFC users among MUD residents



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Which best describes your primary residence?

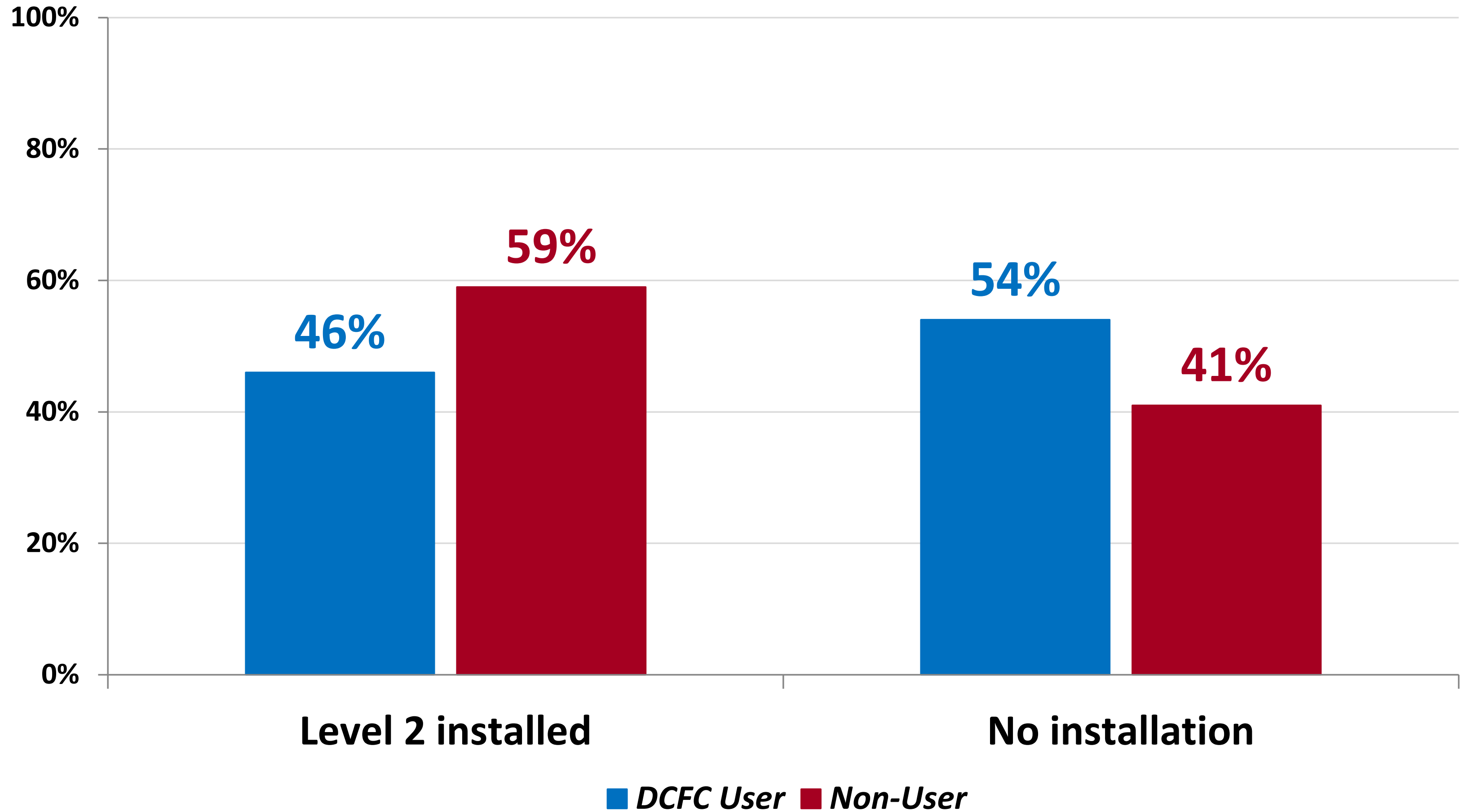
Majority of MUD residents surveyed have used a DCFC on their BEV



Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Have you ever used a DC Fast Charger on your BEV?

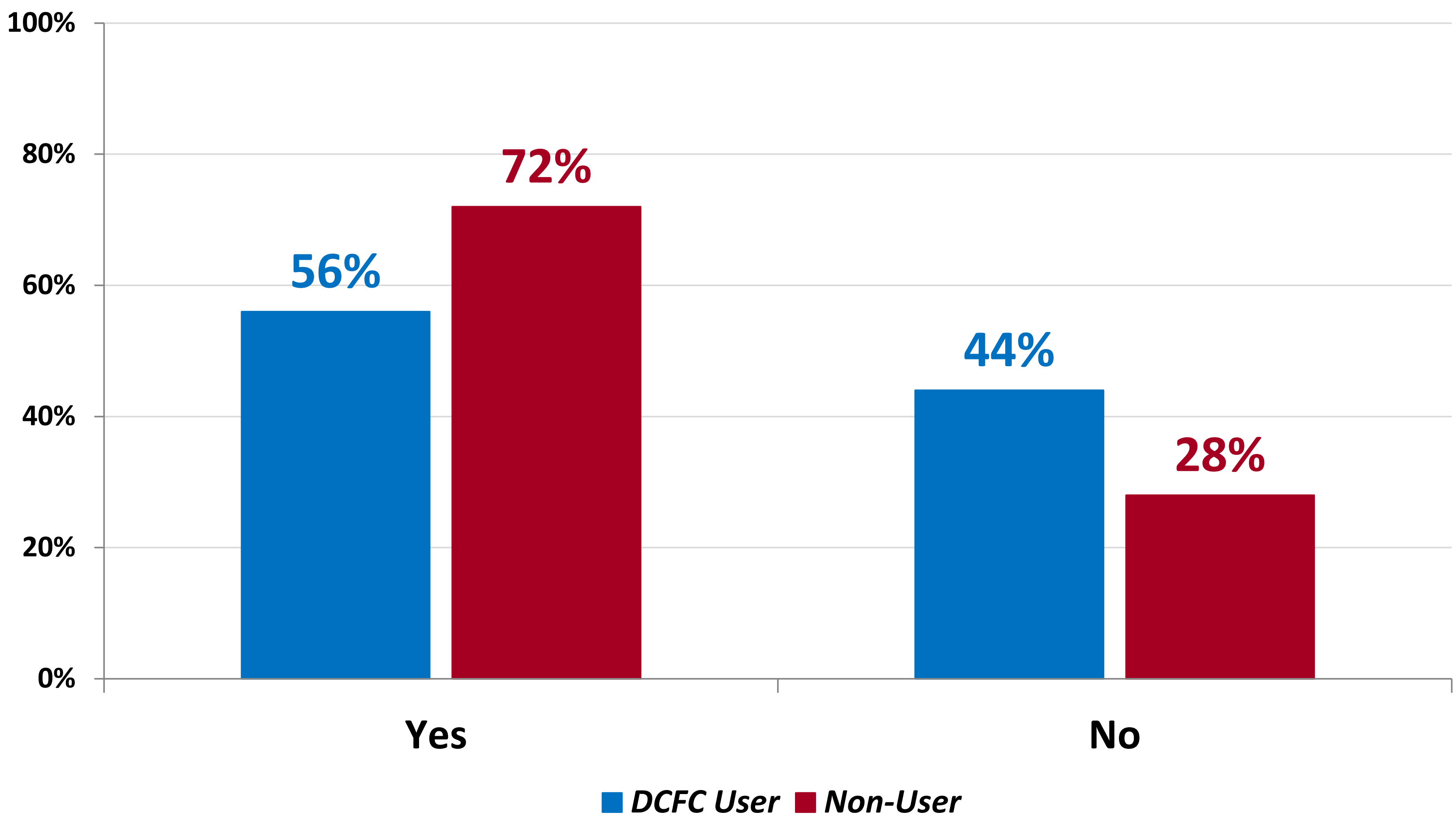
DCFC users are less likely to have a Level 2 charger installed at home



Do you have a Level 2 charger installed at your home?

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

DCFC users are less likely to have home solar



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Does your home have solar / photovoltaic (PV System)?

[NEM, CGS, or CSS vs. Solar Water Heater or No]

Contents

- Residential Customers (Non-EV)
- Hybrid Vehicle Drivers (HEV)
- Plug-in Vehicle Drivers (PEV)
- DCFC User Comparison – BEV Segment
- Appendix – Supplemental Results

Other information customers want to learn

Selected verbatim comments

- Battery life and cost of replacement
- Can a charging system be set up at the residence at an affordable price?
- installing a charging station at a condominium property
- Can they be charged on any standard electric outlet, say in my garage?
- How far can you drive on one charge?
- Free parking at airport and zipper lane access, anything else?
- How much money would I save using an electric vehicle over a conventional vehicle for about a year's time period?
- a specific goal and timeline plan for the state to convert to electric vehicles

Is there any additional information you would like to learn about electric vehicles? Please select all that apply.

Reasons affecting decisions to purchase or lease an electric vehicle

Selected verbatim comments

Yes, but no longer planning on doing it

- cost savings do not pencil out
- No way to charge it at home
- Cost of vehicle and cost of electricity in Hawaii.

Yes, but I am undecided at this time

- Gas is cheap now.
- will contemplate when trading in current vehicle
- Vehicle range seems small even in Hawaii.

No, but I am open to the consideration

- I'm not ready to buy another car yet.
- do not know how it fits into my lifestyle on Big Island
- The cars, except for Tesla, are UGLY!!!!!

No, and I have no intention to do so

- Not cost effective in Hawai‘i
- I drive a biodiesel powered car and am happy with it
- Simple. Do the math. It is an overhyped mode of transportation that has distance limitations, recharging constrictions in both time requirements and available sites. Remove the subsidies and "free" charging cost(s), factor in the real cost of operation, repairs, eventual battery replacement costs and you are left with an extremely expensive method of transportation with no soul. It is an appliance only....a modern day Edsel.

Other EV purchase or lease influences

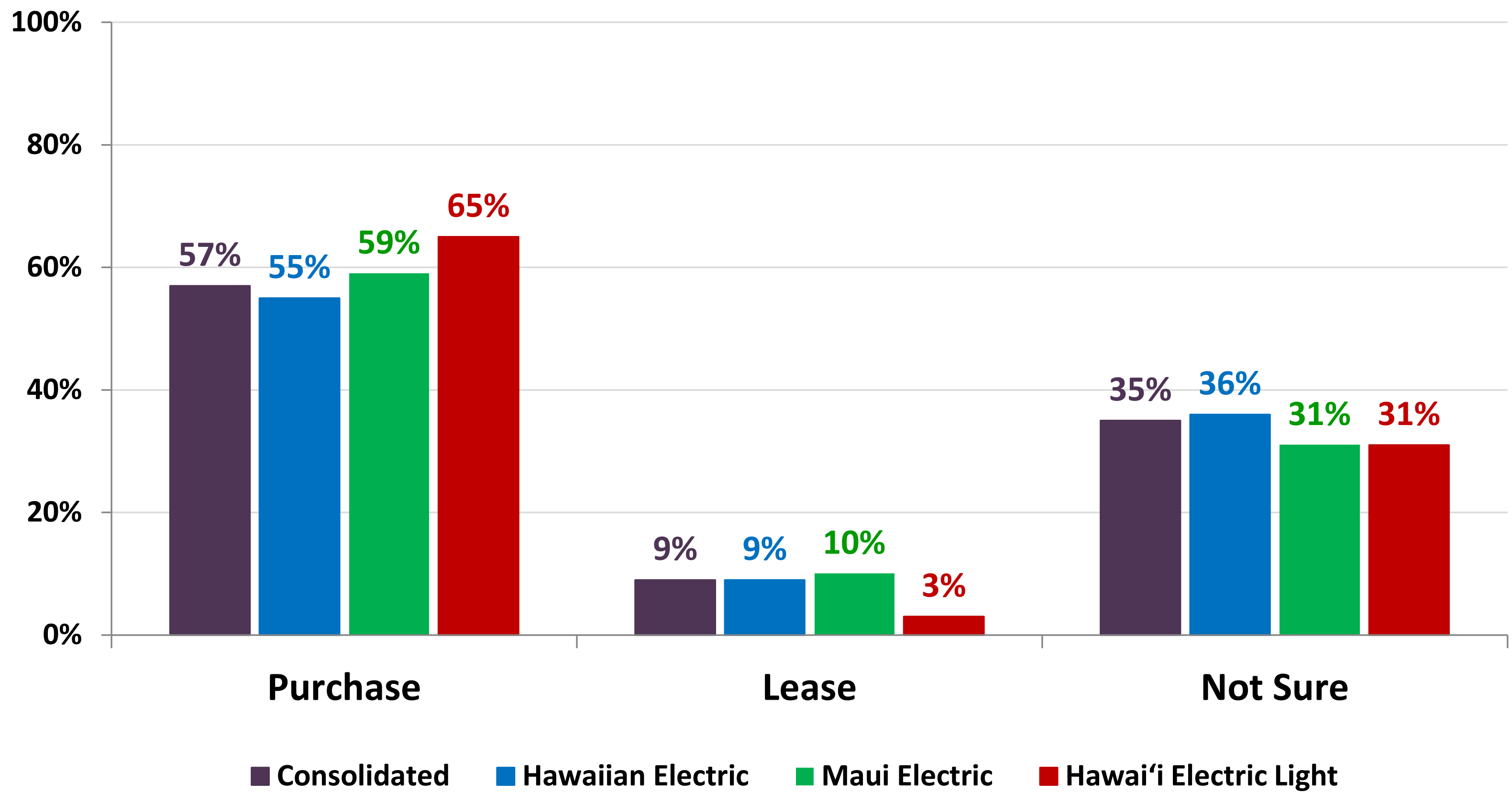
Selected verbatim comments

- a 4x4 EV would be good, with better range
- Electric SUV
- EV mini Vans
- If I can add more solar roof panels in order to charge an EV
- battery reliability / reduced cost for battery replacement
- shorter charging time
- Charger at my condo complex home
- fool proof way of disposing of the batteries and electrical parts that does not pollute or damage the earth
- If electricity produced has smaller carbon foot print.
- Only if the dealer offers 0% interest for 72 months

