

City of Palo Alto Electrification Funding Study

Multifamily Residential Sector Study Report (FINAL DRAFT)

December 2025



Energy+Environmental Economics

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Executive Summary

In 2020, the City of Palo Alto (City) announced an update to the Sustainability and Climate Action Plan (S/CAP) to develop the strategies needed to meet its sustainability goals, including the goal of reducing greenhouse gas (GHG) emissions 80% below 1990 levels by 2030 (the 80 x 30 goal). In January 2024 the City Council approved a contract with E3 and Willdan to complete an S/CAP Funding Study to determine the costs of achieving these goals. They also approved three parallel Building Sector Studies covering the single-family residential, multifamily residential, and non-residential sectors. These studies are meant to provide building data for the S/CAP Funding Study and to help City staff identify opportunities to electrify equipment in the multi-family and non-residential building sectors. This report and its attachments document the process and results of the Multifamily Residential Building Sector Study.

Willdan analyzed public data for 574 multifamily parcels (after screening for data outliers), representing 11,389 individual residential customers and “house” accounts. For the purposes of this study, “multifamily” is defined as multi-unit residential facilities with 3-units or greater, including both rental units and occupant-owned units. Not included in this “multifamily” designations are duplexes/accessory dwelling units¹, hotels/motels², or mobile home parks. In addition, Willdan performed detailed field-based site assessments of a sample of seven sites (plus two mixed-use nonresidential/multifamily residential sites). Willdan estimates that this sector in total consumes approximately 6% of the community’s electricity and 9% of the community’s gas. The categories of equipment in this sector that use the most gas are water heating and space heating, which are estimated to each account for approximately 40% of multifamily sector gas use (80% combined). These systems represent the largest opportunities for electrification.

Within these categories of equipment, however, cost-effectiveness of electrification ranges greatly. Water heating electrification costs in multifamily properties can range from approximately \$7,000 to \$40,000 per residential unit. Space heating (i.e., HVAC) electrification costs can range from approximately \$15,000 to \$30,000 per unit. These in unit values include the cost of electrical infrastructure upgrades. Per unit costs are lower in multi-family buildings with larger numbers of units for their central heating systems due to economies of scale and in properties where existing electrical infrastructure is robust enough to support the new electric loads. Income-qualified residential customers may be eligible for existing and future financial assistance programs to help defray the high costs of these projects³.

Implementation of heat pumps for space heating offers the opportunity to add summertime air-conditioning capabilities to the estimated 28% of Palo Alto multifamily residents that currently do not have access to A/C, since heat pumps also have space cooling capabilities. Additionally, heat

¹ Duplexes and accessory dwelling units are included in a separate single-family study.

² Hotels and motels are included in a separate non-residential study.

³ Examples of existing programs include High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates provided through TECH Clean California, and the California Department of Community Services and Development Low-Income Weatherization Program (LIWP).

pumps represent an efficiency improvement opportunity for customers that already have older electric resistance-style equipment: it is estimated that over 40% of multi-family customers utilize inefficient electric resistance systems for heating, and over 30% use these types of systems for water heating.

Using data from the Multifamily Building Sector Study as a foundation, the S/CAP Funding and Financing Study has ultimately projected that the total community cost to eliminate gas use in the multifamily building segment would be between **\$465 and \$593 million** in nominal dollars. This would be offset by between **\$408 and \$528 million** in avoided costs for like for like equipment replacement plus Federal, State, and/or Regional incentives. Operational savings from switching from gas to electricity would provide additional benefits and are incorporated into the S/CAP Funding and Financing Study results.

Summary of Analysis Inputs

Public Data

In pursuit of the characterization of multifamily buildings in Palo Alto, Willdan identified available public data sources. This analysis is documented in detail in a standalone report, *Multifamily Residential Building Inventory and Equipment Saturation Analysis-Public Data*, which is included here as Attachment A. To summarize, Attachment A describes the following activities:

- + Our collection and processing of multiple City and public data sets
 - City Utility Account Data
 - County of Santa Clara Tax Assessor Records
 - National Renewable Energy Laboratories (NREL) ResStock Modeling Data
- + Our analysis of the customer sector data
 - Total number of customers and square footage
 - Building age distribution
 - Total energy consumption across the sector
- + Segmentation of the buildings for modeling purposes across multiple categories
 - Building type segmentation (number of dwelling units per site)
 - Building vintage segmentation
 - Presence of air conditioning in the dwelling units
- + Estimation of technology type impacts. Here, technology types refer to primary energy consuming appliances and systems for things like space cooling and heating, laundry, cooking, and pools and spas. The two main impact results evaluated are:
 - Applicability by segment – percentage of customers in the segment using the technology types
 - Electricity and natural gas use impacts of the specific technology types

Refer to Attachment A for detailed documentation of the public data evaluation process and findings. Some key takeaways discussed in Attachment A are as follows:

- + Most multifamily buildings in Palo Alto (86%) are older than 1987, which means that they were built prior to the establishment of the California Building Standards Code (Title 24) and therefore were not held to uniform code standards for design and efficiency.. The largest portion of multi-family residential utility customers fall under the 1960 to 1987 building vintage segment (49%), with the next largest portion under the pre-1960 vintage segment (37%). The portion of customers under the post-1987 vintage segment is significantly smaller (14%)

- + For the estimated 72% of multifamily residential customers with air conditioning, the primary cooling type estimated based on the Palo Alto-specific NREL models (in approximately 90% multifamily units) is direct expansion packaged units, where a refrigerant is used to transfer heat between the unit and the outdoors.
 - Units with direct expansion cooling and gas furnace heating can be easily converted to all-electric heat pump systems, where the refrigerant heat transfer can be switched from summer operation when heat is moved out of the unit, to winter operation when heat is moved into the unit.
- + Based on the NREL models, 46% of Palo Alto multifamily residential customers are estimated to have resistance space heating, be that electric baseboard heating or electric resistance coils in packaged HVAC units. While Willdan observed this technology in the limited sample of on-site surveys (see the following section), this limited sample does not conclusively confirm or disprove the NREL modeling.
- + Space heating via air-source heat pump systems appears in the NREL models, most prevalently in post-1987 vintage buildings, but also in 1960 to 1987 vintage buildings. Approximately 7% of multifamily customers overall are served by these air-source heat pump systems
- + Gas storage water heating systems are the most prevalent (40 to 73%), but there is also a significant amount of electric-resistance storage water heating systems (14 to 52%). The prevalence of gas vs. electric resistance cooking ranges depends on building vintage (Pre 1960 vintage buildings average 40% electric cooking/60% gas cooking; 1960 to 1987 vintage building average 64% electric cooking/36% gas cooking; Post 1987 vintage buildings average 70% electric cooking/30% gas cooking). During the on-site surveys we observed a mix of technologies in alignment with these estimates.
- + While the NREL models show extremely low per-customer gas usage for specific, evaluation of actual per-customer CPAU billing data demonstrates higher gas usage. Data used for the S/CAP Funding and Financing Study has been corrected to align with actual CPAU billing data.

Site Surveys

As part of this comprehensive study, site surveys were conducted for seven multifamily buildings that were picked based on the segmentations above. These visits served as a critical step in gathering detailed and site-specific information necessary for subsequent analysis and reporting. During the surveys, Willdan documented the inventory of HVAC equipment, water heating systems, laundry equipment, and other types of systems installed in buildings and/or individual units using a customized tool based on the ArcGIS platform, which is described further in this section. This information provided valuable insights into the current electrical infrastructure and mechanical equipment across the buildings. Using the data collected during these visits, Willdan formed the foundation for developing customized customer reports, which will be detailed in a later section. With these reports, Willdan aims to provide actionable recommendations tailored to the unique

characteristics of each property, supporting informed decision-making for energy efficiency upgrades and electrification opportunities.

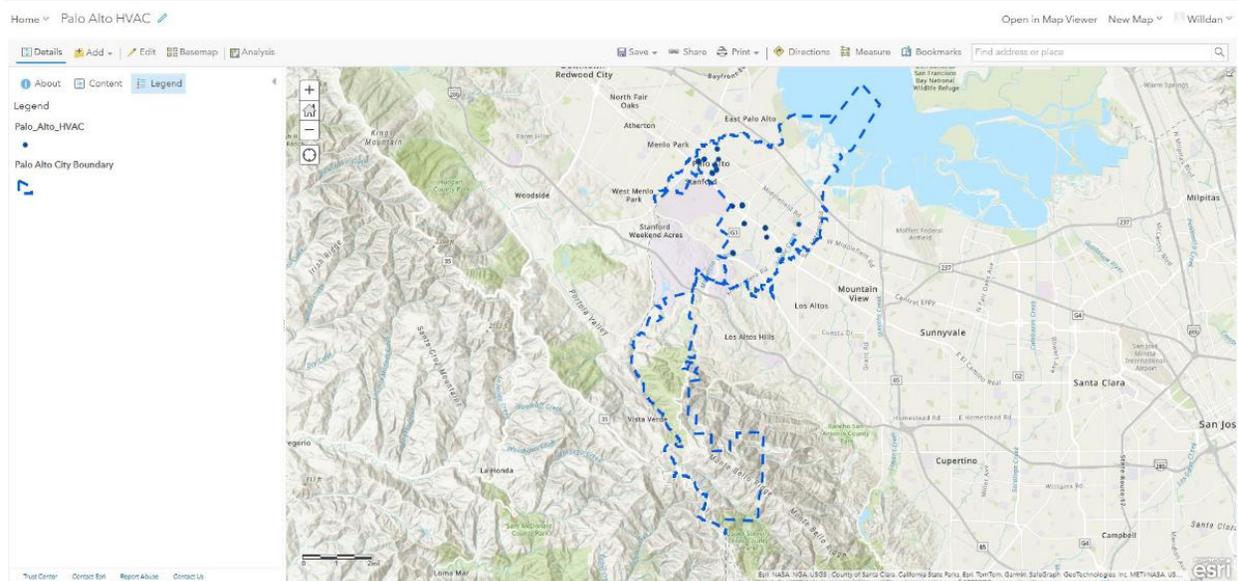
ArcGIS Tool Development and Execution

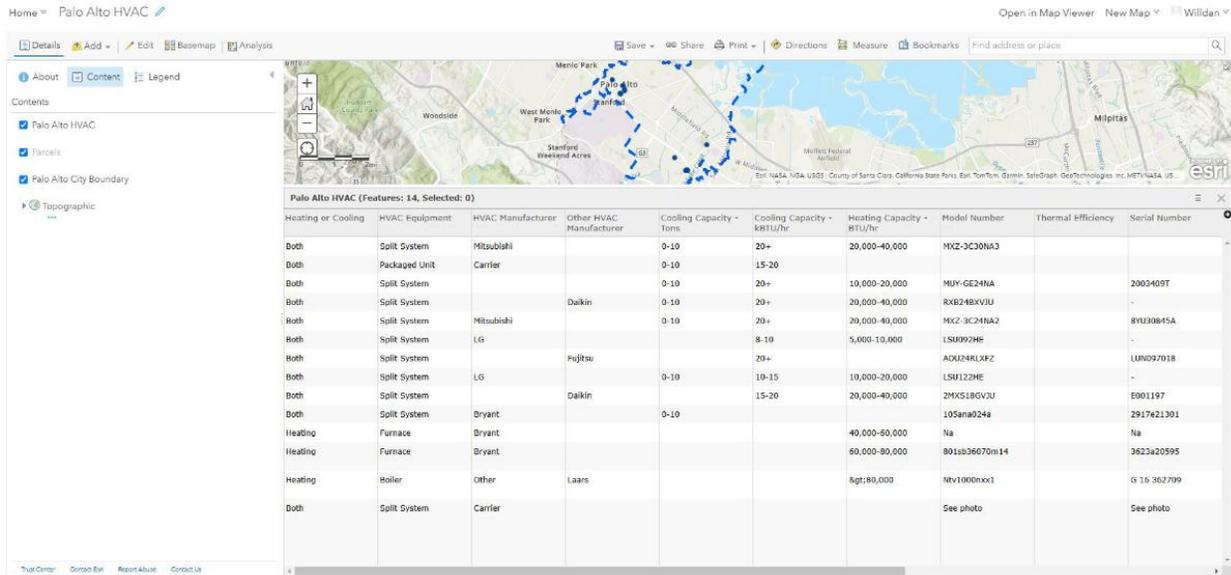
To most accurately and efficiently collect data during these site surveys, Willdan used the ArcGIS platform. This tool is a data collecting app that lets the user collect photos, notes, and data in the field while automatically tracking that data geospatially using the geographic information system (GIS). Willdan created seven different modules to capture the data. The different modules covered:

- + HVAC
- + Water Heating
- + Kitchen Equipment
- + Laundry Equipment
- + Pools
- + Electrical Infrastructure and General Site
- + Plug Loads and Others

Exhibit 1 shows an example of the data visualization and collection functionality of the ArcGIS tool used for this Study. A comprehensive collection of information from the tool can be found in Attachments C.2 and C.3.

Exhibit 1. – Example ArcGIS Tool Data Visualization and Collection Screens





Customer Selection and Outreach

Willdan performed initial customer screening based on a data set consisting of information from County Assessor Records and City utility customer usage data. During this screening process, Willdan segregated the customers based on the segmentation described above (e.g., building types, building vintages, etc.), and filtered out energy-consumption outliers, such as customers with no gas use, or abnormally high- or low-electricity use per square foot.

After each site visit and data collection, customers received a brief Electrification Assessment Report for each individual property. The assessment reports included an identification of the primary technology systems in use at the site, conceptual electrification alternatives where applicable and associated rough-order-of-magnitude (ROM) budgeting ranges, identification of electric infrastructure, upgrades needed to support electrification projects and associated ROM budget range and estimates of the annual GHG emissions avoidance that would result from these projects. The individual customer Electrification Assessment Reports are included here under Attachment B.

Comparison of Site Survey Data and Public Data

This section focuses on comparing public data with the Willdan-collected detailed survey data from the seven sample sites collected by Willdan engineers, to verify whether the public data accurately reflects field observations.

The comprehensive data shown in Exhibits 2, 3, and 4 were derived from NREL’s ResStock modeling data and represent the percentages of customers in each segment that are estimated to use the various technology types. See Attachment A for information on the development of this data in detail.

The call-out boxes overlaid on the exhibits highlight the seven sites Willdan engineers visited in the field. The rows indicate which technologies were observed during the site visits, and the columns indicate their customer type segment (number of units, vintage of building, existence of A/C).

Exhibit 2. – HVAC Technologies in Multifamily Buildings: Categorization Based on Publicly Available Data.

Initial Building-Technology Mapping/Shares and Full Palo Alto Stock [% of customers have Y technology; there are Z # of customers]

Customer Type Segments	Space Cooling						Space Heating				
	Electric-Cooling-Split System	Electric-Cooling-PTAC/Packaged DX	Electric-Cooling-PTHP/Packaged HP	Electric-Cooling-WC Chiller	Electric-Cooling-AC Chiller	Electric-Cooling-VRF	Electric-Space Heating-Packaged Unit-Electric Resistance	Electric-Space Heating-ASHP	Gas-Space Heating-Packaged Unit	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace
	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%
MF-3-4 Unit-Pre-1960-AC-Any	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	59.09%	0.00%	22.73%
MF-5-20 Unit-Pre-1960-AC-Any	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	47.37%	0.00%	2.63%
MF-Over 20 Unit-Pre-1960-AC-Any	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	47.06%	5.88%	23.53%
MF-3-4 Unit-Pre-1960-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	28.56%	0.00%	50.01%
MF-5-20 Unit-Pre-1960-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	25.01%	4.99%	15.00%
MF-Over 20 Unit-Pre-1960-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.01%	0.00%	40.91%	4.54%	4.54%
MF-3-4 Unit-1960-1987-AC-Any	5.09%	89.83%	5.09%	0.00%	0.00%	0.00%	37.94%	10.35%	27.58%	1.72%	22.41%
MF-5-20 Unit-1960-1987-AC-Any	0.00%	80.85%	19.15%	0.00%	0.00%	0.00%	45.33%	19.42%	16.55%	0.72%	17.98%
MF-Over 20 Unit-1960-1987-AC-Any	0.00%	90.17%	9.83%	0.00%	0.00%	0.00%	42.60%	10.06%	25.44%	0.59%	21.30%
MF-3-4 Unit-1960-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	36.96%	0.00%	28.26%	0.00%	34.78%
MF-5-20 Unit-1960-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	57.14%	0.00%	21.43%	7.14%	14.28%
MF-Over 20 Unit-1960-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	77.50%	0.00%	10.00%	0.00%	12.50%
MF-3-4 Unit-Post-1987-AC-Any	6.07%	87.87%	6.07%	0.00%	0.00%	0.00%	18.76%	12.51%	21.87%	0.00%	46.87%
MF-5-20 Unit-Post-1987-AC-Any	5.71%	82.86%	11.43%	0.00%	0.00%	0.00%	47.12%	17.31%	12.50%	0.96%	22.12%
MF-Over 20 Unit-Post-1987-AC-Any	7.92%	76.98%	15.09%	0.00%	0.00%	0.00%	48.65%	23.55%	6.96%	1.83%	18.92%
MF-3-4 Unit-Post-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	42.86%	0.00%	25.00%	3.57%	28.58%
MF-5-20 Unit-Post-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.11%	1.85%	25.92%

Site A and Site B, both fall under the 5-20 unit sites segmentation. Cooling and heating for both facilities is provided by split heat pumps.

Site C and Site G, both fall under the over 20 unit sites segmentation. Cooling and heating for both facilities is provided by split heat pumps.

Site D, Site E, and Site F are served by a combination of split heat pumps, individual gas furnaces, and a natural gas boiler

Exhibit 3. – Dryer and Cooking Technologies in Multifamily Buildings: Categorization Based on Publicly Available Data.

Customer Type Segments	Cooking					Clothes Drying	
	Electric-Cooking Range-Resistance Stove	Electric-Cooking Range-Induction Stove	Electric-Cooking Range-Oven	Gas-Cooking Range-Stove	Gas-Cooking Range-Oven	Electric-Clothes Dryer-Electric Dryer	Gas-Clothes Dryer-Gas Dryer
	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%
MF-3-4 Unit-Pre-1960-AC-Any	16.67%	0.00%	16.67%	33.33%	33.33%	13.64%	45.45%
MF-5-20 Unit-Pre-1960-AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MF-Over 20 Unit-Pre-1960-AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MF-3-4 Unit-Pre-1960-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MF-5-20 Unit-Pre-1960-No AC-Any	25.00%	0.00%	25.00%	25.00%	25.00%	0.00%	0.00%
MF-Over 20 Unit-Pre-1960-No AC-Any	25.00%	0.00%	25.00%	25.00%	25.00%	0.00%	0.00%
MF-3-4 Unit-1960-1987-AC-Any	36.21%	0.00%	36.21%	13.79%	13.79%	36.20%	20.69%
MF-5-20 Unit-1960-1987-AC-Any	28.21%	0.00%	28.21%	21.79%	21.79%	19.15%	4.96%
MF-Over 20 Unit-1960-1987-AC-Any	29.53%	0.88%	30.41%	19.59%	19.59%	20.81%	6.36%
MF-3-4 Unit-1960-1987-No AC-Any	22.22%	0.00%	22.22%	0.00%	0.00%	25.00%	18.18%
MF-5-20 Unit-1960-1987-No AC-Any	34.38%	0.00%	34.38%	0.00%	0.00%	21.43%	5.36%
MF-Over 20 Unit-1960-1987-No AC-Any	37.50%	0.00%	37.50%	0.00%	0.00%	27.50%	5.00%
MF-3-4 Unit-Post-1987-AC-Any	36.21%	0.00%	36.21%	13.79%	13.79%	12.12%	24.24%
MF-5-20 Unit-Post-1987-AC-Any	34.13%	1.92%	36.06%	13.94%	13.94%	42.86%	6.67%
MF-Over 20 Unit-Post-1987-AC-Any	30.04%	0.95%	30.99%	19.01%	19.01%	47.17%	7.92%
MF-3-4 Unit-Post-1987-No AC-Any	42.86%	1.78%	44.64%	5.36%	5.36%	48.15%	14.81%
MF-5-20 Unit-Post-1987-No AC-Any	0.00%	0.00%	0.00%	0.00%	0.00%	21.70%	43.64%

Site A and Site B, both have electric range stoves and electric dryers.

Site F and Site G, both have electric ranges on each dwelling unit, and mostly electric dryers.

Site C, Site D, and Site E, both all gas range stoves and gas dryers.

Exhibit 4. – Water Heating Technologies in Multifamily Buildings: Categorization Based on Publicly Available Data.

