ENERGY
TRANSITIONS
INITIATIVE
U.S. Department of Energy

Partnership Project

ETIPP Kauai, Task 3: Kauai Electric Vehicle Charging Network Study

Yanbo Ge[a], Cemal Akcicek[a], Venu Garikapati[a], Chun Ho Chow[b], Natalie Popovich[b]

[a] National Renewable National Laboratory
[b] Lawrence Berkeley National Laboratory

ETIPP Kauai: Electric Vehicle (EV) Study Summary

Kauai, also called the garden island, is known for its emerald valleys, sharp mountain spires, and jagged cliffs. The unique terrains and the rural characteristics set it apart from other Hawaiian islands. However, like many other areas developed in the last half century, Kauai's transportation system has been designed around moving cars as opposed to moving people. Its transportation system and tourism-centered economy are overly dependent on automobiles and petroleum fuels, which creates key resilience challenges for this remote island community. The long-term energy resilience goal of the island is to eliminate fossil fuel use in the ground transportation sector by 2045.

Vehicle electrification is an important component of Kauai's transportation decarbonatization blueprint. Through the Energy Transitions Initiative Partnership Project (ETIPP), the technical assistance team, including researchers from the National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL), applied NREL's Electric Vehicle Infrastructure Projection Tool (EVI-Pro) to quantify the electric vehicle (EV) charging demand of the private light duty vehicle fleet of Kauai island. This slide deck summarizes how the various EVI-Pro inputs are generated for the EVI-Pro runs and shows the EVI-Pro results for different electrification scenarios. These results will guide Kauai County on their EV charging network planning.

1. Background

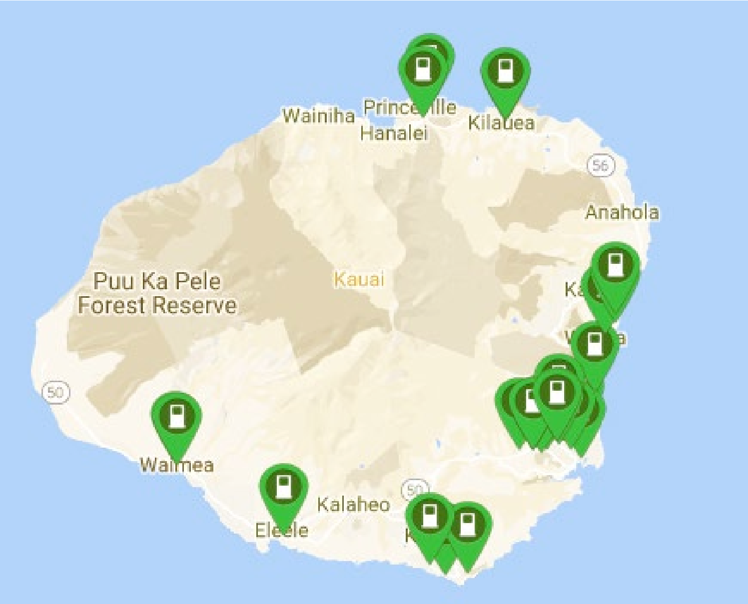
Task 3 Scope

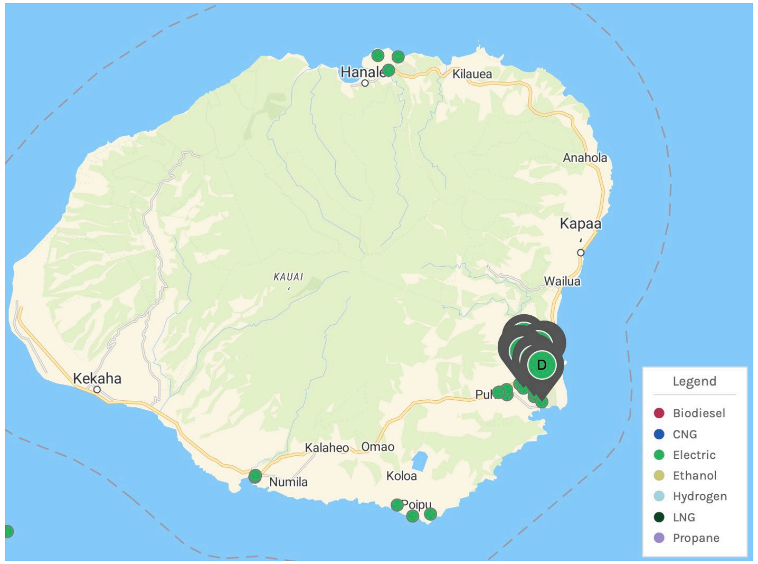
- **Goal**: Create a charging infrastructure plan including a Fast Charger station map to encourage EV use.
- **Tasks**:
  1. Understand data requirement and availability.
     - Current EV charging network (location, level pricing, etc.)
     - Driving demand/patterns of residents and visitors
     - Local/federal incentives on EV adoption/use
     - Activity hotspots and their characteristics (e.g., typical dwell time)
       - *Popular shopping locations*
       - *Frequently used gas stations*
       - *Remote/isolated areas.*
  2. Use EVI-Pro to estimate EV charging infrastructure needs for future years.
     - Number of chargers of different levels
     - Load profile. Identify EV charging station sites and sizing.
  3. Identify EV charging station sites and sizing.
- **Deliverables**:
  1. Charging station map with station size and prioritization scores
  2. Prioritization of proposed charging station locations.

Current Charger Map

Alternative Fuels Data Center (AFDC) charging stations

City Name	Number of Charging Stations
Lihue	18
Princeville	3
Kilauea	2
Koloa	3
Poipu	3
Eleele	2
Waimea	2
Kapa’a	3

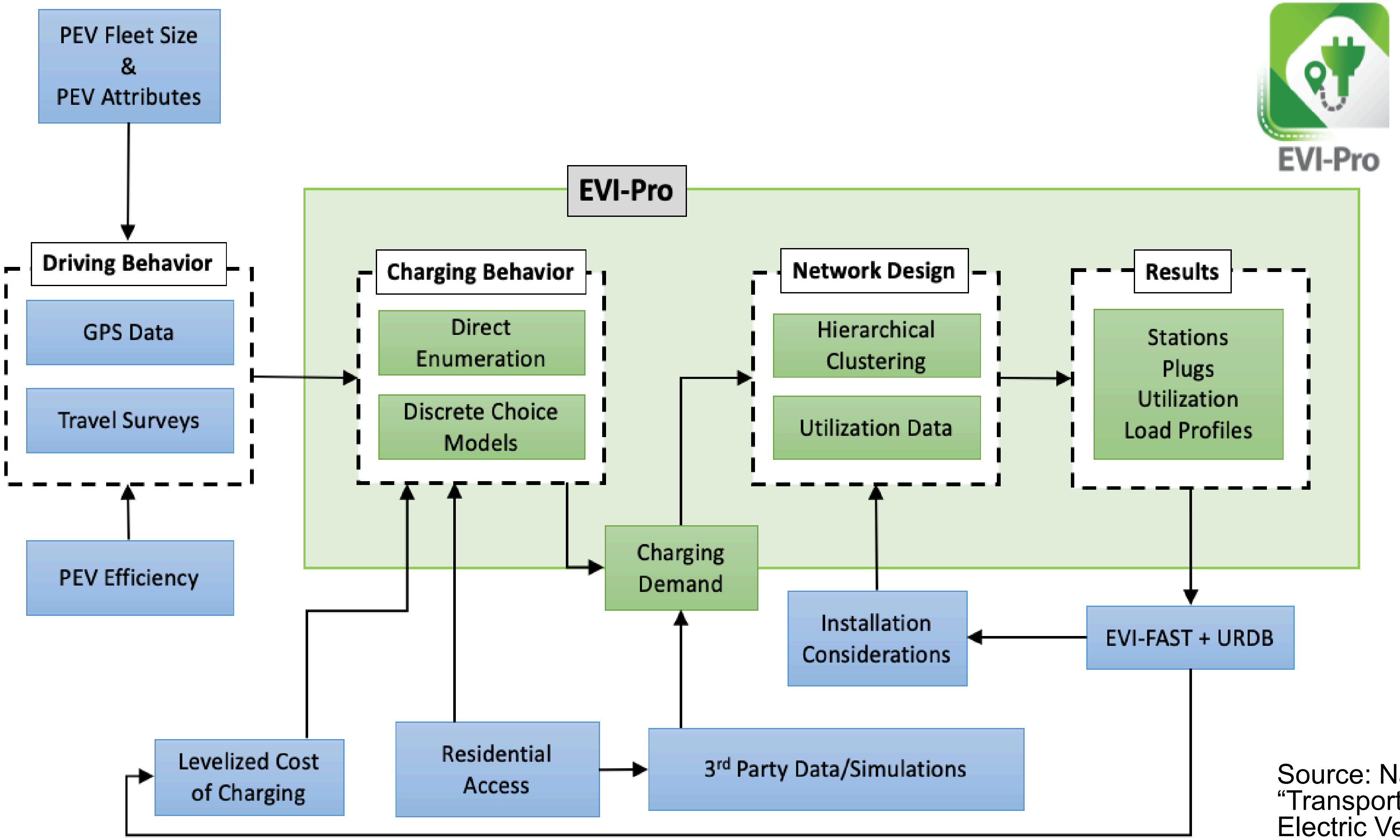




2. EVI-Pro Modeling Framework

EVI-Pro Model

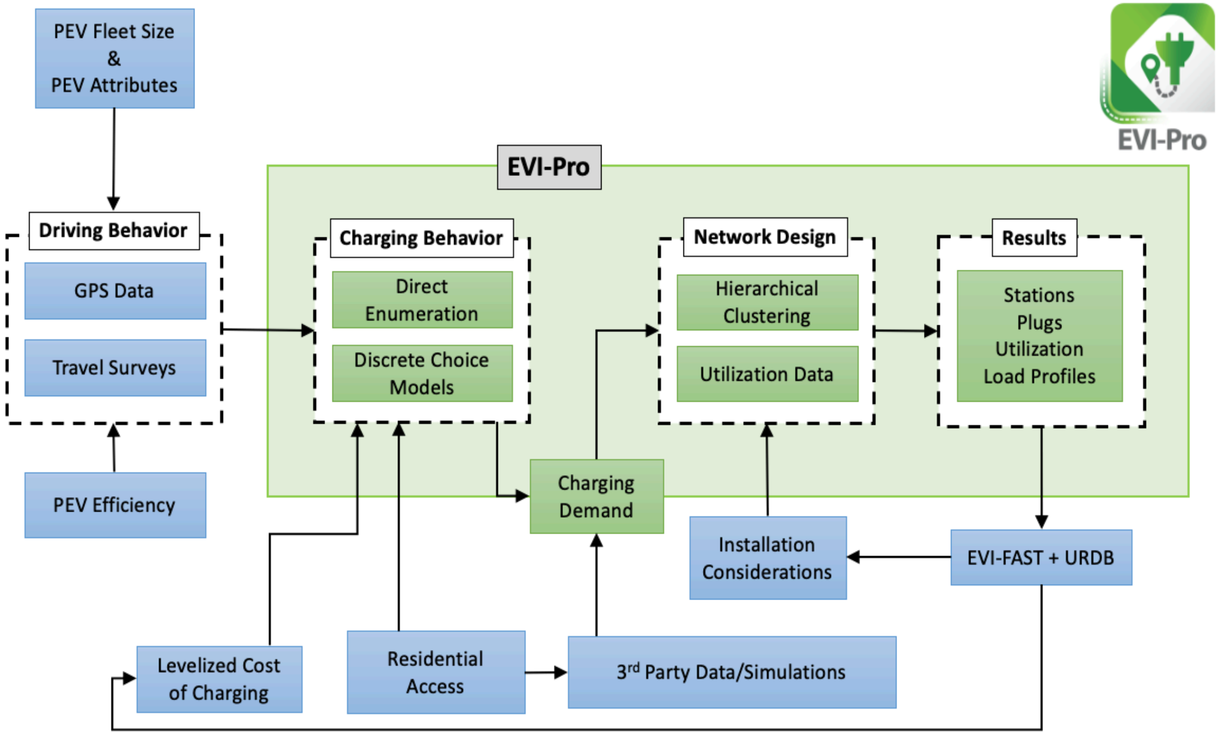
EVI-Pro: a tool developed and maintained by NREL researchers on plug-in electric vehicle (PEV) infrastructure projection. https://www.nrel.gov/transportation/evi-pro.html



Source: National Renewable Energy Laboratory. "Transportation & Mobility Research: EVI-Pro: Electric Vehicle Infrastructure—Projection Tool." Accessed December 19, 2023. https://www.nrel.gov/transportation/evi-pro.html.

