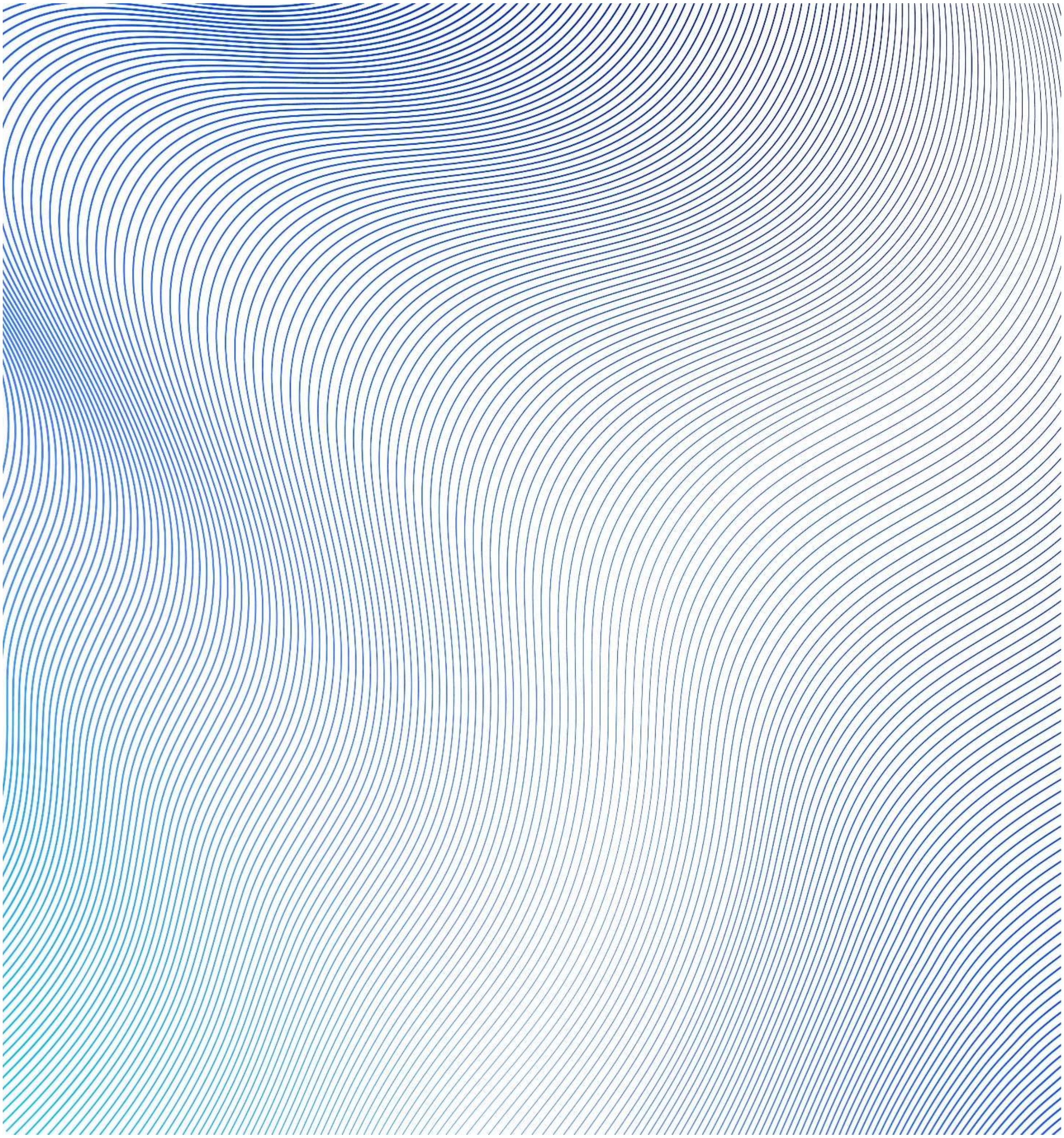
Heather Village HOA

ELECTRIFICATION FEASIBILITY STUDY

November 2023



Introba

Project Office
1111 Broadway, Suite 1450
Oakland, CA 94607

925 Fort Stockton Dr, Suite 201
San Diego, CA 92103

Project Contacts:

Noah Zallen

noah.zallen@introba.com

Tom Abram

tom.abram@introba.com

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Table of Contents

1 Executive Summary

Heather Village is a multi-family Homeowners Association (HOA) in Culver City, CA, built in 1970. The complex has aging infrastructure, a carbon neutrality goal, and desire for air conditioning to adapt to climate change. This study explores the feasibility of staged electrification to address these goals. This feasibility study was funded through the TECH Clean California's Quick Start Grant program. The focus is on developing concept level solutions to use heat pumps for domestic hot water and space heating while considering future load increases for full site electrification. The study also assessed the economic and carbon impacts of electrification. The results of the study reinforced the need to consider the full electrification journey while making short term decisions, especially due to electrical constraints within the units.

The existing electrical service is anticipated to be adequate to meet the increased electrical load. Our recommended approach limits the downstream electrical upgrades required. However, there will be some upgrades required, including increased the size of some electrical distribution panels and feeders.

For **domestic hot water**, the proposed solution relies on modular, CO2 based heat pumps and large storage tanks to reduce peak electrical demand. As a refrigerant, CO2 has a significantly lower global warming potential than other options.

For **space heating (and air conditioning),** the proposed solution is a variable refrigerant flow system. Central outdoor condensing units would serve individual fan coils within each housing unit. Compared to individual mini-split systems, this reduces the electrical load placed behind unit subpanels which would trigger significant electrical upgrades. This will require more involved coordination between residents but will limit outdoor equipment and electrical upgrades.

Pool and spa heaters would transition to air-source heat pumps. Central **clothes dryers** would be replaced with heat pump options. However, residents interested in in-unit washers and dryers should consider combination washer/dryers that use heat pump or condensing technology. Additional assessment would be required, especially in regards to the plumbing systems. Electrification of **cooking ranges** poses one of the larger challenges, due to the large current draw from most full-size induction ranges and limited electrical capacity of the units (typically three units share a 90A breaker). Energy storage enabled devices can avoid this but have higher upfront costs (which can be substantially reduced via incentives).

The lifecycle cost analysis indicates that deployment of heat pumps for domestic hot water and space heating at Heather Village has economic benefits to the residents, though incentives are an important element to making this economically feasible. Electrification of water heating and space heating is anticipated to reduce lifecycle costs by $2.1 million over the next 15 years, with an additional $0.5 million unlocked by enabling more on-site solar and storage. Full-site electrification is also anticipated to reduce costs over the 15 years.

The project will reduce in significant reduction in carbon emissions, especially due to Clean Power Alliance's 100% Green Power offering. Electrification of space heating and water heating is anticipated to reduce GHG emissions by 875 metric tons per year.

There were several challenges encountered, including aging infrastructure and urgent needs. However, the feasibility study identified a pathway for Heather Village to electrify domestic hot water and space heating by through efficient and economic heat pump deployment. Furthermore, this can be achieved while also enabling a pathway for full site electrification. Heather Village has the opportunity to be the model for multi-family HOA electrification across the state of California and beyond.

2 Overview

Heather Village is a multifamily Homeowners Association (HOA) community located in Culver City, California on a site of approximately 625,000 ft^2 and comprised of 404 residences. The complex was built in 1970 and has aging infrastructure, including failing central domestic hot water systems and natural gas distribution lines with a history of leaks. The HOA also has a goal to achieve carbon neutrality. The HOA was interested in exploring electrification projects, with a priority on the domestic hot water systems. Introba identified and helped secure a Quick Start Grant through the TECH Clean California program to assess the feasibility to electrify building systems, with an emphasis on using heat pumps for the domestic hot water and space heating systems. The study also considered loads from future electrification elements, including electric vehicle charging, clothes dryers, and cooking ranges.

The community is seeking to assess the feasibility of completely electrifying the existing residences' appliances, heating, and hot water systems, as well as providing the homeowners with a new cooling system – all while being able to separately monitor and bill heating and cooling consumption. and completely electrify the site, which currently relies on gas for space and water heating and appliances. With these goals in mind, Introba has prepared a detailed electrification study for Heather Village HOA that addresses scope items:

1. Feasibility and concept design for one to three central heat pump water heating systems to replace aging natural gas systems
2. Feasibility of replacing all remaining central water heating systems with heat pump water heating systems
3. Feasibility of replacing natural gas furnaces in units with heat pumps that will provide both heating and cooling for residents
4. Electrification strategy for water heating and space heating that considers the potential electrical load increases from remaining building electrification (pool and hot tub heating, cooking, and dryers) and electric vehicle charging
5. Economic and carbon analysis for these electrification scenarios, also considering the additional benefits of unlocking the ability to justify an increase on-site solar photovoltaic and energy storage capacity

Figure 1: Heather Village Satellite Image

The following sections will address the recommended improvements and their approach for the mechanical, electrical, and hot water systems, to achieve the project's goals in the most feasible and least disruptive manner for the residents of Heather Village.

3 Hot Water Systems

3.1 Overview of Existing Systems

Besides heating, ventilation, and air conditioning, heating water in multifamily buildings represents one of the most substantial energy loads when looking at overall energy consumption. This load is the energy required to heat the water and maintain its temperature throughout the building's distribution piping. There are currently 15 boilers on the property, 14 are paired together in seven rooftop locations with each pair serving an average of 56 units, while one is located in a boiler room and serves a laundry room along with 68 units. However, out the 15 boilers, 3 are currently not operational; these would be the highest-priority areas for immediate replacement. Many of the other units are also in poor condition. There is a significant amount of uninsulated piping and no central boiler controls, further contributing to the inefficiencies of the system. Solar thermal systems were installed many years ago but are no longer functional.

Figure 2: Existing Domestic Hot Water System

3.2 Hot Water System Groups

Heather Village is currently served by eight (8) separate hot water systems. These systems are named as follows, in the table below, which also indicates the location of the existing boiler system that serves the hot water group as well as the number of dwelling units served in the hot water group. These names come from the Heather Village documentation provided to Introba. The L stands for Laundry, and the number(s) indicate the group within the Heather Village complex.

Hot Water Group	Existing Boiler Location	# of Dwelling Units
L-1-2	1C (Basement of 6645)	72
L-3	6B (Roof of 6625)	49
L-4	3B (Roof of 6525)	61
L-5-6	**5A (Roof of 6415)**	**66**
L-7	3A (Roof of 6315)	36
L-8	**2A (Roof of 6305)**	**41**
L-9	7A (Roof of 6355)	43
L-10	**7C (Roof of 6375)**	**36**

Figure 3: Hot Water System Groups

3.3 Hot Water System Groups Distribution Map

Each hot water system serves its own set of buildings with distribution to every dwelling unit in those buildings. The map below shows the region boundaries (as dashed black lines) for the buildings served by each hot water system. At the most granular, each building is labeled in the background of the image using the 4-digit building number. Next in granularity, each structure has been annotated with its "Number-Letter" format name (1A, 7D, etc) that is used to describe buildings in the Heather Village site map and original as-built engineering drawings. For each hot water system the building that houses the current boilers is indicated by a black circle with white fill around that building label – for example, 1C is where the boilers are in Hot Water System L-1-2.

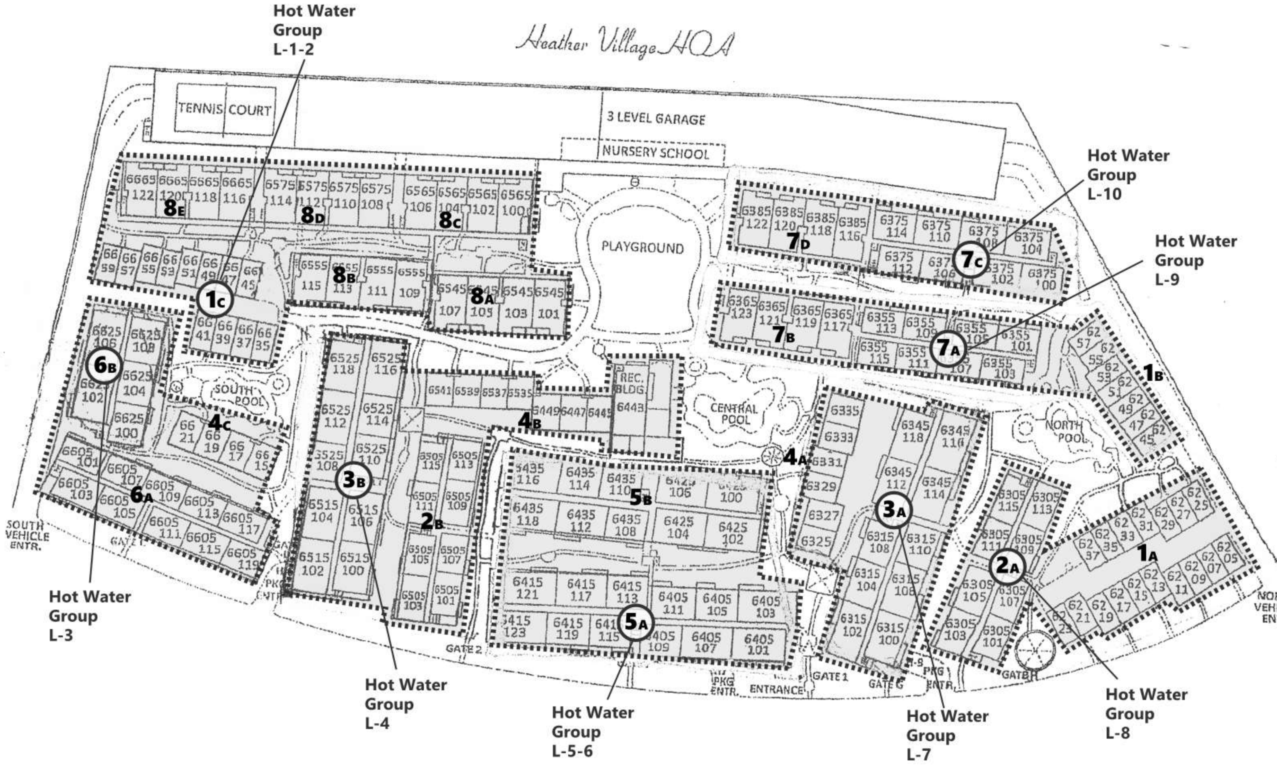

Figure 4: Hot Water Group Map

3.4 Hot Water Heater System Options

Traditional hot water delivery systems rely on high-capacity boilers to meet demand. In Heather's Village case, these are natural gas boilers. Oversizing these systems results in wasted energy. As we explored options for electrification of the hot water systems, we arrived upon the use of Heat Pump Water Heaters (HPWHs) for all water heating needs.

HPWHs use electricity to transfer heat energy from one source to domestic water, instead of generating heat directly as with electric water heaters. This is three to four times more efficient than conventional electric resistance water heater, and even more than that vs. a gas-fired boiler water heater. A stand-alone air-source HPWH pulls heat from the surrounding air and transfers it, at a higher temperature, to heat water in a storage tank. During periods of low use, the heat pumps produce more hot water than is being used. This excess hot water foes back into storage and, once this storage is fully recovered, the stored hot water is left on standby, ready for the cycle to repeat. As a result, utilizing properly sized HPWHs have the potential for significantly reduced energy use.

Being mindful of electrification, the projects' location, and global warming potential of the products we select, **we are proposing a type of Heat Pump Water Heater that uses CO2 (R-744) as the refrigerant, also known as a CO2 Heat Pump**, due to its ability to function in outdoors in any Heather Village weather (work above 0F), its low global warming potential (GWP of 1 compared to GWP of 2080 for R-410A), and its industry leading hot water generation efficiency (COP's of 4-5 compared with gas-fired COP's of ~0.8, meaning about 5 times less energy than a gas boiler).

