research & economic analysis division

Solar PV Installations in Honolulu

an analysis based on building permit data

2017 Update

Statistics Report

Largely incentivized by generous tax credits and declining solar PV price, installation of solar PV system has been proliferating nationwide. With high-electricity prices and abundant solar resources in the state, Hawaii was one of the states that led the movement.

This statistical report was prepared to fill the need of learning detailed solar PV activities in Hawaii. The building permit has served as a useful tool in monitoring solar projects occurring in the area as the building permit is a prerequisite to install solar PV system. This report analyzed building permits issued in Honolulu County from January 2000 to June 2017.

The first section presents that the cumulated number of building permits issued for PV installation in Honolulu County reached 56,655 by June 2017, and over 2.1 billion dollars were spent for PV installation. Removing double counts of PV permits issued for the same house, the number of housing units with rooftop PV was estimated at 48,475 in section two. Residential rooftop PV market penetration rate was estimated at 14.0 percent when all housing units were considered as the potential market and 19.4 percent when single-family houses and townhouses, where rooftop PV can be installed, as the potential market. PV permits and the estimated number of housing units with rooftop PV were aggregated to over 200 census tract areas in section three to calculate area-specific PV market penetration rates, which were presented in tables and heat-map. It was also shown that the areas with higher owner-occupancy rate, higher share of single-family house, higher share of married-couple family households, and higher household income were associated with higher PV installation rates.

September 2017

Research and Economic Analysis Division
Department of Business, Economic Development and Tourism

State of Hawaii

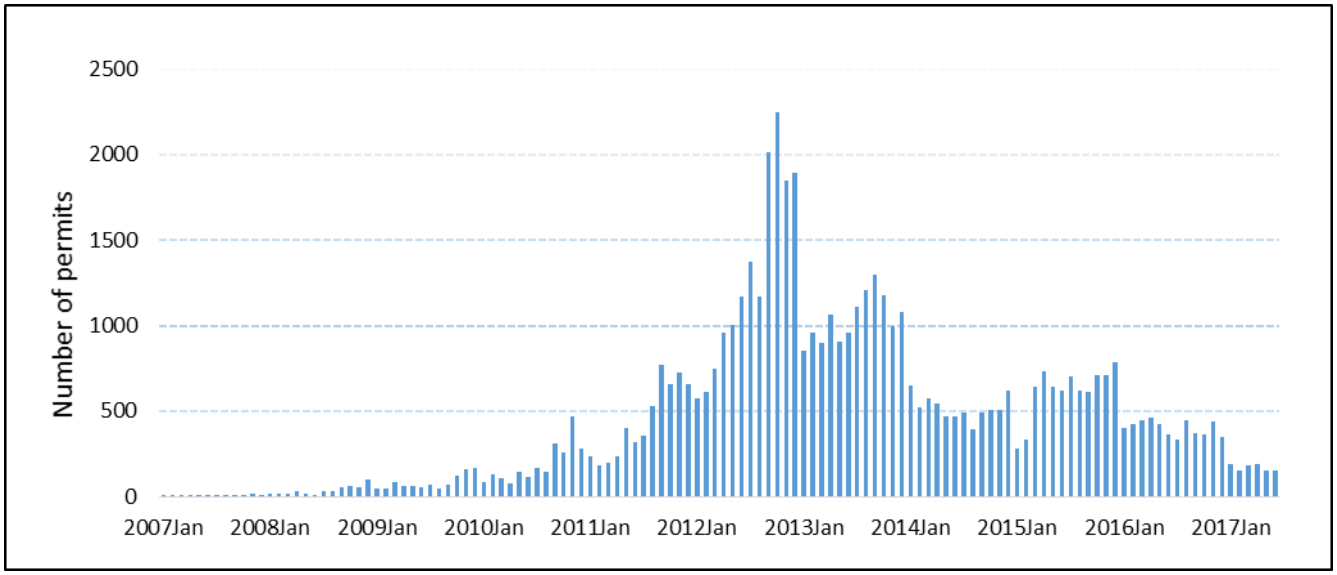
1. PV Installation by Building Permit

Trend

Solar PV installation in Honolulu started to increase gradually since 2008. After years of slow progress, PV installation exploded in 2012. A peak of PV installation was observed in September to December 2012. With the expected enforcement of new rules for Hawaii state solar tax credit, over 2,000 permits for PV installation were submitted each month during the period. Although it slowed down a little bit, the solar boom continued in 2013. Excluding the permits that were cancelled or revoked later, a total of 15,612 permits for 2012 and 12,507 permits for 2013 were issued for solar PV installation in Honolulu County.

PV installation on Oahu substantially slowed down from 2014. Total number of permits issued for PV installation in 2014 and 2015 was about half of the number the market experienced during the 2012-2013 peak period. PV installation further slowed down after 2016 with less than 5,000 PV permits issued in 2016 and mere 1,000 permits in the first six months of 2017.

Figure 1. Number of PV permits Issued per month: January 2007- June 2017



The cumulated number of building permits issued for PV installation in Honolulu County reached 56,655 by the end of the first half of 2017. In terms of spending, over 2.1 billion dollars were spent for PV installation by June 2017 based on the permit values reported on building permits.

The majority of PV permits were for residential buildings, accounting for 97.6 percent of total PV permits issued since 2000. Of the 55,288 residential PV permits, 53,869 permits (97.4 percent) was for single family houses, while 502 and 917 permits were issued for two family houses and apartment building respectively.[1]

[1] It will be discussed in the next section that many townhouse units reported them as single-family house in permits.

The building permits issued for PV installation at non-residential buildings, such as hotel, industrial and commercial building, were negligible in terms of number of permits, making up about 2 percent of total PV permits. PV projects for non-residential buildings were usually large in scale, however, and accounted for 27 percent of total PV permit value.

Table 1. Number of PV permits issued until June 2017 by Housing Type

Year	Number of PV Permits [1]							% of Permits closed as of July 2017	Total PV Permit Value [2] (1,000 current $)
	Total	For Residential Building				Hotel	Other types		
		Residential Total	Single Family	Two Family	Apartment				
2000-2005	22	19	19				3	100%	894
2006	39	36	32	3	1		3	100%	1,292
2007	70	55	54	1			15	98.6%	7,837
2008	433	374	370	2	2		59	99.3%	26,208
2009	984	922	905	10	7		62	99.9%	39,689
2010	2,273	2,180	2,130	35	15		93	99.9%	87,626
2011	5,255	5,090	4,949	78	63		165	100.0%	233,110
2012	15,612	15,444	15,201	167	76		168	99.8%	620,817
2013	12,507	12,257	11,998	69	190	2	248	99.0%	421,368
2014	6,234	6,124	5,955	55	114		110	96.3%	188,711
2015	7,392	7,201	6,998	38	165		191	97.0%	267,090
2016	4,822	4,622	4,373	24	225		200	94.5%	227,089
2017(~June)	1,012	964	885	20	59		48	66.8%	36,739
Total (2000-June 2017)	56,655	55,288	53,869	502	917	2	1,365	97.8%	2,158,470

1 Permits that were cancelled or revoked after being issued were excluded.
Housing types were based on the self-reported information on permits

2 There were 141 PV permits that included other works that were not related to PV installation. For those permits, median PV permit value of its housing type was used instead of the value reported on permits.