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

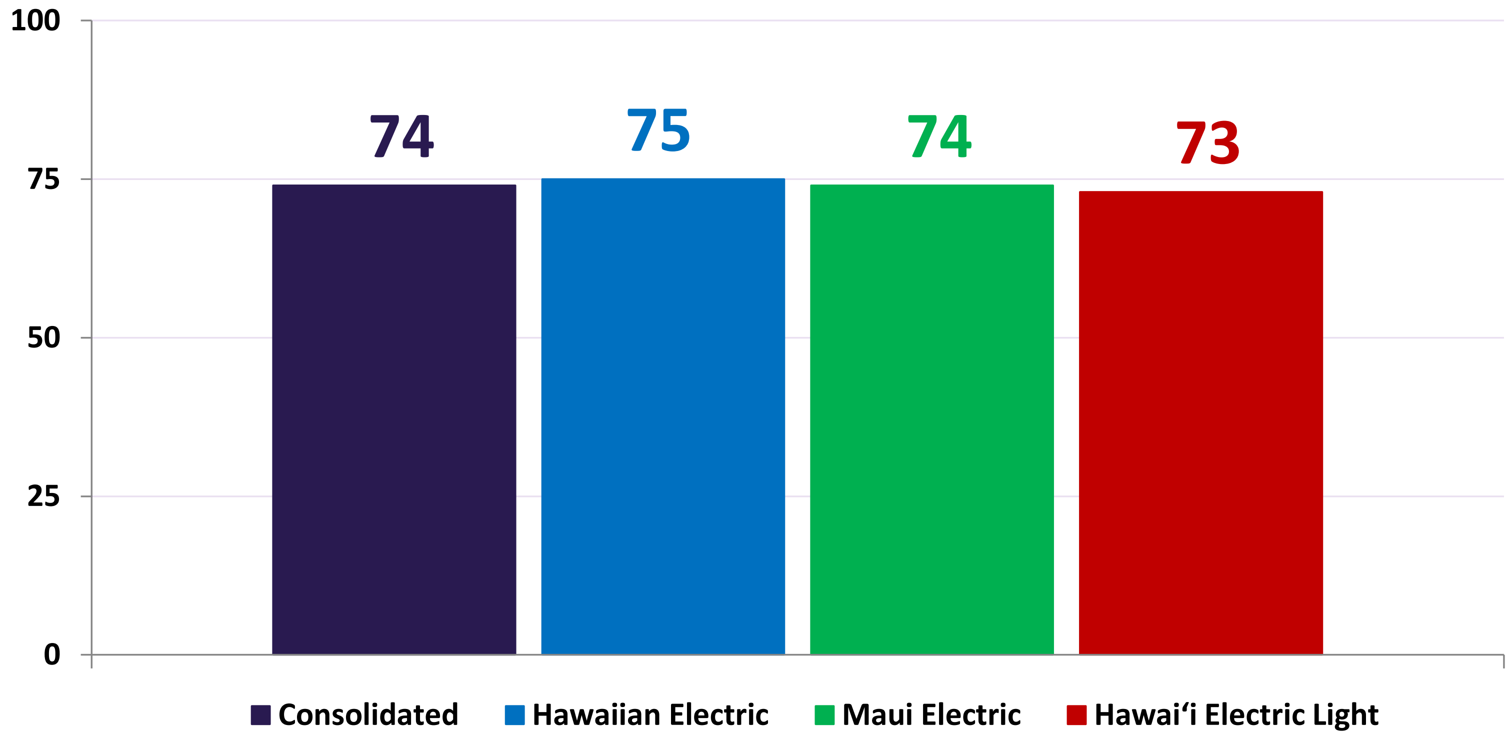
What would make you more likely to purchase or lease an electric vehicle? Please select all that apply.

Among those considering an EV, more are likely to purchase than lease



Would you be more likely to purchase or lease an electric vehicle?

Support for the transition to electric vehicles scores in the mid-70s



Scores rescaled to 100 from a 0 – 10 rating scale

- 10: Strongly Support
- 0: Strongly Oppose

Overall, what is your level of support for the transition to electric vehicles for Hawai'i's energy future?

Residential Customers (Non-EV)

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Final comments by support levels

Selected verbatim comments

Support: 7 - 10

- Excited by the Tesla revolution and enthusiastic CEO Elon Musk
- At this point I think that an EV is only cost effective in Hawai`i for people who have PV solar at home.
- Battery technology is evolving rapidly. It is only because of the expense and quick obsolescence of current battery technology that I haven't committed to buying an electric vehicle yet.
- Put in tax credits like California
- Make the bottom line attractive, like a net after credit and discounts cost about the same as an econo-car, ~$20k, and I'm there!

Support: 4 - 6

- As long as our electricity is generated by fossil fuel there really isn't a "green" advantage to electric vehicles.
- I've heard positive and negative things about EV. I think it's a great alternative to gas vehicles because of the environment.
- charging is unimportant as I make my own electricity
- I prefer rural living which is not appropriate for EV.

Support: 0 - 3

- Please stop drinking the EV Kool-Aid! And stop forcing it down consumer throats!
- Anything needing taxpayers subsidies is not viable.
- Transition to all electric vehicles by government force is total B.S.. The market should determine the pace of transition as it becomes more affordable and more reliable…

Please provide any final comments you may have regarding the topics covered throughout this survey.

Initial influences to get a hybrid

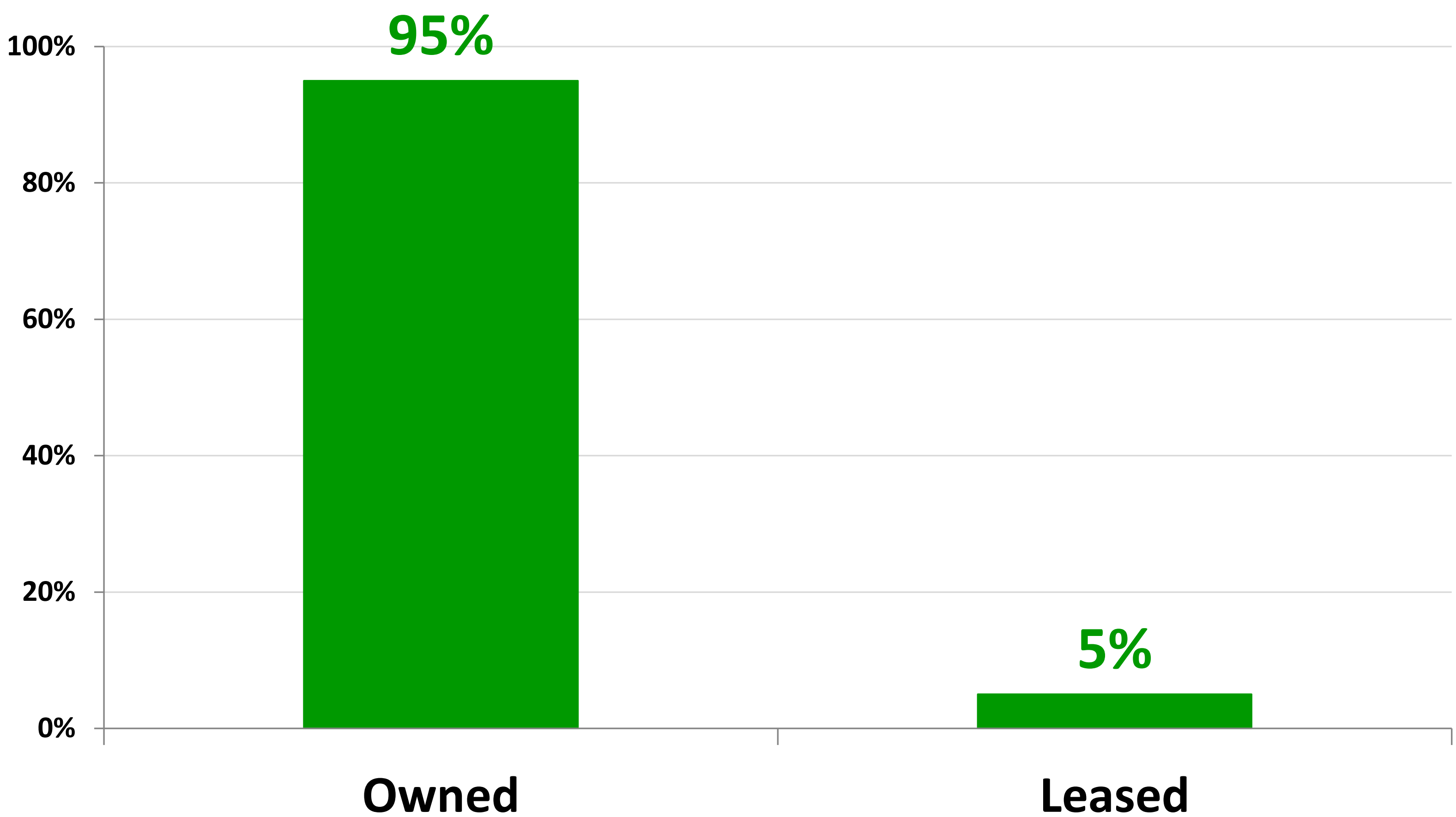
Selected verbatim comments

- hybrids were new then, and Toyota was the most advanced at the time
- Saving a significant amount of money in fuel.
- Gas prices were soaring and we were travelling about 200 miles once or twice a week
- Mileage and doing what I can until the BEVs have better range.
- I liked the increased mpg and power. The vehicle is a pleasure to drive. Still watching the all electric models and plug in hybrids.
- I needed a car that seated seven, and I could get a hybrid Highlander for not that much more than a minivan, and it had AWD and got better mileage.
- I drive long distances but a plug-in wouldn't work here on this island because of not enough plug-in places.

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

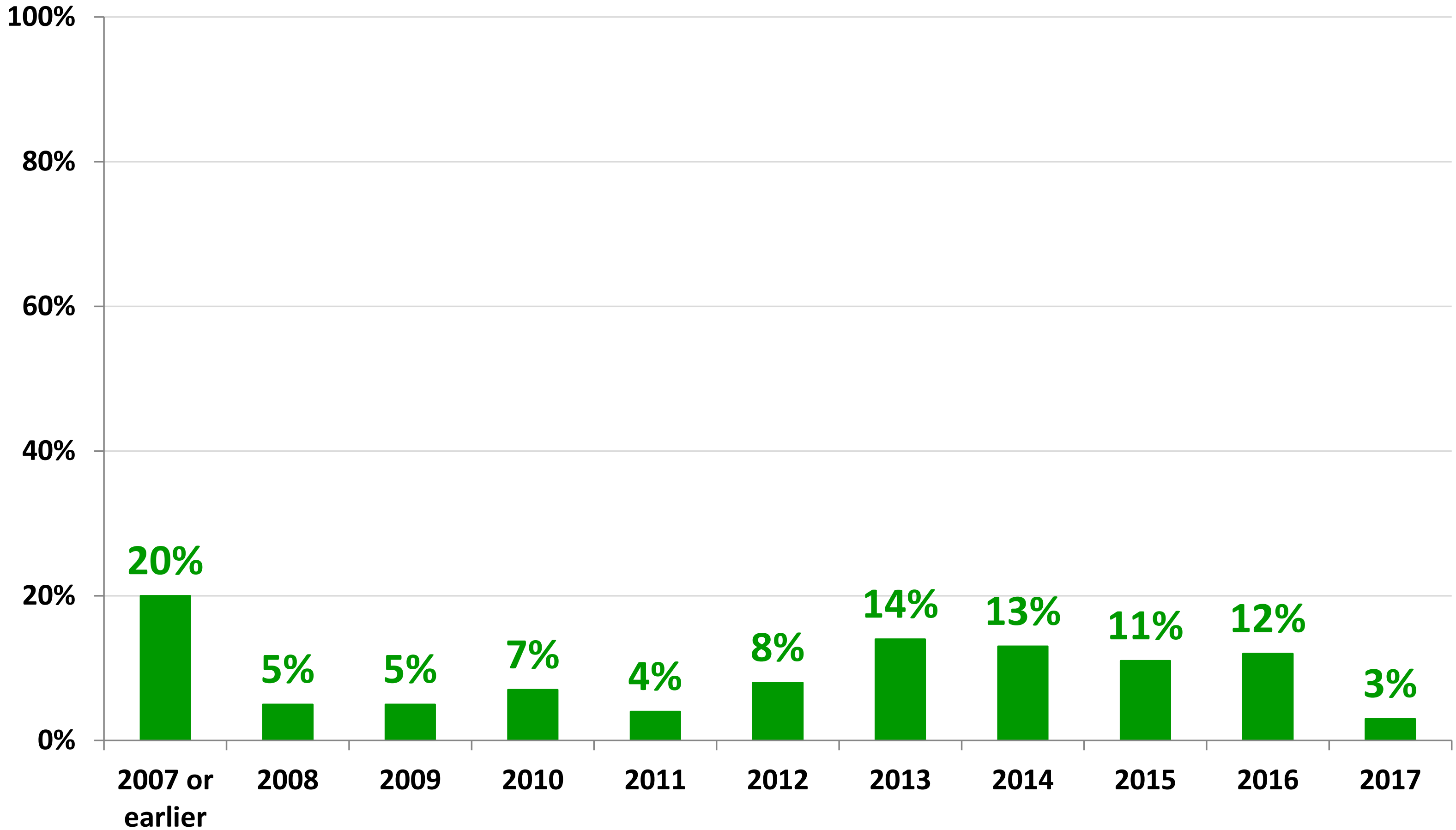
What initially influenced you to get a hybrid electric vehicle?

Most own their hybrid



Is the hybrid electric vehicle owned or leased?

Four out of five hybrids are less than 10 years old



What year is your hybrid electric vehicle?