EVI-Pro Model

- **Important inputs**:
  - Trip dataset
    - Trip origin/destination
    - Dwell time
    - Rough starting/ending time.
  - Residential charging access
  - PEV fleet size and attributes
  - EV charging option choice set (e.g., for DC fast chargers, 50KW, or 150KW)
  - Leveled cost of charging
- **Outputs**:
  - Number of chargers by type
  - Location of the chargers
  - Load profile

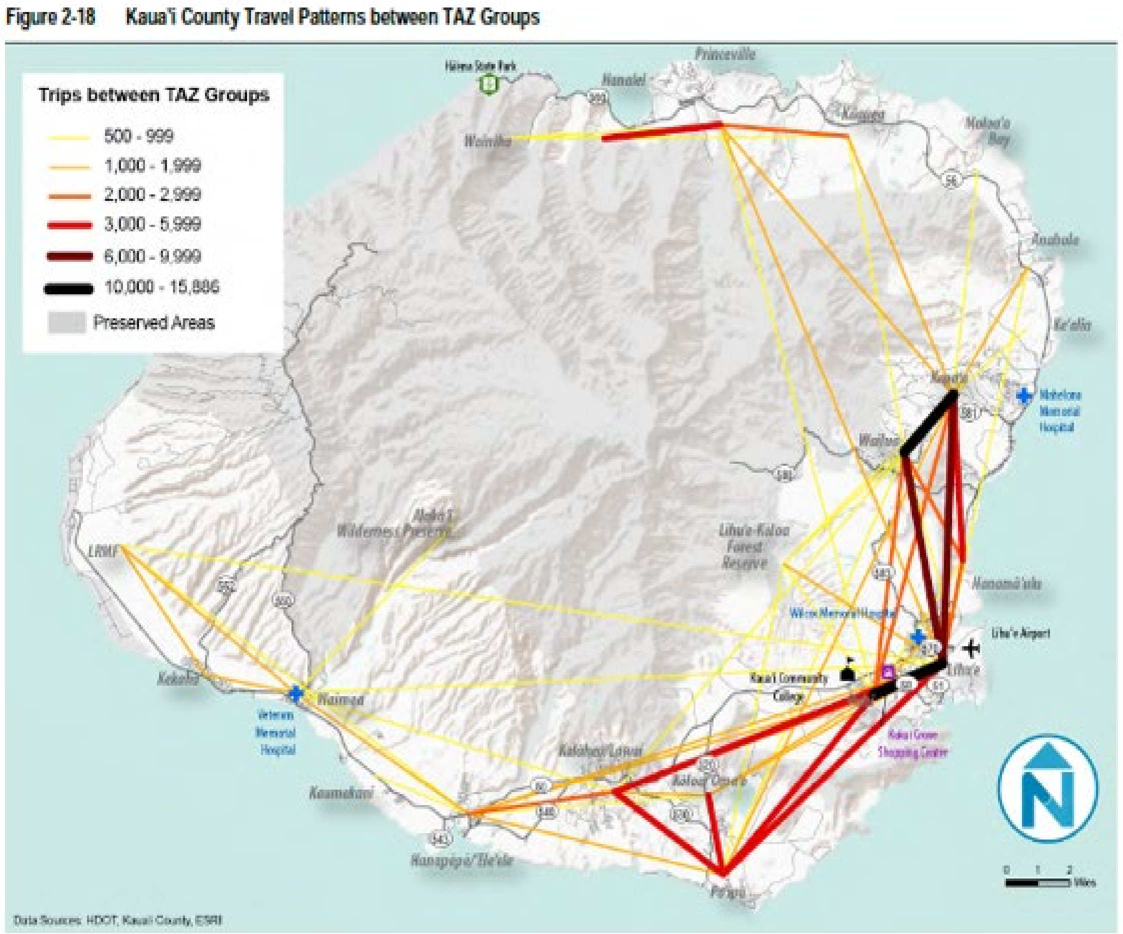


3. Travel Demand Data for EVI-Pro Run

Travel Demand Data

Source 1: Hawaii Department of Transportation (HDOT) Kauai Travel Demand Model (TDM) (base 2010)

- ~2010 data, and 2020 and 2035 forecasts
- Pros:
  - Comprehensive data sources model
- Cons Validated:
  - Analyses conducted a decade ago based on older data



Source: HDOT Kauai Travel Demand Model.

Travel Demand Data

Source 2: Near cellphone data requested

- Pros
  - More up-to-date
  - Possible source for mode approximation
  - Trip chaining.
- Cons
  - Potential biases (locations without cellphone signal).

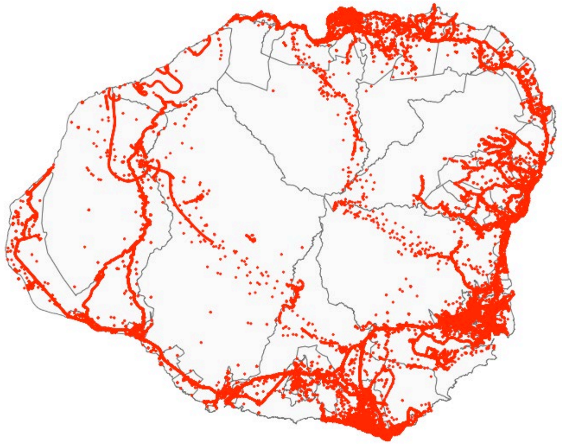
Complementary source: Parking data of the Kauai parks

- Researchers also considered using the travel demand model. However, the most recent round of travel demand model was built more than a decade ago and updating the model to make it appropriate for current day required significant resources and time. In comparison, app-based cellphone data is very affordable and can be updated very frequently. The granularity that cellphone data offers is also great compared with travel demand model – it allows the observation of seasonal and even weekly travel patterns.

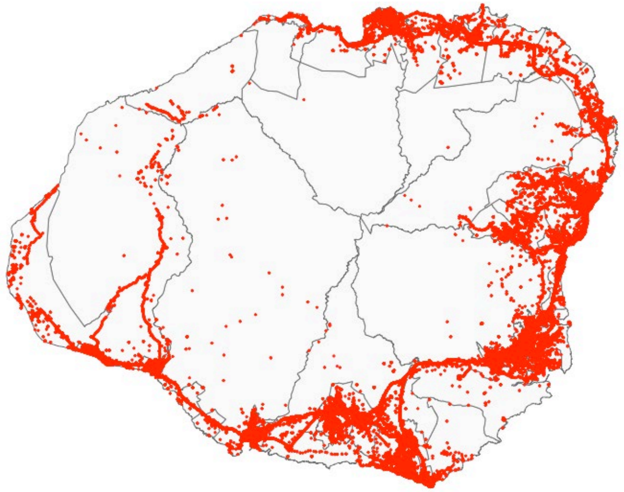
Travel Demand Data: Near Data Summary

- First week of data (July 22-28, 2019)
- ~15,000 devices
- ~2 million GPS points reported
- 99% devices from United States
- ~60% from Hawaii
  - Followed by California, Texas, Washington, Oregon, Colorado, Arizona, Illinois, New York, Florida.
- ~55% from Kauai (residents)
- Residents: 8,546 (11.8% of the county population)
- Visitors: 6,941(21.8% of tourist volume)

- July 2019 additional data:
  - July 15–22, 2019
- Winter holiday weeks:
  - Dec. 19, 2021– Jan. 5, 2022
- Valentine’s Day travel:
  - Feb. 6–26, 2022
- Spring break weeks:
  - March 13–April 16, 2022
- “Off season”:
  - April 25–May 14, 2022
- Summer travel:
  - July 14–27, 2022
- “Off season”
  - Sept. 1–21, 2022



Visitor daytime activity location (based on shared near data of July 2019).

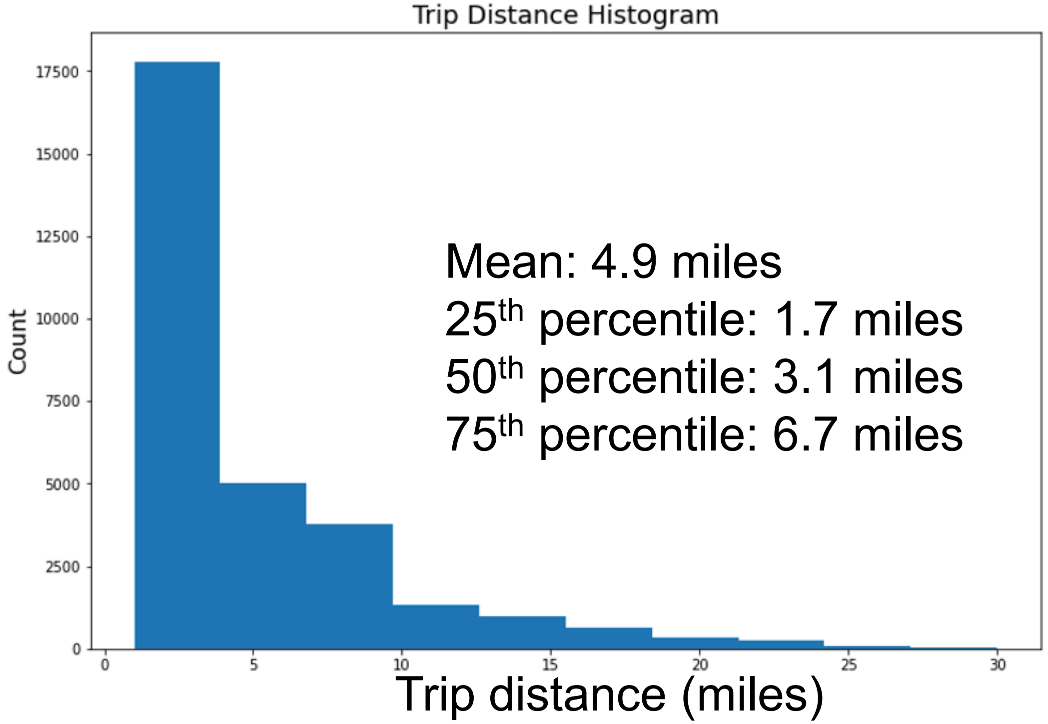


Resident activity location (based on shared near data of July 2019).

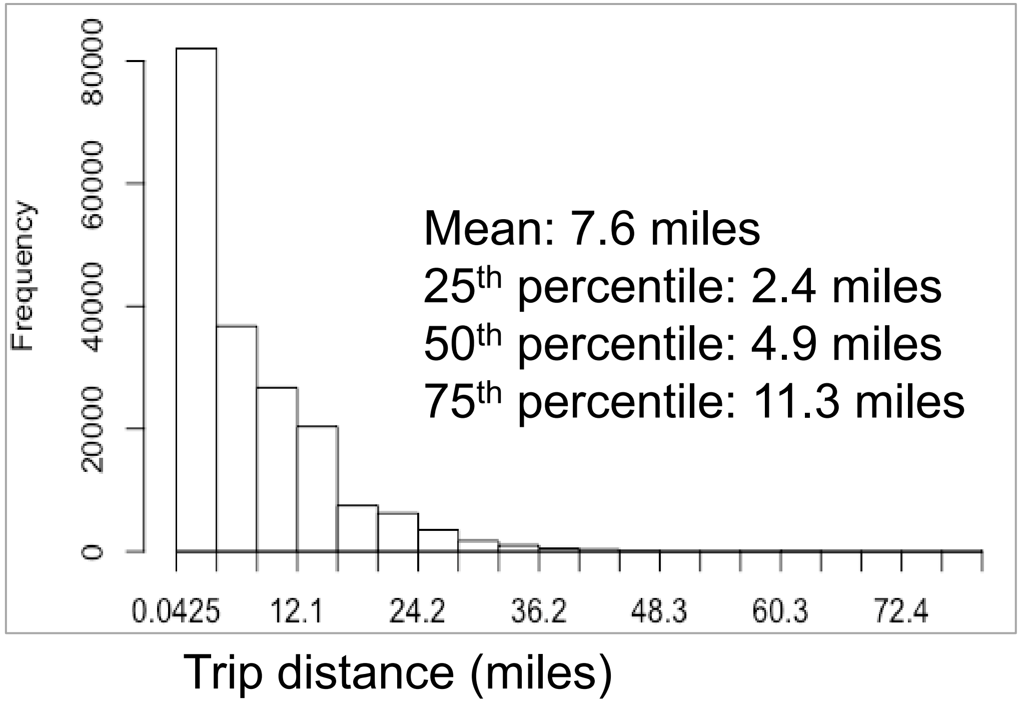
Travel Demand Data: Residents' Trip Distance

Comparison of the two data sources

Near Sample (July 2019 near data)



HDOT TDM (2035)

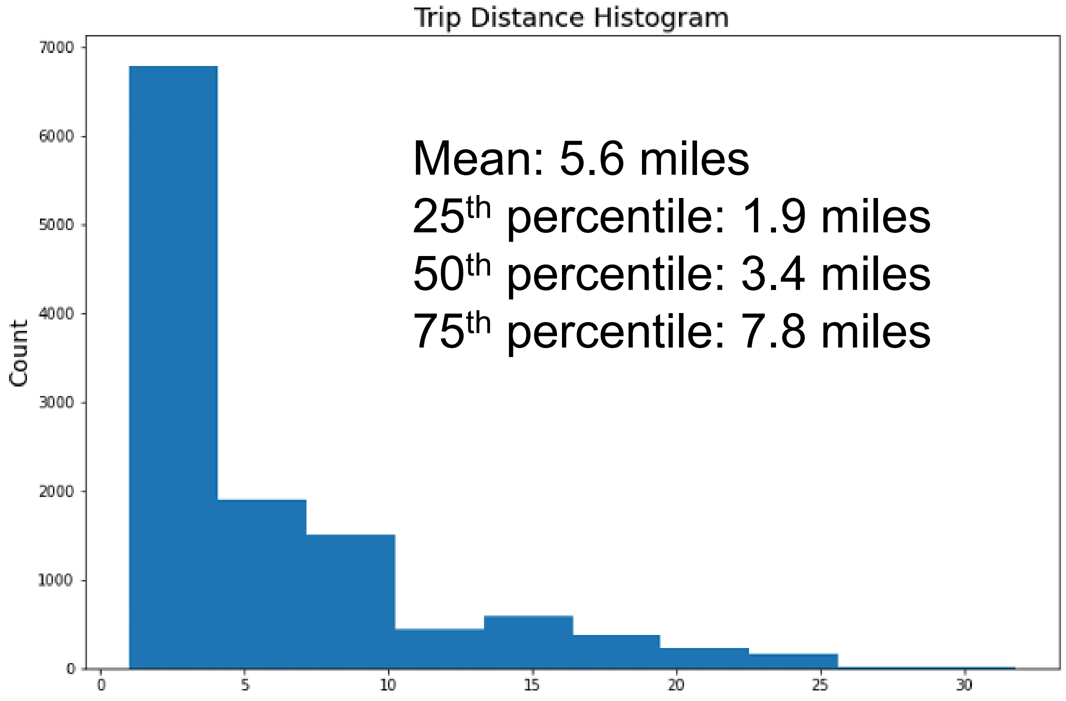


Takeaway: Only destination chargers are needed; midtrip chargers are probably not necessary.