Cost of rooftop solar PV

We estimated how much people have been spending to install rooftop PV using the value accepted in PV permits issued for single family houses. To make the permits issued in different years comparable, we adjusted the values in 2000-2016 permits for inflation using Honolulu consumer price index. Another issue for cost estimation was the permits that were combined with other jobs that were not related to PV installation. Although a separate building permit was required for PV

installation, some PV permits were still combined with other unrelated jobs such as fence, wet bar, etc. These permits were excluded from the calculation.

Table 2 presents the distribution of cost that households in Honolulu have paid to install a rooftop PV system. Among 53,804 PV permits that were issued for single family house from 2000 to June 2017 and not combined with other jobs, 31.8 percent were in the $30,000-$50,000 range and 84.2 percent were in the $10,000-$50,000 price range. The median cost to install a PV system at single family house was $27,247 in 2017 dollar.

As will be discussed in the next section, non-negligible number of single family houses had more than one PV permit issued for the house. It means that those houses installed PV system in multiple steps and the true cost of installing rooftop PV for those houses was more than the amount reported on one permit. For that reason, Table 2 tends to underestimate the actual cost to some extent.

Table 2. Distribution of PV installation cost for single family house in 2017 dollar (Jan 2000-Jun 2017)

Value reported in PV permit	PV permits (% of total PV permits for single family houses*)	
Less than 5,000	1.4%	
5,000 ≤ value < 10,000	4.4%	
10,000 ≤ value < 20,000	**24.7%**	
20,000 ≤ value < 30,000	**27.7%**	Mean: $29,848
30,000 ≤ value < 50,000	**31.8%**	Median: $27,247
50,000 ≤ value < 100,000	9.6%	
100,000 ≤ value < 200,000	0.5%	
200,000 ≤ value < 500,000	0.04%	
Over 500,000	0.01%	

*The category of "Single Family House" was based on the housing type reported on permits
Permits that included non-related works were excluded.

2. Estimation of the Number of Housing Units with Rooftop PV

Many housing units with multiple PV permits

Since building permit is required to install a solar PV system, the number of building permits approved for PV installation at residential buildings is a good indicator of the number of housing units with a PV system. However, the actual number of households with a PV system can be much smaller than the number of permits issued for residential PV installation. This is because a house

can install PV system in multiple steps requiring multiple building permits. Some households may have done in that way simply to maximize the benefit from the solar tax credit. It is also likely for a house to submit the second and third PV permit to add more panels to the existing PV system when it finds additional need for it.

All property lots in Hawaii are identified by a 9-digit TMK (Tax Map Key) assigned by the real property tax office, and this TMK information is included in building permits. For typical single family houses, the 9-digit TMK represents each housing unit. According to building permits issued until June 2017, however, a total of 53,869 PV permits were issued to 44,674 unique TMK lots that were reported as single-family house. The number of TMKs was much smaller than permit numbers because about 6,000 TMKs, which were reported as single-family house, had more than one PV permit issued for the lot. About 4,900 TMKs had two PV permits while the rest had three or more PV permits. If our interest is in the number of housing units with a PV system, not the number of PV permits itself, we must include only one PV permit for each housing unit even though more than one permits were issued to the housing unit.

Should PV permits for all residential housing types be included in the count?

Residential PV permits presented in Table 1 include not only the rooftop PV system for individual housing units but also various types of PV projects for commercial or common area of residential buildings. PV permits issued for high-rise buildings or low-rise buildings where individual units don't have their own roof may subject to the latter type. Although residential units in the building with any PV system would benefit from the system in some ways, it would make better sense to exclude those PV permits in the estimation of housing units with rooftop PV because they are not for the exclusive use of individual housing units.

Technical challenges

Removing duplicated counts was challenging for the reason that the building permit data doesn't provide enough information to identify each housing unit if it is not a lot for single-family house. If a high-rise building or townhouse community was developed as a Condominium Property Regime (CPR) on a property lot, all housing units on the lot, sometimes hundreds of units, would share the same 9-digit TMK. Although each CPR unit can be identified by the additional 4-digit unit number at the end of each TMK, the unit numbers are not reported in building permits.

Another technical challenge was misspecification of housing type in building permits. Since the information in the permit was self-reported by permit applicant, housing type was often misspecified. For instance, a total of 46 permits were issued for PV installation at a TMK lot where more than 300 townhouse units were on it. Among the 46 permits, 20 permits described them as "Single Family House" while the rest 26 permits described them as "Apartments". This is only one example of many townhouse units that reported them as single-family house in the permit. Since all units on a CPR lot have the same 9-digit TMK, it would result in dropping many valid counts if we

include only one PV permit for single-family house TMKs based on the housing type reported in the permit.

Estimating the number of housing units with rooftop PV counting one PV permit per house

For the purpose of estimating the housing units with rooftop PV, we considered two housing types; "type 1" where rooftop PV for individual unit's use can be installed and "type 2" where it is difficult for individual unit to have its own PV system. Single-family house, duplex, and townhouse would subject to "type 1" while high-rise and non-townhouse type low-rise building would fall in "type 2". We then re-identified, instead of using the housing type reported in the permit, the type of housing units on each TMK lot using the condominium data from the State Department of Commerce, and Consumer Affairs (DCCA) and the city's property tax database.[2]

Among all residential PV permits, 55,080 permits (99.7 percent) were for single-family house or townhouse when this new housing types were employed. By applying the following rules, we estimated total number of housing units that have installed rooftop PV until June 2017 at 48,475.

1. PV permits that were issued for non-townhouse type multi-unit buildings (type 2) were not included as they were mostly for common area or commercial use of the building.
2. PV permits that were issued for single-family house or townhouse type multi-unit building (type 1) were included but only up to the number of residential units on the lot. For single-family house lots, only one permit was included. For townhouse CPR lots, PV permits were included up to the number of residential units on the lot.
3. Among PV permits that were issued for townhouse type multi-unit buildings, the permit was excluded if the permit says explicitly "Commercial" and if the value of the permit was over $50,000.