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

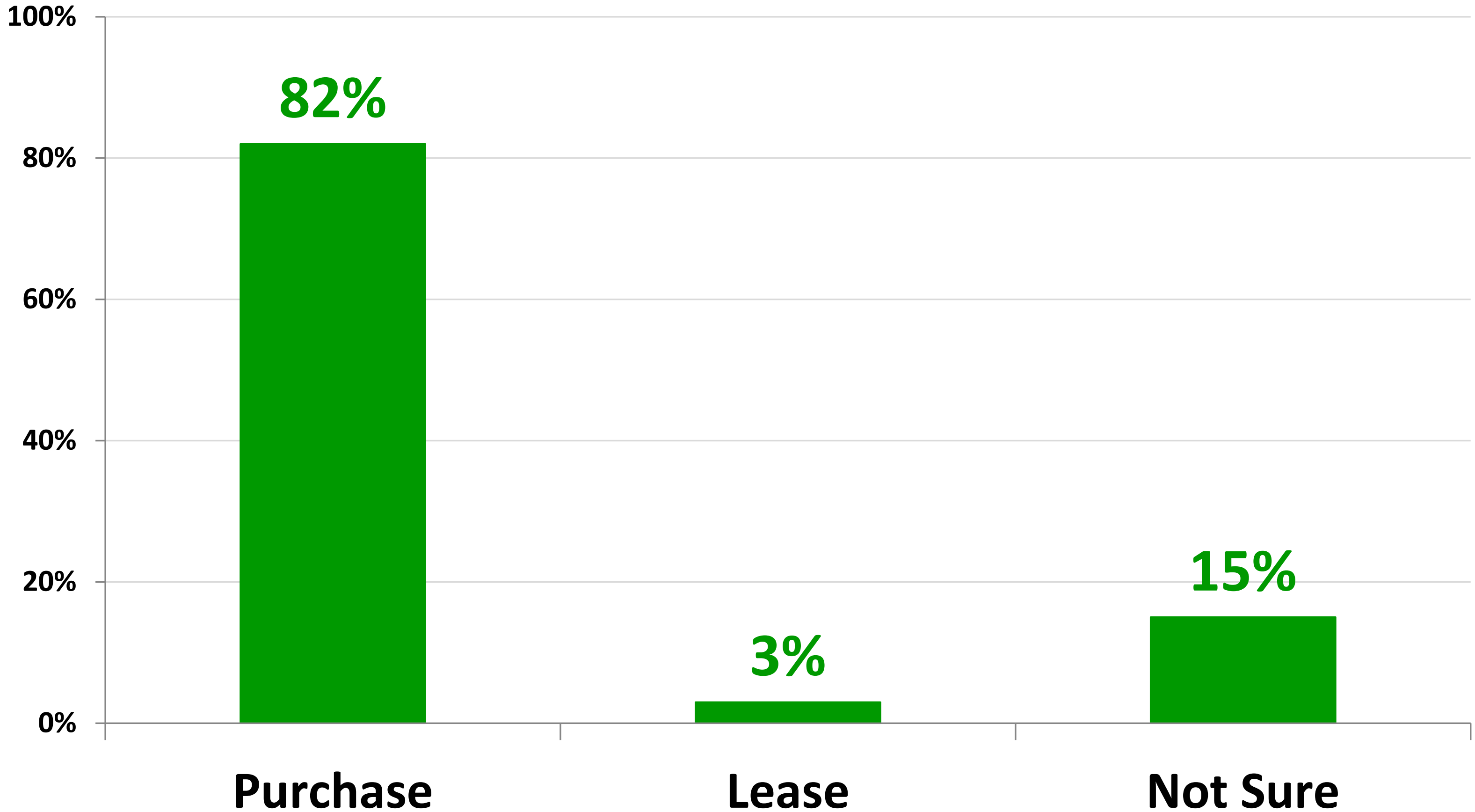
Reasons why plug-in hybrids and battery EVs are not being considered for their next vehicle

Selected verbatim comments

- For distance, we still feel the hybrid is best. But if the range of an all battery vehicle gets to the point where we could drive to and back from Hilo, then ok.
- As long as electricity in Hawaii is primarily generated using petroleum, all-electric vehicles are delusional re: pollution and fossil fuel independence.
- Plug-in electric's still use fossil fuels for power. Don't know of any battery vehicles that get all power from renewable energy sources
- The complexity of dealing with HECO to install a home charging station at home is scary.
- I live in a condominium and would not have access to a "plug".
- When I next purchase, we will purchase another Prius.
- Still enjoying the Prius at 120,000 miles. But will probably get another similar.
- Toyota doesn't make one yet.

Are you considering the purchase of either a battery electric or plug-in hybrid as your next vehicle? [No – please explain]

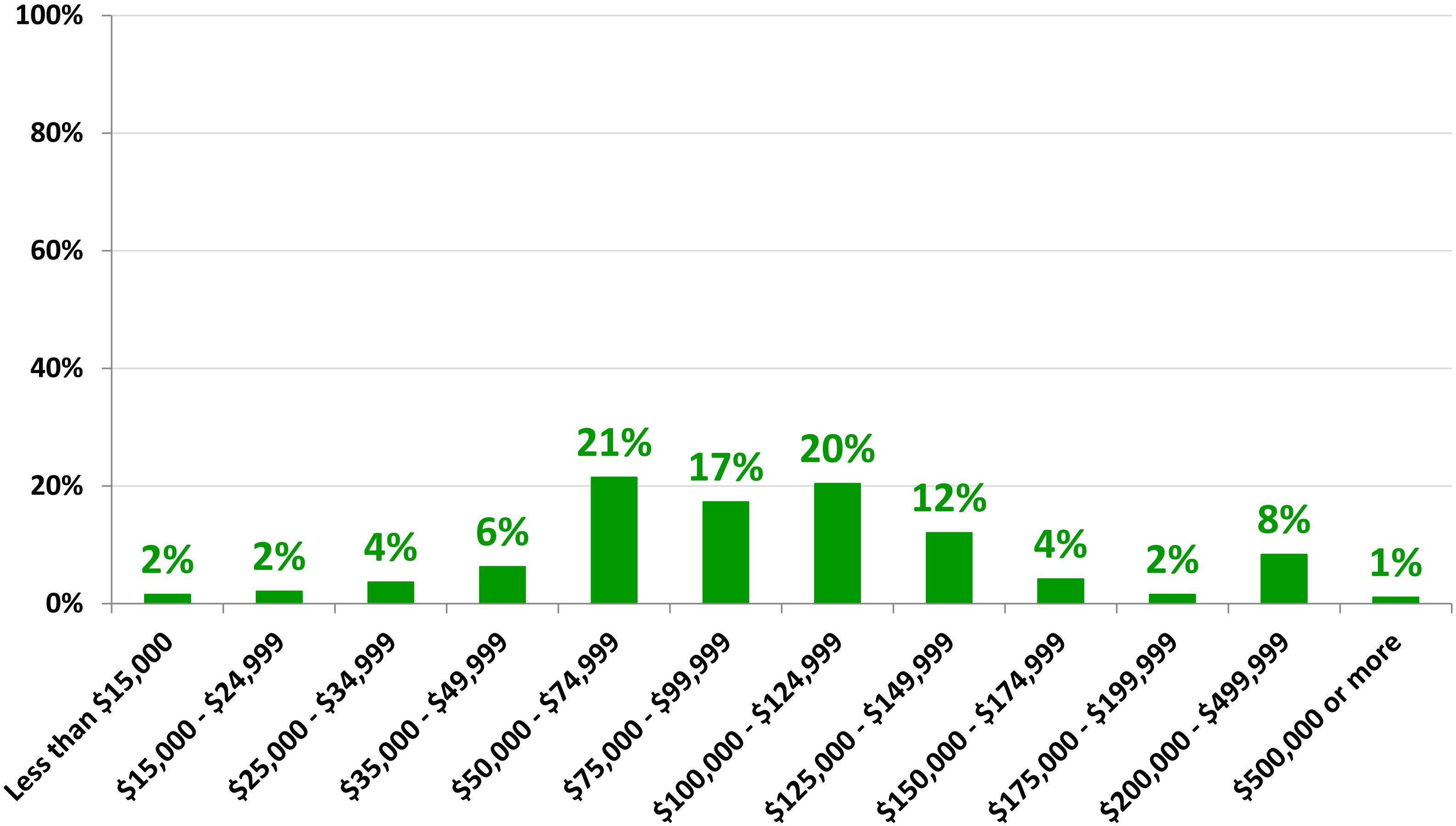
Most will likely own their plug-in hybrid or battery electric vehicle if they switch from their hybrid



Would you be more likely to purchase or lease your next electric vehicle? [if plug-in or battery EV is considered]

Hybrid Vehicle Drivers (HEV)

Median HH income of the hybrid drivers surveyed is $96,590



Please choose the group that represents your annual household income.

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Final comments from hybrid drivers

Selected verbatim comments

- Support for EV depends upon how the electricity is generated - fossil fuels vs wind/solar.
- Hawaii's cost of electricity is a major deterrent to people getting green vehicles.
- At this time, the full electric vehicle cannot go very long distances, and I wouldn't consider. My friend has a Leaf, and he cannot go around the island of Oahu.
- We are waiting for better batteries (like the Tesla) before we buy an electric car.
- I have waited many years for an affordable electric vehicle with adequate range to be produced. Tesla Motors says they are now coming out with that vehicle.
- I have paid $1000 to reserve a Tesla 3.
- Another issue was not enough public stations to recharge...now there are more which is why I'd consider.
- Although my interest is in electric battery vehicles, I am also interested in hydrogen fueled vehicles (fuel cells).

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Please provide any final comments you may have regarding the topics covered throughout this survey.

Influences to get an EV

Selected verbatim comments

- Free charging since we generate excess electricity with our PV system
- To achieve goal of completely fossil fuel free life using only electric tools, vehicles, and being net PV contributor to grid.
- Want to go as green as possible
- Environmental concerns. Trying to reduce my carbon footprint.
- When I first leased the Nissan Leaf, gas prices were almost $5/gal. I thought with the electricity and lease cost, I would save money on my vehicle.
- We wanted to buy electric vehicle for several years but the increase in range for the 2017 Leaf made me think about this year. The offer by HELCO to discount the price by $10,000 made us decide to buy now.
- Gas prices on Molokai.

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

What influenced you to get an electric vehicle?

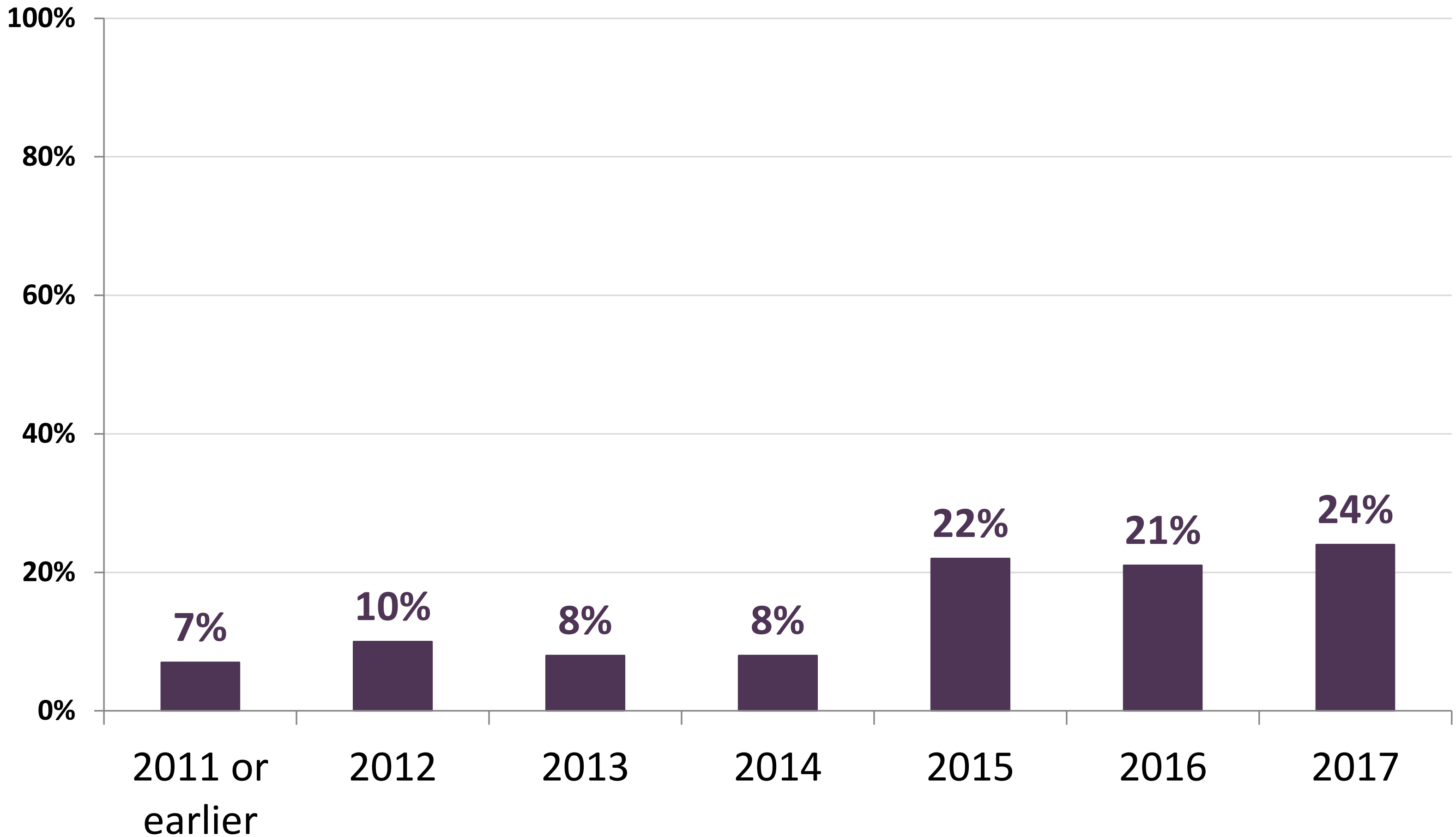
EV Charging Routine

Selected verbatim comments

- Usually charged from 9 p.m. to 6 a.m. using the slow charge.
- Some at home but it takes too long, mostly charging stations twice a week.
- home charger (level II), set on timer to start charging @ midnight (80%). Also at mall free charging stations
- I just purchased this vehicle, so it is difficult to say. I expect that I would normally charge it during the day while the PV system is producing excess electricity.
- Charge @ home after 9pm using my time of use meter, usually until 7am. Sometimes use public chargers, but my range is over 250 miles on a full charge, so I do not rely on outside sources for top off of car.
- We go to the mall every Friday for dinner. We charge the car while we eat. When we're done, we go home. Sometimes, I charge it on the way home from errands at other locations (county building, etc.)
- After each use. I had a Plugless Charging System installed. This is a induction charging system, so the car is automatically charged every time it is parked at home.
- With the 2017 Leaf with a better battery system we now charge the car about every three days vs the old Leaf which was charged almost daily.
- Drive to work (under 10 miles) return home, plug it in.