Customer Type Segments	Service Water Heating					
	Electric-Water Heating- Electric Resistance Water Heater	Electric-Water Heating-Heat Pump Water Heater	Electric-Water Heating-Tankless	Gas-Water Heating-Storage Water Heater	Gas-Water Heating-Boiler	Gas-Water Heating-Tankless
	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%
MF-3-4 Unit-Pre-1960-AC-Any	18.18%	0.00%	0.00%	72.72%	0.00%	9.10%
MF-5-20 Unit-Pre-1960-AC-Any	22.50%					60%
MF-Over 20 Unit-Pre-1960-AC-Any	16.66%					12%
MF-3-4 Unit-Pre-1960-No AC-Any	14.29%					29%
MF-5-20 Unit-Pre-1960-No AC-Any	40.01%					99%
MF-Over 20 Unit-Pre-1960-No AC-Any	22.73%	0.00%	9.10%	59.08%	0.00%	9.10%
MF-3-4 Unit-1960-1987-AC-Any	25.42%	0.00%	3.39%	64.41%	0.00%	6.78%
MF-5-20 Unit-1960-1987-AC-Any	40.00%	0.00%	5.71%	50.00%	0.00%	4.29%
MF-Over 20 Unit-1960-1987-AC-Any	29.48%	0.58%	3.47%	63.58%	0.00%	2.89%
MF-3-4 Unit-1960-1987-No AC-Any	30.43%	0.00%	4.35%	60.87%	0.00%	4.35%
MF-5-20 Unit-1960-1987-No AC-Any	18.52%	0.00%	7.41%	64.81%	0.00%	9.26%
MF-Over 20 Unit-1960-1987-No AC-Any	52.50%	0.00%	5.00%	40.00%	0.00%	2.50%
MF-3-4 Unit-Post-1987-AC-Any	21.21%	0.00%	6.07%	69.70%	0.00%	3.03%
MF-5-20 Unit-Post-1987-AC-Any	38.09%	0.00%	6.67%	49.52%	0.00%	5.71%
MF-Over 20 Unit-Post-1987-AC-Any	40.30%	0.38%	5.70%	46.77%	0.00%	6.84%
MF-3-4 Unit-Post-1987-No AC-Any	28.58%	0.00%	3.57%	60.71%	0.00%	7.15%
MF-5-20 Unit-Post-1987-No AC-Any	27.78%	0.00%	7.41%	57.41%	0.00%	7.41%

Sites A through G are served by gas storage water heaters.

For the purposes of this study, “multifamily” is defined as multi-unit residential facilities with 3-units or greater, including both rental units and occupant-owned units. Not included in this “multifamily” designations are duplexes/accessory dwelling units⁴, hotels/motels⁵, or mobile home parks. Using assessor data and cross-referencing it with CPAU customer account data, Willdan estimated that the total number of active multifamily customers is 11,389.

Out of these customers, a total of seven multifamily facilities were visited. While the number of sites visited is not a large enough sample to statistically verify the customer technology usage data, the information collected during the field surveys confirms the presence of many of the different technology types identified in the public data. However, it is notable that Electric Packaged Terminal Air Conditioners (PTACs)/Packaged DX units are very prevalent in the modeling data, none were observed in sample sites visited. Similarly, both Electric resistance storage water heaters and gas space-heating packaged units are prevalent in the modeling data, but were not found at the observed sites. The table below shows the overall percentages of modeled technology types, and where those types were found at the observed sites.

⁴ Duplexes and accessory dwelling units are included in a separate single-family study.

⁵ Hotels and motels are included in a separate non-residential study.

Exhibit 5. – Technology Types Modeled vs. Observed in the Field.

Technology Types	Percentage of Customers Modeled	Observed Sites						
		Site A	Site B	Site C	Site D	Site E	Site F	Site G
Electric-Cooling-Split System	1%	•	•	•	•	•	•	•
Electric-Cooling-PTAC/Packaged DX	66%							
Electric-Cooling-PTHP/Packaged HP	6%							
Electric-Space Heating-Packaged Unit-Electric Resistance	46%		•					
Electric-Space Heating-ASHP	7%	•	•	•	•	•	•	•
Electric-Water Heating-Electric Resistance Water Heater	31%							
Electric-Water Heating-Tankless	6%							
Electric-Clothers Dryer-Electric Dryer	18%	•	•	•				•
Electric-Cooking Range-Resistance Stove	27%	•	•	•			•	•
Electric-Cooking Range-Induction Stove	1%							
Electric-Cooking Range-Oven	27%	•	•	•			•	•
Electric-Pool Heater-Electric Heater	Not Modeled							
Electric-Spa Heater-Gas Heater	Not Modeled							
Gas-Space Heating-Packaged Unit	28%							
Gas-Space Heating-Boiler	2%			•		•		
Gas-Space Heating-Furnace	17%				•	•		
Gas-Water Heating-Storage Water Heater	58%	•	•	•	•	•	•	•
Gas-Water Heating-Tankless	5%							
Gas-Clothers Dryer-Gas Dryer	7%				•	•	•	•
Gas-Cooking Range-Stove	23%				•	•		
Gas-Cooking Range-Oven	23%				•	•		
Gas-Pool Heater-Gas Heater	Not Modeled	•	•					•
Gas-Spa Heater-Gas Heater	Not Modeled							

Characterization of Sector Gas Consumption

Public Data

By matching County assessor data to CPAU utility consumption data based on customer addresses, Willdan estimated the natural gas consumption of various sizes of multifamily sites in Palo Alto. These sizes are characterized by the number of dwelling units on the parcel, which is informed by the County Assessor’s assigned land use codes. Consumption data is summarized in the table below. Note that the multifamily sector is estimated to consume approximately 6% of all CPAU-supplied electricity and 9% of all CPAU supplied gas.⁶

Exhibit 6. – Sector Energy Consumption Information

Multifamily Building Types - Land Use Codes	Estimated Annual Electricity Consumption, kWh	Percentage of Electricity Across Sector	Estimated Annual Natural Gas Consumption, therms	Percentage of Natural Gas Across Sector	Total Parcels	Estimated Number of CPAU Customers
Three and Four Units	4,200,000	9%	260,000	11%	464	1,160
5-10 Units	4,200,000	9%	290,000	12%	231	2,150
11-20 Units	2,800,000	6%	200,000	8%	77	1,480
21-50 Units	6,300,000	13%	260,000	11%	42	1,350
51-100 Units	8,400,000	17%	380,000	16%	30	2,050
Over 100 Units	23,110,000	47%	1,010,000	42%	32	3,190
Total	49,010,000	100%	2,400,000	100%	876	11,380

Based on publicly available NREL ResStock data, Willdan estimated the typical gas consumption of specific technologies for multifamily customers that have these appliances/systems in their properties. These are shown in the following table on a “per customer” basis. Note that not every customer uses every technology.

Note that the NREL ResStock data for multifamily sector appears to undercount the gas impacts for space heating purposes. This statement is based Willdan’s past experience evaluating multifamily buildings, but more importantly on our analysis of the billing history of the seven sample sites included in this study along with the gas burning equipment that was observed at those sites⁷. Willdan’s investigation into this aspect of the NREL models is inconclusive but it may be the result of modeling individual dwelling units rather than whole multifamily properties. This approach may be undercounting the effects of central heating systems, heating for common areas, and/or overall

⁶ Note that the energy consumption analyzed for this Report includes both individual multifamily resident accounts and multifamily master-meter accounts (i.e., accounts typically serving common areas and energy loads at a property).

⁷ See Exhibit 8 below for a summary of this analysis.

heat losses from the comprehensive building envelope, but that alone doesn't seem to be sufficient to explain the magnitude of the discrepancy.

In Exhibit 6 below, both the ResStock data and "Study Adjusted Values" are presented that more closely reflect the relative gas impacts estimated from data collected during customer site surveys. Data used for the S/CAP Funding and Financing Study has been adjusted to align with actual site-based data.

Willdan and E3 worked together to arrive at suitable adjustment multipliers that reflected field observations of space heating gas consumption at sample sites as well as align with our engineering judgement and experience with this gas end use in the multifamily sector as a percentage of total sector consumption.

For detailed documentation of how public data was evaluated to reach these findings along with similar data for electricity use per technology type, refer to Attachment A.

Exhibit 7. – Typical Annual Energy Impacts of Technology Types by Segment – Natural Gas Technologies

Customer Type Segments	NREL ResStock Values			Study Adjusted Values									
	Gas-Space Heating-Packaged Unit-Gas Heat	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace	Gas-Space Heating-Packaged Unit-Gas Heat	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace	Gas-Water Heating-Storage Water Heater	Gas-Water Heating-Boiler	Gas-Water Heating-Tankless	Gas-Clothes Dryer-Gas Dryer	Gas-Cooking Range-Stove	Gas-Cooking Range-Oven	Gas-Other ⁸
	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.	therm / cust.
MF-3-4 Unit-Pre-1960-AC-Any	1.5	--	3.9	30.3	0	78.7	56.6	--	0	0.7	3.9	5.2	0
MF-5-20 Unit-Pre-1960-AC-Any	1.6	--	0.4	89.4	0	23	63.3	--	53.5	--	6.9	9.4	0.2
MF-Over 20 Unit-Pre-1960-AC-Any	0.4	1.2	0.9	21.6	69	51.8	72	--	26.7	--	6.9	9.3	1.6
MF-3-4 Unit-Pre-1960-No AC-Any	1	--	0.3	65.1	0	20.5	72.5	--	16.4	1.1	5.4	7.3	1.7
MF-5-20 Unit-Pre-1960-No AC-Any	2.7	0	0.8	164.8	0	49.9	59.1	--	89.6	--	5.5	7.4	0
MF-Over 20 Unit-Pre-1960-No AC-Any	1.2	0.2	0	135.2	23.4	0	48.6	--	61.2	--	6.7	9.1	2
MF-3-4 Unit-1960-1987-AC-Any	3.1	2.9	2.1	81.8	78.1	55.6	93.9	--	55.4	1.3	8.4	11.4	0.8
MF-5-20 Unit-1960-1987-AC-Any	2.6	1.1	1.1	138.5	58.3	59.8	125.9	--	51.8	2.1	11.6	15.7	2.5
MF-Over 20 Unit-1960-1987-AC-Any	1.9	2.6	1.4	85.9	114.3	64	118	--	65	2	10.2	13.8	2
MF-3-4 Unit-1960-1987-No AC-Any	2.1	--	2	115	0	112.5	135.9	--	100.5	2.5	11.9	16.1	2.9
MF-5-20 Unit-1960-1987-No AC-Any	1.7	0.5	4.7	58.6	19.2	163.1	106.3	--	60.6	1.3	10.8	14.6	1.3
MF-Over 20 Unit-1960-1987-No AC-Any	0.7	--	0.4	100.7	0	60.4	88.4	--	78.9	1.1	9	12.2	0
MF-3-4 Unit-Post-1987-AC-Any	1	--	0.4	85.9	0	29.4	103.8	--	16	1.6	8.4	11.4	1.8
MF-5-20 Unit-Post-1987-AC-Any	3.4	1	0.3	147.2	43.2	15.1	79	--	63.3	1.3	7.6	10.3	2
MF-Over 20 Unit-Post-1987-AC-Any	0.8	0.3	0.3	135.6	43.4	46.6	93.4	--	62.9	1.5	8.8	11.9	1.1
MF-3-4 Unit-Post-1987-No AC-Any	0.8	1	0.8	108	125.9	104.9	87.5	--	147.2	1.5	8.3	11.3	0
MF-5-20 Unit-Post-1987-No AC-Any	0.7	0.3	1.1	72.2	33.2	111.6	87.1	--	63.1	1.5	8.8	11.9	1.2
MF-Over 20 Unit-Post-1987-No AC-Any	0.5	0	0.1	150.8	0	26.1	86.8	--	97.1	1.1	8.3	11.2	1.1

⁸ Gas-Other” includes the following use types from the ResStock Models: gas fireplaces and gas (natural gas) grills.

Site Surveys

The table below shows the potential reduction in GHG emissions in metric tons of CO₂ for the sites surveyed as well as reductions in annual therms usage by each site.

Exhibit 8. – CO₂ Reduction Potential

Facility	Annual GHG Emissions Avoided (Metric Tons CO ₂ e ⁹)	Potential Annual Therms Saved / Therms Used by End-Use ¹⁰						Affordable Housing?
		Space Heating	Water Heating	Kitchen	Laundry	Pool / Spa Heating	Total	
Site A 18 Unit	80	0	4,200	0	0	3,300	7,500	Yes
Site B 19 Unit	50	0	2,500	0	0	2,100	4,700	No
Site C 50 Unit	440	20,300	20,300	1000	0	0	41,500	Yes
Site D 52 Unit	180	13,200	2,000	800	600	0	17,000	Yes
Site E 18 Unit	140	7,500	4,500	500	300	0	13,200	Yes
Site F 50 Unit	70	0	5,800	0	500	0	6,600	Yes
Site G 42 Unit	100	0	3,300	0	100	6,300	9,400	No

Affordable Multifamily-Focused Surveys

Affordable multifamily housing units differ from standard multifamily units primarily in their income-qualified eligibility criteria. These thresholds vary by property and are often determined by factors such as tax credits received or deed restrictions. Some affordable housing developments offer all units as income-restricted, while others, such as newer developments that are subject to Below Market Rate requirements, feature a mix of market-rate and affordable units, with affordability thresholds tied to the local Area Median Income (AMI).

Depending on the income-levels of residents and the number of income-qualified units within a property, affordable multifamily properties may be able to participate in programs targeting low-

⁹ CO₂ and CO₂ equivalents are calculated here as, 0.0053 metric ton / therm from CO₂, 0.0024ton / therm from CH₄, and 0.0029 metric ton / therm from N₂O.

¹⁰ For the purposes of our detailed customer site evaluations for seven customers, we attempted to find electrification solutions for every gas burning system found. Therefore, the total potential savings also equals the total annual use.

income residents. For instance, TECH Clean California¹¹ offers incentives, technical assistance, and training for electrification and energy efficiency upgrades in multifamily properties. Similarly, the California Department of Community Services and Development's Low-Income Weatherization Program (LIWP)¹² supports energy efficiency upgrades and electrification tailored to affordability needs.

Participation in these programs often requires compliance with California Department of Industrial Relations (DIR) Prevailing Wage and Public Works Requirements. The DIR requirements ensure that projects adhere to state labor standards while delivering energy efficiency benefits to low-income residents.

In the exhibit above, we identify which of the facilities visited participate in the affordable housing program. It is worth noting that no significant differences were observed between affordable and non-affordable housing buildings. This outcome is likely due to the small sample size of sites visited, which may not provide a representative comparison.

¹¹ <https://techcleanca.com/incentives/multifamily-information/>

¹² <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Estimated Costs of Electrification Measures & Infrastructure Upgrades

Cost Estimating Approach

Willdan developed cost estimates for the electrification projects and associated infrastructure upgrades described in this Report from a variety of sources. The primary foundation of the approach is based on Willdan's current role running large retrofit and new-construction incentive programs across California, as well as Willdan's experience as a turn-key performance contractor developing these electrification conceptual designs and costs.

Willdan used in-house estimating tools that draw base-level material and installation cost data from industry-standard databases like RSMeans and ProEst, plus Willdan's independent research and experience with equipment distributors and contractors. Appropriate soft costs (e.g., design and development, permitting, contractor overhead, and profit, etc.) and localization factors were then added to reasonably estimate ranges for total cost to complete these types of projects in Palo Alto. The costs generated by Willdan's in-house estimating tools were calibrated against recent project cost data received from licensed contractors (mechanical, electrical, and plumbing) that work with Willdan in California both locally and state-wide. For some technologies, Willdan saw it necessary to apply a discount factor for economies of scale where specific customer segment types were more likely to install multiple quantities simultaneously.

Willdan estimated the costs for electrical infrastructure upgrades separately from the technologies being evaluated, as the electrical infrastructure upgrades would be applicable to multiple technologies and customer types.

HVAC

Multifamily space heating in Palo Alto is estimated to be 41% driven by electricity and 59% by gas, on an equivalent Btu basis. 60 to 70% of multifamily units are estimated to be served by in-unit systems and 30 to 40% by central systems. The following types of gas equipment are estimated to be in Palo Alto:

- **Gas furnaces:** 1,982 units (17% of all multifamily units) being served by gas furnaces. Furnaces may be wall furnaces or standalone furnaces located in a closet or other space in the unit, or central furnaces located in a basement or rooftop mechanical area. Furnaces are expected to be replaced by split system air source heat pumps (for smaller furnaces), or by central ducted heat pumps.
- + Gas furnaces can be found in all building sizes and vintages, but larger and older buildings may be served by boilers instead (see next bullet for details).

- **Gas boilers for space heating:** 173 units (2% of all multifamily units), all of which are assumed to be central systems and which are expected to be replaced by electric heat pump water heating systems or heat recovery chillers.
 - Gas boilers are most common in buildings with over 20 units and pre-1960 vintage buildings, and least common in buildings with less than 5 units, and post-1987 vintage buildings.
 - Larger, older buildings are more likely to have this type of heating.
- **Gas package units:** 3190 units (28% of all multifamily units) are served by gas packaged unit heating. These may be small packaged systems all of which are assumed to serve individual dwelling units, or larger central packaged systems serving multiple dwelling units. These units provide air conditioning as well and are expected to be replaced by all-electric packaged heat pump units.
 - Gas package units are most common in larger buildings with 5 or more units size and pre 1987 vintage buildings.
 - Larger, and older buildings are most likely to have this type of heating.

All of the above types of equipment were observed in Willdan's site surveys, except packaged units.

The basis for determining the HVAC cost estimates is the cost-estimating platform database that Willdan has compiled for use within Willdan's Net Energy Optimizer (NEO) tool. The database uses RSMeans¹³ construction cost estimating data as the foundation and contains cost estimates for various system types at varying system capacities and varying components. Because the base RSMeans cost data is obtained roughly one year before its release date, is more applicable to new construction direct contractor costs, and is generalized to be used for varying applications throughout the U.S., various factors were applied to tailor the cost data for this study. The factors applied included: RSMeans cost factor for the applicable region, prevailing wage, permit/plan check fees, consulting fees, taxes, contingency, and inflation factors to adjust for present day costs.

These totals for the tailored cost estimates were then averaged and categorized into the electric and gas technology options that would be used in the analysis. To make these costs scalable, the cost estimates were converted into dollar per square foot (\$/ft²) values using common metrics such as: dollars per ton of cooling (\$/ton) and square feet per ton of cooling (ft²/ton). The resulting \$/ft² values were then applied to their respective electric and gas technologies for the varying customer type segments. Where opportunities for economies of scale seemed likely, a reduction factor was applied.

Once the initial HVAC cost estimates were generated, they were reviewed and adjusted by the larger stakeholder team¹⁴ to match the group's wider experience with these types of projects. These adjustments were based on the following factors:

¹³ RSMeans is a regularly updated construction industry standard reference for detailed cost data (<https://www.rsmeans.com/>)

¹⁴ CPAU staff, E3 staff, and Willdan.

- + Soft costs (e.g., engineering, plan check/permit fees, etc.) and some ancillary hard costs (e.g., gas connections) were increased for gas-electric hybrid systems, compared to all-electric systems that only require an electrical connection.
- + Costs were added to the air source heat pump (ASHP) retrofit, associated with removing baseline equipment in one location (e.g., in-wall furnaces) when replacing them with all-electric solutions that would be located elsewhere (e.g., on the roof.)
- + Costs were added to the ASHP retrofit, associated with adapting these systems in a retrofit scenario such as curb adapters and other duct rerouting, and final electrical connections.

Exhibit 8a. – Range of HVAC Electrification Cost Estimates

Range Customer Type	Electric-Cooling-PTHP/Packaged HP	Electric-Space Heating-Packaged Unit-Electric Resistance	Electric-Space Heating-ASHP
MF-3-4 Unit-Pre-1960-AC-Any	\$10,786	\$5,893	\$10,306
MF-5-20 Unit-Pre-1960-AC-Any	\$10,247	\$5,598	\$9,791
MF-Over 20 Unit-Pre-1960-AC-Any	\$9,707	\$5,304	\$9,275
MF-3-4 Unit-Pre-1960-No AC-Any	\$10,786	\$5,893	\$10,306
MF-5-20 Unit-Pre-1960-No AC-Any	\$10,247	\$5,598	\$9,791
MF-Over 20 Unit-Pre-1960-No AC-Any	\$9,707	\$5,304	\$9,275
MF-3-4 Unit-1960-1987-AC-Any	\$19,349	\$10,572	\$18,489
MF-5-20 Unit-1960-1987-AC-Any	\$18,382	\$10,043	\$17,564
MF-Over 20 Unit-1960-1987-AC-Any	\$17,414	\$9,514	\$16,640
MF-3-4 Unit-1960-1987-No AC-Any	\$19,349	\$10,572	\$18,489
MF-5-20 Unit-1960-1987-No AC-Any	\$18,382	\$10,043	\$17,564
MF-Over 20 Unit-1960-1987-No AC-Any	\$17,414	\$9,514	\$16,640
MF-3-4 Unit-Post-1987-AC-Any	\$17,398	\$9,505	\$16,624

Range Customer Type	Electric-Cooling-PTHP/Packaged HP	Electric-Space Heating-Packaged Unit-Electric Resistance	Electric-Space Heating-ASHP
MF-5-20 Unit-Post-1987-AC-Any	\$16,528	\$9,031	\$15,793
MF-Over 20 Unit-Post-1987-AC-Any	\$15,658	\$8,555	\$14,962
MF-3-4 Unit-Post-1987-No AC-Any	\$17,398	\$9,505	\$16,624
MF-5-20 Unit-Post-1987-No AC-Any	\$16,528	\$9,031	\$15,793
MF-Over 20 Unit-Post-1987-No AC-Any	\$15,658	\$8,555	\$14,962

Exhibit 8b. – Range of HVAC Like for Like Gas System Cost Estimated (per Customer)

Range Customer Type	Gas-Space Heating Package Unit	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace
MF-3-4 Unit-Pre-1960-AC-Any	\$8,528	\$11,569	\$9,594
MF-5-20 Unit-Pre-1960-AC-Any	\$8,101	\$10,991	\$9,114
MF-Over 20 Unit-Pre-1960-AC-Any	\$7,675	\$10,412	\$8,634
MF-3-4 Unit-Pre-1960-No AC-Any	\$8,528	\$11,569	\$9,594
MF-5-20 Unit-Pre-1960-No AC-Any	\$8,101	\$10,991	\$9,114
MF-Over 20 Unit-Pre-1960-No AC-Any	\$7,675	\$10,412	\$8,634
MF-3-4 Unit-1960-1987-AC-Any	\$9,721	\$13,188	\$10,937
MF-5-20 Unit-1960-1987-AC-Any	\$9,235	\$12,529	\$10,390
MF-Over 20 Unit-1960-1987-AC-Any	\$8,749	\$11,869	\$9,843
MF-3-4 Unit-1960-1987-No AC-Any	\$9,721	\$13,188	\$10,937
MF-5-20 Unit-1960-1987-No AC-Any	\$9,235	\$12,529	\$10,390
MF-Over 20 Unit-1960-1987-No AC-Any	\$8,749	\$11,869	\$9,843

Range Customer Type	Gas-Space Heating Package Unit	Gas-Space Heating- Boiler	Gas-Space Heating- Furnace
MF-3-4 Unit-Post-1987-AC-Any	\$8,741	\$11,858	\$9,834
MF-5-20 Unit-Post-1987-AC-Any	\$8,304	\$11,265	\$9,342
MF-Over 20 Unit-Post-1987-AC-Any	\$7,867	\$10,673	\$8,850
MF-3-4 Unit-Post-1987-No AC-Any	\$8,741	\$11,858	\$9,834
MF-5-20 Unit-Post-1987-No AC-Any	\$8,304	\$11,265	\$9,342
MF-Over 20 Unit-Post-1987-No AC-Any	\$7,867	\$10,673	\$8,850

Water Heating

Water heating in Palo Alto is estimated to be 25% driven by electricity and 75% by gas, on an equivalent Btu basis. The NREL models used to generate overall estimates don’t make a distinction between “in-unit” and central (shared) water heating systems, but note that all seven sample sites that were physically observed were served by central systems.