While co2 heat pump water heaters have a higher initial cost than conventional electric resistance water heaters, they are comparable if not cheaper in cost versus other heat pump water heaters and they have much lower operating costs than any other option, which can offset higher purchase and installation costs, especially on a multifamily site where the hot water demand is very high. Additionally, solar PV electricity generated onsite can go towards further reducing heat pump electrical bills.

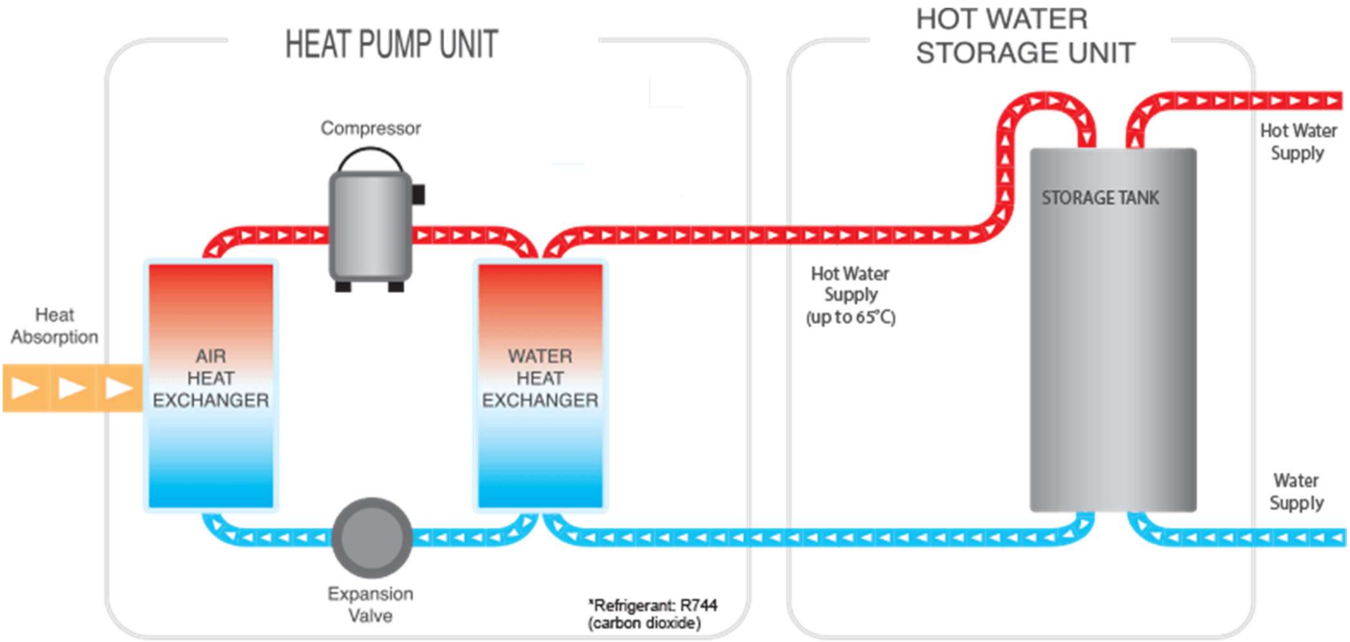

Figure 5: Diagram of CO2 Heat Pump Water Heater System

CO2 Heat Pump Products Explored

We explored three sizes of CO2 Heat Pump Water Heaters for Heather Village (large, medium, and small)

- Lync by Watt - For Large, we explored Lync by Watt CO2 Heat Pump. It's requirement for 460V service, which Heather Village Doesn't have, and it's overly large size of a single unit eliminated it as an option for Heather Village.
- Heat2O by Mitsubishi – For Medium we explored Heat20 by Mitsubishi, which uses 208V, but has a smallest unit size of 138.5 kbtuh, which is larger than the full system size needed for the largest hot water system group. It is required to have at least 2 heat pumps in the system, so one can operate if the other is being serviced. That means this option would force Heather Village to buy over 2x the heat pump it needs, which is cost prohibitive.
- **Sanden SanCO2** – For Small we explored SanCO2 by Sanden, which uses 208V, but has a unit size of 15.4 ktbuh, which is much more in range of Heather Village's needs. While this will require anywhere from 4 to 8 heat pumps per hot water system group (see subsequent sections), this is the most common product used in multifamily heat pump hot water heating at this time and is the recommendations of engineers and contractors alike. Redundancy is achieved much more economically as the number of SanCO2 is more than 2 for all systems by virtue of meeting the heating capacity.

Figure 6: SanCO2 Heat Pump Water Heating System

Prefabrication

One consideration is for a prefabricated package solution. We recommend exploring WaterDrop, a complete offsite fabricated skid solution that is an all-in-one CO2 heat pump central plant domestic hot water system. Sizing of heat pumps and storage amount is customizable and scalable to meet Heather Village’s needs. WaterDrop’s works with many local contractors and provides its own warranty and avenue for customer service regarding operation and controls. It is not a requirement to use WaterDrop, and a contractor might be able to provide better pricing on their own. Whatever avenue is chosen, it is recommended the WaterDrop option be explored again in future upgrades as WaterDrop plans to release a newer control product in 2024.

Figure 7: WaterDrop System

3.5 Hot Water System Sizing, Selection, and Schedules

To size the heat pump hot water systems, we utilized the Ecosizer tool in conjunction with inputs calibrated by ASHRAE and installed multifamily case studies with co2 heat pumps. Accordingly, we sized each scenario as follows, using each hot water system group's total number of dwelling units.

- Each dwelling unit will have a peak annual hot water consumption of 40 gal/day/dwelling-unit (accomplished via 2 people per dwelling unit each at a maximum of 20 gal/day/person)
- The hot water system will be large enough to allow for no heat pump operation during peak times (6am to 9am, and also 4pm to 9pm) for 90% of days in the year.
- 145F hot water storage temperature
- Swing tank utilized to maintain system temperature (sized to CA T24 requirements)

From the case study perspective, MDPI's "Field Measurement of Central CO2 Heat Pump Water Heater for Multifamily Retrofit", found that 25 gal/day/dwelling-unit was the 95th percentile consumption over the year. The maximum consumption in a single day for an entire year of measurement was 35 gal/day/dwelling-unit. Sizing to the 95th percentile is common practice, so to be conservative, we sized to the 100th percentile and still added another 5 gal/day/dwelling-unit to arrive at this 40 gal/day/dwelling unit maximum consumptions. Separately, ASHRAE Applications 2015 section 51.9 provides an estimate of a maximum daily consumption of 20 gal/day/person in an apartment building for the occupancy type and size of those in Heather village. Taken together, this informs the 40 gal/day/dwelling-unit maximum coupled with the 20 gal/day/person to achieve that total.

Because the hot water system sizing involves upsizing to be able handle the self-imposed handicap of not operating heat pumps during peak hours of the day, this ensures that if there are any days where the hot water demand does exceed this 40 gal/day/dwelling-unit consumption, the system can simply disregard the voluntary shutoff and operate all hours to ensure hot water is always sufficient. This extra capacity in heat pump and storage ensures a robust system that can save substantially amounts on electricity bills by avoiding peak load hours, provides redundancy in terms of if a heat pump should need servicing (with the additional amount of heat pump and storage), and results in an appropriately right sized system based on actual measured best practice for multifamily residential building hot water use to ensure money is not wasted on buying too much heat pump like is common practice with gas boilers.

The resulting new CO2 heat pump hot water system sizes are shown in the table below. The electrical information is provided in the next section.

Hot Water Group #	**# of Dwelling Units**	**Water Heater Model**	**# of Water Heater Units[1]**	**# of Storage Tanks[2]**	**Swing Tank Size**	**Total Heat Pump Heating Capacity**	**Total Storage Size**
L-1-2	68	Sanden SanCO2	(8)	(12)	288 gal	123 kBtuh	1,428 gal
L-3	53	Sanden SanCO2	(6)	(7)	288 gal	92 kBtuh	833 gal
L-4	61	Sanden SanCO2	(7)	(10)	288 gal	108 kBtuh	1,190 gal
L-5-6	66	Sanden SanCO2	(8)	(10)	288 gal	123 kBtuh	1,190 gal
L-7	36	Sanden SanCO2	(4)	(6)	168 gal	62 kBtuh	714 gal
L-8	41	Sanden SanCO2	(5)	(6)	168 gal	77 kBtuh	714 gal
L-9	43	Sanden SanCO2	(5)	(7)	168 gal	77 kBtuh	833 gal
L-10	36	Sanden SanCO2	(4)	(6)	168 gal	62 kBtuh	714 gal

Figure 8: HPWH Sizes by Hot Water Group

Notes:

1. Each Sanden SanCO2 heat pump has a 15.4kbtuh heating capacity accounting for defrost
2. Each Sanden Storage Tank is 119 gal capacity.

3.6 Hot Water System Electrical Information

The hot water system sizes shown in the section above have the following electrical requirements. This information is used in the Electrical Systems to assess electrical infrastructure impacts and any necessary upgrades. This section here serves to provide the electrical requirements for the hot water equipment, with the implications examined in the Electrical Systems section.

Hot Water Group #	# of Dwelling Units	# of Water Heater Units	Heat Pump Electric Requirements (Each) (V/Ph/MCA)	Swing Resistive Capacity	Total Electric Requirements (V/Ph/MCA)	Electrical Service (of Boiler Location)
L-1-2	68	(8)	208V, 1ϕ, 7.7A	12.6 kW	208V, 1ϕ, 70.6A	Service #1 (in 6B)
L-3	53	(6)	208V, 1ϕ, 7.7A	8.6 kW	208V, 1ϕ, 50.6A	Service #1 (in 6B)
L-4	61	(7)	208V, 1ϕ, 7.7A	10.7 kW	208V, 1ϕ, 60.9A	Service #2 (in 3B)
L-5-6	66	(8)	208V, 1ϕ, 7.7A	11.5 kW	208V, 1ϕ, 67.5A	Service #3 (in 5B)
L-7	36	(4)	208V, 1ϕ, 7.7A	6.3 kW	208V, 1ϕ, 35.3A	Service #4 (in 2A)
L-8	41	(5)	208V, 1ϕ, 7.7A	7.2 kW	208V, 1ϕ, 42.2A	Service #4 (in 2A)
L-9	43	(5)	208V, 1ϕ, 7.7A	7.5 kW	208V, 1ϕ, 43.1A	Service #5 (in 7D)
L-10	36	(4)	208V, 1ϕ, 7.7A	6.3 kW	208V, 1ϕ, 35.3A	Service #5 (in 7D)

Figure 9: HPWH Electrical Sizes by Hot Water Group

3.7 Next Steps

In order to move from strategy to implementation, the next step for Heather Village is to engage with a contractor to provide a bid on one hot water system group being replaced with a co2 heat pump system. It is recommended that this be for one of the hot water system groups that are currently operating with only one boiler, as the other is broken, such as L5-6. This step has already begun. The most critical step is to have the contractor provide their own supplied engineer of record drawings for both hot water and electrical to ensure that there is substantial agreement and no barriers to implementing this strategy. Thus far, the communications between contractor and Introba have shown substantial agreement on heat pump hot water system sizes and hot water approach.

The new heat pump hot water systems cannot be installed with the electrical existing distribution panels, as there is not any single panel that can carry the additional amperage for the new equipment. Heather Village has already begun reaching out to contractors about upgrading the electrical distribution panels with larger amperage, and there are additional considerations. See Section 5, Electrical Systems, for more information and discussion.

4 Mechanical Systems

The mechanical renovations involve the electrification of the existing space heating systems as well as the addition of space cooling while taking into consideration the different layouts of the residences. Currently, most residences have gas furnaces for space heating inside the apartments and either no space cooling at all or small window air conditioning units plugged into a 120V wall outlet. The intent of the mechanical study is to select a feasible, fully electrical, HVAC system that can provide heating and cooling with the least electrical impact on the site distribution and on the homeowner's residences. The following sections will review the different mechanical system options that were considered for the project, the proposed mechanical system benefits and considerations, and their electrical impact on the existing site distribution.

4.1 Mechanical System Options

Under the current parameters and restrictions, an air-source heat pump system offers an energy-efficient alternative to the existing furnaces and air conditioners. Air-source heat pumps can do both heating and cooling, making it a viable option to avoid installing separate cooling and heating systems. In cooler months, a heat pump pulls heat from the outdoor air and transfers it indoors, while on warmer months it pulls heat out of the indoor air to cool the home. They are composed of two main components, an indoor and an outdoor unit that are powered by electricity and transfer heat between each other using refrigerant pipes.

While the above description applies all heat pumps, there are multiple options available in terms installation and layout. Two heat pump options were deemed to be the most feasible for this project:

1. A one-to-one heat pump system, where each residence has one or more indoor units and their own outdoor mechanical unit.
2. A central heat pump system, where each residence has one or more indoor units and shares one or more outdoor mechanical units with other residences in the building.

Both options are common in multifamily housing complexes, function similarly, and are appropriate for the residences in Heather Village. However, there are differences in their installation, the number of units required, their electrical requirements, and the space requirements between both options that are relevant to our application and bring several advantages and disadvantage with them.

Starting with the largest components, a one-to-one air-source heat pump system, commonly known as a mini-split, requires us to provide one outdoor unit, like what's shown in Figure 1, for each residence.

Figure 10: Option 1 Air-Source Heat Pump Outdoor Units

In a one-to-one system, the placement of outdoor units is limited to a few places. It is preferable to place the outdoor unit as close to the indoor unit it is supplying due to limitations in refrigerant line lengths – Depending on the manufacturer and piece of equipment, the outdoor unit may only be so many feet away from the indoor unit. Additionally, because of the large number of outdoor units we would need (one per residence), we are limited in the number of locations. The roofs are not a reliable option, as many are sloped roofs and there is no assurance that the roofs would be structurally sound with the additional weights of so many outdoor units. The most feasible option is placing each outdoor unit in the balcony of the residence it supplies.

In a central heat pump system, approximately, as many as 24 indoor units could be connected to one outdoor unit depending on the manufacturer. While the outdoor units' footprints are larger and taller than those in a one-to-one system option, only as many as two to three would be required per building making this a more flexible option in terms of placement around the building due to the lower required footprint.

Figure 11: Central Heat Pump System Outdoor Units

In terms of indoor units, these come in many shapes and sizes for the two system options. The units fitted for our application, are wall-mounted and ceiling-concealed units as shown below in Figure 2.

Figure 12: Air-Source Heat Pump Indoor Unit Options

A wall-mounted unit as the name suggests, is mounted on a wall. While this is a very straightforward installation option, the unit is not only visible to the residents but also the space cooling is limited to the room the unit is in. This means that one unit is required per bedroom and living room which not only increases the cost, but also increases the number of units each resident needs to maintain. On the other hand, a ceiling concealed ducted unit, is concealed within the ceiling, but is more disruptive to the resident in terms of installation. Not only do we need space for the unit in the ceiling, but also for its ductwork distribution into every room. However, once the unit is installed, the resident's only concern is the maintenance of one unit, and the unit is well hidden into the ceiling.

4.2 Mechanical System Selection

Looking at the options discussed in the previous section, we selected a mechanical system based on parameters such as installation feasibility, total footprint required for installation, cost, and electrical requirements. While there is a lot of ground space to place mechanical units, most of these are visible from pathways and sidewalks around the buildings that are used by the residents daily. Having one outdoor unit per residence, becomes an overwhelming number to maintain and place for both the residents and the HOA, no matter their placement. A central heat pump system is much more beneficial for this application since we can decrease the number of outdoor units, the amount of maintenance by each of the residents, and the total area required for their installation.