Please provide an overview of your typical charging routine.

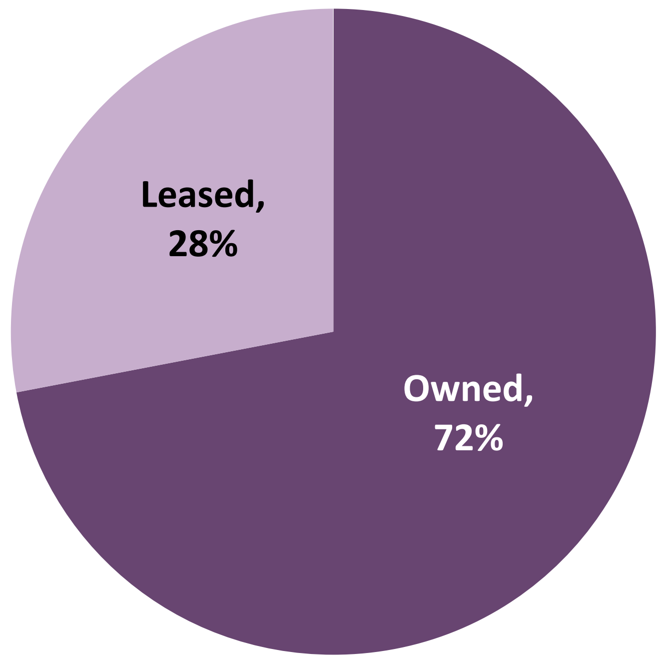
Quarter of the EVs represented are five years or older



What year is your plug-in hybrid or battery electric vehicle?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

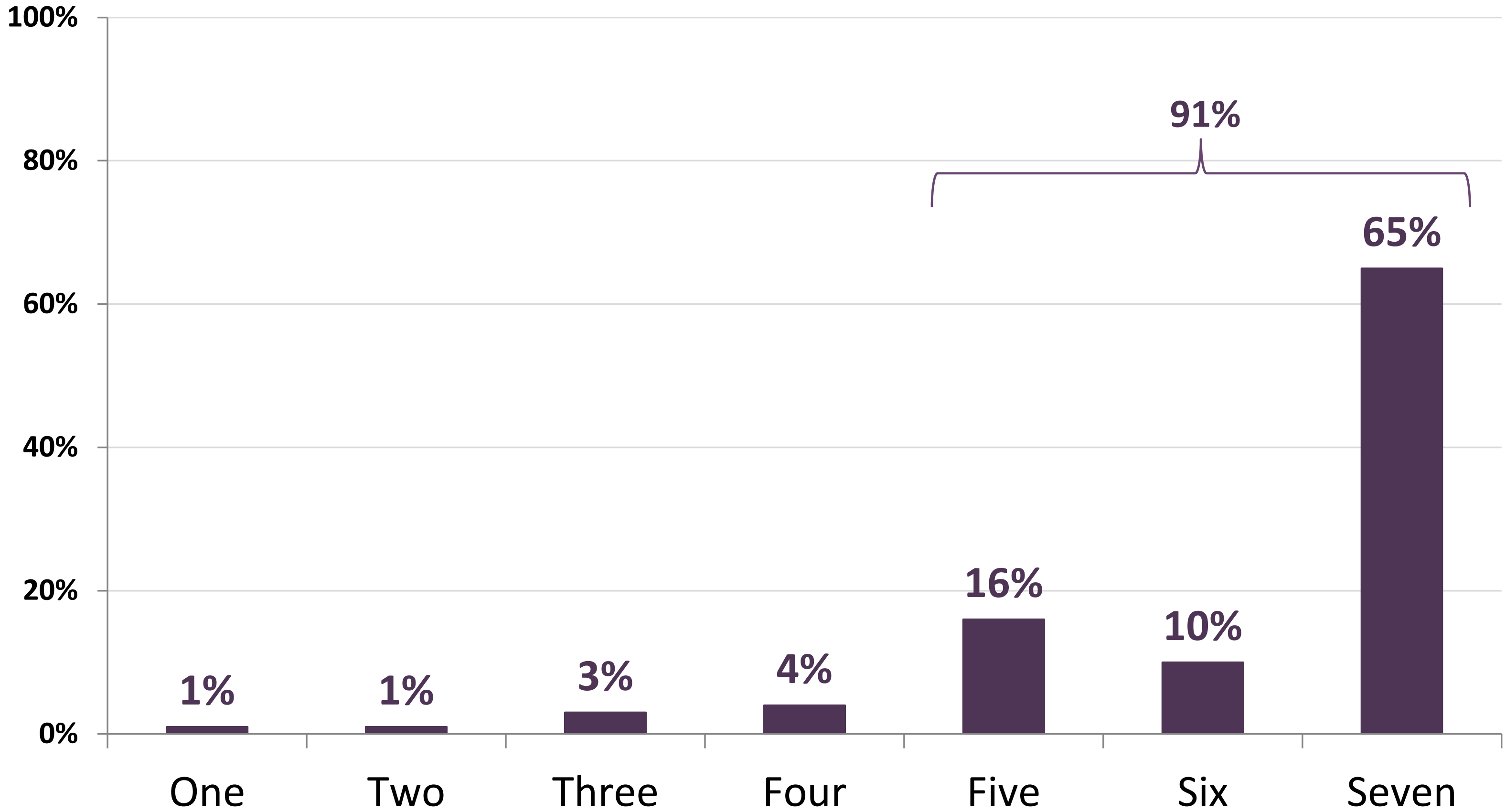
Most own their electric vehicle



Is your electric vehicle owned or leased?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

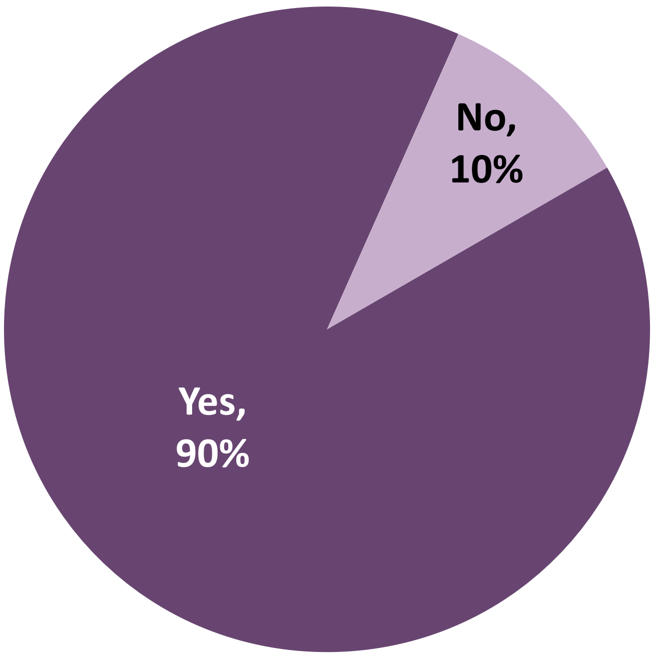
Nine out of ten drive their EVs at least five times a week



How many days a week is your household's electric vehicle driven?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Majority drive their EV for all occasions



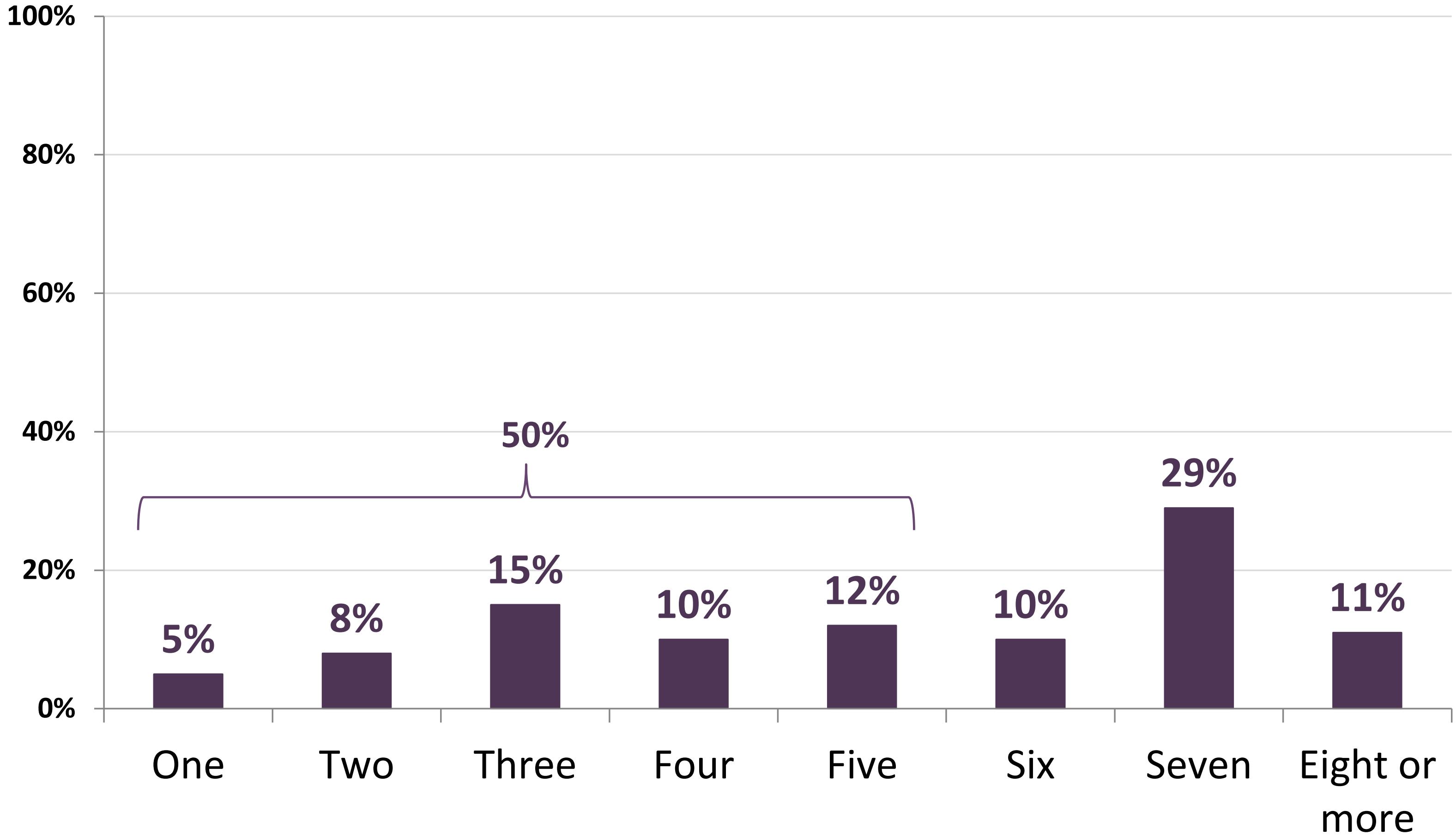
For what reasons is your EV not used when you need to travel?*

- Range anxiety is real. battery deteriorates over time (6 years) and car currently has range of under 50 miles (down from 90)
- Availability of charging stations while out. Not having enough energy.
- long trips
- mileage worries... unable to recharge, due to not working chargers or not having the right card to unlock chargers
- It's a motorcycle. Can't take the kids on it.

Is your household's electric vehicle used for all occasions (commutes, shopping, weekend outings, etc.)?