Rooftop PV market penetration rate can be calculated as percentage of the number of housing units with rooftop PV among all housing units in Honolulu County. According to the 2016 American Community Survey 1-year estimates, there were a total of 347,458 housing units in Honolulu County in 2016, resulting in 14.0 percent rooftop PV market penetration. For a more useful market penetration rate, we may use single family houses and townhouses only, where rooftop PV can be installed, as the denominator. However, the estimates of total number of single-family houses and townhouses in Honolulu County was not readily available for our use. Hence, we estimated total

[2] All CPR project have to register with the real estate commission at DCCA before any unit in the project is offered for sale. The data provides basic description of the CPR project, such as how many buildings, stories of the buildings, and how many residential units on the CPR lot. Using the information available from the DCCA condominium data, we classified one- and two- story buildings as type 1, and 4 or higher story buildings as type 2. 3 story buildings were assigned either into type 1 or type 2 depending on whether it has townhouse type architectural style or not. For the property lots that were not included in the condominium data, we found the number of housing units on the lot from the city's property tax database.

number of single family houses and townhouses (type 1) by subtracting residential units in non-townhouse type multi-unit buildings (type 2) from total housing units. We first subtracted residential units in non-townhouse type multi-unit buildings on DCCA's condominium list, which was estimated at 86,200. In addition to that, we also subtracted those units on the affordable housing inventory list because rental-only buildings were not included in the DCCA's condominium data. [3] In this way, total number of single family houses and townhouses in Honolulu County was estimated at 249,990, and rooftop PV market penetration rate using this number as the denominator was then estimated at 19.4 percent.

Table 3. Estimated number of housing units with rooftop PV and market penetration rate

Building permits issued for PV installation	
PV permits for all residential buildings	55,288
- PV permits issued for "single-family house or townhouse type multi-unit building"	55,080 [1]
Number of housing units with rooftop PV (HUpv)	
Single family houses and townhouses with rooftop PV, counting only one PV permit per house	48,475 [1]
Housing units	
Total number of housing units in Honolulu County in 2016 (HU)	347,458 [2]
- Housing units in "single-family house or townhouse type multi-unit building" (HU-type1)	249,900 [1]
Rooftop PV market penetration rate	
'Housing units with PV" among "all housing units" (HUpv/HU)	14.0%
"Housing units with PV" among "all single family houses and townhouses" (HUpv/HU-type1)	19.4%

1. DBEDT estimates
2. U.S. Census Bureau, 2016 American Community Survey 1-Year Estimates

[3] Hawaii Housing Finance and Development Corporation, Affordable Housing Inventory
There were 11,380 of them excluding about 1,000 units that were included in DCCA's condominium data.

3. Solar PV Installation by Area

How many PV systems have been installed in each geographic area is useful information for numerous planning purposes. We summarized the residential PV installation status in Honolulu County in two geographic levels. To provide a general idea on residential PV activities on Oahu, Table 4 presents the number of building permit issued for PV installation until June 2017, and the estimated number of housing units with rooftop PV as of July 2017 by city's 35 neighborhood areas. The biggest market on Oahu for solar PV was Ewa area where 5,183 housing units were estimated to have installed rooftop PV so far. Other areas where PV installation has been very active include Waipahu (3,766), Kailua (3,704), Makakilo/Kapolei (3,251), Hawaii Kai (2,798), Aiea (2,656), Mililani/Waipio/Melemanu (2,605), and Kaneohe (2,505).

We also aggregated the statistics by census tract, the geographic area much smaller than the neighborhoods. Table 5 on page 11 presents PV permits and the estimated number of housing units with rooftop PV for over 200 census tracts in Honolulu County with the selected household characteristics associated with the area. While there is more than one way to define PV market penetration rate, we calculated PV market penetration rates in Table 5 by dividing the estimated number of housing units with rooftop PV by total number of housing units in the area. Please note that the latest data available for housing units at census tract level was the 2015 American Community Survey 5 year estimates, which was the average statistics for the 2010-2015 period. On the other hand, the estimated number of housing units with rooftop PV included all PV permits issued until June 2017. We considered adjusting this time difference using the fact that housing units in Honolulu County grew on average 0.5 percent annually between 2010 and 2016. However we decided not to do that and left the adjustment to the users of statistics, because the growth in housing units occurred only in certain areas, not evenly in all areas.

Since census tract is the statistical geography where various social, economic, and housing indicators are available from U.S. Census Bureau, aggregation of PV activities by census tract allowed us to examine how different household characteristics in the area have affected to solar PV installation in the area. Scatter plots of 220 census tract areas in Figure 2 show the relationship between PV installation and four selected household characteristics that seem to have had a positive effect on PV installation. The areas with higher owner-occupancy rate, higher share of single-family house, higher share of married-couple family households, and higher household income were associated with higher PV installation rates. However, the relationships shown on the scatter plots are inclusive of the effects of other variables rather than the exclusive effect of the characteristic on the X axis. In order to see the impacts of each characteristic after factoring out the effect of other variables, we conducted a simple OLS multiple regression analysis with the four household characteristics as independent variables. The regression results showed that all four characteristics had a statistically significant positive effect on PV installation after factoring out the effect of other variables.

Table 4. PV installation by Neighborhood

Neighborhood	Number of building permits issued for PV installation			Estimated number of Housing units with a rooftop PV [1]
	Total	For non-residential building	For residential building	
AIEA	3,099	59	3,040	2,656
AIRPORT	68	59	9	8
ALA MOANA/KAKAAKO	82	49	33	21
ALIAMANU/SALT LAKE/FOSTER VILL	1,232	13	1,219	1,065
DIAMOND HEAD/KAPAHULU/ST. LOUI	1,194	45	1,149	981
DOWNTOWN	39	25	14	10
EWA	5,802	32	5,770	5,183
HAWAII KAI	3,220	15	3,205	2,798
KAHALUU	938	13	925	812
KAILUA	4,380	49	4,332	3,704
KAIMUKI	1,787	23	1,764	1,531
KALIHI VALLEY	605	9	596	540
KALIHI-PALAMA	718	228	490	419
KANEOHE	2,904	37	2,867	2,505
KOOLAULOA	681	20	661	562
KULIOUOU-KALANI IKI	2,125	13	2,112	1,822
LILIHA/KAPALAMA	1,292	36	1,257	1,077
MAKAKILO/KAPOLEI/HONOKAI HALE	3,699	120	3,580	3,251
MAKIKI/LOWER PUNCHBOWL/TANTALU	545	37	508	405
MANOA	1,472	48	1,424	1,201
MILILANI MAUKA-LAUNANI VALLEY	2,255	10	2,245	2,030
MILILANI/WAIPIO/MELEMANU	3,000	28	2,972	2,605
MOANALUA	593	8	585	512
McCULLY/MOILIILI	265	48	217	165
NANAKULI/MAILI	1,115	27	1,089	1,003
NORTH SHORE	905	28	878	750
NUUANU/PUNCHBOWL	1,035	19	1,016	867
PALOLO	764	12	752	631
PEARL CITY	2,658	37	2,621	2,287
WAHIAWA	974	26	948	849
WAIALAE-KAHALA	1,178	19	1,159	1,000
WAIANAE	1,101	49	1,053	943
WAIKIKI	19	11	8	2
WAIMANALO	601	14	588	520
WAIPAHU	4,317	108	4,209	3,766