Furthermore, one of the most important limitations of the site is the electrical service and the electrical panel size at each unit. Because we need approximately about one-ton of cooling per 2-bedroom unit and the smallest unit size for wall-mounted units is 0.75 tons, having one wall-mounted per residence would approximately provide us with 3 times the cooling we need. This would translate to increased electrical requirements. One unit per bedroom and living room would triple the electrical requirements and provide us with a lot more cooling than necessary. By using a ceiling-concealed ducted unit, which comes in as small as one-ton units, we are using exactly the cooling that is required as well as adding the lowest load possible to the existing electrical service. For units that already have ducted heating, the existing ductwork might be used as well.

With the previous points in mind, the most feasible option for Heather Village is the central VRF air-source heat pump system with one ducted ceiling concealed unit per residence. The limited electrical draw of the indoor ducted units allows them to be placed on the existing subpanels without an upgrade and the outdoor units can be placed on the soon-to-be upgraded distributions panels. However, individual split systems for each dwelling unit would require electrical upgrades between the distribution panels and the subpanels.

4.3 Mechanical System Layout

To visualize what a mechanical layout for a residence would look like and approximate mechanical unit quantities, we had to focus on one manufacturer since many aspects of the layout vary by manufacturer. These include but are not limited to the refrigerant line lengths, how many indoor units can be connected to an outdoor unit, and size of indoor and outdoor units. As a result, we have selected Daikin as the basis of design.

There are multiple ways to lay out the outdoor and indoor units and all of these are dependent in the building they are located and the layout of the apartment. However, we have developed a proposed typical layout that is feasible for most of the residences on site.

Each outdoor unit weights approximately 800 lbs. Because there is currently no information on the existing's roof bearing capacity, we recommend placing the outdoor units on the ground. These can be hidden by landscaping strategies or placed next to the building's electrical room. As previously mentioned, we calculated that each building would have anywhere between one to two outdoor units. The refrigerant piping can then run up to a mechanical controller located at every level, and from there distributed throughout the corridors to each apartment's indoor unit. Refer to Figure 7 for a visual representation of the refrigerant distribution from the mechanical outdoor unit to the indoor unit a very level.

Additionally, one the overall goals is to cause as little interruptions as possible to the overall look of the site and the residences. With this in mind, we sought to keep the refrigerant piping out of sight. From the outdoor unit, the refrigerant piping would follow a route of being tight to the walls and ceiling until connecting to the branch selector, which would ideally be located within the building's electrical room or a utility room at every level. From there, the refrigerant piping would enter each apartment at a point where it is feasible to lower the ceiling within the apartment. We have identified the bathroom ceilings for this. Refer to Figure 6 for a visual representation of the distribution at every level.

Even though the outdoor units still will require new dedicated space around the site, it is worth mentioning that there are multiple ways outdoor units can be hidden. Some options include using garden beds, sheds or lattice panels as shown on Figure 4. If the necessary minimum ventilation requirements are met for the mechanical units, these can be disguised as desired.

Figure 13: Mechanical Outdoor Unit Covers

The indoor units' layouts have more restrictions than the outdoor units due to the differences in every layout. We have chosen a typical two-bedroom layout, as this is the most common for the site, to portray what an approximate layout would look for the residences.

Structurally, in terms of installation, the ceiling is made up of beams located four feet off enter. The indoor units are approximately 28" by 26" in footprint and 8" in height. Because we can fit the units within four feet with enough clearance for maintenance, the intent is to locate each indoor unit within a beam pocket, ideally in a hallway within the apartment. Although the ceiling does not need to be lowered for the indoor mechanical unit, the ceiling height will be affected wherever the ductwork distribution takes place since the ductwork needs to be routed underneath the beams to avoid penetrating any of the existing structural beams. Therefore, we propose locating the indoor unit in the hallway, so that the ductwork distribution can also happen in the hallway, and we only need to peek into each bedroom and living room with a grille for supply.

Figure 14: Mechanical Indoor Unit Installation

The overall layout of both the indoor and outdoor mechanical units and their distribution is visually represented on the plan and section views shown in Figure 6 and 7 on the following pages.

PLAN VIEW

① Mechanical Outdoor Unit

VRF heat recovery unit which may be located at ground level adjacent to corresponding building or roof level depending on roof structural assessment.

② Mechanical Controller

VRF branch selector that directs refrigerant flow from the outdoor mechanical unit to the indoor fan coil unit. May be located indoors at the corridor or a building mechanical room. More than one may be needed for each building depending on load. Can connect up to 290 MBH of load.

③ Indoor Fan Coil Unit

VRF concealed ceiling ducted unit for conditioning. Approximately, (1) 1-ton unit is required for a 2-bedroom residence. This unit may be concealed within a soffit on the ceiling with ductwork distribution to the rest of the bedrooms and living room. Each fan coil unit will require. This may be the size of the footprint of the unit plus any required access clearance.

④ Supply Ductwork

Additional soffits may be required for supply ductwork routing dependant on each individual residence's layout.

⑤ Building Electrical Panel

All Mechanical Outdoor Units and Mechanical Controllers are to be connected to the existing building electrical panel.

⑥ Residence Electrical Panel

Each indoor fan coil unit is to be connected to the existing residence electrical panel it serves.

Figure 15: Mechanical Layout Plan View

① Mechanical Outdoor Unit

VRF heat recovery unit which may be located at ground level or roof level depending on roof structural assessment or ground level adjacent to corresponding building.

② Mechanical Controller

VRF branch selector that direct refrigerant flow from the outdoor mechanical unit to the indoor fan coil unit. May be located indoors at the corridor or a building mechanical room. More than one may be needed for each building depending on load. Can connect up to 290 MBH.

③ Indoor Fan Coil Unit

VRF concealed ceiling ducted unit for conditioning. Approximately, (1) 1-ton unit is required for each residence. This unit may be concealed within a soffit on the ceiling between two beams, therefore the ceiling only needs to be lowered for ductwork distribution to the rest of the bedrooms and living room. Each fan coil unit will require This may be the size of the footprint of the unit plus any required access clearance.

④ Ceiling Height

Each indoor fan coil ducted unit will require at least a 10" deep soffit for installation. Fan coil units can be installed between structural beams which sit at 4'-0" O.C. throughout the residences. This may be the size of the footprint of the unit plus any required access clearance. Ductwork shall provide air distribution throughout the apartment unit. Ceiling will be 12" lowered.

Figure 16: Mechanical Layout Section Views

4.4 Mechanical System Schedules

As previously mentioned, each apartment will house (1) 1-ton ceiling concealed ducted unit. Using Daikin as a basis of design, there are two options for indoor units depending on height and static pressure requirements, the 1.0-Ton Daikin Slim Duct Built-in Concealed Ceiling Unit and the 1.0-Ton DC-Ducted Concealed Ceiling Unit. For these two units, the indoor unit to outdoor unit connection ratio is of 200%. The minimum connection ratio for outdoor units (specifically for phasing) is of 50%. Following these design guidelines, the following table shows a summary of the approximate number of mechanical units:

Building	# Apt. Units	# Outdoor Units		Building	# Apt. Units	# Outdoor Units
1A	17	1		**6A**	15	1
1B	7	1		**6B**	24	1
1C	12	1		**7A**	12	1
2A	24	1		**7B**	24	1
2B	30	2		**7C**	12	1
3A	30	2		**7D**	12	1
3B	6	1		**8A**	12	1
4A	7	1		**8B**	12	1
4B	4	1		**8C**	12	1
4C	36	2		**8D**	12	1
5A	30	2		**8E**	12	1
5B	30	2				

Figure 17: Mechanical System Schedules

4.5 Mechanical System Electrical Information

Because Heather Village space heating is currently served by natural gas and space cooling is nonexistent, analyzing the current electrical service and visualizing how much load would be added in air conditioning and heating systems is one of the most important aspects of this electrification study. Following the above mechanical system schedules and basis of design, each 1-ton indoor unit requires 1.4 MCA and 15 MOP. This load would be added into the corresponding electrical panel.

The outdoor units' electrical load will be added into the corresponding building electrical panel. Each outdoor unit requires 55 MCA and 70 MOP. The following table summarizes the approximate total load:

Building	Approximate Total Load			Building	Approximate Total Load	
	MCA (A)	MOP (A)			MCA (A)	MOP (A)
1A	55	70		**6A**	55	70
1B	55	70		**6B**	55	70
1C	55	70		**7A**	55	70
2A	55	70		**7B**	55	70
2B	110	140		**7C**	55	70
3A	110	140		**7D**	55	70
3B	55	70		**8A**	55	70
4A	55	70		**8B**	55	70
4B	55	70		**8C**	55	70
4C	110	140		**8D**	55	70
5A	110	140		**8E**	55	70
5B	110	140				

Figure 18: Mechanical System Electrical Information

4.6 Next Steps

Before looking at any possible manufacturers it is important to verify what there is currently available at each

apartment in terms of electrical capacity, space cooling and space heating to confirm how much spare electrical capacity we have for the electrification upgrades. Overall, we expect that by removing the existing furnaces and any other additional equipment currently being used for space cooling and heating, there should be enough space for the 1-ton indoor mechanical unit, as these require a very small amperage. The outdoor units will require upgraded distribution panels to be able to provide enough power. The Electrical Systems section provides more insight on the electrical requirements.

In terms of installation, obtaining a structural engineer's analysis on the roof bearing capacity for each building is worth looking into to confirm whether mechanical outdoor units can be installed completely out of sight at roof level. If the roof is not an option, verifying which trails and walkways are the most transited provides a good insight of which sections around the building one should avoid for installing the outdoor units.

Another factor to consider prior to finalizing the mechanical indoor and outdoor units' placement is the refrigerant line length limitations. These vary by manufacturer and provide restrictions on how far apart the outdoor units can be from the branch selectors and from the indoor units. Identifying any restrictions will aid in choosing the final placement for the mechanical units.

One drawback of the selected system is the amount and type of refrigerant used, which has a relatively high global warming potential. To address this issue, we encourage installing piping with brazed fittings, pressure testing, and finding and repairing any leaks during installation.

Most of the work comes when looking at the interior of the apartments. The proposed mechanical layout described in this report addresses the overall intent and best practices. However, since there are multiple floorplans at Heather Village which may or may not have been modified from its original layout, the contractor might have to develop a slightly different installation strategy for each unique floorplan and prepare for any modifications. For instance, the two photos below, show two different units located at Heather Village. These photos illustrate how much the floorplans can vary between residences, with some of them even having the possibility of ductwork pathways.

Figure 19: Examples of Residences' Layouts

It is important to verify the existing conditions of each apartment prior to proceeding with the mechanical upgrades.

5 Electrical Systems

5.1 Overview of Existing Systems

Heather Village's electrical systems are almost entirely original to the construction of the complex and have been in service for over 50 years. There are several noticeable constraints or equipment issues that have a major influence on electrification implementation pathways. The sections below seek to explain how infrastructure connects and provide power to each use. This section here seeks to provide a summary of those components and any relevant impacts. More discussion is given over the rest of the Electrical Systems section.

Main Switchgear – Utility service is connected to main switchgear and main busbar sized for the utility service. Heather Village hired a firm to inspect and assess the condition of the main switchgear. No current issues have been raised with the condition and functionality of the main switchgear and main busbar.

Distribution Panels – The typical distribution panel is 200A and serves (4) 90A circuits (that each serve 3 dwelling units), though there is variance across the property. Since power tripping off at distribution panels is not an occurrence Heather Village described as happening, it is assumed that the distribution panels are able to provide 200A for 12 residences (4 groups of 3 dwelling units), but any more amperage would not reliably be able to allocated from the distribution panels to additional dedicated electrified equipment unless the distribution panel capacity is upgraded. The distribution panels are all currently Zinsco panels, original to the construction. For 2024, the insurance company for Heather Village informed that they would be increasing rates enormously to cover the insured risk against malfunction from Zinsco panels. This increase in cost is nearly 5-fold and poses a substantial impact on the Heather Village HOA finances. Heather Village was informed of this nearly a year ago and has been working on having these replaced with safer newer panels that will allow insurance premiums to continue at their current levels. With this in mind, replacing Distribution Panels is something being undertaken not for the sake of electrification but for insurance premiums, so that context is critical when evaluating required work for the sake of electrification. See more in the Next Steps section for further discussion on Distribution Panels.

Dwelling Unit Groups Circuits – each dwelling unit is served in groups, typically 3, by the same circuit of the distribution panels. These circuits are typically 90A and thus is a small amount of amperage to serve 3 dwelling units that want electrified appliances. This current limitation is a major factor in electrification implementation strategy for Heather Village.

Dwelling Unit Panels – each dwelling unit has a Zinsco panel, original to the construction, which has the same insurance premium impacts as described in the distribution panels paragraph above. Heather Village is already undertaking the replacement of these Zinsco dwelling unit panels with 125A new code compliant panels. However, while this addresses insurance premiums, it does not increase the total amount of electricity each group of dwelling units can use as the upstream circuit from the distribution panels is a choke point with its 90A limit for all dwelling units to share instead of the 375A the dwelling unit panels would suggest (125A x 3).

5.2 Electrical Utility Service Site Map

Heather Village is served by 6 separate electrical utility services, which are original to the construction of the complex. These services, like the hot water system, each provide power to their own physical region of Heather Village, and collectively these provide power to all areas of Heather Village.

The annotated site map below shows the boundaries of each utility electrical service in thick solid line bright colored polygons. At the most granular, each building is labeled in the background of the image using the 4-digit building number. Next in granularity, each structure has been annotated with its "Number-Letter" format name (1A, 7D, etc) that is used to describe buildings in the Heather Village site map and original as-built engineering drawings. For each electrical utility service, the approximate location of the utility connection is shown as a circle with fill the same as the service's boundary polygon, and annotated with a line leading to the text "Electrical Utility Service" – for example, in Electrical Service 1, it connects on the right side of building 6B.