***Selected verbatim comments**

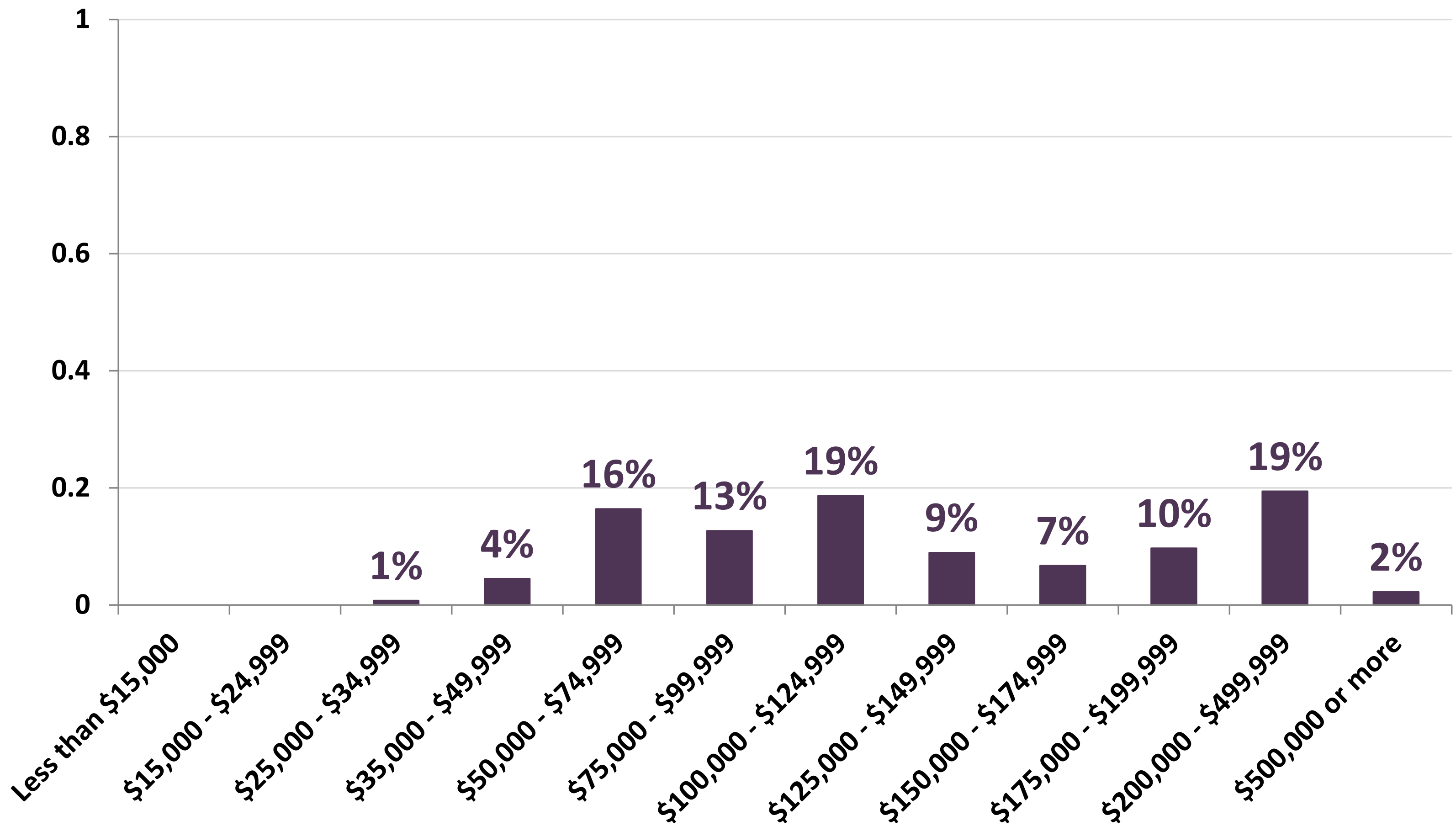
Half charge their EV five times or less per week



During a typical week, how many times is your electric vehicle charged?

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

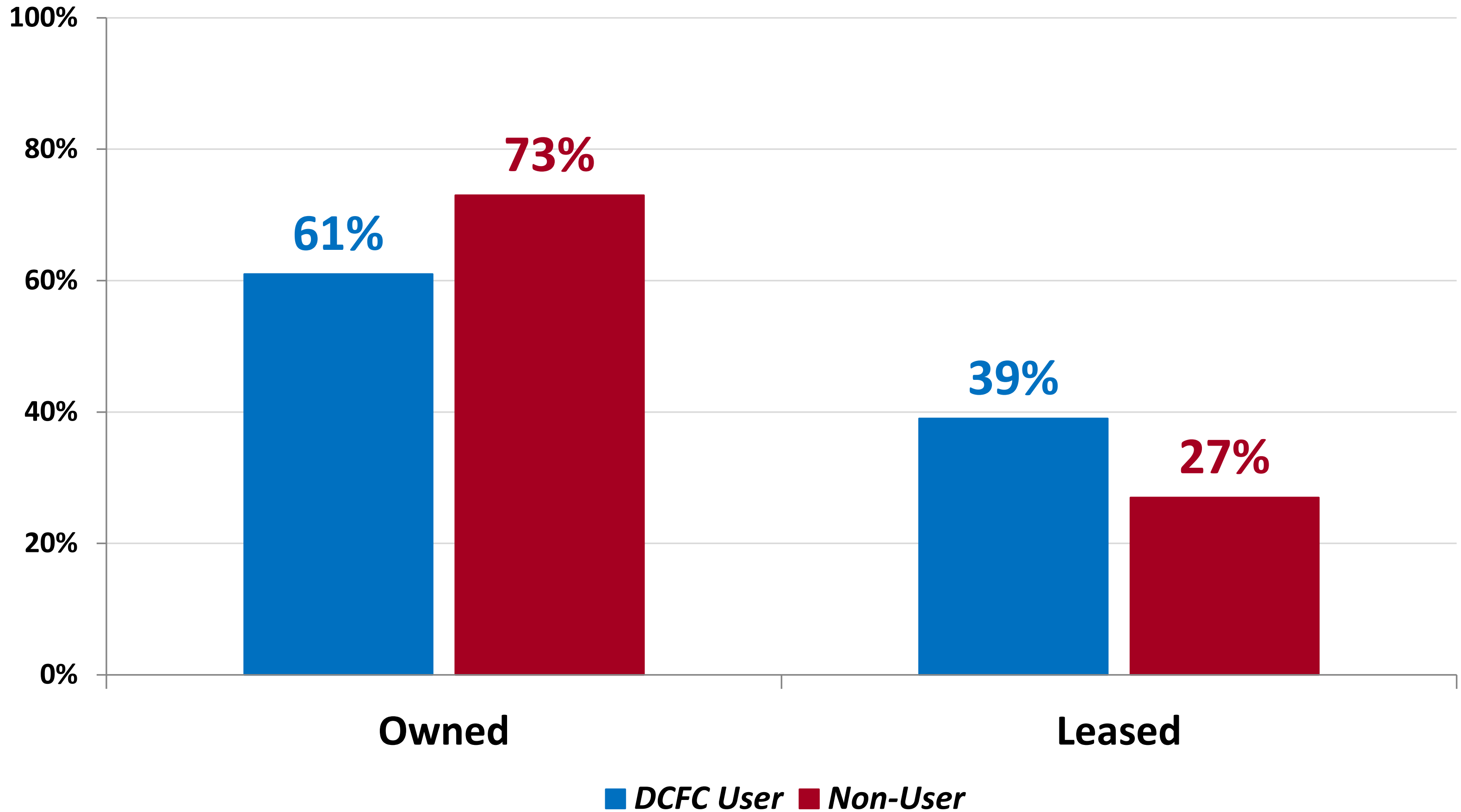
Median HH Income of the EV Drivers surveyed is $120,999



Please choose the group that represents your annual household income.

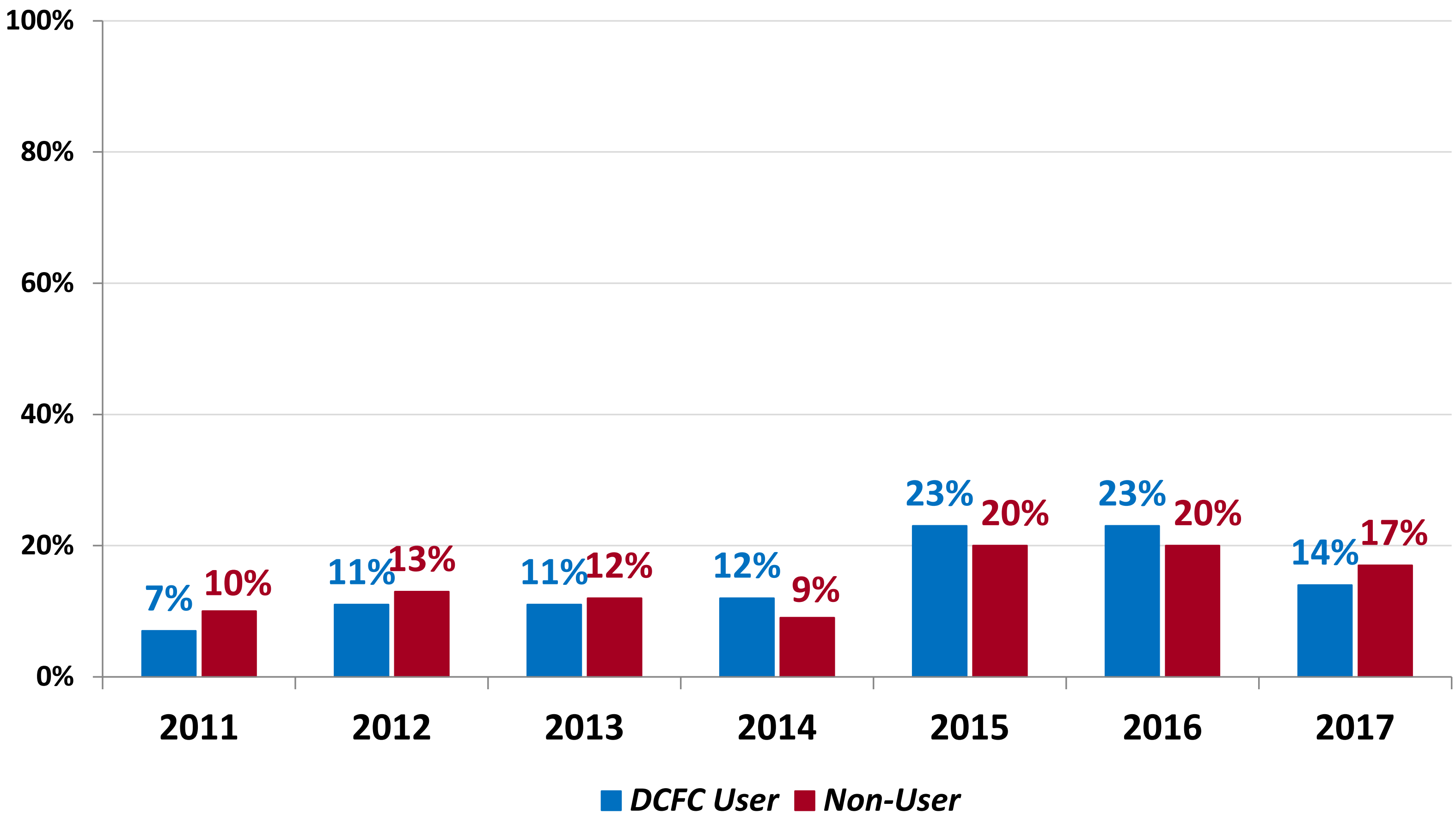
Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Two out of five DCFC users lease their BEV



Is the electric vehicle owned or leased?

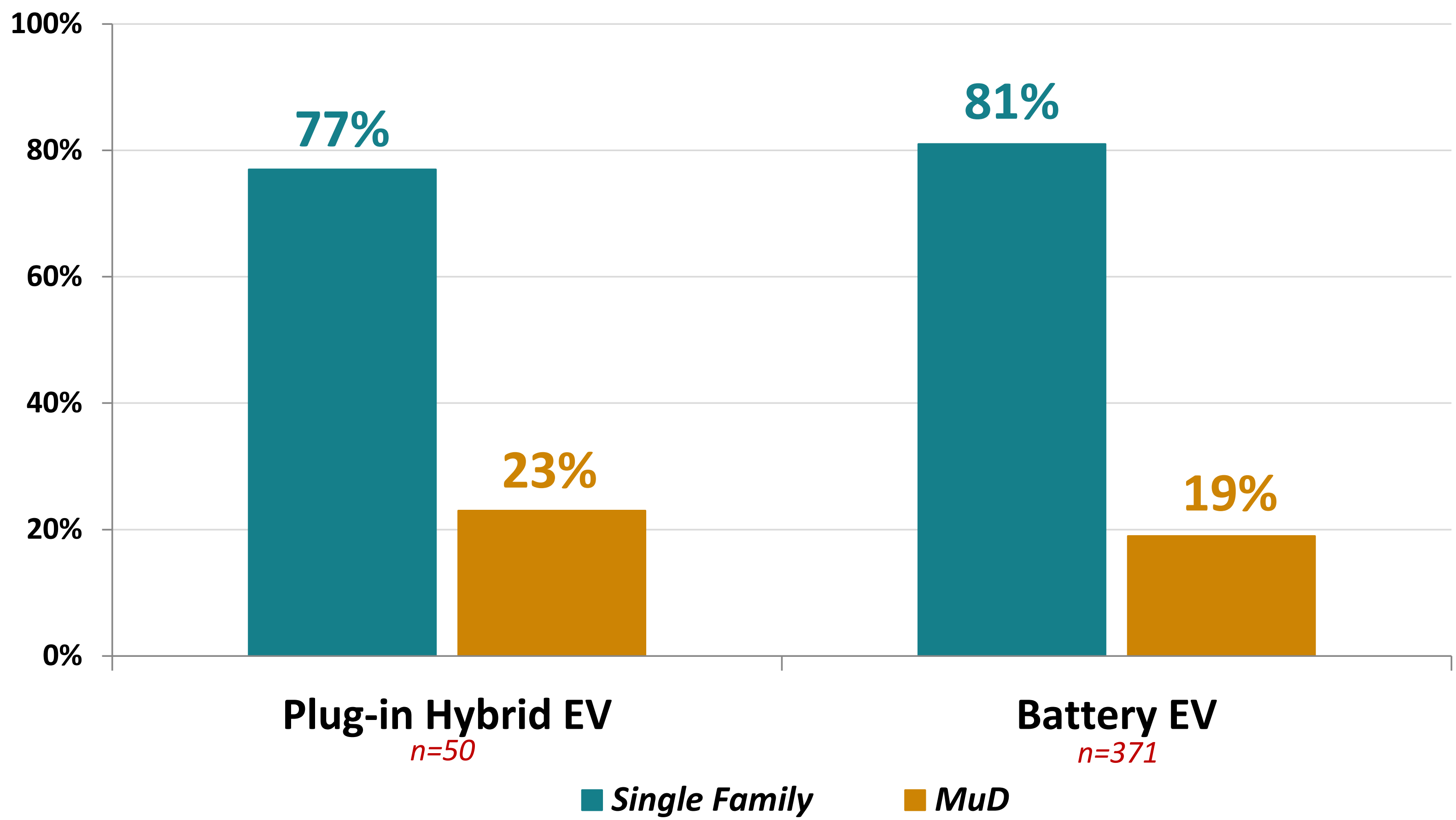
Year of BEV Model



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

What year is your electric vehicle?