[1] DBEDT estimates

Figure 2. PV installation and selected household characteristics

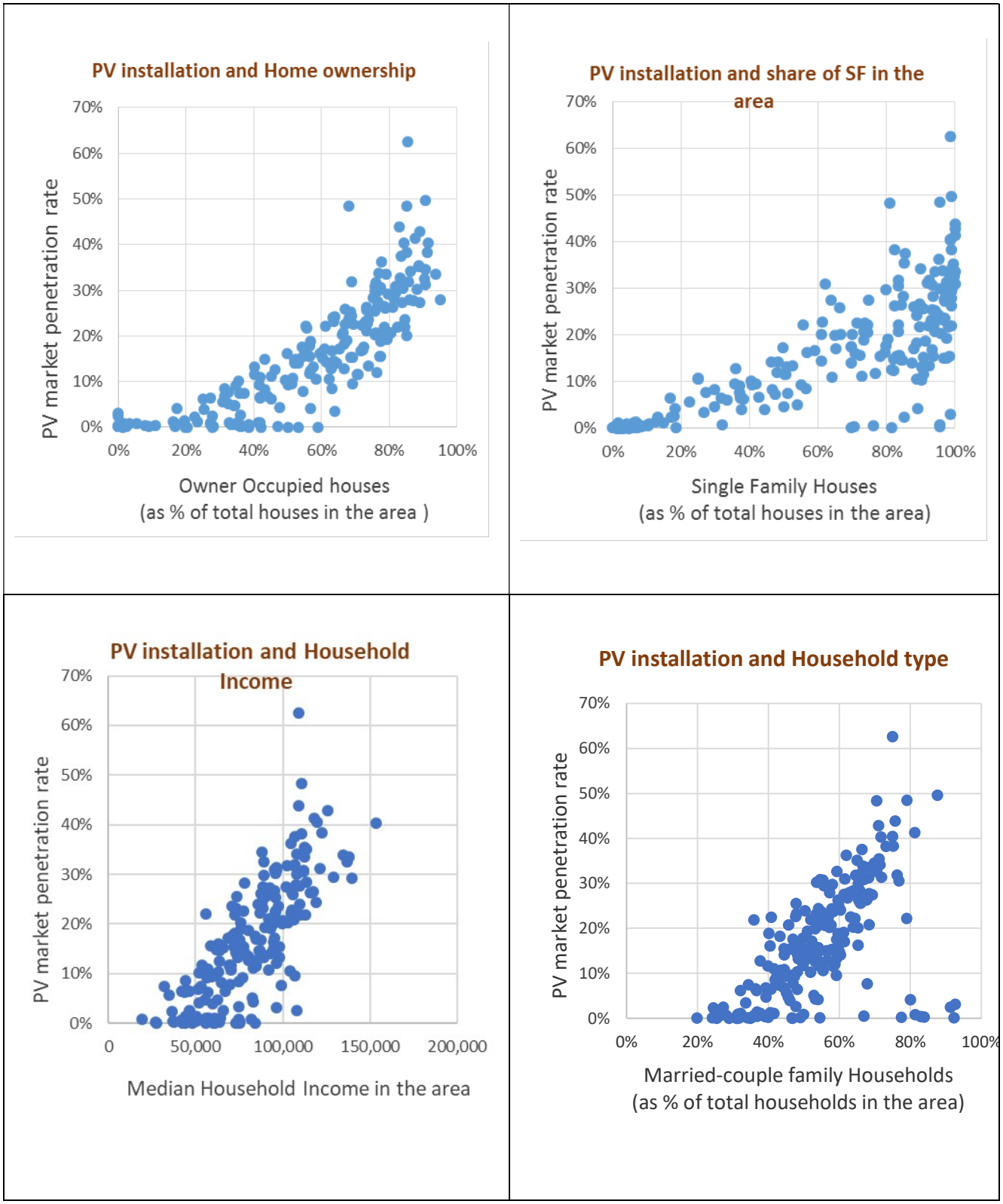


Figure 3. Rooftop PV market penetration rate by census tract as of July 2017

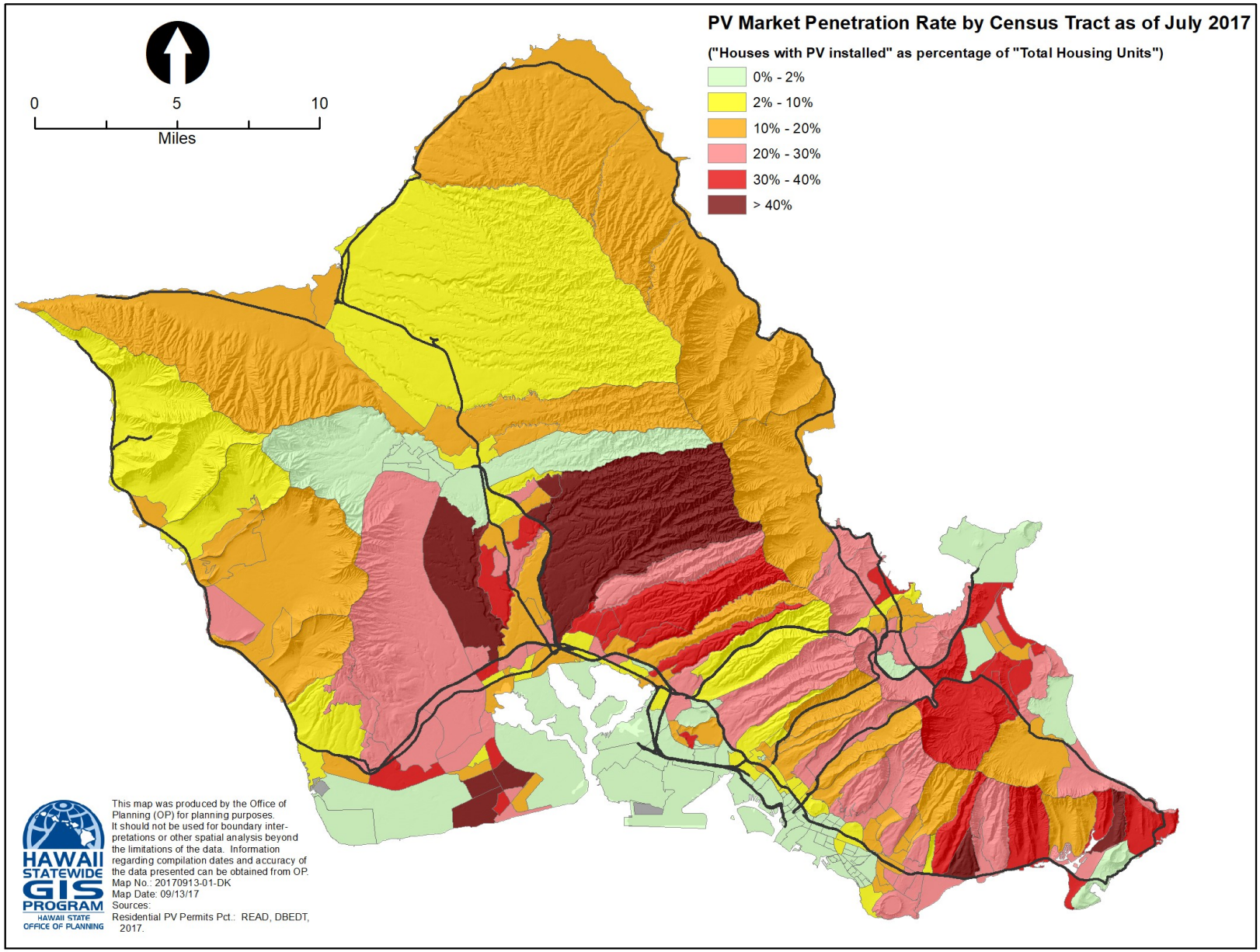


Table 5. PV installation and Housing characteristics by Census Tract

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
1.06	Hahaione-Mariners Ridge	480	4	476	403	3,341	12.0%	76.2%	48.0%	58.8%
1.07	Kuapa Isle	334	1	333	292	955	30.5%	84.1%	83.5%	76.8%
1.08	Hawaii Kai Marina	342	3	339	302	1,330	22.7%	73.5%	61.1%	56.9%
1.10	Kalama Valley	657	1	656	559	1,459	38.3%	91.2%	98.9%	75.2%
1.11	Lunalilo Park Subdivision	703	1	702	624	1,457	42.8%	89.0%	100.0%	71.0%
1.12	Koko Marina	456	5	451	411	2,049	20.1%	85.1%	70.0%	65.2%
1.14	Portlock	246	1	245	205	611	33.5%	93.6%	100.0%	67.9%
10	Upper Palolo	175	1	174	149	1,109	13.4%	73.9%	92.4%	52.7%
100	Kawailoa	82	8	74	67	1,619	4.1%	17.3%	44.4%	80.0%
101	Waimea-Kahuku	482	19	463	391	3,031	12.9%	62.9%	90.4%	56.7%
102.01	Hauula-Kaaawa	299	4	295	252	2,005	12.5%	46.3%	81.4%	53.2%
102.02	Laie	282	3	279	228	1,556	14.7%	53.0%	84.5%	60.1%
103.03	Kahaluu-Waikane	258	12	246	216	1,439	15.0%	60.3%	97.6%	47.8%
103.05	Ahuimanu	347	0	347	304	1,442	21.1%	73.3%	94.0%	53.8%
103.06	Haiku	506	1	505	438	2,109	20.8%	80.5%	73.3%	68.4%
103.08	Kapunahala	317	1	316	274	1,003	27.3%	89.1%	96.9%	61.6%
105.03	Kaneohe District Park	101	2	99	86	552	15.5%	54.5%	78.1%	49.3%
105.04	Waikalua Road	275	4	271	228	1,406	16.2%	59.5%	79.4%	65.3%
105.05	Heeia Kea	392	4	388	340	1,085	31.3%	90.6%	97.6%	71.8%
105.07	Kahuhipa Street	190	6	184	165	1,784	9.2%	50.1%	40.7%	47.3%
105.08	Lilipuna Road	121	3	118	106	1,111	9.5%	69.2%	41.7%	59.2%
106.01	Puohala	212	11	201	171	1,106	15.4%	77.1%	82.9%	51.5%
106.02	Castle High School-Halekou	494	4	490	431	1,613	26.7%	76.5%	89.7%	62.3%
107.01	Kokokahi	347	4	343	299	1,444	20.7%	80.5%	83.4%	57.7%
107.02	Mokulele Drive	289	0	289	267	1,180	22.6%	67.0%	73.5%	47.7%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology
[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
108.01	Mokapu West	1	0	1	1	819	0.1%	1.2%	81.6%	92.3%
108.02	Mokapu East	10	2	8	7	1,951	0.4%	0.0%	70.4%	83.0%
109.01	Kalaheo Hillside	380	4	376	318	1,019	31.2%	83.2%	92.0%	68.3%
109.03	Oneawa Street-Kawainui	294	2	292	252	1,431	17.6%	54.1%	69.6%	46.9%
109.04	Maluniu Avenue	311	1	310	269	1,118	24.0%	63.4%	95.1%	60.3%
109.05	Ulupaina Street	210	12	198	170	902	18.8%	56.6%	73.4%	40.1%
11	Central Palolo	153	4	149	127	1,159	11.0%	41.7%	64.1%	41.6%
110	Maunawili	453	11	442	369	1,131	32.6%	83.1%	98.7%	70.5%
111.03	Olomana	464	2	462	410	1,222	33.5%	79.0%	94.3%	66.8%
111.04	Enchanted Lakes	568	2	566	480	1,500	32.0%	85.7%	98.3%	65.8%
111.05	Kailua Town	201	4	197	167	1,547	10.8%	51.5%	25.0%	44.4%
111.06	Keolu	614	1	613	536	1,888	28.4%	81.2%	93.6%	65.8%
112.01	Kalaheo Avenue	676	8	668	567	1,676	33.8%	76.8%	96.5%	66.7%
112.02	Lanikai	182	2	180	145	697	20.7%	66.4%	94.3%	45.7%
113	Waimanalo	281	9	272	239	1,395	17.2%	60.8%	87.9%	52.2%
114	Waipio Peninsula	2	2	0	0	755	0.0%	3.9%	91.0%	84.0%
115	Kapolei	680	21	659	611	2,016	30.3%	75.8%	62.2%	61.6%
12.01	Waialae Avenue-Pukele Avenue	215	9	206	165	1,167	14.1%	52.0%	69.6%	44.5%
12.02	Lower Palolo	216	1	215	184	1,089	16.9%	71.6%	93.2%	48.2%
13	Kaimuki: 6th Avenue	324	20	304	266	1,654	16.1%	49.7%	70.8%	40.5%
14	Kapaolono Field	254	0	254	220	901	24.4%	68.8%	95.0%	54.1%
