DAC HTR Statewide Single Family Housing Characteristics Study

Final Report

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Executive Summary

The *DAC HTR Statewide Single Family Housing Characteristics Study* offers a comprehensive analysis of the housing conditions within disadvantaged communities (DACs) and hard-to-reach (HTR) single family residences across California. Conducted in 2024, this study represents the second phase of a broader research effort initiated in 2022/2023. The primary objective is to assess the readiness of these communities for electrification, understand the barriers they face, and provide actionable insights to guide the design and implementation of utility programs aimed at equitable electrification.

The study surveyed 300 single family homes across various regions, leveraging networks of Energy Savings Assistance (ESA) program contractors and community-based organizations (CBOs).

Key Findings and Insights

- **Housing Stock and Electrification Readiness:** The data reveals significant variability in housing stock, with many homes built before 1980, lacking modern infrastructure, and having limited readiness for electrification. Electrical panel capacity, especially in homes with 100A or less capacity, and necessary panel upgrades are critical challenges. Notably, readiness differences are observed across building types and regions, with distinct needs in rural versus urban DAC and HTR communities.

- **Barriers to Electrification:** The study highlights several barriers to electrification in DACs and HTR communities, including high upfront costs, inadequate electrical infrastructure, and prevalent myths and misconceptions about electrification technologies. Cultural and emotional barriers also play a significant role, with residents expressing concerns about the reliability and safety of all-electric homes.

- **Electrification Sentiment:** While there is mixed but cautious sentiment toward electrification, respondents who had already adopted some forms of electrification (e.g., heat pumps, induction ranges) were more likely to have a positive view. The study's sentiment scores show a clear need for targeted education and outreach to address common misconceptions and build acceptance of electrification measures.

- **Cost Implications:** The cost of necessary upgrades, including electrical panel and service upgrades, was identified as a significant barrier, particularly in homes with underground power lines or limited panel capacities. These upgrades are essential for supporting electrification but present a prohibitive cost burden without targeted financial support.

Recommendations

- **Program Design:** To support ongoing electrification efforts, the study recommends developing tailored programs that address financial, technical, and cultural barriers. Programs should include incentives that offset the costs of necessary upgrades and provide participants with hands-on technical assistance, demonstrations, and training on how to maximize the benefits of new appliances. Outreach strategies should also be culturally sensitive, leveraging online campaigns and community testimonials to improve public perception of electrification technologies and build trust.

- **Electrification Score:** This study introduces an Electrification Readiness Score, a standardized metric to evaluate the combined cost, complexity, and duration of electrification projects. This score will enhance the planning and implementation efforts of agencies, utilities, and program administrators by providing a consistent reference across homes, housing types, and climate zones throughout the state.
- **Funding and Reporting:** It is recommended that stakeholders lobby federal agencies, state and local governments, and utilities for adequate funding based on a clear understanding of electrification costs in DACs and HTR communities. Future funding should be unrestricted, layered up to set caps per home, and managed in a centralized, trackable repository to ensure transparency and prevent fraud.
- **Education and Awareness:** The study reveals that knowledge gaps about electrification technologies persist. Sentiment analysis suggests that households with prior experience using electric appliances are more likely to view electrification favorably. Broad, targeted educational campaigns are essential to bridging this knowledge gap and helping residents see electrification as a practical and beneficial choice.
- **Safety Nets:** The primary concern for DACs and HTR communities considering electrification is the potential for increased electricity costs, closely followed by worries about power outages. The study recommends installing battery backup systems that can charge during off-peak hours and supply power when rates are high or during outages. This strategy can mitigate cost concerns and enhance resilience, with solar photovoltaic (PV) panels as a supplemental option where feasible.
- **Training:** Ensuring that electricians and contractors are trained in strategic commissioning for technologies like heat pumps, solar PV, and battery storage is essential. Current incentive structures focus on installation rather than comprehensive commissioning, highlighting an opportunity to expand contractor capabilities and support long-term electrification success.
- **Looking Ahead:** The resultant dataset from the 300 surveys is a rich resource that was thoroughly analyzed to compile the findings of this final report. However, opportunities still exist for further research, and we would encourage supplementary analysis of the dataset by Southern California Edison (SCE) and other authorized users.

Summary of Stakeholder Feedback

The DAC HTR Housing Characteristics Study Stakeholder Sessions provided essential insights and targeted recommendations to address the unique challenges of electrifying DACs and HTR communities. Stakeholders highlighted pressing concerns around energy affordability, infrastructure readiness, and program accessibility, emphasizing these as critical areas for future program design

- **Energy Cost Concerns and Utility Involvement:** Stakeholders underscored the rising cost of electricity and the need to engage investor-owned utilities (IOUs) directly to manage customer impact, especially as electrification advances. Concerns were voiced over bill increases due to rising electricity demands and infrastructure requirements, with calls for IOUs and the California Public Utilities Commission (CPUC) to consider financial support, such as California Alternate Rates for Energy (CARE)-like discounts, to ease the transition for low-income households.

- **Infrastructure and Electrification Barriers:** Many stakeholders, particularly from rural areas, noted the high costs of electrical upgrades and grid limitations as substantial hurdles. The study corroborates these concerns, revealing that DACs and HTR communities face unique challenges with older housing conditions and limited electrical capacity. Recommendations included prioritizing affordability and exploring community microgrids as a potential solution to enhance resilience and manage costs.

- **Cultural and Emotional Ties to Gas:** Strong cultural and emotional attachments to gas appliances emerged as a substantial barrier among DAC and HTR residents. Stakeholders emphasized the importance of educational materials tailored to address these perceptions, alongside early adopter testimonials to build trust and highlight electrification benefits.

- **Solar as a Gateway to Electrification:** Some survey data indicated that solar adoption could encourage openness to further electrification. Stakeholders recommended leveraging new federal funding to support DAC-focused solar installations, ideally paired with battery storage, to alleviate concerns about power outages and energy costs.

- **Inclusion of Smaller Utility Districts:** Stakeholders advocated for engaging smaller utility districts in future study phases. They suggested that smaller utilities, with closer community ties, could provide valuable insights into DAC and HTR electrification strategies. Building partnerships with these utilities, local contractors, and business associations could enhance program delivery and community support.

Conclusion

The *DAC HTR Statewide Single Family Housing Characteristics Study* provides critical insights into the unique challenges faced by DACs and HTR communities in the context of electrification. The findings underscore the need for carefully designed equitable programs that not only address the technical and financial barriers, but also engage and educate residents in fostering a positive transition to an all-electric future. By leveraging the data and recommendations from this study, stakeholders can better prioritize resources and efforts to ensure that California's decarbonization goals are met in a way that is inclusive and equitable for all communities.

Abbreviations and Acronyms

Acronym	Meaning
CARE	California Alternate Rates for Energy
CBO	Community-Based Organization
DAC	Disadvantaged Community
EE	Energy Efficiency
ESA	Energy Savings Assistance
GHG	Greenhouse Gas
HTR	Hard-to-Reach
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility
kWh	Kilowatt-hour
LIWP	Low-Income Weatherization Program
LMI	Low-or-Moderate Income
PA	Program Administrator
PG&E	Pacific Gas & Electric
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SFR	Single Family Residence
TPM	Technology Priority Map

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Introduction

This market characterization study builds on the efforts and findings of the 2022/2023 CalNEXT Residential Housing Characteristics Study ET22SWE0022. The ET22SWE0022 study's objectives were to:

- Characterize existing DAC single family residence (SFR) building stock through publicly available census data relevant to electrification and electrification programs.
- Develop and validate a field survey by gathering information from a sample of 50 DAC and HTR housing sites.
- Characterize existing DAC SFR building stock and electrification readiness, based on census and limited field survey analysis.
- Develop recommendations for future programs and interventions necessary for facilitating equitable electrification in DACs and HTR communities.

The 2022/2023 study met its objectives but also revealed that a statewide field survey effort was necessary to make meaningful characterization of DAC and HTR housing conditions and their readiness for electrification. The field survey included only 50 homes, as it was intended to evaluate the effectiveness and usefulness of the survey questions and approach. The results were limited to a small sample, yet successfully demonstrated that the survey tool would be instructive for the second phase of the effort and would more accurately characterize the building stock. To do so, significantly more surveys were required.

The 2022/2023 study laid the groundwork for phase two of the conducted 2024 DAC HTR Statewide Single Family Housing Characteristics Study (ET24SWE0011). 300 surveys were completed statewide. This second phase completes the picture and understanding commenced in 2022/2023.

Background

While high-level data, such as the number of homes in DACs and other key demographic and market information (e.g., housing age and access to broadband) can be obtained from census and other research, data on the baseline physical conditions, current appliances, fuel types, and electrical infrastructure is lacking (i.e., structural integrity, hazards, electrical panel capacity, wiring technology, and code issues). This information is foundational in sizing the total available market for emerging technologies and developing effective, properly budgeted program pathways to serve and "electrify" these communities. Moreover, the team aims to assess the electrification readiness levels of DAC households across the state.

Objectives

The project's main outcome is a dataset that can directly support the design and implementation of utility electrification programs for DAC and HTR populations. The findings include:

- Assessment of electrification readiness in DAC and HTR households.
- Cost estimates associated with such work in DAC and HTR households.
- What is needed to develop effective, properly budgeted program pathways to serve and electrify DACs and HTR communities.
- The various psychological and emotional barriers or concerns with electrification common in DACs and HTR communities.
- The overall sentiment and willingness of moving away from gas and other fossil fuels in DACs and HTR communities.

The results of this expanded field-collected housing survey dataset will complement the census data analysis in the first phase of the study and address information gaps regarding the electrification of DAC and HTR single family homes.

Methodology and Approach

The approach for data collection leveraged the networks of ESA contractors, CBOs, and independent energy specialists across the state for in-home surveys, utilizing an online survey tool. This tool is a revamped version of what was used for the first phase (ET22SWE0022). As part of the scope of work for this study, the team updated the field data collection tool and methodology for use in the survey of 300 homes.

The analysis examined the survey data to assess electrification readiness across DAC housing statewide. Survey data is consolidated across “categories” such as building type, building vintage, and utility company territory. Sample sizes for each category were used to inform confidence levels and where confidence was low, analysis was pushed to higher levels of consolidation. For instance, where county-level data was low-confidence due to sample sizes and data variability, utility territory consolidation was examined instead. Averages and distributions across answers for each survey question were explored independently across these categories.

In the final report, an Electrification Readiness Score has been formulated for each household. This single value score represents the amount of effort needed to electrify any given home, based on the data specific to that household. This is an untested methodology but could be highly advantageous in designing programs, estimating costs for individual houses, and for prioritizing electrification efforts. Estimated full and partial electrification costs will be similarly assessed and, if possible, related to survey data or electrification scores. Finally, these findings will be extrapolated to the full market size based on observed averages, weighted to existing market building categories, based on the results of the preceding phase one study published in 2023.

The project included several stages, each with its own timeframe:

- Survey tool updates and finalization: This was completed in the first two months of the program launch. The team modified and refined the survey. To the extent possible, questions were simplified with common metrics and units (e.g., tons for equipment capacity). Several qualitative questions regarding occupant receptiveness to electrification measures were added. Photo guidelines and a user manual for the survey were developed and used when training data collection personnel. A self-reporting survey tool for participants was created to reduce onsite field contractor work and provide the final checkpoint for participant gift card distribution. Using this tool, each customer automatically received a copy of their completed survey and access to selecting a gift card.
- Field contractor training: The team conducted presentations and training for field survey contractors covering the survey questions, data entry process, and expectations. Training focused on technical aspects of collecting household appliance data that may not be obvious, such as how to identify equipment type or size. Four hour-long training sessions were conducted: 3/15, 4/24, 4/30, 5/2.
- Survey implementation: Survey implementation managed by the team was conducted over four months by a variety of field contractors. The survey rollout and management were informed by a target sample size distributed across the state, designed to yield representative statewide results. As data accumulated, the team reviewed the data quality and answers to ensure quality and provide feedback to surveyors.
- Data analysis: Survey data analysis is ongoing. Anomalies and poor data entry were corrected where necessary through cross-checking answers and photographs taken at each site. Survey data was supplemented with building vintage and livable square footage using public real estate records. The results will be consolidated across building categories and assessed for electrification readiness, remediation costs, existing conditions, and necessary measures for partial and full electrification. Results will be extrapolated to the statewide DAC building stock, based on census statistics that were gathered during phase one.

  The project team included The Ortiz Group, AESC, and ASK Energy. The Ortiz Group team members worked and managed a variety of organizations to conduct field surveys including ESA contractors, CBOs, and independent energy specialists. These included:

1. Lovotti, Inc.
2. Staples Energy
3. Self Help Enterprises
4. Community Housing Opportunities Corporation
5. Green Energy Solutions

Literature Review

The project team conducted a review of various studies, extracting findings dealing with electrification, specifically as they relate to the unique challenges and barriers faced by DACs and HTR customers, for the adoption of efficient electrification and decarbonization technologies. The key themes identified in these studies and the missing links helped shape the questions and data to be collected as part of the housing characteristics study.

Below are excerpts from these studies, including arguments, conclusions, and recommendations that frame the scene for electrifying DAC and HTR households. Each study is summarized individually with the common themes among these studies as follows:

1. Low-income multifamily housing faces significant challenges in electrification, including electrical infrastructure limitations, space constraints, and complex program navigation.
2. Older homes, which make up about 75 percent of California's residential buildings, face additional obstacles to decarbonization, due to inadequate electrical systems and potential structural issues.
3. The high upfront costs of electrification and building envelope upgrades pose a major barrier for low and moderate-income households, with long payback periods often not feasible.
4. Energy burden is significantly higher for low-income households than for the broader market.
5. Equity considerations are crucial in decarbonization efforts, requiring collaboration among agencies, local governments, utilities, and community groups.
6. Targeted programs and incentives for low-income households are essential, as they require the most upfront capital and assistance for upgrades.
7. Marketing strategies for energy upgrades should be tailored to different consumer segments, with a focus on reducing total costs and emphasizing affordability for low-income customers.

Insights from Innovative Programs on Barriers and Opportunities for Heat Pump Adoption (Outcault, et al. 2024)

(Note: this project was in progress at time of writing this report)

The goal of this project is to create a resource on programs and strategies that encourage heat pump adoption in new and existing homes by targeting non-cost barriers to adoption. California has identified heat pumps as a keystone technology to its path to decarbonization and plans to prioritize dissemination among low-income households and DACs.

Low-Income Multifamily Housing Characteristics Study (McGrath, O'Connell and Parker 2023)

This study examines the barriers and opportunities in low-income multifamily housing for the adoption of efficient electrification and decarbonization technologies. The population analysis uses data from the United States (U.S.) Census Bureau and Department of Energy to examine multifamily housing in California.

- The study reveals that about a third of low-or-moderate income (LMI) households in California reside in multifamily buildings with five or more units, with over 90 percent renting their homes.
- These households are already housing cost burdened, spending 30 percent of their income on housing costs.
- The study suggests that electrical service upgrades will be needed at many multifamily affordable housing buildings, with opportunities for replacing gas-fired domestic hot water (DHW) systems with heat pump water heaters.
- Electric vehicle charging infrastructure and solar PVs are rare, underscoring an equity issue for this market segment.
- Multifamily affordable housing properties face challenges in electrifying their buildings, including electrical infrastructure limitations, space considerations, load reduction requirements, and the navigation of multiple programs with varying eligibility requirements.
- Emerging technologies like prefabricated DHW systems and low-power, plug-in heat pumps may help move electrification projects along. However, stakeholders also highlight the need for comprehensive, free technical assistance for multifamily affordable housing property owners, who may not have the capacity to develop scopes and roadmaps for their portfolios in-house.
- The industry must address these challenges and find ways to reduce energy demands and improve efficiency in these buildings.

Technology Development Recommendations

- Continued support for DHW electrification and innovative approaches like prefabricated heat pump water heater systems could expedite efforts to electrify.
- Market demonstration of in-unit heat pumps: Support for adoption of alternatives for electrifying heating loads and adding cooling for thermal comfort.
- Support for additional demonstration of integrated mechanical pods: Potential to reduce costs and accelerate deep energy retrofits in multifamily affordable housing.
- Support for market innovation by manufacturers of induction cooktops: New induction stoves that can operate using standard 120 volt (V)/20 amp (A) outlets could alleviate challenges of cooking electrification.
- Incentivize new in-unit heat pump clothes dryers: Ventless 120V condensing washer/heat pump clothes dryer combinations could be retrofitted into apartments with existing laundry appliances.

Program Development Recommendations

- Pair electrification with energy efficiency measures through weatherization programs like the Low-Income Weatherization Program (LIWP) and ESA Multifamily Energy Savings program.
- Incentivize electrical infrastructure upgrades, such as service upgrades to the transformer, to overcome barriers to full electrification.

- Support the deployment of solar PV and electric vehicle (EV) charging infrastructure to address equity issues.
- Conduct additional research on common area laundry facilities, involving leased appliances from third-party "route operators."
- Leverage other survey efforts to refine understanding of the market sector.
- Enhance workforce skills for the installation and service of electrification technologies.
- Provide technical assistance support, especially for nonprofit affordable housing providers.
- Reduce project costs and timelines through innovation in technology supports.
- Support upfront costs like engineering, permitting, and construction costs.
- Streamline program requirements and processes to make comprehensive electrification projects feasible in multifamily affordable housing.

Residential Electrical Service Upgrade Decision Tool (Douglass-Jaimes, et al. 2024)

California's climate and clean air goals require electrification of residential housing, but assuming it requires panel and service upgrades in dwelling with panels that have less than 200A capacity, the costs could range from $25–40 billion, impose additional stress on the electrical grid, and require significant upstream investments.

The proposed project aims to provide a Residential Service Upgrade Decision Tool for existing residential buildings.

- The Tool is aimed at utilities, homeowners, contractors, regulators, and policy makers.
- The Tool provides guidance on when to upsize electrical panels and service and manage available capacity to electrify homes.
- Differentiated information is provided based on the intended audiences, including homeowners, contractors, and policy makers.

Residential Water Heater Sizing Measure Package Support (TRC Advanced Energy 2022)

Current incentives for energy efficient water heater retrofits require a like-for-like replacement, however contractors often upsize heat pump water heater replacements compared to existing gas water heaters and electric resistance water heaters. The project explores incentives for non-like-for-like size replacement and provides updates to the DEER Water Heater Calculator V 5.1 (California Public Utilities Commission 2022).

- Heat pump water heaters consumes significantly less energy compared to alternatives.

- Incentives based on tank size could discourage retrofits from electric resistance and gas water heaters to heat pump water heaters.
- A survey of 16 plumbing contractors in the TECH Clean California program reveals most contractors are upsizing tanks when moving from a gas or electric resistance water heater to a heat pump water heater.
- Heat pump water heater replacements require circuit breaker upgrades in approximately half of their projects.
- The most common type of replacement is from natural gas water heater to a heat pump water heater.

Equitable Electrification Analysis for Existing Buildings in Richmond, CA (Moe and Gibbs 2023)

This report analyzed 98 percent of residential and 55 percent of non-residential building square footage in Richmond, California, using data tools developed by National Renewable Energy Laboratory (NREL). It examined energy consumption, fuel use patterns, greenhouse gas (GHG) emissions, costs, utility bill impacts, employment impacts, and health impacts of building envelope and electrification upgrades. The findings include the following low-income specific challenges and considerations for electrification:

- Richmond's households pay an average of two percent of their income on energy costs.
- Extremely low-income households in Richmond (i.e., those earning less than 100 percent of the federal poverty level) spend an estimated 16 percent of their household income on average on energy, compared with about one percent for households earning more than 400 percent of the federal poverty level.
- The high upfront cost of both envelope and electrification measures may be a barrier to low- and moderate-income owner households, and to small-scale landlords (i.e., those that own single family and small multifamily rental properties).
- Even when items are cost-effective over the lifetime of the measures, a 15- to 30-year payback may not be feasible for many households — especially low-income households and for People of Color — who are more likely to be living paycheck to paycheck and with limited savings (Despard, et al. 2020).
- In addition, depending on interest rate levels which are currently at 15-year highs (FRED, n.d.), the cost to finance these measures will reduce some of the savings they could generate.
- At a city-wide scale, based on the modeled results, only envelope measures have a positive return-on-investment over the lifetime of the measures without considering potential rebates.
- Higher-efficiency electrification plus envelope measures become cost-effective when currently available rebates are applied, and higher-efficiency electrification alone comes close to being cost-effective when rebates are applied.

- Modeled residential upgrades in Richmond are expected to result in less savings for lower-income households, renters, and multifamily buildings, compared with higher-income households, owners, and single family buildings, reducing the likelihood of a positive return-on-investment for upfront costs, particularly electrification upgrades.

Statewide 120-Volt Heat Pump Water Heater Field Study (Khanolkar, Egolf and Gabriel 2023)

Heat pump water heaters are a key component for facilitating building decarbonization and energy efficiency. However, challenges exist, including high upfront costs, space requirements, installation complexity, inadequate electrical infrastructure, and a bias toward conventional models. Plug-in 120V heat pump water heaters aim to address these barriers.

- New Buildings Institute (NBI) collaborated with 120V heat pump water heater manufacturers and utilities in California for a statewide field validation program.
- The Quick Start Grant project examined energy performance, installation, equipment, operating costs, and customer satisfaction for 120V heat pump water heaters.
- Stakeholders developed a technical specification for an efficient, load-shifting-capable heat pump water heater that could be plugged into an outlet on a shared 120V 15A circuit.
- The specification addressed technology and cost barriers that prevent widespread conversion of gas water heaters to heat pump water heaters.
- Installing a 240V heat pump water heater can necessitate electrical panel and infrastructure upgrades, which can cost more than $20,000.
- By contrast, the 120V heat pump water heater option can minimize or eliminate these infrastructure upgrade costs altogether.
- The study concluded that 120V heat pump water heaters are a robust solution for meeting decarbonization or electrification goals for the retrofit market sector.
- However, the market needs more innovative solutions like this emerging technology to support the gaps where a 120V heat pump water heater is not feasible.
- While 22 percent of the study sites could be directly supported by plug-in water heaters, the remaining sites still need unique solutions for replacements.
- There is an immediate need for smaller footprint and smaller form factor products, as well as products with improved compressor capability for cold climates.
- While European and Asian markets have distinctive products to meet space constraints, more such products should be manufactured within the U.S.

Heat Pump HVAC Retrofit Cost Drivers (Sarkisian, et al. 2023)

A major barrier to heat pump adoption in residential retrofit markets is its higher purchasing cost, compared with conventional gas alternatives. Additionally, benefits like energy savings and grid value are not fully capturable at the time of installation. The findings from this research aims to help California homeowners; heating, ventilation, and air-conditioning (HVAC) contractors; policymakers; agencies; other incentive program implementers; and a variety of other stakeholders make more informed investment decisions.

- Improved equipment performance — e.g., higher Seasonal Energy Efficiency Ratio (SEER), performing a duct replacement, and performing Manual-D / Manual-J, — increases the project cost, but is considered a worthwhile investment.
- An electrical panel upgrade and heat pump HVAC retrofit increase the total project cost by approximately $1,500.
- DAC status is not a cost driver.
- Installations in old homes cost more at a rate of $826 per 10 years of average age: A heat pump HVAC system in a home in a census tract with an average home age of 60 years is likely to cost over $4,000 more than the equivalent heat pump HVAC installation in a census tract with an average home age of 10 years.
- Heat pump HVAC retrofits in homes with air conditioners cost approximately $1,000 less than homes without air conditioners.
- Projects in counties served by more TECH Clean California-enrolled contractors cost $1,031 less, on average, than projects in counties not served by TECH Clean California-enrolled contractors.
- Less expensive equipment types are popular, but the least expensive is not the most popular: Ducted split unitary systems were installed in more than 60 percent of projects.

Impact of Decarbonization on the Resiliency of Single-Family Homes in Palo Alto (Jahangard 2021)

The study explores the impact of decarbonization on the resiliency of single family homes in Palo Alto. It compares the reliability and resiliency of mixed-fuel homes versus all-electric homes, considering various outage scenarios and energy supply options. Worth noting, the study examines its own geographic location as a whole, as opposed to specific demographics or segments of the population individually.

- Home Appliance Survey: Conducted a survey categorizing appliance operation during electricity and natural gas disruptions, finding major electricity uses and impacts on homeowners.
- EVs vs. Internal Combustion Engine (ICE) Vehicles: Explored EV options, range, and backup electricity provisions, concluding that fully electrified homes may be more resilient due to onsite generation.
- Electricity Use Comparison: Modeled electricity use of mixed fuel versus all-electric homes, highlighting significant increases in electricity consumption for electrified homes.
- Methods to Enhance Resiliency: Explored energy supply products, such as rooftop solar plus storage, mobile power stations, and backup generators, to enhance home resiliency.

- Reliability Comparison: Compared reliability metrics of Palo Alto's electricity and natural gas systems, indicating fewer interruptions in natural gas service than electricity service.
- Resiliency Comparison: Examined outage scenarios including earthquakes, localized power outages, and cyberattacks, highlighting inconclusive findings on mixed fuel versus all-electric home resiliency.
- City of Palo Alto Utilities Initiatives: Outlined initiatives to enhance energy reliability and resiliency, including adding electric transmission lines, undergrounding electric distribution lines, and replacing natural gas pipes.
- Summary of Findings: Summarized key findings, including the inconclusive nature of mixed-fuel home resiliency, the importance of energy resiliency products, and the impact of transmission line loss scenarios on fully electrified homes.
- In conclusion, the study provides insights into the complexities of enhancing home resiliency amidst decarbonization efforts, emphasizing the need for tailored solutions and further research in this domain.

California Building Decarbonization Assessment – Final Commission Report (Kenney, et al. 2021)

The California Building Decarbonization Assessment is the initial report addressing the mandates from Assembly Bill (AB) 3232. Compiled by the California Energy Commission (CEC), the results of the AB 3232 assessment, as detailed in the California Building Decarbonization Assessment – Final Commission Report, are both extensive and comprehensive, highlighting a number of findings, conclusions, and recommendations relating to the barriers to electrification for low-income households and DACs, which can ultimately help guide California's building decarbonization policy.

Residential Building Stock

- Older homes face significant obstacles to decarbonization, such as inadequate electric panels, insulation, ventilation, and structural issues.
- Approximately 75 percent of California's residential buildings, totaling around 9.75 million units, were constructed before 1990.
- Structural retrofits may be necessary for older buildings, which can complicate decarbonization efforts.
- Older homes often contain unhealthy materials and equipment, leading to higher health risks for occupants, particularly low-income individuals.
- California's housing crisis exacerbates barriers for low-income households, with insufficient affordable housing options and owners often unable to finance upgrades.

Financial Barriers

- The costs of upgrades are substantial, potentially preventing lower- and middle-income residents from participating in decarbonization efforts.

- Building owners require assurances of financial incentives to cover upgrade expenses before committing to the process.
- Some electric technologies have premium prices, which can be a barrier to adoption, particularly for low-income individuals or families.
- Retrofit costs for existing homes to decarbonize vary based on factors like size, age, and climate zone, which may impact low-income households differently.
- Upgrading electric panels to accommodate new electric equipment can be costly, especially for older homes, posing a barrier to electrifying existing homes and promoting access to EVs.
- Utility rates have been rising, which could disproportionately affect low-income and DAC households. However, transitioning to all-electric homes and EVs could potentially lower energy bills, offering relief to some households.
- Electrification scenarios could lead to varied effects on customers' bills, depending on factors like building operation, end use, rate changes, building type, age, climate zone, and integration with other technologies, such as rooftop PV, battery storage, or EVs.
- There are concerns about the ongoing equity issues surrounding rate increases and the coverage of utility costs, which may exacerbate disparities in utility bill burdens.

Capital Constraints in Retrofit Projects

- Lack of upfront capital hinders participation in energy retrofits for both residential and commercial buildings.
- Retroactive rebates fail to cover sufficient costs, limiting customer involvement.
- Low- or moderate-income households require access to zero-to-low upfront cost programs and technical assistance for participation.

Equity Considerations

- Low-income households and DACs face complex barriers to decarbonization, due to limited disposable income and a disproportionate burden from environmental pollutants.
- These communities primarily consist of Hispanic, Black, Native American, and other People of Color, where systemic discrimination, environmental hazards, and poverty intersect.
- Low-income households experience a higher percentage of total income devoted to energy costs, termed as "energy burden," leading to conservation measures that may not be healthy or safe.
- Low-income homeowners may face barriers to decarbonizing their buildings through electrification, including affordability, program design, and the age of existing buildings.
- Renters, particularly Native American, Black, and Hispanic households, face higher energy burdens, compared with non-low-income households.

- Barriers include upfront costs of upgrades, age of existing buildings, effects of energy upgrades on tenant rents, unstable project cashflow, maintenance costs, availability of local contractors, renter status, and resource availability.
- The global pandemic exacerbates these issues.

Rural Areas

- Rural areas face limited program and financing options, lack access to the state's electric grid, and may have higher energy burden due to reliance on expensive fuels and increased pollution.

California Native American Tribes

- Tribes face challenges with unreliable access to electricity or gas lines, limited access to federal funding for retrofitting, and housing issues like mold, wood rot, and asbestos.
- State and local governments need to increase partnerships to support tribes in transitioning to clean energy.

Impacts of Existing Programs and Bills

- The California Solar Initiative (CSI) provided substantial rebates to customers, totaling over $2.9 billion. However, wealthier customers took advantage of favorable rooftop PV rates, leading to an increased financial burden on lower-income customers who had to bear the utility investment costs.
- The Self-Generation Incentive Program (SGIP), administered by the CPUC, aims to reduce emissions and enhance the system reliability through distributed generation incentives. It primarily funds energy storage projects but also supports wind turbines, combined heat and power, and fuel cells. Approximately 25 percent of the SGIP budget is allocated for disadvantaged and low-income communities.
- Achieving the goals of Senate Bill 100 is expected to bring benefits such as improving public health by reducing the need for fossil fuels in electricity generation, advancing energy equity by ensuring that low-income households and DACs benefit from the clean energy future, and stimulating a clean energy economy through innovation and market development for renewable energy, energy efficiency, energy storage, low-carbon fuels, and zero-emission vehicles.
- Residential Property Assessed Clean Energy (PACE) is an option but has limitations and affordability concerns for low- and middle-income households.

Workforce Impacts and Needs

- The clean energy sector in California, while growing, faces challenges such as job losses due to the COVID-19 pandemic, lack of representation from women and People of Color, and below-average unionization rates.
- Building decarbonization may lead to job gains in construction, trades, and electric utility sectors but job losses in the gas sector.
- To meet climate goals, California needs to expand its clean energy workforce and ensure a just transition for workers from the gas sector.

Financial Needs for Decarbonization

- An estimated $5 billion annually is needed to decarbonize the residential sector, particularly for low- to moderate-income households.
- On-bill financing (OBF) leverages funds from capital providers, collected through a tariff tied to the building meter, and can be applied to both occupant-owned and rented units.

Conclusions and Recommended Strategies

- Equity considerations are paramount and require collaboration amongst agencies, local governments, utilities, and community groups.
- Decarbonization initiatives should involve environmental justice communities throughout the effort and reflect their needs and priorities.
- Decarbonization strategies must address barriers that could disproportionately affect low-income households or DACs.
- Energy efficiency upgrades in low-income housing could result in significant bill savings for tenants and create long-term job opportunities.
- The implementation of a statewide on-bill program could remove upfront costs, support the clean energy workforce, and drive building decarbonization.
- Direct-installation programs, like the LIWP, have proven successful but are underfunded and need promotion and funding. LIWP is underfunded with a waitlist of more than 10,000 homes.
- Targeted programs for low-income households are crucial, as they require the most upfront capital and assistance for upgrades.
- Program designs should avoid exacerbating equity issues by ensuring benefits reach low-income households and DACs.
- Efforts are needed to distribute resources equitably and avoid primarily benefiting higher-income households.
- Energy code compliance is crucial for tracking building decarbonization success.
- Programs must be available in multiple languages to ensure accessibility for all Californians.

Residential Building Electrification in California: Consumer economics, greenhouse gases and grid impacts (Mahone, et al. 2019)

The 2018 study suggested that building electrification could be a lower cost carbon mitigation option than other alternatives. However, the study did not include a detailed assessment of the customer economics of building electrification, or of the market barriers and opportunities for electrification.

- Electrification can aid sustainability and equity policies, with heat pump HVAC systems offering climate adaptation benefits. These systems, combined with better building design and resilient communities, can protect public health in low-income and vulnerable areas during severe heatwaves.

- Incentives and low-cost financing for landlords and low-income consumers should be the CPUC's primary focus, in order to remove capital cost barriers and benefit all communities from clean energy. This will ensure that consumers can purchase new equipment if their current equipment malfunctions and help remove any upfront barriers.

Messaging Comprehensive Retrofits (Sussman, Lewallen and Conrad 2024)

The study aims to understand the factors driving homeowners' decisions regarding home energy upgrades, identify preferences among different demographic segments, and recommend tailored retrofit packages and marketing strategies to increase uptake.

- Homeowners prioritize upfront costs, bill savings, and home comfort when considering energy upgrades.
- Although many homeowners are willing to spend at least $1,000, comprehensive retrofits tend to be more expensive.
- A zero-interest loan with no upfront costs was the most effective incentive in shifting behaviour toward upgrading.
- Recommendations include tailoring retrofit packages and marketing approaches based on consumer segments and offering comprehensive upgrades after trigger points like an HVAC replacement or new home purchase.
- Most preferred standalone upgrades include windows and door upgrades, solar panel installation, and HVAC upgrades, though windows and solar are less appealing as part of comprehensive, bundled retrofit packages.
- Lowest-income households and those with less education prefer packages with upgraded heating and cooling systems and heat pump hot water heaters but are less interested in EV chargers or efficient windows due to high costs and lower bill savings.
- Low-income homeowners are strongly motivated by packages that include solar, along with other energy upgrades, except windows.
- A significant portion of homeowners are unable or unwilling to invest even $1,000 in energy upgrades, preferring the cheapest options regardless of benefits.
- Marketing campaigns for low-income customers should focus on reducing total costs and emphasizing program measures to make upgrades more affordable.

Findings

Overview

The survey results yielded a large amount of data that was analyzed and organized into subsections, starting with high-level findings and getting more granular toward the end:

- **Demographics of the Housing Stock:** Survey distribution, building types, square footage, vintage, and locations within California relative to IOU service region.
- **Electrical Infrastructure:** The location of the power lines (above ground or buried), service capacity, electrical panel capacity, and distance between electrical and gas meters.
- **End Uses:** Individual end uses including space heating, space cooling, water heating, cooking appliances, and clothes dryers, including the specific technology, size, and fuel type.

Current Market Barriers and Gaps

- **Gauging Electrification Sentiment:** Electrification sentiment is one of the greatest barriers to market transformation. The final part of the survey was designed with targeted questions to uncover the realities and perceptions (truths and myths) surrounding electrification that exist, along with any potential correlations between participant groups and segments.
- **Electrification Sentiment Score:** To represent a homeowner's sentiment toward electrification with a single value, an "electrification sentiment score" was used. This score combines the eight true/false responses to electrification myths and the six electrification interest questions into a single number.