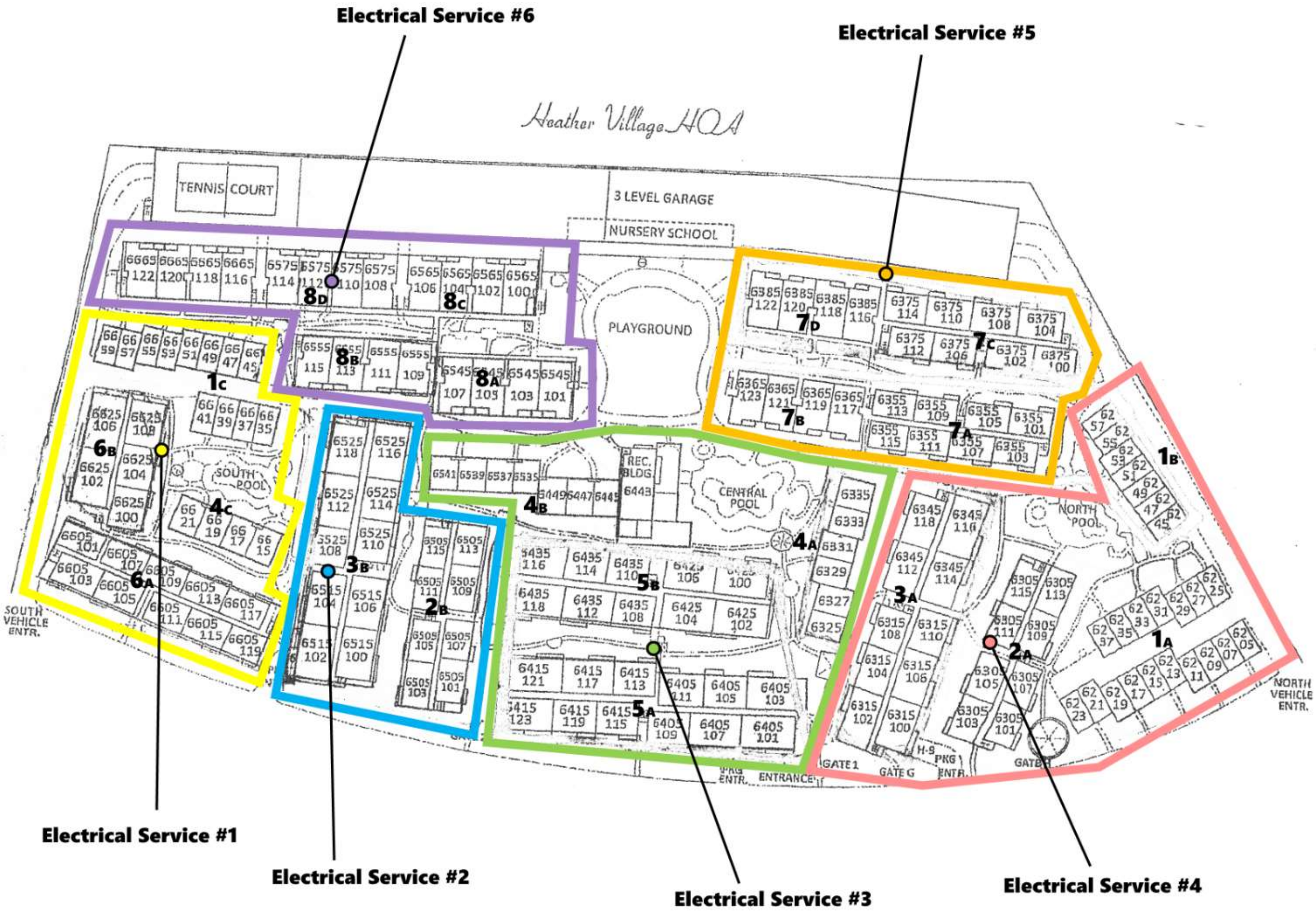

Figure 20: Electrical Utility Service Site Map

Building Name	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	#1				#2		#3				#4				#5				#6				
Dwelling Units	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Total # Units	61				54		79				78				72				60				

Figure 21: Dwelling Units Per Utility Service and Distribution Panel

5.3 Electrical Distribution Illustrative Diagram

The illustrative diagram below is intended to help give a summary of how power is distributed within Heather Village. The diagram moves from left to right, starting with utility power connection and ending with every major use of electricity.

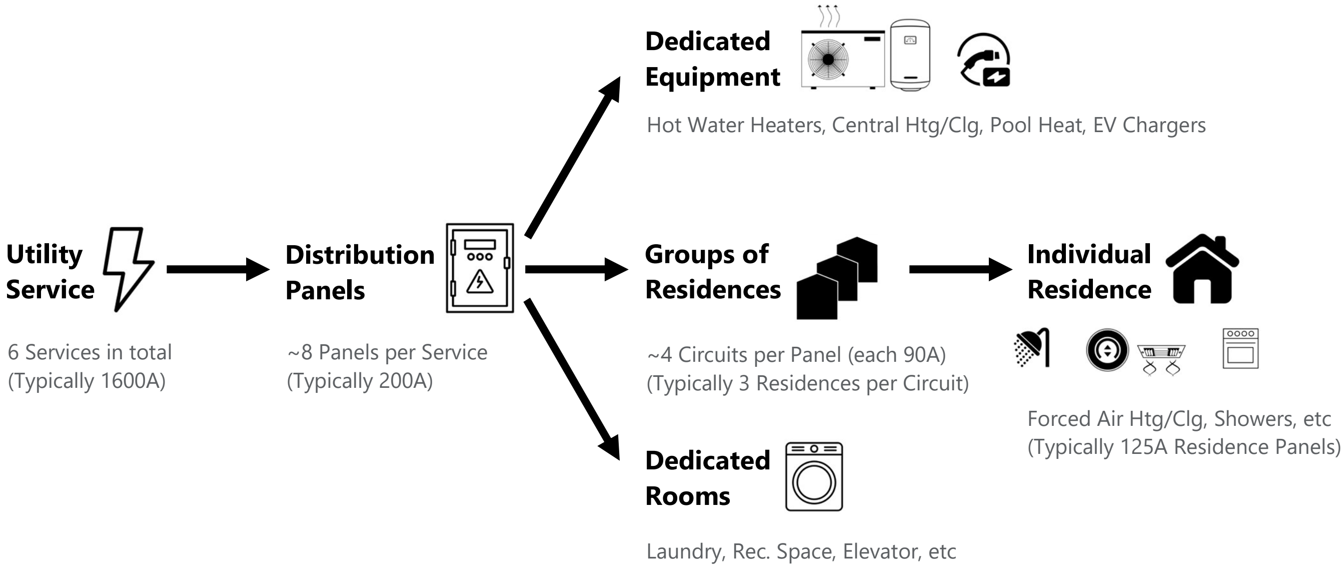

Figure 22: Electrical Distribution Diagram

(1) Utility Service and Main Switchgear – Power enters the Heather Village complex at two utility transformers. Each of these transformers have more than sufficient size to provide power to all Heather Village uses, and future electrification uses described within this section. From there power is run to 6 separate Utility Services, and each serve their own independent physical region of the Heather Village complex. From the perspective of each Utility Service, this is the first step, where the electrical utility wires pop up from underground and connect to main switchgear. This happens separately for each of the 6 electrical utility services. This main switchgear directs power to anything in that electrical service. For nearly everything, there are subsequent steps in the wiring journey before it is powered, but there are a small handful of items that are powered by circuits run directly from the main switchgear (elevators and the occasional dwelling unit). For everything else, again the vast majority, the next step in the wiring is separate individual circuits from the main switchgear to each distribution panel located in each building served by that utility service (see below).

(2) Distribution Panels – In this second step, circuits are run off the main switchgear to each distribution panel (on average 8 distribution panels per electrical utility service. These distribution panels are the primary way power is fed to each electrical use in Heather Village. There are typically multiple distribution panels per building and each electrical service serves many buildings. In nearly all cases, the circuit from the main switchgear to a distribution panel is run underground in conduit before popping up again in a new building. This is because there is no other way to get to those locations. The distribution panels provide power via individual circuits run from the distribution panel in the following three ways: (a) Dedicated Equipment, Groups of Residences, and Dedicated Rooms (see below). The distribution panels are typically 200A and serve (4) 90A circuits that each serve a group of 3 residences. Since this is already serving 12 residences (4 circuits x 3 residences per circuit) with 200A, the amount typically given to One new single family home, it is not safe to assume any of the distribution panels can reliably handle additional dedicated electrical equipment (see below) without an increase in distribution panel capacity.

(3a) Dedicated Equipment – In this application, the circuit from the distribution panel goes directly to dedicated equipment, such as Hot Water Heaters, Central Space Heating/Cooling, Pool Heaters, EV Chargers, etc. This equipment is not in anyone's residence and is a large enough amperage that it is individually circuited. Note, that for the new heat pump hot water heaters, the distribution panel will feed one circuit that connects to a subpanel that would run circuits to each heat pump, etc).

(3b) Groups of Residences – In this application the circuit from the distribution panel goes to multiple residences that all share a single circuit, on average 3 residences per circuit. This means if the collective amperage draw from the 3 residences exceeds the circuit limit, it will trip off power to all 3 residences. This is typically 90 amps in total that is shared by 3 residences. This circuit does feed individual residence electrical panels, but those 3 residence panels are all fed by the same single circuit from the upstream distribution panel. This is not how residences are wired in modern buildings, but in Heather Village, all dwelling units are wired in this manner. So, while individual dwelling units are having 125A panels installed, until the circuit feeding that group of dwelling units is increased in amperage, the set of three dwelling units cannot draw more than 90A in total (even though the wiring at each dwelling unit would suggest 375A could be drawn (125A x 3). This small amount of amperage for sets of residences is why new equipment for electrifying functions is being done almost entirely at the more centralized level of the distribution panels (more discussion later in Section 5, Electrical Systems).

(3c) Dedicated Rooms – in this application, the circuit from the distribution panel goes to a dedicated room (that isn’t a dwelling unit), such as laundry, rec spaces, etc. This is for any non dwelling unit space that doesn’t have a single piece of electrical equipment large enough to warrant its own dedicated circuit. In some rooms there may be a subpanel, fed by the single circuit from the upstream distribution panel, just like in each dwelling unit.

5.4 Current Electrical Use

Heather Village currently has substantial extra electrical capacity at all 6 electrical utility services. In the table below, the maximum amperage draw over 1 year’s time is shown to be between 12% to 19% of the service size. The following sections use this as a starting point and add load for an electrification scenario to show how it increases. This analysis shows that all functions within Heather Village can be electrified without the need to increase or upgrade any utility infrastructure.

SCENARIO 0 – EXISTING ELECTRICAL USE

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	**194 A**				**186 A**		**303 A**				**231 A**				**194 A**				**214 A**				
% Service Size	**16%**				**19%**		**15%**				**14%**				**12%**				**13%**				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12

5.5 Electrification Implications: Hot Water Systems

The first scenario explored is electrification of hot water for all of the Heather Village complex. This consists of central heat pump hot water heating systems that add load to the distribution panels (called central in the table below). NEC requires that new hot water heating equipment be considered at maximum amperage at the same time the measured maximum current use occurs. This is conservative, but a code requirement. In the future, after 1 year of measured data, the baseline for measured use is reset (lowered) and any additional electrical loads are added to this reset down baseline.

The electrification of hot water results in a very minor impact on the electrical utility service, with ranges of 13% to 26% of the maximum service load.

SCENARIO 1 – ELECTRIFY HOT WATER

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	194 A				186 A		303 A				231 A				194 A				214 A				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Central Hot Water Equip (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Central NEC Added Load (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Residence NEC Added Load (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total NEC Added Load	121 A				61 A		68 A				78 A				78 A				0 A				
Max NEC Service Load	**316 A**				**247 A**		**370 A**				**308 A**				**273 A**				**214 A**				
Max NEC Load % Service Size	**26%**				**25%**		**19%**				**19%**				**17%**				**13%**				

5.6 Electrification Implications: Mechanical Systems

The next scenario explored is the electrification of space heating and cooling. This was explored on top of electrifying hot water equipment. This consists of equipment at each residence, essentially a small fan in the "fan coil" inside each residence, and an outdoor unit by each building. The indoor unit is almost non-existent, with 1A of draw, while the Outdoor Unit is much larger. The table below how this adds up on "central" aka distribution panels vs. residence sub panels. All the load ultimately adds up to the electrical service. Again, this load is conservative as NEC requires that this new equipment load be treated as occurring at maximum at the same time as the current maximum observed amperage. This would be reset down for any future electrification after measuring actual electrical draw from 1 year's worth of time.

Electrifying Hot Water and Space Heating and Cooling is still a relatively minor impact on electrical use, with a range of 29% to 42% of maximum service size.

SCENARIO 2 – ELECTRIFY HOT WATER + SPACE HEATING & COOLING

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	194 A				186 A		303 A				231 A				194 A				214 A				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Central Hot Water Equip (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Central Htg & Clg Equip (A)	38	27	74	43	55	74	31	38	93	74	55	38	55	74	55	38	55	38	38	38	38	38	38
Residence Htg & Clg Equip (A)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Central NEC Added Load (A)	109	27	74	94	55	135	31	38	161	74	55	38	97	109	98	38	90	38	38	38	38	38	38
Residence NEC Added Load (A)	11	4	27	14	22	27	5	6	32	27	15	6	22	27	22	11	22	11	11	11	11	11	11
Total NEC Added Load	358 A				238 A		375 A				370 A				329 A				244 A				
Max NEC Service Load	**553 A**				**425 A**		**677 A**				**600 A**				**524 A**				**458 A**				
Max NEC Load % Service Size	**46%**				**42%**		**34%**				**38%**				**33%**				**29%**				

5.7 Electrification Implications: Future Growth

While the emphasis of this feasibility study was on the electrification of the common domestic hot water systems and space heating, there are additional future electrification uses that should be considered. We included high-level estimates for this growth to ensure proposed solutions for domestic hot water and space heating & cooling align with full future electrification. Pathways and recommendations for future electrification are provided below.

5.7.1 Cooking

Induction cooktops provide substantial performance improvements over both electric resistance cooktops and natural gas cooktops. Induction stoves perform at approximately 85% cooking efficiency, compared to gas stoves at about 32% and electric resistance at 70% to 80%. Gas stoves are also a major source of indoor air pollution (which can increase rates of asthma in children) and methane leakage (a major contributor to global warming). There are currently incentives, including California Energy Smart Homes, that will incentive all-electric alterations.

Typical, full-size induction ranges are 240 V and have a considerable electrical draw compared to the limited available capacity in the Heather Village Units. A full range replacement with induction (or electric resistance) stoves will have considerable implications on code loads. This will likely require a new feed from the distribution panels to each unit's subpanel, potentially within the existing conduit.

There are emerging products that will allow residents to electrify their ranges without requiring an electrical upgrade. The Channing Street Copper Co induction range, Charlie, is a 120 V plug-in unit that has a built-in battery to limits electrical draw. The battery enables the range to continue to operate during an outage, both to the range or other appliances (such as a refrigerator) plugged into its outlet. While the cost of the initial reservation was relatively expensive ($6k) the manufacturer claims the battery qualifies for the federal Investment Tax Credit at 30%. This brings the additional premium of this energy storage enabled induction range over a standard induction range to $3k, while avoiding the need to replace wiring or conduits between unit subpanels and distribution panels.

Figure 23: Energy-Storage Enabled Cooking Range by Channing Street Copper Co https://www.channingcopper.com/

Additional analysis is suggested, including the potential to perform load tests on individual units and multi-unit breakers, although we would expect upgrades would be required in most cases.

For residents interested in a more immediate and lower cost option, there are table-top induction hot plates that be plugged into existing outlets. This is a low-cost way for residents to experience the benefits of induction cooking, including an improved cooking experience and reduction in indoor gas combustion. Residents can purchase these units for less than $100 or borrow them from the SCE Induction Lending Library at no-cost.

https://sce.myturn.com/library/

5.7.2 Pool and Hot Tub Heating

The current gas-fired water heaters for the pools and hot tubs can be replaced with heat pump. Pools and hot tubs require temperatures that are significantly lower than the temperatures needed by the domestic hot water systems. Due to the lower hot water supply temperatures, pool and hot tub heat pumps are very efficient with coefficients of performance of 5 or more. There are combination units that can provide the heating for both the pool and hot tub. This is a very mature technology and one of the most efficient and affordable uses of a heat pump.

The U.S. Department of Energy has an excellent overview of heat pump water heating for pools and hot tubs: https://www.energy.gov/energysaver/heat-pump-swimming-pool-heaters

Figure 24: Pool and Hot Tub Heat Pump Water Heaters

Two Examples of many heat pump pool water heater products (Arctic, FibroPool). Consult a qualified contractor for their recommendation.

5.7.3 Dryers

Currently, residents have central laundry rooms with gas dryers. Our analysis assumes that these dryers become replaced with either conventional electric resistance clothes dryers or ventless condensing heat pump dryers in the future, fed by upgraded distribution panels. Residents are also interested in the possibility of having in-unit washers and dryers. This had been tried by some residents in the past, but resulted in issues from increased electrical draw. These dryers would have likely been electric resistance units. There are now efficient, ventless combination washer and dryer units that use either heat pump or condensing technologies that limit power draw to roughly 1/3rd that of a conventional electric resistance dryer, while providing the same total amount of heat. Users place their clothes in these units and the entire wash and dry cycle is completed without a need to switch clothes over from a washer to a dryer.