- **Storage gas water heaters:** 6,603 units (58% of all multifamily units) being served by gas storage water heaters. Gas storage water heaters are expected to be replaced by integrated or split system heat pump water heaters.
 - There is neither a strong correlation between building age, nor building size when determining whether a building is served by gas storage water heaters, but they can generally be expected to be found in small to mid-sized buildings.
- **Gas boilers for water heating:** a small percentage of buildings are served by gas boilers, with attached storage, all of which are assumed to be central systems and which are expected to be replaced by heat pump water heating systems.
 - Note that the NREL models used to generate overall estimates do not evaluate this type of water heating system for residential customers, but site surveys conducted under this study found two multi-family properties with this type of system
 - Larger buildings are likely to have this type of water heating.
- **Tankless gas water heaters:** 593 units (5% of all multifamily units), are served by gas, tankless water heaters. These units are expected to be replaced by heat pump water heating systems.
 - There is neither a strong correlation between building age, nor building size when determining whether a building is served by gas tankless water heaters, but they

can generally be expected to be found in newer vintage, small to mid-sized buildings.

All of the above types of equipment, except gas-tankless water heaters, were observed in Willdan's site surveys.

The primary basis for determining the cost of water heating systems is derived from the Southern California Edison (SCE) Commercial Energy Efficiency Program (CEEP) and Pacific Gas & Electric (PG&E) Government and K-12 Program (GK12) project cost records for 2021 to 2023. The project cost records include data from installations in hotels, grocery stores, retail buildings, and assembly building types. For the multifamily sector, hotels were identified as the closest comparable building type, and their data was used to estimate costs.

After analyzing the pricing records for CEEP hotel building types in detail, Willdan found that costs for electrification options can vary greatly depending on existing conditions and infrastructure upgrades needed. As such, Willdan elected to use projects with typical field conditions and an average project cost to represent the basic minimum level of water heating electrification project. These typical projects include installations where there is sufficient space, adequate ventilation, and no additional infrastructure work is needed. Minimal electrical costs were captured, such as installing an electrical conduit run or relocating units within existing structures. For the purposes of estimating the total costs for Palo Alto customers in this sector, Willdan added these types of additional infrastructure costs as a separate line-item applied to different portions of the overall cohort as expected based on experience with the sector. Willdan's cost estimates for the non-infrastructure-related costs include the following key assumptions for water heating cost estimates:

- + Each building is served by central water heating systems
- + Adequate space is available to accommodate additional water storage if necessary
- + No significant costs would be needed to existing structures or utility infrastructures to accommodate electric water heating options. Costs for infrastructure upgrades were estimated separately.

Willdan used the following methodology to estimate the costs for the various water heating technologies:

- + Determine a baseline water heating system for each customer type segment
 - For each customer type segment, the average quantity of units per parcel was used for estimating the water heating capacity needed
 - CEEP project cost records for projects with similar water heating capacities were referred to and the costs were used as the base cost component
 - The applicable CEEP project costs then had adjustment factors added such as regional cost indexing, prevailing wage adders, permit/plan check fees, consulting fees, taxes, contingency
- + Determine appropriately sized electric water heating system options or alternative gas systems for each customer type segment, based on the baseline water heating systems

- Wherever sufficient cost data was not available, RSMeans was referred to for determining the base cost

The outlined methodology combines baseline determination, cost analysis, and system sizing to deliver actionable insights for suitable replacements. By tailoring the CEEP data with regional adjustments and project-specific considerations, average costs have been derived for the varying technologies. However, it is important to note that when implementing energy-efficient solutions such as heat pump water heaters (HPWHs), it is necessary to consider the details of individual projects to ensure that new HPWH systems are properly sized to serve the needs of the facilities.

The standard water heating electrification approach considered here in multifamily buildings is with central systems (versus smaller in-unit systems), via heat-pump water heaters with storage. All seven site surveys revealed central storage water heating systems. Central heat pump water heating systems tend to have higher overall performance efficiency. Where in-unit water heating systems are desired, the likely approach would be to use less efficient electric tankless products.

Exhibit 10a. – Range of Water Heating Electrification Cost Estimates

Range	Electric-Water Heating-Electric Resistance Water Heater	Electric-Water Heating-Heat Pump Water Heater	Electric-Water Heating-Tankless
MF-3-4 Unit-Pre-1960-AC-Any	\$16,023	\$33,938	\$9,253
MF-5-20 Unit-Pre-1960-AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-Pre-1960-AC-Any	\$1,942	\$4,114	\$946
MF-3-4 Unit-Pre-1960-No AC-Any	\$16,023	\$33,938	\$9,253
MF-5-20 Unit-Pre-1960-No AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-Pre-1960-No AC-Any	\$1,942	\$4,114	\$946
MF-3-4 Unit-1960-1987-AC-Any	\$16,023	\$33,938	\$9,253

Range	Electric-Water Heating- Electric Resistance Water Heater	Electric-Water Heating-Heat Pump Water Heater	Electric-Water Heating- Tankless
MF-5-20 Unit-1960-1987-AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-1960-1987-AC-Any	\$1,942	\$4,114	\$946
MF-3-4 Unit-1960-1987-No AC-Any	\$16,023	\$33,938	\$9,253
MF-5-20 Unit-1960-1987-No AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-1960-1987-No AC-Any	\$1,942	\$4,114	\$946
MF-3-4 Unit-Post-1987-AC-Any	\$16,023	\$33,938	\$9,253
MF-5-20 Unit-Post-1987-AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-Post-1987-AC-Any	\$1,942	\$4,114	\$946
MF-3-4 Unit-Post-1987-No AC-Any	\$16,023	\$33,938	\$9,253
MF-5-20 Unit-Post-1987-No AC-Any	\$8,217	\$17,404	\$4,271
MF-Over 20 Unit-Post-1987-No AC-Any	\$1,942	\$4,114	\$946

Exhibit 10b. – Range of Water Heater Like for Like Gas System Cost Estimated (per Customer)

Range	Gas Water Heating Storage Water Heater	Gas Water Heating Tankless
MF-3-4 Unit-Pre-1960-AC-Any	\$6,908	\$10,584
MF-5-20 Unit-Pre-1960-AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-Pre-1960-AC-Any	\$1,570	\$1,082
MF-3-4 Unit-Pre-1960-No AC-Any	\$6,908	\$10,584
MF-5-20 Unit-Pre-1960-No AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-Pre-1960-No AC-Any	\$1,570	\$1,082
MF-3-4 Unit-1960-1987-AC-Any	\$6,908	\$10,584
MF-5-20 Unit-1960-1987-AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-1960-1987-AC-Any	\$1,570	\$1,082
MF-3-4 Unit-1960-1987-No AC-Any	\$6,908	\$10,584
MF-5-20 Unit-1960-1987-No AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-1960-1987-No AC-Any	\$1,570	\$1,082

Range	Gas Water Heating Storage Water Heater	Gas Water Heating Tankless
MF-3-4 Unit-Post-1987-AC-Any	\$6,908	\$10,584
MF-5-20 Unit-Post-1987-AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-Post-1987-AC-Any	\$1,570	\$1,082
MF-3-4 Unit-Post-1987-No AC-Any	\$6,908	\$10,584
MF-5-20 Unit-Post-1987-No AC-Any	\$6,377	\$4,885
MF-Over 20 Unit-Post-1987-No AC-Any	\$1,570	\$1,082

Appliances (Kitchen and Laundry)

Cost-estimating data for residential kitchen and laundry applications is provided separately from commercial applications by RSMeans, and as such, was not readily available for Willdan’s use. Therefore, as an alternative to RSMeans, Willdan derived residential-type kitchen and laundry appliance costs for the various gas and electric technologies through independent research of material costs for typical residential applications and labor costs for installation. Where available, Energy Star-certified products were selected. The material and labor costs served as the basis for the cost estimates and the same approach to the HVAC cost estimates was taken in which various factors were applied to tailor the cost estimates for the study.

Per-customer costs estimates for laundry appliances assume shared laundry facilities. Of the seven multi-family sites visited, six had shared laundry facilities, and the one with in-unit laundry appliances were already fully electric.

Exhibit 11a. – Range of Appliance Electrification Cost Estimates

Range	Electric-Clothes Dryer-Electric Dryer	Electric-Cooking Range-Resistance Stove	Electric-Cooking Range-Induction Stove
Low Range	\$193 per customer	\$1,024 per customer	\$1,611 per customer
High Range	\$1,416 per customer	\$2,040 per customer	\$3,212 per customer

Exhibit 11b. – Range of Like fo Like Gas Appliance Cost Estimates

Range	Gas-Clothes Dryer-Gas Dryer	Gas-Cooking Range- Stove
Low Range	\$92 per customer	\$498 per customer
High Range	\$674 per customer	\$2,112 per customer

Electrical Infrastructure

Costs for electrical infrastructure upgrades were derived separately between electrical panel upgrade costs and main service upgrade costs. This provides a degree of transparency when substantial infrastructure upgrades are expected. Only infrastructure upgrades on the “customer” side of the meter were evaluated under this study; infrastructure upgrades required on the “Utility” side of the meter (e.g. Utility-owned transformers, etc.) were not evaluated here.

Costs for electrical infrastructure upgrades were derived primarily from historical project cost data from Willdan-evaluated or developed projects. More specifically, historical contractor cost data for these projects that have been implemented within California over the past four years, served as the majority data source. RSMeans construction cost data, as well as vendor pricing, was then used to complement the contractor cost data to account for variances, especially when larger service upgrades may be required. The total costs that were derived were then increased to account for prevailing wage, permit/plan check fees, consulting fees, taxes, contingency, and inflation for approximately two years.

Willdan compared the cost estimates for upgrading an electrical panel with the electrical panel upgrade cost range stated on the City of Palo Alto’s website for residential customers to ensure consistency.

As each customer meter results in a separate electrical panel per customer, the cost estimates for electrical panel upgrades were applied directly as a price per customer (\$/customer) cost. Electrical infrastructure upgrades to the main service, however, are performed at the facility or parcel level. As such, the average quantity of customers per parcel was used to estimate the potential upgrades needed, and the resulting cost estimates were then divided by the average quantity of customers per parcel to obtain a \$/customer cost, which could be allocated to the per-customer electrification costs.

Key assumptions made for electrical infrastructure upgrades include:

- + Base cost for an electrical panel upgrade: \$2,000
- + Cost for an electrical panel upgrade for customers with larger square footage increased the base cost by \$1,000 to account for a larger panel and additional circuits.
- + Building stock data identified that parcels with greater than 20 units resulted in an average of 88 units/parcel. As such, Willdan assumed that a 4000A switchboard and the costs associated with its installation may be necessary to accommodate the average units/parcel.

Exhibit 12. – Range of Electrification Infrastructure Cost Estimates

Range	Electrical Infrastructure Upgrades
Low Range	\$2,000 per customer
High Range	\$8,800 per customer

Cost Scenarios for Typical Customer/Building Prototypes

Willdan developed Electrification Assessment Reports for a sample of multifamily customers using the information collected during the detailed field surveys. Each report provides valuable insights and identifies specific potential electrification measures along with associated implementation costs. The table below summarizes the types of customers visited:

Exhibit 13. – Details of Multifamily Buildings Surveyed

Building Type	Customers Visited	Vintage	AC
5-20 unit sites	2	1960 to 1987	Yes
Over 20-unit sites	5	1960 to 1987 and Post-1987	Yes

The following table represents a list of potential electrification measures and their estimated implementation costs for one of the sites. The costs provided are presented as a range for preliminary budgeting purposes, as more detailed analysis and gathering of contractor bids is required to accurately determine implementation costs. Similar summary tables were created for all seven sites visited and can be accessed in the appendix.

The installation price range was developed using the cost methodology discussed in previous sections as the foundation, with adjustments made based on the specific conditions and requirements of each site.

An example of the assessment findings is shown in the table below. See Attachment C.4 for a compiled table of the opportunities found across the full sample of all customers visited.

Note that the final row in the table characterizes “Electrical Infrastructure” and the estimated improvements that will be needed to support the other electrification projects identified. These upgrades do not reduce emissions on their own but support the emissions avoidance of the associated opportunities. Typical upgrades in this category include things like new high-voltage outlets, upgraded subpanels, and upgraded main electrical service, as applicable to each site.

Exhibit 14. – Example of Customer Electrification Assessment Results Showing Identified Opportunities and Budgetary Price Ranges: Site D

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range ¹⁵	Annual GHG Emissions Avoided
Water Heating	(4) 100-gallon Storage Gas Water Heaters	Heat Pump Water Heater Systems	\$240k to \$320k	48 metric tons CO ₂ e
HVAC	One 65 kBtu/h gas furnace for each dwelling unit	Ducted split system heat pumps	\$20k to \$24k Each Unit	80 metric tons CO ₂ e
Kitchen	One gas range for each dwelling unit	Electric Induction Ranges	\$1k to \$1.5K Each unit	5 metric tons CO ₂ e
Washers	(5) Electric Vended Washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A
Dryers	(5) Gas Vended Dryers	Electric Vended Dryers	\$14k to \$17k	3 metric tons CO ₂ e
Pool Heaters	Pool exists but is decommissioned and will be removed	N/A	N/A	N/A
Electrical Infrastructure	Each unit has 100 Amp Service plus (4) 100 Amp House Meters	This site will likely require the installation of new house services to feed electrified water heating systems and dryers. Preliminary estimate of total combined capacity needed is approximately 400 Amps.	\$51k to \$61k	Supports emissions avoidance shown above

¹⁵ These installation costs are for the full project. They do not account for future gas savings, potential rebates, or avoidance of like-for-like replacements

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range ¹⁵	Annual GHG Emissions Avoided
		<p>If furnaces and kitchen ranges in individual units are electrified, individual unit panels may need to be upgraded. Preliminary estimate of additional capacity needed is 50 Amps per unit.</p> <p>Electric dryers will need new 240V receptacles</p> <p>Specific electrical design parameters will need to be determined by engineers.</p> <p>Confirm upstream transformer capacity with CPAU.</p>		
Total Annual Emissions Reduction Potential Identified				441 metric tons CO₂e

Total Costs to Electrify All City Buildings in Sector

Willdan has taken the findings of this Multifamily Sector Study and delivered customer building characterization, technology saturation, and energy consumption data to E3 for detailed modeling of costs to electrify customers in this sector. These total rough-order-of-magnitude (ROM) costs are shown below (in nominal dollars), along with likely available incentives from federal, state, and regional entities. The bottom row of the table shows the costs to replace the systems in question with like-for-like, non-electrified, gas-burning alternatives. The incremental cost to electrify is the electrification capital expenditures (capex), minus the like-for-like replacement capex.

Exhibit 15. – Total Cost to Electrify All Buildings in Sector

Sector	Metric	Total ROM Cost (Nominal \$)		
		Low Local Action	Medium Local Action	High Local Action
Multifamily Residential	Total Cost of Electrification Capex	\$586,000,000	\$503,000,000	\$463,000,000
	Potential Federal / State / Regional Incentives	\$51,000,000	\$54,000,000	\$50,000,000
	Like-for-Like Replacement Capex	\$419,000,000	\$338,000,000	\$297,000,000
	Incremental Replacement Capex	\$167,000,000	\$165,000,000	\$166,000,000

In the above table, three scenarios are presented: low-, medium-, and high-local action. In the low local action scenario building electrification is assumed to take place at a much slower pace than the high local action scenario, leading to greater cost escalation. The medium-local action scenario lies between these two. Due to cost escalation, and the fact that costs are denominated in nominal rather than real dollars, this estimate is higher than would be calculated by multiplying the costs shown in previous sections by the number of units served, leading to a conservatively high estimate.

For detailed documentation of this cost modeling and projection, refer to E3's, *Palo Alto Electrification Funding & Financing Study Final Report*. This report also includes the operational savings from electrifying gas equipment due to the energy efficiency of heat pumps, which is not included in the above estimate.

Key Findings

Several key findings have been identified through this study and have been summarized below, grouped by focus area.

+ Existing and proposed technologies observed in Public and Site Survey data:

- There is estimated to be some marginal level of adoption of heat pumps for space heating in newer multifamily buildings, particularly in buildings with more than five dwelling units - (~7% of multifamily customers, according to our NREL-data based modeling)
- A large number of multifamily buildings are estimated to utilize inefficient electric resistance heating sources (e.g., in wall heaters, baseboard heating) - (~46% of multifamily customers). Modeling data shows these as most prevalent at 3-4 unit buildings, and those built before 1960. Heat pumps could reduce bills for these customers.
- A significant number of multifamily buildings are estimated to utilize inefficient electric resistance water heaters (~31% of multifamily customers). There is not a strong correlation with building size, but it appears to be slightly correlated with post-1987 vintage buildings. Heat pumps could reduce bills for these customers.
- An insignificant number of multifamily buildings are estimated to utilize heat pump water heaters - (<1% of multifamily customers)
- Heat pump technologies for HVAC and water heating are still very significant electrification opportunities for further adoption at multifamily buildings and may also be used to upgrade electric resistance systems for far greater energy efficiency.

+ Existing natural gas consumption:

- Large complexes (>100 dwelling units) are estimated to consume over 40% of the natural gas across the multifamily sector, meaning these may be an efficient area of focus for electrification programs. The most common natural gas equipment found in these buildings are gas storage water heaters, gas packaged HVAC units, gas furnaces, and gas cooking equipment (i.e., ranges, stoves).
- The multifamily sector consumes 9% of all gas supplied by CPAU, so efforts to electrify the multifamily sector will have an overall limited impact on GHG emissions reduction if not paired with electrification of the single family residential and commercial sectors.

+ The cost to electrify:

- The cost to electrify space heating efficiently using air-source heat pumps is about 20% higher than the cost for standard electrification through electric resistance. However, this can be offset by ongoing electricity cost savings, due the heat pump HVAC technology being 2 to 3 times as efficient as resistance technology.

- The up-front cost to electrify domestic water heating is lowest using electric tankless technologies, which are nearly 50% less than electric resistance water heater technologies and nearly 75% less than HPWH solutions. Electric tankless technologies, on the other hand are 1/3rd to 1/5th as efficient as HPWHs, which will be reflected in ongoing higher electricity costs with this technology. The preferred approach (as modeled) is to replace gas water heaters with electric HPWH technology. Electric resistance water heaters are generally a back-up electrification option when constructability barriers to HPWHs exist.
- The up-front cost to electrify stove technologies efficiently using induction is over 50% higher than the cost of electric resistance stoves. Out of the various technologies evaluated, electric resistance stoves appear to provide the lowest incremental cost to electrify, over standard natural gas options. Electric resistance stoves, however, are estimated to be 10% less efficient than induction models, which will be reflected in lower electricity bills. In addition, induction models provide faster cooking times, more precise temperature control, and enhanced user safety features. Induction cooking replacements are the preferred, modeled solution.
- When combined, permit fees, plan check fees, engineering, and contingency can increase the prevailing wage materials and labor-related construction costs by 20 – 30%.
- Larger buildings can be more cost-efficient to upgrade. For example, as the cost for electrical infrastructure upgrades to the main service becomes necessary, the \$/customer tends to decrease when more units are present, despite the need for more substantial upgrades to accommodate a greater quantity of units. Therefore, larger building may require more upfront capital to electrify, but the per unit cost of electrification is lower.
- The cost to perform HVAC retrofits is consistently the most expensive in 1960-1987 building vintages, regardless of HVAC technologies. This appears to be due to the fact that modeling shows the average customer unit size (i.e., square footage) is slightly higher for buildings in this vintage, leading to slightly higher capacity HVAC systems.
- When considering the total cost to electrify, high local action may require greater funding support by CPAU, as discussed in a separate report, the S/CAP Funding and Financing Study, especially in the near term, but may reduce overall nominal costs to all City stakeholders in the long term. Contributing factors to the lower overall cost are more rapid adoptions which reduce inflationary cost increases, plus greater availability of non-local incentives which will likely expire if projects aren't implemented until later periods.