Market Opportunities

- **Electrification Measure Costing:** The cost of electrification for DACs and HTR communities is arguably the single most critical component for electrification. The average cost of electrification, itemized by specific measure and based on building type (mobile home, multi-unit, single family), is explored in this section.
- **Electrification Readiness Score:** An assessment of 'electrification readiness,' including barriers, remediation costs, equipment sizing, and the appliance mix at each home is possible through a standardized 'Electrification Score.' This score assigns a single value to each home, based on a weighted accounting of each datapoint, estimated costs for electrification measures, and the estimated complexity of the remediation steps and electrification measure installation. The lower the score, the more complicated, expensive, and time consuming the electrification project will be. The higher the score, the simpler, cheaper, and less time consuming the electrification project will be.

Stakeholder Feedback

As part of the study, stakeholders from CBOs, contractors, energy experts, and civic leaders provided valuable feedback on barriers and opportunities for electrification in DACs and HTR communities. Key themes from the feedback sessions included:

- **Affordability and Utility Support:** Stakeholders voiced concerns over rising energy costs and emphasized the importance of utility involvement to help offset costs for low-income households.
- **Infrastructure Challenges**: Prohibitive upgrade costs and grid limitations, particularly in rural areas, were highlighted as significant barriers. Microgrid solutions were proposed to address resilience and cost-effectiveness, especially for rural DACs and HTR communities.

- **Cultural Ties and Misinformation**: Strong cultural attachments to gas appliances and misinformation on electrification presented challenges. Stakeholders suggested tailored educational outreach and using early adopter testimonials to build trust and encourage adoption.
- **Solar as a Transitional Step**: Participants recommended prioritizing solar installations with battery storage as a gateway to electrification, leveraging federal funding for DACs and HTR communities to reduce costs and improve energy resilience.

Demographics of the Housing Stock

The survey data analyzed 300 participating households, comprising a range of building types, square footage, building vintages, and locations within California. The following figures demonstrate the spread of data across these categories. The participants were engaged with ESA programs, and, as such, may deviate slightly from the general population in undetermined ways. Additionally, of the 300 participants, only five were in rural zip codes and seven in "small towns," as designated by the U.S. Department of Agriculture (USDA n.d.). Therefore, the results should be considered as primarily representative of urban and metro-adjacent areas.

Figure 1 shows the distribution of DAC and HTR cities and towns across California where the surveys were conducted plotted on a map.

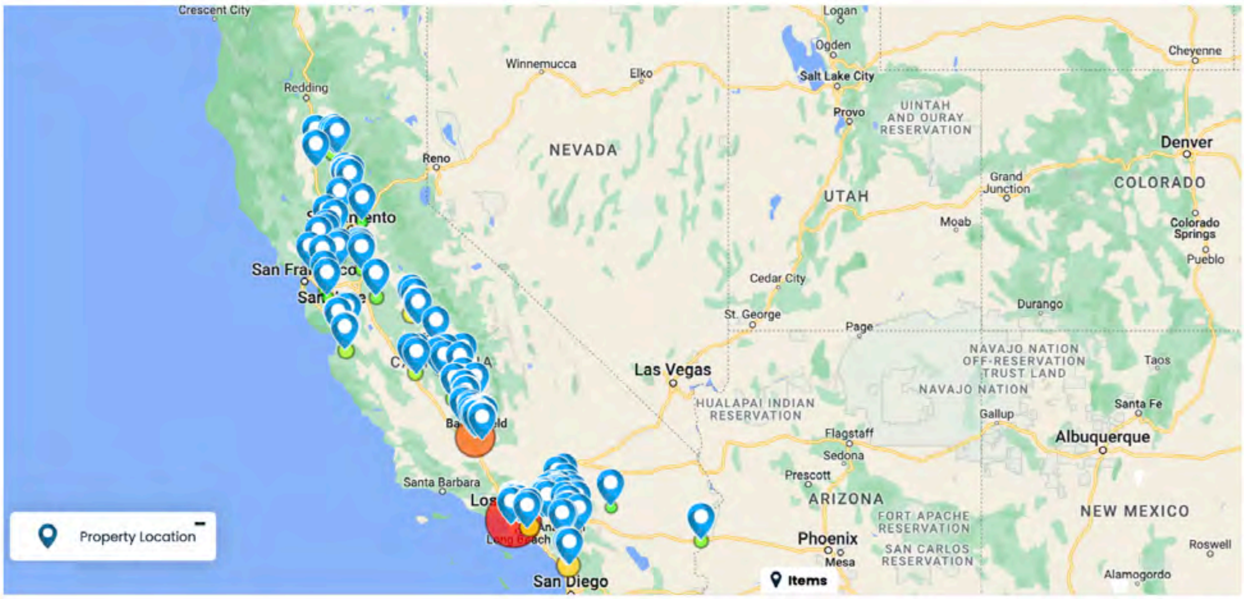


Figure 1: Survey responses by city/town plotted on a map of California.

Table 1 shows the total number of surveys conducted for each respective California county by building type.

Table 1: Survey Responses By County And Building Type

County	Mobile Homes	Single Family Homes	Totals
Alameda	0	2	2
Butte	3	3	6
Contra Costa	0	4	4
Fresno	5	3	8
Glenn	3	3	6
Kern	8	49	57
Kings	2	4	6
Los Angeles	13	62	75
Madera	3	4	7
Merced	0	6	6
Monterey	0	8	8
Orange	0	5	5
Riverside	4	15	19
Sacramento	0	1	1
San Bernadino	4	21	25
San Diego	1	20	21
San Joaquin	0	5	5
Santa Clara	0	3	3
Santa Cruz	0	3	3
Solano	0	4	4

County	Mobile Homes	Single Family Homes	Totals
Stanislaus	0	5	5
Sutter	2	5	7
Tulare	4	6	10
Yolo	0	2	2
Yuba	4	1	5
	56	**244**	**300**

The share of survey responses for each IOU, seen in **Error! Reference source not found.**2, is roughly proportional to the size of each utility's physical territory.

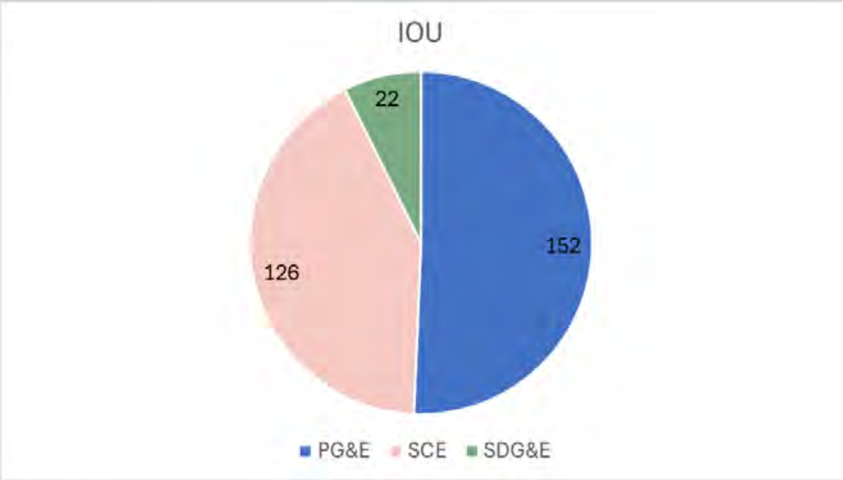


Figure 2: Survey responses by utility territory.

The survey received responses from different climate zones, seen in Table 2; however, they were unevenly distributed, therefore an in-depth analysis by climate zone was not performed.

Table 2: Survey Responses by Climate Zone

Climate Zone	Totals
1	0
2	0
3	13
4	3
5	0
6	0
7	21
8	80
9	0
10	34
11	25
12	25
13	88
14	3
15	5
16	3

Error! Reference source not found. shows the breakdown of responses by building type: detached single family home, mobile/modular home, duplex, triplex, or fourplex (i.e., attached single family home). The responses for manufactured homes (i.e., mobile and modular homes) are mainly representative of mobile homes, as the survey results included 56 responses for mobiles homes and only four responses for modular homes.

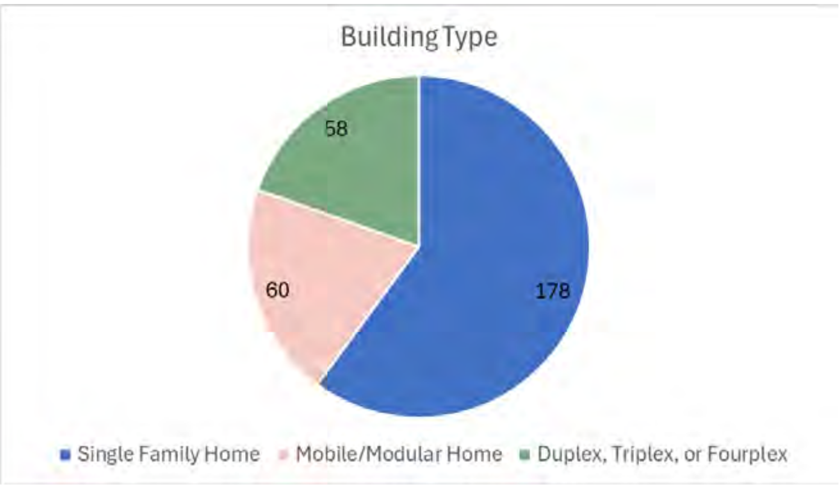


Figure 3: Survey responses by building type.

The distribution of survey responses across building vintage and building square footage are shown in **Error! Reference source not found.** and **Error! Reference source not found.**.

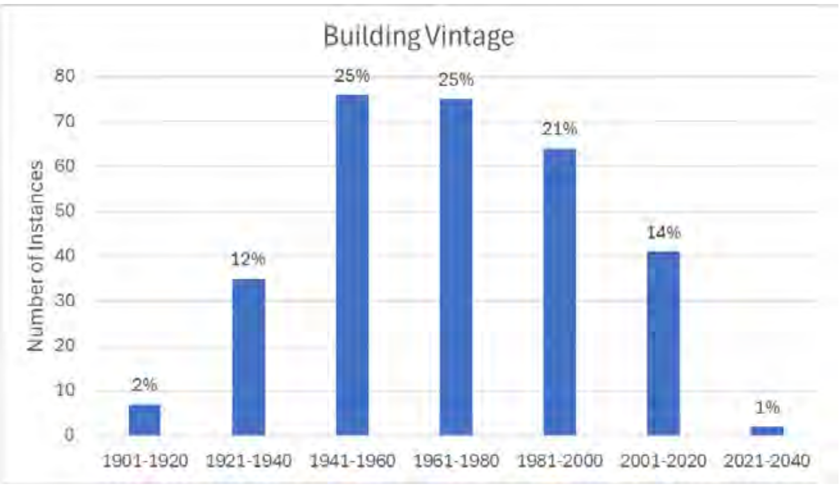


Figure 4: Survey responses by building vintage.

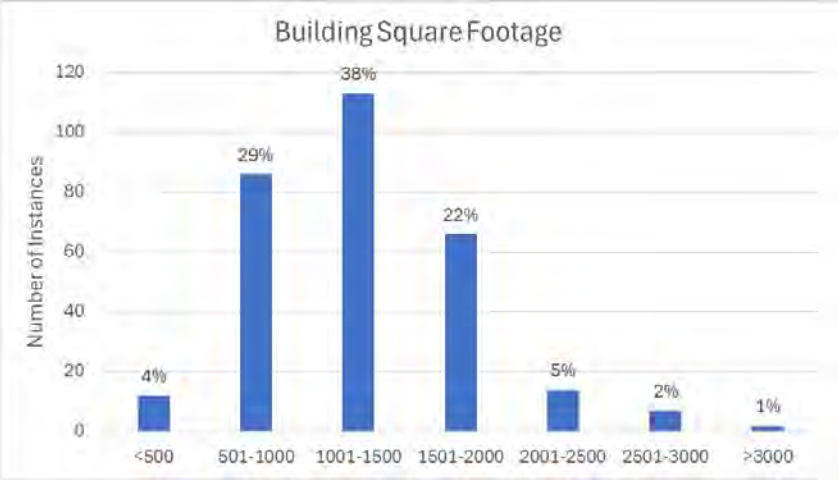


Figure 5: Survey responses by building square footage.

Electrical Infrastructure

The survey included several questions related to electrical infrastructure conditions at each site. These conditions are particularly important as remediation costs for electrical service and panel upgrades can often be one of the highest cost factors in electrification of existing homes.

Electric delivery location can impact the cost of electrification if power lines or service capacity need to be upgraded. Homes with underground power lines are likely to greatly increase costs if upgrades are needed.

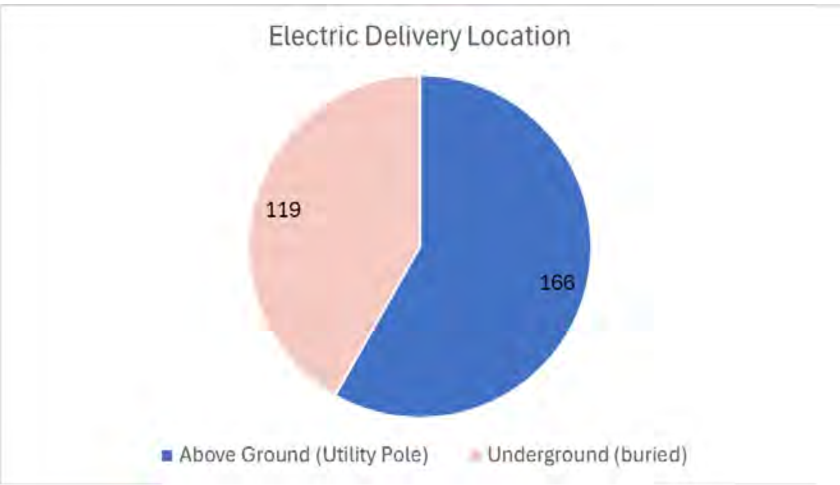


Figure 6: Survey responses by electric delivery location.

Error! Reference source not found. and **Error! Reference source not found.** show a correlation in the survey data of building vintage and size, with electric delivery location demonstrating that newer and larger houses are more likely to have underground service. Of the houses surveyed, newer houses tended to be slightly larger; however, this did not fully account for the increased likelihood of larger houses being served by underground power lines.

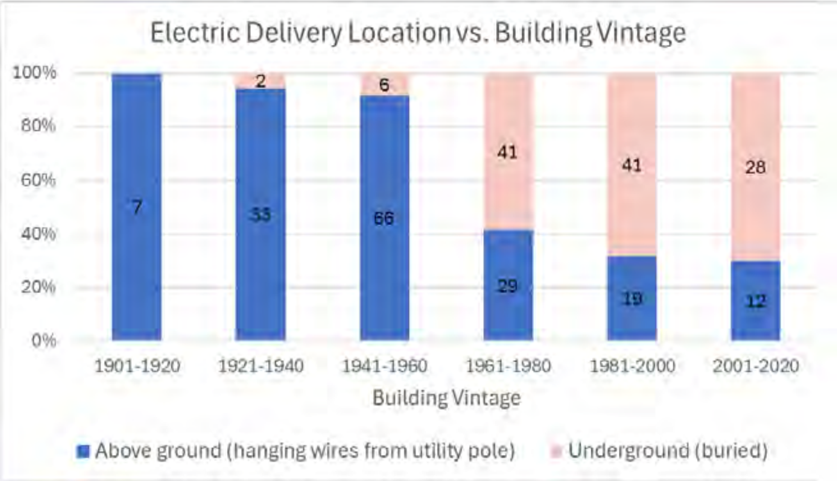


Figure 7: Distribution of electric delivery location by building vintage.

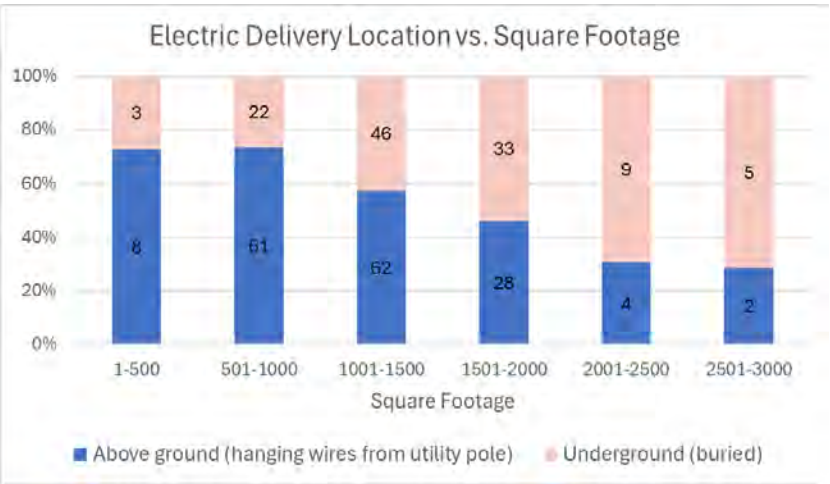


Figure 8: Distribution of electric delivery location by building size.

If a house already has an electrical panel with a large capacity, upgrades are less likely to be needed, and underground power lines may not pose a significant cost barrier. However, **Error! Reference source not found.** shows that, of the houses surveyed, houses with smaller panel capacities, which are more likely to require an upgrade, were also more likely to have underground power lines.

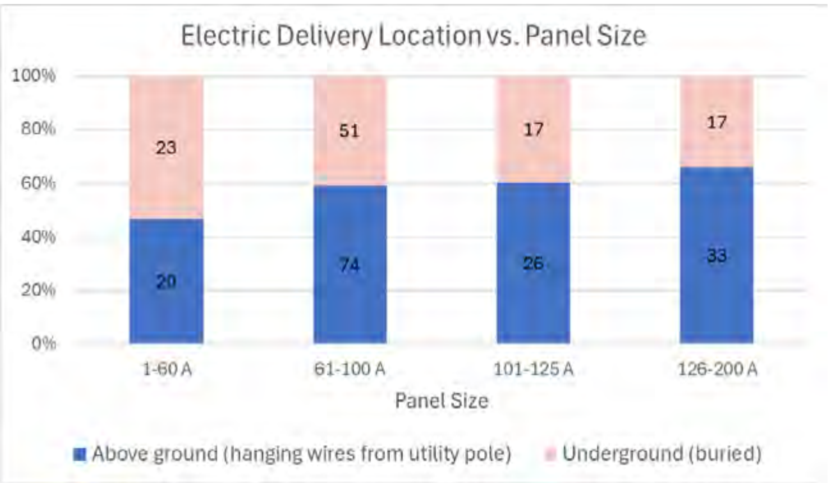


Figure 9: Distribution of electric delivery location by panel size.

Of the surveyed households, nearly two-thirds have an electrical panel size of 100A or less, which may need a panel upgrade during electrification or other solutions such as circuit splitters. **Error! Reference source not found.** shows that both mobile homes and multiplexes are more likely to have a panel of 100A or less, or panels of 60A or less. **Error! Reference source not found.** shows that larger houses also tend toward larger panel sizes.

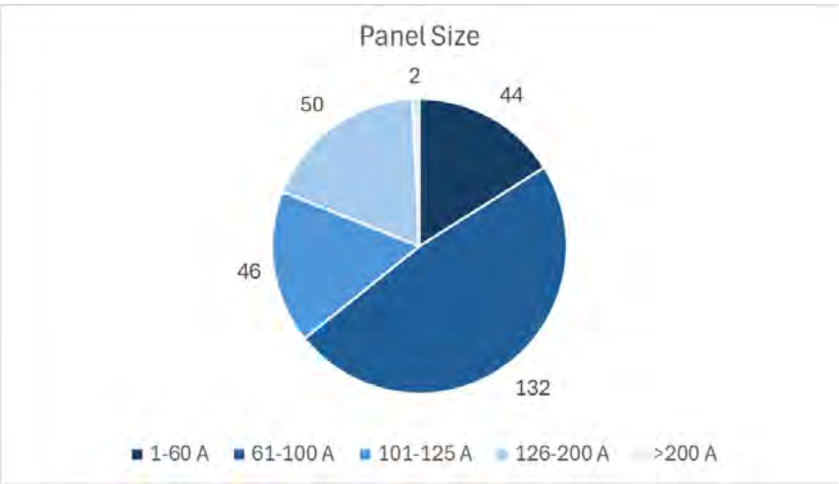


Figure 10: Survey responses by panel size.

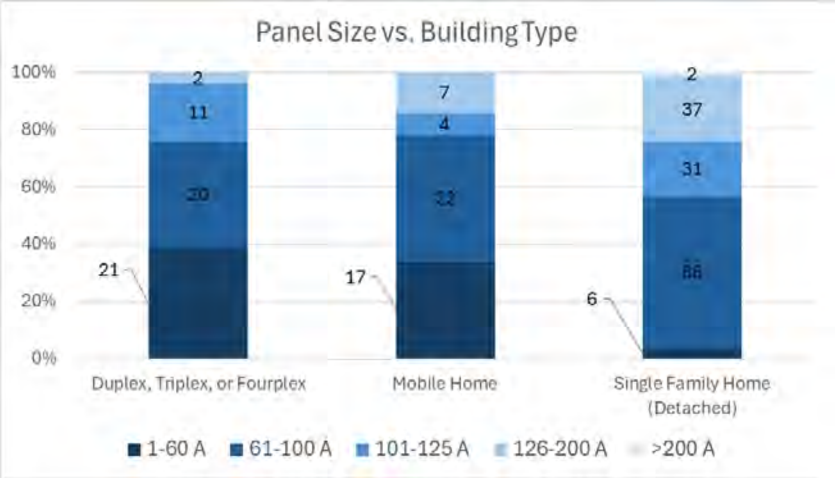


Figure 11: Distribution of panel size by building type.

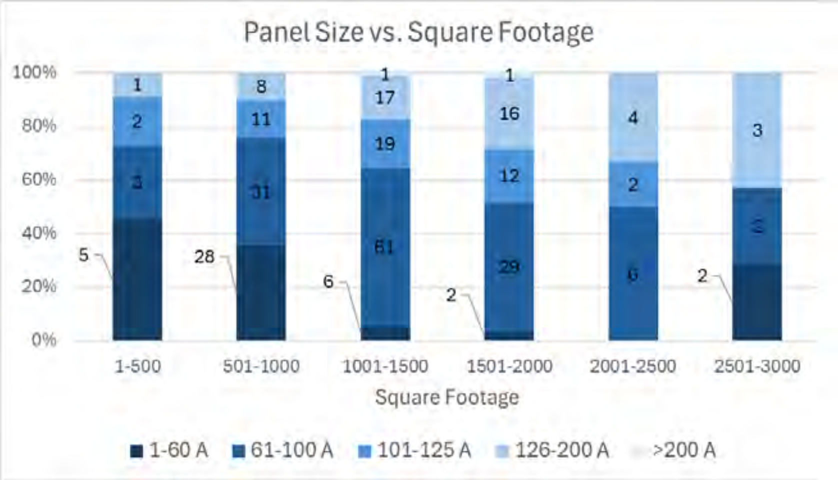


Figure 12: Distribution of panel size by building square footage.

Distribution of panel size between utilities may be of interest when developing electrification programs. Per survey data, **Error! Reference source not found.** shows that houses surveyed in Pacific Gas and Electric (PG&E) territory are most likely to have a panel size of 100A or greater and that houses in San Diego Gas and Electric (SDG&E) territory have the largest share of both panels of 60A or less and panels greater than 100A.

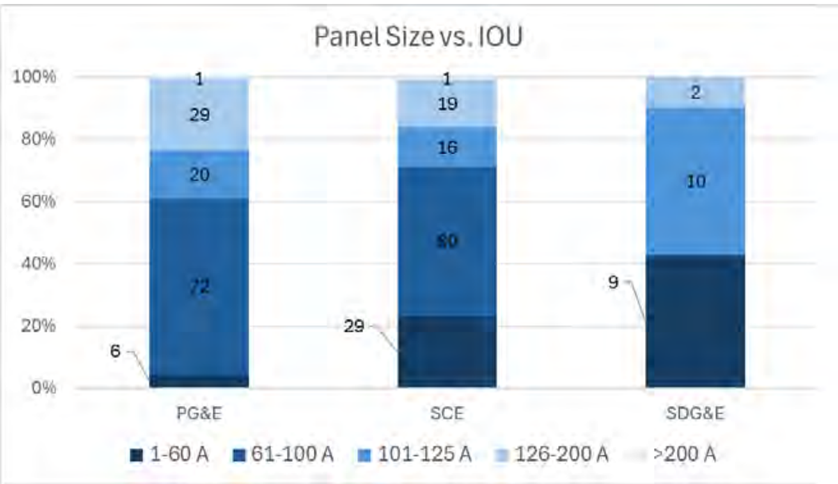


Figure 13: Distribution of panel size by utility.

Approximately one-fourth of survey responses indicate that the electrical or gas meter may need to be relocated in the case of a panel upgrade. **Error! Reference source not found.**15 shows that a far greater portion of houses surveyed in SDG&E territory have electrical and gas meters that are within five feet of each other. **Error! Reference source not found.** shows a surprising fact — that newer houses may be more likely to have meters near each other.

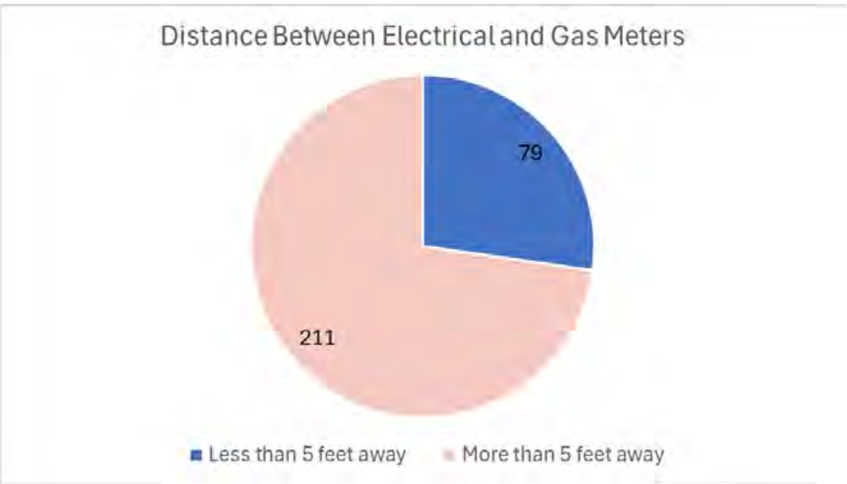


Figure 14: Survey responses by electrical and gas meter proximity.

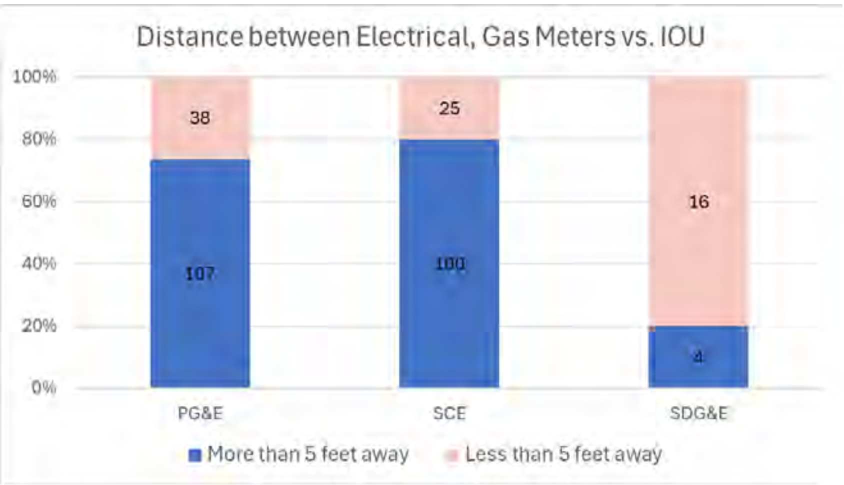


Figure 15: Distribution of electrical/gas meter proximity by utility.

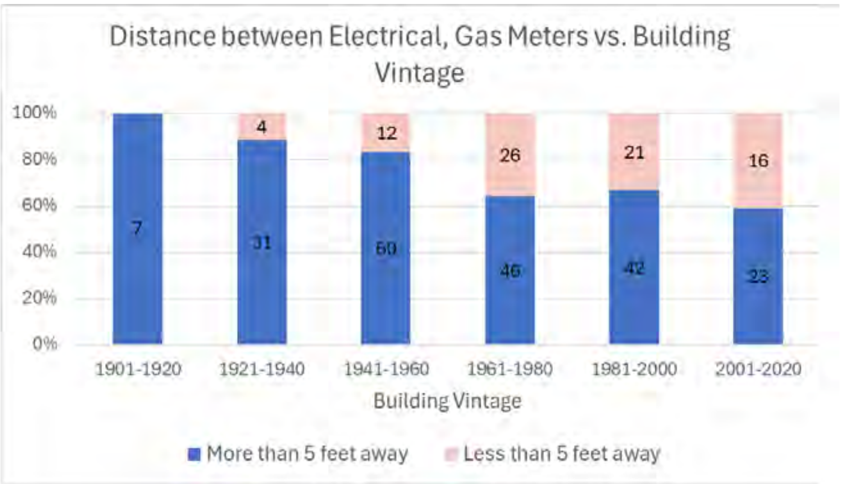


Figure 16: Distribution of electrical/gas meter proximity by building vintage.

End-Uses

The survey also includes data on individual end uses, including space heating, space cooling, water heating, cooking appliances, and clothes dryers.

Error! Reference source not found. shows the types of space heating equipment used in the surveyed homes. The "Other" category includes equipment types — such as baseboard heater, stove, fireplace, window unit, and more — which occurred in very few responses. **Error! Reference source not found.** shows that most households surveyed reported a properly sized heating system except for houses using wall heaters, which were often undersized, suggesting that they will need additional capacity. **Error! Reference source not found.** gives the reported capacity of each equipment type.

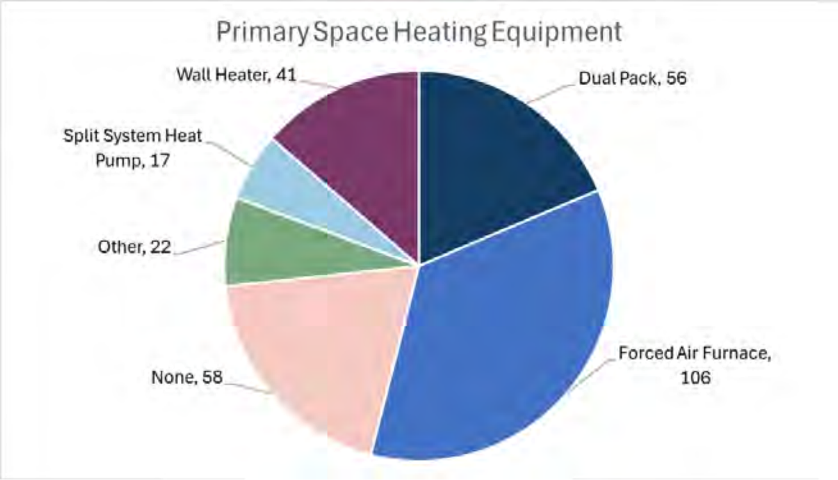


Figure 17: Survey responses by space heating type.

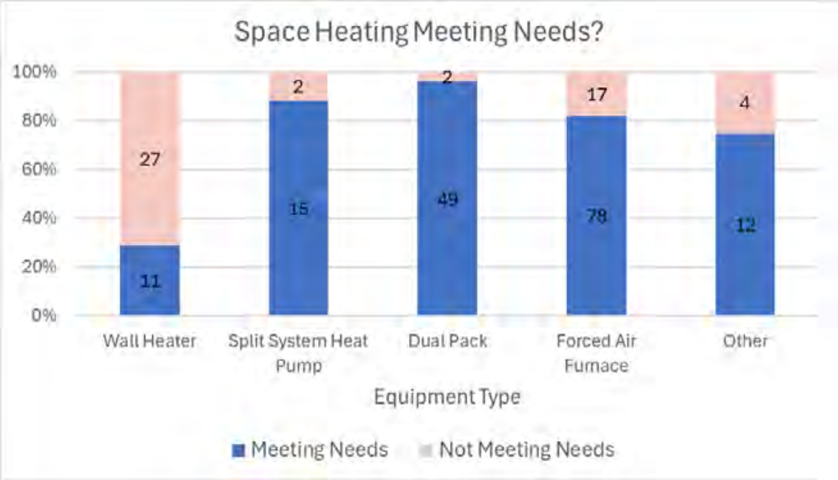


Figure 18: Distribution of undersized heating systems by equipment type.

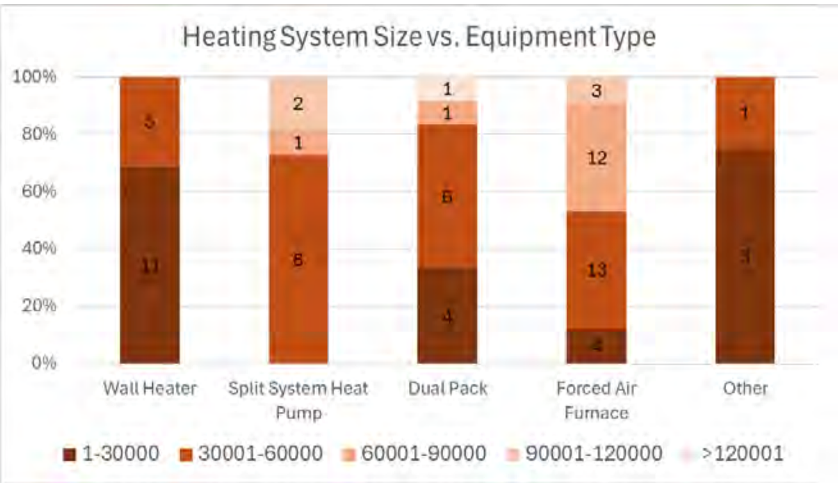


Figure 19: Distribution of heating capacities by equipment type, in Btu/hr.

Error! Reference source not found. shows the types of space cooling equipment used in the surveyed homes. The "Other" category includes equipment types — such as mini split, evaporative cooler, packaged terminal air conditioner (PTAC), and more — which occurred in very few responses. **Error! Reference source not found.** shows that most households surveyed reported a properly sized/oversized cooling system except for houses using wall and window AC units, which were often undersized, suggesting that they need additional capacity. **Error! Reference source not found.** gives the reported capacity of each equipment type.