Ventless Heat Pump Combo Washer Dryers

- Uses only 120V and only draws 10A (very small compared to 240V 30A electric resistance dryers)
- Could be installed “affordably” anywhere that already has plumbing connection, like a wet bar (affordably refers to zero electrical work since these are 120V standard plug appliances)
- **Can only be in some residences** because the electrical might not be able to support all residences on the same circuit using heat pump dryers, hair dryers, microwave, space heater, simultaneously
- The consequence would be that the circuit breaker to 3 residences would trip off, and they’d lose power. The breaker could be reset at the distribution panel, but that situation is not ”ideal”
- To avoid this, ideally only 1 (and max 2) residences can have a heat pump dryer per circuit of 3 residences

Electrical Summary - If only one residence in any group asks for either of these washer/dryer, this should be acceptable electrically. If two residences install one of these washer/dryers, it likely will be fine, but there is no guarantee. If all three residences on a shared circuit install a heat pump clothes dryer, there is a decent chance they could trip off the circuit. One option would be for Heather Village to offer approval for in-unit heat pump clothes dryers on a first come first served basis and not allow all three residences to install such a unit. There are many approaches Heather Village could take.

Plumber Summary - From a plumber’s standpoint, these are relatively standard washers. They can review the specs on the Home Depot website link provided.

Figure 25: GE-Profile-4-8-cu-ft-UltraFast-Combo-Washer-Dryer-with-Ventless-Heat-Pump-Technology - The Home Depot

5.7.4 Electric Vehicles

Adding Electric Vehicle Charging can and should be done in a manner that does not require a utility service upgrade. Currently EV charging exists primarily in the shared garage and uses ChargePoint infrastructure. In order to expand EV charging throughout the Heather Village complex, charging will take one of two forms.

Townhome EV Charging: In townhomes there are parking spots within the structure that can (from a distance standpoint) have an EV chargers directly connected as a circuit to the local electrical panel. In this application, a load control center must be used to ensure that whenever the power draw from the EV charger would exceed the limit on the electrical panel that power is instead temporarily cutoff to the EV charger until that condition has passed. These devices measure current at the electrical panel feeder, and if the current exceeds 80% of the limit, it shuts off power to the control circuit, in this case the EV charging circuit. Power automatically resumes as soon as 15 minutes pass with the current below the 80% threshold. A recommended product for such a load control center is the DCC-12 Electric Vehicle Management System. Shown below is a diagram that is most similar to the townhome situation. Heather Village should require that any townhome owner use this or another approved load control center product for any EV charging equipment they install. The townhome owner can use any EV charging product of their choosing up to a certain amperage to ensure that this does not cause the power to trip off to the EV Charger too frequently. Each situation could be different, but recommend a max 30A 240V EV charger unless careful study of loads on the electrical panel is done that supports higher amperage working within the available power. 30A 240V is a standard level 2 EV charging size.

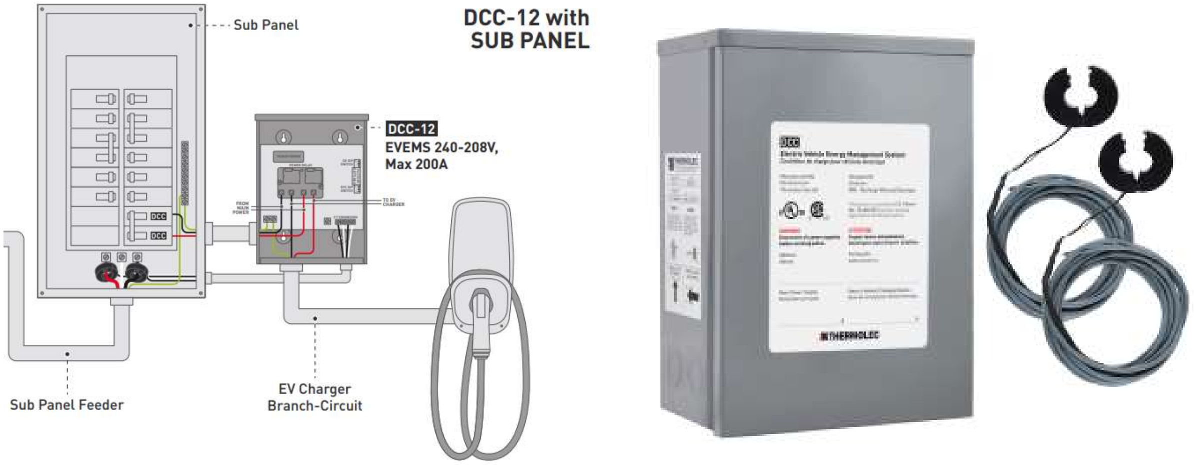

Figure 26: Load Control Center

Shared Space EV Charging: For shared spaces, a load control center should also be utilized to ensure power does not exceed the limit of the electrical panel providing power. There are different larger products than the DCC-12 for large number of EV chargers that can be used. The Electrical Engineer or Contractor Heather Village uses for these installations must be familiar with such load control centers (and should be disqualified if they are unfamiliar). In addition to load control centers that make sure the total power draw stays within the required limits, there also devices that maximize the amount of electric vehicle charging stations by intelligently distributing power amongst simultaneously charging vehicles at lower than maximum charging rates so more vehicles can charge at the same time. For example, the PowerFlex control system uses a system that collects information on when users need to be charged and at what level. The system then prioritizes charging speed based on each user's needs. This can often double the amount of charging stations that can be accommodated over a traditional circuit sharing approach. Another potential option would be ChargePoint's Dynamic Load Management offering.

Billing: For the shared spaces EV chargers, a single vendor must be employed to allow for billing to be separate for each residence of Heather Village. For the townhome EV chargers, the billing can just be part of the measured electricity usage that informs electricity bills for that townhome owner, as the charger is dedicated to the townhome owner.

5.7.5 Future Scenario Electrification – Add Cooking

The first future electrification scenario explored was cooking in the dwelling units. The order of the electrification is not required to be any specific way. These were chosen to help walk through what it would look like if it were these, in this order. For cooking, NEC allows a diversity to be taken on all of the electric cooking equipment. As shown below this varies by the number of dwelling units in the electrical service, but are all between 23% to 25%. This is a substantial reduction, but still conservative when compared to actual electrical draw. For example, this would be saying that 25% of dwelling units are running all four cooktop “burners” at maximum power, or all dwelling units are running one “burner” at maximum power. Only time will tell, with 1 year of measurement, but commonly observed practice suggests it will be lower than the NEC calc dictates.

Electrifying Cooking, on top of Hot Water and Space Heating & Cooling still fits within every electrical service using the required conservative NEC code to calculate draw. After 1 year of measurement it is all but guaranteed that the actual maximum draw will be substantially less, and any additional future electrification would be added to this lower baseline than shown below.

SCENARIO 3 – ELECTRIFY HOT WATER + SPACE HEATING & COOLING + COOKING

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	194 A				186 A		303 A				231 A				194 A				214 A				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Central Hot Water Equip (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Central Htg & Clg Equip (A)	38	27	74	43	55	74	31	38	93	74	55	38	55	74	55	38	55	38	38	38	38	38	38
Residence Htg & Clg Equip (A)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Residence Cooking (A)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Cooking NEC[1] Demand Factor	24%				25%		23%				23%				23%				24%				
Central NEC Added Load (A)	109	27	74	94	55	135	31	38	161	74	55	38	97	109	98	38	90	38	38	38	38	38	38
Residence NEC Added Load (A)	126	42	315	158	262	327	61	71	364	303	172	71	242	303	242	121	242	121	126	126	126	126	126
Total NEC Added Load	944 A				778 A		1,101 A				1,087 A				992 A				820 A				
Max NEC Service Load	**1,138 A**				**965 A**		**1,404 A**				**1,318 A**				**1,186 A**				**1,034 A**				
Max NEC Load % Service Size	**95%**				**96%**		**70%**				**82%**				**74%**				**65%**				

5.7.6 Future Scenario Electrification – Add Cooking + Pool Heating

The next future electrification scenario explored is pool heating, on top of cooking. Pool heating is a very minor electrical addition to the "central" aka distribution panels for the services that have pools. NEC does not allow a diversity factor on pool heating.

Electrifying Pool Heating with Cooking, on top of Hot Water and Space Heating & Cooling still is within the utility service size. Again, as all of this work will take time, the measured max reading will all but be guaranteed to be lower than the one used in the calculation below by that time.

SCENARIO 4 – ELECTRIFY HOT WATER + SPACE HEATING & COOLING + COOKING + POOL HEATING

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	194 A				186 A		303 A				231 A				194 A				214 A				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Central Hot Water Equip (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Central Htg & Clg Equip (A)	38	27	74	43	55	74	31	38	93	74	55	38	55	74	55	38	55	38	38	38	38	38	38
Residence Htg & Clg Equip (A)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Residence Cooking (A)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Central Pool Htg Equip (A)	0	37	0	0	0	0	37	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0
Cooking NEC[1] Demand Factor	24%				25%		23%				23%				23%				24%				
Pool Heating Demand Factor	100%				100%		100%				100%				100%				100%				
Central NEC Added Load (A)	109	64	74	94	55	135	68	38	161	74	55	75	97	109	98	38	90	38	38	38	38	38	38
Residence NEC Added Load (A)	126	42	315	158	262	327	61	71	364	303	172	71	242	303	242	121	242	121	126	126	126	126	126
Total NEC Added Load	980 A				778 A		1,138 A				1,124 A				992 A				820 A				
Max NEC Service Load	**1,175 A**				**965 A**		**1,441 A**				**1,355 A**				**1,186 A**				**1,034 A**				
Max NEC Load % Service Size	**98%**				**96%**		**72%**				**85%**				**74%**				**65%**				

5.7.7 Future Scenario Electrification – Add Cooking + Pool Heating + Laundry

The final future electrification scenario explored was Laundry (clothes dryers). The NEC does not allow a diversity factor for clothes dryers, which results in much more load than will actually occur, in that the maximum draw for the rest of Heather Village will not coincide with the time all clothes dryers are at maximum heat at the same time (if that were ever to occur). The table below shows what the NEC calculated electrical load would be if all services were electrified (Hot Water, Space Heating & Cooling, Cooking, Pool Heating, Laundry) using the current maximum reading. All but two of the utility services stay below the 100% threshold in this scenario. For Utility Services 1 and 2, which are shown above 100%, it is critical to note that it is guaranteed that the measured baseline maximum electrical draw in the year proceeding the final batch of work will allow the NEC calculation to be substantially lower. Both electrical services 1 and 2 are fully expected to be far below 100% when the calculation is performed at that future date as the Hot Water and Space Heating & Cooling will be less than their maximums in reality. Likewise cooking will be less than the NEC calculation. The NEC calculation at the time of construction yielded a size that Heather Village isn't exceeding even 20% of, suggesting all services should be fine to electrify.

All future electrification can occur (including Cooking, Pool Heating, and Laundry) on top of Hot Water and Space Heating & Cooling, as long as all of that work is not completed within 1 years' time from today.

SCENARIO 5 – ELECTRIFY HOT WATER + SPACE HEATING & COOLING + COOKING + POOL HEATING + LAUNDRY

BUILDING	**1C**	**4C**	**6A**	**6B**	**2B**	**3B**	**4A**	**4B**	**5A**	**5B**	**1A**	**1B**	**2A**	**3A**	**7A**	**7B**	**7C**	**7D**	**8A**	**8B**	**8C**	**8D**	**8E**
Utility Service	**#1**				**#2**		**#3**				**#4**				**#5**				**#6**				
Service Size	**1,200 A**				**1,000 A**		**2,000 A**				**1,600 A**				**1,600 A**				**1,600 A**				
Max Reading	194 A				186 A		303 A				231 A				194 A				214 A				
# of Residences	12	4	30	15	24	30	6	7	36	30	17	7	24	30	24	12	24	12	12	12	12	12	12
Central Hot Water Equip (A)	71	0	0	51	0	61	0	0	68	0	0	0	42	35	43	0	35	0	0	0	0	0	0
Central Htg & Clg Equip (A)	38	27	74	43	55	74	31	38	93	74	55	38	55	74	55	38	55	38	38	38	38	38	38
Residence Htg & Clg Equip (A)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Residence Cooking (A)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Central Pool Htg Equip (A)	0	37	0	0	0	0	37	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0
Central Laundry Equip (A)	125	0	0	104	0	125	0	0	125	0	0	0	83	83	104	0	83	0	0	0	0	0	0
Cooking NEC[1] Demand Factor	24%				25%		23%				23%				23%				24%				
Pool Heating Demand Factor	100%				100%		100%				100%				100%				100%				
Laundry Demand Factor	100%				100%		100%				100%				100%				100%				
Central NEC Added Load (A)	109	64	74	94	55	135	68	38	161	74	55	75	97	109	98	38	90	38	38	38	38	38	38
Residence NEC Added Load (A)	126	42	315	158	262	327	61	71	364	303	172	71	242	303	242	121	242	121	126	126	126	126	126
Total NEC Added Load	1,209 A				903 A		1,263 A				1,291 A				1,179 A				820 A				
Max NEC Service Load	**1,404 A**				**1,090 A**		**1,566 A**				**1,521 A**				**1,374 A**				**1,034 A**				
Max NEC Load % Service Size	**117%**				**109%**		**78%**				**95%**				**86%**				**65%**				

5.8 Next Steps

The first step Heather Village should take is to engage with an electrical contractor to upgrade the size of the distribution panels so they can accommodate the electrification of Hot Water and Space Heating & Cooling. The current typical distribution panel is 200A in size and it is recommended to install 400A in its place. Installing these new panels immediately will resolve the issue of the massive increase in insurance premiums from the Zinsco panels that currently exist. The wires can all be connected to the new panels in their current form with the future new wires to unlock the 400A worth of power able to be done in a future time.

The next step that should be undertaken is asking the hot water contractor which electrical panel they would like to pull from for the heat pump water heaters for the first installation, and to hire an electrical contractor to run new wire and conduit as needed to that chosen distribution panel to provide the full 400A power.

Beyond those first immediate needs, the rest of Heather Village's electrification journey can occur in many ways. The graphic below suggests a possible order, trying to convey the bigger picture of electrifying Hot Water and Space Heating & Cooling first, followed by future electrification as desired.