Higher EV adoption among survey respondents in single family dwellings*



*Combined samples from DCFC User Comparison and Plug-in Vehicle Drivers survey efforts

Which best describes your primary residence?

Hawaiian Electric
Maui Electric
Hawai‘i Electric Light

Attachment B

Electric Vehicle Pilot Rates Report

Electric Power Research Institute

Interim Report on

Battery Storage with DC Fast Charging

ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage Paired with Electric Vehicle DC Fast Charging

Demonstration and Analysis in Hawaii

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Energy Storage Paired with Electric Vehicle DC Fast Charging

Demonstration and Analysis in Hawaii

3002012710

Technical Update, March 2018

EPRI Project Manager

M. Evans

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Principal Investigator
M. Evans

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ABSTRACT

This interim report documents initial findings based on 2017 data collected from a project pairing stationary energy storage with a DC fast charger (DCFC) at Kapolei Commons, a shopping, dining, and entertainment center in West O'ahu. The primary purpose of this stationary energy storage system is to reduce peak power drawn from the grid with as little impact to customer electric vehicle (EV) charging times as possible. This report examines the efficacy of stationary storage in combination with a DCFC at achieving HECO goals and meeting customer charging needs. The report also provides an overview of the state of the stationary energy storage system. The following key topics are addressed:

- Assess grid impact/benefit
- Evaluate customer impact/benefit
- Assess performance, durability, cycling dispatch
- Determine usage and grid impacts
- Quantify application benefits and validate methods using analytics benefit tools
- Examine deployment and operation experience

Keywords
Stationary energy storage
DC fast charger (DCFC)
Electric vehicle (EV)
Grid impacts

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ELECTRIC POWER RESEARCH INSTITUTE

Deliverable Number: 3002012710

Product Type: Technical Update

Product Title: Energy Storage Paired with Electric Vehicle DC Fast Charging: Demonstration and Analysis in Hawaii

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PRIMARY AUDIENCE: Utilities, especially Hawaiian Electric Company (HECO)

KEY RESEARCH QUESTION

How does the inclusion of stationary energy storage with a DC fast charger (DCFC) impact the grid and the customer electric vehicle (EV) charging experience?

RESEARCH OVERVIEW

Three types of data from the installed charging system—1-minute power quality (PQ) monitoring data, 1-second battery management system (BMS) data, and charging event data—were collected for the months of November 2017 and December 2017. This data was cleaned, processed, and visualized to clarify how much customer time was lost/saved as a result of an imposed 23-kW limit on power from the grid and the inclusion of stationary energy storage. Additionally, the effectiveness of the overall DCFC system for meeting the maximum grid power requirement was assessed.

KEY FINDINGS

- Over the two-month period, the addition of stationary storage allowed the DCFC to deliver power to customer EVs at a higher rate than would normally be allowed by the distribution infrastructure, reducing the total customer charging time by an estimated 21.8 hours.
- The average power delivered to vehicles at the test site was still 77% of that of comparable chargers nearby.
- Reduction of charging time in the future will depend on whether the energy capacity of stationary storage is sized to meet future increases in EV energy capacity.

WHY THIS MATTERS

The impact to the grid from a growing EV market combined with higher charging power and greater vehicle energy storage capacity will need to be addressed. DC fast charging demand involves a load with very tall, thin peaks and a very low load factor. This demand could be met by the traditional distribution power capacity infrastructure, but the shape of the load lends itself well to stationary energy storage. The demonstration described in this report is a real-world exploration of the benefits and potential pitfalls of the stationary storage approach. While it is impossible to perfectly predict the future, the results of this study speak to the value of energy storage to hedge against future growth in charging power/energy and the risk of installing an undersized storage system.

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HOW TO APPLY RESULTS

This short interim report may be used by a utility or product designer interested in creating/installing stationary energy storage with EV chargers to reduce peak load while minimizing impact on customer charge times. The lessons learned here could be valuable for sizing a stationary storage system, understanding its use, or valuing this type of application.

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PROGRAM: P94: Energy Storage and Distributed Generation

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LIST OF TABLES

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1
STATIONARY ENERGY STORAGE PAIRED WITH DC FAST CHARGING

This interim report will serve to report initial findings based on the data collected in 2017 from the stationary storage paired with DC fast charger (DCFC) project at Kapolei Commons, HI. The primary purpose of the stationary storage is to reduce the peak power drawn from the grid with as little impact to customer charging times as possible. This interim report examines the efficacy of the stationary storage at achieving its goals and provides an overview of the state of the stationary storage. The research questions to be answered in this report are outlined below.

- Assess Grid Impact/benefit
- Assess Customer impact/benefit
- Assess performance, durability, cycling dispatch
- Assess DC fast charging usage and grid impacts
- Quantify application benefits and validate benefit methods using analytics benefit tools
- Assess deployment and operation experience

The data presented below represents three distinct data streams. There is 1-minute AC power data taken from the PQ monitor which represents the net power drawn from the grid by the DCFC and stationary storage. The battery management system (BMS) provides 1-second power information to/from the stationary storage and the vehicle. Finally, charging event data, including a timestamp, duration, and total energy transferred to the vehicle is also collected. For comparison and context, usage data from two similar, nearby chargers (Ward Ave 1 &2) are occasionally presented.

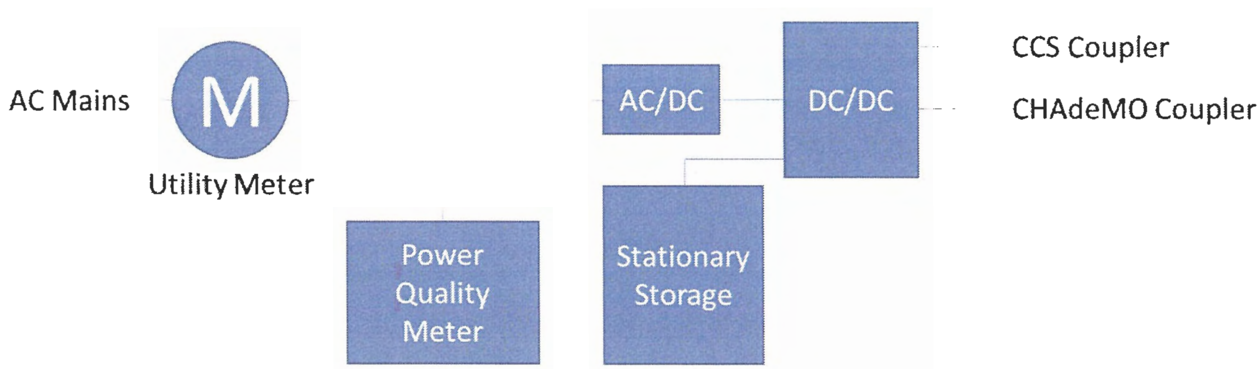

Figure 1-1
System Block Diagram

Power vs Time Profile

The effect of the stationary storage can be seen on a representative sample of the facility's power profile below. Before the stationary storage, the vehicle charger would draw a peak load of >40kW from the grid during this time period but because of the stationary storage's discharger, the peak load is limited to 25.35 kW. The 1-second BMS data is aggregated into 1-minute intervals for combination with the 1-minute PQ monitor data.

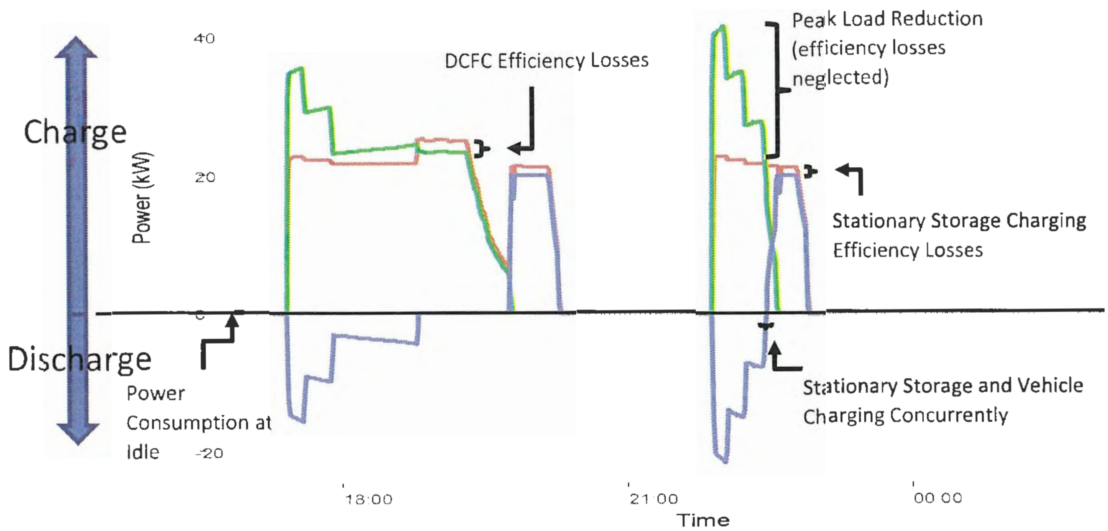

Figure 1-2
Representative Data Sample

The sign convention for the plot above is positive means power flow away from the grid, negative means power flow towards the grid. This contradicts the usual stationary storage sign convention because in this case, negative power means the stationary storage is discharging. This shows up in the state of charge of the stationary storage, shown below.

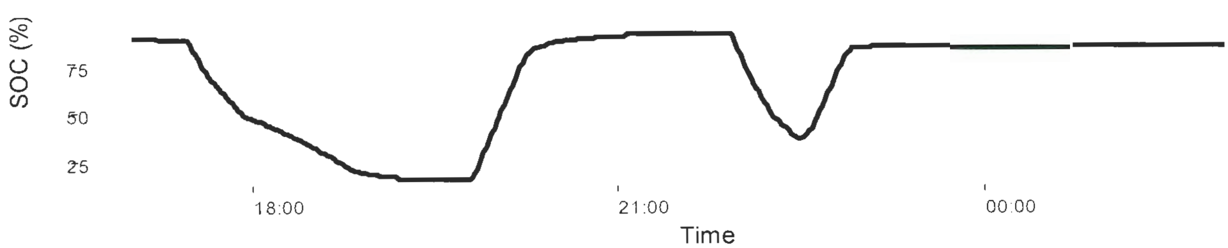

Figure 1-3
Stationary Storage State of Charge (SOC)

The data in Figure 1-4 represents the charging patterns for all three vehicle chargers for the 176 days between 08/17 and 12/2017. The chargers are used the most between 7am and. There are charging reports available for the Kapolei Commons charger for 119 of those days. On an average day, the Kapolei Commons charger is used 2.62 times, delivering an average of 22.88 kWh per charge (see Figure 1-4).

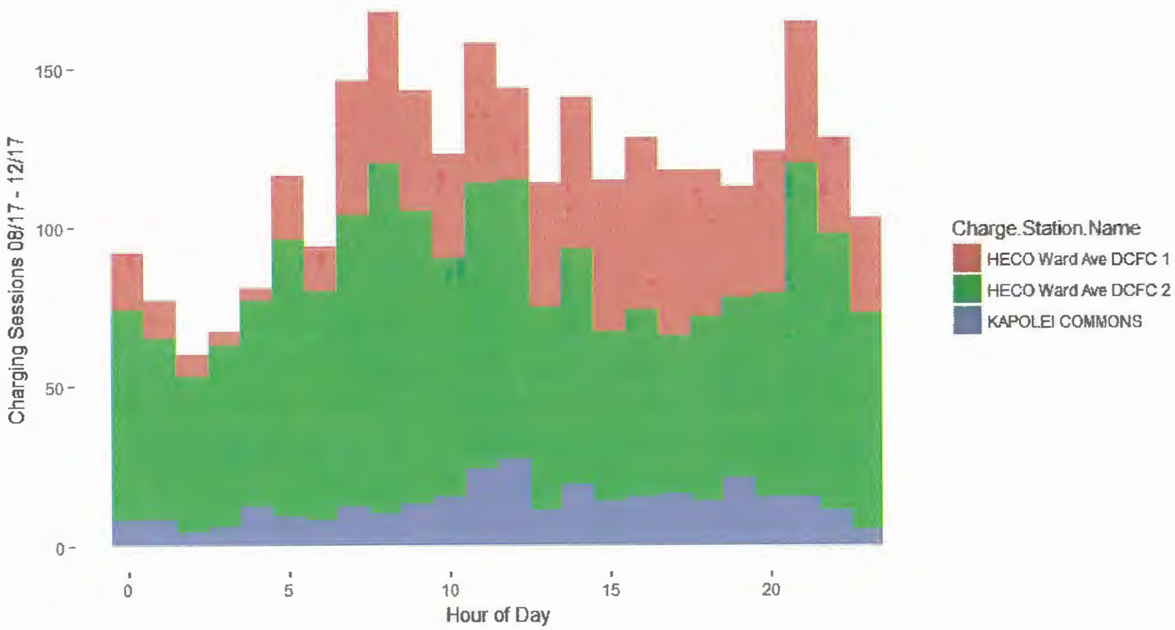

Figure 1-4
Charging Patterns for Kapolei Commons and Ward Ave. 1&2.

All of the chargers deliver a similar amount of energy per charging session.

Figure 1-5
Vehicle Charge Energy per Session

The average charging energy for one session is 22.88 kWh. The stationary storage was designed with small electric vehicles in mind, like Nissan Leafs, with on-board energy capacities around 24 kWh. However, vehicles with larger batteries have become more prevalent and so charging sessions consuming as much as 70 kWh are relatively common. These charging sessions are much more likely to deplete the stationary energy storage, causing the vehicle to charge solely from the grid at 23 kW. The effect of this on customer charging times is discussed in the customer impacts section below.

Power Consumption at Idle

When both the stationary battery and the fast charger are idle (consuming and producing approximately zero power), the average power draw recorded by the PQ meter is 58.3 Watts.

Efficiency

This section requires the note that there is an offset in the battery power data of -80W. In other words, when there are no power flows anywhere else in the system, the battery reports it is discharging at about 80W while not losing state of charge. Without correction, this indicates an efficiency greater than 1, which is impossible unless there is another source of energy. The vehicle charging power does not have any offset like this. The following efficiency calculations control for the 80W battery power offset.