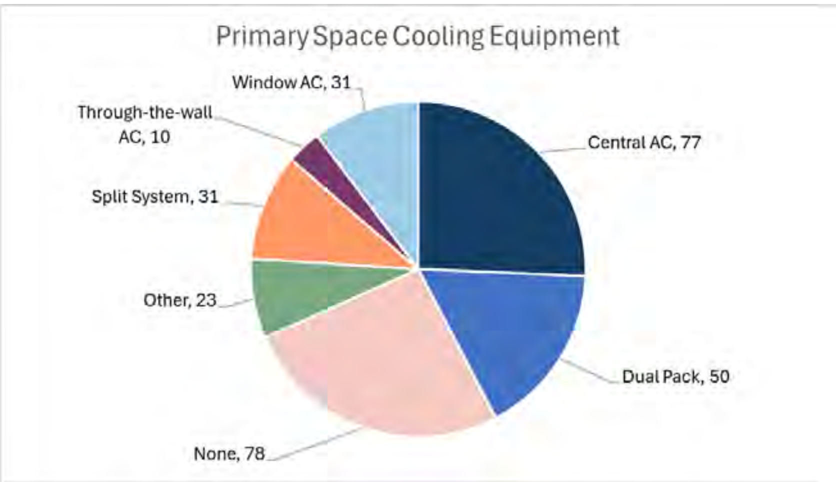


Figure 20: Survey responses by space cooling type.

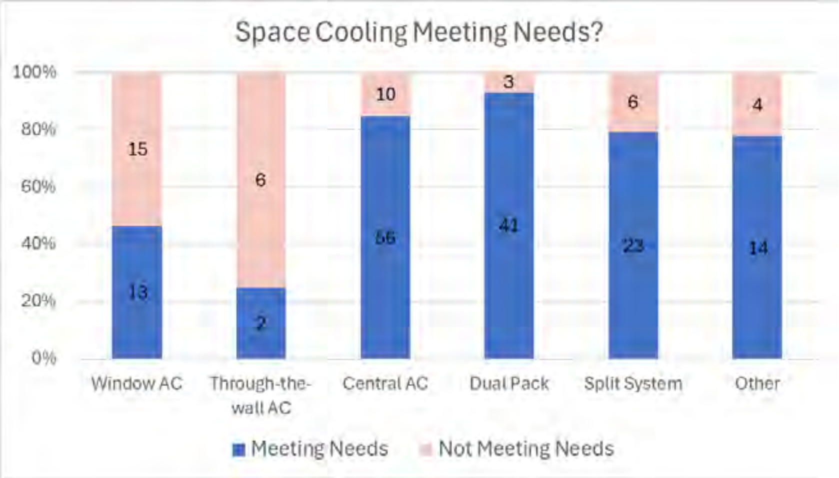


Figure 21: Distribution of undersized cooling systems by equipment type.

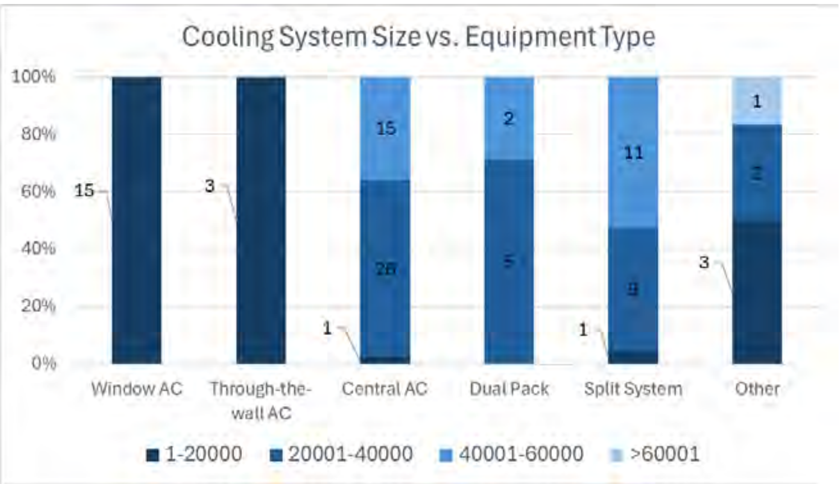


Figure 22: Distribution of cooling capacities by equipment type in Btu/hr.

More than 95 percent of surveyed households reported having a water heater, with a large majority served by gas and mostly in the “Storage Tank – Gas” category as shown in **Error! Reference source not found.**. Note the distinct low penetration of heat pump water heaters in this market and the remaining high-priority opportunity to replace electric resistance water heaters. **Error! Reference source not found.** shows the sizes of the storage tank water heaters surveyed, which are typically recommended for upsizing storage volume when moving to a heat pump water heater.

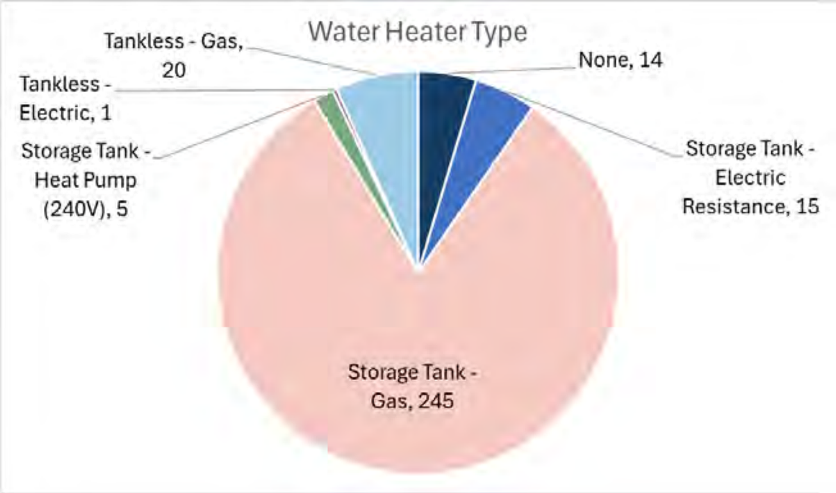


Figure 23: Survey responses by water heater type.

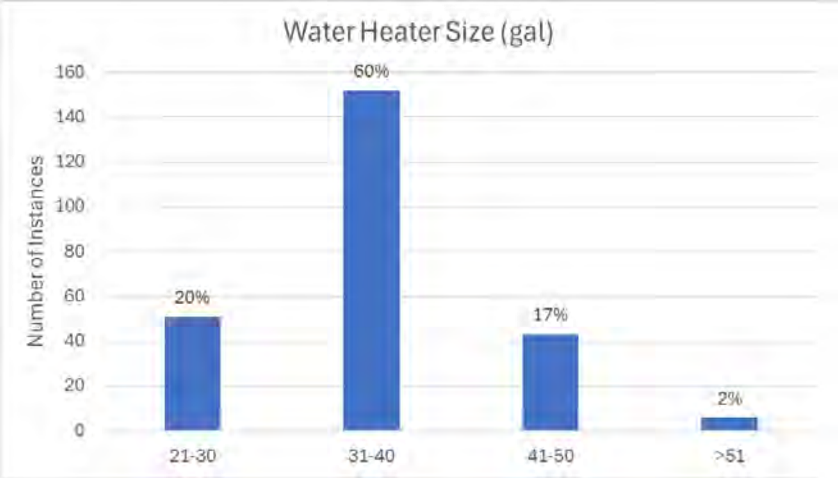


Figure 24: Distribution of storage tank water heater sizes.

Error! Reference source not found. shows the locations of existing water heaters in the households surveyed. Only approximately one-third of water heaters are currently located in a garage, which is one of the preferred locations to install a heat pump water heater. Approximately half of water heaters are in either an interior or exterior closet. These locations will often require modifications to provide the necessary airflow or space for a heat pump water heater, such as relocation to a garage or other space, expansion of a closet, or addition of louvers or ducting. The reported closet sizes are shown in **Error! Reference source not found.**. Almost all of these closets are smaller than what would normally be the minimum required space (84 ft³ e.g. 3 x 3½ x 8 ft with either a fully louvered door or ducting for both intake and exhaust to another space) (Larson and Larson 2022) for a heat pump water heater.

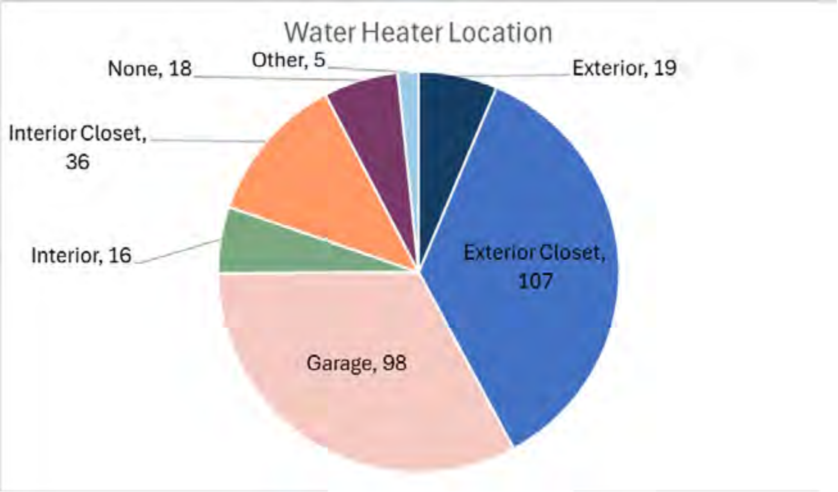


Figure 25: Survey responses by water heater location.

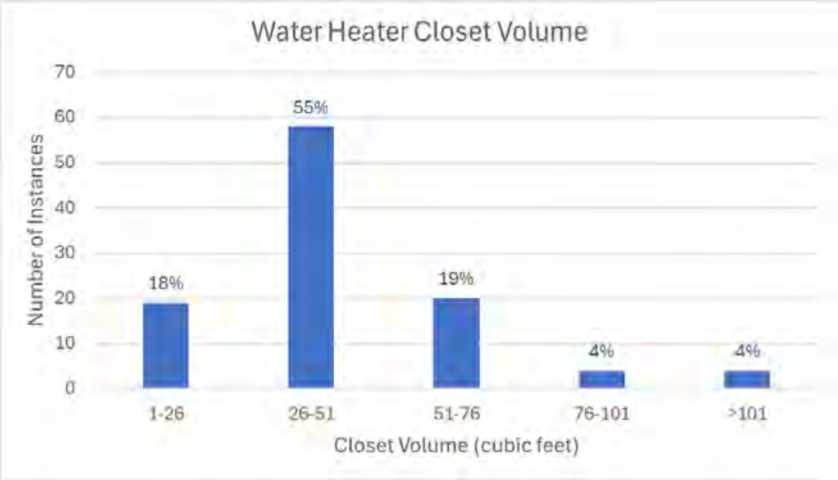


Figure 26: Distribution of closet size for responses with closet water heater.

The survey also asked if participants had a garage and if so, whether there is space in the garage for a water heater. **Error! Reference source not found.** and **Error! Reference source not found.** show that newer and larger houses are significantly more likely to have a garage with space for a water heater. Mobile/modular homes were excluded, as they are not expected to have a garage. Two mobile home surveys reported having a garage with no space for a water heater.

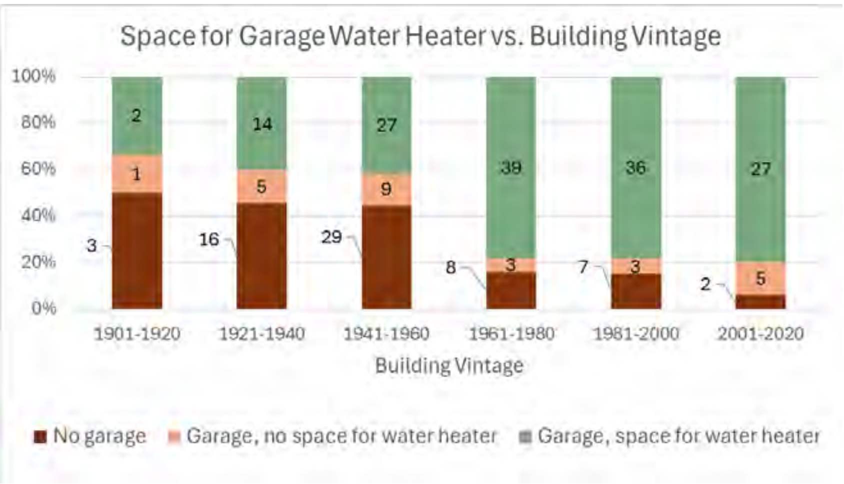


Figure 27: Distribution of potential for garage water heater by building vintage.

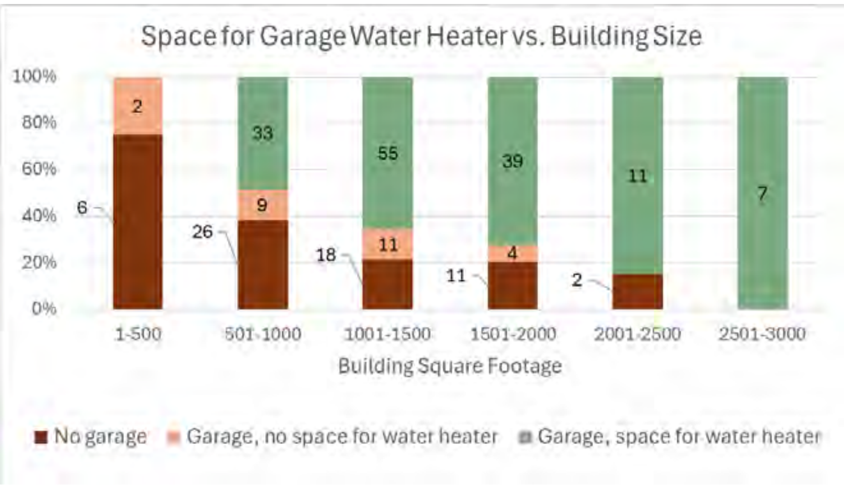


Figure 28: Distribution of potential for garage water heater by building size.

Error! Reference source not found. shows the number of participants who reported regularly running out of hot water, which may indicate that the water heater capacity should be increased. About ten percent of responses indicated running out of hot water regardless of tank size. Of the 21 responses with a tankless water heater, two reported regularly running out of hot water.

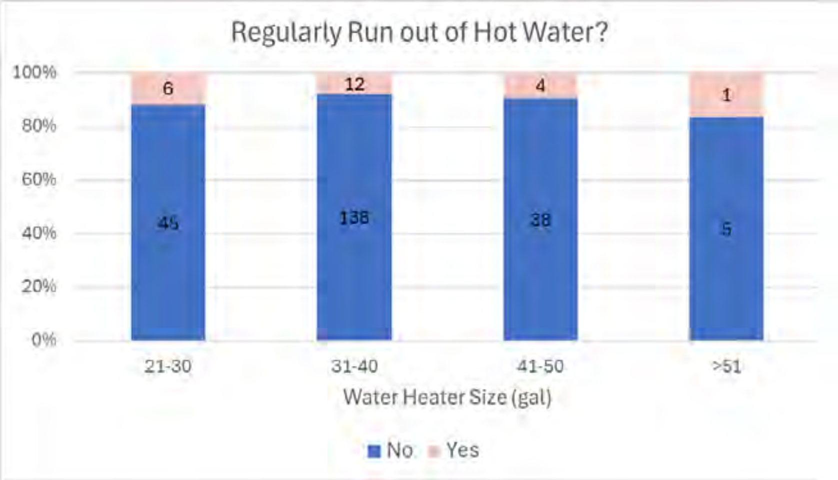


Figure 29: Distribution of houses that regularly run out of hot water by tank size.

Survey responses show that slightly more than one-fourth of houses had partial electrification via an electric clothes dryer, range, cooktop, or oven. Most common was an electric clothes dryer, which was found in 70 houses, and 27 houses had an electric range. Most houses had a range rather than a separate cooktop and/or oven. The survey found possible correlations with a larger share of electrification of these appliances in larger houses and in houses in PG&E territory.

The following figures show the electrification status of appliances (clothes dryer and cooking) across the full survey data set.

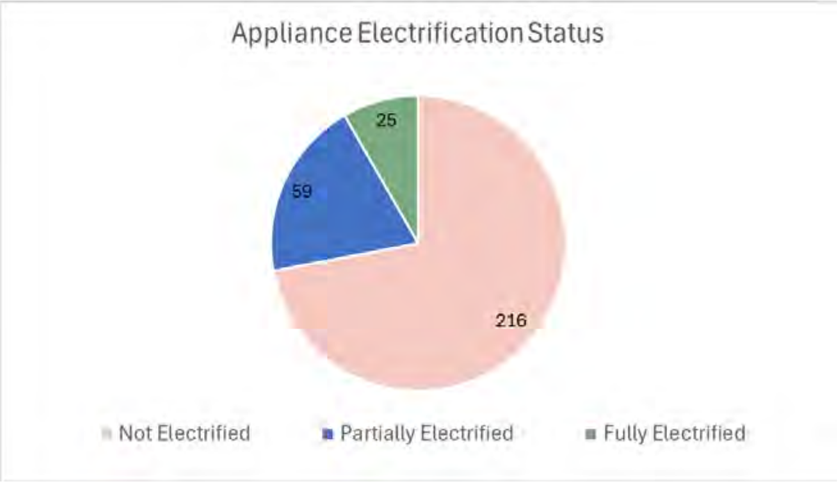


Figure 30: Appliance electrification status across entire survey responses.

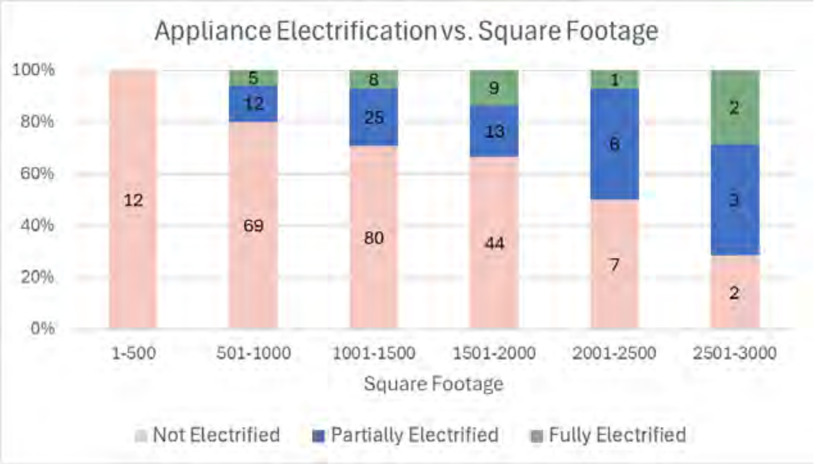


Figure 31: Appliance electrification status distribution across building sizes.

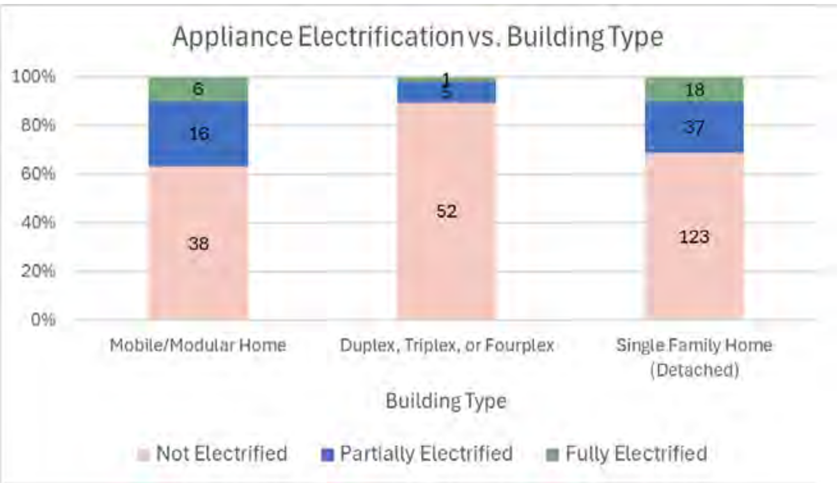


Figure 32: Appliance electrification status distribution across building type.

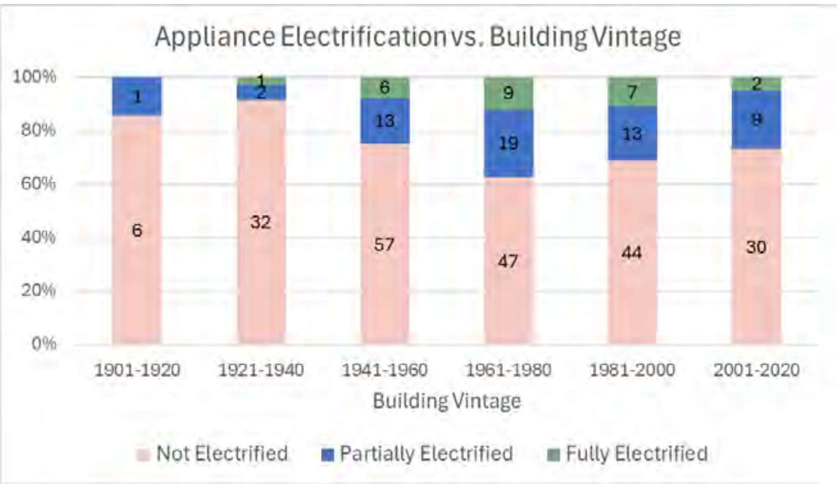


Figure 33: Appliance electrification status distribution across building vintage.

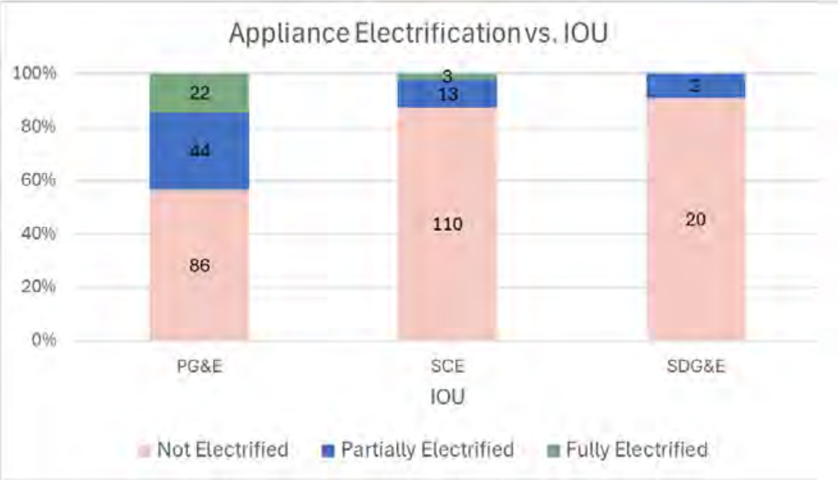


Figure 34: Appliance electrification status distribution across IOU territory.

The following figure shows the distribution of homes with zero, partial, and full electrification of the entire home (clothes dryer, cooking, water heater, and space heating). Only 2.7 percent of homes were found to be fully electrified.

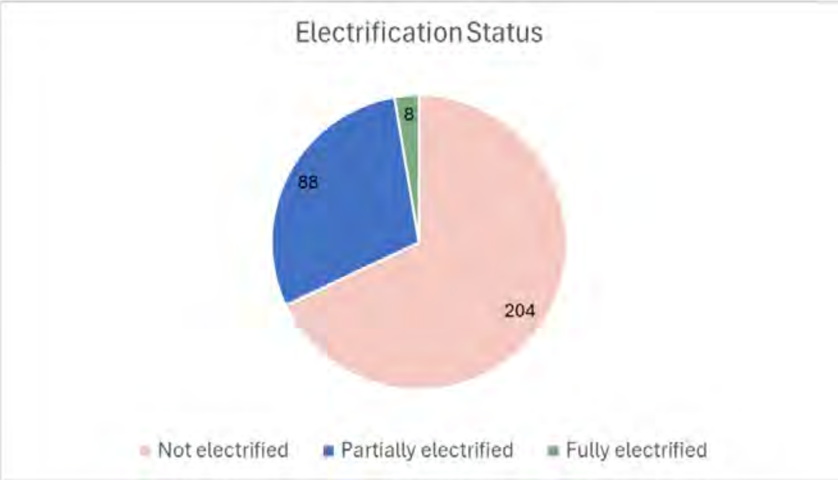


Figure 35: Electrification status of homes across the full survey dataset.

Current Market Barriers and Gaps

Gauging Electrification Sentiment

Electrification sentiment is an important metric since no home can be electrified without the occupant's willingness and interest.

Survey respondents were asked to answer six questions on a scale of one (disagree/not at all) to five (agree/very) regarding concern/excitement about electrification and seven true/false questions about common electrification myths. **Error! Reference source not found.** through **Error! Reference source not found.**47 show the responses to these questions. The language used for some myths in

Error! Reference source not found.43 is summarized to be more concise. The wording presented to participants can be found in Appendix A.

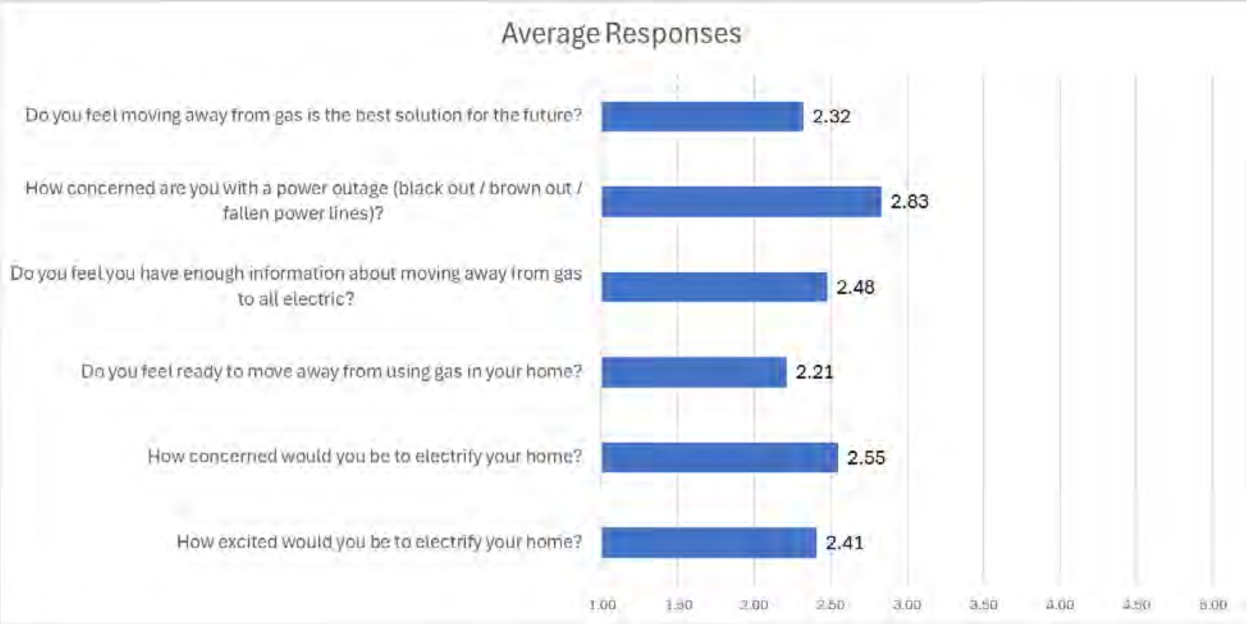


Figure 36: Average electrification sentiment responses.

Figure 37: Future electrification sentiment responses.

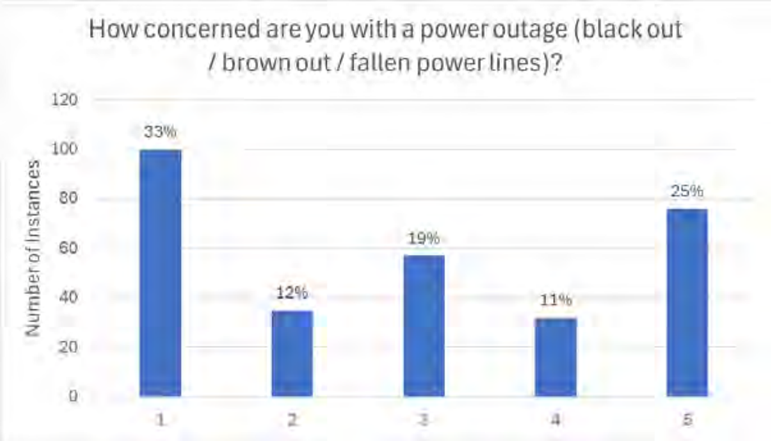


Figure 38: Electric outage concern responses.

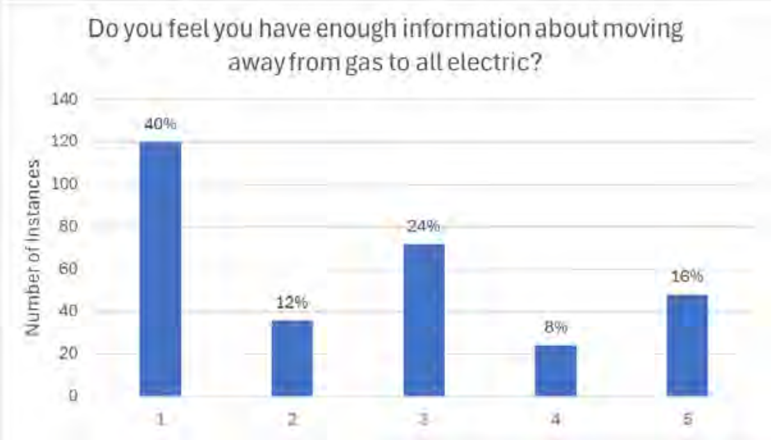


Figure 39: Electrification information access responses.

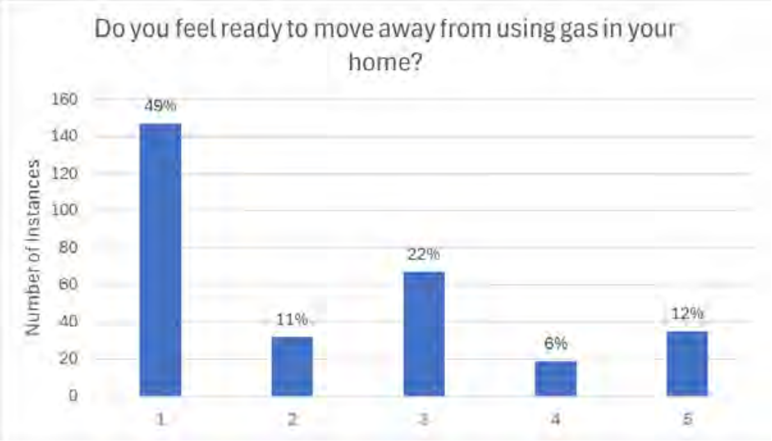


Figure 40: Current electrification sentiment responses.

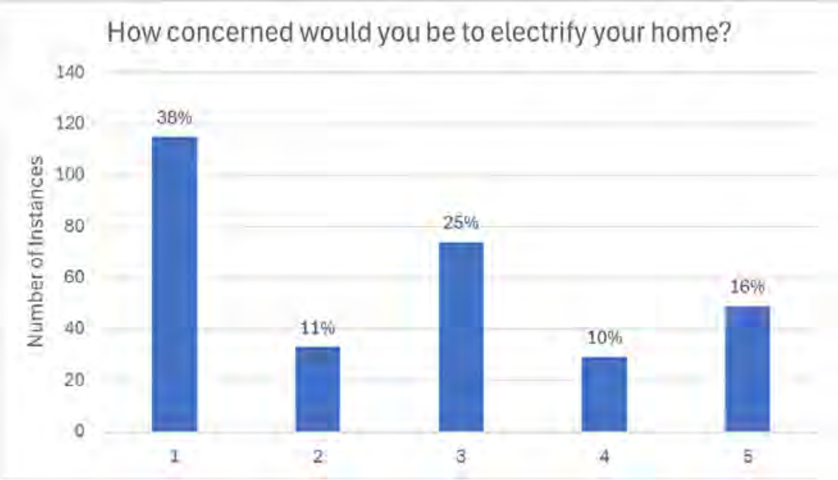


Figure 41: Electrification concern responses.

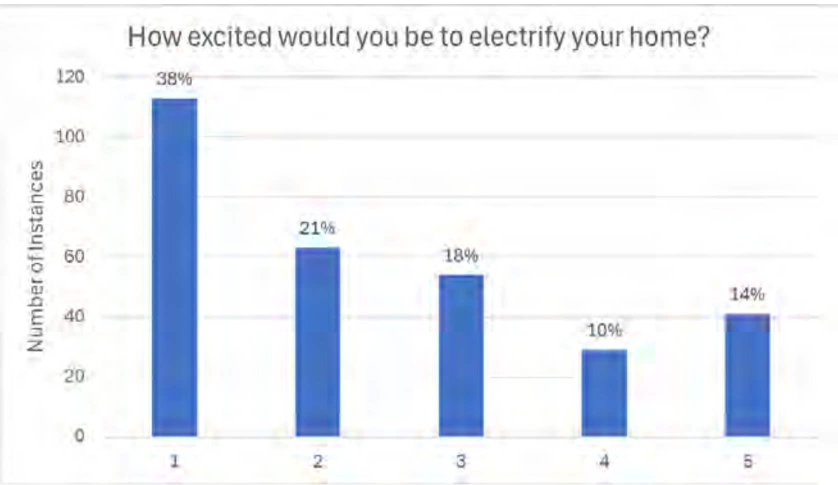


Figure 42: Electrification excitement responses.

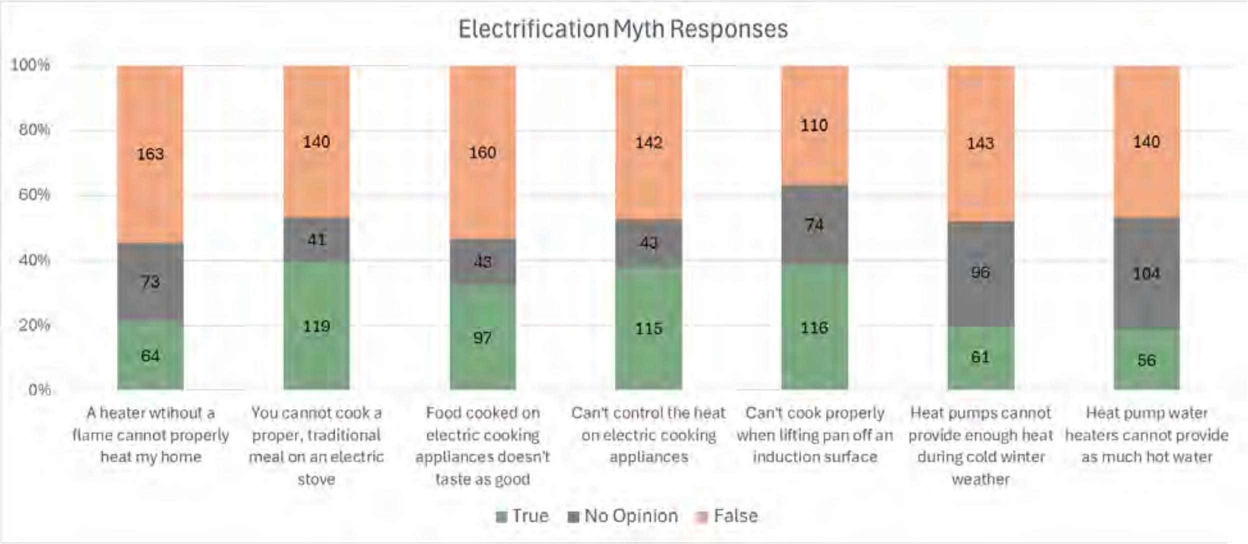


Figure 43: Electrification myth responses.