Travel Demand Data: Visitors' Trip Distance

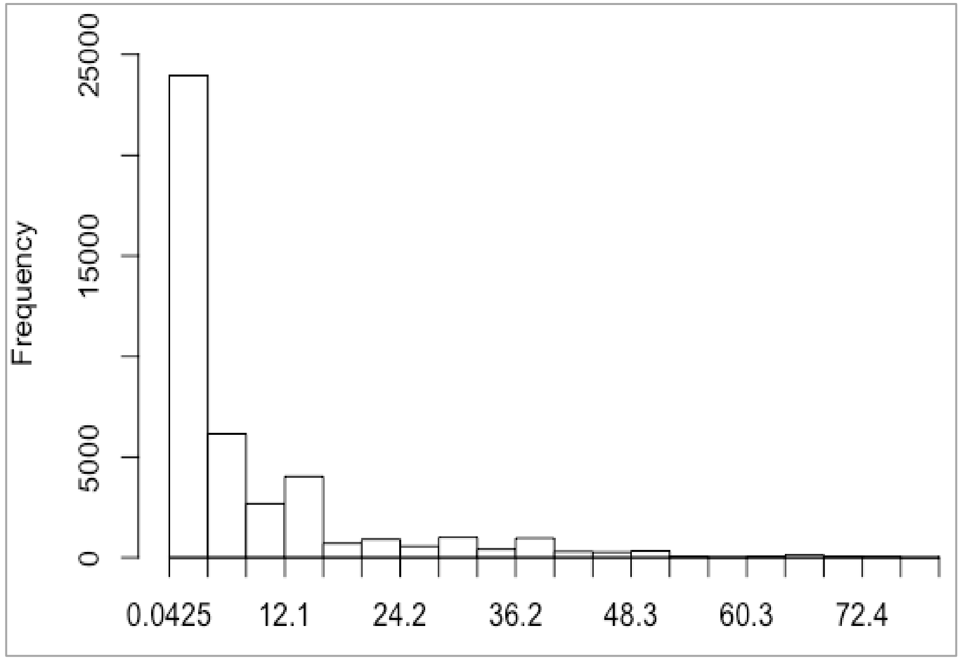
Comparison of the two sources

Near Sample (July 2019 near data)



Trip distance (miles)

HDOT TDM (2035)

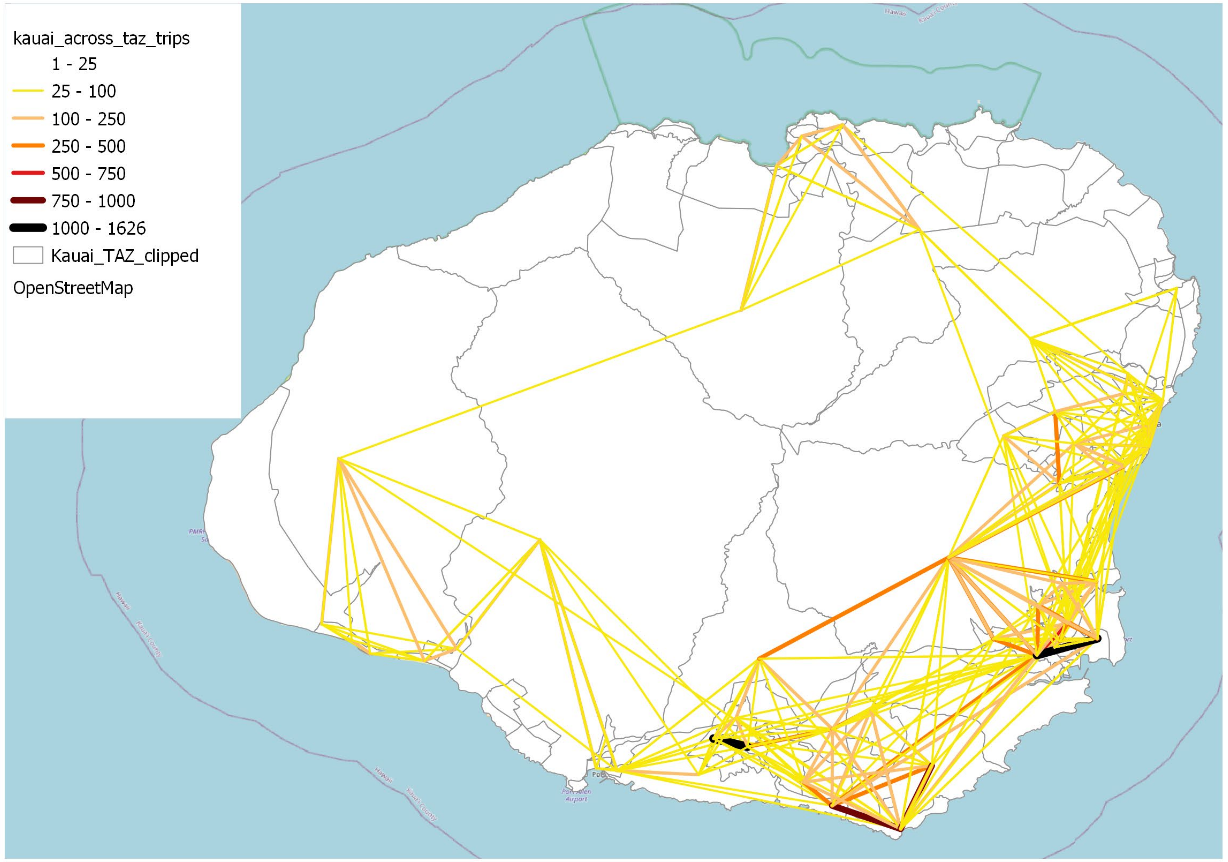


Trip distance (miles)

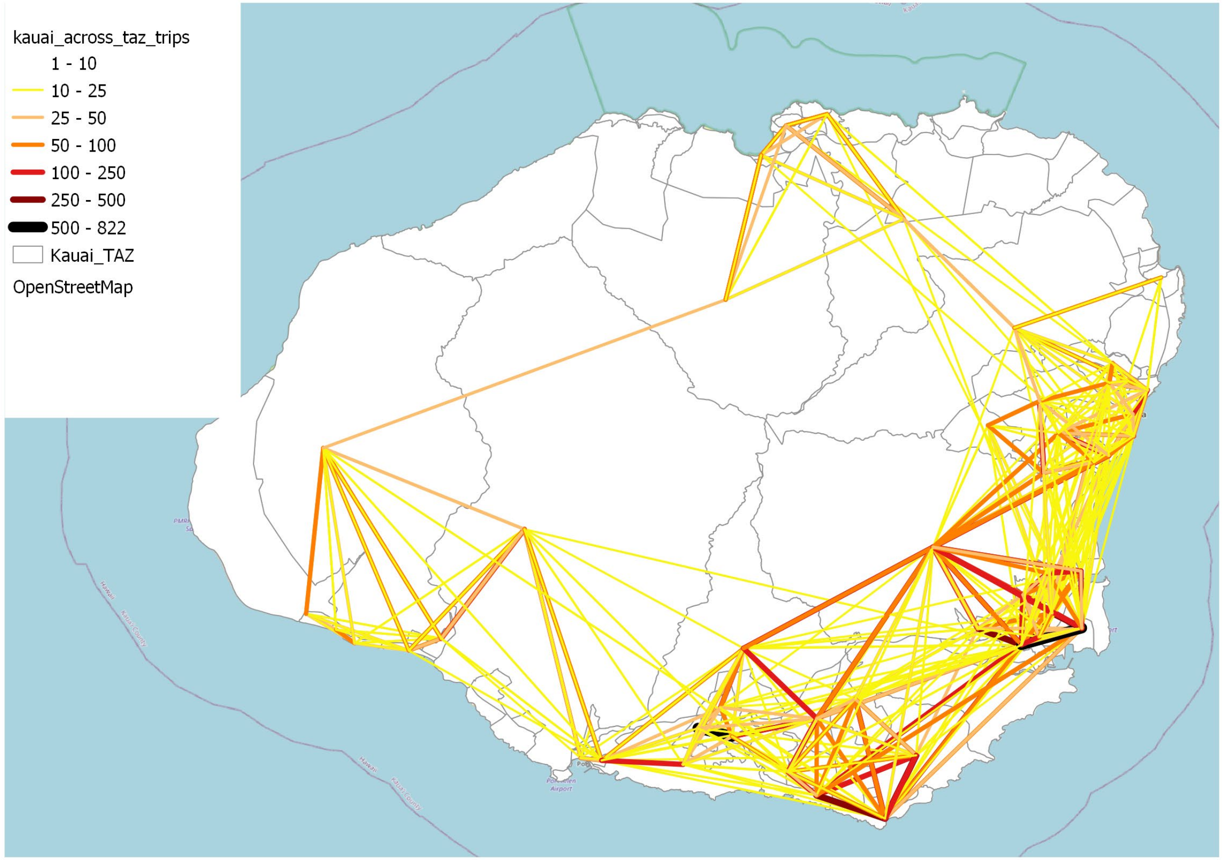
Takeaway: Only destination chargers are needed; midtrip chargers are probably not necessary.

Travel Demand Data: Trip Distribution

Comparison of the two sources



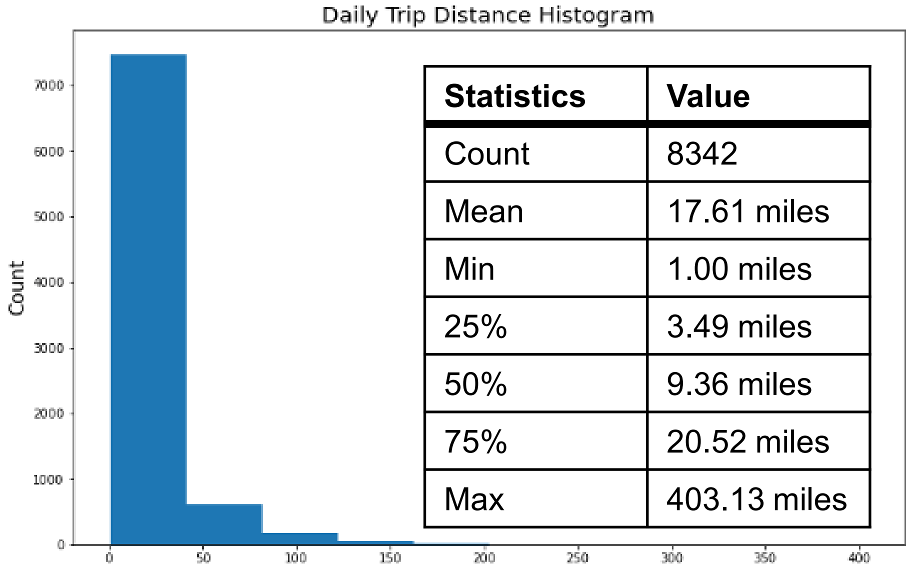
Near Sample



HDOT TDM (2035)

Travel Demand Data: Daily Vehicle Miles Traveled (VMT)

Data source	Category	Avg. Daily VMT (miles)
Near Data	Residents	17.6
HDOT TDM	Residents	16.8
Near Data	Visitors	19.3
HDOT TDM	Visitors	17.7



Statistics	Value
Count	8342
Mean	17.61 miles
Min	1.00 miles
25%	3.49 miles
50%	9.36 miles
75%	20.52 miles
Max	403.13 miles

Residents Daily VMT Using Near Sample (Miles)

Percent of travel days that potentially need out-of-home charging, assuming home charging is available.