The overall efficiency of the DCFC system is 88.01%. This is the total energy delivered to cars through the Kapolei Commons DC fast charger divided by the total energy passed through the PQ monitor. Note that this does not include any onboard conversion or charging efficiency losses within the vehicles. This can be broken out into a roundtrip efficiency of the stationary storage and an efficiency of the DC fast charger. To make sense of these efficiencies, it is important to note that not all of the energy delivered to vehicles goes through the stationary storage. Of the 4037 kWh delivered to vehicles through the DC fast charger, only 838 kWh were discharged by the stationary storage. A stationary storage roundtrip efficiency (DC-DC) of roughly 90% applies to this energy. Note that because the data comes from different sources, not all data can be directly compared. The numbers in the figure below come from the log files at > 1/second sampling frequency. The PQ monitor doesn't report this frequently, so the higher-frequency data has to be merged into this, resulting in some loss of data.

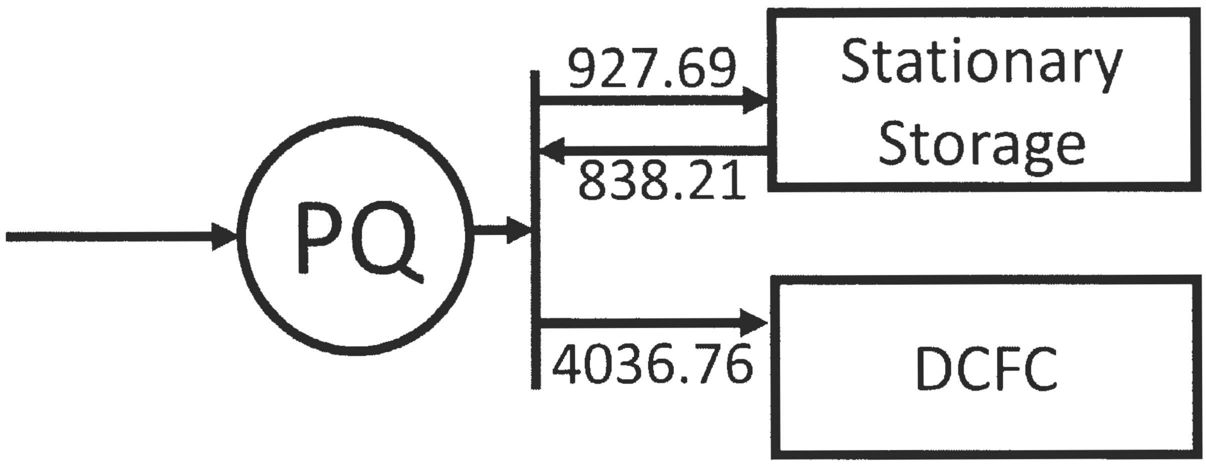

Figure 1-6
System Energy Flows (kWh)

Degradation

As with any similar battery energy storage system, this stationary storage is expected to degrade over time and with use. Ideally, a full discharge (100% SOC to 0% SOC) at rated power would be conducted periodically to estimate the remaining useful energy capacity of the storage system. This would interrupt the operation of the DCFC and would cause more degradation itself. Instead, we estimate the remaining useful energy capacity of the storage system using operational data by leveraging the internal SOC calculation.

To do this, we relate how much energy the battery cumulatively discharged in November and December, 2017 to the corresponding cumulative drops in SOC. In November and December, the storage system discharged a cumulative 852.8 kWh of energy. These discharges correspond to drops in the SOC of the battery equal to 7100%. In other words, 71 equivalent full discharges of the battery produced 852.8 kWh. This means that one full discharge should provide 852.8/71 = 12.0 kWh, which is the rated energy capacity of the storage system. However, the minimum SOC typically seen in the battery is 16% and the maximum is 95% (although the battery often stops charging between 80-95% SOC). This means that 95%-16% = 79% of the energy capacity of the storage system is being used regularly, representing **9.48 kWh**.

Another method is to identify a time when the battery is continuously discharged from a high SOC to a low SOC to mimic the preferred remaining useful energy capacity test. One event like this happened on 2017-10-20 and is shown below.

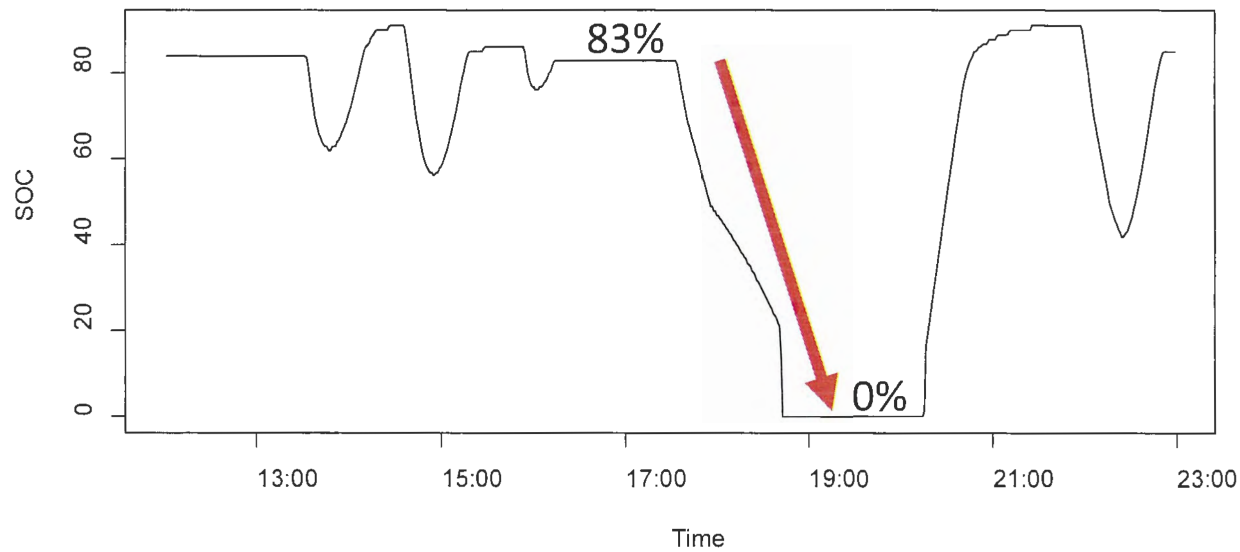

Figure 1-7
Large Stationary Storage Discharge Event

During this time, the stationary storage discharged continuously from a SOC of 83% to a SOC of 0% between 5pm and 7pm. This discharge resulted in a cumulative 7.863 kWh of energy being discharged from the stationary storage. However, it appears that no energy was transferred when the SOC dropped from 16% to 0%. So, this discharge represents only 67% of the energy storage capacity. Assuming the SOC calculation is correct, this means that a full discharge will contain **11.74** kWh of energy, similar to what was observed in the previous test. Regardless of how much the cells have actually degraded, it appears that roughly 9.5 kWh of useful energy capacity remain and only slightly less than the rated energy capacity assuming a full discharge.

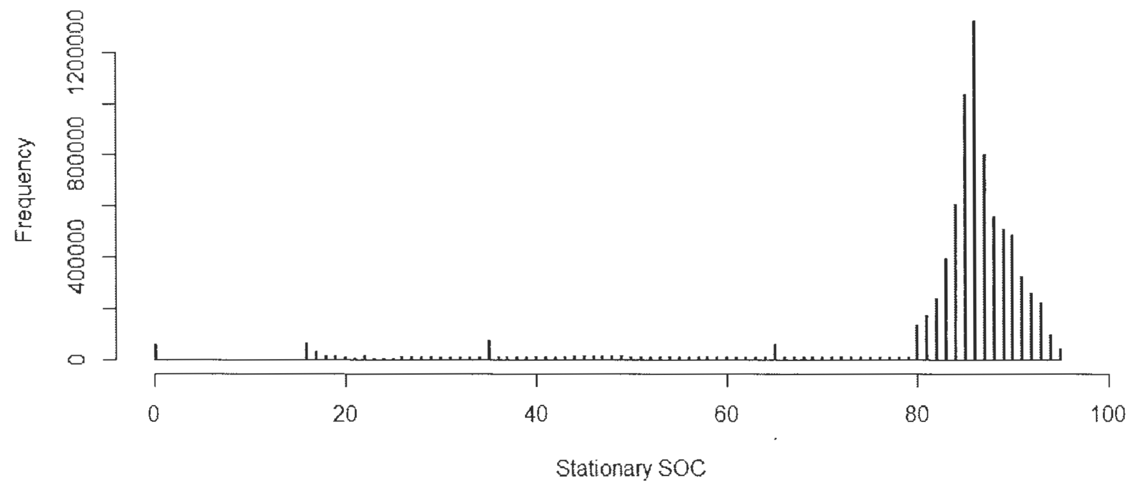

Figure 1-8
Histogram of Stationary Storage SOC

Simultaneous DC fast charging and stationary storage charging

The system can deliver power to a vehicle when the stationary storage is charging as well. The stationary storage will begin to recharge after a vehicle's charging power drops below 23 kW. The stationary limits its charging power to keep the total grid power beneath the 23 kW threshold.

Utility Impacts

Energy Cost Management

At the moment, the stationary storage is kept at a high state of charge when inactive (max=95%) and responds only to vehicle charging sessions. It is not generating any benefit from energy time shift and, due to the efficiency losses from charging and discharging, the stationary ESS will actually increase energy costs.

Peak Load Reduction

The stationary storage reduces the overall 1-second peak load from the DCFC by 19.55 kW. However, the PQ meter reads 1-minute average power values above the 23kW setting and above the 25kW grid limit. This is under investigation currently.

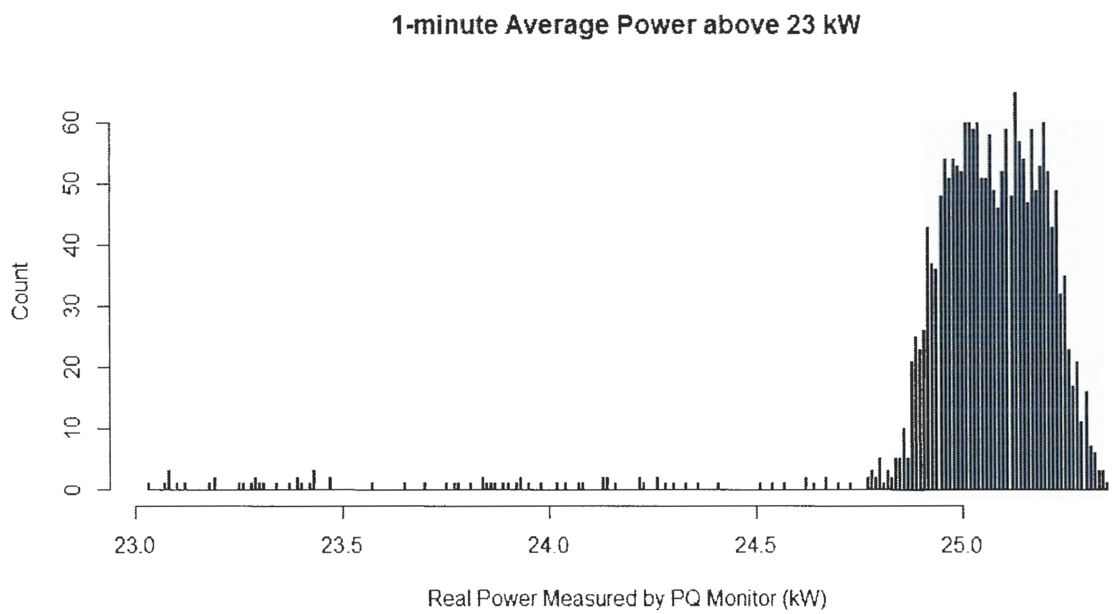

Figure 1-9
PQ Meter AC Power Readings above 23 kW

Customer Impacts

Vehicles cannot charge as quickly at a high state of charge and the longer a vehicle charges, the more likely it is to achieve a high state of charge. The time it takes a vehicle to charge to a high state of charge depends on its energy capacity and its state of charge at the beginning of the charging session. The plot below shows the charging duration on the x-axis and the energy delivered in the charging session on the y-axis for the two Ward Ave chargers, neither with a grid power limit or stationary storage. There is a reference line at an average of 25 kW over the charging session. A well-utilized charger would have charging sessions with high average powers (well above the red line). In general, we see charging sessions are clustered toward the 40kW line for long-duration charging sessions, although the average power per session drops off at very high charging durations. For short charging sessions, the average charging power is very broadly distributed between 10 kW and 40kW, representing a mix of vehicle types and beginning SOCs.