Error! Reference source not found. shows the responses to four true/false questions which were related to cooking appliances (primarily stove/cooktop) and the difference in responses between participants who had an electric range/cooktop/oven, and those who did not. The responses show that for all four of the cooking electrification myths, more than half of participants who did not have an electric cooking appliance had an anti-electric sentiment. The responses do not indicate whether the more positive response of participants who had an electric cooking appliance was due to their experience with an electric appliance, or if they chose to install an electric cooking appliance because of their more positive sentiment. This suggests that, regardless of the reason for having an electric cooking appliance, those appliance owners were generally satisfied and did not subscribe to common electric cooking myths.

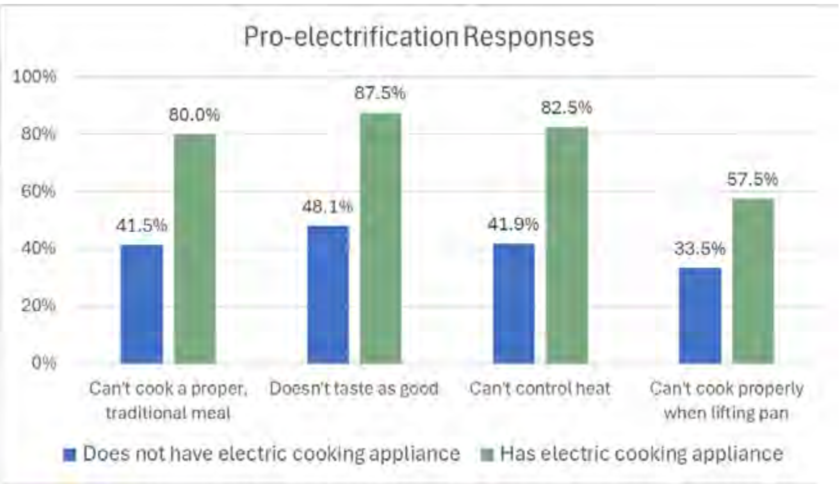


Figure 44: Opinion of electric cooking appliances by electric cooking appliance ownership.

Error! Reference source not found. and **Error! Reference source not found.** show responses to electrification myths about heat pump water heaters and space heating. Similar to the questions regarding cooking, participants who had used electric space heating or water heating were more likely to have positive opinions of heat pumps. The questions about heat pumps had approximately 30 percent respondents answering "no opinion," compared with about ten percent for questions about electric cooking appliances, indicating that education and outreach about heat pump water heaters may be lacking.

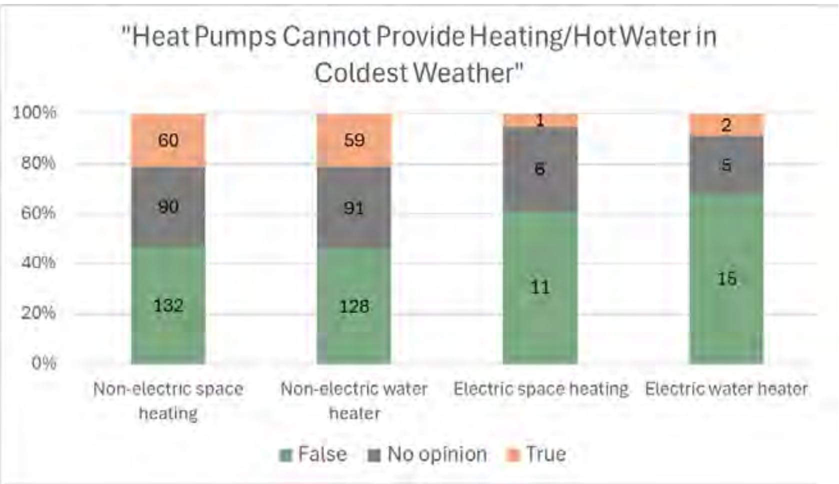


Figure 45: Opinion of heat pumps by electric heater/water heater ownership

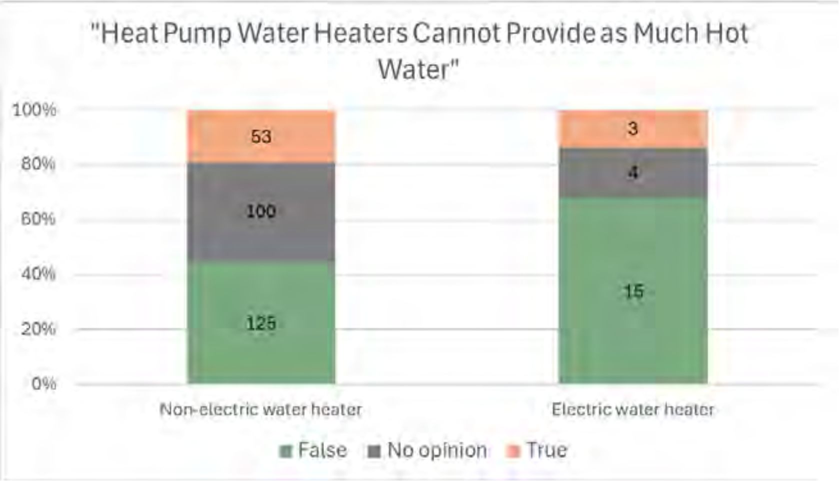


Figure 46: Opinion of heat pump water heaters by electric water heater ownership.

The survey also asked participants about their greatest concern with electrification, as shown in **Error! Reference source not found.**. Responses that are labeled "other" include respondents who stated they preferred gas, lacked information, had safety concerns, or did not want to make changes to their house.

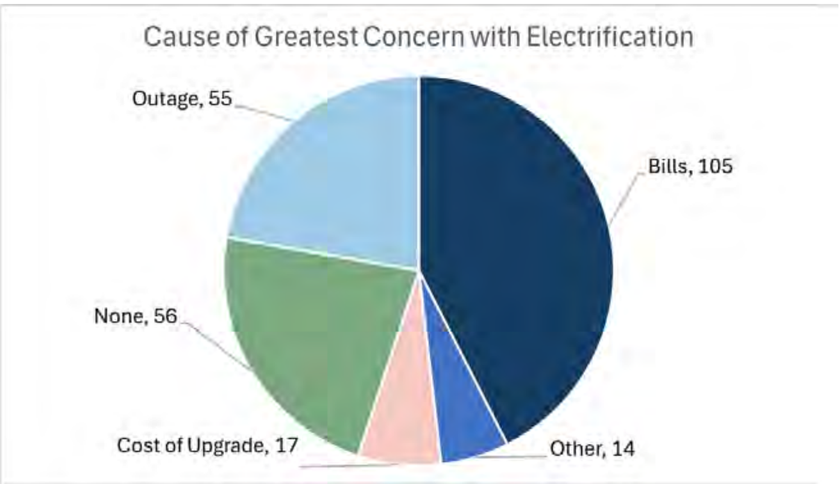


Figure 47: Greatest causes of concern with electrification for survey respondents.

Electrification Sentiment Score

To represent a homeowner's sentiment toward electrification with a single value, an "electrification sentiment score" was used. This score combines the eight true/false responses to electrification myths and the six electrification interest questions with a 1 to 5 range for possible answers into a single number. The responses to the multiple questions about electric stovetops were combined into a single value to prevent overweighting of sentiment toward electric cooking appliances. A "true" response to a myth was treated as a 1, a "false" response was treated as a 5, and "no opinion" was treated as a 3. These responses were combined into a single sentiment score with each response weighted equally, with the final sentiment score normalized to a scale from 1 to 10, with 1 being the lowest sentiment toward electrification (negative opinion) and 10 being the highest sentiment (positive opinion). **Error! Reference source not found.** shows the distribution of the electrification sentiment scores across the entire surveyed population. About 62 percent of the population had opinions between 1 and 5.

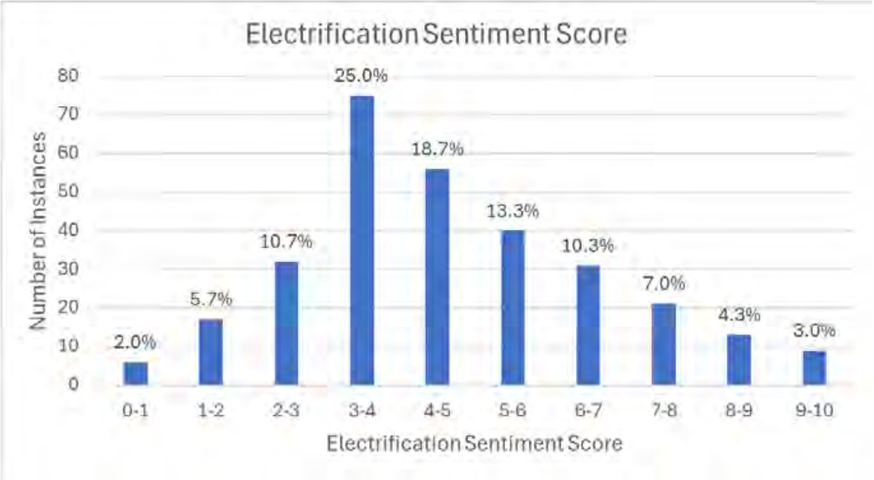


Figure 48: Distribution of electrification sentiment scores.

There was no correlation noted between building data (e.g., vintage and square footage) and the electrification sentiment score. There was also limited or no correlation noted for demographic information collected (e.g., age and language). These graphs are found in Appendix B. The most notable factors correlated with the electrification sentiment were IOU territory and electrification status.

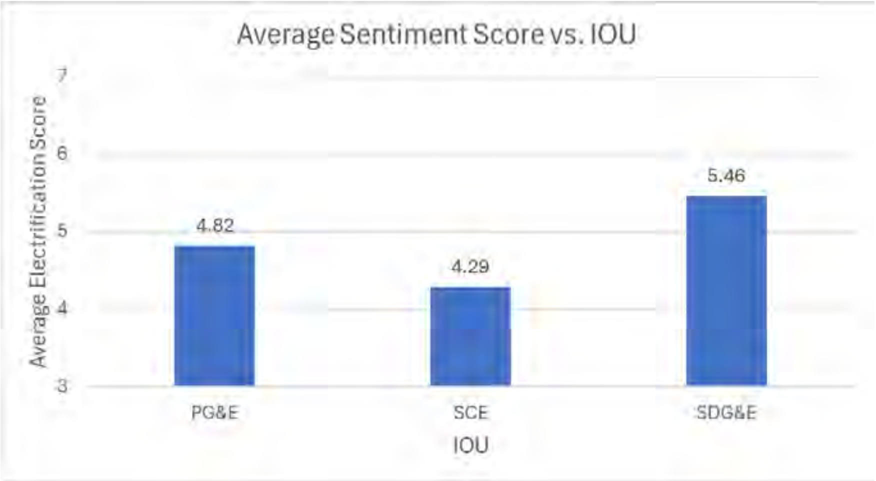


Figure 49: Distribution of electrification sentiment scores vs. IOU.

The much higher electrification sentiment scores in homes that were more electrified indicates that experience with electrification plays a large role in dispelling common electrification myths in this population.

Figure 50: Distribution of electrification sentiment scores vs. electrification status.

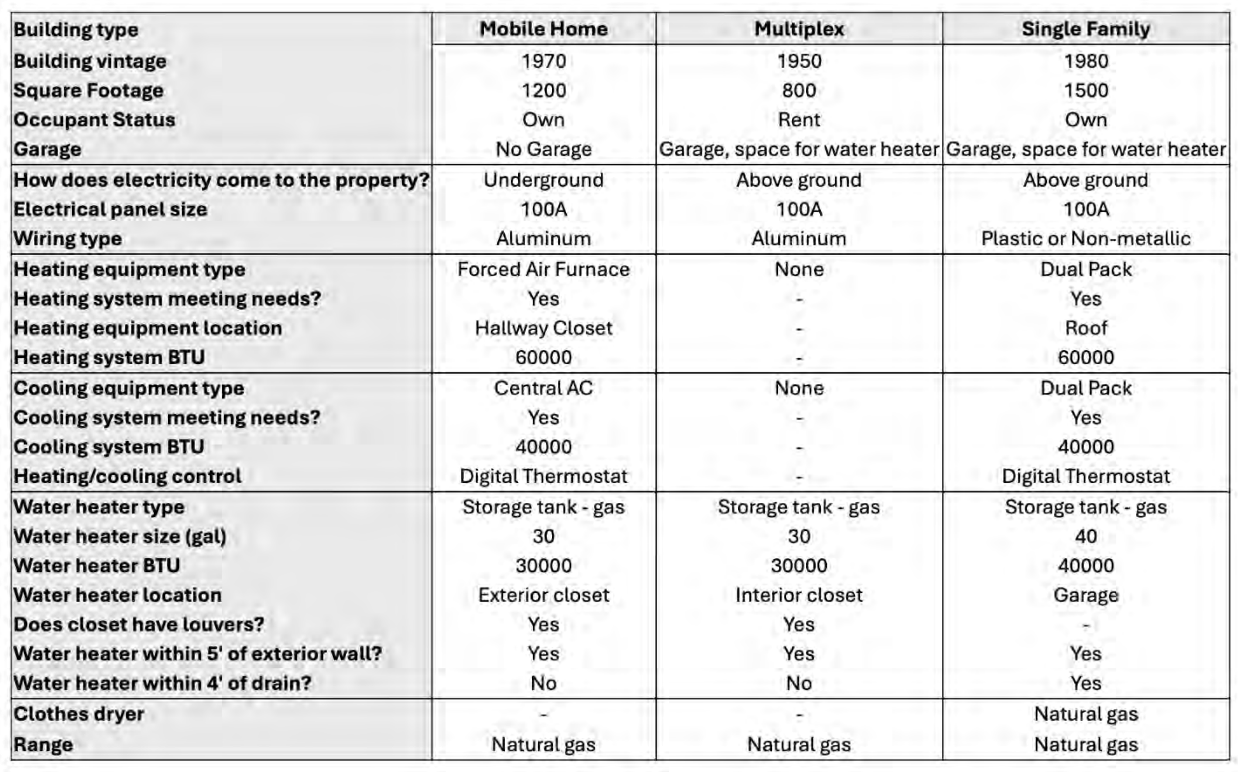
Market Opportunities

Electrification Measure Costing

The cost of electrification for DACs and HTR communities is arguably the single most critical component for electrification. The average cost of electrification, itemized by specific measure and based on building type (mobile home, multi-unit, single family) is explored in this section. Common measure and remediation costs for electrification efforts were gathered from three sources. The average costs are shown in the table in Appendix B.

As an example, the three scenarios shown in Table 3 were selected for demonstrating a representative typical cost for the electrification of a home. These scenarios were not survey responses but were deemed to be representative of a typical mobile home, multiplex, or single family home, based on the most common survey responses.

Table 3: Representative Mobile Home, Multiplex, and Single Family Home



Building type	**Mobile Home**	**Multiplex**	**Single Family**
Building vintage	1970	1950	1980
Square Footage	1200	800	1500
Occupant Status	Own	Rent	Own
Garage	No Garage	Garage, space for water heater	Garage, space for water heater
How does electricity come to the property?	Underground	Above ground	Above ground
Electrical panel size	100A	100A	100A
Wiring type	Aluminum	Aluminum	Plastic or Non-metallic
Heating equipment type	Forced Air Furnace	None	Dual Pack
Heating system meeting needs?	Yes	-	Yes
Heating equipment location	Hallway Closet	-	Roof
Heating system BTU	60000	-	60000
Cooling equipment type	Central AC	None	Dual Pack
Cooling system meeting needs?	Yes	-	Yes
Cooling system BTU	40000	-	40000
Heating/cooling control	Digital Thermostat	-	Digital Thermostat
Water heater type	Storage tank - gas	Storage tank - gas	Storage tank - gas
Water heater size (gal)	30	30	40
Water heater BTU	30000	30000	40000
Water heater location	Exterior closet	Interior closet	Garage
Does closet have louvers?	Yes	Yes	-
Water heater within 5' of exterior wall?	Yes	Yes	Yes
Water heater within 4' of drain?	No	No	Yes
Clothes dryer	-	-	Natural gas
Range	Natural gas	Natural gas	Natural gas

The cost estimates for electrification of these representative homes, based on some assumed conditions, are found in Table 4.

Table 4: Representative Home Electrification Costs

Building type	Mobile Home Retrofit	Mobile Home Retrofit Cost	Multiplex Retrofit	Multiplex Retrofit Cost	Single Family Retrofit	Single Family Retrofit Cost
How does electricity come to the property?	150A - Underground Electric Service Upgrade	$ 10,000.00	200A - Overhead Electric Service Upgrade	$ 6,000.00	200A - Overhead Electric Service Upgrade	$ 6,000.00
Electrical panel size	Electric Panel Upgrade	$ 3,924.84	Electric Panel Upgrade	$ 3,924.84	Electric Panel Upgrade	$ 3,924.84
Wiring type						
Heating equipment type	Package heat pump (3 ton)	$ 7,418.00			Package heat pump (4 ton)	$ 8,058.00
Heating system meeting needs?						
Heating equipment location					Crane Rental	$ 800.00
Heating system BTU						
Cooling equipment type	Package heat pump (3 ton)				Package heat pump (4 ton)	
Cooling system meeting needs?						
Cooling system BTU						
Heating/ cooling control	Smart Thermostat	$ 280.00			Smart Thermostat	$ 280.00
Water heater type	Install 40 gal Electric Resistance WH (240V)		Install 50 gal HPWH (240V)	$ 4,110.43	Install 65 gal HPWH (240V)	$ 4,766.28
Water heater size (gal)						
Water heater BTU						
Water heater location						
Does closet have louvers?						
Water heater within 5' of exterior						
Water heater within 4' of drain?						
Clothes dryer					Heat pump clothes dryer	$ 1,706.33
Range	Electric induction range	$ 2,636.28	Electric induction range	$ 2,636.28	Electric induction range	$ 2,636.28
New Electrical Circuits for Fuel Switching	New Electrical Circuit	$ 2,869.38	New Electrical Circuit	$ 1,912.92	New Electrical Circuit	$ 3,825.84
Repair Damaged Flooring under water heater	Repair Damaged Flooring Under Water Heater	$ 190.00	Repair Damaged Flooring Under Water Heater	$ 190.00	Repair Damaged Flooring Under Water Heater	$ 190.00
Crawl Space Insulation & Sealing	Crawl Space Insulation &	$ 7,548.00			Crawl Space Insulation &	$ 9,435.00
Ceiling Insulation - Residential; Blown in Cellulose (R-60)	Ceiling Insulation - Blown in Cellulose (R-60)	$ 3,360.00			Ceiling Insulation - Blown in Cellulose (R-60)	$ 4,200.00
Duct Sealing	Duct Sealing	$ 730.67			Duct Sealing	$ 730.67
A/C Removal	A/C Removal	$ 1,260.00				
Cap Gas Line	Cap Gas Line	$ 617.39	Cap Gas Line	$ 411.60	Cap Gas Line	$ 823.19
Drywall Repair	Drywall Repair	$ 190.00	Drywall Repair	$ 190.00	Drywall Repair	$ 190.00
Dormer Vents (4)	Dormer Vents (4)	$ 420.00			Dormer Vents (4)	$ 420.00
Electrical Permit	Electrical Permit	$ 200.00	Electrical Permit	$ 200.00	Electrical Permit	$ 200.00
Load Calculation	Load Calculation	$ 648.68			Load Calculation	$ 648.68
Electrical Panel Calculation	Electrical Panel Calculation	$ 339.00	Electrical Panel Calculation	$ 339.00	Electrical Panel Calculation	$ 339.00
Total Cost		**$ 42,632.24**		**$ 19,915.07**		**$ 49,174.12**

Electrification Readiness Score

The collected data can support an assessment of electrification readiness, based on the necessary measures, remediation needs, equipment sizing, and appliance mix at each home. A readiness score methodology was developed that assigns a single readiness score value to each home, based on a weighted accounting of each datapoint and the estimated complexity and costs of electrification. This is the Electrification Readiness Score. This score, the combination of a cost score and a complexity score, was derived with the following formulas:

$$Total\ Cost\ Score\ = \left(1 - \frac{\sum_{i=1}^{n} MC_i + \sum_{i=1}^{n} RC_i}{\sum_{i=1}^{N} MC_i + \sum_{i=1}^{N} RC_i}\right) \times 9 + 1$$

$$Complexity\ Score\ = \left(\frac{10 - \sum_{i=1}^{n} CX_i}{10}\right) \times 9 + 1$$

$$Electrification\ Readiness\ Score\ = 60\% \times Total\ Cost\ Score\ +\ 40\% \times Complexity\ Score$$

The total cost score is given on a scale of 1 to 10, where *MC* is the measure cost for any particular electrification measure (e.g., heat pump water heater installation), *RC* is the remediation cost needed to enable the electrification measures (e.g., electrical panel upgrade), lower case *n* represents the number of measures and remediation necessary for any given home, and upper case *N* represents the maximum possible number of necessary measures and remediation in the observed dataset. For the total cost score, 10 represents a fully electrified home and 1 represents a home where the maximum cost of measures and remediation are needed to fully electrify (~$50,000).

The complexity score is also given on a scale of 1 to 10, where *CX* is the estimated complexity of remediation and installation for a particular electrification measure that may be necessary at any given home. For this study, the relative complexity of each measure and necessary remediation were weighted as follows:

- Electrical panel upgrades: 20 percent
- HVAC measures: 20 percent
- Water heater, clothes dryer, and range measures: 10 percent each
- Standalone cooktop and wall oven measures: 5 percent each
- Water heater relocation: 10 percent
- Crane rental for rooftop HVAC: 10 percent

For the complexity score, a 10 represents a home that is fully electrified and 1 represents a home with the maximum complexity to fully electrify. These two values were combined into an Electrification Readiness Score, weighted at 60 percent total cost score and 40 percent complexity score.

As an applied example of this, the representative mobile home, multiplex, and single family homes shown in Table 3 and Table 4 were calculated to have Electrification Readiness Scores of 2.7, 6.3, and 1.6, respectively.

The distribution of electrification scores across the survey dataset is approximately normal, with a majority of scores between 3 and 6, indicating that the cost and complexity of electrification for most homes is approximately 60 percent of the “worst” case scenario.

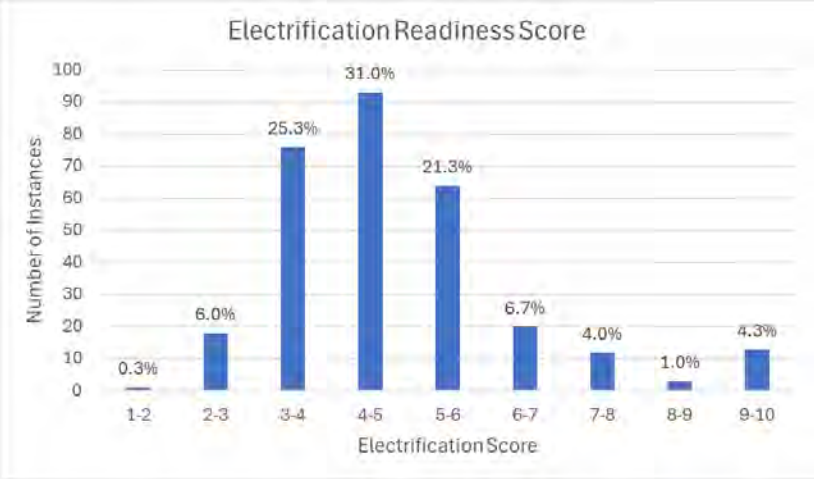


Figure 51: Distribution of Electrification Readiness Scores.

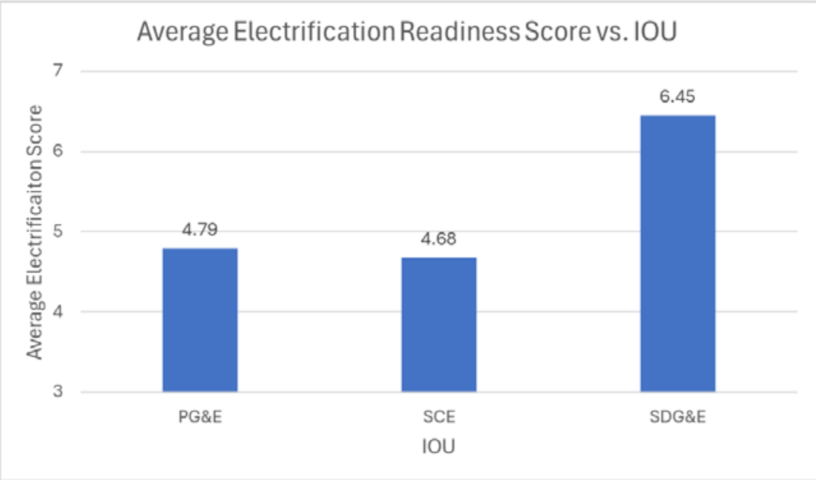


Figure 52: Distribution of Electrification Readiness Scores vs. IOU.

In general, surveyed homes with more positive sentiment scores also had higher electrification scores. This reflects that homeowners with more positive views of electrification may have already implemented some electrification measures, and so less work is needed to reach full electrification.

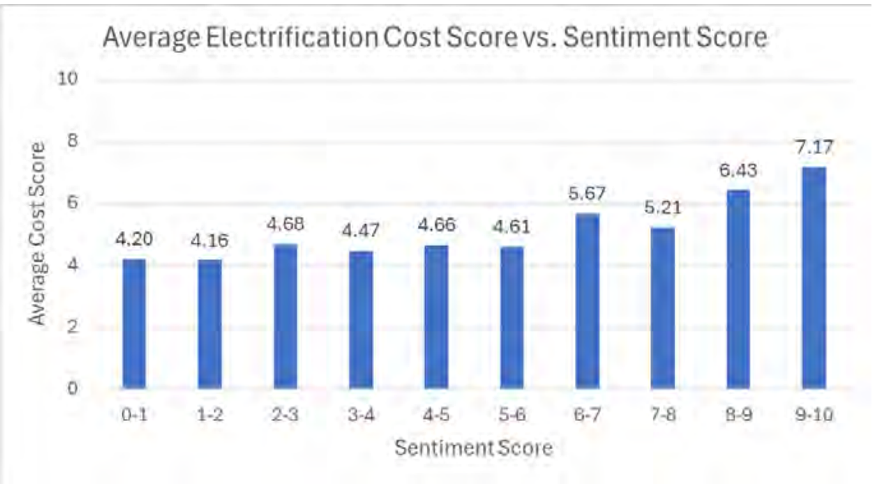


Figure 53: Distribution of electrification scores by sentiment score.

Stakeholder Feedback

To enhance the relevance and applicability of the DAC HTR Statewide Single family Housing Characteristics Study, the research team engaged a diverse group of stakeholders representing CBOs, low-income energy efficiency program installation contractors, civic leaders, and CalNEXT partners. These stakeholders were invited for their direct experience working within DACs and HTR communities and their practical knowledge of electrification challenges and opportunities.

Two feedback sessions, held on October 8 and 10, 2024, gathered qualitative insights through interactive discussions and surveys. Approximately 22 stakeholders attended the meetings. This engagement provided a comprehensive view of the unique barriers to electrification faced by DACs and HTR communities, highlighting actionable strategies and potential solutions.

Key Takeaways from Stakeholder Engagement

1. **Energy Affordability and the Role of Utilities**
   The dominant theme across sessions was the increasing cost of energy and the potential burden on low-income households as they transition to electrification. Stakeholders advocated for active utility involvement, particularly in the form of financial incentives that would alleviate bill impacts. Suggested measures included CARE-like automatic discounts and bill protection mechanisms that could ease the transition for income-verified DAC and HTR households.

2. **Infrastructure and Grid Limitations**
   Stakeholders, especially those representing rural areas, emphasized significant infrastructure barriers. High costs associated with panel and service upgrades, combined with grid limitations, were seen as critical obstacles. Rural stakeholders suggested microgrid development as a means of providing both cost savings and energy resilience. This feedback underscored the need for program designs that accommodate infrastructure variability across urban and rural areas, ensuring equity in access to electrification resources.

3. **Cultural Attachments to Gas and Educational Needs**
   Many stakeholders observed a strong cultural attachment to gas appliances in DACs and HTR communities. Misinformation about electrification, combined with emotional ties to gas, presents a substantial challenge in promoting new technologies. Stakeholders recommended using culturally tailored, community-based educational outreach, leveraging trusted voices within the community, and showcasing testimonials from early adopters to build trust and encourage acceptance of electrification measures.

4. **Solar as an Entry Point for Electrification**
   Solar technology was frequently discussed as a transitional solution, with stakeholders noting that households familiar with solar were more open to considering additional electrification upgrades. Stakeholders recommend prioritizing solar installations with battery storage for DACs and HTR communities, using available federal funding. They highlighted solar as a gateway to electrification that could reduce energy costs, increase resilience, and potentially address customer concerns about energy security during outages.

5. **Engagement of Smaller Utility Districts and Local Contractors**
   Stakeholders suggested that smaller utility districts, with their closer ties to customers, could play an essential role in future phases of the program. Additionally, stakeholders encouraged partnerships with local contractors, business associations, and other community organizations that serve DACs and HTR communities, noting that these partnerships could enhance outreach, build community trust, and improve program accessibility. The inclusion of local actors was seen as a way to increase program adoption and effectiveness.

Incorporating Stakeholder Feedback into Study Recommendations

The insights gathered from stakeholder engagement have directly shaped several recommendations within this study:

- **Focus on Affordability and Financial Protections:** Based on feedback around cost concerns, the study emphasizes the importance of affordability mechanisms, such as rebates, financial assistance, and bill protection measures, to ease the financial transition to electrification for DAC and HTR households. Utility engagement and automatic opt-in features were highlighted as potential solutions to address these challenges.
- **Prioritizing Infrastructure Readiness:** Stakeholders' concerns regarding high upgrade costs and grid limitations have reinforced the study's recommendation to incorporate infrastructure support into program design. The Electrification Readiness Score introduced in this study reflects an effort to quantify infrastructure needs, providing a practical tool for assessing costs and prioritizing investments across varying household and regional contexts.
- **Emphasis on Community-Based Education, Cultural Sensitivity, and Customer Sentiment**: Stakeholders highlighted strong emotional and cultural ties to gas appliances, along with prevalent myths and misinformation about electrification. Findings on customer sentiment — particularly residents' cautious attitudes toward electrification and concerns about reliability — underscore the importance of using these insights to tailor outreach materials. The study recommends creating educational content that is accessible, culturally relevant, and that directly addresses common misconceptions. By leveraging early adopters' testimonials and addressing key concerns raised in customer sentiment data, such as safety and comfort, the program can work to build trust and encourage positive perceptions of electrification technologies within DACs and HTR communities.
- **Encouraging Solar as a Transitional Measure**: In response to stakeholder advocacy for solar as an entry point to electrification, the study recommends leveraging federal funding to support solar installations with battery storage in DACs and HTR communities. Solar adoption is framed as a practical first step that can increase household energy resilience, reduce costs, and build openness toward further electrification upgrades.
- **Collaborative Partnerships with Smaller Utilities and Local Contractors**: The feedback on engaging smaller utility districts and local contractors has informed the study's emphasis on local partnerships. Collaboration with these local entities is encouraged to foster trust, enhance program awareness, and improve implementation efficiency. Such partnerships also align with the study's goal of delivering resources in a way that respects and addresses unique local needs.

Tech Transfer and Handoff

While initial workshops provided valuable opportunities for stakeholder engagement, a full tech transfer process has yet to be completed. To support a seamless handoff of insights and findings, the team recommends implementing additional activities aimed at equipping program designers, utility partners, and other stakeholders with the tools needed to integrate study recommendations effectively.

A key component of this process would involve data sharing and access. The team proposes making the collected data available to relevant stakeholders, including anonymized data sets from the study. This would enable utility partners, program designers, and researchers to analyze and build upon the findings independently, fostering a data-informed approach to program design in DACs and HTR communities.

Further engagement could be facilitated through additional workshops or one-on-one meetings. Building on the initial feedback sessions, the team recommends organizing targeted workshops with utility partners to explain key findings, delve into the electrification readiness scoring mechanism, and provide guidance on applying these insights to program planning. These workshops could also include collaborative discussions around potential program designs, offering stakeholders an opportunity to address challenges like affordability, customer sentiment, and infrastructure barriers directly within the program framework. Additionally, in-depth sessions on the Electrification Readiness Score would equip program implementers with a standardized baseline for evaluating infrastructure needs and cost impacts, allowing them to prioritize investments more strategically.

Although based on a sample size of 300, this study offers a comprehensive baseline of current electrification readiness in DACs and HTR communities. The baseline, combined with the electrification readiness scoring mechanism, provides a valuable framework for assessing progress and making iterative improvements to programs over time. By using this baseline to inform ongoing program adaptation, stakeholders can foster a responsive, collaborative approach to supporting DACs and HTR communities in their transition to electrification.

Recommendations

The DAC HTR Statewide Single Family Housing Characteristics Study (2024) revealed many important findings to advance electrification in DACs and HTR communities across California, which have led to the following recommendations:

- **Program Design:** To support the ongoing electrification of DACs and HTR communities in California, the study recommends the development of targeted programs that address both the financial and technical barriers. This includes offering incentives that are appropriately funded for necessary upgrades; providing participants with comprehensive technical assistance, demonstrations, and training on how to best use their new appliances; and creating tailored outreach strategies (e.g., online marketing campaigns through ads and social media showcasing all of the amazing benefits of heat pump technology and where they can sign up to participate) to improve the public perception of and willingness to adopt electrification technologies.
- **Electrification Score:** Leverage the Electrification Readiness Score, a standardized metric introduced as part of this study, that can be used to appraise or rate the combined cost, complexity, and timeframe of an electrification project. This will enhance the planning and implementation capabilities of agencies, utilities, program administrators, and program implementers alike. This standardized unit of measure will also help everyone communicate in a consistent and clear manner when discussing electrification for a specific home, as well as housing groups across climate zones, IOU territories, and other localized segments and neighborhoods throughout the state.
- **Funding and Reporting:** Lobby federal agencies, state and local governments, and utilities on the true data-driven cost of electrification for DACs and HTR communities, to seek appropriate levels of grants and debt financing. Ensure all future funding is unrestricted and available to be layered up to set caps per home. Funding allocation should be standardized and trackable in a

centralized repository, to ensure appropriate recordkeeping, reporting, progress tracking, and to avoid fraud.