15	Upper Kapahulu	266	6	260	230	1,263	18.2%	66.6%	88.8%	43.2%
16	Lower Kapahulu	253	12	241	213	1,457	14.6%	52.1%	84.3%	48.3%
17	Kapiolani Park	71	3	68	57	1,682	3.4%	64.0%	26.7%	33.6%
18.01	Koa Avenue	3	3	0	0	1,319	0.0%	28.8%	0.8%	22.3%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology
[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
18.03	Tusitala Street	3	0	3	0	2,324	0.0%	27.7%	1.6%	25.4%
18.04	Jefferson School	1	1	0	0	1,275	0.0%	40.8%	4.7%	42.0%
19.04	Hobron Lane	1	1	0	0	3,145	0.0%	45.2%	2.3%	35.3%
2	Kuliouou	687	5	682	590	1,917	30.8%	81.9%	93.4%	54.5%
20.03	Seaside Avenue	3	2	1	0	1,858	0.0%	38.5%	4.6%	28.9%
20.04	International Market Place	4	1	3	1	1,029	0.1%	27.9%	6.8%	24.2%
20.05	Ala Wai-Niu Street	2	1	1	1	1,692	0.1%	20.2%	0.0%	19.8%
20.06	Ala Wai-Olohana Street	2	2	0	0	1,785	0.0%	44.9%	6.3%	26.7%
21	Olokele Avenue	42	6	36	24	1,817	1.3%	23.4%	12.6%	25.0%
22.01	Kamoku Street-Iolani School	14	4	10	7	1,948	0.4%	36.3%	5.1%	31.8%
22.02	Ala Wai Park-Lauiki Street	8	5	3	3	1,784	0.2%	47.1%	5.4%	39.9%
23	Moiliili	24	5	19	14	2,797	0.5%	33.8%	9.4%	31.5%
24.01	Lower McCully	26	0	26	18	1,511	1.2%	16.3%	14.8%	40.5%
24.02	Upper McCully	30	1	29	22	1,616	1.4%	19.6%	6.7%	36.8%
25	Lower Pawaa	67	8	59	51	2,232	2.3%	22.4%	13.2%	24.4%
26	Bingham Tract	90	25	65	49	2,002	2.4%	27.7%	17.1%	27.2%
27.01	UH Manoa Campus	116	15	101	82	707	11.6%	40.2%	50.5%	39.9%
27.02	Punahou School	249	19	230	183	2,211	8.3%	43.3%	46.5%	42.2%
28	St. Louis Heights	371	4	367	302	1,461	20.6%	76.0%	74.4%	56.0%
29	East Manoa	151	6	145	127	954	13.3%	40.3%	52.6%	59.3%
3.01	Aina Haina-Hawaii Loa Ridge	366	0	366	317	1,147	27.7%	87.2%	97.2%	68.4%
3.02	Wailupe	323	5	318	277	1,052	26.3%	80.9%	98.9%	67.7%
30	Judd Hillside-Lowrey Avenue	472	9	463	390	1,603	24.3%	63.9%	88.8%	57.9%
31.01	Woodlawn	331	1	330	275	1,344	20.4%	77.2%	95.9%	53.8%
31.02	Upper Manoa	291	1	290	259	1,180	21.9%	78.4%	98.9%	56.8%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology
[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
32	Round Top-Tantalus	99	2	97	75	343	21.9%	84.5%	98.1%	54.2%
33	Makiki Heights	141	1	140	121	411	29.4%	81.7%	98.2%	55.7%
34.03	Thurston Street	47	3	44	32	3,055	1.0%	41.9%	4.0%	37.7%
34.04	Makiki Fire Station	36	2	34	26	2,452	1.1%	32.6%	6.1%	32.2%
34.05	Poki Street	19	1	18	12	1,994	0.6%	27.1%	4.3%	28.1%
34.06	Lower Makiki	29	2	27	19	3,036	0.6%	33.2%	10.3%	36.0%
34.07	Maryknoll School	8	1	7	6	574	1.0%	35.3%	6.7%	25.2%
35.01	Academy of Arts	20	6	14	8	1,394	0.6%	38.5%	5.2%	31.2%
35.02	Upper Pawaa	30	16	14	10	2,190	0.5%	35.5%	2.1%	26.1%
36.01	Sheridan Street	33	7	26	20	2,236	0.9%	16.6%	7.3%	31.4%
36.03	Ahana Street	3	1	2	0	1,770	0.0%	19.8%	2.3%	31.1%
37	Ala Moana	18	16	2	1	4,042	0.0%	59.0%	3.0%	46.7%
38	Kakaako	27	24	3	0	2,390	0.0%	42.2%	1.3%	34.9%
39	Civic Center	6	6	0	0	225	0.0%	22.2%	0.0%	3.6%
4.01	Waialae Nui Ridge-Ainakoa	437	6	431	371	1,024	36.2%	77.7%	95.4%	62.0%
4.02	Waialae Iki	662	3	659	566	1,403	40.3%	91.6%	98.6%	71.7%
40	Financial District	4	4	0	0	992	0.0%	33.3%	3.8%	33.4%
41	Queen's Hospital	42	10	32	24	2,432	1.0%	27.3%	10.7%	27.4%
42	Queen Emma Gardens	6	5	1	0	2,020	0.0%	53.0%	2.6%	31.4%
43	Punchbowl	153	7	146	122	2,589	4.7%	34.3%	29.6%	39.3%
44	Pauoa	361	3	358	315	1,621	19.4%	79.4%	97.4%	51.0%
45	Dowsett Highlands	416	8	408	343	2,359	14.5%	63.7%	61.0%	53.9%
46	Puunui-Waokanaka Street	359	6	353	299	1,264	23.6%	84.5%	97.0%	55.0%