Stats	Percentage
Larger than 50 miles	18.26%
Larger than 100 miles	2.03%
Larger than 150 miles	0.29%
Larger than 200 miles	0.00%
Larger than 300 miles	0.00%

Travel Demand Data: Takeaways

1. Only destination charging is necessary
    - Home
    - Public/workplace
2. Use case of DC fast chargers
    - Mainly serve vehicles without home charging
3. Travel demand for EVI-Pro
    - Trip chains from near data (only devices that have at least one GPS location every half hour)

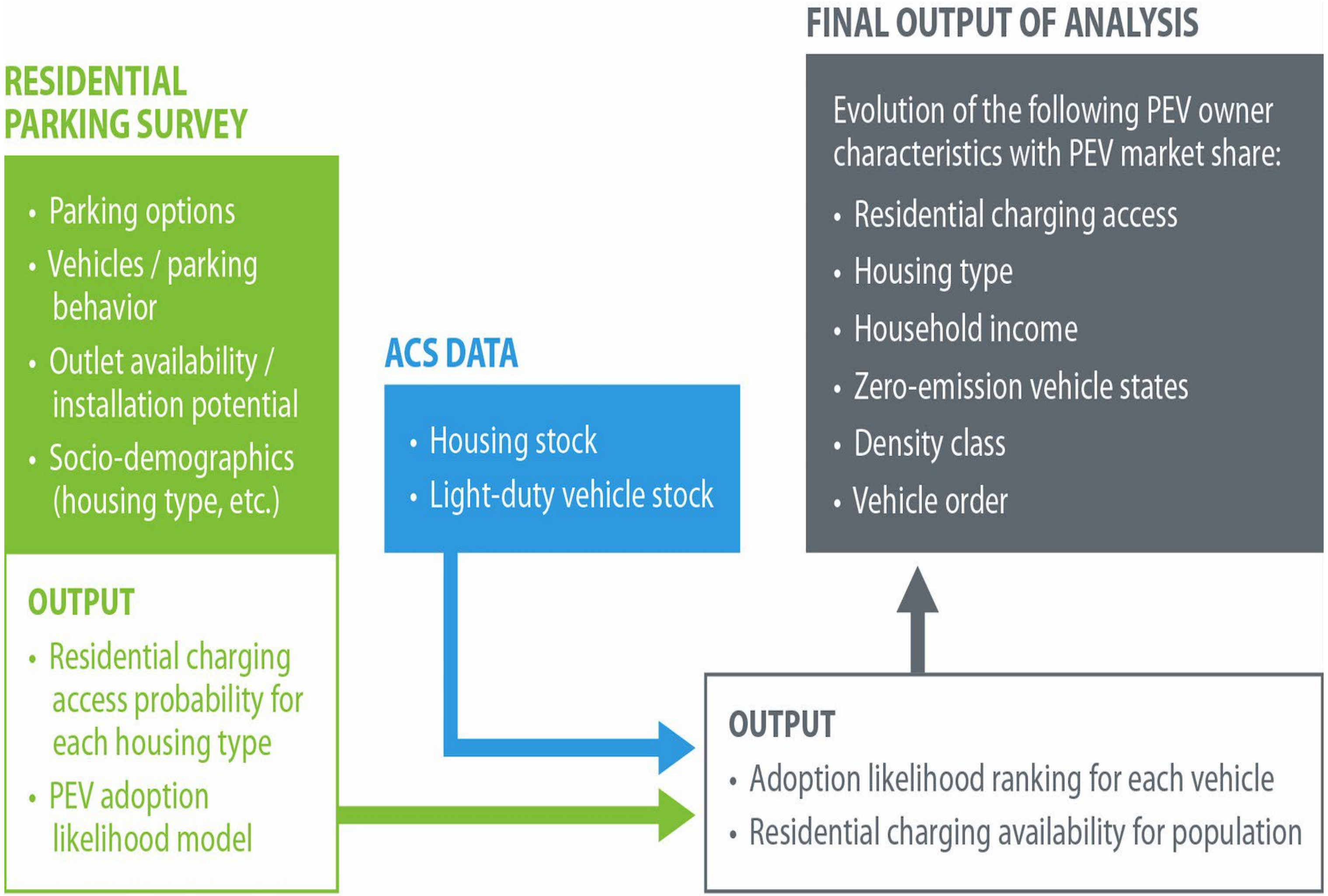
Stats	Percentage
Larger than 50 miles	18.26%
Larger than 100 miles	2.03%
Larger than 150 miles	0.29%
Larger than 200 miles	0.00%
Larger than 300 miles	0.00%

Home charging access is the most important input

4. Residential Charging Access

Future Residential Charging Access

- Though the overwhelming majority of the EV charging is done at home and most current EV users have access to charging at home, this will change in the future when EV adoption extends from single-family homeowners to renters and multi-unit dwellers.
- An NREL residential charging access study developed a process for estimating residential charging access for different electrification levels.
- This approach starts with looking into home parking options and electric access at different types of parking locations.



Residential Charging Access Analysis Framework

Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

Future Residential Charging Access

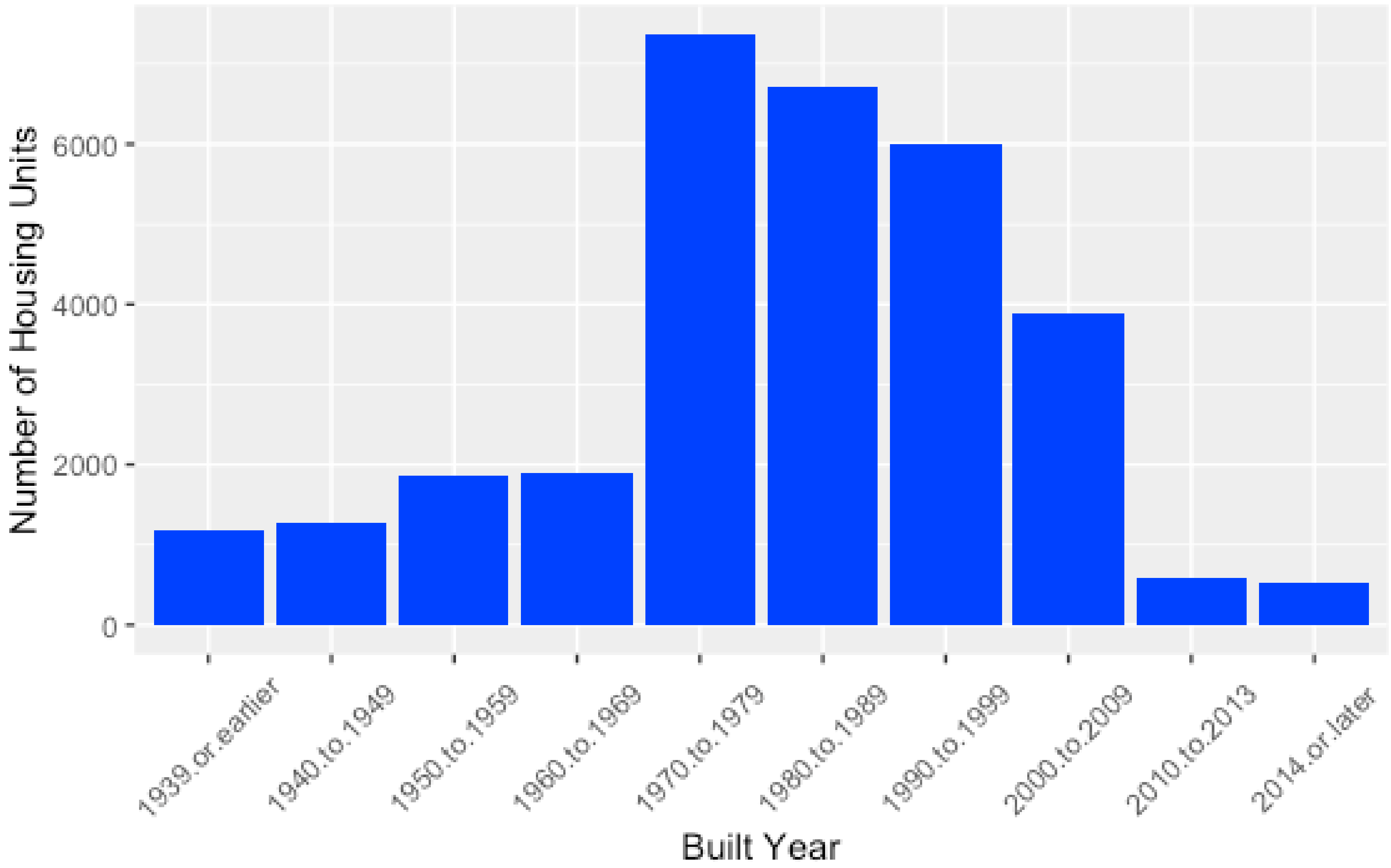
Variables

- American Community Survey (ACS)
- National survey on outlet availability
- Kauai resident transportation preference survey

- Housing age
- Housing type
- Parking by housing/tenure type
- Outlet availability by parking type/building age