Attachments

Attachment A - Public Data / Saturation Study

Attachment B - Customer Reports

Attachment C - Primary Data Files

Attachment C.1 - Cost Data Incorporated into S/CAP Funding Model

Attachment C.2 - ArcGIS Map Images and Data Summaries

Attachment C.3 - ArcGIS Field Data Compiled

Attachment C.4 - Compiled Customer Electrification Assessment Report Tables

Attachment C.5 - Preliminary Online Surveys and Results

Attachment C.6 – Basic HVAC and Water Heating Technology Descriptions

City of Palo Alto Electrification Funding Study

Task 4.2 - Multi-Family Residential Building Inventory and Equipment Saturation Analysis-Public Data

October 2024



Energy+Environmental Economics

Introduction

E3 and Willdan Energy Solutions are performing a study of the multi-family building sector in the City of Palo Alto that will accomplish the following tasks:

- Characterize gas usage in multi-family buildings by end-use (e.g., space heating, water heating, cooking, clothes drying)
- Estimate the cost of electrification for various gas end-uses and behind-the-meter electrical upgrades
- Identify cost effective efficiency opportunities in multi-family buildings
- Estimate the cost of electrifying all multi-family homes in the City of Palo Alto

In pursuit of this larger Study, we have identified available public data sources that can be used to characterize multi-family building stock in the City of Palo Alto. The following document summarizes the results of our analysis of these data sources.

In a later stage of the project, we will be conducting interviews and on-site evaluations of a sample set of these customer sites, to determine if this public data review accurately reflects field observations.

Data Sources

City of Palo Alto multi-family housing building stock has been generally characterized using the data sources described in the following sections.

This base-level building stock characterization based on these available data sources will be followed up with assessments of specific sample multi-family sites and will include on-premises inspections and interviews with site owners, managers, and occupants to align the base-level characterizations with facts from the field. This evaluation of sample sites will occur at a later stage.

For the purposes of this evaluation, multi-family housing sites are those with greater than three units of housing located at one parcel or contiguous related parcels.

+ City of Palo Alto Utilities Utility Account Data

- 12-months of natural gas and electric billing data for calendar year 2023
- Both individual dwelling unit accounts and multi-family site master meter accounts
- Approximately 11,400 active Utility accounts for multi-family customers > 2 dwelling units

+ County of Santa Clara Tax Assessor Records

- Cross referenced with CPAU Utility account addresses
- Contains detailed information not captured by account data
 - Land use codes indicate number of dwelling units per parcel
 - Includes building square footage per parcel
 - Includes building year-built, and effective-year-built for major renovations

+ National Renewable Energy Laboratories (NREL) ResStock Modeling Data¹

- A tool for large-scale residential energy analysis combining public and private data sources, statistical sampling, building simulations, and high-performance computing.
 - *“The U.S. residential building sector stock energy model, ResStock™, is a highly granular, bottom-up model that uses multiple data sources, statistical sampling methods, and advanced building energy simulations of the residential building stock across the contiguous United States.*

ResStock asks and answers two main types of questions: 1) How is energy used in the U.S. housing stock? and 2) What are the impacts of modifying the housing stock with different technologies?”²

¹ <https://www.nrel.gov/buildings/resstock.html>

² Quoted from ResStock’s Github page: <https://nrel.github.io/ResStock.github.io/>

- ResStock draws from major publicly available data sources including the Residential Energy Consumption Surveys (RECS) from the U.S. Energy Information Administration, Public Use Microdata Samples (PUMS) for the American Community Survey, and the American Housing Survey associated with the 2022 U.S. Census. Full technical reference documentation can be found on ResStock’s Github page².
- ResStock modeling data was gathered at the County level for both Santa Clara and San Mateo counties as representative of multi-family City of Palo Alto Utility customers
- The following ResStock data was mapped to CPAU multi-family customer accounts according to various customer segments:
 - Building technology type saturation
 - Technology type typical system ages for average customer
 - Technology type electricity and natural gas energy impacts for average customer

Sector Footprint, Construction Year, and Energy Consumption

Number of Customers and Building Square Footage

The County Assessor data indicates the following total building footprint and parcel count for various multi-family building types in Palo Alto.

Exhibit 1. – Assessor Footprint and Parcel Count Information

Multi-family Building Types - Land Use Codes	Total Building Square Footage	Number of Parcels
Two Family*	855,000	391
Three and Four Family	1,482,000	464
5-10 Units	1,158,000	231
11-20 Units	763,000	77
21-50 Units	1,086,000	42
51-100 Units	1,584,000	30
Over 100 Units	4,272,000	32
Others (Primarily Lifecare w Nursing)*	1,376,000	18
Total	12,576,000	1,285

*These building types are not being considered as “multi-family” for the purposes of this analysis. Information provided here for reference only.

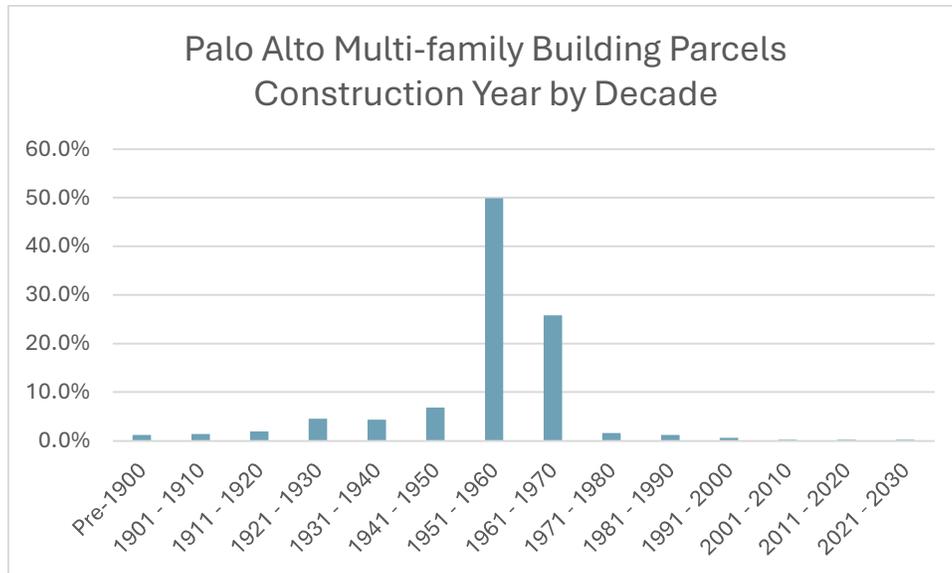
Note that the total number of individual multi-family customer accounts, and master meter accounts don't necessarily align with the number of Parcels. A single complex may span multiple parcels, or a parcel may be undeveloped or currently not operating as a multi-family residence.

According to our current evaluation, there are approximately 10,500 individual multi-family customers, and approximately 900 multifamily master meter accounts, with currently active CPAU accounts (greater than 2-unit multifamily sites).

Construction Year Distribution

The County Assessor data provides records of the year in which each multi-family building was constructed. The distribution of these construction years is shown below. The data shows that approximately 75% of the buildings were constructed between 1950 and 1970. The pace of construction of multi-family units was slower before and after this period, as can be seen in the chart.

Exhibit 2. – Year-Built Distribution Curve for Multi-Family Buildings in Palo Alto



Total Energy Consumption Across the Sector

An analysis of the County Assessor data and CPAU customer account usage data together indicates the following estimates for annual energy consumption for various multi-family building types in Palo Alto.

Exhibit 3. – Sector Energy Consumption Information

Multi-family Building Types - Land Use Codes	Estimated Annual Electricity Consumption, kWh	Percentage of Electricity	Estimated Annual Natural Gas Consumption, therms	Percentage of Natural Gas
Three and Four Family	4,200,000	9%	260,000	11%
5-10 Units	4,200,000	9%	290,000	12%
11-20 Units	2,800,000	6%	200,000	8%
21-50 Units	6,300,000	13%	260,000	11%
51-100 Units	8,400,000	17%	380,000	16%
Over 100 Units	23,110,000	47%	1,010,000	42%
Total	49,010,000	100%	2,400,000	100%

Electrification Funding Study Customer Segmentation

For the purposes of the funding study model, CPAU customers have been segmented into representative groups. The segmentation of multi-family residential sector customers follows the distinctions of Building Type, Building Vintage, and Air Conditioning (AC) Status.

For model segmentation purposes, an individual customer account in the fundamental unit. This sector includes both individual multifamily resident customer accounts, and multifamily master meter accounts. These account types correspond to CPAU account types “20” and “70”, respectively. A single multifamily building will be associated with multiple accounts.

Segmentation by Building Type

In the multi-family residential building sector, building types have been segmented by the number of dwelling units on a parcel. Segments are as follows:

- 3- or 4-unit sites
- 5- to 20-unit sites
- Over 20-unit sites

Segmentation by Building Vintage

Building vintages have been segmented according to the following distinctions:

- Pre-1960
- 1960 to 1987
- Post-1987

1988 is when Title 24 was applied to all occupancy types in the State of California. Title 24 combined all building standards under a single code, and importantly for this study, includes energy efficiency standards (Title 24, Part 6). For this reason, the “Post-1987” segment was chosen here. The “Pre-1960” and “1960 to 1987” segments have been chosen because they break up the remaining Palo Alto building stock approximately evenly.

Segmentation by Air Conditioning Status

Finally, this customer sector has been segmented based on whether the site is served by air conditioning (AC) or not.

- AC
- No AC

Electrification Funding Study Technology Types

Under this funding study, we are evaluating what common building technology types are present for each customer segment, to what extent they are present, and their estimated energy impacts.

End Use and Fuel Type

The technologies being investigated have been categorized by end-use, and fuel type

- End-uses
 - Space Cooling
 - Space Heating
 - Water Heating
 - Clothes Drying
 - Cooking
 - Pool and Spa Heating
- Fuel types
 - Electricity
 - Natural gas

For the purposes of modeling, we have also evaluated “other” loads as an end-use type for both electricity and natural gas. Other loads are defined as any end-uses not specified above. Since this is a generalized category, there are no technology types associated with this category of end-use.

Technology Types

The list of technology types being evaluated is shown below:

Exhibit 4. – Funding Study Technology Types

Fuel	End-Use Type	Technology
Electric	Cooling	Split Systems
Electric	Cooling	Packaged Terminal Air Conditioners (PTACs) / Packaged Unit Air Conditioners
Electric	Cooling	Packaged Terminal Heat Pumps (PTHPs) / Packaged Unit Heat Pumps
Electric	Cooling	Water-cooled Chiller Systems
Electric	Cooling	Air-cooled Chiller Systems
Electric	Cooling	Variable Refrigerant Flow (VRF) Systems
Gas	Space Heating	Packaged HVAC Units-Gas Heat
Electric	Space Heating	Packaged HVAC Units-Electric Resistance Heat
Electric	Space Heating	Air-source Heat Pumps (ASHPs)
Gas	Space Heating	Boiler Systems
Gas	Space Heating	Furnaces
Gas	Water Heating	Gas Storage Water Heaters
Gas	Water Heating	Service Water Boilers
Electric	Water Heating	Electric Storage Water Heaters
Electric	Water Heating	Heat Pump Water Heaters
Gas	Water Heating	Tankless Gas Water Heaters
Electric	Water Heating	Tankless Electric Water Heaters
Electric	Clothes Dryer	Electric Dryers
Gas	Clothes Dryer	Gas Dryers
Gas	Cooking Range	Gas Stoves
Gas	Cooking Range	Gas Ovens
Electric	Cooking Range	Electric Resistance Stoves
Electric	Cooking Range	Electric Induction Stoves
Electric	Cooking Range	Electric Ovens
Electric	Pool Heater	Electric Pool Heaters
Gas	Pool Heater	Gas Pool Heaters
Electric	Spa Heater	Electric Spa Heaters
Gas	Spa Heater	Gas Spa Heaters

Public Data Results

The review of public data leads us to the following information about CPAUs multi-family residential customers. In a later stage of the project, we will be conducting interviews and on-site evaluations of a sample set of these customer sites, to determine if this public data review accurately reflects field observations.

The data shown in Exhibit 5 derives from the County Assessor data, which includes information regarding the number of residential units per parcel, and the year of construction. For the purposes of this study, we are using the Assessor field “Effective Year Built” which accounts for major building renovations that would result in upgraded base systems, as opposed to the “Year Built” field which reflects initial year of construction.

The Assessor data was cross-referenced with CPAU customer account data to estimate the number of active multifamily customers in each segment. The Active Customers shown include both CPAU Account Class 20 (individual dwelling unit accounts) and Account Class 70 (“house” or “master meter” accounts). This estimated count represents the total in a given month, such that if an individual dwelling unit had two residents during a year at different times with separate accounts, only one account associated with that unit is counted.

Exhibit 5. – Number of Customers in Each Segment and Average Building Ages

Customer Type Segments	Full Palo Alto Stock	Average Building Age in 2025
	<i>Estimated # of Active Customers</i>	<i>Years</i>
MF-3-4 Unit-Pre-1960-AC-Any	595	80
MF-5-20 Unit-Pre-1960-AC-Any	1,549	77
MF-Over 20 Unit-Pre-1960-AC-Any	848	78
MF-3-4 Unit-Pre-1960-No AC-Any	247	76
MF-5-20 Unit-Pre-1960-No AC-Any	651	76
MF-Over 20 Unit-Pre-1960-No AC-Any	377	76
MF-3-4 Unit-1960-1987-AC-Any	215	55
MF-5-20 Unit-1960-1987-AC-Any	825	55
MF-Over 20 Unit-1960-1987-AC-Any	3,016	55
MF-3-4 Unit-1960-1987-No AC-Any	83	55
MF-5-20 Unit-1960-1987-No AC-Any	304	55
MF-Over 20 Unit-1960-1987-No AC-Any	1,132	55
MF-3-4 Unit-Post-1987-AC-Any	14	32
MF-5-20 Unit-Post-1987-AC-Any	231	32
MF-Over 20 Unit-Post-1987-AC-Any	942	26
MF-3-4 Unit-Post-1987-No AC-Any	5	33
MF-5-20 Unit-Post-1987-No AC-Any	72	32
MF-Over 20 Unit-Post-1987-No AC-Any	283	26
TOTAL	11,389	

Exhibits 6 and 7 show data derived from NREL’s ResStock modeling data. We’ve evaluated the weighted counts of ResStock models that are mapped to our specific Customer Type Segments for San Mateo and Santa Clara Counties and counted the weighted customer models that incorporate each type of technology. We’ve then represented those weighted counts as a percentage of the total population.

Exhibit 6. - Applicability of Technology Types by Segment – Electric Technologies

Customer Type Segments	Electric-Cooling-Split System	Electric-Cooling-PTAC/Packaged DX	Electric-Cooling-PTHP/Packaged HP	Electric-Cooling-WC Chiller	Electric-Cooling-AC Chiller	Electric-Cooling-VRF	Electric-Space Heating-Packaged Unit-Electric Resistance	Electric-Space Heating-ASHP	Electric-Water Heating-Electric Resistance Water Heater	Electric-Water Heating-Heat Pump Water Heater	Electric-Water Heating-Tankless	Electric-Clothes Dryer-Electric Dryer	Electric-Cooking Range-Resistance Stove	Electric-Cooking Range-Induction Stove	Electric-Cooking Range-Oven	Electric-Other
	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%
MF-3-4 Unit-Pre-1960-AC-Any	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	18.2%	0.0%	18.2%	0.0%	0.0%	13.6%	16.7%	0.0%	16.7%	100.0%
MF-5-20 Unit-Pre-1960-AC-Any	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	22.5%	0.0%	7.5%	0.0%	20.5%	0.0%	20.5%	100.0%
MF-Over 20 Unit-Pre-1960-AC-Any	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	23.5%	0.0%	16.7%	0.0%	11.1%	5.6%	11.8%	0.0%	11.8%	100.0%
MF-3-4 Unit-Pre-1960-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21.4%	0.0%	14.3%	0.0%	7.1%	0.0%	21.4%	0.0%	21.4%	100.0%
MF-5-20 Unit-Pre-1960-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	55.0%	0.0%	40.0%	5.0%	5.0%	0.0%	25.0%	0.0%	25.0%	100.0%
MF-Over 20 Unit-Pre-1960-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	22.7%	0.0%	9.1%	0.0%	25.0%	0.0%	25.0%	100.0%
MF-3-4 Unit-1960-1987-AC-Any	5.1%	89.8%	5.1%	0.0%	0.0%	0.0%	37.9%	10.4%	25.4%	0.0%	3.4%	36.2%	36.2%	0.0%	36.2%	100.0%
MF-5-20 Unit-1960-1987-AC-Any	0.0%	80.9%	19.2%	0.0%	0.0%	0.0%	45.3%	19.4%	40.0%	0.0%	5.7%	19.2%	28.2%	0.0%	28.2%	100.0%
MF-Over 20 Unit-1960-1987-AC-Any	0.0%	90.2%	9.8%	0.0%	0.0%	0.0%	42.6%	10.1%	29.5%	0.6%	3.5%	20.8%	29.5%	0.9%	30.4%	100.0%
MF-3-4 Unit-1960-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	37.0%	0.0%	30.4%	0.0%	4.4%	25.0%	22.1%	0.0%	22.1%	100.0%
MF-5-20 Unit-1960-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	57.1%	0.0%	18.5%	0.0%	7.4%	21.4%	34.8%	0.9%	35.7%	100.0%
MF-Over 20 Unit-1960-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	77.5%	0.0%	52.5%	0.0%	5.0%	27.5%	37.2%	2.6%	39.8%	100.0%
MF-3-4 Unit-Post-1987-AC-Any	6.1%	87.9%	6.1%	0.0%	0.0%	0.0%	18.8%	12.5%	21.2%	0.0%	6.1%	12.1%	36.4%	0.0%	36.4%	100.0%
MF-5-20 Unit-Post-1987-AC-Any	5.7%	82.9%	11.4%	0.0%	0.0%	0.0%	47.1%	17.3%	38.1%	0.0%	6.7%	42.9%	34.1%	1.9%	36.1%	100.0%
MF-Over 20 Unit-Post-1987-AC-Any	7.9%	77.0%	15.1%	0.0%	0.0%	0.0%	48.7%	23.6%	40.3%	0.4%	5.7%	47.2%	30.0%	1.0%	31.0%	100.0%
MF-3-4 Unit-Post-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	42.9%	0.0%	28.6%	0.0%	3.6%	48.2%	42.9%	1.8%	44.6%	100.0%
MF-5-20 Unit-Post-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	61.1%	0.0%	27.8%	0.0%	7.4%	43.6%	25.5%	2.8%	28.3%	100.0%
MF-Over 20 Unit-Post-1987-No AC-Any	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	61.8%	0.0%	29.1%	0.9%	7.3%	45.1%	32.1%	0.5%	32.6%	100.0%
Total Estimated Quantity of Customer with This System Type	100	7,501	635	0	0	0	5,295	749	3,503	56	633	2,095	3,051	75	3,126	11,389

Exhibit 7. - Applicability of Technology Types by Segment – Natural Gas Technologies

Customer Type Segments	Gas-Space Heating-Packaged Unit-Gas Heat	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace	Gas-Water Heating-Storage Water Heater	Gas-Water Heating-Boiler	Gas-Water Heating-Tankless	Gas-Clothers Dryer-Gas Dryer	Gas-Cooking Range-Stove	Gas-Cooking Range-Oven	Gas-Other
	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%	0-100%
MF-3-4 Unit-Pre-1960-AC-Any	59.1%	0.0%	22.7%	72.7%	0.0%	9.1%	45.5%	33.3%	33.3%	100.0%
MF-5-20 Unit-Pre-1960-AC-Any	47.4%	0.0%	2.6%	67.5%	0.0%	2.5%	0.0%	29.5%	29.5%	100.0%
MF-Over 20 Unit-Pre-1960-AC-Any	47.1%	5.9%	23.5%	61.1%	0.0%	11.1%	0.0%	38.2%	38.2%	100.0%
MF-3-4 Unit-Pre-1960-No AC-Any	28.6%	0.0%	50.0%	64.3%	0.0%	14.3%	28.6%	28.6%	28.6%	100.0%
MF-5-20 Unit-Pre-1960-No AC-Any	25.0%	5.0%	15.0%	45.0%	0.0%	5.0%	0.0%	25.0%	25.0%	100.0%
MF-Over 20 Unit-Pre-1960-No AC-Any	40.9%	4.5%	4.5%	59.1%	0.0%	9.1%	0.0%	25.0%	25.0%	100.0%
MF-3-4 Unit-1960-1987-AC-Any	27.6%	1.7%	22.4%	64.4%	0.0%	6.8%	20.7%	13.8%	13.8%	100.0%
MF-5-20 Unit-1960-1987-AC-Any	16.6%	0.7%	18.0%	50.0%	0.0%	4.3%	5.0%	21.8%	21.8%	100.0%
MF-Over 20 Unit-1960-1987-AC-Any	25.4%	0.6%	21.3%	63.6%	0.0%	2.9%	6.4%	19.6%	19.6%	100.0%
MF-3-4 Unit-1960-1987-No AC-Any	28.3%	0.0%	34.8%	60.9%	0.0%	4.4%	18.2%	27.9%	27.9%	100.0%
MF-5-20 Unit-1960-1987-No AC-Any	21.4%	7.1%	14.3%	64.8%	0.0%	9.3%	5.4%	14.3%	14.3%	100.0%
MF-Over 20 Unit-1960-1987-No AC-Any	10.0%	0.0%	12.5%	40.0%	0.0%	2.5%	5.0%	10.3%	10.3%	100.0%
MF-3-4 Unit-Post-1987-AC-Any	21.9%	0.0%	46.9%	69.7%	0.0%	3.0%	24.2%	13.6%	13.6%	100.0%
MF-5-20 Unit-Post-1987-AC-Any	12.5%	1.0%	22.1%	49.5%	0.0%	5.7%	6.7%	13.9%	13.9%	100.0%
MF-Over 20 Unit-Post-1987-AC-Any	7.0%	1.9%	18.9%	46.8%	0.0%	6.8%	7.9%	19.0%	19.0%	100.0%
MF-3-4 Unit-Post-1987-No AC-Any	25.0%	3.6%	28.6%	60.7%	0.0%	7.2%	14.8%	5.4%	5.4%	100.0%
MF-5-20 Unit-Post-1987-No AC-Any	11.1%	1.9%	25.9%	57.4%	0.0%	7.4%	7.3%	21.7%	21.7%	100.0%
MF-Over 20 Unit-Post-1987-No AC-Any	16.4%	0.9%	20.9%	54.6%	0.0%	8.2%	3.6%	17.4%	17.4%	100.0%
Total Estimated Quantity of Customer with This System Type	3,190	173	1,982	6,603	0	593	816	2,568	2,568	11,389

Exhibits 8 and 9 show data derived from NREL’s ResStock modeling data. We’ve evaluated the energy impacts in the ResStock models for each type of technology for both electricity and natural gas. The values below represent the energy impacts of these technologies for the average customer using that technology in each segment. Note that the averages do not include the customers that do not utilize a given technology, which would give an impact of zero for that given technology and show lower values for each technology.