47	Alewa-Kawananakoa	451	8	443	373	1,611	23.2%	73.1%	96.7%	53.4%
48	Kamehameha Heights	377	5	372	318	1,788	17.8%	56.5%	79.7%	49.7%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
49	Lanakila	117	12	105	96	1,027	9.3%	41.5%	55.1%	45.0%
5	Waialae-Kahala	523	4	519	444	1,673	26.5%	78.6%	84.3%	65.3%
50	Kuakini	117	7	110	100	1,627	6.1%	45.1%	33.4%	32.1%
51	Foster Botanical Garden	1	1	0	0	1,579	0.0%	30.1%	1.7%	37.2%
52	Chinatown	5	2	3	2	1,456	0.1%	0.0%	3.0%	35.1%
53	Aala	17	7	10	7	1,613	0.4%	10.8%	0.6%	36.8%
55	Palama	40	0	40	36	636	5.7%	30.7%	22.5%	45.1%
56	Kapalama	170	11	159	140	1,906	7.3%	35.7%	47.4%	43.1%
57	Iwilei-Anuenue	84	82	2	1	891	0.1%	16.8%	5.5%	31.8%
58	Waiakamilo Road	7	6	1	1	987	0.1%	36.4%	4.7%	54.5%
59	Mokauea Street	68	66	2	1	642	0.2%	8.9%	18.4%	49.0%
6	Diamond Head	192	8	184	156	534	29.3%	79.7%	98.9%	56.9%
60	Umi Street	121	40	81	66	1,296	5.1%	32.5%	53.9%	52.8%
61	Kalihi Waena	111	6	105	93	829	11.2%	45.0%	72.9%	55.0%
62.01	Kam IV Road	94	8	86	70	1,470	4.7%	34.2%	49.9%	45.6%
62.02	Linapuni Street	6	2	4	4	411	0.9%	3.2%	7.3%	49.9%
63.01	Kalihi Valley Park	133	5	128	115	869	13.2%	57.5%	90.2%	51.0%
63.02	Kalena Drive	42	0	42	39	600	6.4%	27.3%	37.3%	48.1%
64.01	Gulick Avenue-Likelike	73	0	73	62	441	14.1%	53.1%	87.5%	60.3%
64.02	Kamanaiki Street	180	2	178	161	1,519	10.6%	58.5%	88.8%	55.4%
65	Upper Kalihi Valley	176	0	176	164	1,064	15.4%	56.4%	93.6%	44.4%
66	Kahauiki Street	11	3	8	8	243	3.1%	0.0%	98.6%	92.7%
67.01	Tripler-Moanalua	577	4	573	501	1,958	25.6%	73.4%	90.7%	66.0%
67.02	Red Hill	6	2	4	4	1,066	0.4%	8.0%	8.4%	39.0%
68.02	Aliamanu	245	1	244	214	1,725	12.4%	56.7%	82.1%	54.7%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
68.04	Aliamanu Crater	4	0	4	4	1,346	0.3%	0.0%	95.5%	84.0%
68.05	Salt Lake Country Club	339	4	335	288	2,706	10.6%	62.1%	25.0%	43.5%
68.06	Ala Lilikoi	219	0	219	197	570	34.5%	90.7%	99.1%	69.8%
68.08	Ala Ilima Mauka	30	2	28	23	2,160	1.1%	41.3%	1.6%	41.5%
68.09	Ala Ilima Makai	4	3	1	0	2,017	0.0%	50.0%	1.5%	46.7%
69	Arizona Road	1	1	0	0	1,239	0.0%	0.0%	96.0%	87.1%
7	Kaimuki: 22nd Avenue	274	5	269	245	1,034	23.6%	73.7%	96.4%	58.2%
70	Navy Marine Golf Course	1	1	0	0	1,741	0.0%	0.7%	89.9%	75.9%
74	Ford Island	19	10	9	8	994	0.8%	1.5%	95.6%	81.4%
75.02	Halawa Valley	17	13	4	4	142	2.5%	0.0%	85.2%	91.3%
75.03	Halawa Heights	491	9	482	413	1,636	25.2%	68.7%	94.3%	59.8%
75.04	Aloha Stadium	89	2	87	77	841	9.2%	34.6%	36.9%	42.3%
75.05	Foster Village	394	4	390	342	1,695	20.2%	75.7%	66.7%	57.2%
77.01	Lower Aiea	216	11	205	183	1,220	15.0%	52.3%	96.8%	56.4%
77.02	Aiea Heights	589	4	585	514	1,675	30.7%	77.3%	97.4%	55.4%
78.04	Lower Pearl City	217	0	217	182	588	30.9%	83.9%	100.0%	67.0%
78.05	Waiau Townhouses	228	4	224	194	1,683	11.5%	70.8%	50.4%	58.3%
78.07	Pearl Ridge High Rise	5	1	4	3	2,983	0.1%	36.1%	7.3%	34.1%
78.08	Pearlridge Center	95	12	83	70	1,075	6.5%	41.7%	31.6%	40.7%
78.09	Newtown	494	0	494	428	1,120	38.2%	85.1%	82.4%	73.2%
78.10	Royal Summit	754	0	754	673	1,897	35.5%	88.7%	85.1%	71.2%
78.11	Pearl Country Club	422	0	422	366	1,841	19.9%	78.5%	65.0%	53.1%
8	Kaimuki: Kapiolani Community	353	6	347	299	1,334	22.4%	72.0%	93.9%	40.8%
80.01	Hale Mohalu Hospital	54	5	49	43	698	6.2%	25.1%	38.2%	36.7%
80.02	Lower Waiau	210	11	199	176	804	21.9%	82.3%	92.1%	51.9%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
80.03	Manana	104	7	97	72	1,826	3.9%	25.4%	37.5%	46.0%