- **Education and Awareness:** Widespread knowledge gaps concerning available electrification technologies and their relative benefits need to be addressed. The study found a correlation in the sentiment of participants between being more positive toward electrification if they, for example, already had a heat pump or induction range, suggesting that personal knowledge and experience with electrical appliances are key to transforming the market.
- **Safety Nets:** The single biggest concern among DACs and HTR communities for electrification was the potential for bill increases. A close second was losing power in a blackout. Both concerns can be addressed with a strategic battery backup solution. Allowing customers to charge up their batteries when electricity is cheap, and then using the electricity from the batteries when rates are high, will go a long way toward reducing the overall cost burden associated with the increased electricity use. It will also provide the necessary backup power in the event of an outage. Solar PV panels can be added as a bonus, but the primary strategy would be to install appropriately sized battery systems.
- **Training:** Ensuring electricians and other electrification professionals are appropriately trained is paramount, especially when it comes to the strategic commissioning of new heat pump, solar PV, and battery backup technologies. Most contractors that work in this space are solely concerned with the installation, as that is where the incentives are currently. Strategic commissioning is not yet a mainstream capability.
- **Looking Ahead:** The resultant dataset from the 300 surveys is a rich resource that was thoroughly analyzed to compile the findings of this final report. However, opportunities still exist for further research and the team encourages supplementary analysis of the dataset by SCE and other authorized users.

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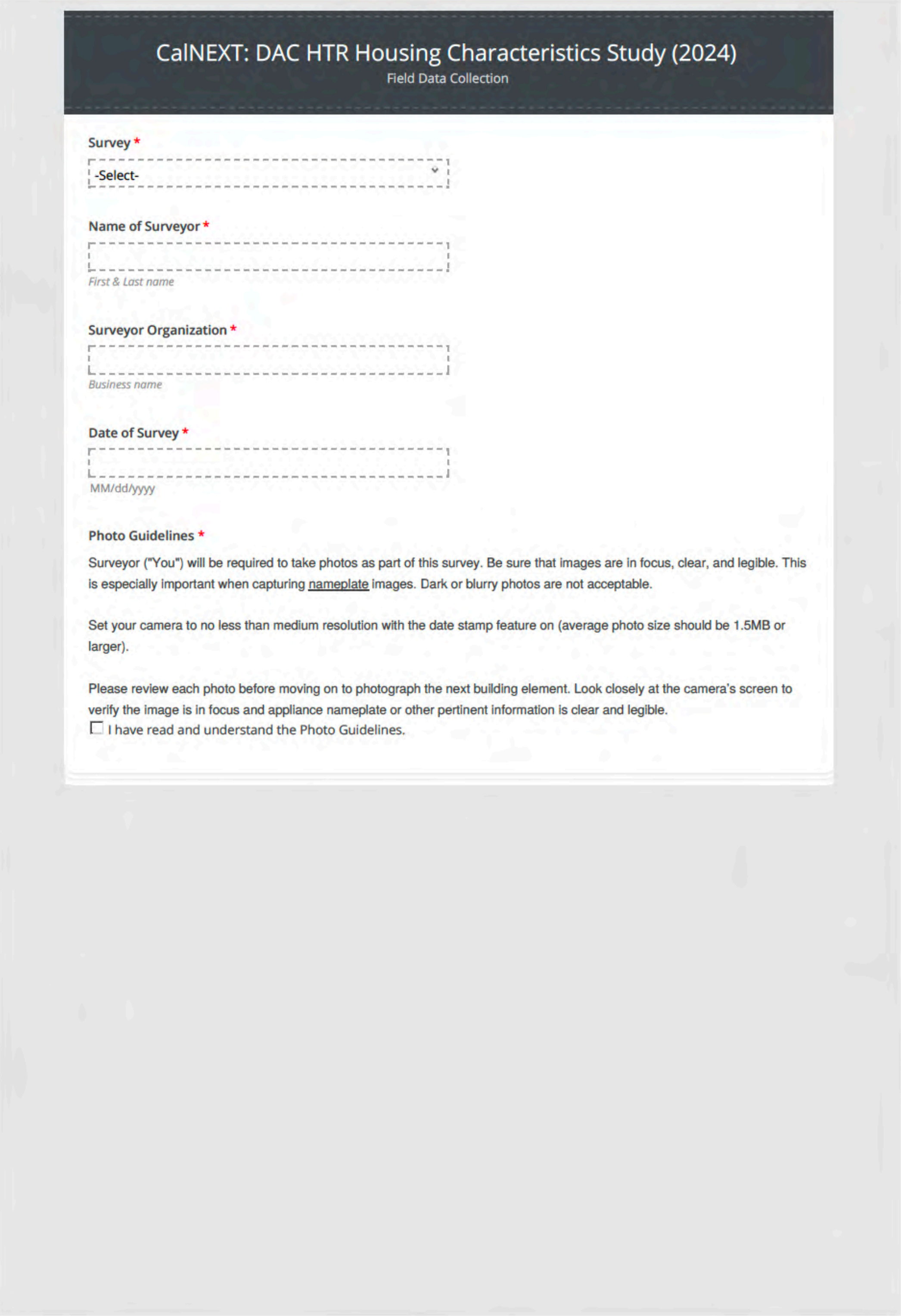
Appendix A: Primary Survey in English



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Survey *

-Select-

Name of Surveyor *

First & Last name

Surveyor Organization *

Business name

Date of Survey *

MM/dd/yyyy

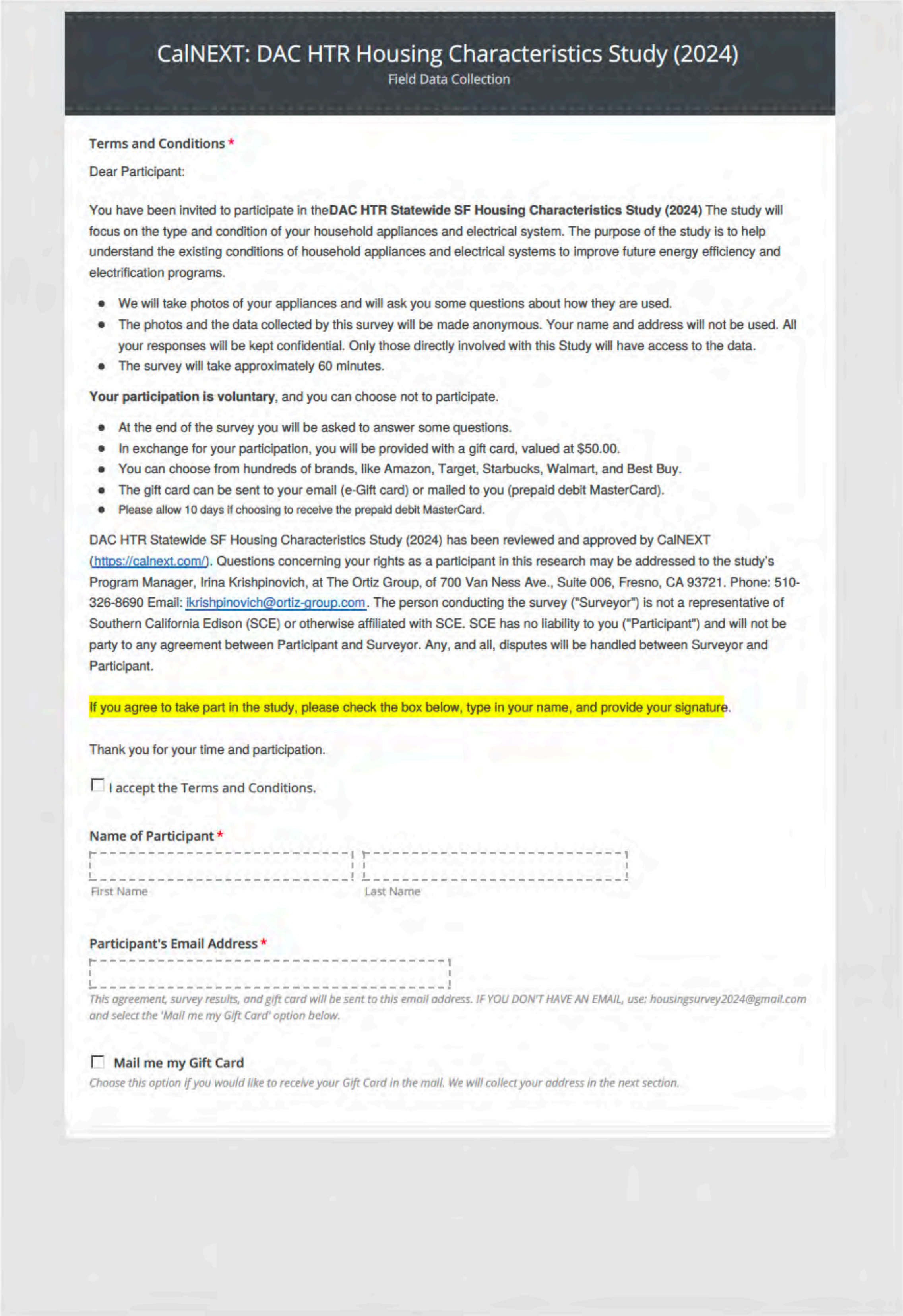
Photo Guidelines *

Surveyor ("You") will be required to take photos as part of this survey. Be sure that images are in focus, clear, and legible. This is especially important when capturing nameplate images. Dark or blurry photos are not acceptable.

Set your camera to no less than medium resolution with the date stamp feature on (average photo size should be 1.5MB or larger).

Please review each photo before moving on to photograph the next building element. Look closely at the camera's screen to verify the image is in focus and appliance nameplate or other pertinent information is clear and legible.

☐ I have read and understand the Photo Guidelines.



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Terms and Conditions *

Dear Participant:

You have been invited to participate in the**DAC HTR Statewide SF Housing Characteristics Study (2024)** The study will focus on the type and condition of your household appliances and electrical system. The purpose of the study is to help understand the existing conditions of household appliances and electrical systems to improve future energy efficiency and electrification programs.

- We will take photos of your appliances and will ask you some questions about how they are used.
- The photos and the data collected by this survey will be made anonymous. Your name and address will not be used. All your responses will be kept confidential. Only those directly involved with this Study will have access to the data.
- The survey will take approximately 60 minutes.

Your participation is voluntary, and you can choose not to participate.

- At the end of the survey you will be asked to answer some questions.
- In exchange for your participation, you will be provided with a gift card, valued at $50.00.
- You can choose from hundreds of brands, like Amazon, Target, Starbucks, Walmart, and Best Buy.
- The gift card can be sent to your email (e-Gift card) or mailed to you (prepaid debit MasterCard).
- Please allow 10 days if choosing to receive the prepaid debit MasterCard.

DAC HTR Statewide SF Housing Characteristics Study (2024) has been reviewed and approved by CalNEXT (https://calnext.com/). Questions concerning your rights as a participant in this research may be addressed to the study's Program Manager, Irina Krishpinovich, at The Ortiz Group, of 700 Van Ness Ave., Suite 006, Fresno, CA 93721. Phone: 510-326-8690 Email: ikrishpinovich@ortiz-group.com. The person conducting the survey ("Surveyor") is not a representative of Southern California Edison (SCE) or otherwise affiliated with SCE. SCE has no liability to you ("Participant") and will not be party to any agreement between Participant and Surveyor. Any, and all, disputes will be handled between Surveyor and Participant.

If you agree to take part in the study, please check the box below, type in your name, and provide your signature.

Thank you for your time and participation.

☐ I accept the Terms and Conditions.

Name of Participant *

First Name

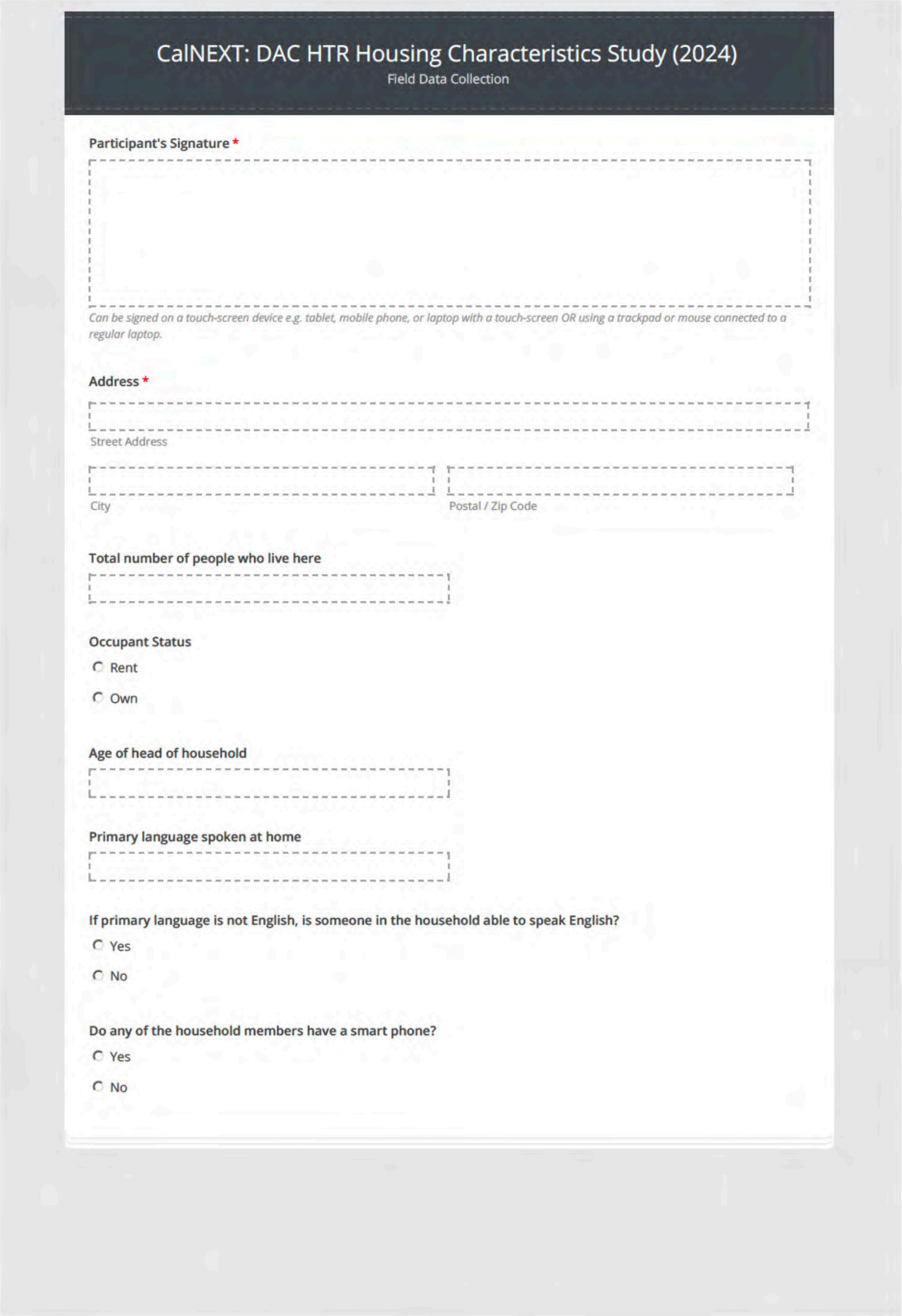
Last Name

Participant's Email Address *

This agreement, survey results, and gift card will be sent to this email address. IF YOU DON'T HAVE AN EMAIL, use: housingsurvey2024@gmail.com and select the 'Mail me my Gift Card' option below.

☐ **Mail me my Gift Card**

Choose this option if you would like to receive your Gift Card in the mail. We will collect your address in the next section.



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Participant's Signature *

Can be signed on a touch-screen device e.g. tablet, mobile phone, or laptop with a touch-screen OR using a trackpad or mouse connected to a regular laptop.

Address *

Street Address

City

Postal / Zip Code

Total number of people who live here

Occupant Status

○ Rent

○ Own

Age of head of household

Primary language spoken at home

If primary language is not English, is someone in the household able to speak English?

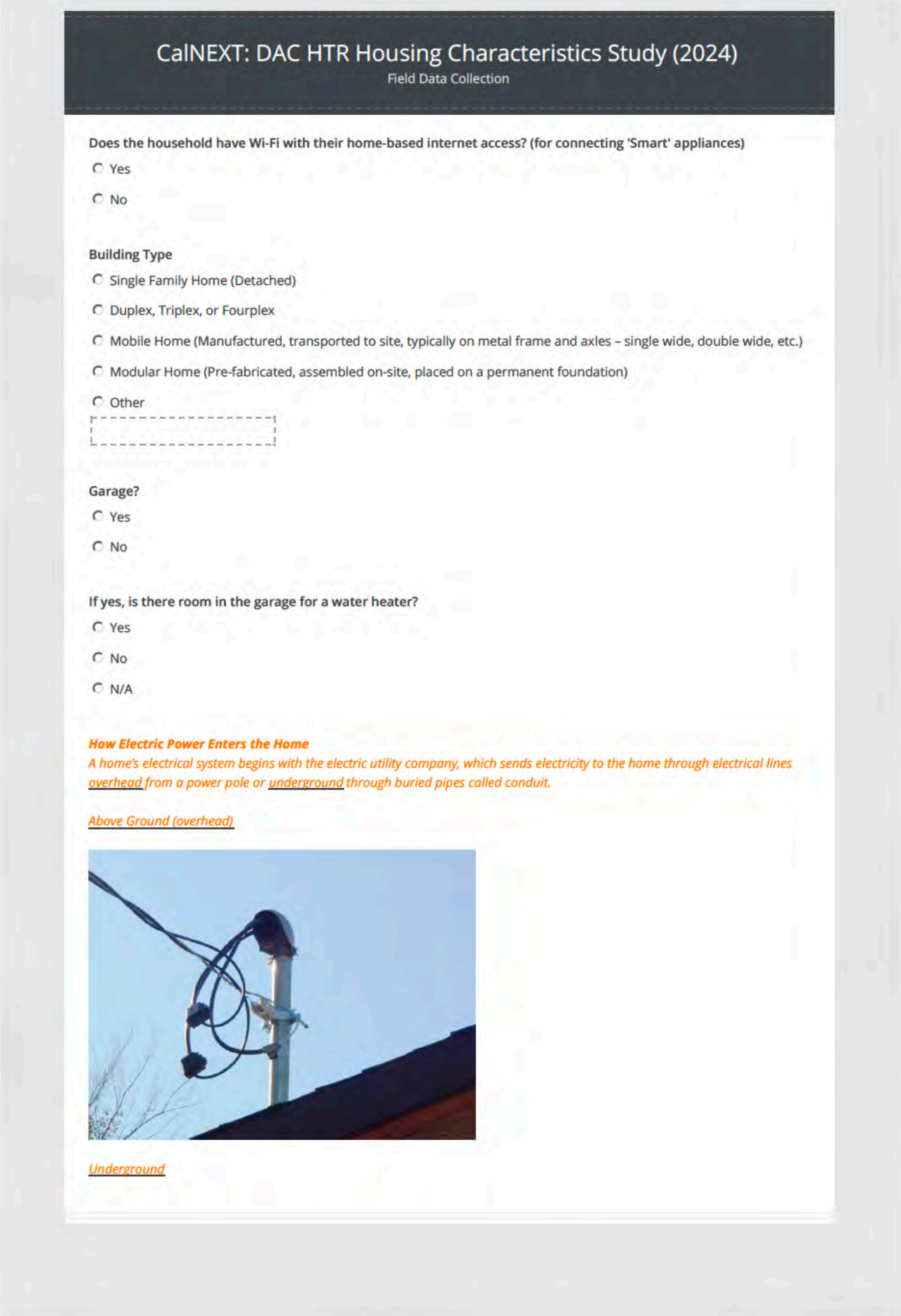
○ Yes

○ No

Do any of the household members have a smart phone?

○ Yes

○ No



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Does the household have Wi-Fi with their home-based internet access? (for connecting 'Smart' appliances)

○ Yes

○ No

Building Type

○ Single Family Home (Detached)

○ Duplex, Triplex, or Fourplex

○ Mobile Home (Manufactured, transported to site, typically on metal frame and axles – single wide, double wide, etc.)

○ Modular Home (Pre-fabricated, assembled on-site, placed on a permanent foundation)

○ Other

Garage?

○ Yes

○ No

If yes, is there room in the garage for a water heater?

○ Yes

○ No

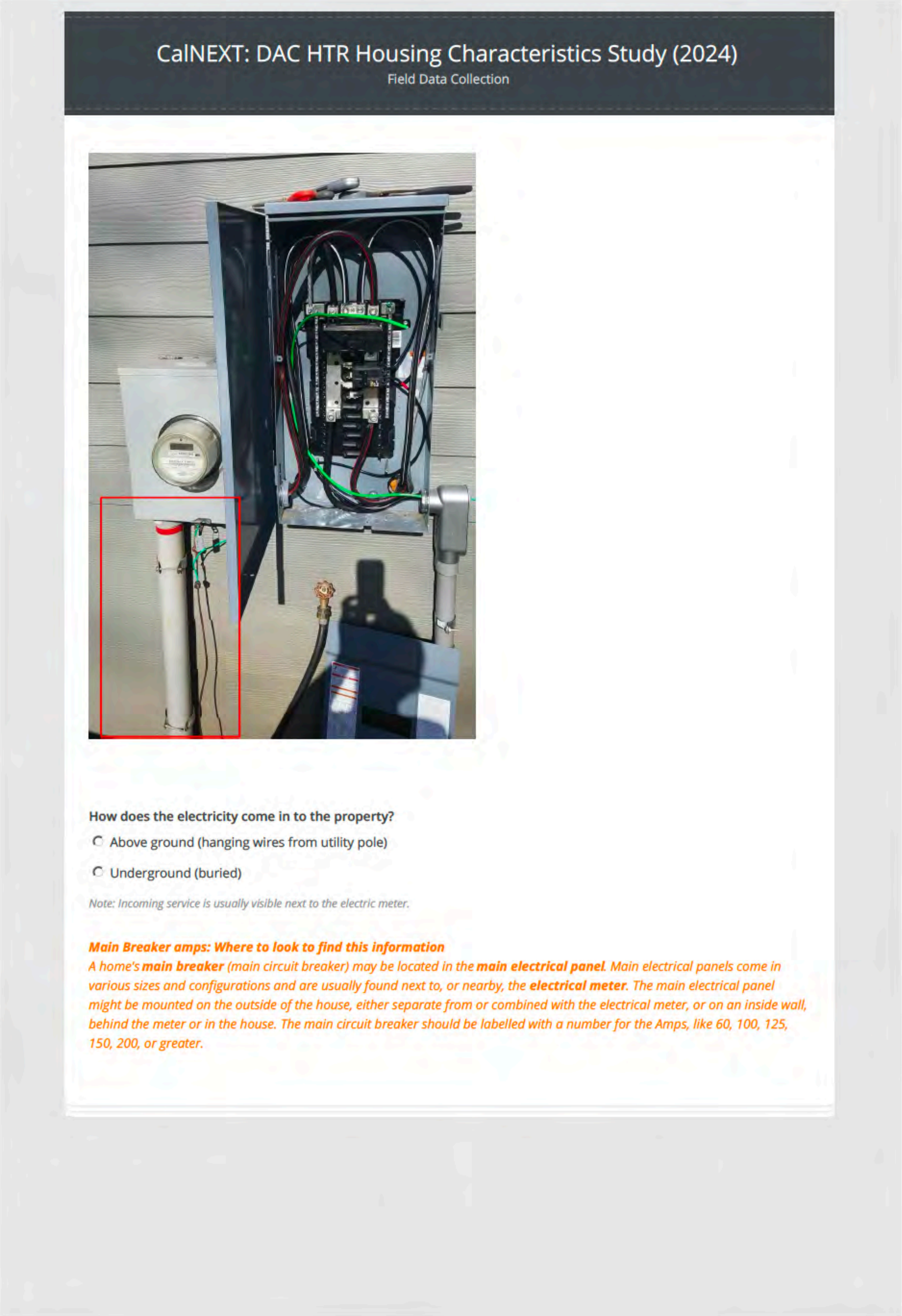
○ N/A

How Electric Power Enters the Home

A home's electrical system begins with the electric utility company, which sends electricity to the home through electrical lines overhead from a power pole or underground through buried pipes called conduit.

Above Ground (overhead)

Underground



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

How does the electricity come in to the property?

○ Above ground (hanging wires from utility pole)

○ Underground (buried)

Note: Incoming service is usually visible next to the electric meter.

Main Breaker amps: Where to look to find this information

*A home's **main breaker** (main circuit breaker) may be located in the **main electrical panel**. Main electrical panels come in various sizes and configurations and are usually found next to, or nearby, the **electrical meter**. The main electrical panel might be mounted on the outside of the house, either separate from or combined with the electrical meter, or on an inside wall, behind the meter or in the house. The main circuit breaker should be labelled with a number for the Amps, like 60, 100, 125, 150, 200, or greater.*

CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

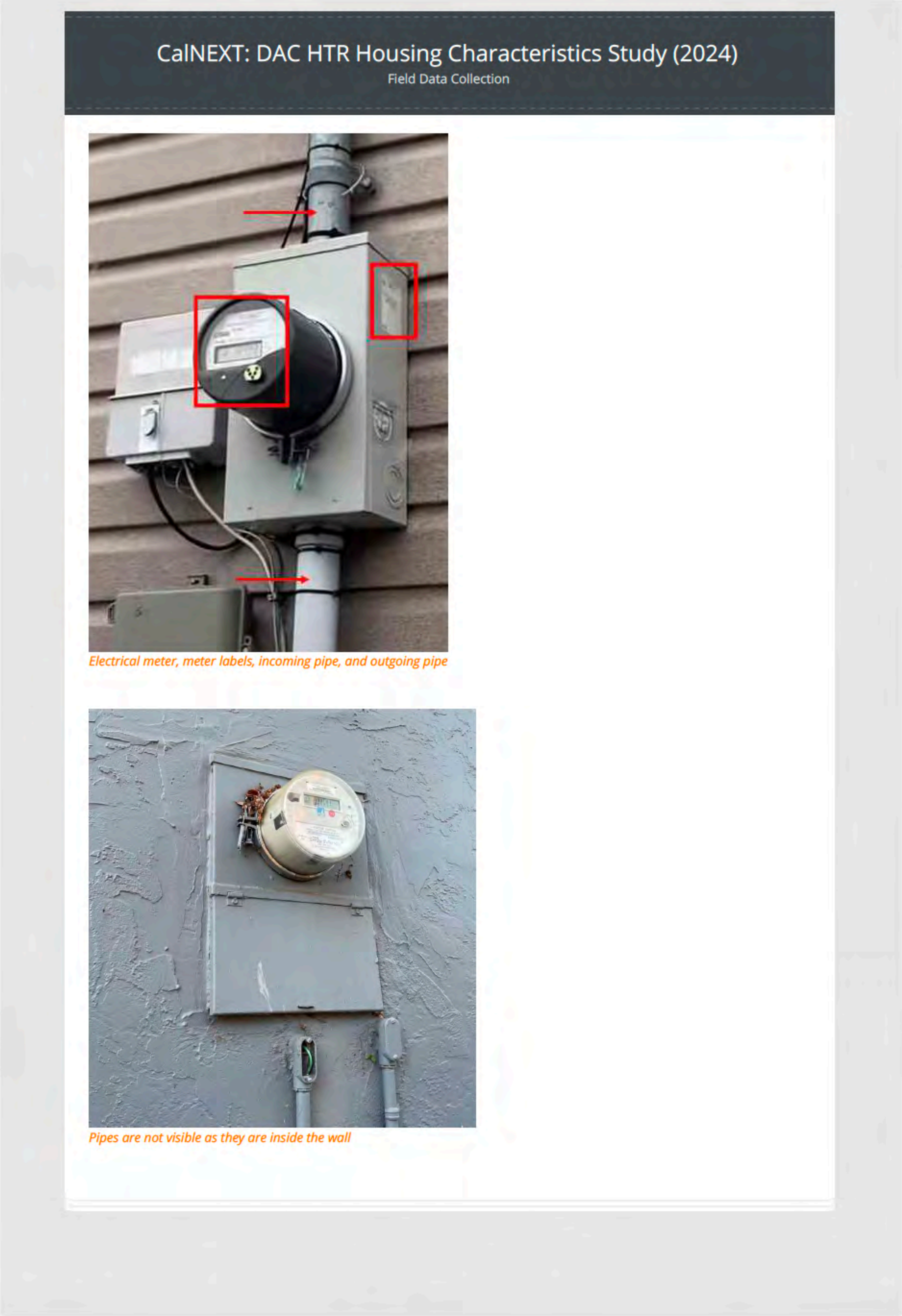
'Main circuit breaker' or 'main breaker'

Main breaker next to electrical meter

Electrical Meter, Meter Label, Incoming Pipe, Outgoing Pipe

For the purposes of this study, we are interested in the size of the pipe coming into the meter (incoming pipe) and coming out of it (outgoing pipe). Below is a photo showing the possible locations of the electrical meter labels along with the incoming and outgoing pipes.

The next photo below that shows an electrical meter with no visible incoming or outgoing pipes, since they are inside the wall (those other pipes beneath the meter are not the ones we're after). In these instances, you won't be able to measure the pipes and should indicate, 'Pipes are not visible'.

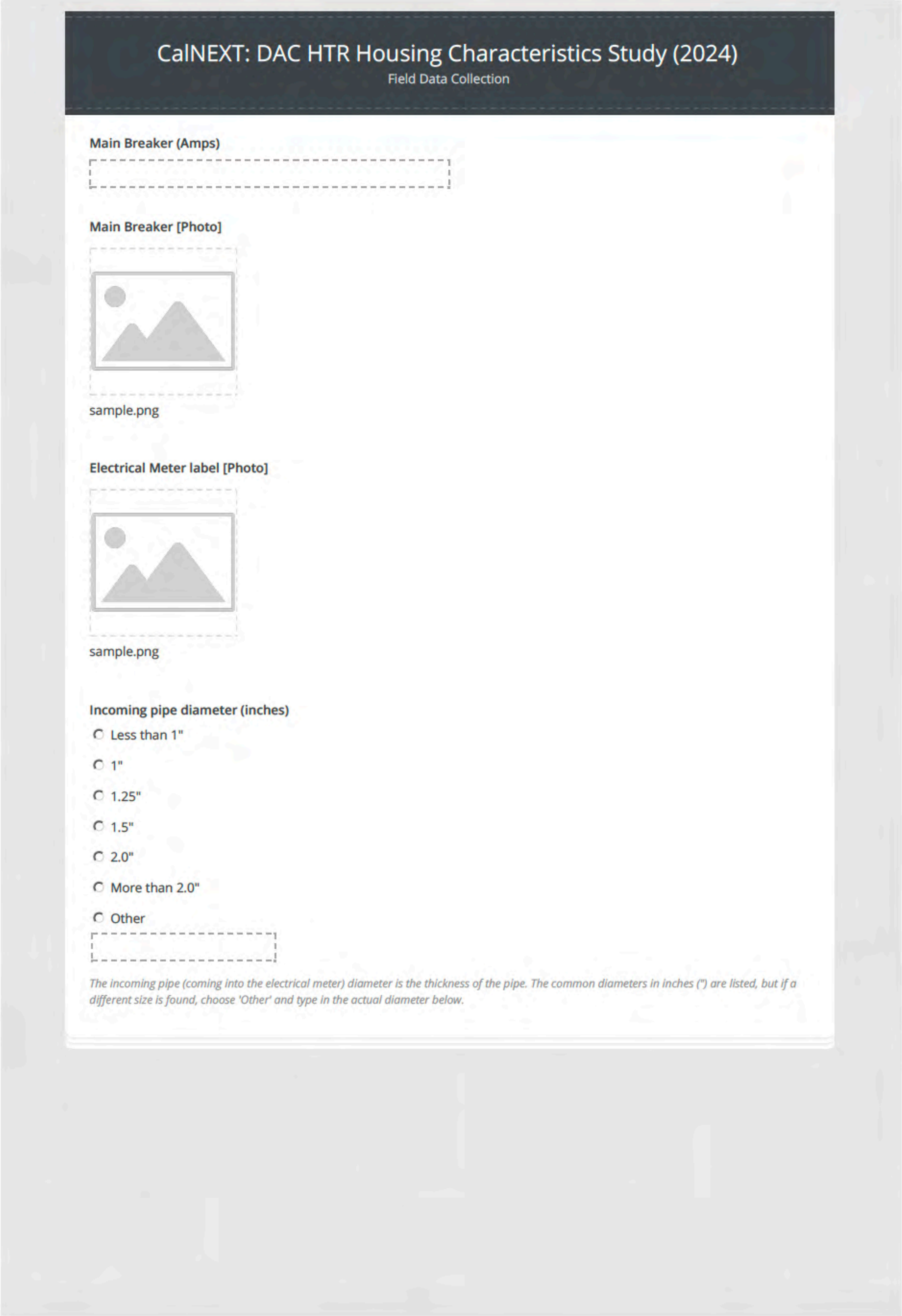


CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Electrical meter, meter labels, incoming pipe, and outgoing pipe

Pipes are not visible as they are inside the wall



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Main Breaker (Amps)

Main Breaker [Photo]

sample.png

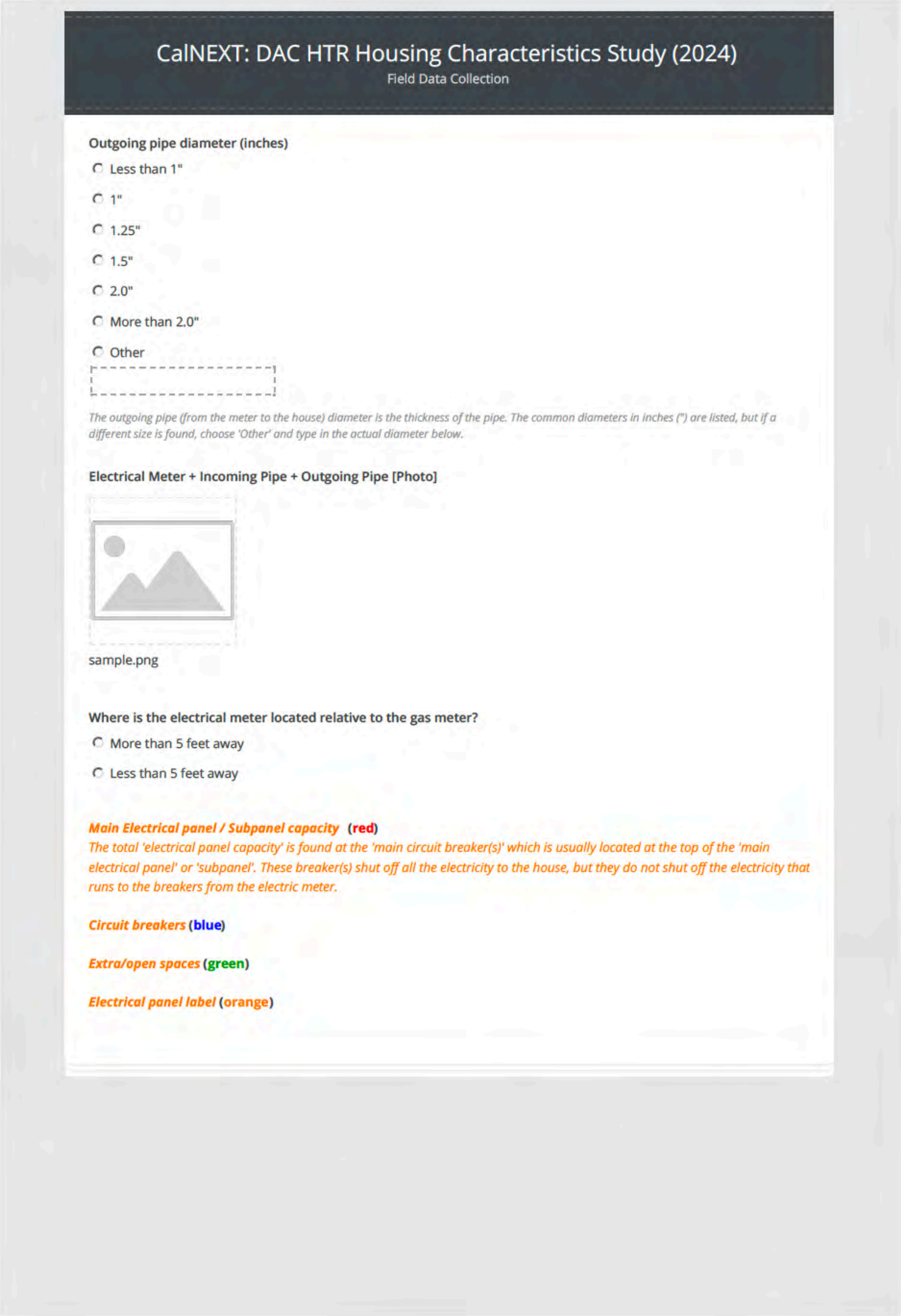
Electrical Meter label [Photo]

sample.png

Incoming pipe diameter (inches)

- ○ Less than 1"
- ○ 1"
- ○ 1.25"
- ○ 1.5"
- ○ 2.0"
- ○ More than 2.0"
- ○ Other

The incoming pipe (coming into the electrical meter) diameter is the thickness of the pipe. The common diameters in inches (") are listed, but if a different size is found, choose 'Other' and type in the actual diameter below.