Exhibit 8. - Typical Annual Energy Impacts of Technology Types by Segment – Electric Technologies

Customer Type Segments	Electric-Cooling-Split System	Electric-Cooling-PTAC/Packaged	Electric-Cooling-PTHP/Packaged	Electric-Cooling-WC Chiller	Electric-Cooling-AC Chiller	Electric-Cooling-VRF	Electric-Space Heating-Packaged Unit	Electric-Space Heating-ASHP	Electric-Water Heating-Electric Resistance	Electric-Water Heating-Heat Pump Water	Electric-Water Heating-Tankless	Electric-Clothes Dryer-Electric Dryer	Electric-Cooking Range-Resistance	Electric-Cooking Range-Induction Stove	Electric-Cooking Range-Oven	Electric-Other ³
	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.	kWh / Cust.
MF-3-4 Unit-Pre-1960-AC-Any	--	297	--	--	--	--	3,819	--	771	--	--	288	71	--	119	1,240
MF-5-20 Unit-Pre-1960-AC-Any	--	419	--	--	--	--	1,336	--	946	--	223	--	76	--	126	1,521
MF-Over 20 Unit-Pre-1960-AC-Any	--	439	--	--	--	--	852	--	991	--	752	252	68	--	113	1,727
MF-3-4 Unit-Pre-1960-No AC-Any	--	--	--	--	--	--	1,266	--	1,069	--	2,105	--	97	--	161	1,764
MF-5-20 Unit-Pre-1960-No AC-Any	--	--	--	--	--	--	1,783	--	899	147	689	--	83	--	138	1,395
MF-Over 20 Unit-Pre-1960-No AC-Any	--	--	--	--	--	--	861	--	732	--	627	--	71	--	118	1,321
MF-3-4 Unit-1960-1987-AC-Any	418	815	503	--	--	--	3,820	837	1,287	--	464	594	124	--	207	2,414
MF-5-20 Unit-1960-1987-AC-Any	--	692	1,081	--	--	--	2,062	1,165	1,819	--	1,476	429	131	--	219	2,725
MF-Over 20 Unit-1960-1987-AC-Any	--	774	1,456	--	--	--	1,259	726	1,960	393	2,292	622	150	120	236	2,781
MF-3-4 Unit-1960-1987-No AC-Any	--	--	--	--	--	--	3,090	--	1,515	--	1,503	368	125	--	208	2,936
MF-5-20 Unit-1960-1987-No AC-Any	--	--	--	--	--	--	3,023	--	2,445	--	3,115	517	140	89	199	2,504
MF-Over 20 Unit-1960-1987-No AC-Any	--	--	--	--	--	--	1,272	--	1,385	--	2,246	503	120	96	189	2,247
MF-3-4 Unit-Post-1987-AC-Any	1,175	962	342	--	--	--	1,666	193	861	--	1,101	424	95	--	158	2,130
MF-5-20 Unit-Post-1987-AC-Any	567	874	819	--	--	--	985	439	1,430	--	1,271	383	108	55	141	1,982
MF-Over 20 Unit-Post-1987-AC-Any	700	896	936	--	--	--	363	242	1,638	610	1,795	425	110	100	184	2,245
MF-3-4 Unit-Post-1987-No AC-Any	--	--	--	--	--	--	819	--	1,527	--	2,350	595	118	110	200	2,426
MF-5-20 Unit-Post-1987-No AC-Any	--	--	--	--	--	--	677	--	1,525	--	1,054	350	104	57	139	2,024
MF-Over 20 Unit-Post-1987-No AC-Any	--	--	--	--	--	--	454	--	1,619	289	1,546	471	120	0	100	2,239

³ “Electric-Other” includes the following use types from the ResStock Models: ceiling fans, dishwashers, freezers and refrigerators, lighting (interior, garage, exterior), plug loads, and well pumps.

Exhibit 9. - Typical Annual Energy Impacts of Technology Types by Segment – Natural Gas Technologies

Customer Type Segments	Gas-Space Heating-Packaged Unit-	Gas-Space Heating-Boiler	Gas-Space Heating-Furnace	Gas-Water Heating-Storage Water Heater	Gas-Water Heating-Boiler	Gas-Water Heating-Tankless	Gas-Clothers Dryer-Gas Dryer	Gas-Cooking Range-Stove	Gas-Cooking Range-Oven	Gas-Other ⁴
	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>	<i>therm / cust.</i>
MF-3-4 Unit-Pre-1960-AC-Any	1.5	--	3.9	56.6	--	0.0	0.7	3.9	5.2	0.0
MF-5-20 Unit-Pre-1960-AC-Any	1.6	--	0.4	63.3	--	53.5	--	6.9	9.4	0.2
MF-Over 20 Unit-Pre-1960-AC-Any	0.4	1.2	0.9	72.0	--	26.7	--	6.9	9.3	1.6
MF-3-4 Unit-Pre-1960-No AC-Any	1.0	--	0.3	72.5	--	16.4	1.1	5.4	7.3	1.7
MF-5-20 Unit-Pre-1960-No AC-Any	2.7	0.0	0.8	59.1	--	89.6	--	5.5	7.4	0.0
MF-Over 20 Unit-Pre-1960-No AC-Any	1.2	0.2	0.0	48.6	--	61.2	--	6.7	9.1	2.0
MF-3-4 Unit-1960-1987-AC-Any	3.1	2.9	2.1	93.9	--	55.4	1.3	8.4	11.4	0.8
MF-5-20 Unit-1960-1987-AC-Any	2.6	1.1	1.1	125.9	--	51.8	2.1	11.6	15.7	2.5
MF-Over 20 Unit-1960-1987-AC-Any	1.9	2.6	1.4	118.0	--	65.0	2.0	10.2	13.8	2.0
MF-3-4 Unit-1960-1987-No AC-Any	2.1	--	2.0	135.9	--	100.5	2.5	11.9	16.1	2.9
MF-5-20 Unit-1960-1987-No AC-Any	1.7	0.5	4.7	106.3	--	60.6	1.3	10.8	14.6	1.3
MF-Over 20 Unit-1960-1987-No AC-Any	0.7	--	0.4	88.4	--	78.9	1.1	9.0	12.2	0.0
MF-3-4 Unit-Post-1987-AC-Any	1.0	--	0.4	103.8	--	16.0	1.6	8.4	11.4	1.8
MF-5-20 Unit-Post-1987-AC-Any	3.4	1.0	0.3	79.0	--	63.3	1.3	7.6	10.3	2.0
MF-Over 20 Unit-Post-1987-AC-Any	0.8	0.3	0.3	93.4	--	62.9	1.5	8.8	11.9	1.1
MF-3-4 Unit-Post-1987-No AC-Any	0.8	1.0	0.8	87.5	--	147.2	1.5	8.3	11.3	0.0
MF-5-20 Unit-Post-1987-No AC-Any	0.7	0.3	1.1	87.1	--	63.1	1.5	8.8	11.9	1.2
MF-Over 20 Unit-Post-1987-No AC-Any	0.5	0.0	0.1	86.8	--	97.1	1.1	8.3	11.2	1.1

⁴ Gas-Other” includes the following use types from the ResStock Models: gas fireplaces and gas (natural gas) grills.

Key Takeaways

Here are some preliminary key takeaways that will inform the broader Electrification Funding Study and strategies with CPAU multi-family residential customers.

- The largest portion of multi-family residential utility customers fall under the 1960 to 1987 building vintage segment (49%), with the next largest portion under the pre-1960 vintage segment (37%). The portion of customers under the post-1987 vintage segment is significantly smaller (14%)
- For multifamily residential buildings with air conditioning, the primary cooling equipment type found in the NREL models is packaged DX systems (including packaged-terminal air conditioning, PTAC).
- Surprisingly, the NREL models show a high prevalence of electric resistance space heating, be that electric baseboard heating or electric resistance coils in packaged HVAC units. We intend to validate this later against data collected from field evaluations of multi-family residential sites conducted under this study.
- Space heating via air-source heat pump systems appears in the models, most prevalently in post-1987 vintage buildings, but also in 1960 to 1987 vintage buildings.
- Gas storage water heating systems are the most prevalent (40 to 73%), but there is also a significant amount of electric-resistance storage water heating systems (14 to 52%). Ranges depend on building vintage. We intend to validate this later against data collected from field evaluations of multi-family residential sites conducted under this study.
- Per customer gas usage for specific technologies resulting from the NREL models appears extremely low for multi-family residential buildings. We intend to validate this later against data collected from field evaluations of multi-family residential sites conducted under this study.

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:
Site B

Willdan Primary Contact:
Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:
December 3, 2024

Electrification Opportunity Summary

Multi-family Condominium Property with 19 individual dwelling units

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(2) 100-gallon Gas-fired Storage Water Heaters, 199 kBtu/h each	Heat Pump Water Heater System	\$90k to \$160k	27 metric tons CO ₂ e
HVAC	(11) Ducted Split System Heat Pumps (upgraded units)	System already electric	N/A	N/A
HVAC	(8) Electric Baseboard Radiator Heating Systems (non-upgraded units)	System already electric. Additional energy efficiency savings can be gained through the installation of ducted split system heat pumps	\$20k to \$24k per unit	N/A
Kitchen	(19) Electric Ranges (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1k to \$1.5k each unit	N/A
Washers	(19) Electric washers (1 per unit)	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Dryers	(19) Electric Dryers (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of ventless combination heat pump washer/dryers	\$1.5k to \$2.5k each unit	N/A
Pool Heater	(1) Swimming Pool Heater (266 kBTU/hr)	Heat Pump Pool Water Heater System	\$65k to \$95k	22 metric tons CO2e
Electrical Infrastructure	<p>(19) 90-Amp panels for individual units. House Panel is 125-Amps.</p> <p>Each unit has an electrical vehicle charger fed by their individual unit panels, but charger capacity is limited by the panel capacities. Chargers are on circuit sharing devices with other unit loads</p>	<p>This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 400 Amps.</p> <p>CPAU transformer on property likely needs to be upgraded to provide additional capacity. Occupants also may want to enhance vehicle charging capacity which adds capacity considerations</p> <p>Confirm upstream transformer capacity with CPAU</p>	\$150k to \$225k	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				49 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearerebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.
- California Department of Community Services and Development Low-Income Weatherization Program (LIWP): <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Typical Project Milestones



- **PLANNING** – Decide what opportunities will be pursued, and in what order of prioritization
- **TECHNICAL ASSESSMENT**- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- **FUNDING IDENTIFICATION** – Secure funding for the projects and apply for any available rebates
- **PROCUREMENT**- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- **IMPLEMENTATION** – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- **REVIEW THIS OPPORTUNITY SUMMARY** – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- **START THE PLANNING PROCESS** – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:

Site D

Willdan Primary Contact:

Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:

November 19, 2024

Electrification Opportunity Summary

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(4) 100-gallon Storage Gas Water Heaters	Heat Pump Water Heater Systems	\$240k to \$320k	48 metric tons CO2e
HVAC	One 65 kBtu/h gas furnace for each dwelling unit	Ducted split system heat pumps	\$20k to \$24k Each Unit	80 metric tons CO2e
Kitchen	One gas range for each dwelling unit	Electric Induction Ranges	\$1k to \$1.5K Each unit	5 metric tons CO2e
Washers	(5) Electric Vended Washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A
Dryers	(5) Gas Vended Dryers	Electric Vended Dryers	\$14k to \$17k	3 metric tons CO2e
Pool Heaters	Pool exists but is decommissioned and will be removed	N/A	N/A	N/A
Electrical Infrastructure	Each unit has 100 Amp Service plus (4) 100 Amp House Meters	This site will likely require the installation of new house services to feed electrified water heating systems and dryers. Preliminary estimate of total combined capacity needed is	\$51k to \$61k	Supports emissions avoidance shown above

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
		<p>approximately 400 Amps.</p> <p>If furnaces and kitchen ranges in individual units are electrified, individual unit panels may need to be upgraded. Preliminary estimate of additional capacity needed is 50 Amps per unit.</p> <p>Electric dryers will need new 240V receptacles</p> <p>Specific electrical design parameters will need to be determined by engineers.</p> <p>Confirm upstream transformer capacity with CPAU.</p>		
Total Annual Emissions Reduction Potential Identified				136 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

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- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
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- FUNDING IDENTIFICATION – Secure funding for the projects and apply for any available rebates
- PROCUREMENT- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- IMPLEMENTATION – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

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- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:
Site G

Willdan Primary Contact:
Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:
December 2, 2024

Electrification Opportunity Summary

Multi-family Property with 42 individual dwelling units

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(1) Water Heating Boiler with Attached Storage	Heat Pump Water Heater System	\$90k to \$120k	35 metric tons CO2e
HVAC	(42) Split Heat Pumps	System already electric	N/A	N/A
Kitchen	(42) Electric Ranges (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1k to \$1.5k each unit	N/A
Washers	(42) Electric stacked washer/dryers (1 per unit)	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above Additional energy efficiency savings can be gained through the installation of ventless combination heat pump washer/dryers	\$1.5k to \$2.5k each unit	N/A

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Washers	(1) Commercial Electric Washer	System already electric. Washer consumes hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A
Dryers	(1) Commercial Gas Dryer	(1) Commercial Electric Dryer	\$8k to \$10k	1 metric ton CO2e
Pool Heater	(1) Swimming Pool Heater (199 kBTU/hr)	Heat Pump Pool Water Heater System	\$65k to \$95k	67 metric tons CO2e
Electrical Infrastructure	Main service is 1,200 Amps.	<p>This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 250 Amps.</p> <p>Commercial electric dryer will likely require installation of a new 240V outlet.</p> <p>If all electrification options are pursued, a main service upgrade may be required. Confirm upstream transformer capacity with CPAU</p>	\$10k to \$25k	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				103 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearerebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.
- California Department of Community Services and Development Low-Income Weatherization Program (LIWP): <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Typical Project Milestones



- **PLANNING** – Decide what opportunities will be pursued, and in what order of prioritization
- **TECHNICAL ASSESSMENT**- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- **FUNDING IDENTIFICATION** – Secure funding for the projects and apply for any available rebates
- **PROCUREMENT**- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- **IMPLEMENTATION** – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- **REVIEW THIS OPPORTUNITY SUMMARY** – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- **START THE PLANNING PROCESS** – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:

Site A

Willdan Primary Contact:

Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:

November 19, 2024

Electrification Opportunity Summary

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(4) 75-gallon Storage Water Heaters	Heat Pump Water Heater System	\$120k to \$140k	45 metric tons CO2e
HVAC	Unable to collect info. Units occupied	Based on gas billing data it appears heating is already electrified	N/A	N/A
Kitchen	Unable to collect info. Units occupied	Based on gas billing data it appears heating is already electrified, assuming electric resistance ranges. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1k to \$1.5K Each unit	N/A
Washers	(2) Washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A
Dryers	(4) Dryers	System already electrified	N/A	N/A
Pool Heaters	(1) Pool Boiler	Heat Pump Pool Heating System. Units will need to be relocated outdoors	\$60k to \$95k	35 metric tons CO2e

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Electrical Infrastructure	Main service is 600 Amps.	<p>This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 250 Amps.</p> <p>If all electrification options are pursued, a main service upgrade may be required.</p> <p>Confirm upstream transformer capacity with CPAU.</p>	\$10k to \$25k	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				80 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearrebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.
- California Department of Community Services and Development Low-Income Weatherization Program (LIWP): <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Typical Project Milestones



- PLANNING – Decide what opportunities will be pursued, and in what order of prioritization
- TECHNICAL ASSESSMENT- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- FUNDING IDENTIFICATION – Secure funding for the projects and apply for any available rebates
- PROCUREMENT- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- IMPLEMENTATION – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- REVIEW THIS OPPORTUNITY SUMMARY – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- START THE PLANNING PROCESS – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:
Site C

Willdan Primary Contact:
Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:
November 6, 2024

Electrification Opportunity Summary

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(4) 100-gallon Storage Water Heaters	Heat Pump Water Heater System	\$340k to \$380k	215 metric tons CO2e
HVAC	(2) 999.9 kBTU/hr Natural Gas Boilers	Heat Pump Boiler System	\$250k to \$480k	215 metric tons CO2e
HVAC	(5) Split Heat Pumps	System already electric	N/A	N/A
Commercial Kitchen	(1) Commercial Gas Range (1) Double Range Gas Oven	(1) 10-Burner Commercial Electric Induction Range (1) Electric Commercial Convection Oven Double Deck	\$60K to 90K	11 metric tons CO2e
Kitchen	Electric Ranges (one per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1k to \$1.5k each unit	N/A
Washers	(4) 14-lb washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A
Dryers	(4) Electric Dryers	System already electrified	N/A	N/A

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Electrical Infrastructure	Main service is 2,000 Amps.	<p>This site will likely require the installation of new electrical subpanels to feed electrified water heating and HVAC boiler systems. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 1,200 to 1,500 Amps.</p> <p>If all electrification options are pursued, a main service upgrade may be required.</p> <p>Confirm upstream transformer capacity with CPAU.</p>	\$70k to \$140k	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				441 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearerebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.

Typical Project Milestones



- PLANNING – Decide what opportunities will be pursued, and in what order of prioritization
- TECHNICAL ASSESSMENT- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- FUNDING IDENTIFICATION – Secure funding for the projects and apply for any available rebates
- PROCUREMENT- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- IMPLEMENTATION – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- REVIEW THIS OPPORTUNITY SUMMARY – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- START THE PLANNING PROCESS – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:
Site D

Willdan Primary Contact:
Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:
November 19, 2024

Electrification Opportunity Summary

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	300 kBtu/h Boiler with Remote Storage	Heat Pump Water Heater System	\$120k to \$160k	21 metric tons CO2e
HVAC	One 45 kBtu/h gas furnace for each standard dwelling unit	Ducted split system heat pumps	\$20k to \$24k Each Unit	140 metric tons CO2e
HVAC	(2) Ducted Split System Heat Pumps for management units	System is already electrified	N/A	N/A
Kitchen	One gas range for each dwelling unit	Electric Induction Ranges	\$1k to \$1.5K Each unit	9 metric tons CO2e
Washers/Dryers	(10) Vended Stacked Combination Gas Washer/Dryers	Vended Stacked Combination Electric Washer/Dryers Washers consume hot water. Additional opportunity comes from replacing gas water heaters with electric heat pumps as shown above	\$43k to \$52k	5 metric tons CO2e
Dryers	(1) Gas Vended Dryers	Electric Vended Dryer	\$3k to \$4k	1 metric ton CO2e

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Electrical Infrastructure	Each unit has 100 Amp Service plus 100 Amp House Meters. Total combined Main Service is estimated to be 2,400 Amps or greater.	<p>This site will likely require the installation of additional house service capacity to feed electrified water heating systems and dryers. Preliminary estimate of total combined capacity needed is approximately 400 to 600 Amps.</p> <p>If furnaces and kitchen ranges in individual units are electrified, individual unit panels may need to be upgraded. Preliminary estimate of additional capacity needed is 50 Amps per unit.</p> <p>Electric dryers will need new 240V receptacles</p> <p>Specific electrical design parameters will need to be determined by engineers.</p> <p>Confirm upstream transformer capacity with CPAU.</p>	\$88k to \$106k	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				177 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearrebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.
- California Department of Community Services and Development Low-Income Weatherization Program (LIWP): <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Typical Project Milestones



- **PLANNING** – Decide what opportunities will be pursued, and in what order of prioritization
- **TECHNICAL ASSESSMENT**- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- **FUNDING IDENTIFICATION** – Secure funding for the projects and apply for any available rebates
- **PROCUREMENT**- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- **IMPLEMENTATION** – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- **REVIEW THIS OPPORTUNITY SUMMARY** – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- **START THE PLANNING PROCESS** – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

City of Palo Alto Utilities Electrification Survey Report

Presented on behalf of City of Palo Alto Utilities (CPAU)



Presented to:
Site F

Willdan Primary Contact:
Lance Kincaid
Willdan Energy Solutions
lkincaid@willdan.com

Date:
November 18, 2024

Electrification Opportunity Summary

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Water Heating	(2) Water Heating Boilers with Remote Storage Tanks Augmented with solar hot water heating system	Heat Pump Water Heater System Recommend incorporating existing solar hot water augmentation into the electrified design	\$150k to \$180k	61 metric tons CO ₂ e
HVAC	(3) Cooling Only Split System Units	System already electrified	N/A	N/A
HVAC	(53) Ducted Split System Heat Pumps	System already electrified	N/A	N/A
Kitchen	(1) Refrigerator, (1) Electric range for each dwelling unit	System is already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1k to \$1.5k each unit	N/A
Washers	(5) Vended Electric Washers	Opportunity comes from electrification of the water heating system described above, which supplies the washers	N/A	N/A

Equipment Type	List of Equipment	Electrification Opportunity	Installation Price Range	Annual GHG Emissions Avoided*
Dryers	(6) Vended Gas Dryers	Vended electric dryers	\$17k to \$20k	5 metric tons CO2e
Electrical Infrastructure	Main service is 600 Amps. Multiple spare circuits are available at the main panel.	<p>This site may require the installation of new electrical subpanels to feed the electrified water heating system.</p> <p>Electric dryers will require new 240V receptacles.</p> <p>Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is estimated to be about 600 amps.</p> <p>If all electrification projects are pursued, a main electrical service upgrade may be required. Confirm upstream transformer capacity with CPAU.</p>	<p>\$20k to \$25k for subpanels and 240V receptacles</p> <p>\$64k to \$77k for new main service upgrade</p>	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified				66 metric tons CO2e

*For ongoing operational savings assumptions, please see section below on typical utility bill impacts.