Residential Charging Access

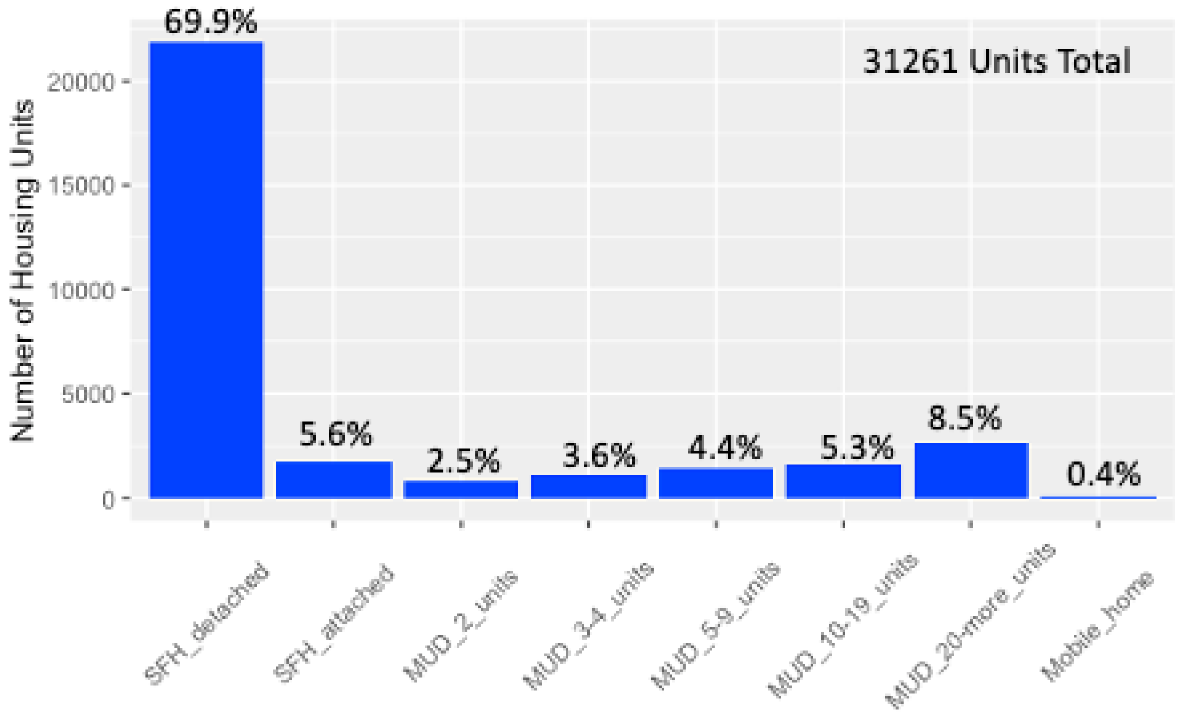
Kauai Housing Age



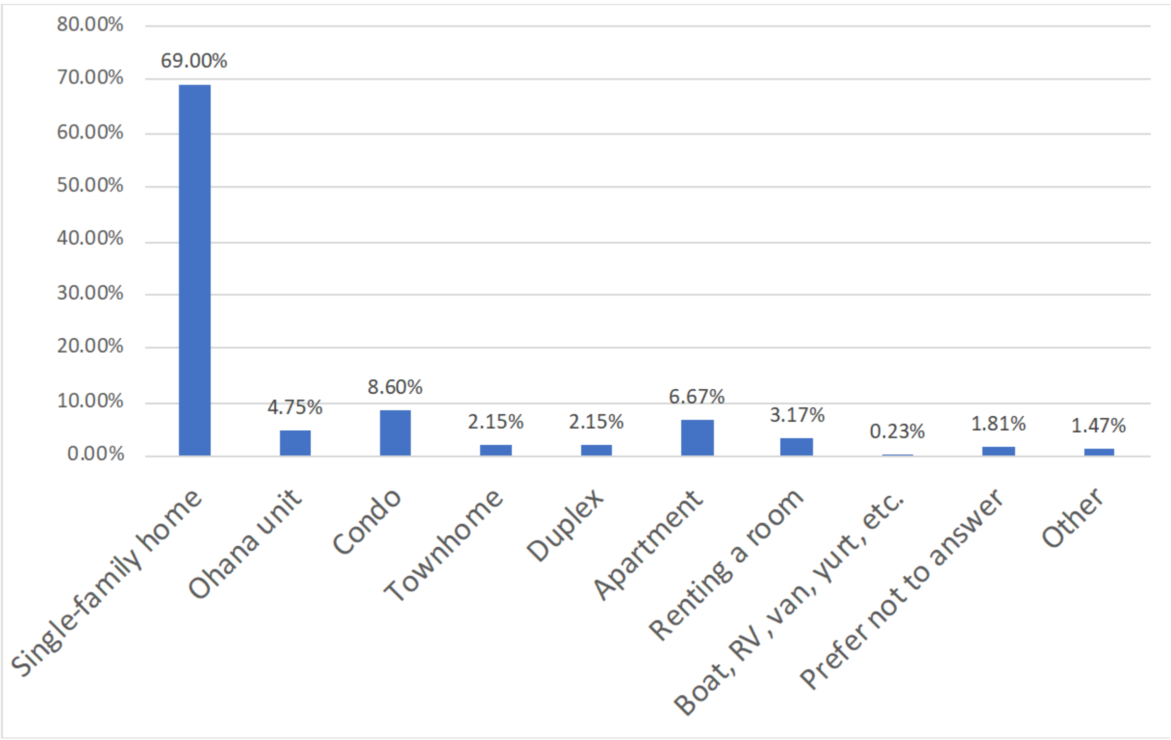
Housing Age in Kauai (ACS 2020 5-year)

Kauai Housing Type

Housing type in Kauai (ACS 2020 5-year)

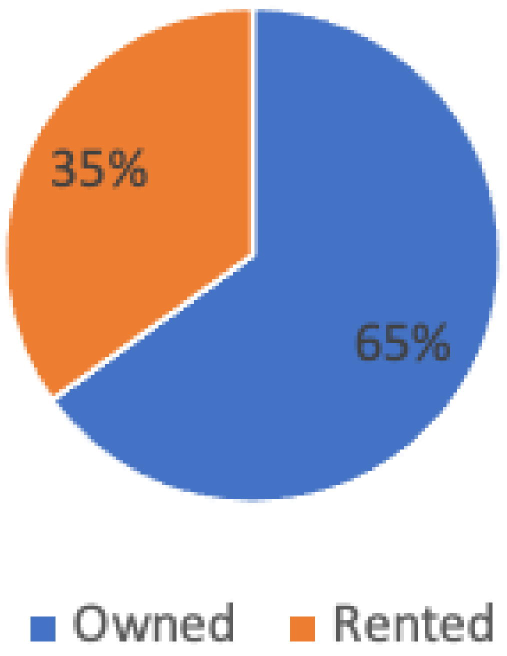


Housing type in transportation preference survey (2022)

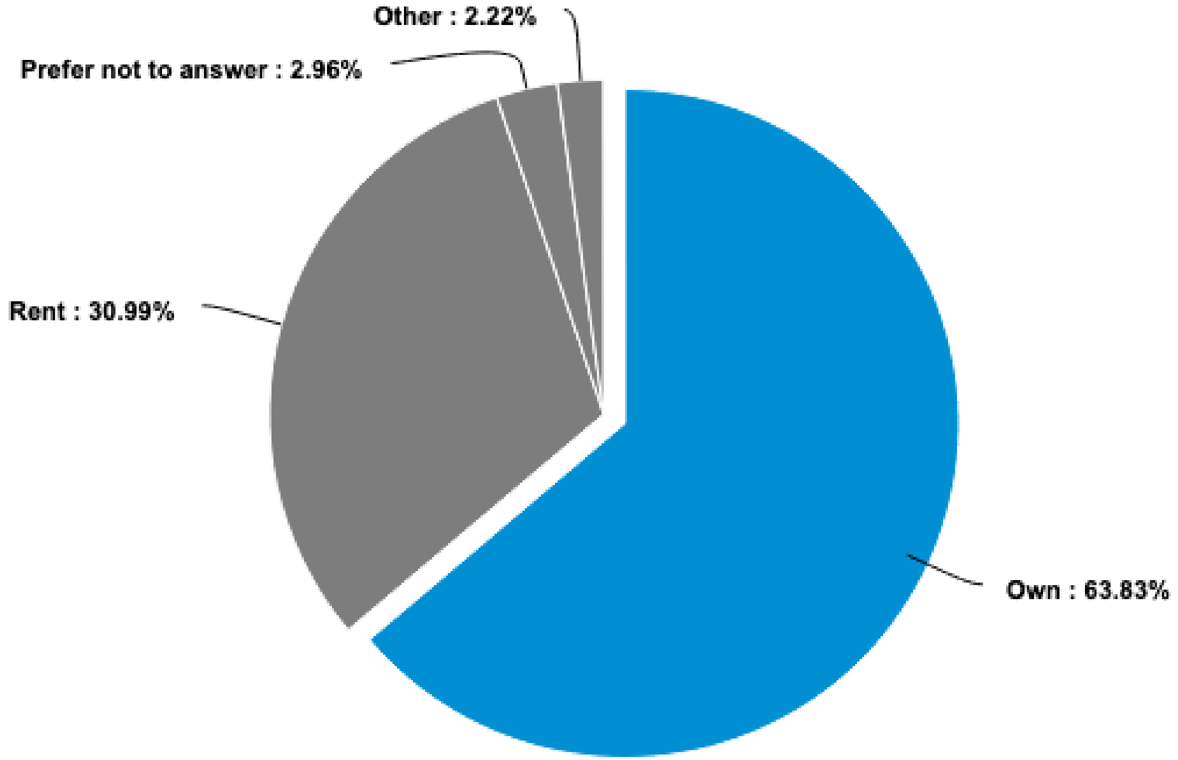


Kauai Housing Tenure

Housing tenure in Kauai (ACS 2020 5-year)

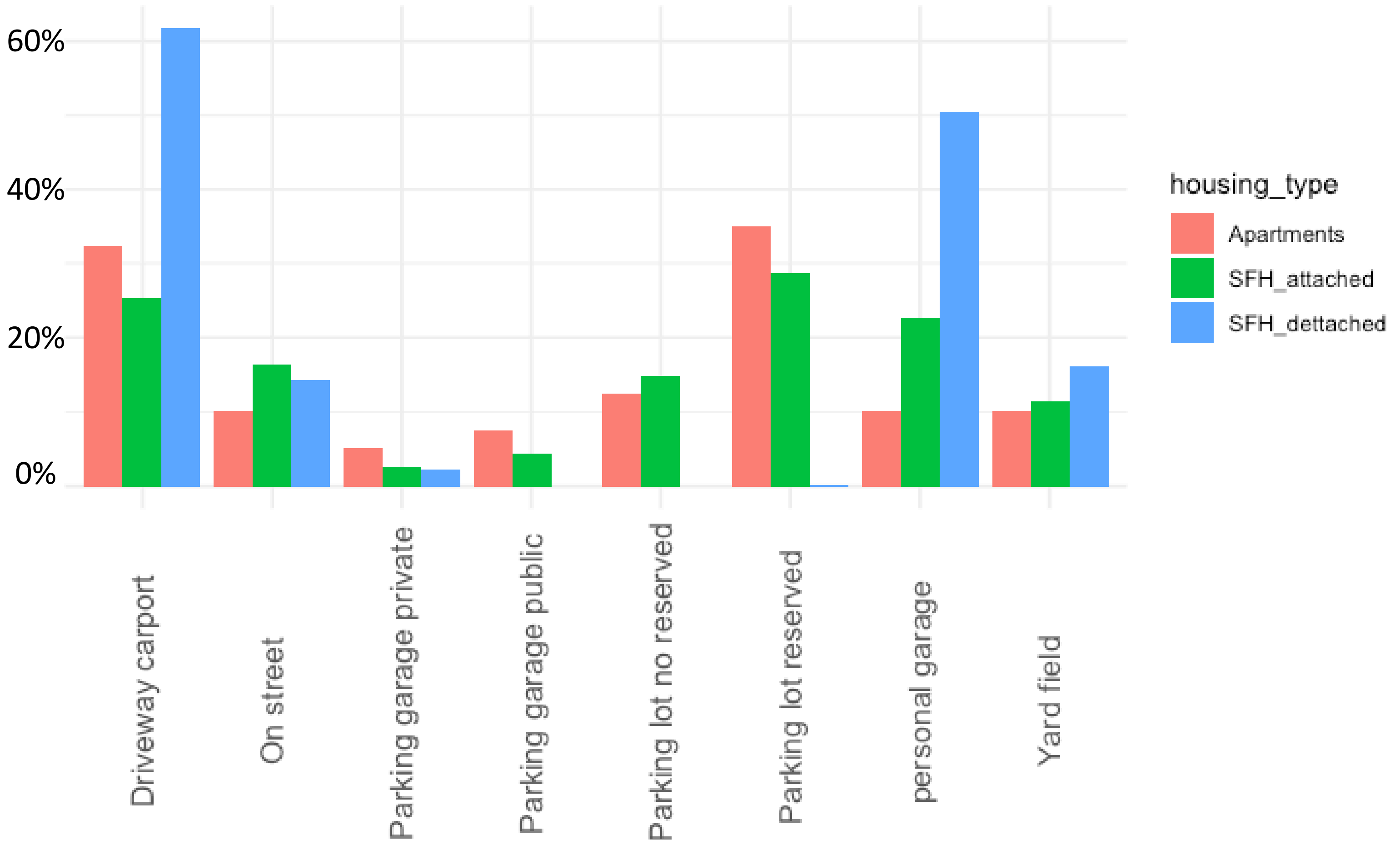


Housing tenure in transportation preference survey (2022)



Parking Type by Housing

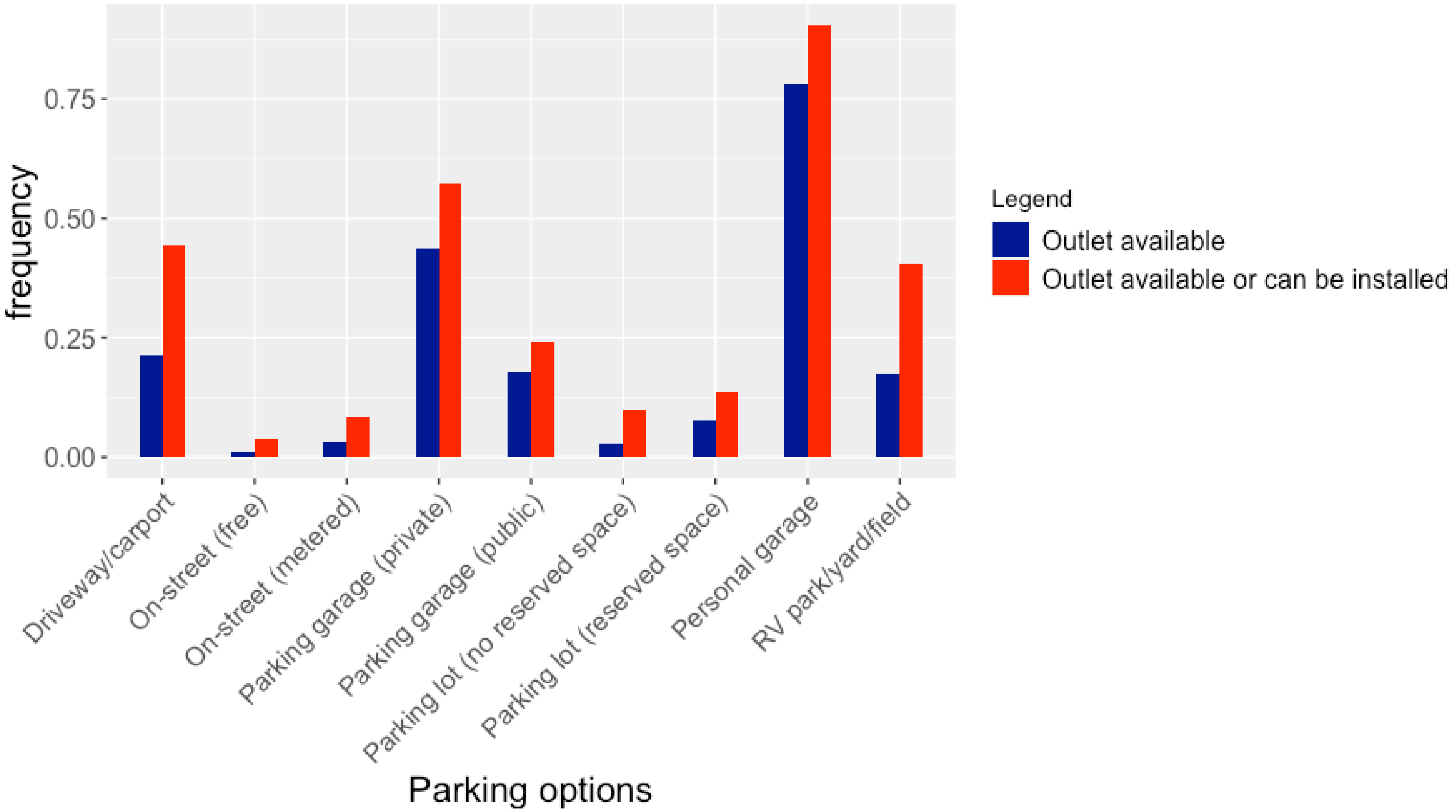
Multi-unit dwelling has less access to personal garages than single-family housing.