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Outgoing pipe diameter (inches)

○ Less than 1"

○ 1"

○ 1.25"

○ 1.5"

○ 2.0"

○ More than 2.0"

○ Other

The outgoing pipe (from the meter to the house) diameter is the thickness of the pipe. The common diameters in inches (") are listed, but if a different size is found, choose 'Other' and type in the actual diameter below.

Electrical Meter + Incoming Pipe + Outgoing Pipe [Photo]

sample.png

Where is the electrical meter located relative to the gas meter?

○ More than 5 feet away

○ Less than 5 feet away

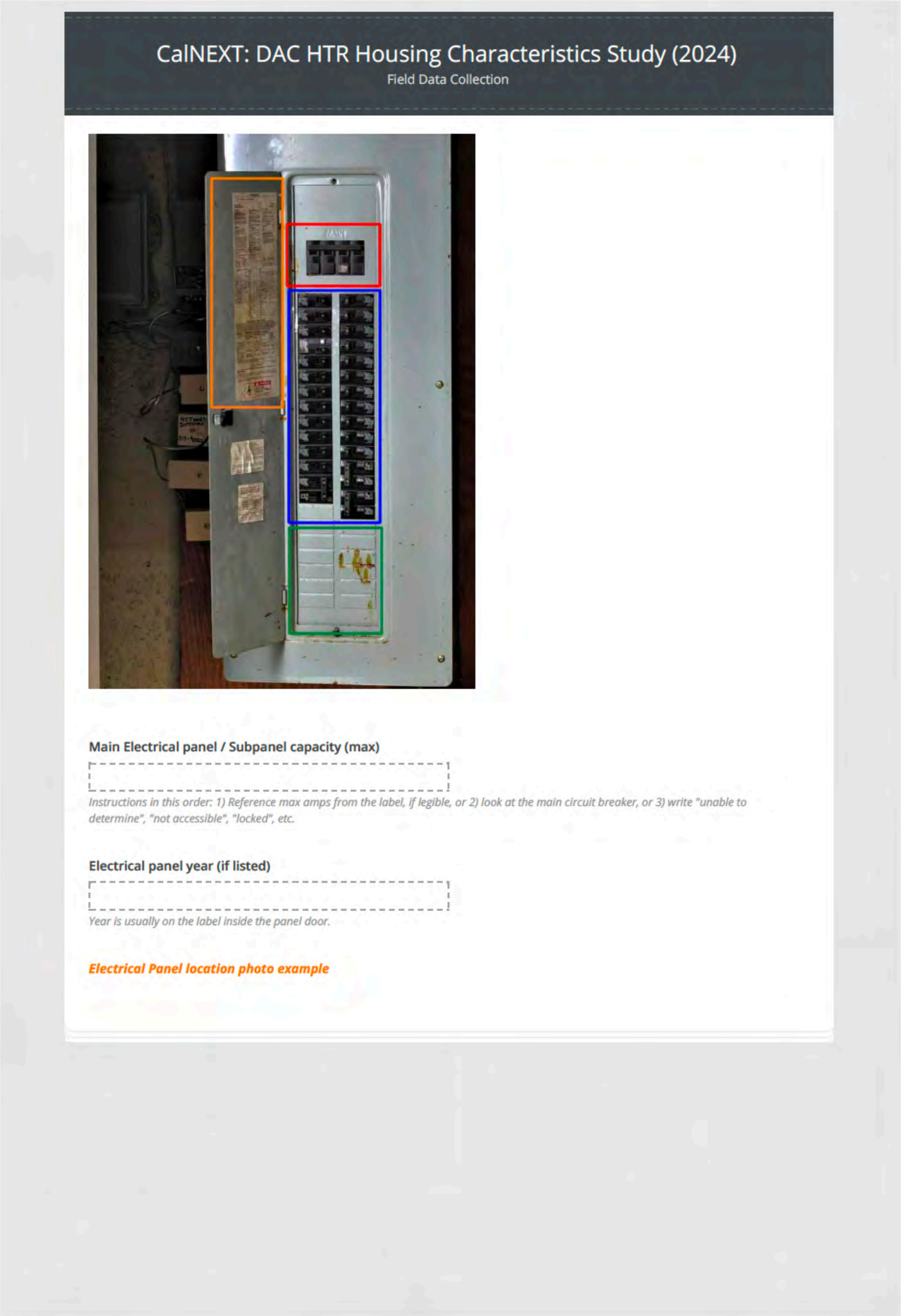
Main Electrical panel / Subpanel capacity **(red)**

The total 'electrical panel capacity' is found at the 'main circuit breaker(s)' which is usually located at the top of the 'main electrical panel' or 'subpanel'. These breaker(s) shut off all the electricity to the house, but they do not shut off the electricity that runs to the breakers from the electric meter.

Circuit breakers **(blue)**

Extra/open spaces **(green)**

Electrical panel label **(orange)**



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

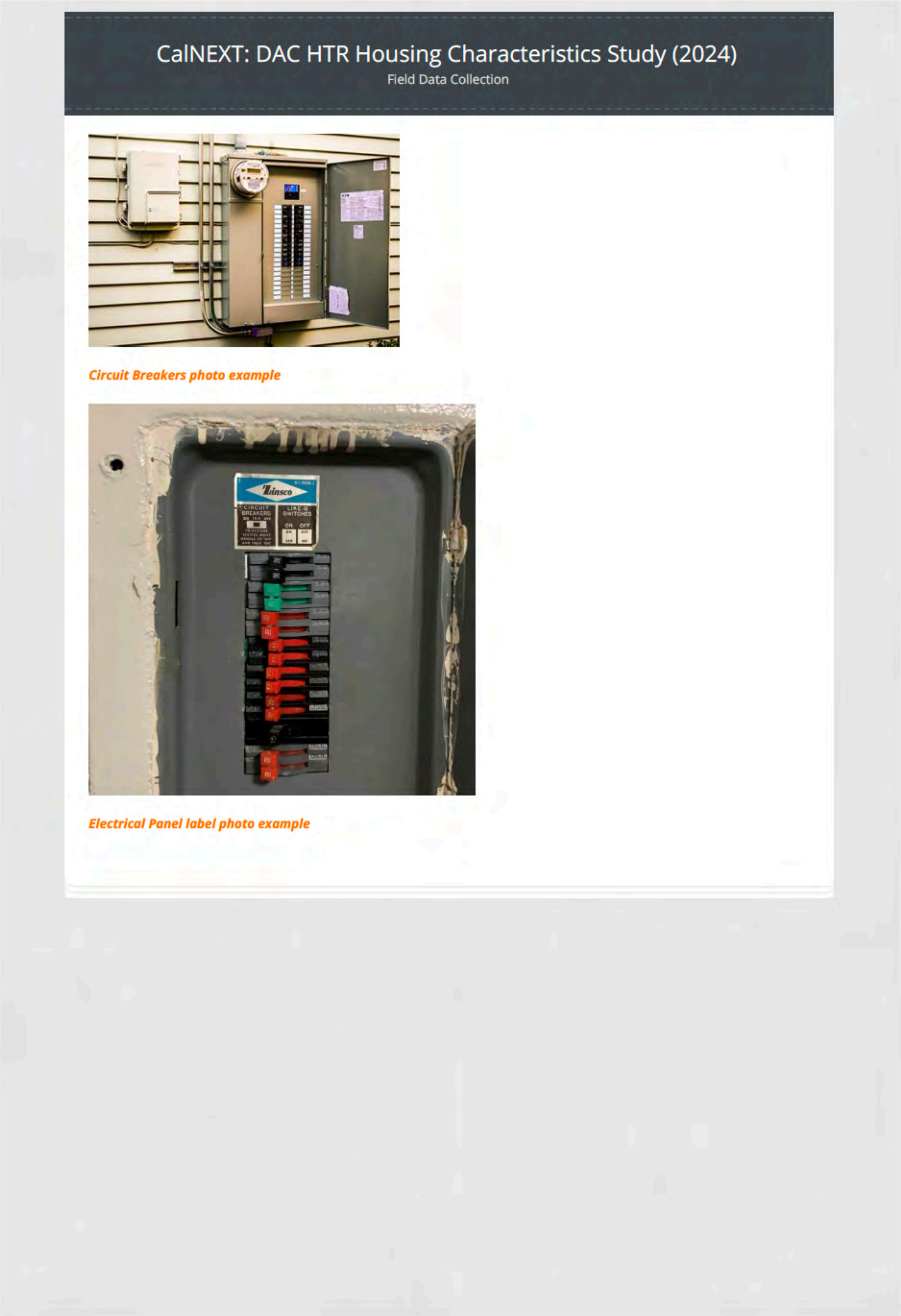
Main Electrical panel / Subpanel capacity (max)

Instructions in this order: 1) Reference max amps from the label, if legible, or 2) look at the main circuit breaker, or 3) write "unable to determine", "not accessible", "locked", etc.

Electrical panel year (if listed)

Year is usually on the label inside the panel door.

Electrical Panel location photo example



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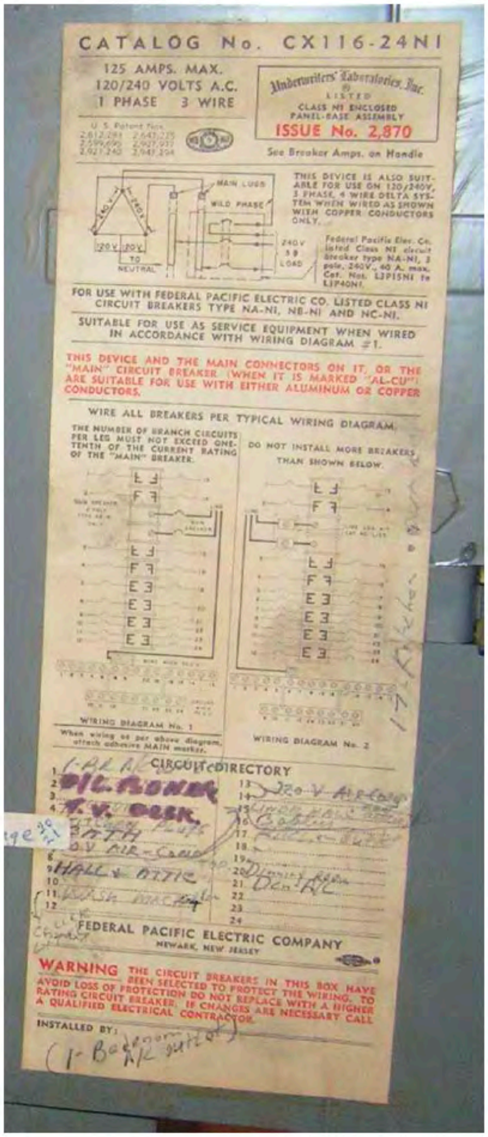
Field Data Collection

Circuit Breakers photo example

Electrical Panel label photo example

CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection



CATALOG No. CX116-24NI

125 AMPS. MAX.
120/240 VOLTS A.C.
1 PHASE 3 WIRE

Underwriters' Laboratories, Inc.
LISTED
CLASS NI ENCLOSED
PANEL-BASE ASSEMBLY
ISSUE No. 2,870

See Breaker Amps. on Handle

THIS DEVICE IS ALSO SUITABLE FOR USE ON 120/240V, 3 PHASE, 4 WIRE DELTA SYSTEM WHEN WIRED AS SHOWN WITH COPPER CONDUCTORS ONLY.

Federal Pacific Elec. Co. listed Class NI circuit breaker type NA-NI, 3 pole, 240V., 40 A. max. Cat. Nos. L3P15NI to L3P40NI.

FOR USE WITH FEDERAL PACIFIC ELECTRIC CO. LISTED CLASS NI CIRCUIT BREAKERS TYPE NA-NI, NB-NI AND NC-NI.

SUITABLE FOR USE AS SERVICE EQUIPMENT WHEN WIRED IN ACCORDANCE WITH WIRING DIAGRAM #1.

THIS DEVICE AND THE MAIN CONNECTORS ON IT, OR THE "MAIN" CIRCUIT BREAKER (WHEN IT IS MARKED "AL-CU") ARE SUITABLE FOR USE WITH EITHER ALUMINUM OR COPPER CONDUCTORS.

WIRE ALL BREAKERS PER TYPICAL WIRING DIAGRAM.

THE NUMBER OF BRANCH CIRCUITS PER LEG MUST NOT EXCEED ONE-TENTH OF THE CURRENT RATING OF THE "MAIN" BREAKER.

DO NOT INSTALL MORE BREAKERS THAN SHOWN BELOW.

WIRING DIAGRAM No. 1

When wiring as per above diagram, attach adhesive MAIN marker.

WIRING DIAGRAM No. 2

CIRCUIT DIRECTORY

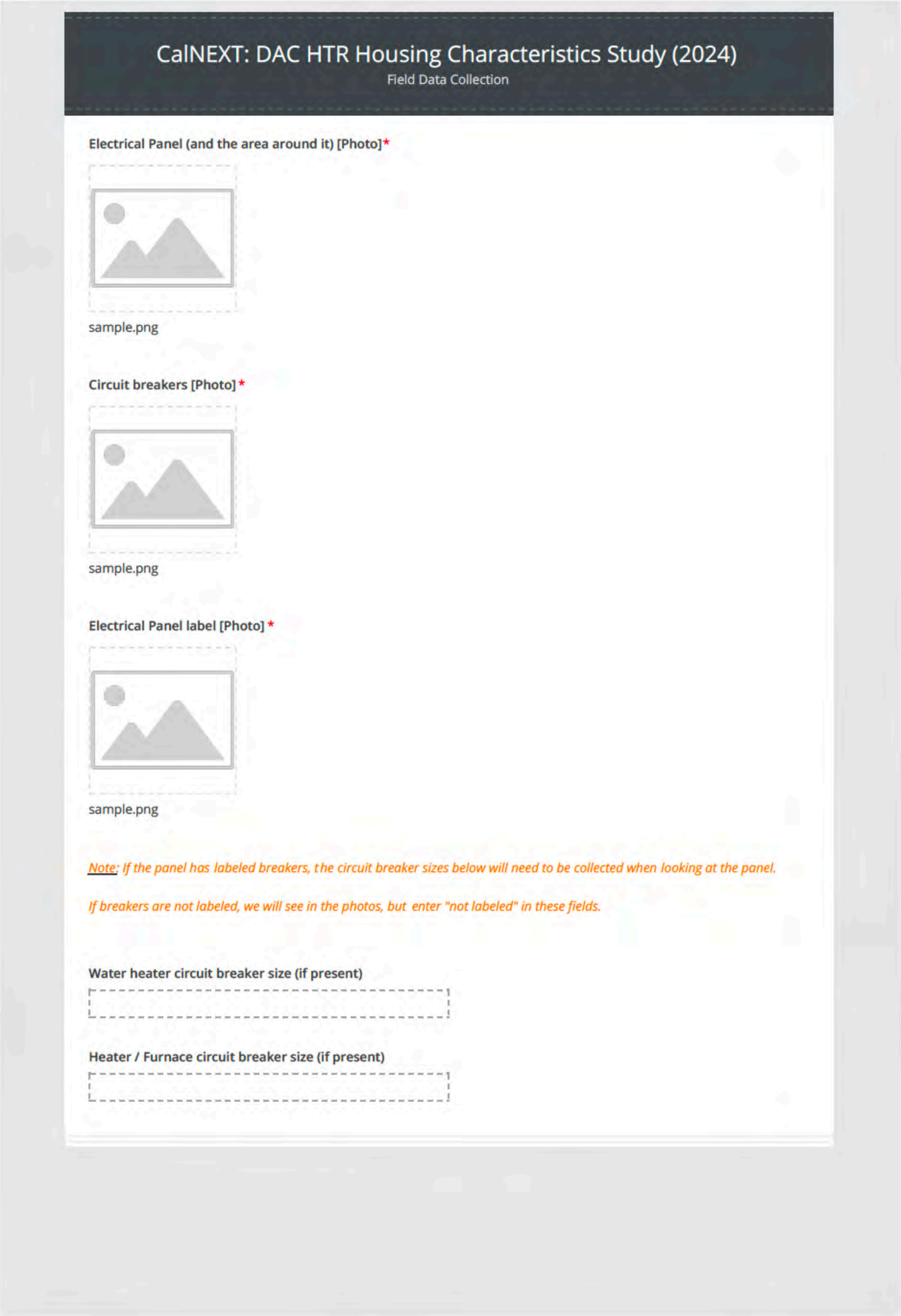
1. [illegible]
2. OIL BURNER
3.
4. T.V. DESK.
5. Kitchen Plugs
6. BATH
7. 220V AIR-Cond
8.
9. HALL + ATTIC
10.
11. WASH MACH
12.
13. 220 V AIR-Cond
14.
15. [illegible]
16. [illegible]
17. [illegible]
18.
19.
20. Dining Room
21. Den A/C
22.
23.
24.

FEDERAL PACIFIC ELECTRIC COMPANY
NEWARK, NEW JERSEY

WARNING THE CIRCUIT BREAKERS IN THIS BOX HAVE BEEN SELECTED TO PROTECT THE WIRING. TO AVOID LOSS OF PROTECTION DO NOT REPLACE WITH A HIGHER RATING CIRCUIT BREAKER. IF CHANGES ARE NECESSARY CALL A QUALIFIED ELECTRICAL CONTRACTOR.

INSTALLED BY:

(1-Bedroom AIR outlet)



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Electrical Panel (and the area around it) [Photo]*

sample.png

Circuit breakers [Photo]*

sample.png

Electrical Panel label [Photo]*

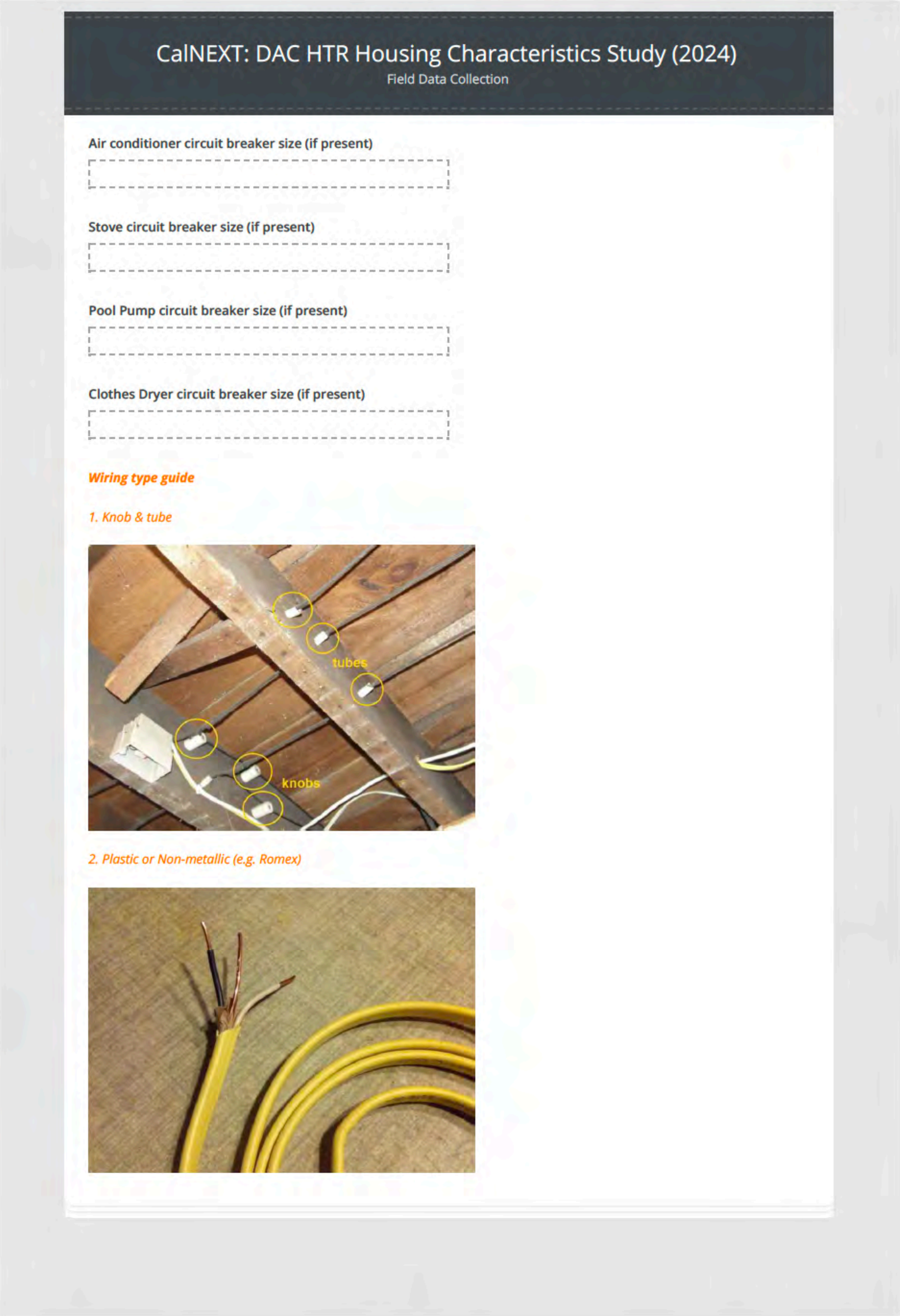
sample.png

Note: If the panel has labeled breakers, the circuit breaker sizes below will need to be collected when looking at the panel.

If breakers are not labeled, we will see in the photos, but enter "not labeled" in these fields.

Water heater circuit breaker size (if present)

Heater / Furnace circuit breaker size (if present)



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

Air conditioner circuit breaker size (if present)

Stove circuit breaker size (if present)

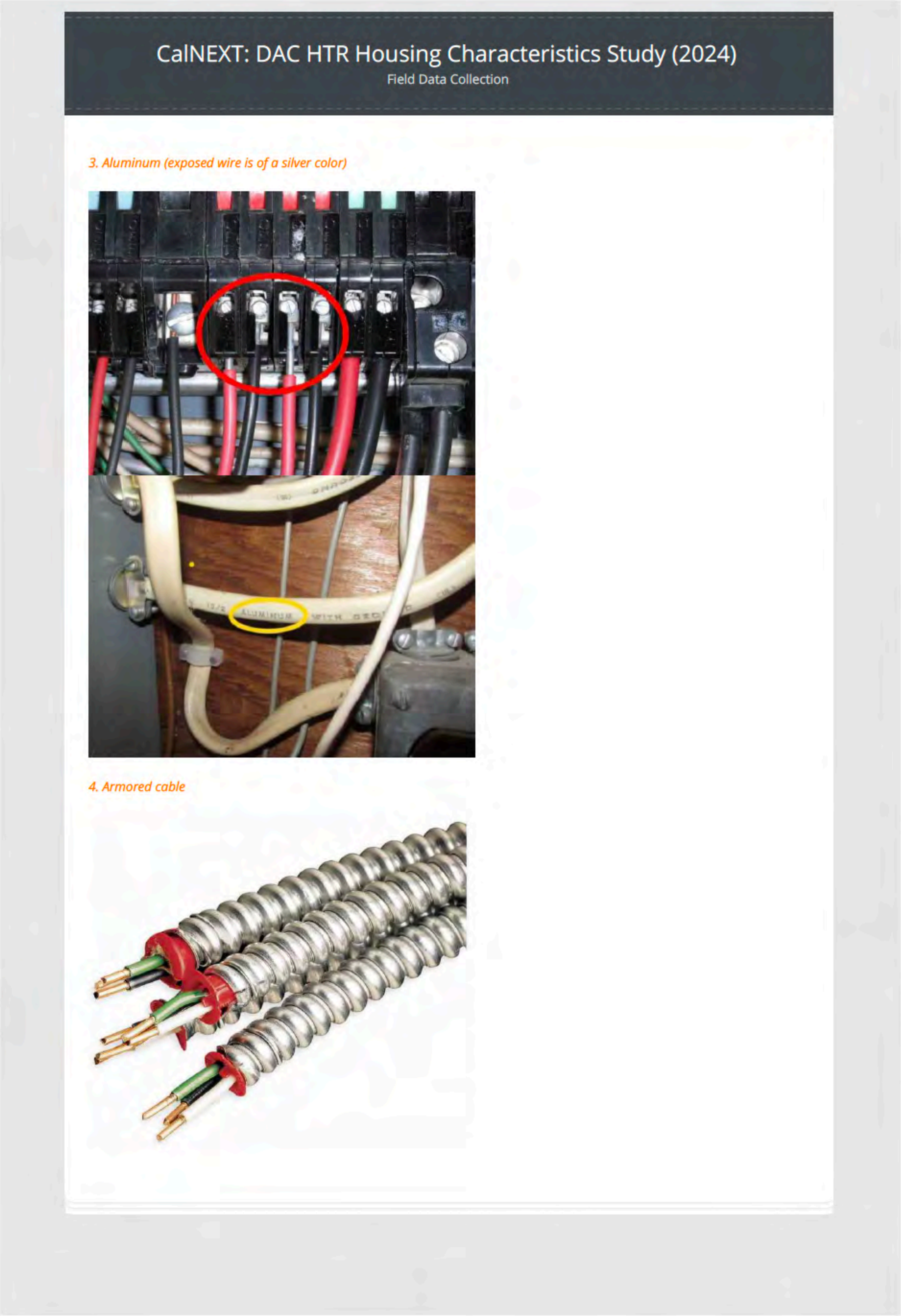
Pool Pump circuit breaker size (if present)

Clothes Dryer circuit breaker size (if present)

Wiring type guide

1. Knob & tube

2. Plastic or Non-metallic (e.g. Romex)

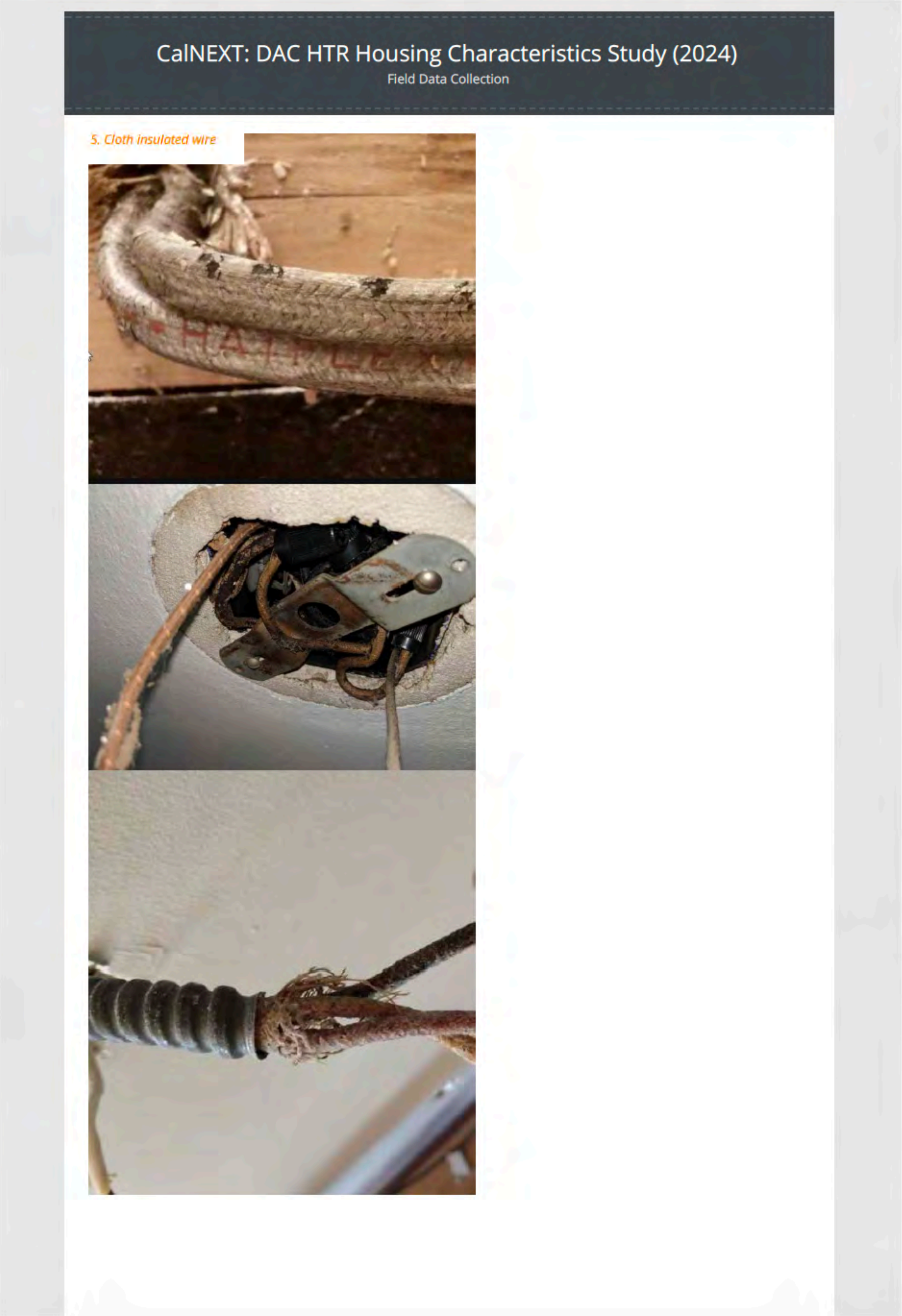


CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

3. Aluminum (exposed wire is of a silver color)

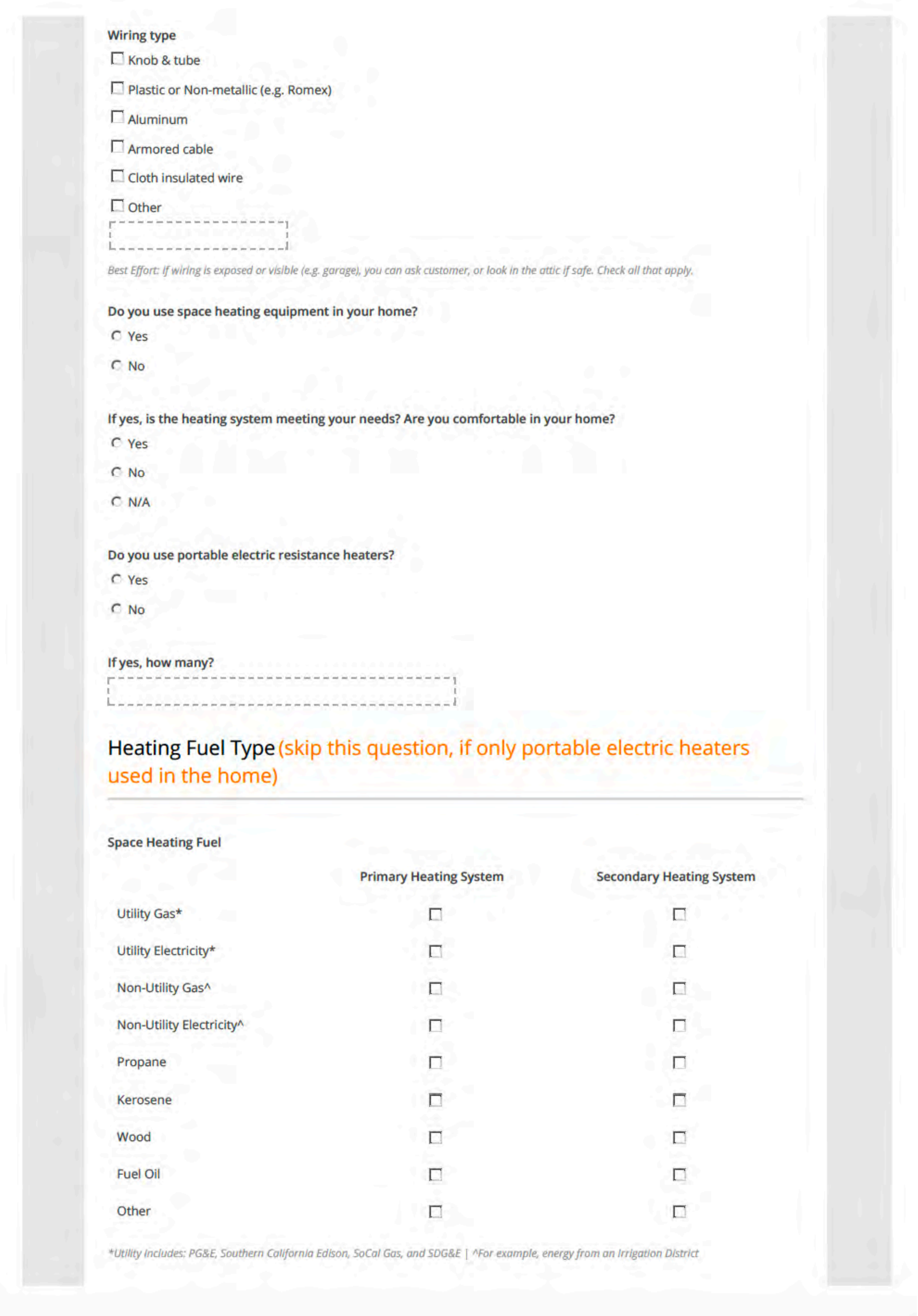
4. Armored cable



CalNEXT: DAC HTR Housing Characteristics Study (2024)

Field Data Collection

5. Cloth insulated wire



Wiring type

☐ Knob & tube

☐ Plastic or Non-metallic (e.g. Romex)

☐ Aluminum

☐ Armored cable

☐ Cloth insulated wire

☐ Other

Best Effort: If wiring is exposed or visible (e.g. garage), you can ask customer, or look in the attic if safe. Check all that apply.