Available Electrification Project Support

- Your participation in this CPAU survey will assist the development of new, future electrification support programs. Keep an eye on the CPAU electrification landing page for existing and future programs: <https://www.cityofpaloalto.org/Departments/Utilities/Sustainability/Electrification>
- Food Service Technology Center - <https://frontierfstc.com/resources/>
- California Energy Wise Foodservice - Instant Rebates <https://caenergywise.com/instant-rebates/>
- High-Efficiency Electric Home Rebate Act (HEEHRA) Federal Rebates for income-qualifying multifamily electrification, provided through TECH Clean California: <https://techcleanca.com/incentives/heehearrebates/>. Please note that participation in this program requires compliance with CA Department of Industrial Relations Prevailing Wage and Public Works Requirements. Using prevailing wages may add 15% to 25% to representative project costs shown above.
- California Department of Community Services and Development Low-Income Weatherization Program (LIWP): <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Typical Project Milestones



- **PLANNING** – Decide what opportunities will be pursued, and in what order of prioritization
- **TECHNICAL ASSESSMENT**- Engage contractors and engineers (for more complicated projects such as large HVAC systems or complex water heating systems) to determine the technical parameters of the electrification solutions
- **FUNDING IDENTIFICATION** – Secure funding for the projects and apply for any available rebates
- **PROCUREMENT**- Identify a qualified contractor and purchase materials. For larger projects you may want to compare multiple bids.
- **IMPLEMENTATION** – Obtain applicable permits and manage the construction of the projects. For larger projects, some customers may wish to hire a dedicated construction manager.

Next Steps

- **REVIEW THIS OPPORTUNITY SUMMARY** – Discuss the electrification opportunities with key decision-makers and other relevant stakeholders, such as your local utility representatives.
- **START THE PLANNING PROCESS** – see typical project milestones above.

Typical Utility Bill Impacts

- The following examples provide comparisons of the utility bill impacts customers would see with typical gas-fired equipment and their electrified equivalents. For these typical scenarios, customers would be close to break-even or even see savings on their utility bills after upgrading to the electrified systems.
- Typical CPAU Energy Rates: Natural Gas = \$2.50 per therm; Electricity = \$0.22 per kWh¹
- Typical Service Water Heating Example: Average Daily Hot Water Usage = 240 gallons, at 70° F Rise²

Standard Gas Fired Water Heater	Electrified Heat Pump Water Heater
<p>Typical Gas Water Heater Thermal Efficiency = 81%</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 81% x 30 days per month x 1 therm per 100,000 Btu = 52 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Water Heating = 52 therms per month x \$2.50 per therm = \$130 per month</p>	<p>Typical Heat Pump Water Heater Uniform Energy Factor (UEF) = 3.0</p> <p>Estimated Monthly Gas Use = 240 gallons per day x 70° F x 8.34 lbs per gallon x 1 Btu per ° F-lb ÷ 3.0 x 30 days per month x 0.00293 kWh per Btu = 411 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 411 kWh per month x \$0.22 per kWh = \$90 per month</p>

- Typical HVAC Space Heating Example: Average Monthly Heating Load = 18,000,000 Btu³

Standard Rooftop Unit (RTU) or Furnace with Gas-Fired Heating	Electrified Heat Pump RTU or Furnace
<p>Typical Gas-Fired HVAC Unit Thermal Efficiency = 82%</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu per month ÷ 82% x 1 therm per 100,000 Btu = 220 therms per month</p> <p>Typical Monthly Charge for Gas-Fired Space Heating = 220 therms per month x \$2.50 per therm = \$550 per month</p>	<p>Typical Heat Pump HVAC Unit Heating Seasonal Performance Factor (HSPF) = 8.0 Btu/W-hr</p> <p>Estimated Monthly Gas Use = 18,000,000 Btu ÷ 8.0 Btu/W-hr x 1 kWh/1,000 W-hr = 2,250 kWh per month</p> <p>Typical Monthly Charge for Heat Pump Water Heating = 2,250 kWh per month x \$0.22 per kWh = \$495 per month</p>

¹ <https://www.cityofpaloalto.org/Departments/Utilities/Customer-Service/Utilities-Rates/Business-Rates>

² Typical medium-sized business customer water heating load, 75-gallon storage water heater example

³ Typical small to medium-sized business customer, single HVAC unit load, 60,000 Btu capacity heating unit example

Attachment C.6 – Basic HVAC and Water Heating Technology Descriptions

This attachment provides basic descriptions and typical images of common HVAC equipment types described in the Sector Study Report.

Electric-Cooling-Split System

A split system is an HVAC setup with separate indoor and outdoor units. The outdoor unit handles heat exchange, while the indoor unit distributes air. They're connected by refrigerant lines. These units may also be configured to provide heat in the winter (heat pump space heating). The indoor unit may be mounted directly to a wall of a space, or may hidden away inside a furnace/air handler.



Electric-Cooling-Packaged DX / Gas-Space Heating-Packaged Unit

A packaged HVAC unit with gas heat combines all components—cooling and heating—into one outdoor unit. It uses a gas furnace for heating and a standard “direct exchange” (DX) air conditioning compressor for cooling. Direct exchange refers to the refrigerant directly exchanging heat with the airflow, rather than through another medium (typically chilled water, as with central cooling plants). These systems are often installed on rooftops or beside buildings.

**Electric-Cooling-Packaged Heat Pump (HP) / Electric-Space Heating-Air Source Heat Pump (ASHP)**

A packaged HVAC heat pump is similar to a packaged HVAC DX unit with gas heat, except it forgoes the use of gas and instead uses the heat pump for both cooling and heating. Externally, they look very similar to packaged units with gas heat, except there is no natural gas connection nor is there a flue to vent combustion exhaust.



Image Credit: Carrier Corporation

Electric-Cooling-Variable Refrigerant Flow (VRF)

Variable refrigerant flow (VRF) cooling systems are a type of split-system, but rather than one outdoor unit connecting to one indoor unit, each individual outdoor unit serves multiple indoor units in different cooling zones. Special controls within the VRF system allow the system to provide different levels of cooling based on each cooling zone's need. These systems also may provide space heating (via heat pump heating).



Electric-Cooling-Water Cooled (WC) Chiller and -Air Cooled (AC) Chiller

Chillers are devices that consume electricity and generate chilled water. Water-cooled chillers reject heat from the chilled water to a separate condenser water loop that then must in turn reject that heat to the atmosphere (typically through a cooling tower). Air-cooled chillers reject heat from the chilled water to the atmosphere directly. Chilled water produced by these chillers is sent around to building air handling units to cool down ventilation air for the spaces being served.



Electric-Space Heating-Electric Resistance

Electric resistance space heating runs electricity directly through a resistive element which heats up air for space heating purposes. This can be found in electric resistance baseboard units or radiators, but also sometime within electric resistance furnaces.



Gas-Space Heating-Furnace

A gas furnace burns gas to heat up air for space heating purposes. It typically has a fan that pushes the air into the conditioned space, but some very old units rely only on the warm air rising into the space (gravity furnaces). Furnaces may be located in mechanical closets, basements, or on the roof of a building.



Gas-Space Heating-Boiler and Gas-Water Heating-Boilers

Similar to how chillers generate chilled water for space cooling, boilers burn gas to create heating hot water for space heating purposes. The heating hot water is typically pumped around the building to radiators or heating coils located in air handlers or fan coil units. Sometimes, boilers may be used to generate domestic hot water, but this is rare and normally only found in very large or old buildings.

**Gas-Water Heating-Storage Water Heater**

A gas storage water heater heats water using natural gas and stores it in an insulated tank, for domestic water uses.



Electric Water Heating-Electric Resistance Water Heater

An electric storage water heater uses electric heating elements to warm water stored in an insulated tank, for domestic water uses.



Electric-Water Heating-Tankless and Gas-Water Heating-Tankless

A tankless water heater heats water on demand without storing it in a tank, for domestic water uses.. It provides continuous hot water and is more energy-efficient than storage models. These units are compact and ideal for saving space. Tankless water heaters may use gas to heat the water, or electric resistance elements.



Electric-Water Heating-Heat Pump Water Heater

Electric heat pump water heaters (HPWHs) are storage-type water heaters, that primarily use heat pumps to heat water for domestic purposes. These HPWHs are usually equipped with backup electric resistance elements which are only used when the heat pump can keep up with short periods of high demand, or if the ambient conditions become too cold for the heat pump to operate efficiently and effectively.



Attachment C – Primary Data Files

Attachment C.2 – ArcGIS Map Images

Exhibit C.2.1.1. – HVAC Equipment: Locations

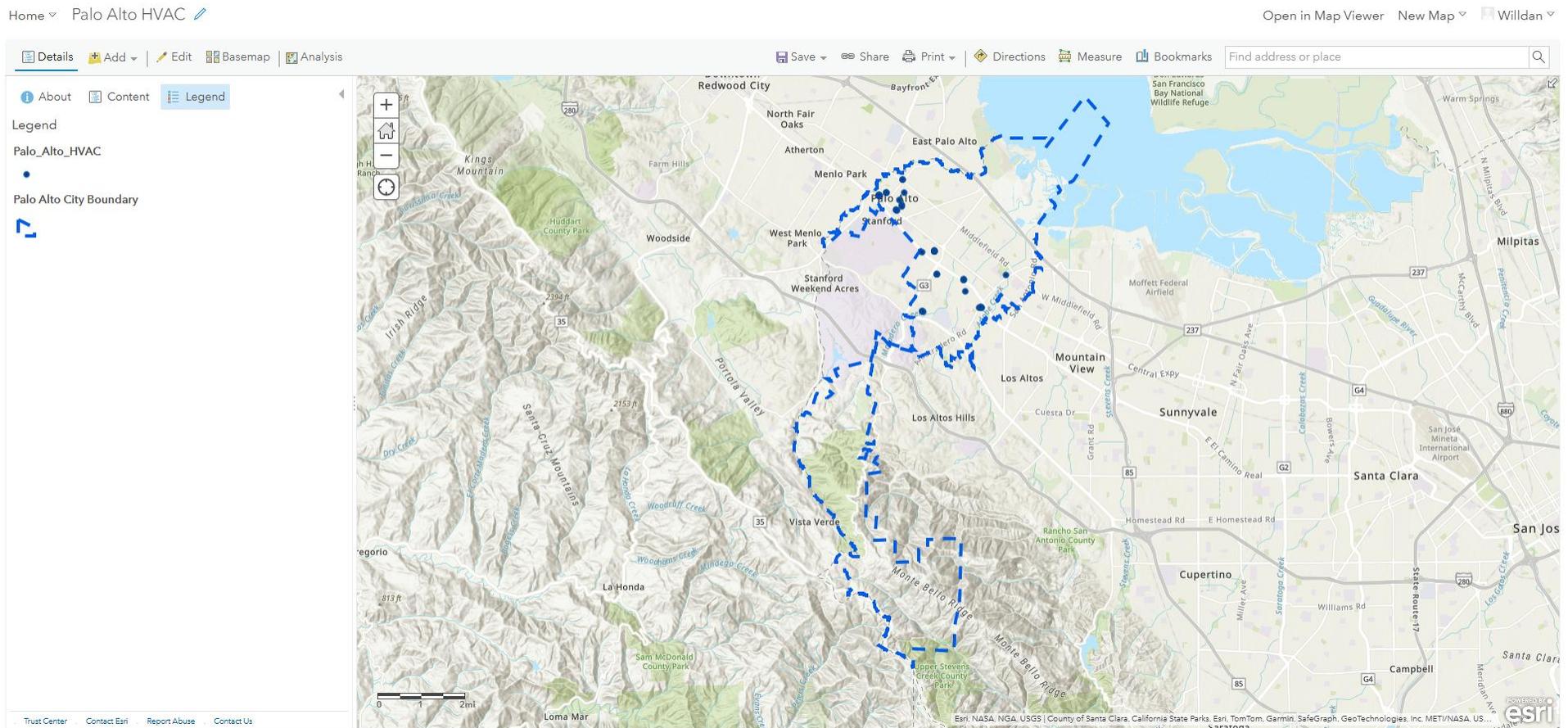


Exhibit C.2.1.2. – HVAC Equipment: Details

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Palo Alto HVAC (Features: 14, Selected: 0)									
Heating or Cooling	HVAC Equipment	HVAC Manufacturer	Other HVAC Manufacturer	Cooling Capacity - Tons	Cooling Capacity - kBTU/hr	Heating Capacity - BTU/hr	Model Number	Thermal Efficiency	Serial Number
Both	Split System	Mitsubishi		0-10	20+	20,000-40,000	MXZ-3C30NA3		
Both	Packaged Unit	Carrier		0-10	15-20				
Both	Split System			0-10	20+	10,000-20,000	MUY-GE24NA		2003409T
Both	Split System		Daikin	0-10	20+	20,000-40,000	RXB24BXVJU		-
Both	Split System	Mitsubishi		0-10	20+	20,000-40,000	MXZ-3C24NA2		8YU30845A
Both	Split System	LG			8-10	5,000-10,000	LSU092HE		-
Both	Split System		Fujitsu		20+		AOU24RLXFZ		LUN097018
Both	Split System	LG		0-10	10-15	10,000-20,000	LSU122HE		-
Both	Split System		Daikin		15-20	20,000-40,000	2MXS18GVJU		E001197
Both	Split System	Bryant		0-10			105ana024a		2917e21301
Heating	Furnace	Bryant				40,000-60,000	Na		Na
Heating	Furnace	Bryant				60,000-80,000	801sb36070m14		3623a20595
Heating	Boiler	Other	Laars			>80,000	Ntv1000nxx1		G 16 362709
Both	Split System	Carrier					See photo		See photo

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City of Palo Alto Electrification Funding Study

2

Exhibit C.2.2.1 – Water Heating Equipment: Locations

Home ▾ Palo Alto Water Heating

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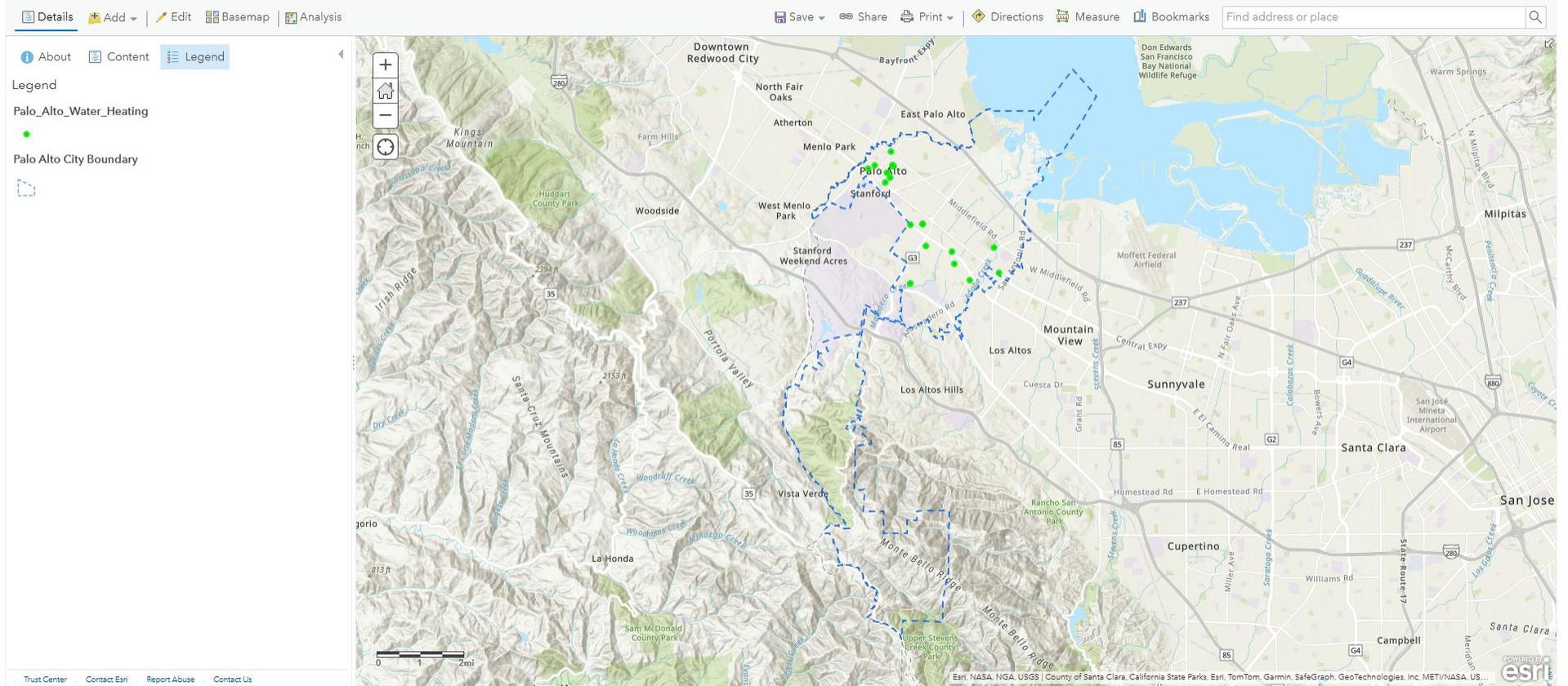


Exhibit C.2.2.2. - Water Heating Equipment: Details

Home ▾ Palo Alto Water Heating 

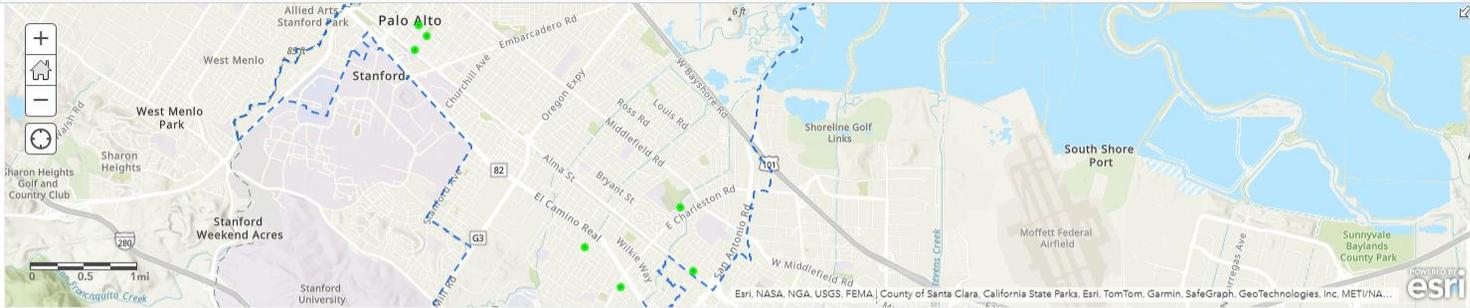
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Palo Alto Water Heating (Features: 7, Selected: 0)

Heater Type	Other Heater Type	Fuel Type	Manufacturer	Other Manufacturer	Capacity - Gallons	Model Number	Gas Input - kBtu per hr	Electric Input: kW	Recovery Rate
Boiler		Natural Gas		Laars	121+	MT2V 300	101-250		
Boiler		Natural Gas	Bradford White	Laars mark	121+	MT2V	251-500		
Storage Water Heater		Natural Gas	Rheem		91-100	Gnu100-200	101-250		200-300 Gal/hr
Storage Water Heater		Natural Gas	Bradford White		71-80	Urg275h6n	76-90		
Boiler		Natural Gas	Bradford White	Laars mark	121+	Ntv399n3	251-500		
Storage Water Heater		Natural Gas	Bradford White		91-100	Ef100t300e3n2	251-500		
Storage Water Heater		Natural Gas	AO Smith	Bradford white	91-100	See photos	101-250		