80.05	Pacific Palisades	628	2	626	552	1,975	27.9%	95.2%	97.0%	57.3%
80.06	Pearl City	508	12	496	437	1,445	30.2%	88.3%	99.3%	53.6%
80.07	Pearl City Highlands	635	4	631	558	1,588	35.1%	88.8%	99.6%	65.0%
83.01	Iroquois Point	12	3	9	8	1,656	0.5%	0.4%	76.2%	66.9%
83.02	Campbell High School	274	8	266	243	1,387	17.5%	72.5%	69.6%	59.3%
84.02	Ewa Beach	521	1	520	446	1,916	23.3%	63.6%	92.9%	47.9%
84.05	Holomua School	435	1	434	405	1,275	31.8%	75.9%	92.6%	64.6%
84.06	Hawaii Prince Golf Course	822	1	821	754	1,717	43.9%	83.0%	100.0%	75.7%
84.07	Ocean Pointe	430	0	430	372	1,167	31.8%	68.9%	83.5%	76.3%
84.08	Hoakalei Country Club	1,190	2	1,188	1,080	2,232	48.4%	68.1%	81.0%	70.5%
84.10	Coral Creek Golf Course	806	6	800	675	1,079	62.5%	85.4%	98.7%	75.0%
84.11	Geiger Road	193	2	191	173	1,216	14.2%	61.5%	46.4%	53.0%
84.12	Ewa Gentry	216	2	214	205	2,440	8.4%	63.0%	29.8%	42.1%
85.02	Kalaeloa	40	31	9	6	762	0.8%	5.5%	31.9%	37.2%
86.06	Kapolei Golf Course	990	6	984	876	2,946	29.7%	75.8%	79.8%	58.0%
86.09	Ko Olina-Honokai Hale	148	7	141	128	784	16.3%	59.9%	56.8%	59.9%
86.10	Ko Olina Resort	82	3	79	79	1,033	7.6%	32.4%	37.1%	67.8%
86.11	Kahe	2	0	2	2	48	4.2%	56.8%	89.2%	54.1%
86.12	Upper Makakilo	491	2	489	457	2,030	22.5%	69.4%	71.5%	63.2%
86.13	Makakilo: Wainohia Street	59	1	58	51	228	22.1%	83.8%	74.6%	78.9%
86.14	Kunia West	826	9	817	731	2,824	25.9%	66.9%	66.3%	66.2%
86.17	Ewa Villages	711	3	708	651	2,495	26.1%	78.8%	88.0%	65.6%
86.22	Lower Makakilo	353	2	351	320	1,070	29.9%	76.6%	95.7%	65.3%
87.01	Leeward Community College	385	5	380	347	1,823	19.0%	67.4%	80.3%	61.2%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
87.02	St. Joseph School	136	13	123	112	1,622	6.9%	44.1%	37.4%	44.2%
87.03	West Loch	217	25	192	175	1,712	10.2%	35.6%	40.4%	51.8%
88	Managers Drive	507	20	487	433	1,650	26.2%	73.4%	82.4%	59.6%
89.06	Mililani Golf Course	257	0	257	235	1,382	17.0%	72.1%	65.3%	61.4%
89.07	Mililani High School	252	8	244	217	1,298	16.7%	63.0%	58.9%	49.0%
89.08	Mililani Marketplace	759	7	752	628	1,841	34.1%	86.3%	90.0%	71.5%
89.09	Mililani District Park	305	1	304	270	1,335	20.2%	66.1%	61.0%	63.9%
89.12	August Ahrens School	160	2	158	133	475	27.9%	86.1%	98.9%	62.8%
89.13	Robinson Heights	299	1	298	270	827	32.6%	90.3%	99.8%	59.3%
89.14	Honowai School	51	6	45	34	1,297	2.6%	36.0%	17.9%	47.7%
89.15	Waipio Acres	216	7	209	187	1,961	9.5%	51.1%	35.6%	46.4%
89.17	Mililani Town Center	655	3	652	586	1,561	37.5%	83.4%	85.4%	66.4%
89.18	Mililani: Nob Hill	557	3	554	483	1,756	27.5%	76.7%	74.8%	61.4%
89.20	Waipio Gentry	257	27	230	214	1,615	13.2%	63.0%	50.9%	48.4%
89.21	Waipio	202	0	202	164	580	28.3%	75.3%	85.0%	63.8%
89.22	Waikele	571	3	568	504	2,925	17.2%	65.2%	49.8%	60.9%
89.23	Seaview	306	2	304	268	1,891	14.1%	64.4%	48.2%	48.2%
89.24	Royal Kunia	917	3	914	830	2,052	40.4%	84.2%	98.7%	75.0%
89.25	Village Park	493	3	490	450	2,032	22.1%	61.1%	55.7%	64.4%
89.26	Laulani Valley-Mililani	38	9	29	30	695	4.2%	47.5%	18.1%	53.2%
89.27	Koolani Drive	544	0	544	477	1,739	27.4%	83.8%	63.9%	69.2%
89.28	Mililani Mauka Middle School	498	1	497	471	1,140	41.3%	87.5%	100.0%	81.3%
89.29	Mililani Mauka-Meheula	289	3	286	259	2,035	12.7%	66.6%	36.0%	37.7%
89.30	Mililani: Ainamakua Drive	434	2	432	400	825	48.5%	85.2%	95.7%	79.1%
89.31	Waiawa Prison	461	3	458	395	796	49.6%	90.6%	98.9%	87.7%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community Survey