Do you use space heating equipment in your home?

○ Yes

○ No

If yes, is the heating system meeting your needs? Are you comfortable in your home?

○ Yes

○ No

○ N/A

Do you use portable electric resistance heaters?

○ Yes

○ No

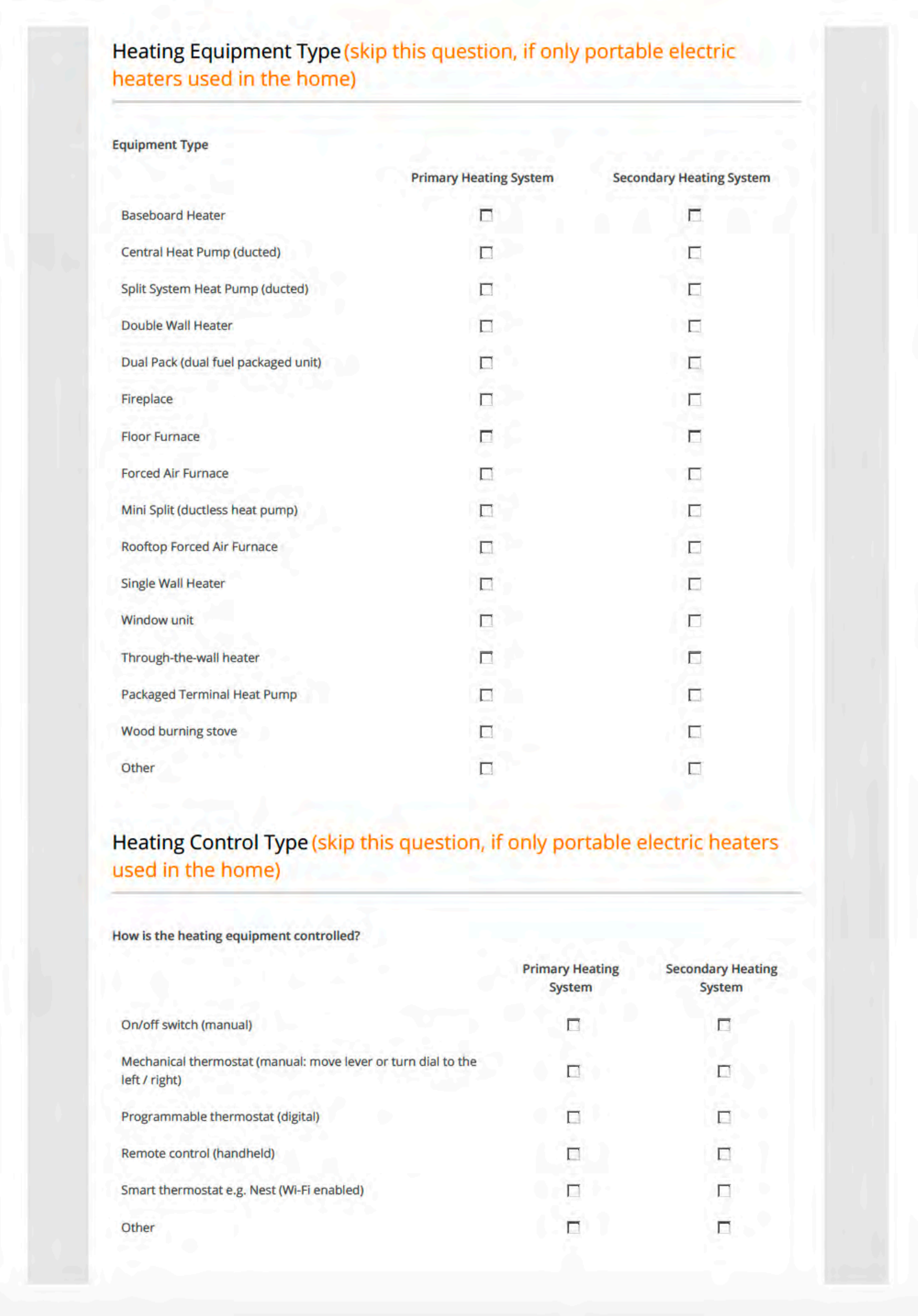
If yes, how many?

Heating Fuel Type (skip this question, if only portable electric heaters used in the home)

Space Heating Fuel

	Primary Heating System	Secondary Heating System
Utility Gas*	☐	☐
Utility Electricity*	☐	☐
Non-Utility Gas^	☐	☐
Non-Utility Electricity^	☐	☐
Propane	☐	☐
Kerosene	☐	☐
Wood	☐	☐
Fuel Oil	☐	☐
Other	☐	☐

**Utility includes: PG&E, Southern California Edison, SoCal Gas, and SDG&E | ^For example, energy from an Irrigation District*



Heating Equipment Type (skip this question, if only portable electric heaters used in the home)

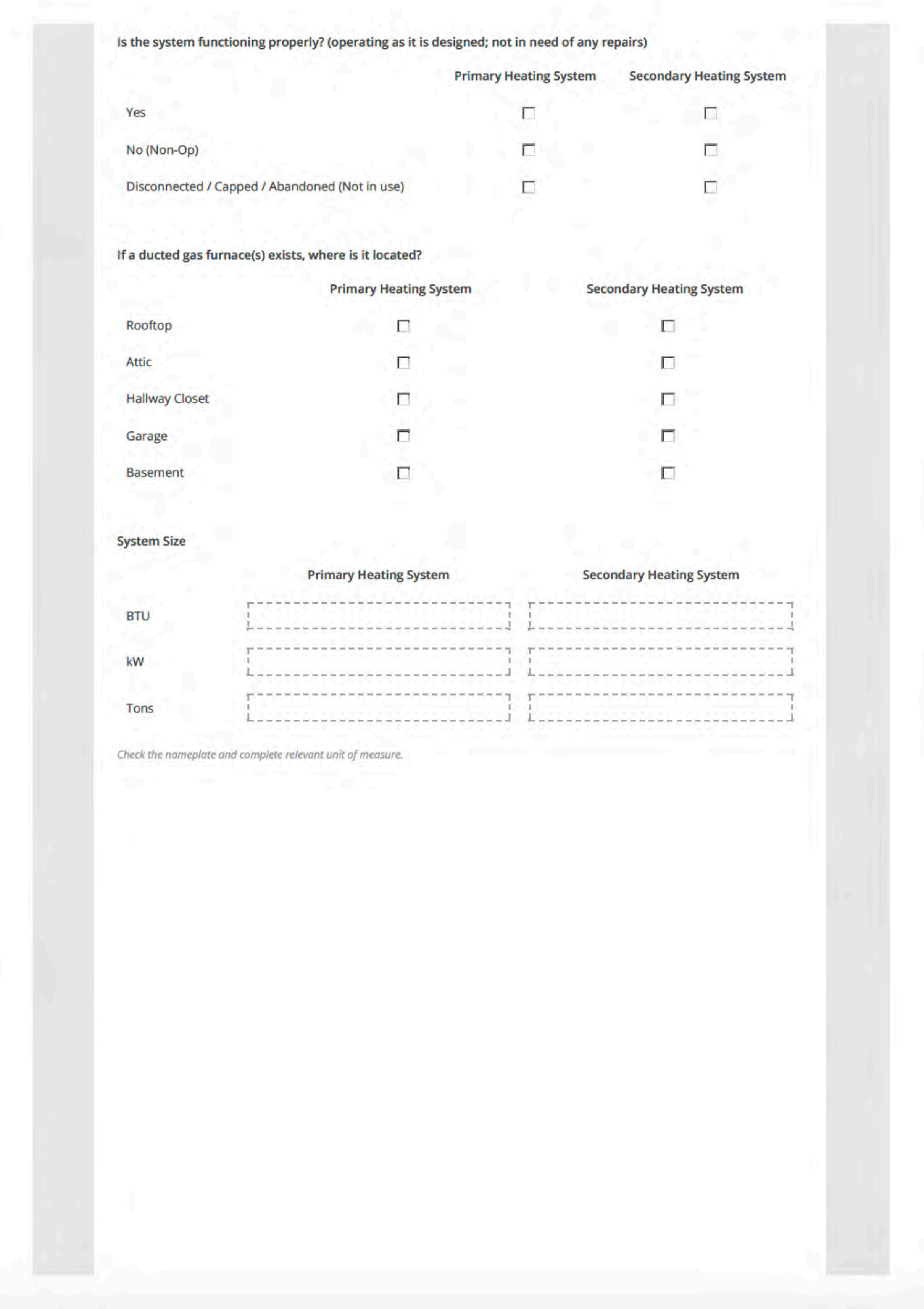
Equipment Type

	Primary Heating System	Secondary Heating System
Baseboard Heater	☐	☐
Central Heat Pump (ducted)	☐	☐
Split System Heat Pump (ducted)	☐	☐
Double Wall Heater	☐	☐
Dual Pack (dual fuel packaged unit)	☐	☐
Fireplace	☐	☐
Floor Furnace	☐	☐
Forced Air Furnace	☐	☐
Mini Split (ductless heat pump)	☐	☐
Rooftop Forced Air Furnace	☐	☐
Single Wall Heater	☐	☐
Window unit	☐	☐
Through-the-wall heater	☐	☐
Packaged Terminal Heat Pump	☐	☐
Wood burning stove	☐	☐
Other	☐	☐

Heating Control Type (skip this question, if only portable electric heaters used in the home)

How is the heating equipment controlled?

	Primary Heating System	Secondary Heating System
On/off switch (manual)	☐	☐
Mechanical thermostat (manual: move lever or turn dial to the left / right)	☐	☐
Programmable thermostat (digital)	☐	☐
Remote control (handheld)	☐	☐
Smart thermostat e.g. Nest (Wi-Fi enabled)	☐	☐
Other	☐	☐



Is the system functioning properly? (operating as it is designed; not in need of any repairs)

	Primary Heating System	Secondary Heating System
Yes	☐	☐
No (Non-Op)	☐	☐
Disconnected / Capped / Abandoned (Not in use)	☐	☐

If a ducted gas furnace(s) exists, where is it located?

	Primary Heating System	Secondary Heating System
Rooftop	☐	☐
Attic	☐	☐
Hallway Closet	☐	☐
Garage	☐	☐
Basement	☐	☐

System Size

	Primary Heating System	Secondary Heating System
BTU		
kW		
Tons		

Check the nameplate and complete relevant unit of measure.

Heating System Photo Instructions *(For each heating system):*

- *Overall image of the appliance showing location and general condition*
- *Nameplate image must be LEGIBLE and include model number, manufacturer, input and output, etc.*

Appliance with location and condition example

Heating system nameplate example

GOODMAN MANUFACTURING COMPANY, L.P.
5151 SAN FELIPE ST., SUITE 500
HOUSTON, TEXAS 77056

CERTIFIED AS A FORCED AIR FURNACE CAT1
EQUIPPED FOR USE WITH NATURAL GAS AT ALTITUDES FROM 0 TO 4500' ABOVE SEA LEVEL
INSTALLATION ONLY IN BUILDING CONSTRUCTED ON SITE
CERTIFIE COMME UN GENERATEUR D'AIR CHAUD CIRCULATION FORCEE
EQUIPE POUR USAGE AVEC LE GAZ NATUREL AUX ALTITUDES DE 0 A 4500' AU – DESSUS DU NIVEAU DE LA MER

MODEL NO. / NO. DE MODELE GME80805CNBB
SERIAL NO. / NO. DE SERIE 1612117501

AHRI CERTIFIED

POWER SUPPLY / CARACTERISTIQUES ELECTRONICS 115 VOLTS 1 PHASE 60 HERTZ
LESS THAN 12 AMPS. / MOINS DE 12 AMPS

	NAT. GAS	L.P. GAS
HEATING INPUT (BTU/HR) DEBIT (BTU/HRE.)	80,000	80,000
OUTPUT CAPACITY (BTU/HR) PUISSANCE (BTU/HRE.)	64,000	64,000
FOR TEMPERATURE RISE OF (°F) ELEVATION DE TEMP. DE L'AIR	35 – 65	35 – 65

C US
Intertek
3073027

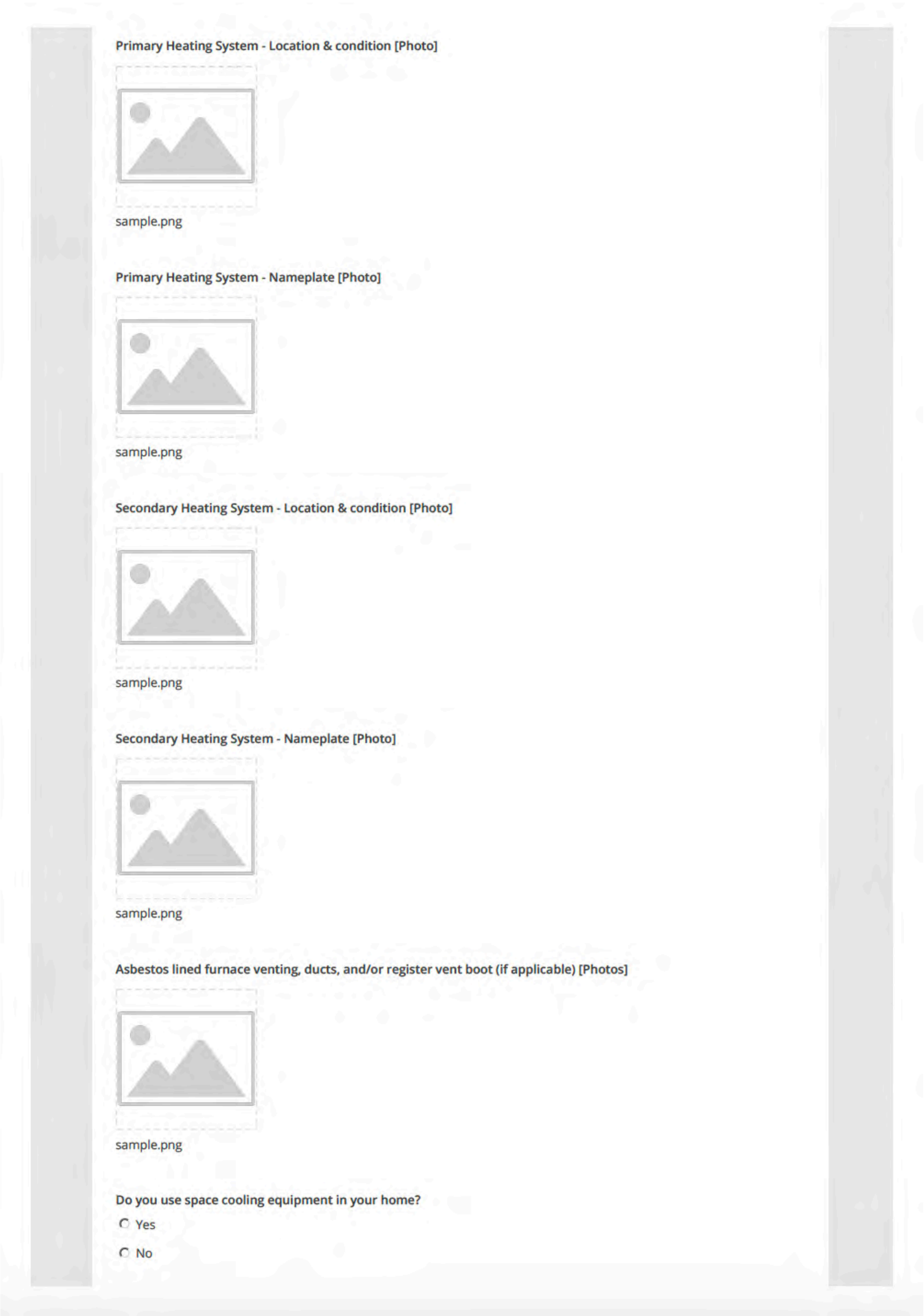
DESIGN MAX. OUTLET TEMP. (°F) / TEMPERATURE MAX. DE L'AIR A LA SORTIE (°F) 165
LIMIT SET (°F) / REGLAGE DE LIMITEUR (°F) 160
FACTORY TESTED EXTERNAL STATIC PRESSURE (IN. W.C.) / PRESSION STATIQUE VERIFIE A L'USINE (PO. C. D'EAU) 0.5
MOTOR (H.P.) / MOTEUR 1
BLOWER (IN.) / SOUFFLEUR (PO.) 10X10
AUX. LIMIT SETTING (F) 120
NOx EMISSION LIMIT – ___ ng/J

	NAT. GAS	L.P. GAS
MAXIMUM GAS SUPPLY PRESSURE TO FURNACE (IN.W.C.) PRESSION DU GAZ A L'ENTREE MAXIMUM (PO.C.D'EAU)	7	14
MINIMUM GAS SUPPLY PRESSURE FOR PURPOSE OF INPUT ADJUSTMENT (IN.W.C.) PRESSION DU GAZ A L'ENTREE POUR L'OBJET D'AJUSTAGE (PO.C.D'EAU)	5	11
MANIFOLD PRESSURE (IN.W.C.) PRESSION TUBULURE (PO.C.D'EAU)	3.5	10
MAIN BURNER ORIFICE SIZE INJECTEUR DE BRULEAUR PRINCIPAL	45	55

ANSI Z21.47/CSA2.3b 2006

GAS – FIRED GRAVITY & FORCED AIR CENTRAL FURNACES STANDARD

THIS FURNACE IS EQUIPPED WITH DUAL SAVER OR TWIN COMFORT TECHNOLOGY. THIS FEATURE REDUCES THE MANIFOLD PRESSURE AND GAS INPUT FOR A LIMITED DURATION. SEE THE INSTALLATION MANUAL FOR FURTHER DETAILS. WHEN ACTIVE THE MANIFOLD PRESSURE IS 2.0" WC (NATURAL GAS) OR 5.0" WC (LP GAS), AND THE GAS INPUT IS 75% OF THAT INDICATED ABOVE.
CETTE FOUMAISE EST MUNIE DE LA TECHOLOGIE DUAL SAVER OU TWIN COMFORT, QUI DIMNUE LA PRESSION D'ADMISSION DU GAZ ET SON DÉBIT D'ALIMENTATION POUR UNE DURÉE DÉTERMINÉE. VEUILLEZ CONSUITER LE MANUEL D'ENTRETIEN POUR PLUS DE DÉTAILS. LORSQUE CETTE TECHNOLOGIE EST EN FONCTION, LA PRESSION D'ADMISSION EST 2,0 PO WC (GAZ DE PÉTROLE LIQUÉFILÉ, ET L'ALIMENTATION EN GAZ S'ÉTABLIT À 75% DE CELLE INDIQUÉE CI – DESSUS.
SR015



Primary Heating System - Location & condition [Photo]

sample.png

Primary Heating System - Nameplate [Photo]

sample.png

Secondary Heating System - Location & condition [Photo]

sample.png

Secondary Heating System - Nameplate [Photo]

sample.png

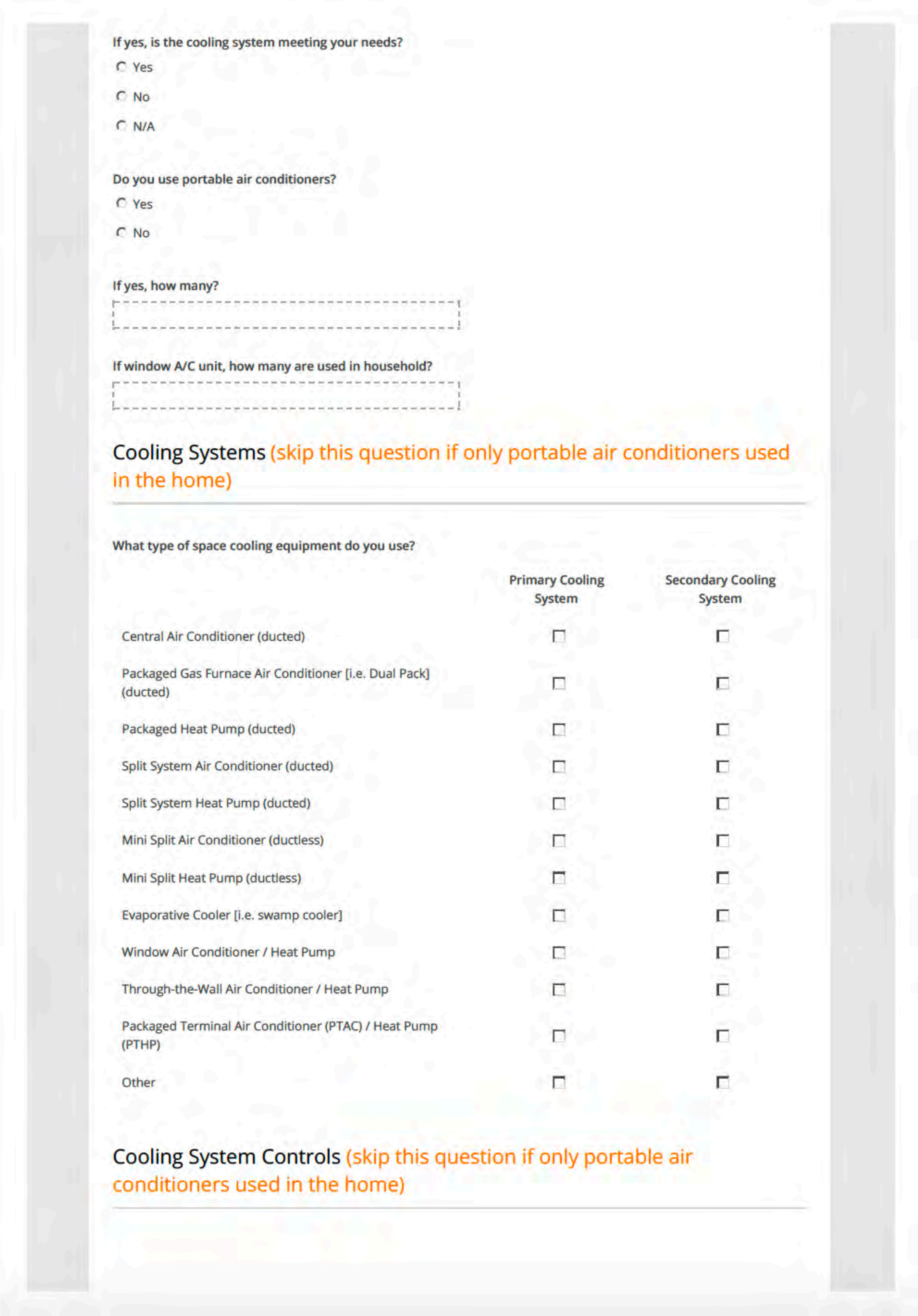
Asbestos lined furnace venting, ducts, and/or register vent boot (if applicable) [Photos]

sample.png

Do you use space cooling equipment in your home?

○ Yes

○ No



If yes, is the cooling system meeting your needs?

○ Yes

○ No

○ N/A

Do you use portable air conditioners?

○ Yes

○ No

If yes, how many?

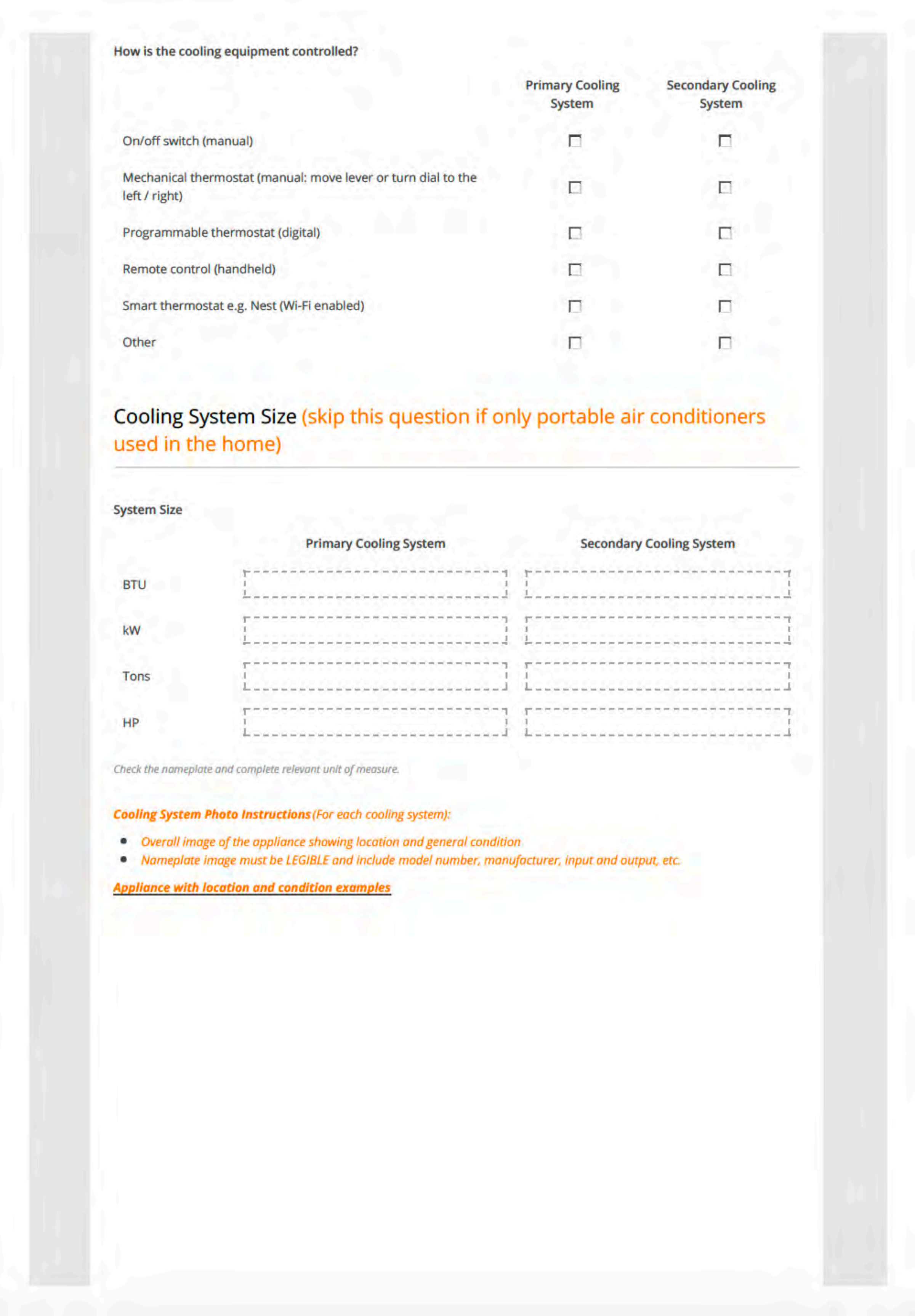
If window A/C unit, how many are used in household?

Cooling Systems (skip this question if only portable air conditioners used in the home)

What type of space cooling equipment do you use?

	Primary Cooling System	Secondary Cooling System
Central Air Conditioner (ducted)	☐	☐
Packaged Gas Furnace Air Conditioner [i.e. Dual Pack] (ducted)	☐	☐
Packaged Heat Pump (ducted)	☐	☐
Split System Air Conditioner (ducted)	☐	☐
Split System Heat Pump (ducted)	☐	☐
Mini Split Air Conditioner (ductless)	☐	☐
Mini Split Heat Pump (ductless)	☐	☐
Evaporative Cooler [i.e. swamp cooler]	☐	☐
Window Air Conditioner / Heat Pump	☐	☐
Through-the-Wall Air Conditioner / Heat Pump	☐	☐
Packaged Terminal Air Conditioner (PTAC) / Heat Pump (PTHP)	☐	☐
Other	☐	☐

Cooling System Controls (skip this question if only portable air conditioners used in the home)



How is the cooling equipment controlled?

	Primary Cooling System	Secondary Cooling System
On/off switch (manual)	☐	☐
Mechanical thermostat (manual: move lever or turn dial to the left / right)	☐	☐
Programmable thermostat (digital)	☐	☐
Remote control (handheld)	☐	☐
Smart thermostat e.g. Nest (Wi-Fi enabled)	☐	☐
Other	☐	☐

Cooling System Size (skip this question if only portable air conditioners used in the home)

System Size

	Primary Cooling System	Secondary Cooling System
BTU		
kW		
Tons		
HP		

Check the nameplate and complete relevant unit of measure.

Cooling System Photo Instructions *(For each cooling system):*

- *Overall image of the appliance showing location and general condition*
- *Nameplate image must be LEGIBLE and include model number, manufacturer, input and output, etc.*

Appliance with location and condition examples

Central Air Conditioner (ducted)

Packaged Gas Furnace Air Conditioner [i.e. Dual Pack] (ducted)

Split System Air Conditioner / Heat Pump (ducted)

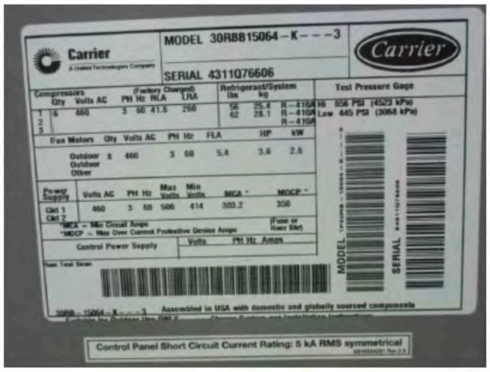
Mini Split Air Conditioner / Heat Pump (ductless)

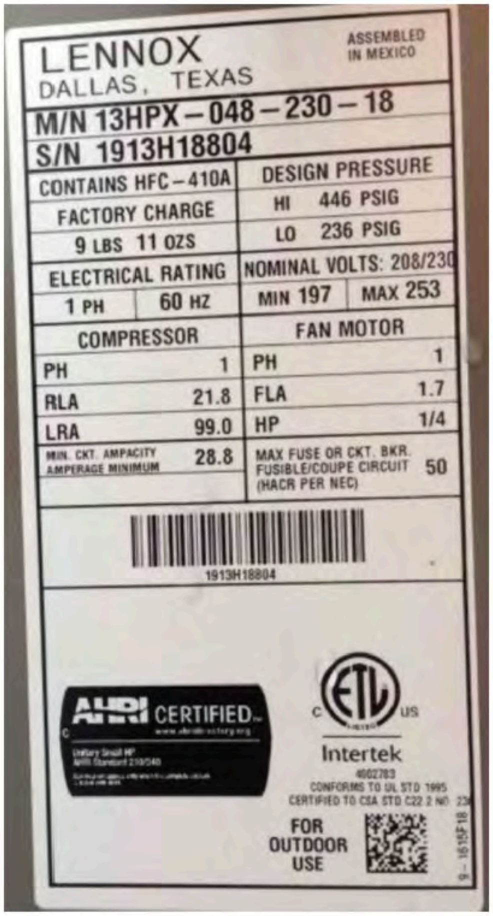
Window Air Conditioner / Heat Pump

Through-the-Wall Air Conditioner / Heat Pump

Packaged Terminal Air Conditioner (PTAC) / Heat Pump (PTHP)

Cooling system nameplate examples





LENNOX
DALLAS, TEXAS

ASSEMBLED
IN MEXICO

M/N 13HPX – 048 – 230 – 18
S/N 1913H18804

CONTAINS HFC – 410A	DESIGN PRESSURE
FACTORY CHARGE	HI 446 PSIG
9 LBS 11 OZS	LO 236 PSIG
ELECTRICAL RATING	NOMINAL VOLTS: 208/23
1 PH 60 HZ	MIN 197 MAX 253

COMPRESSOR		FAN MOTOR	
PH	1	PH	1
RLA	21.8	FLA	1.7
LRA	99.0	HP	1/4
MIN. CKT. AMPACITY AMPERAGE MINIMUM	28.8	MAX FUSE OR CKT. BKR. FUSIBLE/COUPE CIRCUIT (HACR PER NEC)	50

1913H18804

AHRI CERTIFIED

C US
Intertek
4002783
CONFORMS TO UL STD 1995
CERTIFIED TO CSA STD C22.2 NO. 23

FOR
OUTDOOR
USE

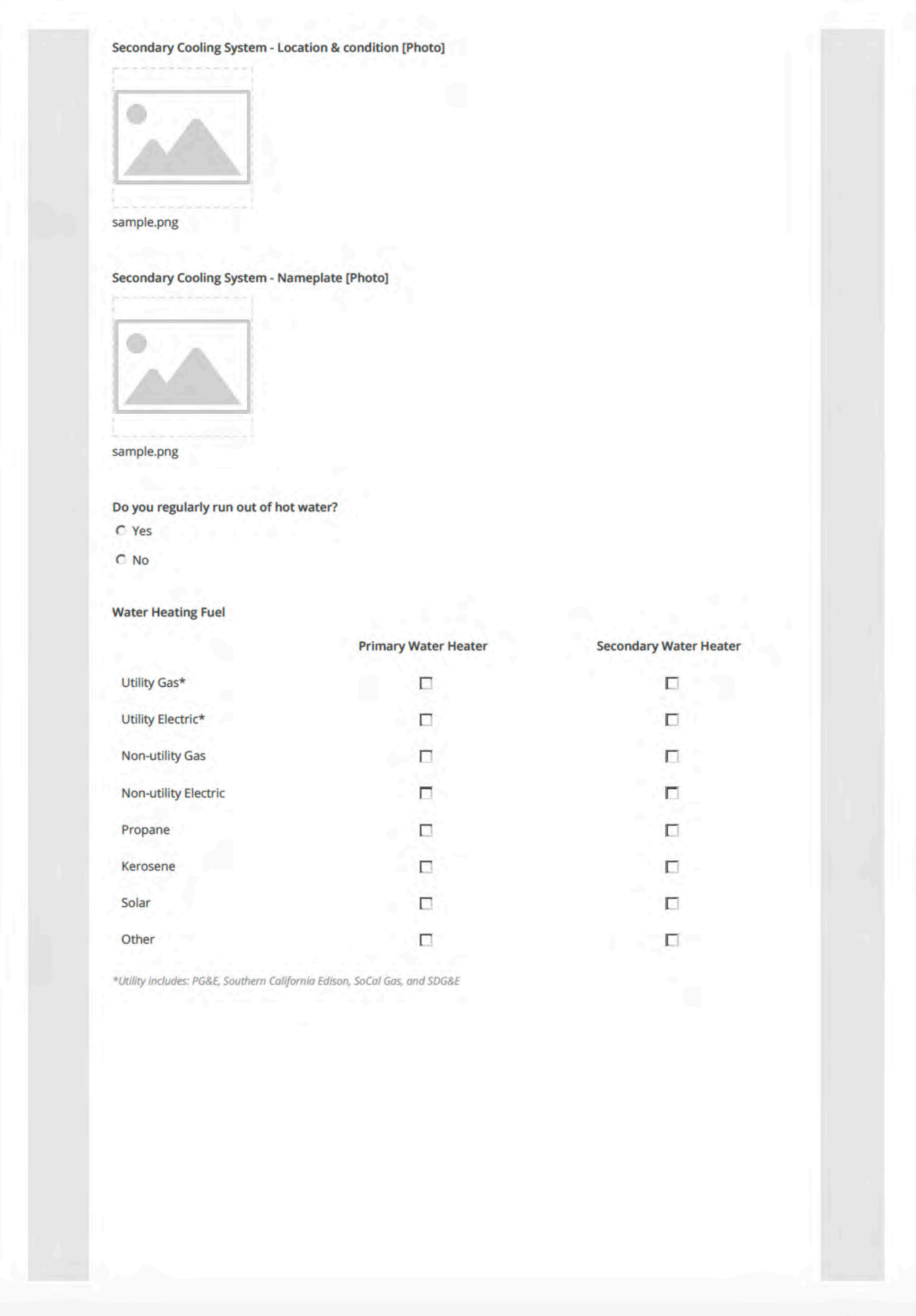
9 – 1615F18

Primary Cooling System - Location & condition [Photo]

sample.png

Primary Cooling System - Nameplate [Photo]

sample.png



Secondary Cooling System - Location & condition [Photo]

sample.png

Secondary Cooling System - Nameplate [Photo]

sample.png

Do you regularly run out of hot water?