Parking Type by Housing Type in Kauai

Outlet Availability by Parking Type

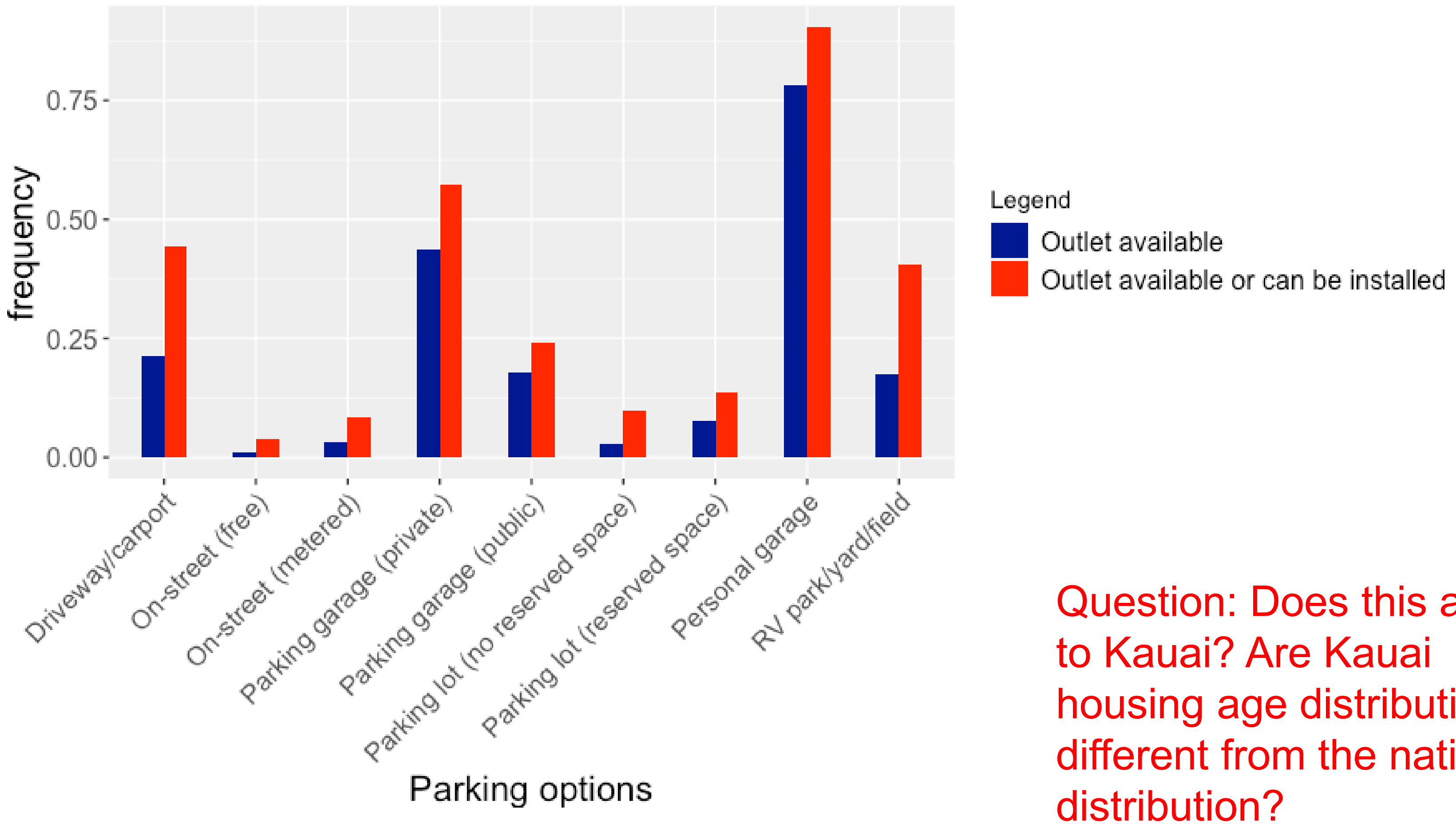
Personal garages and private parking garages have more access to electrical outlets, according to the national study.



Outlet Availability/Potential by Parking Type in the United States

Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

Outlet Availability by Parking Type/Building Age



Question: Does this apply to Kauai? Are Kauai housing age distribution different from the national distribution?

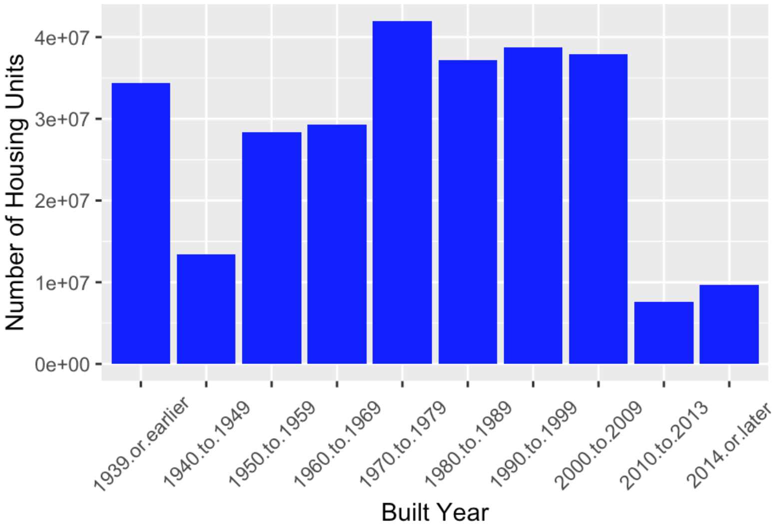
Outlet Availability by Parking Type in the United States

Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

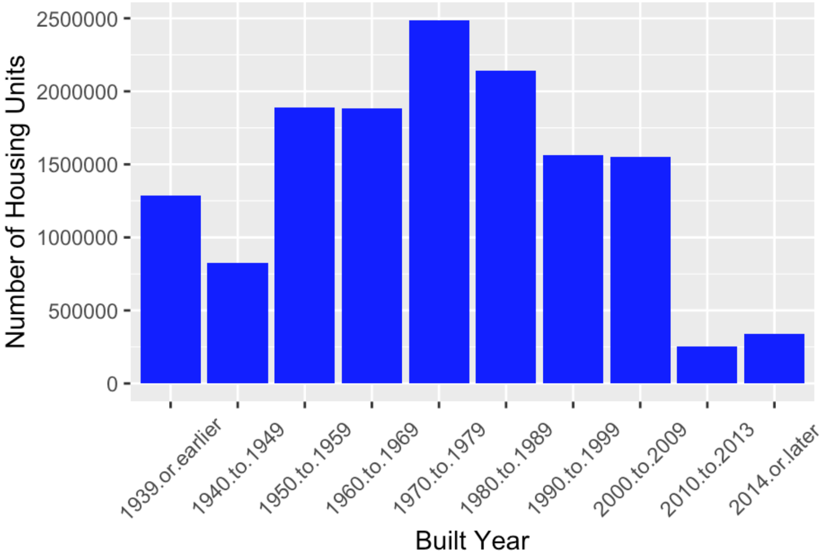
Housing Age

Kauai houses are relatively newer compared with the national distribution

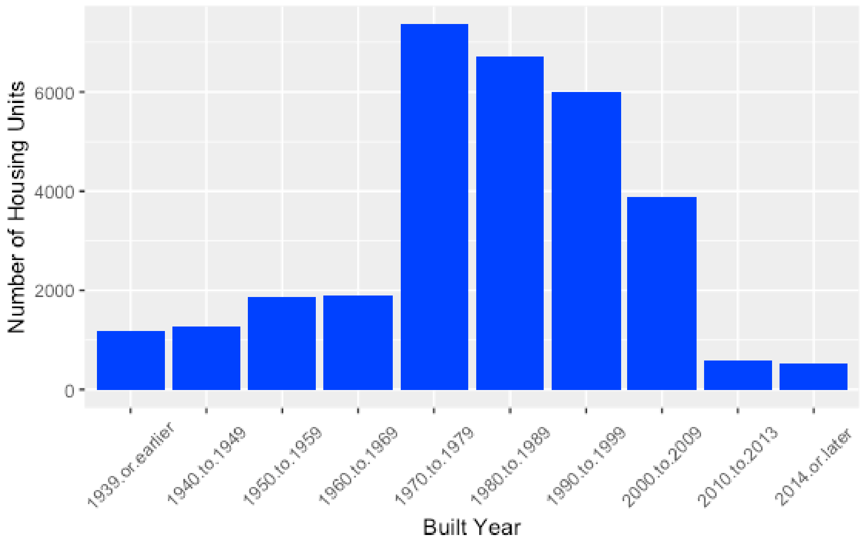
Housing age (ACS 2020 5-year)