Exhibit C.2.3.1 - Kitchen Equipment: Locations

Home ▾ Palo Alto Kitchen Equipment ✎

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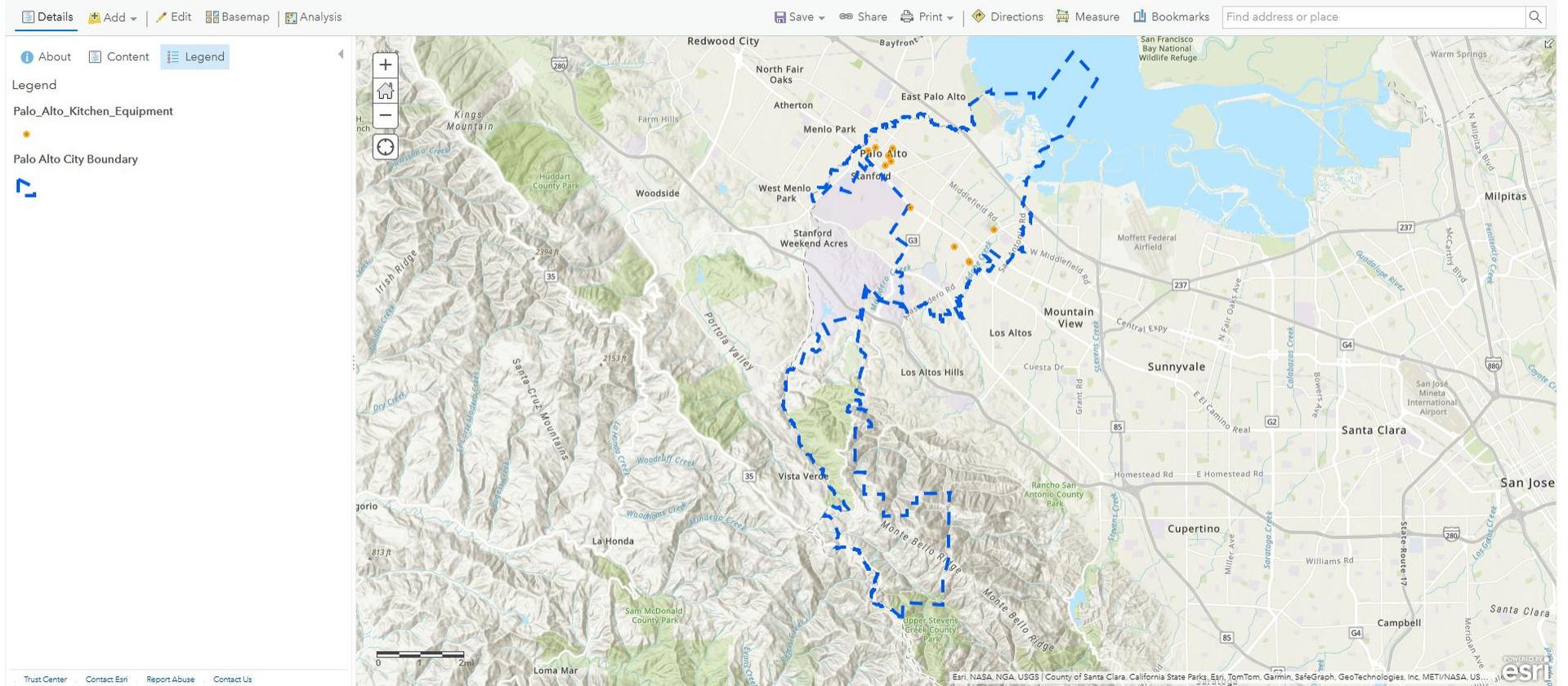


Exhibit C.2.3.2. - Kitchen Equipment: Details

Home ▾ Palo Alto Kitchen Equipment ✎

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Palo Alto Kitchen Equipment (Features: 7, Selected: 0)

Type	Other Type	Fuel Type	Brand	Other Brand	Model Number	Comments 1	Comments 2	Comments 3	Site Name
Stove		Electric	Other	GE	JB645RK4SS				Site G
Stove		Electric	Other	GE	JB645RK6SS				Site G
Stove		Gas	Other	Frigidaire	Fcrg3052asc				Site D
Stove		Gas	Other	General Electric	Jgs760sp5ss				Site E
Stove		Electric	Other	General Electric	J bs15 m1ww				Site F
Stove		Electric	Other	Hotpoint					Site C
Stove		Electric				All units have electric only			Site B

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Exhibit C.2.4.1 - Laundry Equipment: Locations

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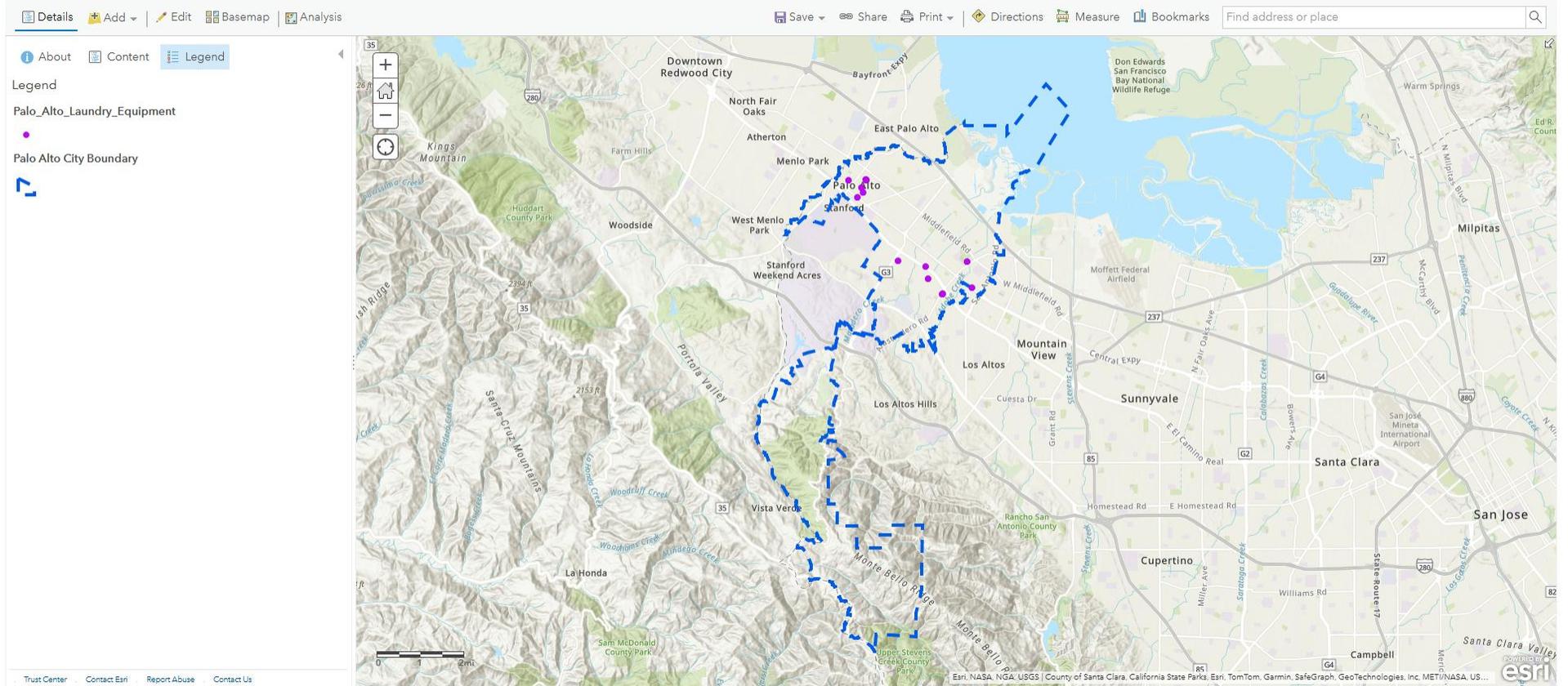


Exhibit C.2.4.2. - Laundry Equipment: Details

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Palo Alto Laundry Equipment (Features: 18, Selected: 0)												
Laundry Equipment	Laundry Brand	Other Laundry Brand	Model Number	Comments 1	Comments 2	Comments 3	Site Name	Address	Land Use	Laundry Equipment Capacity	Dryer Fuel Type	Equipment
Dryer	LG		Dlex2459x				Site B		Multifamily - Apartments	5-7.5 cu. ft.	Natural Gas	1
Front Loading Washer	LG		Wm2450hra				Site B		Multifamily - Apartments	2.5-5 cu. ft.		1
Dryer		SpeedQueen	SSGNYFGSS116TW01				Site F		Multifamily - Apartments		Natural Gas	6
Top Loading Washer		Speed Queen	S				Site F		Multifamily - Apartments		Natural Gas	5
Top Loading Washer		Maytag	MAT20PDAWW0				Site G		Multifamily - Apartments		N/A	
Dryer	Other	Maytag	MDG20PDAWW0				Site G		Multifamily - Apartments		Natural Gas	1
	GE		GUD24ESSM1WW	Washer/Dryer Combo in 42 Units	Double checked model and changed dryer fuel to gas [k]		Site G		Multifamily - Apartments		Electric	1
Front Loading Washer	Other	Maytag	Mlg22pravv1	Combo washers / dryers			Site D		Multifamily - Apartments		Natural Gas	10
Dryer	Other	Speed queen	Sdgbcrs111tv07				Site D		Multifamily - Apartments		Natural Gas	1
Top Loading Washer	Other	Speed queen	Svnnx2sp115tv01				Site E		Multifamily - Apartments		Natural Gas	5
Dryer	Other	Speed queen	Sdgnxrgs116tv01				Site E		Multifamily - Apartments			5
Top Loading Washer	Other	Speed queen	Svlt20vn	2 "laundry / common water heater" rooms			Site A		Multifamily - Apartments			2
Dryer	Other	Speed queen	Sdey07vf	2 similar laundry rooms. 4 dryers total			Site A		Multifamily - Apartments		Electric	4
Top Loading Washer	Other	Speed queen	Svnn2hp115tv01				Site C		Multifamily - Apartments			1
Front Loading Washer	Other	Speed queen	Sfnrcsp115tv02	8 total washers on site			Site C		Multifamily - Apartments			1
Dryer	Other	Speed queen	Sdenxrgs173tv02	4 similar laundry rooms. These numbers are for each laundry room.	8 Total Dryers on site		Site C		Multifamily - Apartments		Electric	2
Dryer	Samsung			Each unit (19) has in unit laundry					Multifamily - Condominiums		Electric	10
Top Loading Washer	Samsung			Each unit has in unit laundry (19)			Site B		Multifamily - Condominiums			10

Exhibit C.2.5.1 - Pool Equipment: Locations

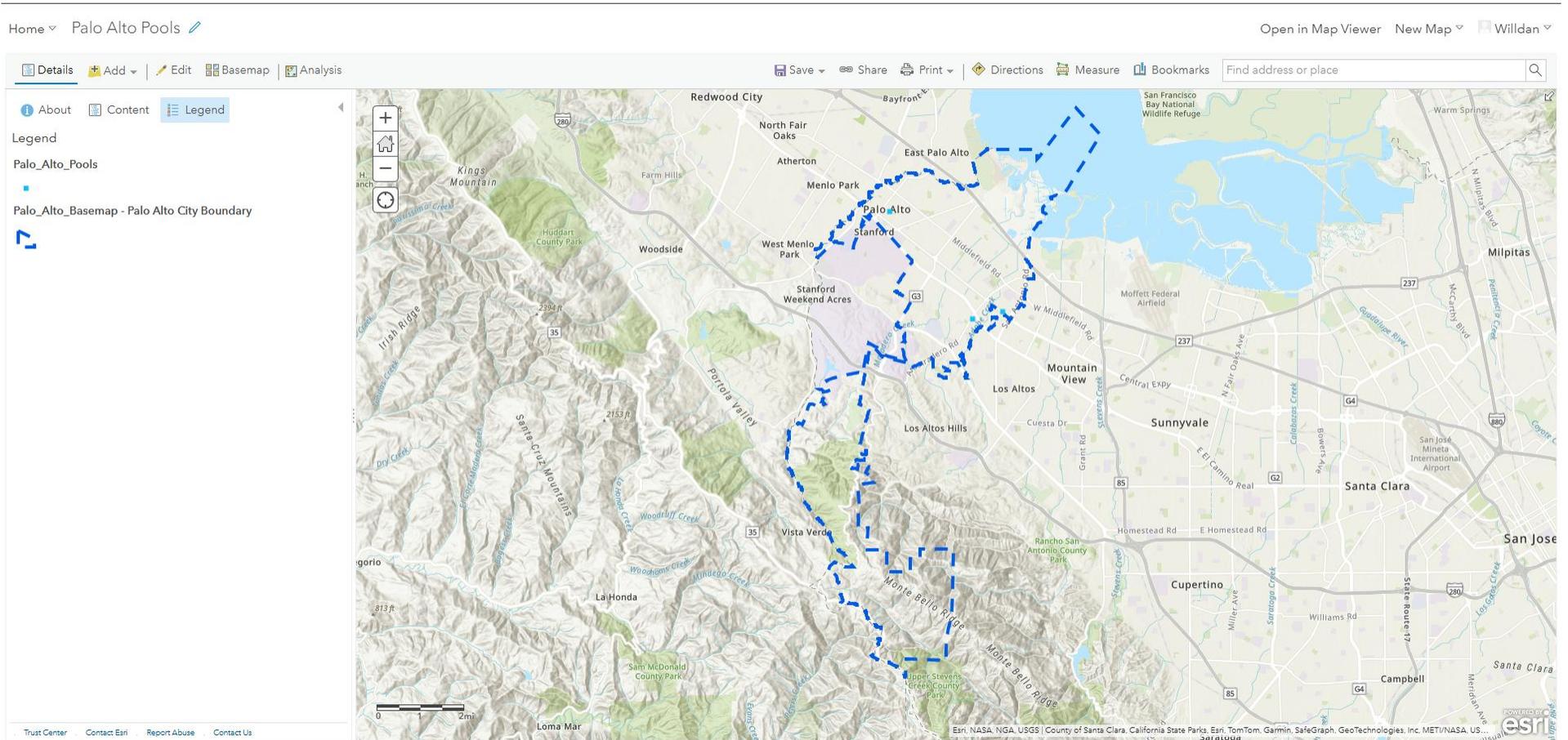


Exhibit C.2.5.2. - Pool Equipment: Details

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Palo Alto Pools (Features: 3, Selected: 0)

Land Use	Pool Equipment	Pool Equipment Brand	Other Pool Equipment Brand	Pool Equipment Capacity	Pool Equipment Fuel Type	Model Number	Condensing or Non-Condensing?	Comments 1	Comments 2
Multifamily - Apartments	Pool Heater	Raypac		250 to 500 kBTU/h	Gas	C-R406A-EN-C ASME		Site G	
Multifamily - Apartments	Pool Heater	Raypac		250 to 500 kBTU/h	Gas	C-r266a-en-c asme	Non-Condensing	Site A	
Multifamily - Condominiums	Pool Heater	Raypac		250 to 500 kBTU/h	Gas	See photo	Non-Condensing	Site B	Space outside available for heat pumps

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Exhibit C.2.6.1 – Electrical Infrastructure and General Site: Locations

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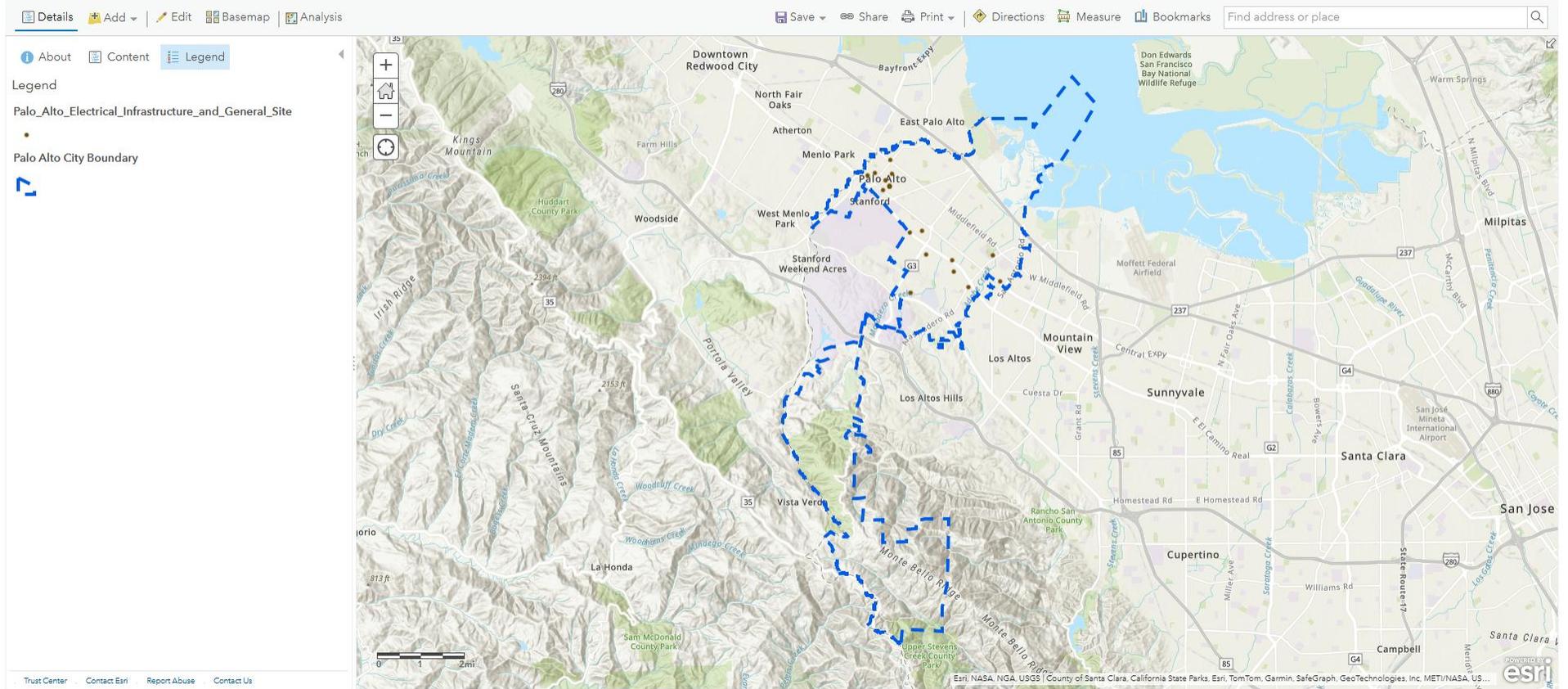


Exhibit C.2.6.2. - Electrical Infrastructure and General Site: Details

Home ▾ Palo Alto Electrical Infrastructure and General Site

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Palo Alto Electrical Infrastructure and General Site (Features: 9, Selected: 0)									
Main Switchboard Volts	Main Switchboard Amps	Main Switchboard Breaker Slots Available	Sub Panels Observed	Avg Sub Panel Breaker Slots Available	Comments 1	Comments 2	Comments 3	Land Use	Main Switchboard Brand
			1	10 to 50% Available Breakers				Multifamily - Apartments	
208	600 or above	0 to 10% Available Breakers	1	0 to 10% Available Breakers				Multifamily - Apartments	Square D
208	400 to 600		1	10 to 50% Available Breakers	Affordable multi family housing. Meeting with Adam and Manuel (site maintenance)			Multifamily - Apartments	Square D
208	600 or above		2	10 to 50% Available Breakers				Multifamily - Condominiums	Square D
120	100 or below							Multifamily - Apartments	Other
120	100 to 150	10 to 50% Available Breakers	1		1 panel next to each water heater plus sub panel plus individual unit meters	Affordable		Multifamily - Apartments	
120	600 or above		2	10 to 50% Available Breakers	120 /240 volt panels			Multifamily - Apartments	Other
208	600 or above	> 50% Available Breakers			Stevenson House			Multifamily - Apartments	Zinsco
208	600 or above	0 to 10% Available Breakers			Ev Chargers are limited to 24 v because each unit only has 90 Amps			Multifamily - Condominiums	Other

Exhibit C.2.7.1 – Plug Loads and Other Equipment: Locations

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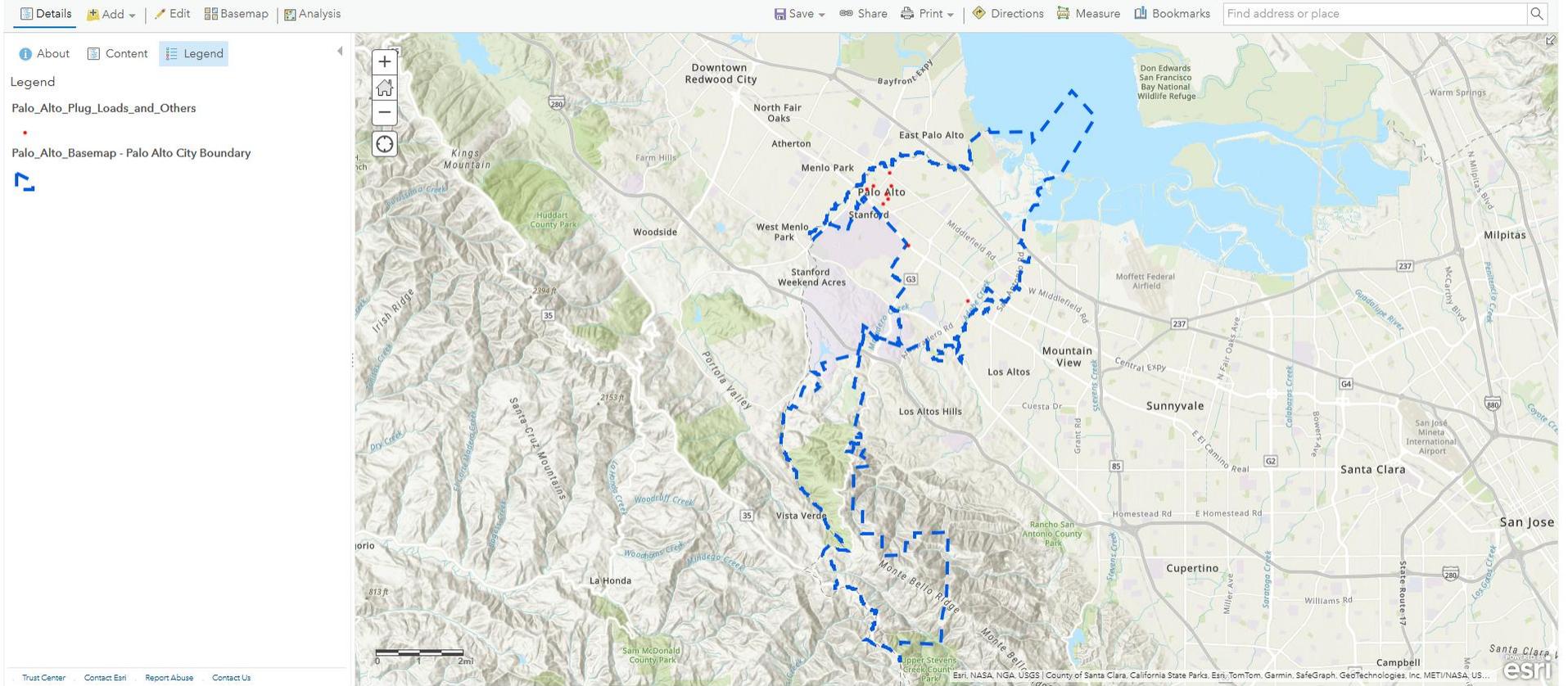