Table 5. PV installation and Housing characteristics by Census Tract --continued

Census tract		No. of Building Permits issued for PV installation			Estimated number of housing units with rooftop PV [1] (HUpv)	Total number of housing units in the area [2] (HU)	Rooftop PV market penetration rate [1] (HUpv/HU)	Household characteristics [2]		
		Total	For non-residential building	For residential building				Owner occupancy rate	Share of 1-unit house	Share of married-couple family H
9.01	Waialae Nui Valley	112	2	110	99	1,268	7.8%	54.5%	27.3%	46.9%
9.02	Maunalani Heights	432	0	432	369	1,546	23.9%	67.9%	95.9%	50.3%
9.03	Lower Wilhelmina	286	1	285	243	1,111	21.8%	55.5%	89.6%	35.9%
90	Wheeler-East Range	1	1	0	0	1,000	0.0%	1.5%	71.5%	81.2%
91	Kaukonahua Road	220	2	218	193	1,226	15.7%	55.7%	83.7%	54.1%
92	Wahiawa Mauka	431	3	428	382	2,502	15.3%	68.6%	90.8%	57.8%
93	Wahiawa Waena	154	7	147	137	1,604	8.5%	31.4%	56.5%	41.9%
94	Wahiawa Makai	151	2	149	133	1,979	6.7%	31.4%	42.8%	39.2%
9400.01	Waimanalo Beach-Homesteads	317	4	313	278	1,091	25.5%	75.8%	93.2%	47.7%
9400.02	Nanakuli	267	9	258	242	1,557	15.5%	77.4%	72.2%	46.6%
95.01	Kolekole Avenue	1	1	0	0	1,729	0.0%	0.0%	74.0%	92.8%
95.04	Leilehua Avenue	1	0	1	1	475	0.2%	2.3%	69.8%	77.5%
96.03	Maili	659	12	647	603	2,730	22.1%	55.4%	83.5%	54.4%
96.08	Lualualei Transmitter	185	5	180	156	1,342	11.6%	70.5%	90.9%	54.4%
97.01	Waianae Kai	173	22	151	144	1,938	7.4%	37.2%	51.2%	34.3%
97.03	Lualualei-Camp Waianae	359	9	350	305	1,624	18.8%	77.3%	91.3%	59.6%
97.04	Lualualei: Halona Road	147	9	138	122	792	15.3%	69.0%	98.4%	46.2%
98.01	Makua Valley	107	2	105	99	1,517	6.5%	41.8%	16.7%	36.4%
98.02	Makaha	321	8	313	275	1,849	14.9%	43.3%	82.1%	50.4%
99.02	Haleiwa	150	2	148	130	1,259	10.3%	49.2%	90.1%	48.1%
99.04	Kaena Point	291	12	279	243	2,078	11.7%	56.4%	76.6%	49.8%

[1] Estimated by DBEDT by excluding duplicated PV permits. See pp5-8 for detailed methodology

[2] U.S. Census Bureau, 2011-2015 5-year American Community