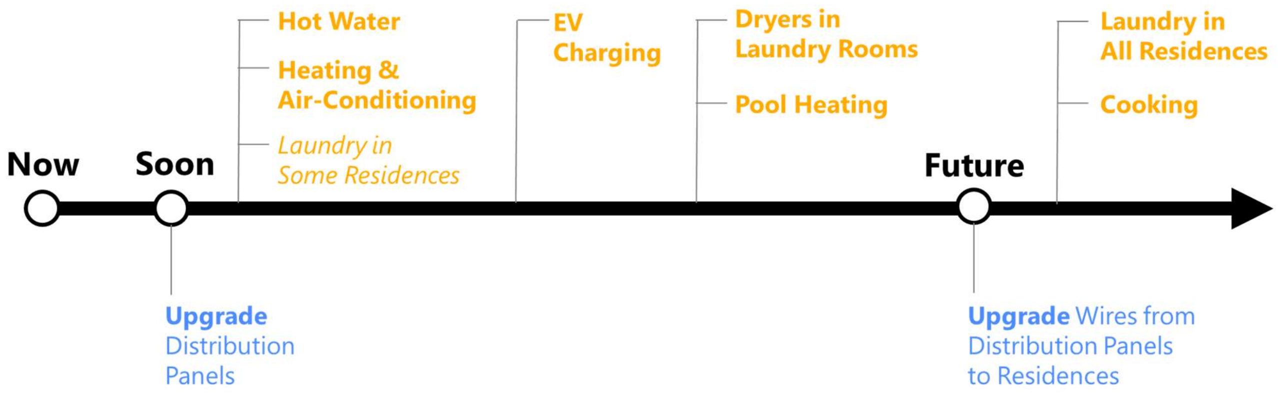

Figure 27: Electrification Timeline

6 Economic and Carbon Analysis

6.1 Overview

Natural gas is served by one utility meter from SoCalGas for the entire site, with the distribution infrastructure owned and maintained by the HOA. There are no on-site natural gas submeters and natural gas costs are spread evenly across units, regardless of direct (like space heating and cooking) or indirect consumption (like water heating). Natural gas consumption averaged 181,804 therms between 2020 and 2022. An estimated disaggregation of end uses was performed, using a combination of methods (including a review of the usage profile and the Energy Information Administration's Residential Energy Consumption Survey of 2020). The majority of baseload natural gas usage is estimated to be from water heating with the majority of variable usage above this baseload is estimated to be due to space heating.

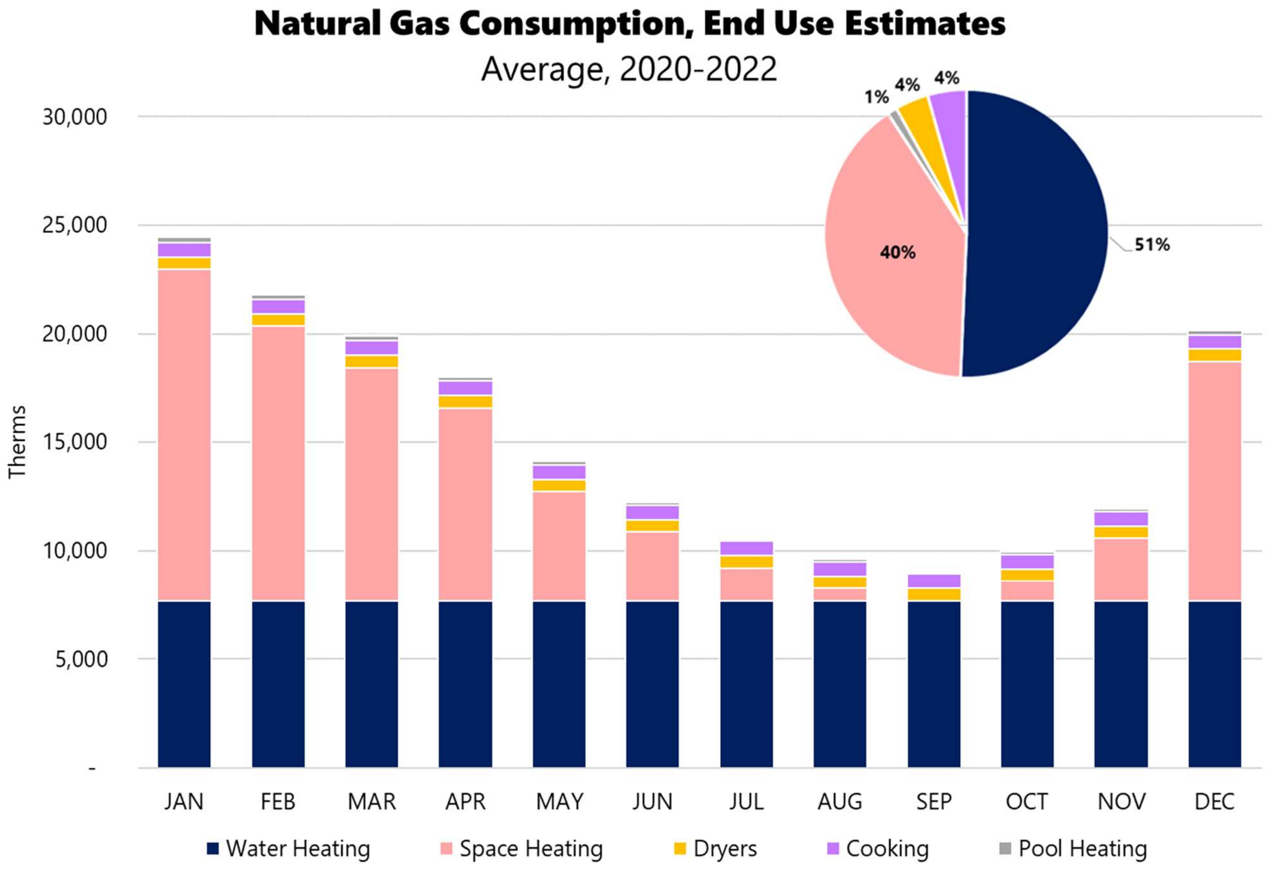

Figure 28: Natural Gas Consumption, End Use Estimates

The Heather Village HOA has six primary utility services and meters (and one dedicated EV service) from Southern California Edison (SCE). The HOA is enrolled in the 100% Green Energy offering through their Community Choice Aggregation (CCA) provider, Clean Power Alliance (CPA). The HOA has their own submeters to allocate electricity costs based on resident usage. The average annual electricity use for the entire site is 1,849,748 kWh. Since this study is focused on electrification of natural gas users, a full disaggregation of the electricity consumption was not performed. There is an increase in electricity use in the summer months, which quantifies some amount of portable air conditioner use. However, this could also be related to energy use from units being occupied more often during the summer (for example, children home from school).

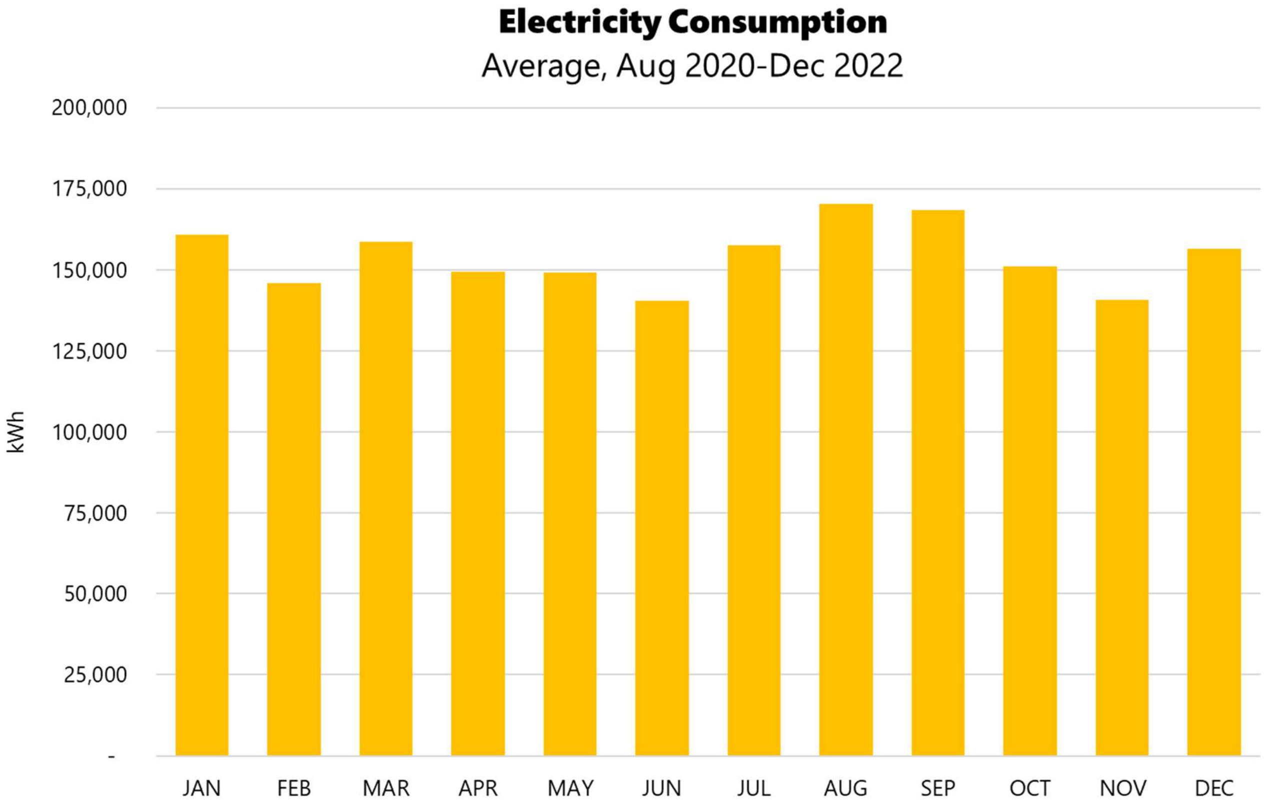

Figure 29: Monthly Electricity Consumption

6.2 Economic Analysis

A lifecycle cost analysis was completed to understand the financial impact of electrification with consideration for first cost, utility costs, and anticipated incentives. The focus of this analysis was on the deployment of heat pumps for domestic hot water and space heating and cooling. However, a higher level estimate for full electrification was also completed, with consideration for the potential natural gas distribution system replacement. We also considered additional utility cost savings from solar photovoltaics and batteries, which become available by shifting the . A summary of the analysis is listed below:

- Annual Utility Costs for Domestic Hot Water and Space Heating: Existing, New Gas, New Heat Pumps
- 15-Year Lifecycle Costs for Domestic Hot Water: New Gas vs New Heat Pumps
- 15-Year Lifecycle Costs for Space Heating: New Gas vs New Heat Pumps
- 15-Year Lifecycle Cost for Domestic Hot Water and Space Heating: New Gas vs New Heat Pumps (With and Without Solar Photovoltaics and Batteries)
- 15-Year Lifecycle Cost for Full Site Electrification: Business as Usual vs New Heat Pumps and Induction Cooking (With and Without Solar Photovoltaics)

In all cases, the 15-year lifecycle cost for the electrification scenario was lower than continuing with the business-as-usual natural gas scenario. However, this includes the anticipated incentives (including grants, rebates, and tax credits) which are a critical element to facilitating electrification cost-effectively in this existing complex.

When available, the installation costs used contractor bids such as in the case of the heat pump water heating system for domestic hot water and the solar and storage power purchase agreement. Otherwise, estimates were built from previous project experience and online research. These estimates can be updated if contractor bids are provided.

A summary of the major assumptions used for the lifecycle analysis is included in the appendix.

6.2.1 Utility Cost Analysis

Electrification of the central water heaters and space heaters with heat pump is estimated to result in a significant reduction in utility costs. The HOA's current electricity and natural gas tariffs were used, using the last three years (2020 to 2023) of historical data for the natural gas procurement rate. Of particular note, SoCal Gas has both baseline and non-baseline natural gas rates. A daily therm allowance per residence varies seasonally and sets the baseline natural gas allowance. Any usage above this baseline allowance is charged at a higher rate. Approximately one-third of the HOA's annual natural gas usage is above this baseline allowance. Electrification of the central water heaters is estimated to reduce 96% of this non-baseline usage. Since this work is anticipated to completed first, this higher savings rate was applied to the water heating system. Electrification of the space heating systems eliminates the remaining usage above the baseline allowance, along with a reduction in most of the remaining baseline gas use.

The analysis used best engineering judgement to estimate when distribute when the electricity would be used for each new electrical end use (domestic hot water, space heating, and appliances) and layered on top of the existing interval data. A critical element of minimizing electricity cost increases due to electrification is to design and operate systems that avoid being used during the most expensive time of day. In SCE territory, this is 4pm to 9pm with some differences based on weekend or weekday and the season. This drove our recommendations to increase the size of the domestic hot water storage to avoid operating during peak periods.

Combined, the electrification of water heating and space heating systems is anticipated to reduce utility costs by $110k per year (14% of baseline electricity and gas costs). The increase in electricity costs due to availability of air conditioning was estimated to be $66k, still leaving $44k in avoided utility costs per year along with an increase in thermal comfort. For the 15-year lifecycle cost comparisons, the estimated increase due to air conditioning was **not** included.

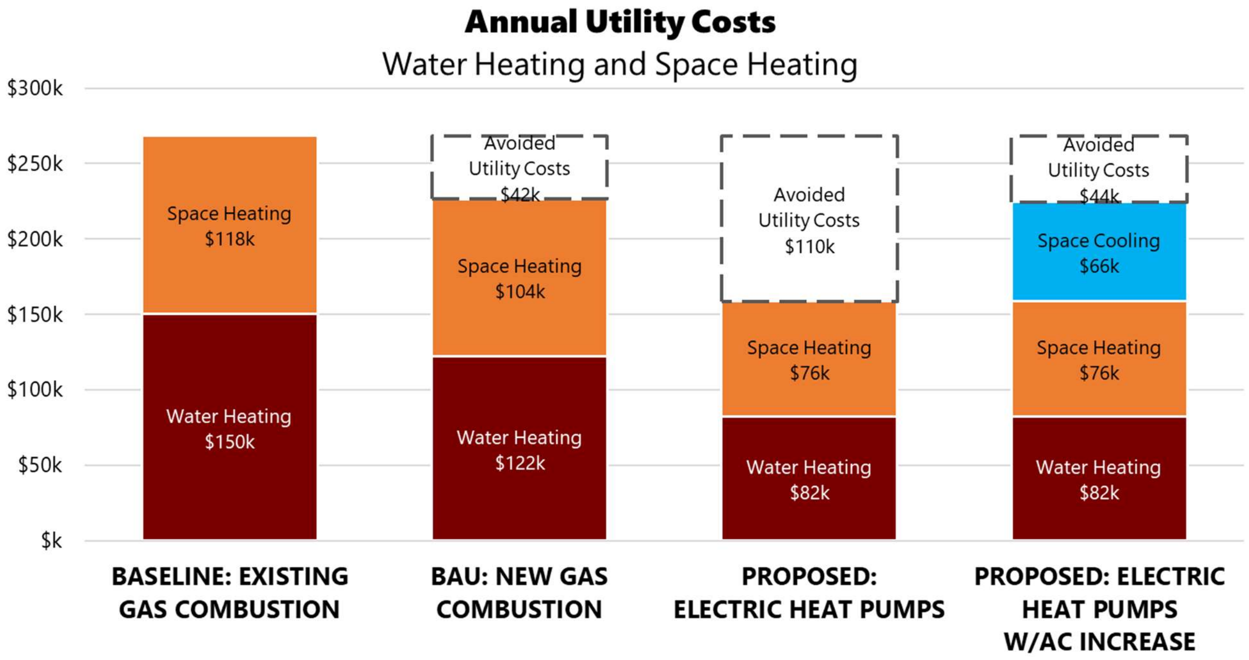

Figure 30: Annual Utility Costs, Water Heating and Space Heating Options

6.2.2 Lifecycle Cost Analysis: Domestic Hot Water

A 15-year lifecycle cost estimate of the water heating system options was conducted. This compares replacing the existing natural gas domestic hot water systems with new, higher efficiency natural gas systems that meets current performance requirements, including insulation of hot water lines. The analysis shows that the proposed case of central heat pump water heaters reduces 15-year lifecycle costs by $948k over the Business-As-Usual (BAU) case of new natural gas water heaters.

Overall project costs were estimated based on initial proposals for replacing one of the eight heat pump water heaters and a contractor estimate to replace all systems. Additional detail on these costs and estimated incentives are available in the appendix.

In each of these lifecycle cost analysis charts, we summarize the estimated utility costs (associated with the specific equipment analyzed), estimated incentives, and remaining project costs **after** application of these incentives.