Exhibit C.2.7.2. - Plug Loads and Other Equipment: Details

Home ▾ Palo Alto Plug Loads and Others ✎

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Palo Alto Plug Loads and Others (Features: 4, Selected: 0)

LEDs Percent Coverage	Standard Consumer Appliances?	EV Charger Quantity	EV Charger Level	Solar Panels Existing	Comments 1	Comments 2	Comments 3	EV Charging Station Manufacturer	Other EV Charging Station Manufacturer
60-70									
40-50	Average	1-3	Level 2	No	2 EV Chargers			ChargePoint	
		15+	Level 2	No				Other	Evocharge

Attachment C.3 ArcGIS Field Data Collected

Water Heater Equipment

Site Name	Land Use	Heater Type	Fuel Type	Manufacturer	Other Manufacturer	Capacity - Gallons
Site G	Multifamily - Apartments	Boiler	Natural Gas		Laars	121+
Site D	Multifamily - Apartments	Boiler	Natural Gas	Bradford White	Laars mark	121+
Site E	Multifamily - Apartments	Storage Water Heater	Natural Gas	Rheem		91-100
Site A	Multifamily - Apartments	Storage Water Heater	Natural Gas	Bradford White		71-80
Site F	Multifamily - Apartments	Boiler	Natural Gas	Bradford White	Laars mark	121+
Site C	Multifamily - Apartments	Storage Water Heater	Natural Gas	Bradford White		91-100
	Multifamily - Condominiums	Storage Water Heater	Natural Gas	AO Smith	Bradford white	91-100

Water Heater Equipment Continuation

Site Name	Model Number	Gas Input - kBTU per hr	Electric Input: kW	Recovery Rate	Thermal Efficiency	Recirculation Pump Present?	Recirculation Pump Controls	Quantity	Serial Number
Site G	MT2V 300	101-250						1	-
Site D	MT2V	251-500				Yes	Uncontrolled	2	C20304451
Site E	Gnu100-200	101-250		200-300 Gal/hr		Yes	Uncontrolled	4	A331914310
Site A	Urg275h6n	76-90				Yes	Uncontrolled	4	Xj48595914
Site F	Ntv399n3	251-500				Yes		2	G12 245023
Site C	Ef100t300e3n2	251-500				Yes	Aquastat	2	Yk50442035
	See photos	101-250				Yes	Uncontrolled	2	See photos

Water Heater Equipment Continuation

Site Name	Panel Location	Distance to Panel (ft)	Location	Age
Site G			Mechanical Room - First Floor	7
Site D	Adjacent Room	20		compliance doc date 2020
Site E				4 years old
Site A				3 Years
Site F				12 year old
Site C	Multiple Floors Down		Rooftop	
	Same Room	20 feet		

HVAC Equipment

Site Name	Land Use	Heating or Cooling	HVAC Equipment	HVAC Manufacturer	Other HVAC Manufacturer	Age
Site B	Multifamily - Apartments	Both	Split System	Mitsubishi		2023
Site F	Multifamily - Apartments	Both	Packaged Unit	Carrier		
Site F	Multifamily - Apartments	Both	Split System			
Site G	Multifamily - Apartments	Both	Split System		Daikin	1
Site G	Multifamily - Apartments	Both	Split System	Mitsubishi		
Site G	Multifamily - Apartments	Both	Split System	LG		
Site G	Multifamily - Apartments	Both	Split System		Fujitsu	
Site G	Multifamily - Apartments	Both	Split System	LG		
Site G	Multifamily - Apartments	Both	Split System		Daikin	2009
Site D	Multifamily - Apartments	Both	Split System	Bryant		
Site D	Multifamily - Apartments	Heating	Furnace	Bryant		
Site E	Multifamily - Apartments	Heating	Furnace	Bryant		1 year
Site C	Multifamily - Apartments	Heating	Boiler	Other	Laars	
	Multifamily - Condominiums	Both	Split System	Carrier		

HVAC Equipment Continuation

Site Name	Cooling Capacity - Tons	Cooling Capacity - kBTU/hr	Heating Capacity - BTU/hr	Model Number
Site B	0-10	20+	20,000-40,000	MXZ-3C30NA3
Site F	0-10	15-20		
Site F	0-10	20+	10,000-20,000	MUY-GE24NA
Site G	0-10	20+	20,000-40,000	RXB24BXVJU
Site G	0-10	20+	20,000-40,000	MXZ-3C24NA2
Site G		8-10	5,000-10,000	LSU092HE
Site G		20+		AOU24RLXFZ
Site G	0-10	10-15	10,000-20,000	LSU122HE
Site G		15-20	20,000-40,000	2MXS18GVJU
Site D	0-10			105ana024a
Site D			40,000-60,000	Na
Site E			60,000-80,000	801sb36070m14
Site C			>80,000+	Ntv1000nxx1
				See photo

HVAC Equipment Continuation

Site Name	Serial Number	Panel Location	Distance to Panel: ft	Location	System Control
Site B					
Site F					
Site F	2003409T				
Site G	-				Smart Thermostat
Site G	8YU30845A				Smart Thermostat
Site G	-				Smart Thermostat
Site G	LUN097018			In unit	Smart Thermostat
Site G	-				
Site G	E001197			In unit	Smart Thermostat
Site D	2917e21301				
Site D	Na				
Site E	3623a20595	One Floor Down	20 feet		
Site C	G 16 362709			Rooftop	
	See photo	Same Floor	20 ft	In unit	Smart Thermostat

Electrical Infrastructure

Site Name	Land Use	Main Switchboard Brand	Main Switchboard Volts	Main Switchboard Amps	Main Switchboard Breaker Slots Available
Site F	Multifamily - Apartments				
Site G	Multifamily - Apartments	Square D	208	600 or above	0 to 10% Available Breakers
Site D	Multifamily - Apartments	Square D	208	400 to 600	
Site D	Multifamily - Condominiums	Square D	208	600 or above	
Site D	Multifamily - Apartments	Other	120	100 or below	
Site E	Multifamily - Apartments		120	100 to 150	10 to 50% Available Breakers
Site A	Multifamily - Apartments	Other	120	600 or above	
Site C	Multifamily - Apartments	Zinsco	208	600 or above	> 50% Available Breakers
	Multifamily - Condominiums	Other	208	600 or above	0 to 10% Available Breakers

Electrical Infrastructure Continuation

Site Name	Sub Panels Observed	Avg Sub Panel Breaker Slots Available
Site F	1	10 to 50% Available Breakers
Site G	1	0 to 10% Available Breakers
Site D	1	10 to 50% Available Breakers
Site D	2	10 to 50% Available Breakers
Site D		
Site E	1	
Site A	2	10 to 50% Available Breakers
Site C		

Laundry Equipment

Site Name	Land Use	Laundry Equipment	Laundry Brand	Other Laundry Brand	Laundry Equipment Capacity	Dryer Fuel Type	Model Number	Equipment Quantity
Site B	Multifamily - Apartments	Dryer	LG		5-7.5 cu. ft.	Natural Gas	Dlex2459x	1
Site B	Multifamily - Apartments	Front Loading Washer	LG		2.5-5 cu. ft.		Wm2450hra	1
Site F	Multifamily - Apartments	Dryer		SpeedQueen		Natural Gas	SSGNYFGSS116TW01	6
Site F	Multifamily - Apartments	Top Loading Washer		Speed Queen		Natural Gas	S	5
Site G	Multifamily - Apartments	Top Loading Washer		Maytag		N/A	MAT20PDAWW0	
Site G	Multifamily - Apartments	Dryer	Other	Maytag		Natural Gas	MDG20PDAWW0	1
Site G	Multifamily - Apartments		GE			Natural Gas	GUD24ESSM1WW	1
Site D	Multifamily - Apartments	Front Loading Washer	Other	Maytag		Natural Gas	Mlg22praww1	10
Site D	Multifamily - Apartments	Dryer	Other	Speed queen		Natural Gas	Sdgbcrgs111tw07	1
Site E	Multifamily - Apartments	Top Loading Washer	Other	Speed queen		Natural Gas	Swnnx2sp116tw01	5
Site E	Multifamily - Apartments	Dryer	Other	Speed queen			Sdgnxrgs116tw01	5
Site A	Multifamily - Apartments	Top Loading Washer	Other	Speed queen			Swlt20wn	2
Site A	Multifamily - Apartments	Dryer	Other	Speed queen		Electric	Sdey07wf	4
Site C	Multifamily - Apartments	Top Loading Washer	Other	Speed queen			Swnc2hp115tw01	1
Site C	Multifamily - Apartments	Front Loading Washer	Other	Speed queen			Sfnncrsp115tw02	1
Site C	Multifamily - Apartments	Dryer	Other	Speed queen		Electric	Sdenxrgs173tw02	2
	Multifamily - Condominiums	Dryer	Samsung			Electric		10
	Multifamily - Condominiums	Top Loading Washer	Samsung					10

Kitchen Equipment

Site Name	Land Use	Type	Fuel Type	Brand	Other Brand	Model Number
Site G	Multifamily - Apartments	Stove	Electric	Other	GE	JB645RK4SS
Site G	Multifamily - Apartments	Stove	Electric	Other	GE	JB645RK6SS
Site D	Multifamily - Apartments	Stove	Gas	Other	Frigidaire	Fcrg3052asc
Site E	Multifamily - Apartments	Stove	Gas	Other	General Electric	Jgs760sp5ss
Site F	Multifamily - Apartments	Stove	Electric	Other	General Electric	J bs15 m1ww
Site C	Multifamily - Apartments	Stove	Electric	Other	Hotpoint	
	Multifamily - Condominiums	Stove	Electric			

Plug Loads

Site Name	Land Use	LEDs Percent Coverage	Standard Consumer Appliances?	EV Charger Quantity	EV Charger Level	EV Charging Station Manufacturer
Site F	Multifamily - Apartments	60-70				
Site G	Multifamily - Apartments	40-50	Average	1-3	Level 2	ChargePoint
Site G	Multifamily - Apartments					
	Multifamily - Condominiums			15+	Level 2	Other

Plug Loads Continuation

Site Name	Estimated Parking Count	Private Parking?	Open Parking?	Restricted Charging?	Is Charging Free?	Charger Capacity
Site F						
Site G	51-100 spaces	Yes	No, assigned parking	No	No, paid through app	0-7 kW
Site G						
	21-50 spaces	Yes	No, assigned parking	Yes, only for residents/employees	No, paid through rent/utilities	

Plug Loads Continuation

Site Name	Solar Panels Existing	Battery Energy Storage System Present?
Site F		
Site G	No	No
Site G		
	No	

Pool Heating Equipment

Site Name	Land Use	Pool Equipment	Pool Equipment Brand	Pool Equipment Capacity	Pool Equipment Fuel Type	Model Number	Condensing or Non Condensing?
Site G	Multifamily - Apartments	Pool Heater	Raypac	250 to 500 kBTU per hr	Gas	C-R406A-EN-C ASME	
Site A	Multifamily - Apartments	Pool Heater	Raypac	250 to 500 kBTU per hr	Gas	C-r266a-en-c asme	Non-Condensing
	Multifamily - Condominiums	Pool Heater	Raypac	250 to 500 kBTU per hr	Gas	See photo	Non-Condensing

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site A	Water Heating	4	75-gal Storage Water Heater	Heat Pump Water Heater System	\$120,000	\$140,000	45
	HVAC	N/A	Unable to collec info. Units occupied.	Based on gas billing data it appears heating is already electrified	N/A	N/A	N/A
	Kitchen	N/A	Unable to collec info. Units occupied.	Based on gas billing data it appears heating is already electrified, assuming electric resistance ranges. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1,000	\$1,500	N/A
	Washers	2	Wahser	Wahsers consume hot water. Opportunities come form replacing gas water heaters with electric heat pumps as shown above	N/A	N/A	N/A
	Dryers	4	Dryers	System already electrified	N/A	N/A	N/A
	Pool Heaters	1	Pool Boiler	Heat Pump Pool Heating System. Units will need to be relocated outdoors	\$60,000	\$95,000	35
	Electrical Infrastructure	N/A	Main Service is 600 Amps	This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 250 Amps. If all electrification options are pursued, a main service upgrade may be required. Confirm upstream transformer capacity with CPAU.	\$10,000	\$25,000	Supports emission avoidance shown above
Total Annual Emissions Reduction Potential Identified							80

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site B	Water Heating	2	100-gallon Gas-fired Storage Water Heaters, 199 kBTU/h each	Heat Pump Water Heater System	\$90,000	\$160,000	27
	HVAC	11	Ducted Split System Heat Pumps (upgraded units)	System already electric	N/A	N/A	N/A
	HVAC	8	Electric Baseboard Radiator Heating Systems (non-upgraded units)	System already electric. Additional energy efficiency savings can be gained through the installation of ducted split system heat pumps	\$20,000	\$24,000	N/A
	Kitchen	19	Electric Ranges (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1,000	\$1,500	N/A
	Washers	19	Electric washers (1 per unit)	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A	N/A
	Dryers	19	Electric Dryers (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of ventless combination heat pump washer/dryers	\$1,500	\$2,500	N/A
	Pool Heating	1	Swimming Pool Heater (266 kBTU/hr)	Heat Pump Pool Water Heater System	\$65,000	\$95,000	22
	Electrical Infrastructure	19	90-Amp panels for individual units. House Panel is 125-Amps. Each unit has an electrical vehicle charger fed by their individual unit panels, but charger capacity is limited by the panel capacities. Chargers are on circuit sharing devices with other unit loads	This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 400 Amps. CPAU transformer on property likely needs to be upgraded to provide additional capacity. Occupants also may want to enhance vehicle charging capacity which adds capacity considerations Confirm upstream transformer capacity with CPAU	\$150,000	\$225,000	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified							49

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site C	Water Heating	4	100-gallon Storage Water Heaters	Heat Pump Water Heater System	\$340,000	\$380,000	215
	HVAC	2	999.9 kBtu/hr Natural Gas Boilers	Heat Pump Boiler System	\$250,000	\$480,000	215
	HVAC	5	Split Heat Pumps	System already electrified	N/A	N/A	N/A
	Kitchen	2	(1) Commercial Gas Range (1) Double Range Gas Oven	(1) 10-Burner Commercial Electric Induction Range (1) Electric Commercial Convection Oven Double Deck	\$60,000	\$90,000	11
	Washers	4	14-lb washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A	N/A
	Dryers	4	14-lb Electric Dryers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	\$1,000	\$1,500	N/A
	Electrical Infrastructure	1	Main service is 2,000 Amps.	This site will likely require the installation of new electrical subpanels to feed electrified water heating and HVAC boiler systems. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 1,200 to 1,500 Amps. If all electrification options are pursued, a main service upgrade may be required. Confirm upstream transformer capacity with CPAU.	\$70,000	\$140,000	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified							441

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site D	Water Heating	1	300 kBtu/h Boiler with Remote Storage	Heat Pump Water Heater System	\$120,000	\$160,000	21
	HVAC	53	45 kBtu/h gas furnace for each standard dwelling unit	Ducted split system heat pumps	\$20,000	\$24,000	140
	HVAC	2	Ducted Split System Heat Pumps for management units	System already electrified	N/A	N/A	N/A
	Kitchen	53	Gas range for each dwelling unit	Electric Induction Ranges	\$1,000	\$1,500	9
	Washers	10	Vended Stacked Combination Gas Washer/Dryers	Vended Stacked Combination Electric Washer/Dryers Washers consume hot water. Additional opportunity comes from replacing gas water heaters with electric heat pumps as shown above	\$43,000	\$52,000	5
	Dryers	1	Vended Gas Dryers	Electric Vended Dryer	\$3,000	\$4,000	1
	Electrical Infrastructure	53	Each unit has 100 Amp Service plus 100 Amp House Meters. Total combined Main Service is estimated to be 2,400 Amps or greater.	This site will likely require the installation of additional house service capacity to feed electrified water heating systems and dryers. Preliminary estimate of total combined capacity needed is approximately 400 to 600 Amps. If furnaces and kitchen ranges in individual units are electrified, individual unit panels may need to be upgraded. Preliminary estimate of additional capacity needed is 50 Amps per unit. Electric dryers will need new 240V receptacles Specific electrical design parameters will need to be determined by engineers. Confirm upstream transformer capacity with CPAU.	\$88,000	\$106,000	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified							177

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site E	Water Heating	4	100-gallon Storage Gas Water Heaters	Heat Pump Water Heater Systems	\$240,000	\$320,000	48
	HVAC	33	One 65 kBtu/h gas furnace for each dwelling unit	Ducted split system heat pumps	\$20,000	\$24,000	80
	Kitchen	33	One gas range for each dwelling unit	Electric Induction Ranges	\$1,000	\$1,500	5
	Washers	5	(5) Electric Vended Washers	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A	N/A
	Dryers	5	(5) Gas Vended Dryers	Electric Vended Dryers	\$14,000	\$17,000	3
	Pool Heaters	1	Pool exists but is decommissioned and will be removed	N/A	N/A	N/A	N/A
	Electrical Infrastructure	N/A	Each unit has 100 Amp Service plus (4) 100 Amp House Meters	<p>This site will likely require the installation of new house services to feed electrified water heating systems and dryers. Preliminary estimate of total combined capacity needed is approximately 400 Amps.</p> <p>If furnaces and kitchen ranges in individual units are electrified, individual unit panels may need to be upgraded. Preliminary estimate of additional capacity needed is 50 Amps per unit.</p> <p>Electric dryers will need new 240V receptacles</p> <p>Specific electrical design parameters will need to be determined by engineers.</p> <p>Confirm upstream transformer capacity with CPAU.</p>	\$51,000	\$61,000	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified							136

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site F	Water Heating	2	Water Heating Boilers with Remote Storage Tanks Augmented with solar hot water heating system	Heat Pump Water Heater System Recommend incorporating existing solar hot water augmentation into the electrified design	\$150,000	\$180,000	61
	HVAC	3	Cooling Only Split System Units	System already electric	N/A	N/A	N/A
	HVAC	53	Ducted Split System Heat Pumps	System already electric	N/A	N/A	N/A
	Kitchen	53	(1) Refrigerator, (1) Electric range for each dwelling unit	System is already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1,000	\$1,500	N/A
	Washers	5	Vended Electric Washers	Opportunity comes from electrification of the water heating system described above, which supplies the washers	N/A	N/A	N/A
	Dryers	6	Vended Gas Dryers	Vended electric dryers	\$17,000	\$20,000	5
	Electrical Infrastructure	1	Main service is 600 Amps. Multiple spare circuits are available at the main panel.	<p>This site may require the installation of new electrical subpanels to feed the electrified water heating system.</p> <p>Electric dryers will require new 240V receptacles.</p> <p>Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is estimated to be about 600 amps.</p> <p>If all electrification projects are pursued, a main electrical service upgrade may be required. Confirm upstream transformer capacity with CPAU.</p>	\$84,000	\$102,000	Supports emissions avoidance shown above
Total Annual Emissions Reduction Potential Identified							66

Facility Name	Equipment Type	Quantity	List of Equipment	Electrification Opportunity	Installation Lower Ranges	Installation Upper Range	Annual GHG Emissions Avoided * (Metric Tons CO2e)
Site G	Water Heating	1	Water Heating Boiler with Attached Storage	Heat Pump Water Heater System	\$90,000	\$120,000	35
	HVAC	42	Split Heat Pumps	System already electric	N/A	N/A	N/A
	Kitchen	42	Electric Ranges (1 per unit)	System already electric. Additional energy efficiency savings can be gained through the installation of induction ranges	\$1,000	\$1,500	N/A
	Washers	42	Electric stacked washer/dryers (1 per unit)	Washers consume hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above Additional energy efficiency savings can be gained through the installation of ventless combination heat pump washer/dryers	\$1,500	\$2,500	N/A
	Washers	1	Commercial Electric Washer	System already electric. Washer consumes hot water. Opportunities come from replacing gas water heaters with electric heat pumps as shown above	N/A	N/A	N/A
	Dryers	1	Commercial Gas Dryer	Commercial Electric Dryer	\$8,000	\$10,000	1
	Pool Heater	1	Swimming Pool Heater (199 kBTU/hr)	Heat Pump Pool Water Heater System	\$65,000	\$95,000	67
	Electrical Infrastructure	N/A	Main service is 1,200 Amps	This site will likely require the installation of new electrical subpanels to feed electrified water heating systems and pool heat pumps. Specific electrical design parameters will need to be determined by engineers. Preliminary estimate of total combined subpanel capacity needed is 250 Amps. Commercial electric dryer will likely require installation of a new 240V outlet. If all electrification options are pursued, a main service upgrade may be required. Confirm upstream transformer capacity with CPAU	\$10,000	\$25,000	Supports emissions avoidance shown above
	Total Annual Emissions Reduction Potential Identified						