National



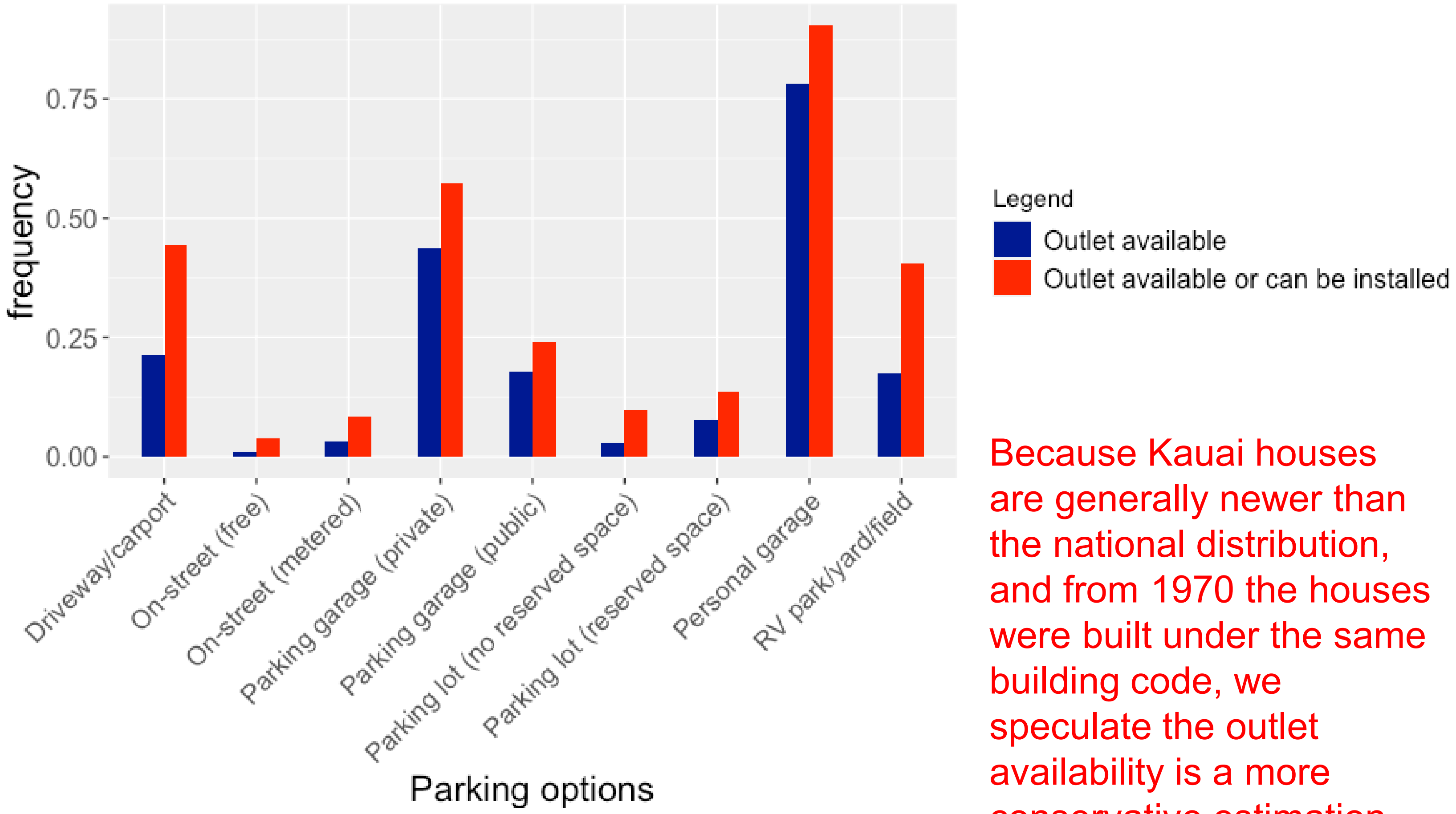
California



Kauai

Future Residential Charging Access

- Outlet availability by parking type/building age

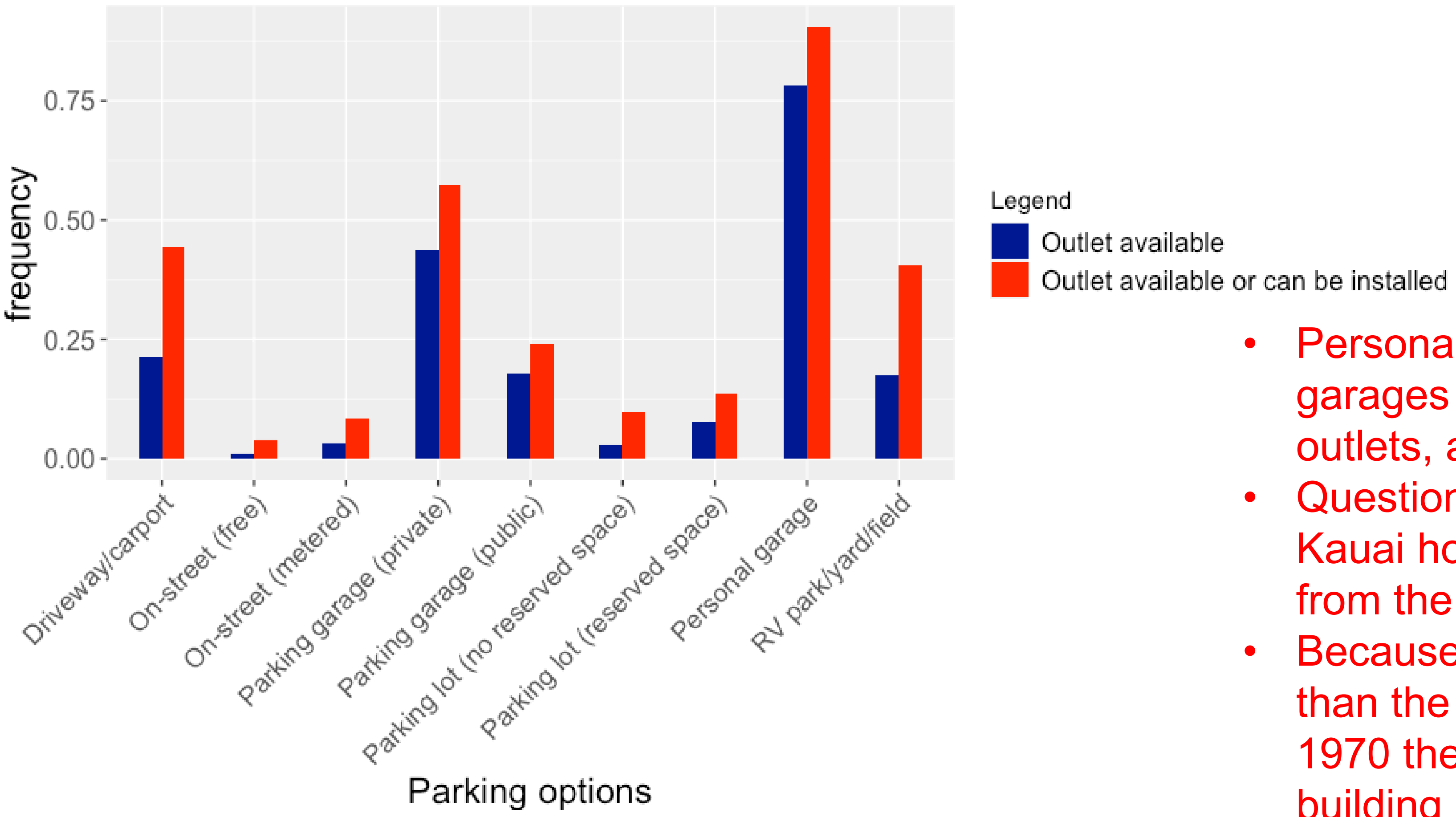


Because Kauai houses are generally newer than the national distribution, and from 1970 the houses were built under the same building code, we speculate the outlet availability is a more conservative estimation for Kauai.

Outlet Availability by Parking Type in the United States

Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

Outlet Availability by Parking Type and Future Residential Charging Access



Outlet Availability by Parking Type in the United States

- Personal garages and private parking garages have more access to electrical outlets, according to the national study.
- Question: Does this apply to Kauai? Are Kauai housing age distribution different from the national distribution?
- Because Kauai houses are generally newer than the national distribution, and from 1970 the houses were built under the same building code, we speculate the outlet availability is a more conservative estimation for Kauai.

Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

Building Division Inputs

- **Outlet availability information for personal garages of single-family housing according to stakeholders:**
  - Newer buildings are required by the code to install receptacles and encouraged to have 30-amp circuit for future EV adoption. (2017 national electric code: requires ground fault circuit interrupter (GFCI) outlets in garages and minimum one receptacle for each wall and ceiling.)
  - Age of the building plays a factor: older buildings do not have this requirement.
  - Adding new outlet or upgrading requires a permit.
  - Older “planation” homes have low amperage limit (60 amp) and upgrading needs a permit and rewiring.
  - Kauai Island Utility Cooperative (KIUC) determines whether there is service limitation to a particular location.
- **Parking garages/lots: no information**
  - Adding new outlet or upgrading requires a permit.

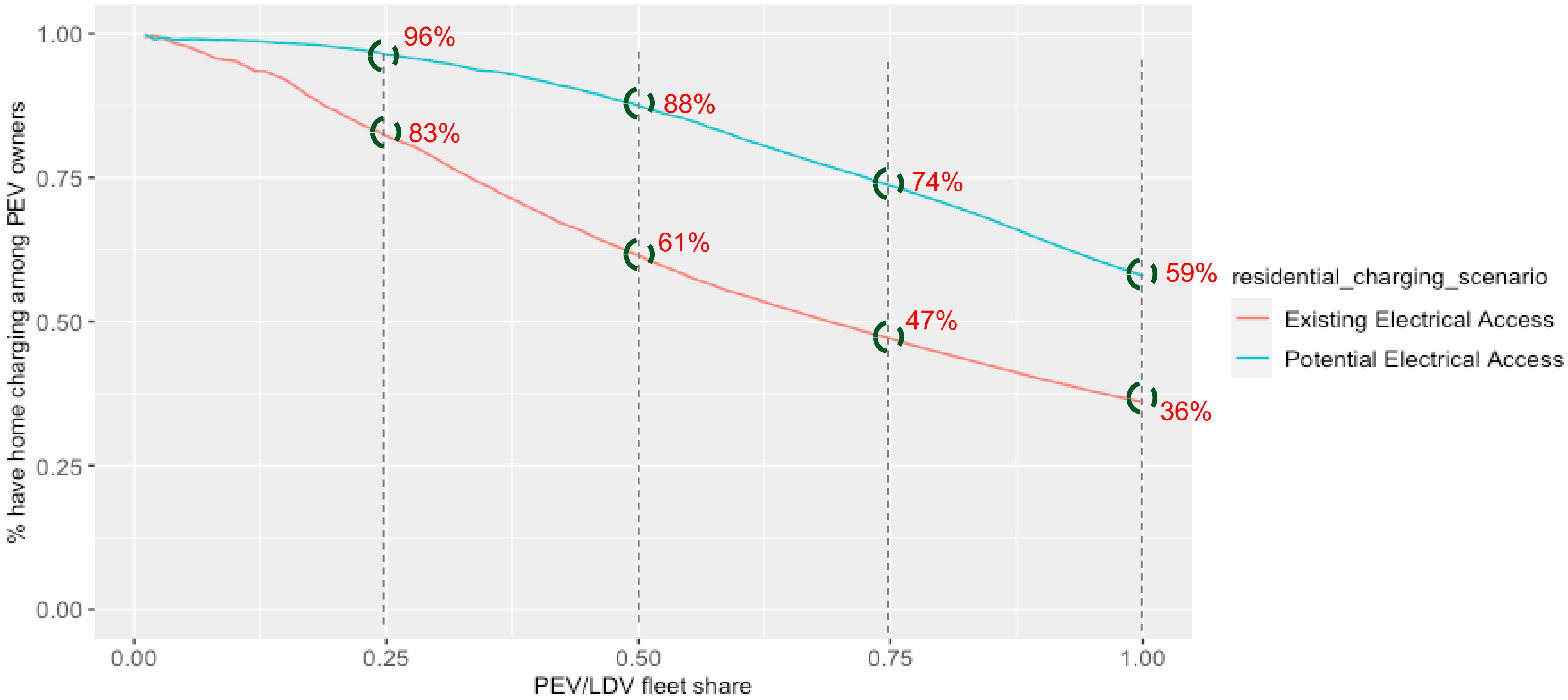
ELECTRICAL CODE

ORDINANCE	REFERENCE	EFFECTIVE DATE
104	National Electric Code of the National Board of Fire Underwriters	Oct. 17, 1959
108	Issuance of Licenses (Amendment to Ordinance 104)	June 7, 1960
210	1971 Edition NEC (Amendment to Ordinance 104)	Apr. 3, 1974
222	GFI Protection (Amendment to Ordinance 104)	June 1, 1974
247	1975 Edition NEC (Amendment to Ordinance 104)	May 9, 1975
360	1978 Edition NEC	Apr. 3, 1979
440	1981 Edition NEC (Amendment to Ordinance 360)	Jan. 8, 1982
483	1984 Edition NEC (Amendment to Ordinance 360)	Jan. 19, 1985
565	1987 Edition NEC	Apr. 17, 1990
687	1993 Edition NEC (Amendment to Ordinance 565)	Nov. 7, 1995
721	1996 Edition NEC	June 22, 1998
774	1999 Edition NEC	Dec. 4, 2001
858	2005 Edition NEC	Jan. 22, 2008
888	2008 Edition NEC (Amendment to Ordinance 858)	Mar. 14,2010
1039	2017 Edition NEC (Bill 2717)	Oct. 2, 2018

Future Residential Charging Access

We estimated a lower and upper bound of residential charging rate at different **adoption levels.**

- Light duty vehicle fleet by housing, tenure, etc.
- Single-family housing and homeowners are likely to adopt PEV earlier.
- Used the algorithm developed in a national study.



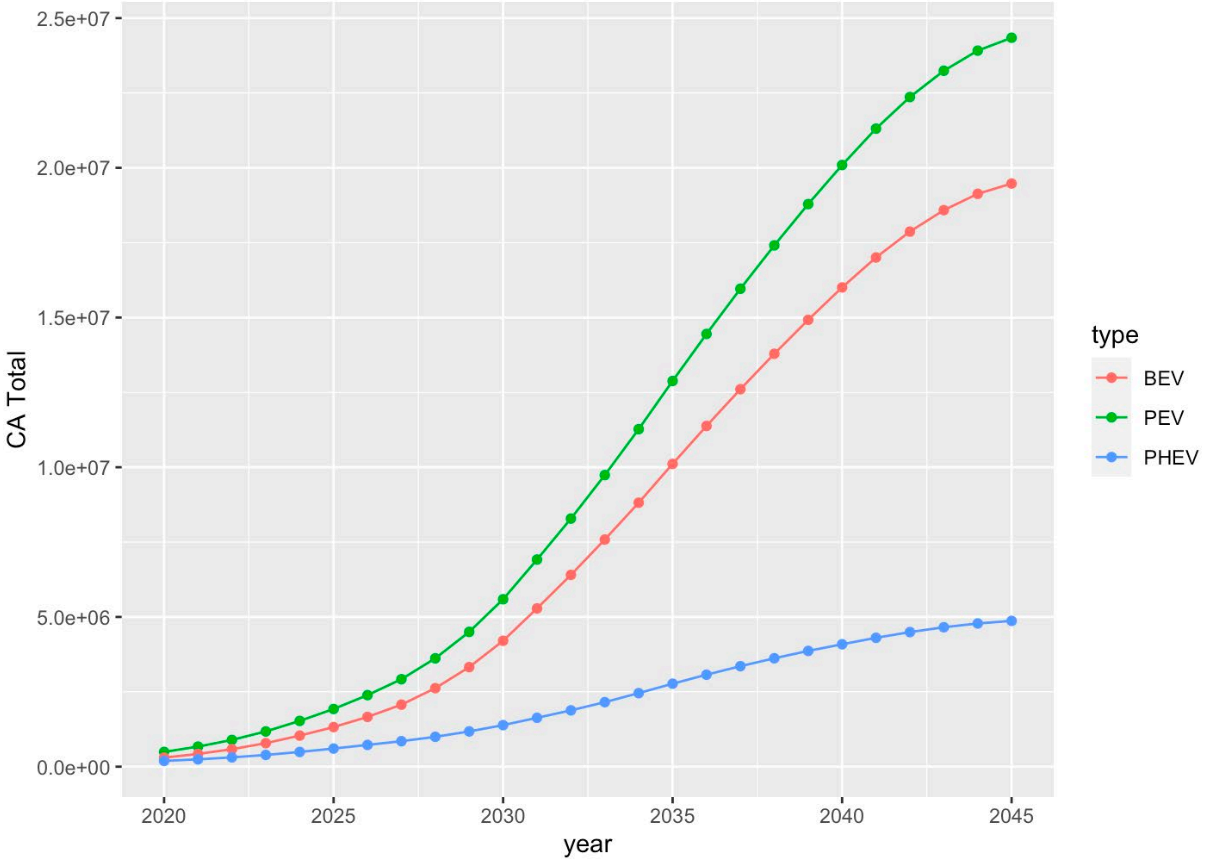
Source: Ge, Yanbo, Christina Simeone, Andrew Duvall, and Eric Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-81065. https://www.nrel.gov/docs/fy22osti/81065.pdf.