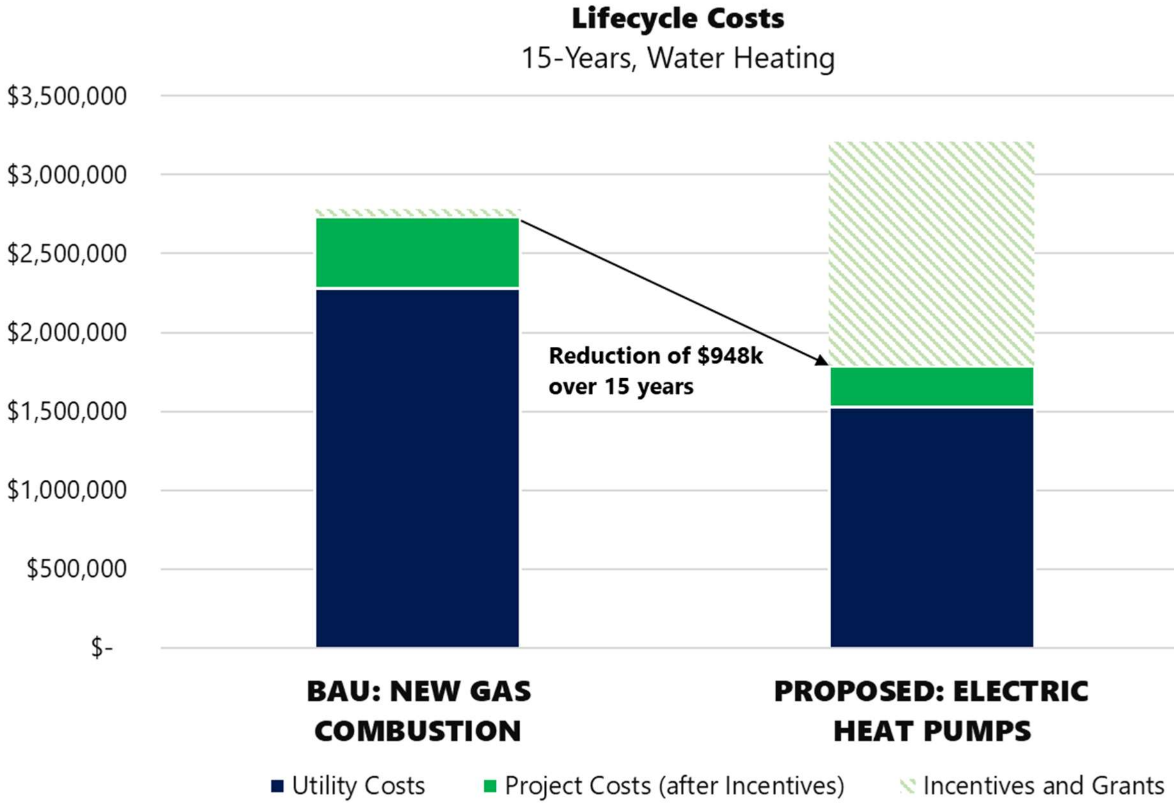

Figure 31: 15-Year Lifecycle Cost: Water Heating Options

	BAU: NEW GAS COMBUSTION	**PROPOSED: ELECTRIC HEAT PUMPS**
Project Cost (before Incentives)	$502,359	$1,680,516
Incentives and Grants	$44,800	$1,422,800
Project Costs (after Incentives)	$457,559	$257,716
Utility Costs	$2,277,195	$1,529,312
Total Lifecycle Costs	$2,734,754	$1,787,028

6.2.3 Lifecycle Cost Analysis: HVAC

A 15-year lifecycle cost analysis of the space heating options was conducted. The BAU case includes replacing a portion of the in-unit natural gas furnaces and the proposed case includes installing electric heat pumps. The analysis shows that the proposed case of heat pumps reduces 15-year lifecycle costs by $1.1k over the BAU case.

Overall project costs are high-level estimates based on previous project experience and online research. Additional detail on these costs and estimated incentives are available in the appendix.

Note that increased electricity use from the air conditioning mode of the heat pumps is **not** included. This is an additional service rather than a shift from one fuel source and technology to another.

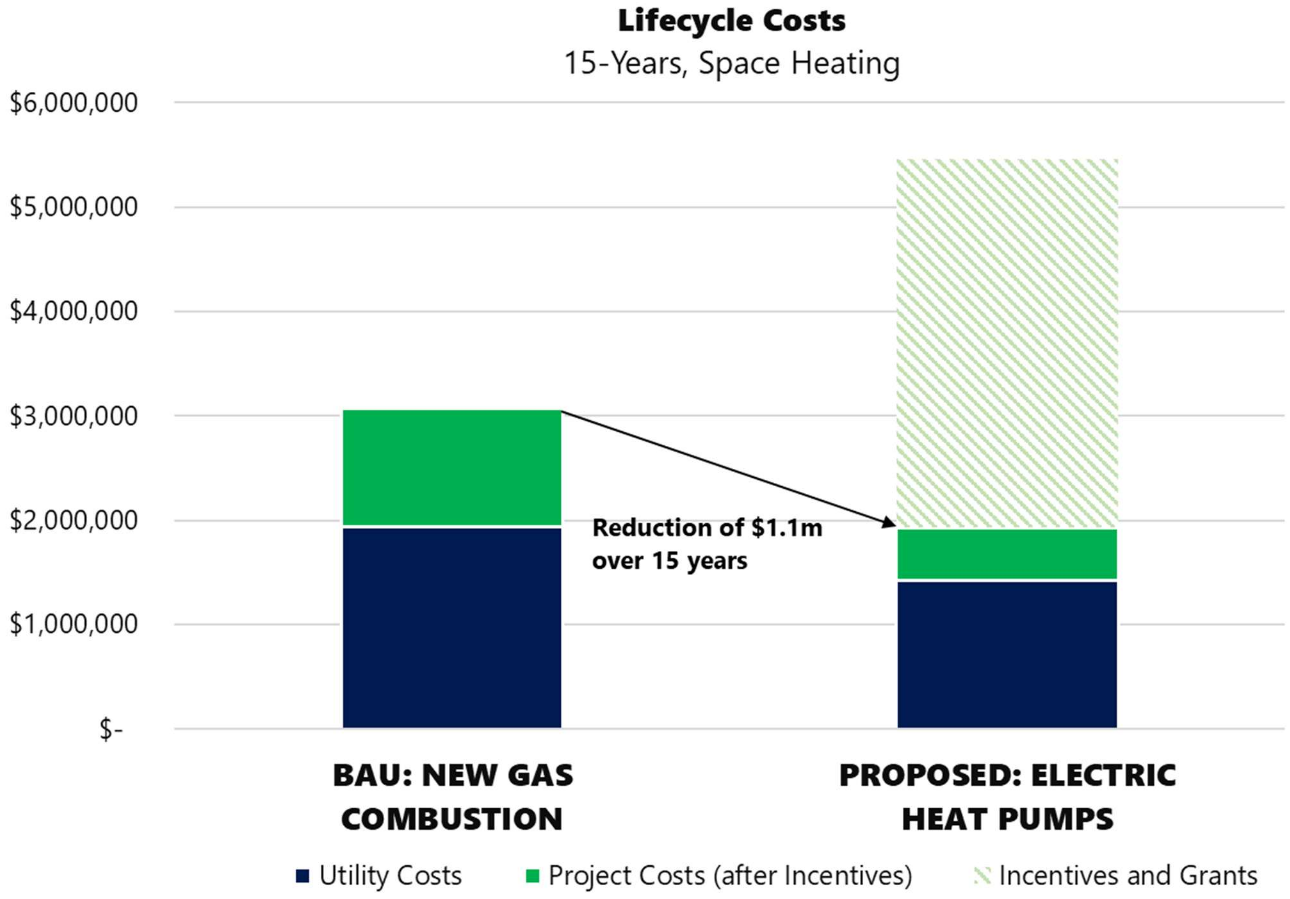

Figure 32: 15-Year Lifecycle Cost: Space Heating Options

	BAU: NEW GAS COMBUSTION	**PROPOSED: ELECTRIC HEAT PUMPS**
Project Cost (before Incentives)	$1,136,250	$4,040,000
Incentives and Grants		$3,532,000
Project Costs (after Incentives)	$1,136,250	$508,000
Utility Costs	$1,937,416	$1,421,650
Total Lifecycle Costs	$3,073,666	$1,929,650

6.2.4 Lifecycle Cost Analysis: Domestic Hot Water and HVAC

A 15-year lifecycle cost analysis of the combined heat pump installations for both domestic hot water and space heating was conducted. This is a summation of the results from the individual domestic hot water and HVAC analyses, with an additional scenario that applies electricity savings from unlocking the ability to install additional solar and storage over time. The estimated solar and storage savings is based on a contractor proposal, which included avoided cost and a power purchase agreement (PPA) rate. The analysis shows that the proposed case of heat pumps reduces 15-year lifecycle costs by $2.1 million over the BAU case and another $0.5 million by installing additional solar and storage to cover the increased electrical usage.

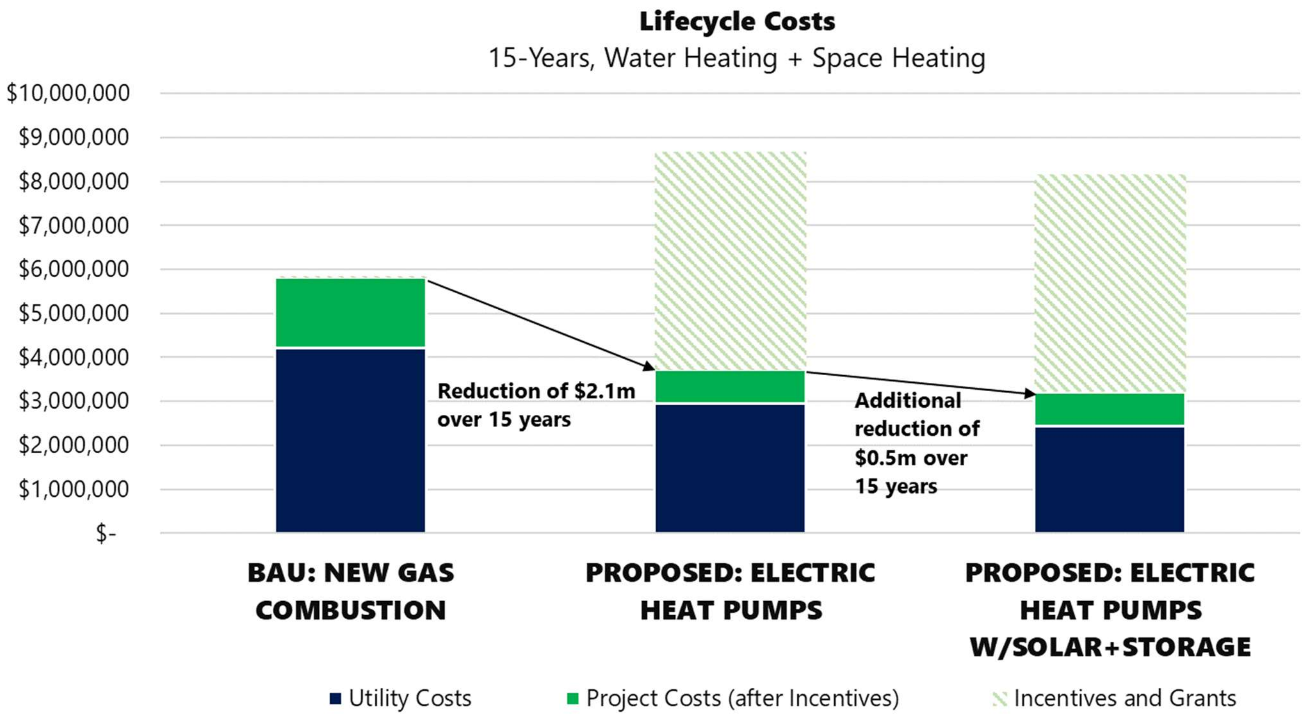

Figure 33: 15-Year Lifecycle Cost: Water and Space Heating Options, With and Without Solar and Storage

	BAU: NEW GAS COMBUSTION	**PROPOSED: ELECTRIC HEAT PUMPS**	**"PROPOSED: ELECTRIC HEAT PUMPS W/SOLAR+STORAGE"**
Project Cost (before Incentives)	$1,638,609	$5,720,516	$5,720,516
Incentives and Grants	$44,800	$4,954,800	$4,954,800
Project Costs (after Incentives)	$1,593,809	$765,716	$765,716
Utility Costs (Includes PPA)	$4,214,611	$2,950,962	$2,441,842
Total Lifecycle Costs	5,808,420	$3,716,678	$3,207,558

6.2.5 Lifecycle Cost Analysis: Full Site Electrification

Finally, a lifecycle cost analysis for full site electrification was conducted. We combined the analysis of heat pumps for domestic hot water and space heating and included additional building electrification elements: pool and spa heaters, common area dryers, and cooking ranges. While the analysis simplistically assumes full site electrification in the immediate future, we would expect a phased implementation. The analysis shows that the proposed case of full electrification reduces 15-year lifecycle costs by $1.3 million over the BAU case and another $0.6 million by installing additional solar and storage to cover the increased electrical usage. This is heavily dependent on securing the incentives identified.

Overall project costs of the additional electrification elements are high-level estimates based on previous project experience and online research. Additional detail on these costs and estimated incentives are available in the appendix.

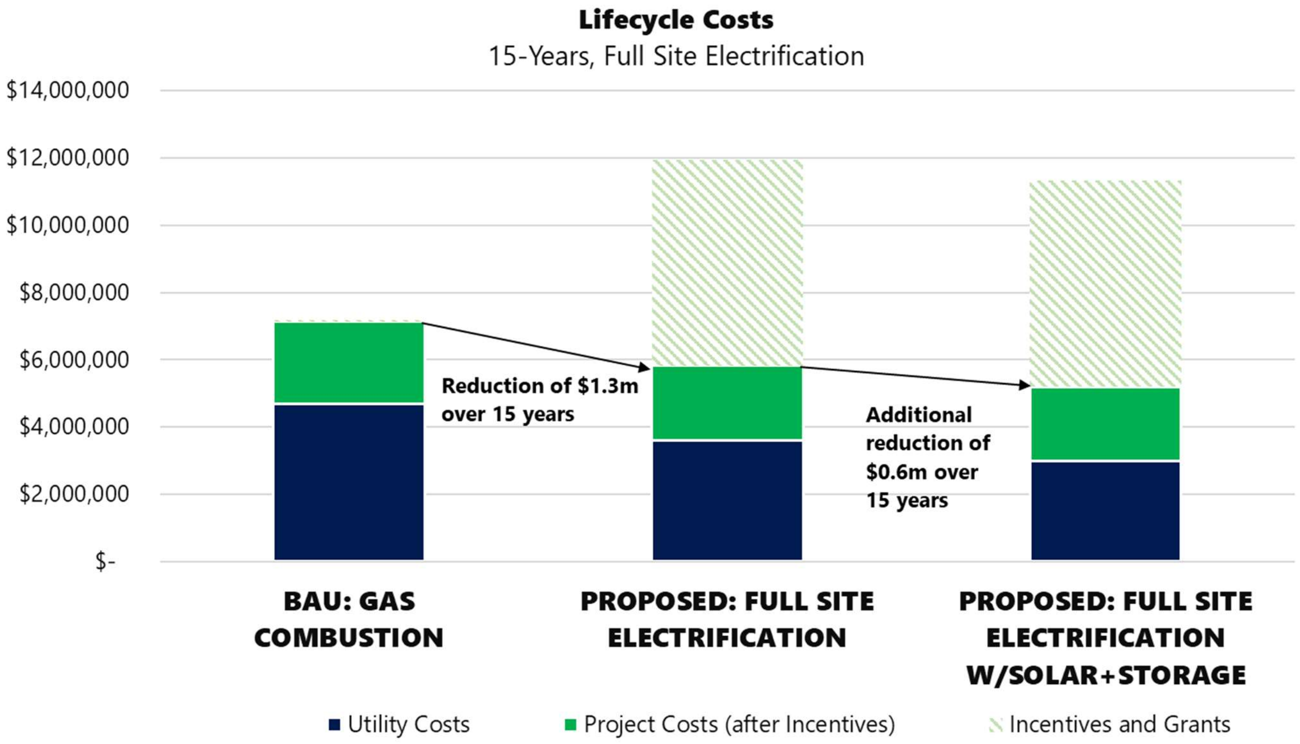

Figure 34: 15-Year Lifecycle Cost: Full Site Electrification, With and Without Solar and Storage

	BAU: GAS COMBUSTION	PROPOSED: FULL SITE ELECTRIFICATION	PROPOSED: FULL SITE ELECTRIFICATION W/SOLAR+STORAGE
Project Cost (before Incentives)	$2,502,134	$8,345,161	$8,345,161
Incentives and Grants	$44,800	$6,125,860	$6,125,860
Project Costs (after Incentives)	$2,457,334	$2,219,301	$2,219,301
Utility Costs	$4,676,384	$3,606,514	$2,978,985
Total Lifecycle Costs	$7,133,717	$5,825,816	$5,198,287

This analysis indicates that the most significant economic benefits of electrification at Heather Village is due to implementation of heat pumps to provide domestic hot water and space heating. This is in large due to domestic hot water and space heating as representing the largest estimated portion of natural gas use, highly efficient heat pump options for these applications, and substantial incentives for these end uses.