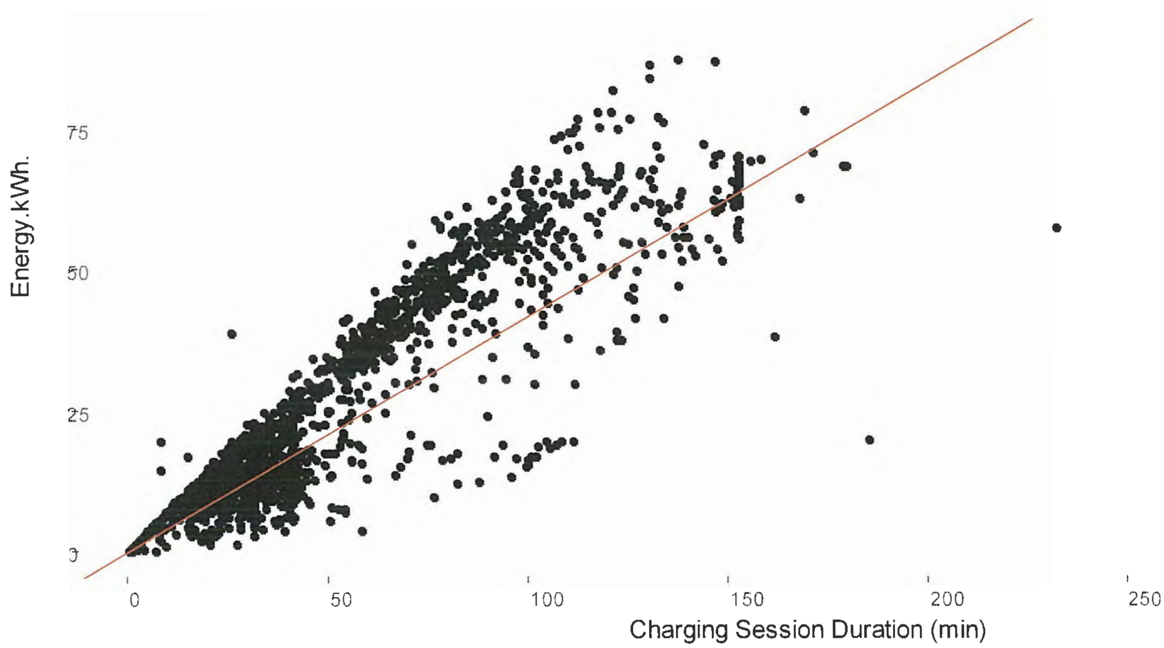

Figure 1-10
Ward Ave. Charging Sessions for Context

For the Kapolei Commons charger with stationary storage, the average charging power is much closer to 23 kW – the grid power limit. Whenever the storage cannot discharge to increase vehicle charging power due to not enough stored energy or any other reason, the charging power is 23 kW maximum (the limit set on the grid power). This impacts the average charge time. The average charging time at the Kapolei Commons charger is 61 minutes for a total energy of 22.9 kWh whereas the average charging time at the Ward Ave chargers is 50 minutes for 24.4 kWh. So, the average vehicle charging power at the Kapolei Commons charger is only 77% of the average charging power at the Ward Ave chargers.

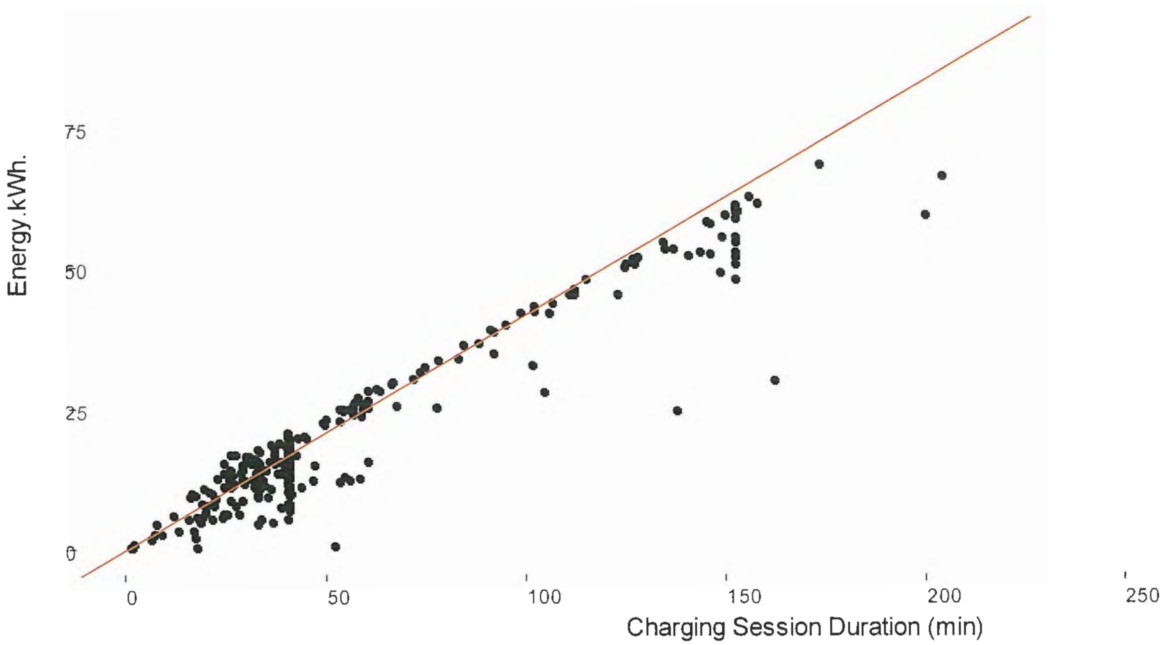

Figure 1-11
Kapolei Commons Charging Sessions

The rated energy capacity of the storage system when it was installed was 12 kWh. Higher-energy charging sessions, like can be expected from Tesla brand cars with large on-board energy capacities, are likely to deplete the stationary energy storage. When this happens, the charging power will be limited to 23 kW from the grid. Additionally, as the vehicles reach high states of charge, they will limit their charging power to avoid damaging their batteries. These effects combine and make the average charging power for long-duration sessions low.

To further explore the effect of this setup on the customers' charging times, two numbers are considered. The first is the number of customer minutes lost due to the grid power limit. When the storage system is depleted, it cannot discharge any more to speed up the customers' charges but the grid power limit is still in place. The second number is the number of customer minutes saved by the storage assuming the grid power limit is necessary.

Customer Time Lost to Grid Power Limit

The base case for this comparison will be a normal 50kW charger. To determine when a lack of energy in the stationary storage is limiting a customer's charging power, we look for vehicle charging power of 23 kW when the SOC of the stationary storage is low. There are many times when the vehicle is charging at the maximum grid power and the stationary battery is not charging or discharging (see below).

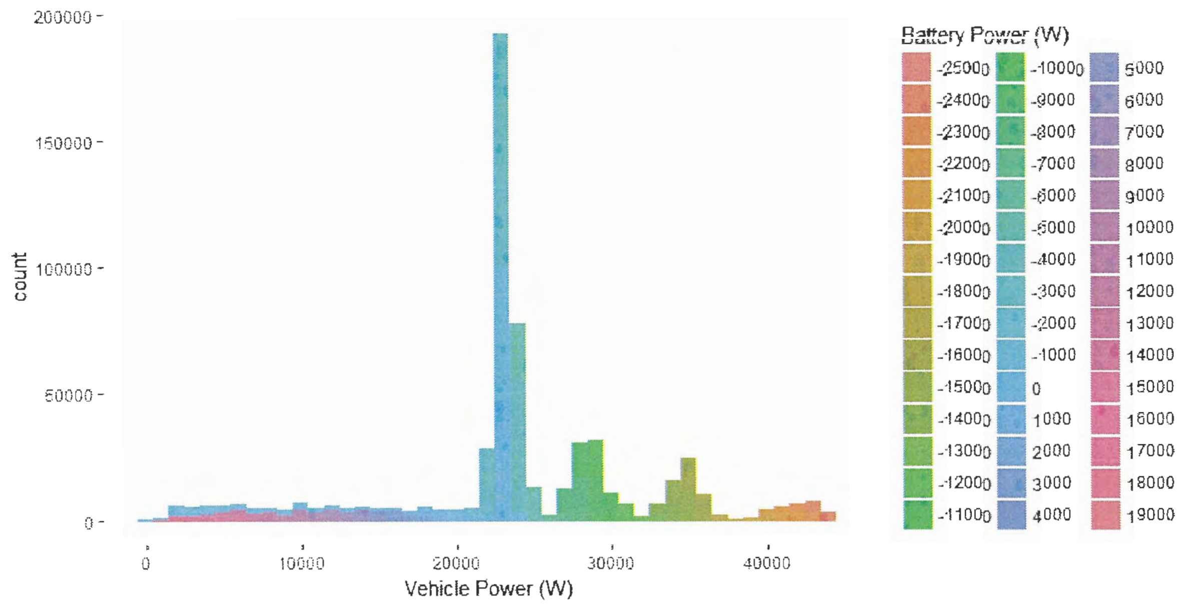

Figure 1-12
Histogram of Nonzero Vehicle Charging Power Colored by Stationary Storage Power

During these times, the SOC of the stationary storage is usually about 16% and the storage rarely discharges below 16%. This means the effective minimum SOC of the stationary storage is 16% and that the vehicle charging power is reduced to 23 kW when 16% is reached. As the plot below shows, this SOC minimum limits vehicle charging power for a considerable amount of time, reducing the average charging power to 77% of similar, nearby chargers.

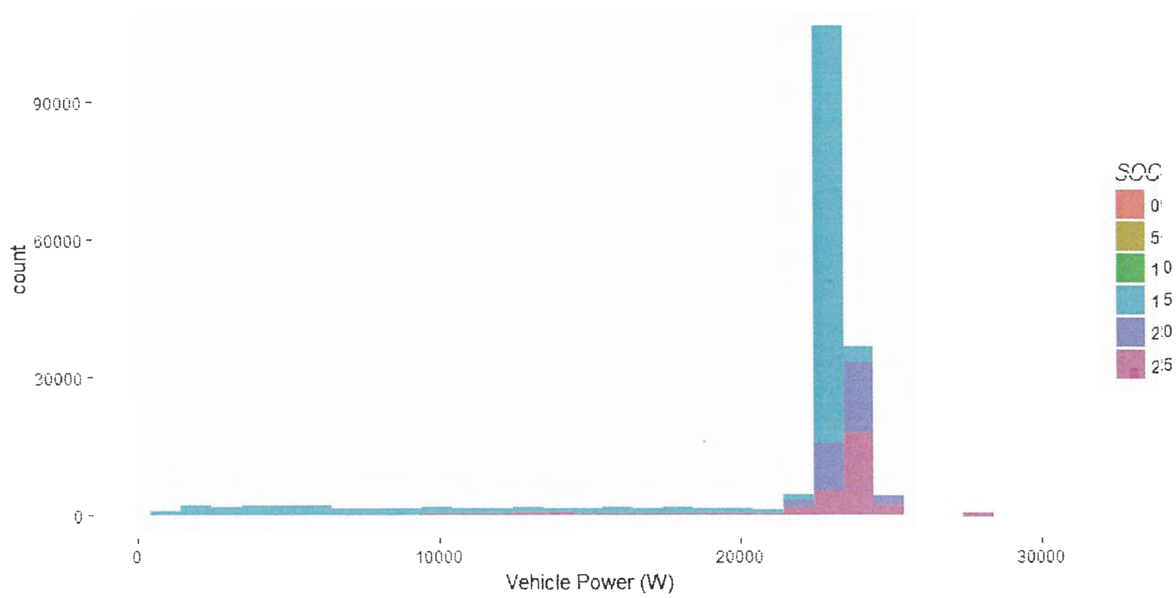

Figure 1-13
Histogram of Vehicle Charging Power Colored by Stationary Storage SOC

Without knowing what power the vehicles would charge at in a normal system we cannot know exactly how much time is lost in each individual charging session due to the grid power limit. However, the average charging power from the Kapolei Commons charger is 77% of the average in the Ward Ave. chargers, meaning that the charging time to deliver the same amount of energy is 1/.77 = 1.3 times longer than it would be in a normal charger. Over November and December, customers spent a cumulative 318 hours charging at the Kapolei Commons charger. This would be smaller by 318/1.3 = **73 hours** if it were a normal DCFC.

Customer Minutes Saved by Stationary Storage

The base case for this comparison is now a 25 kW DCFC with no storage. This simulates a case where there is a 25kW grid power limit but no storage was installed. Calculating how much time the stationary storage saved given a grid power limit of 25 kW is relatively straightforward. To do this, the amount of energy delivered by the stationary battery is converted to time saved by dividing by the 25 kW limit. The total amount of energy delivered by the battery is 545 kWh in the dataset involving mostly November and December 2017 data, which represents a savings of **21.8 customer hours** over those two months.

Simulated Commercial Customer Demand Charge Reduction

For this section, we look at a hypothetical commercial customer under Hawaii Electric Company's Schedule J rates (demand rate = $11.69/kW-mo, energy rate = 16.9734 cents/kWh). This customer has to pay the energy and demand charges incurred by the DCFC. The two options being explored are a case when this customer has the stationary energy storage system (so pays energy and demand charges based on the grid power) and a case where they do not (so pays energy and demand charges based on the DCFC power). The purpose will be to calculate the energy bill savings the stationary storage provides, which could be an input to a cost-benefit analysis to determine whether or not it makes sense to install stationary storage.

If the power being delivered to the vehicles is taken as what the facility's load power would be without a stationary storage system, then the demand charges would be $476 for November and $480 for December based on the maximum power (average in 15-min average) applied to the demand charges from the HECO rate structure: General Service Demand (Schedule J). The same process applied to the net power from the device results in demand charges of $274 for November and $273 for December. This means that the stationary storage would be saving this hypothetical customer an average of $204.5 per month in demand charges as long as we neglect the efficiency losses from any conversions between the billing meter and the DCFC.

Table 1-1
Demand Charges ($)

	Without Stationary Storage	With Stationary Storage	Savings
November	$476	$274	$202
December	$480	$273	$207

To provide any value from energy time shift, the stationary storage would have to charge during off-peak times and discharge during on-peak times. Currently, the stationary storage is not doing this. Additionally, because of the roundtrip efficiency losses from the stationary storage, the effect is to increase energy charges. In these two months, roundtrip efficiency losses in the stationary storage destroyed 51 kWh of energy, costing $8.65 over the two months. The energy cost is small compared to the demand charge reduction benefit. These results do not speak to the net cost or benefit of the system if all capital and operational costs are considered. Instead, they represent the real-world reduction in demand charges this system would have realized under schedule J rates.

Conclusion

This system is reducing the peak load drawn from the grid and is reducing customer charging times under the grid limit. However, a lack of energy capacity in the stationary storage results in slow charging for many customers with large vehicle storage capacities relative to a normal, unconstrained DC fast charger. It is impossible to perfectly predict the future and this result speaks to the value of energy storage to hedge against future growth in charging power/energy and the risk of installing an undersized storage system. For a potential commercial customer offering DC fast charging under schedule J rates, there is room for storage to reduce their demand charges which would have to be weighed in a full cost-benefit analysis.

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