5. Other Input Assumptions

Future PEV Fleet

1. Private light duty vehicle stock (ACS 2020): 48,000.
2. Rental car fleet size: 12,000.
3. PEV type distribution for the future
   - BEV100 (40%): BEVs with 100 miles of range
   - BEV250 (40%): BEVs with 250 miles of range
   - PHEV20 (10%): PHEVs with 20 miles of range
   - PHEV50 (10%): PHEVs with 50 miles of range.

- It is predicted that plug-in hybrid electric vehicles (PHEVs) will have a smaller share in the future PEV market.



PEV type estimates, according to the University of California, Davis, Electric Vehicle Research Center.

Source: University of California, Davis, Electric Vehicle Research Center. EV Toolbox. https://gis.its.ucdavis.edu/toolbox/sgc/datasets/ca.

6. EVI-Pro Results

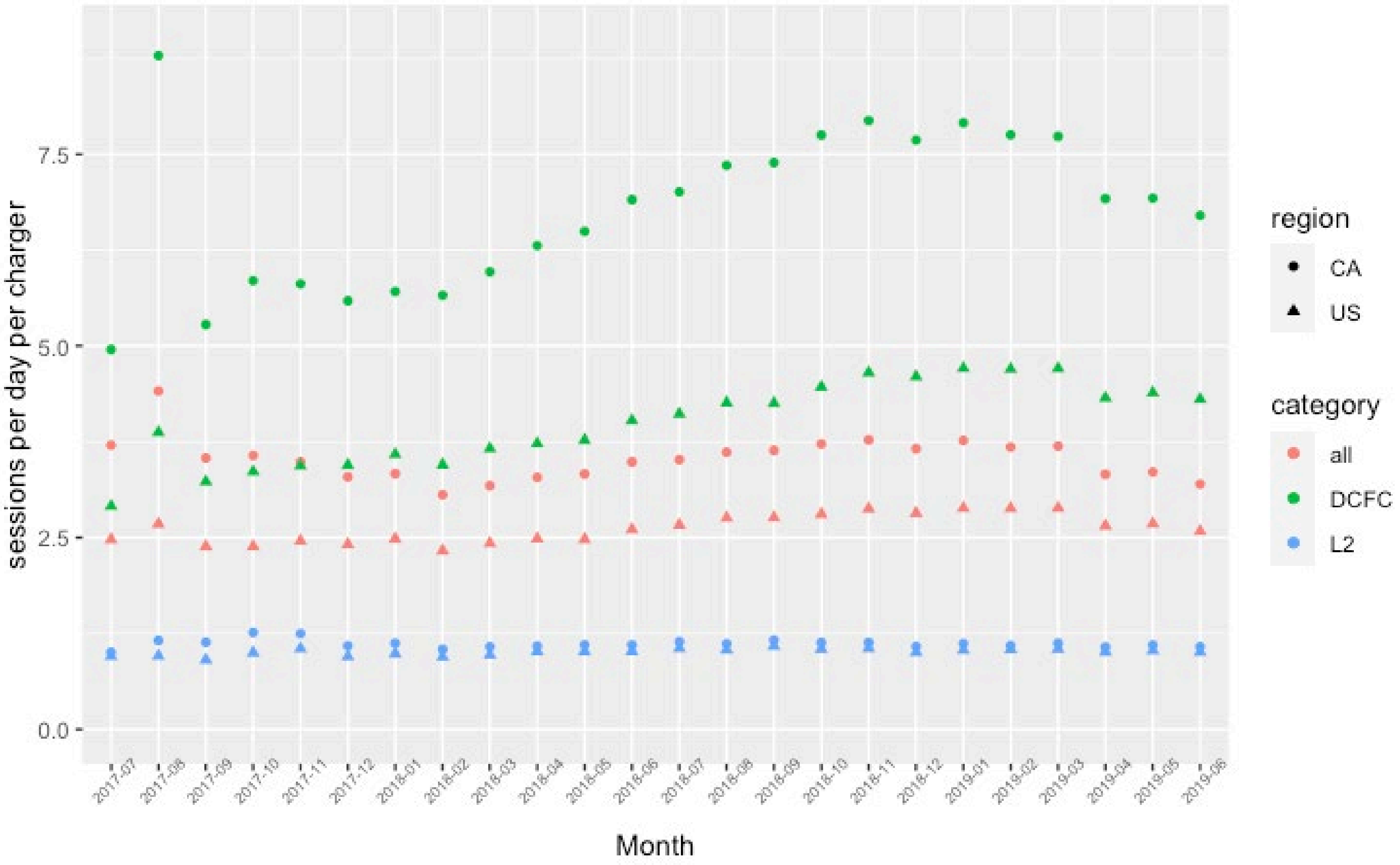
Out-of-Home of Charging Sessions

- Charging simulation carried out for different residential charging access assumptions.
- This table shows the number of **total charging sessions in one day.**

Electrification rate	Residential Charging Access Assumption (lower bound) – existing electrical access		Residential Charging Access Assumption (higher bound) – potential electrical access	
	DCFC charging sessions (daily)	L2 charging sessions (daily)	DCFC charging sessions (daily)	L2 charging sessions (daily)
25% private LDV fleet 50% rental car fleet	133	800	65	356
50% private LDV fleet 100% rental car fleet	484	3050	218	1269
75% private LDV fleet 100% rental car fleet	907	6148	508	3298
100% private LDV fleet 100% rental car fleet	1424	9562	970	6417

Out-of-Home of Charging Ports

- Number of ports = number of sessions/ utilization rate
- Utilization rate generated from empirical data
- DCFC utilization rate chosen here: 5 sessions/day
- Level 2 utilization rate: 1 session/day
- Utilization calculation applied at traffic analysis zone level.



Source: EVSP charging session data (from multiple EV charging networks).

Out-of-Home of Charging Ports

District level estimated DCFC charger counts: Number of ports for different electrification level under different residential charging access assumptions.

Electrification rate	**25% private LDV fleet 50% rental car fleet**		**50% private LDV fleet 100% rental car fleet**		**75% private LDV fleet 100% rental car fleet**		**100% private LDV fleet 100% rental car fleet**	
Residential Charging Assumption	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access
East Kauai	13	11	31	22	51	32	68	55
Hanapepe-Eleele	8	2	13	5	19	13	24	20
Koloa-Poipu-Kalaheo	14	9	23	16	43	27	58	39
Lihue	21	13	50	25	84	49	131	86
North Shore	7	6	17	9	20	16	29	25
Waimea	5	2	10	5	13	12	22	19
Total	68	43	144	82	230	149	332	244

Out-of-Home of Charging Ports

District level estimated Level 2 charger counts: Number of ports for different electrification level under different residential charging access assumptions.

Electrification rate	**25% private LDV fleet 50% rental car fleet**		**50% private LDV fleet 100% rental car fleet**		**75% private LDV fleet 100% rental car fleet**		**100% private LDV fleet 100% rental car fleet**	
Residential Charging Assumption	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access	(lower bound) – existing electrical access	(higher bound) – potential electrical access
East Kauai	161	76	641	262	1213	653	1954	1323
Hanapepe-Eleele	52	21	230	70	427	226	698	446
Koloa-Poipu-Kalaheo	163	61	550	253	1037	567	1548	1000
Lihue	284	128	1114	471	2470	1315	3921	2648
North Shore	85	46	302	108	558	291	768	500
Waimea	51	22	202	97	430	243	647	487
Total	796	354	3039	1261	6135	3295	9536	6404

Out-of-Home of Charging Ports

- GIS map in shapefile: Shows the **number of chargers at the TAZ level** (Kauai EV charger map.zip)

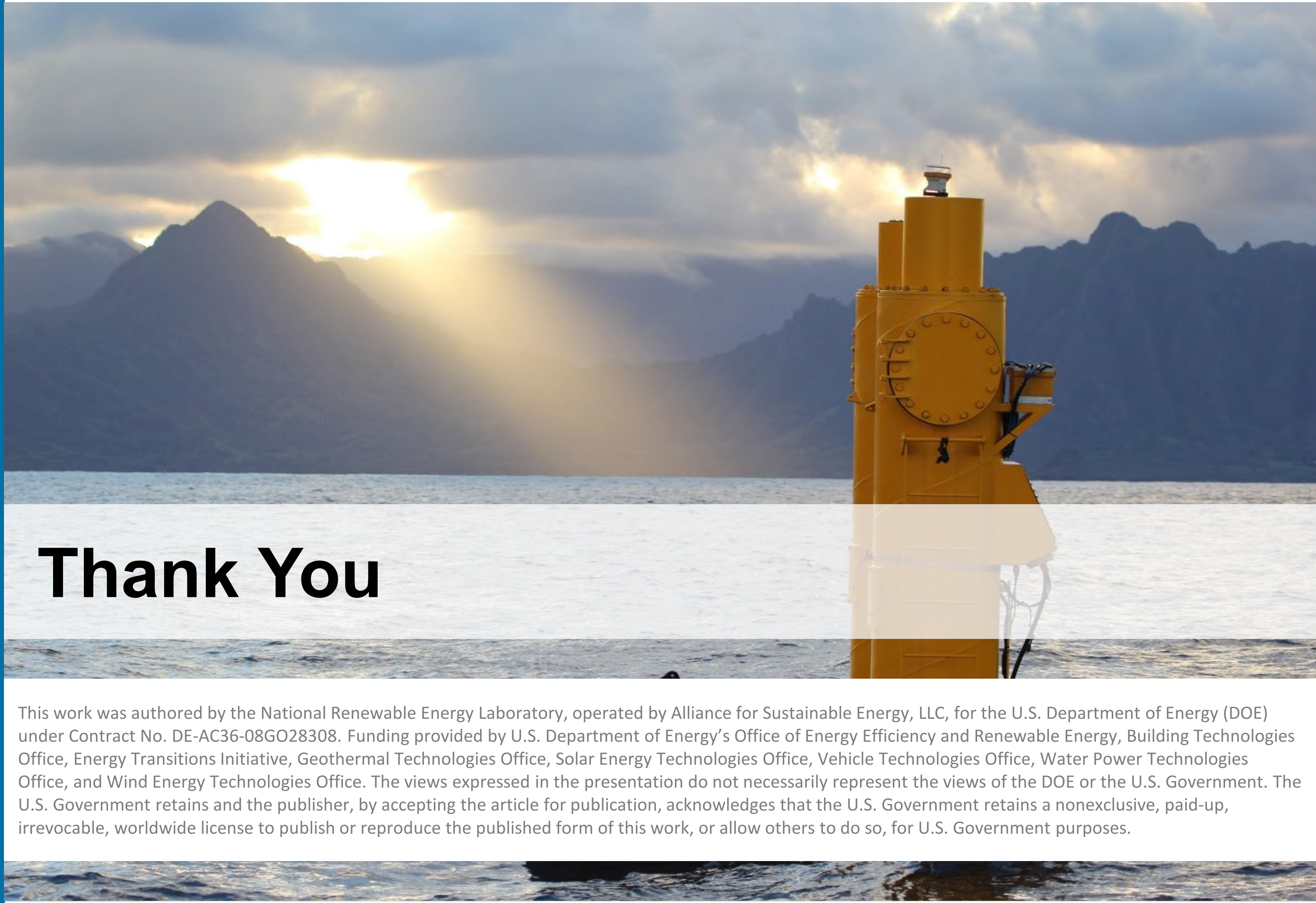
- Column naming:

dcfc_x_25

Type of charger:
DCFC or L2

Residential Charging Access Assumption:
x: existing electrical access (lower bound)
p: potential electrical access (higher bound)

Electrification rate:
- **25**: 25% private LDV; 50% rental car
- **50**: 50% private LDV; 100% rental car
- **75**: 75% private LDV; 100% rental car
- **100**: 100% private LDV; 100% rental car.



Thank You

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