Also, the estimated cost to replace natural gas ranges with induction ranges may be conservative. Our initial analysis suggests that a traditional 240 V induction range would require electrical upgrades, particularly between the distribution boards and individual housing unit. In lieu of a cost estimate for this upgrade (or validation that it is not required), our cost analysis assumes an energy storage enabled induction range (like the Charlie from Channing Street Copper Co). While the cost is high compared to a low or mid-end induction range, the applicability of the 30% ITC for the energy storage element and avoidance of electrical upgrades may make this the least expensive option. Additional analysis is recommended, including the potential to perform load tests on individual units and multi-unit breakers,

There are additional co-benefits of full site electrification not captured by this analysis, including avoiding the health impacts of combusting natural gas indoors (including respiratory illnesses) and avoiding methane leakage associated with distributing natural gas to and within the site.

There have been several natural gas leaks at Heather Village over the last few years. While on-site, SoCalGas has suggested that the natural gas distribution system will likely need to be replaced in the coming years. Since this distribution system is after the utility meter, the HOA would be responsible for the cost of replacing this system. Though most natural gas usage would be reduced from the electrification of water heating and space heating systems, the remaining gas users (including the central dryers, cooking ranges, and pool heaters) would still be reliant on this distribution system. Full electrification of the site would avoid this cost. We estimated the replacement of these costs based on a takeoff of total linear feet of natural gas lines and an estimated cost, based on internet research. We recommend that Heather Village continue to monitor this situation for both safety and planning to potentially avoid these costs by full electrification of the site.

6.2.6 Metering Considerations

There are some complications created from the electrification efforts, primarily due to the existing metering arrangement. Resident electricity usage is sub-metered and recharged based on their proportional contribution, but not their natural gas or hot water usage. Water heating will shift from behind the common natural gas meter to behind the common utility electric meters. Since these costs are being borne by the HOA as a whole, the resulting reduction in natural gas costs and increase in electric costs should not create a challenge in cost allocation. However, the electrification of space heating systems is an opt-in program, with the majority of costs bourn by the residents themselves. The common natural gas usage will decrease, due to investment from residents opting-in. Common electric use will see an increase from the outdoor condensing units. This will also slightly increase the sub-metered electric use of these residents due to the indoor fan coils. The recommended HVAC solution can allocate electric costs associated with the outdoor condensing unit based on individual usage. This will allow the HOA to allocate use and associated costs to each individual resident.

6.3 Carbon Analysis

Electrification greatly reduces carbon emissions, especially when paired with clean sources of electricity. Heather Village is currently buying its electricity through Clean Power Alliance's 100% Green Power program, which has zero emissions. Electrification of the water heating and space heating systems is estimated to reduce natural gas usage by 91% with an equivalent reduction in combustion-related GHG emissions. The increased electricity usage would also be through CPA’s 100% Green Power program and would not result in any additional emissions.

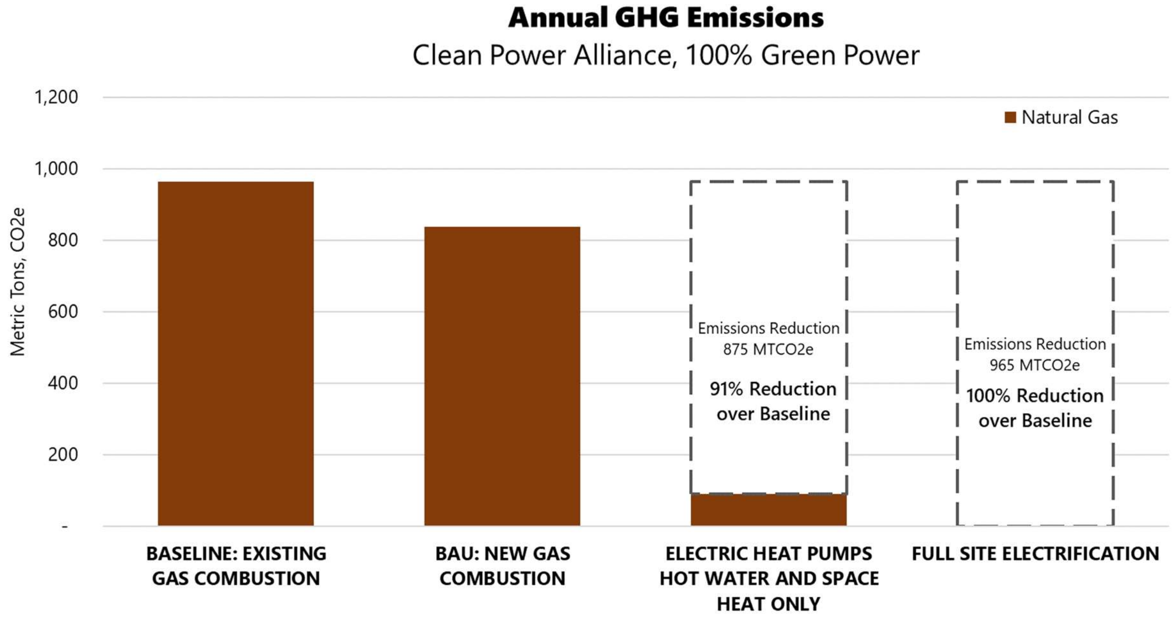

Figure 35: Annual GHG Emissions, With 100% Green Power

Even if Heather Village was purchasing Clean Power Alliance’s base offering (Lean Power), a substantial reduction in emissions would be achieved. This could then be offset through on-site solar and storage.

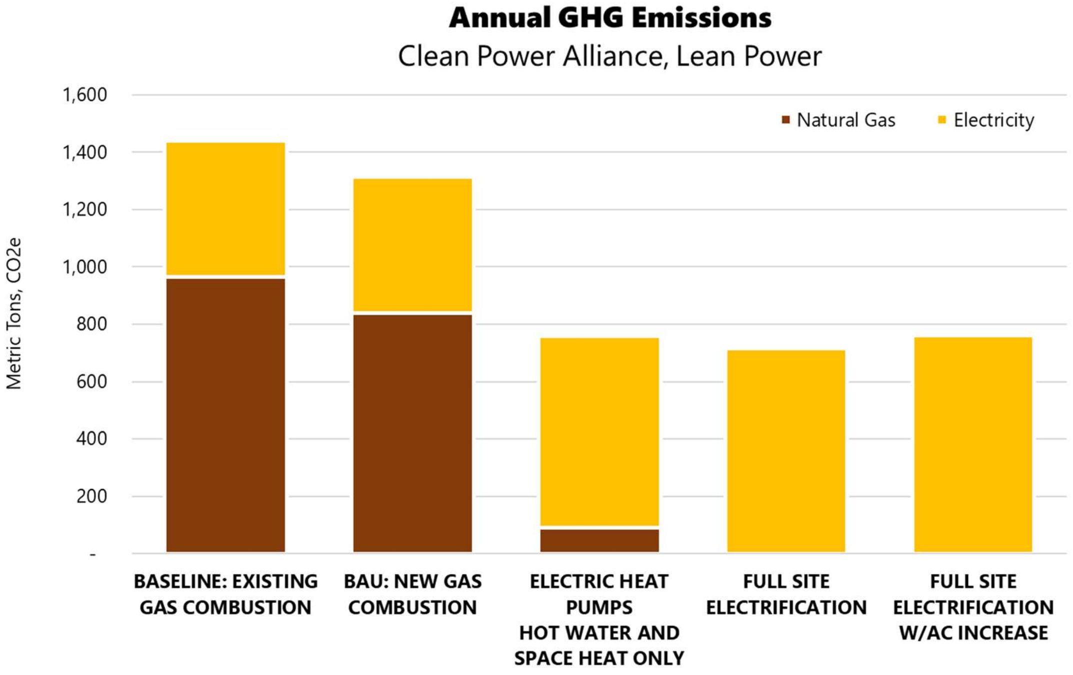

Figure 36: Annual GHG Emissions, With Standard Offering

7 Appendices

7.1 Lifecycle Cost Analysis Assumptions

Utility Rate Escalation

Natural Gas: 3% per year

Electricity: 3% per year

Solar and Storage PPA: 2% per year

Solar Degradation: 0.5% per year

Domestic Hot Water Costs

	Per Housing Unit	**Per HPWH System (Incremental Distribution Panel Cost)**	**Total**	**Source**
Installation Cost	$4,000	$8,065	$1,680,516	Contractor
SoCalREN Incentive			$786,000	Contractor
Incentive: TECH (QSG)			$152,000	Grant
TECH Incentive (Non-QSG)	$1,200		$484,800	TECH
Installation Cost (After Incentives)			$257,716	
BAU (Business as Usual) Cost (New Natural Gas Boilers)			$502,359 ($457,559 after incentives)	Adjusted Estimate Based on Contractor HPWH quotes

Note: This exceeds the per housing unit cost of $3,533 based on the proposal for the first pilot system ($233,151). This pilot system serves 66 units, which is one of the larger systems. Due to the unknowns and range of system sizes, an estimated cost of $4,000 per housing unit was used.

Domestic Hot Water Performance Assumptions

Baseline: 70% AFUE

Business-as-Usual: 85% AFUE

HPWH: 4.5 COP, interpolated from:

https://www.eco2waterheater.com/_files/ugd/e88920_293f399a2a3a432396b1805a76f21c80.pdf

HVAC Costs

	Per Housing Unit	% of Units	Total	Source
Installation Cost	$10,000	100%	$4,040,000	Estimate
SoCalREN Incentive	$743	100%	$300,000	Contractor
TECH Incentive (Non-QSG)	$1,000	100%	$404,000	TECH
Federal Tax Credit	$2,000	100%	$808,000	Rewiring America
Federal Electrification Rebate	$5,000	100%	$2,020,000	Rewiring America
Installation Cost (After Incentives)		100%	$508,000	
BAU Cost (New Natural Gas Furnaces)	$3,750	75%	$1,136,250	Equipment Cost Online and Estimated 50% add for Labor

Note: The assumption is that 75% of the furnaces will be replaced in the next 15 years. The lifecycle analysis simplistically brings these costs to the present and applies the adjusted utility costs over the next 15 years, though this may be phased. The analysis assumes all residents can qualify for the tax credit (either in installation year or applied for the future. The federal electrification rebate uses the moderate-income level cap of 50% project cost although we would expect some residents apply for the low-income level of 100% of project cost and others would not qualify. A total cap of $8,000 for the rebate would apply in all cases.

HVAC Performance Assumptions

Baseline: 60% AFUE

Business-as-Usual: 67% AFUE

This accounts for the poor thermal performance from gravity wall furnaces

https://www.etcc-ca.com/sites/default/files/reports/e12scg0018_wall_furnace_final_report.pdf

Heat Pump: 3.6 COP

http://www.daikinac.com/content/assets/DOC/SubmittalDataSheets/VRV/REYQ/230v/SDS-REYQ144TTJU.pdf

Pool and Hot Tub Heater Costs

	Total	Source
Installation Cost	$50,000	Contractor Estimate
SoCalREN Incentive	$30,000	Contractor
TECH Incentive (Non-QSG)	$7,500	Contractor
Installation Cost (After Incentives)	$12,500	
BAU Cost (New Natural Gas Heaters)	$10,000	Estimate

Pool and Hot Tube Heater Performance Assumptions

Business-as-Usual: 80%

Heat Pump: 5 COP

Dryer Costs

	Per Dryer	Per Laundry Room (Incremental Distribution Panel Cost)	Total	Source
Installation Cost	$1,400	$8,065	$150,645	Online Pricing and Contractor Estimate
Federal Electrification Rebate	$840		$42,000	Rewiring America
Smart Home Incentive	$500		$25,000	Contractor
Installation Cost (After Incentives)			$83,645	
BAU Cost (New Natural Gas Dryers)	$700		$35,000	Online Pricing

Note: The assumption is that all of the dryers will be replaced in the next 15 years. The lifecycle analysis simplistically brings these costs to the present and applies the adjusted utility costs over the next 15 years, though this may be phased. Estimates of 50 common use dryers across site, per HOA. Residents have expressed interest in in-unit dryers; this analysis does not consider those costs. Smart Home Incentive would only apply for buildings that would be all-electric after installation of the dryers.

Dryer Performance Assumptions

Business-as-Usual: 3.5 CEF

Heat Pump: 9 CEF

Induction Range Costs

	Per Induction Range **(With Integrated Battery Storage)**	**% of Units**	**Total**	**Source**
Installation Cost	$6,000	100%	$2,424	Online Pricing (Channing St Copper Co)
Federal Investment Tax Credit	$1,800	100%	$727,200	Rewiring America
Federal Electrification Rebate	$840	100%	$339,360	Rewiring America
Installation Cost **(After Incentives)**		100%	$1,357,440	
BAU Cost **(New Natural Gas Ranges)**	$700	75%	$242,400	Online Pricing

Note: The assumption is that 75% of the ranges will be replaced in the next 15 years. The lifecycle analysis simplistically brings these costs to the present and applies the adjusted utility costs over the next 15 years, though this may be phased. For the proposed case, we used the relatively high end, battery storage enabled Channing Street Copper Company induction range. This was chosen due to lack of pricing to upgrade wiring to individual units and may end up being the most-cost effective option, after incentives are applied. We would recommend getting estimates to rewire housing units to facilitate installation of lower end induction ranges without battery storage for a comparison.

Cooking Performance Assumptions

Business-as-Usual: 32%

Induction: 85%

https://www.energystar.gov/partner_resources/brand_owner_resources/spec_dev_effort/2021_residential_induction_cooking_tops

Natural Gas Distribution System

Distribution Pipe Length: 4,609 ft (from map takeoff)

Replacement Cost: $125/linear ft (internet research and scaling for larger pipe diameters)

Total Replacement Cost: $576,125