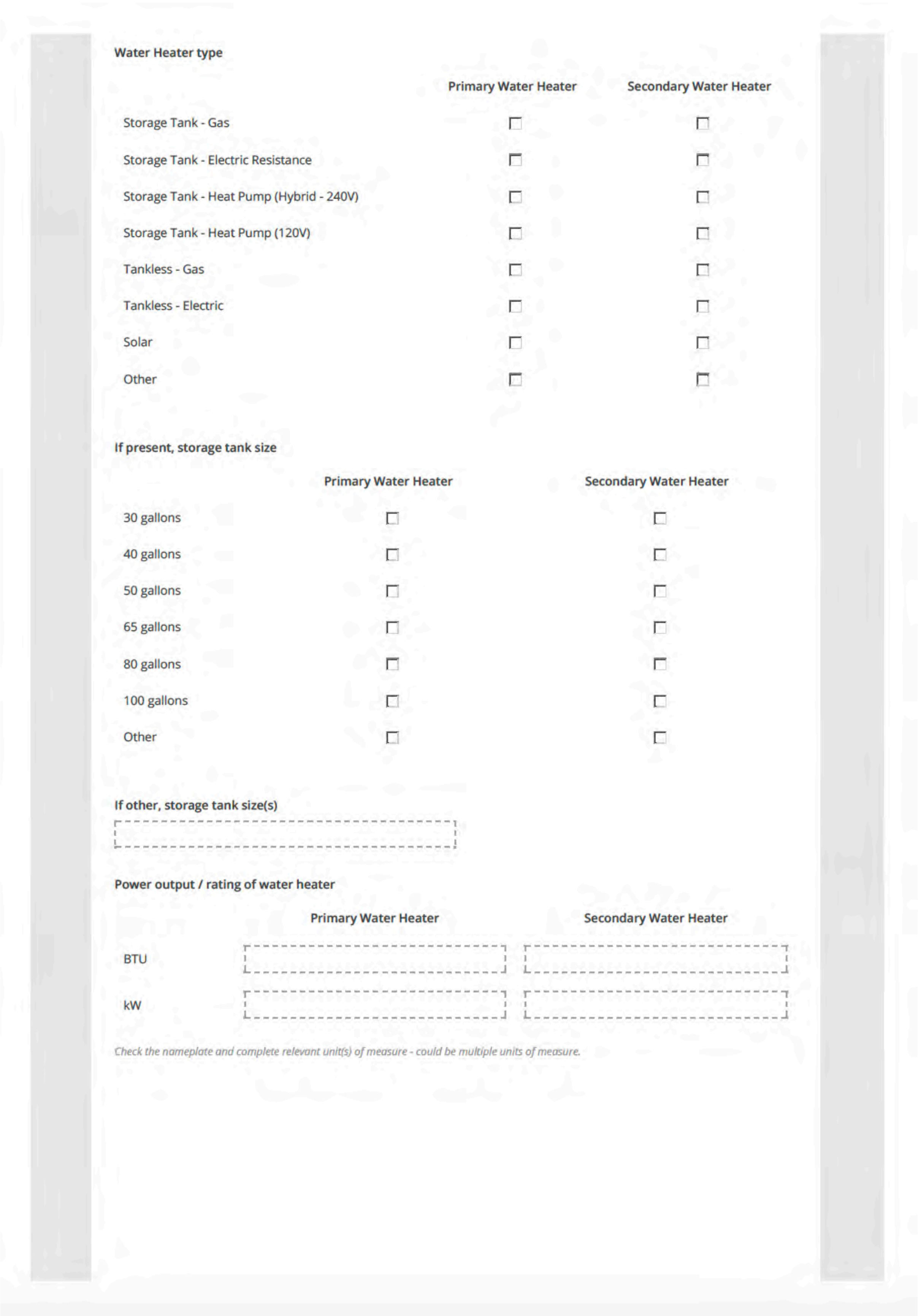
○ Yes

○ No

Water Heating Fuel

	Primary Water Heater	Secondary Water Heater
Utility Gas*	☐	☐
Utility Electric*	☐	☐
Non-utility Gas	☐	☐
Non-utility Electric	☐	☐
Propane	☐	☐
Kerosene	☐	☐
Solar	☐	☐
Other	☐	☐

**Utility includes: PG&E, Southern California Edison, SoCal Gas, and SDG&E*



Water Heater type

	Primary Water Heater	Secondary Water Heater
Storage Tank - Gas	☐	☐
Storage Tank - Electric Resistance	☐	☐
Storage Tank - Heat Pump (Hybrid - 240V)	☐	☐
Storage Tank - Heat Pump (120V)	☐	☐
Tankless - Gas	☐	☐
Tankless - Electric	☐	☐
Solar	☐	☐
Other	☐	☐

If present, storage tank size

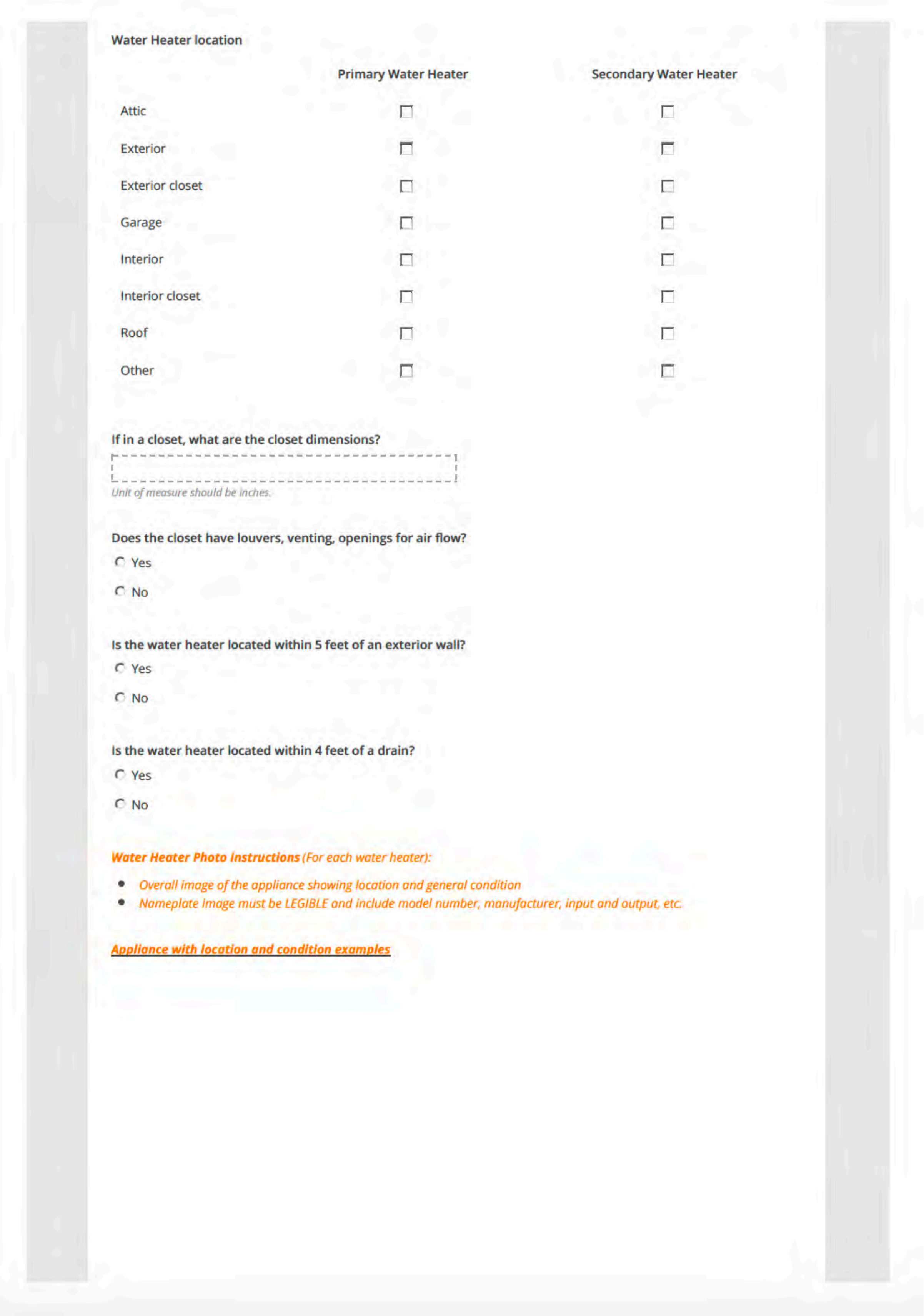
	Primary Water Heater	Secondary Water Heater
30 gallons	☐	☐
40 gallons	☐	☐
50 gallons	☐	☐
65 gallons	☐	☐
80 gallons	☐	☐
100 gallons	☐	☐
Other	☐	☐

If other, storage tank size(s)

Power output / rating of water heater

	Primary Water Heater	Secondary Water Heater
BTU		
kW		

Check the nameplate and complete relevant unit(s) of measure - could be multiple units of measure.



Water Heater location

	Primary Water Heater	Secondary Water Heater
Attic	☐	☐
Exterior	☐	☐
Exterior closet	☐	☐
Garage	☐	☐
Interior	☐	☐
Interior closet	☐	☐
Roof	☐	☐
Other	☐	☐

If in a closet, what are the closet dimensions?

Unit of measure should be inches.

Does the closet have louvers, venting, openings for air flow?

○ Yes

○ No

Is the water heater located within 5 feet of an exterior wall?

○ Yes

○ No

Is the water heater located within 4 feet of a drain?

○ Yes

○ No

Water Heater Photo Instructions *(For each water heater):*

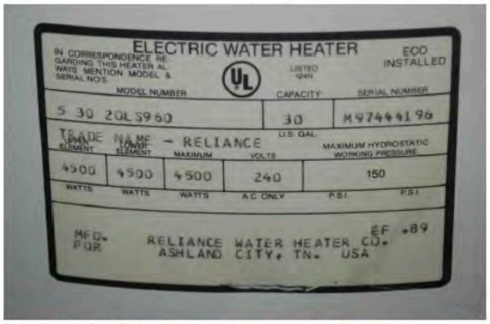
- *Overall image of the appliance showing location and general condition*
- *Nameplate image must be LEGIBLE and include model number, manufacturer, input and output, etc.*

Appliance with location and condition examples

Storage Tank - Gas water heater

Tankless - Gas water heater

Water heating system nameplate examples



ELECTRIC WATER HEATER

IN CORRESPONDENCE REGARDING THIS HEATER ALWAYS MENTION MODEL & SERIAL NO'S

LISTED 124N

ECO INSTALLED

MODEL NUMBER	CAPACITY	SERIAL NUMBER
5 30 20LS960	30 U.S. GAL	M97444196

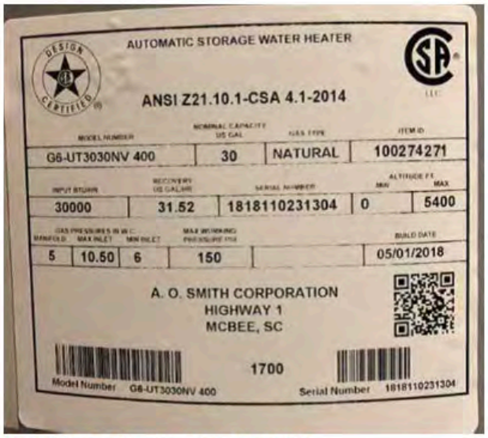
TRADE NAME - RELIANCE

UPPER ELEMENT	LOWER ELEMENT	MAXIMUM	VOLTS	MAXIMUM HYDROSTATIC WORKING PRESSURE
4500 WATTS	4500 WATTS	4500 WATTS	240 A.C. ONLY	150 P.S.I.

MFD. FOR RELIANCE WATER HEATER CO.
ASHLAND CITY, TN. USA

EF .89

Storage Tank - Electric Resistance water heater nameplate



AUTOMATIC STORAGE WATER HEATER

ANSI Z21.10.1-CSA 4.1-2014

MODEL NUMBER	NOMINAL CAPACITY US GAL	GAS TYPE	ITEM ID
G6-UT3030NV 400	30	NATURAL	100274271

INPUT BTU/HR	RECOVERY US GAL/HR	SERIAL NUMBER	ALTITUDE FT MIN	ALTITUDE FT MAX
30000	31.52	1818110231304	0	5400

GAS PRESSURES IN W.C. MANIFOLD	MAX INLET	MIN INLET	MAX WORKING PRESSURE PSI		BUILD DATE
5	10.50	6	150		05/01/2018

A. O. SMITH CORPORATION
HIGHWAY 1
MCBEE, SC

1700

Model Number G6-UT3030NV 400

Serial Number 1818110231304

Storage Tank - Gas water heater nameplate

Primary Water Heater - Location & condition [Photo]

sample.png

Primary Water Heater - Nameplate [Photo]

sample.png

Secondary Water Heater - Location & condition [Photo]

sample.png

Secondary Water Heater - Nameplate [Photo]

sample.png

Asbestos lined water heater venting (if applicable)

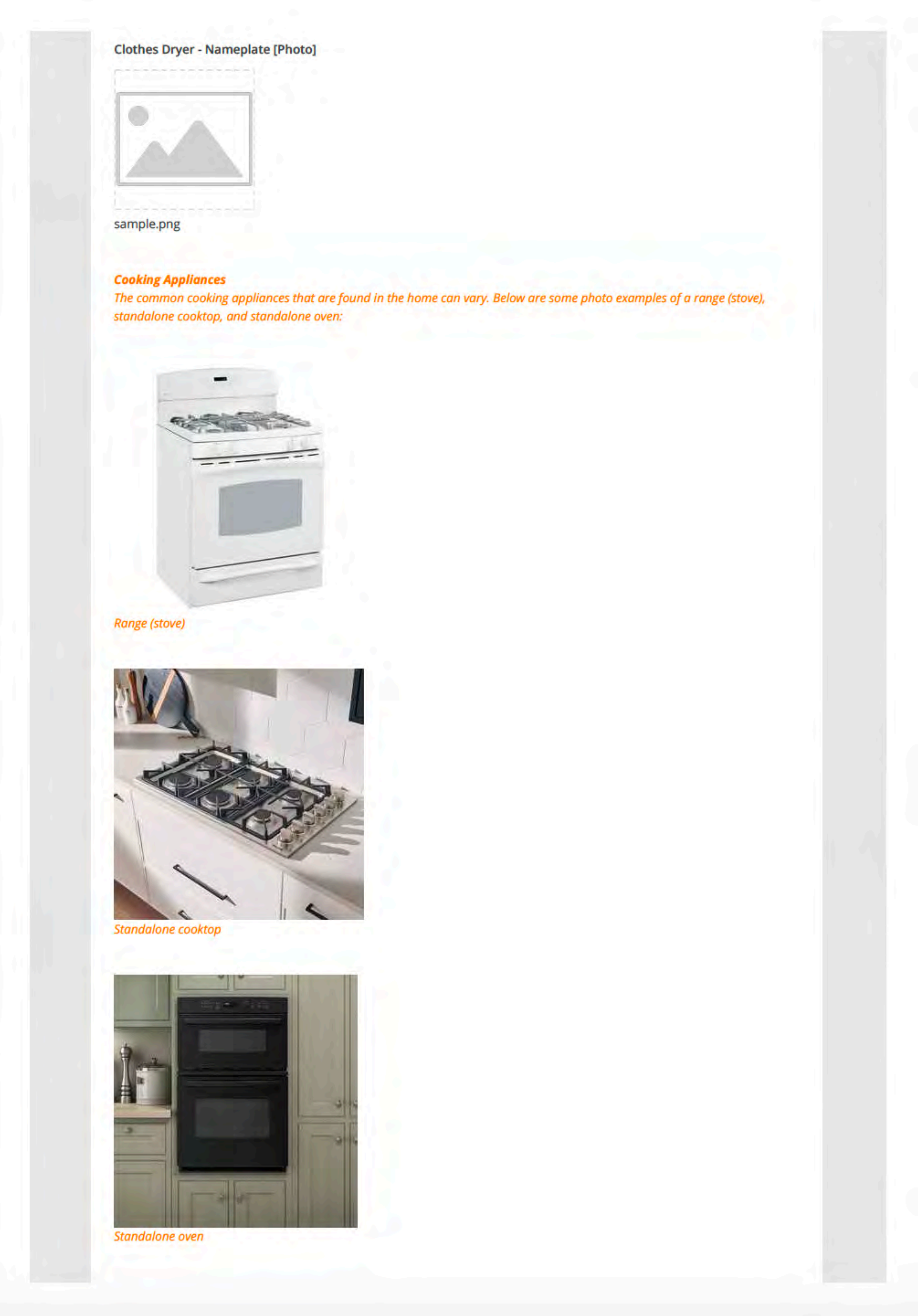
sample.png

Clothes dryer present?

- ○ Electric
- ○ Electric Heat Pump
- ○ Natural Gas
- ○ Propane
- ○ No clothes dryer

Clothes Dryer - Location & condition [Photo]

sample.png



Clothes Dryer - Nameplate [Photo]

sample.png

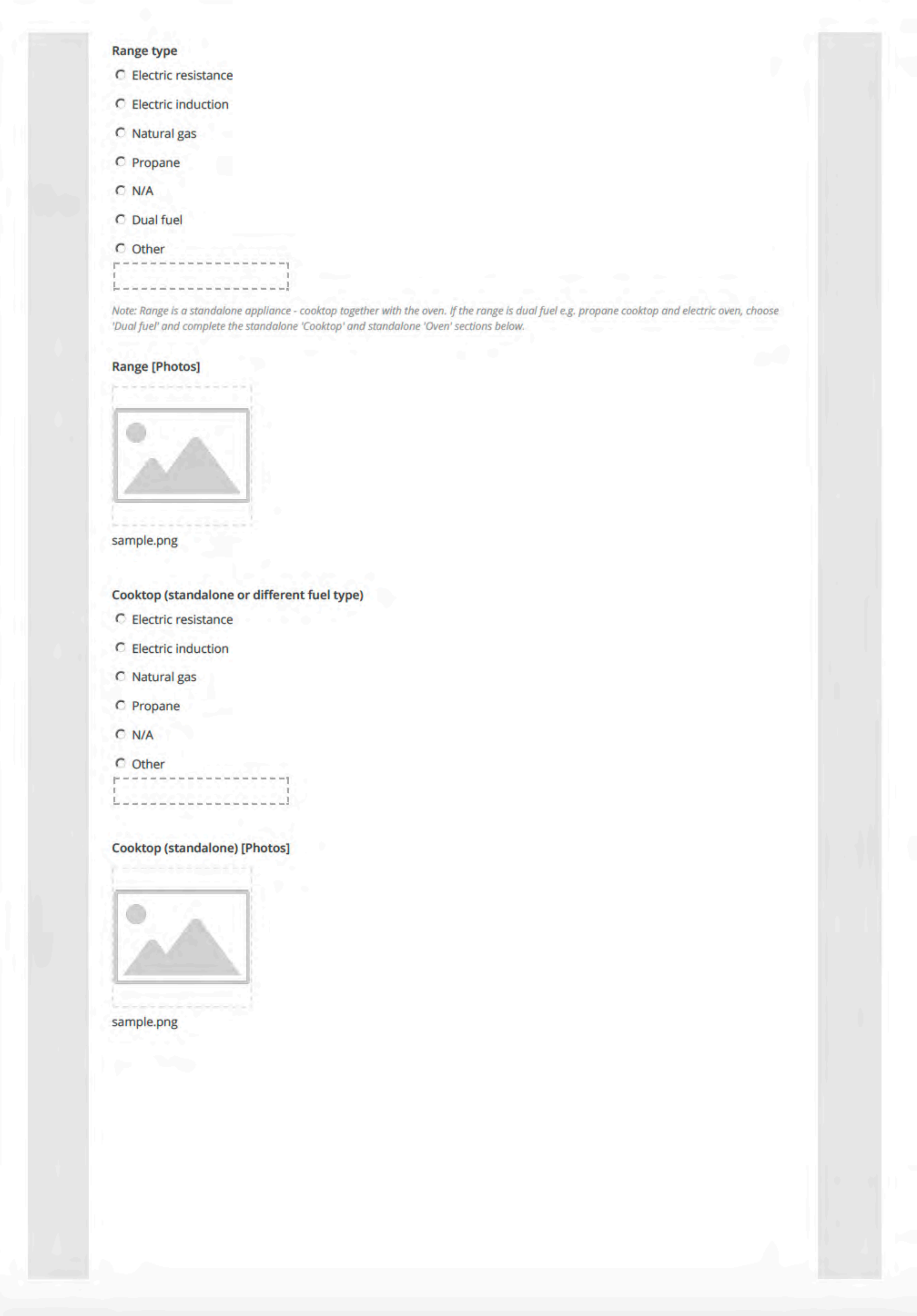
Cooking Appliances

The common cooking appliances that are found in the home can vary. Below are some photo examples of a range (stove), standalone cooktop, and standalone oven:

Range (stove)

Standalone cooktop

Standalone oven



Range type

- ○ Electric resistance
- ○ Electric induction
- ○ Natural gas
- ○ Propane
- ○ N/A
- ○ Dual fuel
- ○ Other

Note: Range is a standalone appliance - cooktop together with the oven. If the range is dual fuel e.g. propane cooktop and electric oven, choose 'Dual fuel' and complete the standalone 'Cooktop' and standalone 'Oven' sections below.

Range [Photos]

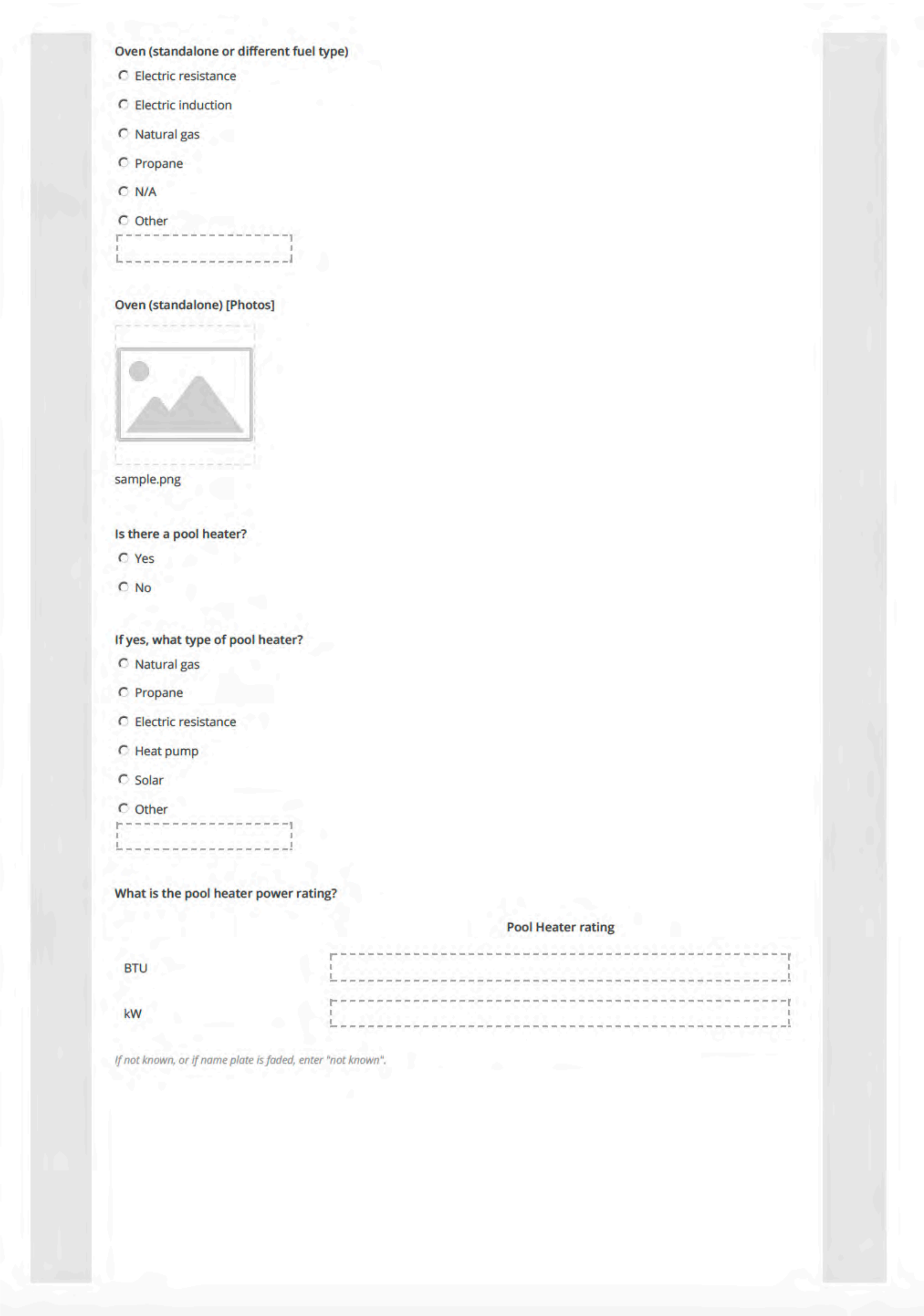
sample.png

Cooktop (standalone or different fuel type)

- ○ Electric resistance
- ○ Electric induction
- ○ Natural gas
- ○ Propane
- ○ N/A
- ○ Other

Cooktop (standalone) [Photos]

sample.png



Oven (standalone or different fuel type)

○ Electric resistance

○ Electric induction

○ Natural gas

○ Propane

○ N/A

○ Other

Oven (standalone) [Photos]

sample.png

Is there a pool heater?

○ Yes

○ No

If yes, what type of pool heater?

○ Natural gas

○ Propane

○ Electric resistance

○ Heat pump

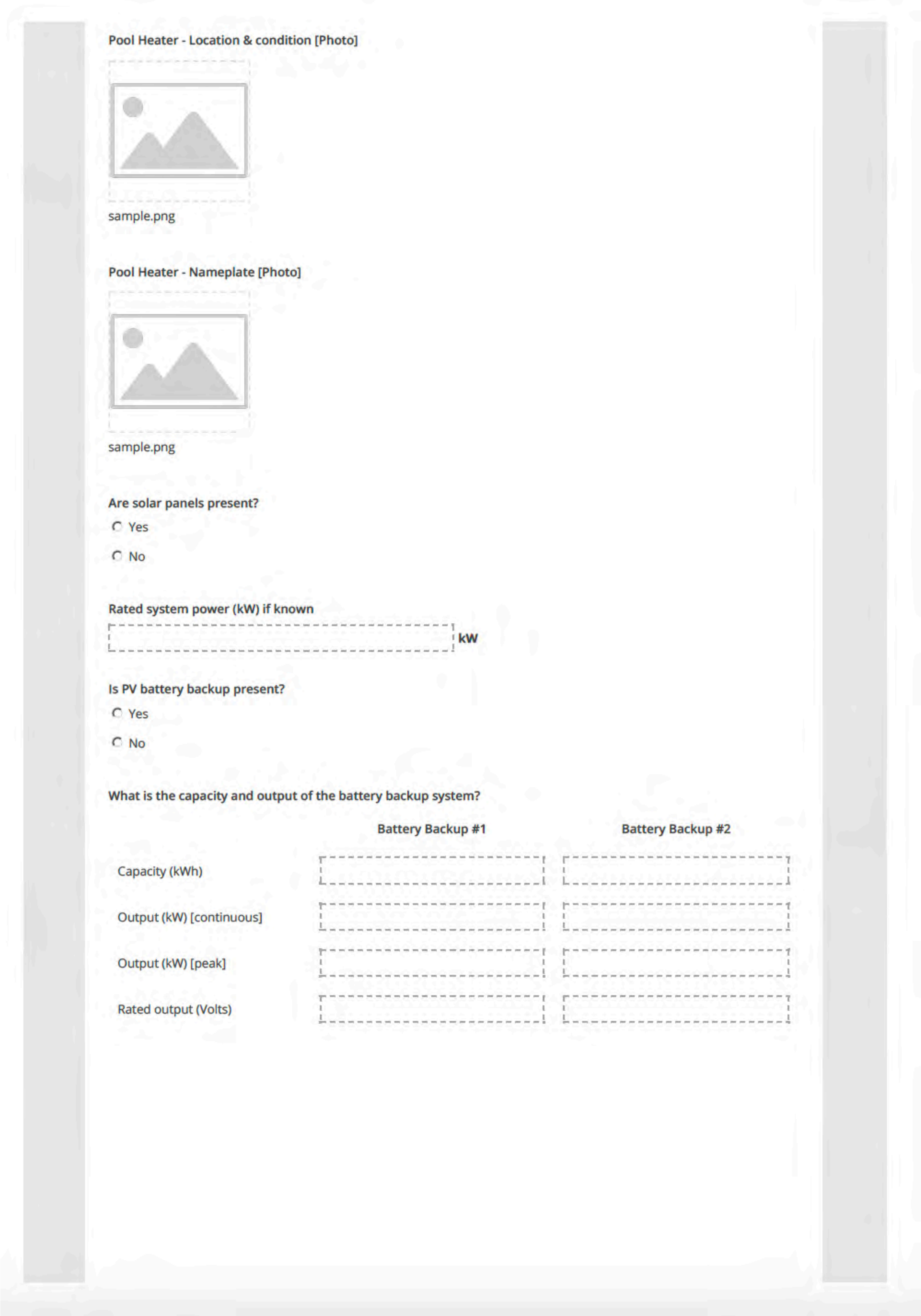
○ Solar

○ Other

What is the pool heater power rating?

	Pool Heater rating
BTU	
kW	

If not known, or if name plate is faded, enter "not known".



Pool Heater - Location & condition [Photo]

sample.png

Pool Heater - Nameplate [Photo]

sample.png

Are solar panels present?

○ Yes

○ No

Rated system power (kW) if known

☐ **kW**

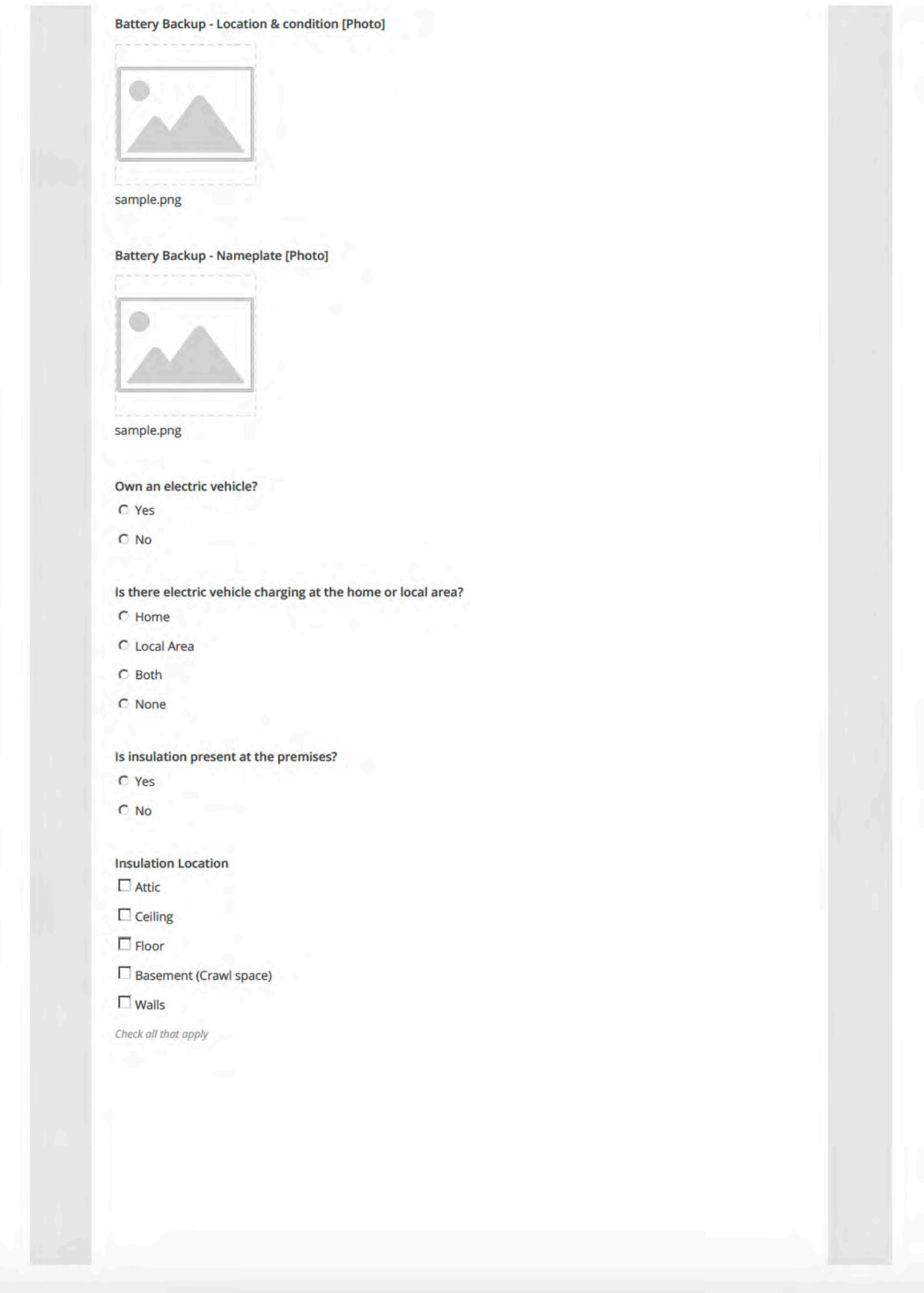
Is PV battery backup present?

○ Yes

○ No

What is the capacity and output of the battery backup system?

	Battery Backup #1	**Battery Backup #2**
Capacity (kWh)		
Output (kW) [continuous]		
Output (kW) [peak]		
Rated output (Volts)		



Battery Backup - Location & condition [Photo]

sample.png

Battery Backup - Nameplate [Photo]

sample.png

Own an electric vehicle?

○ Yes

○ No

Is there electric vehicle charging at the home or local area?

○ Home

○ Local Area

○ Both

○ None

Is insulation present at the premises?

○ Yes

○ No

Insulation Location

☐ Attic

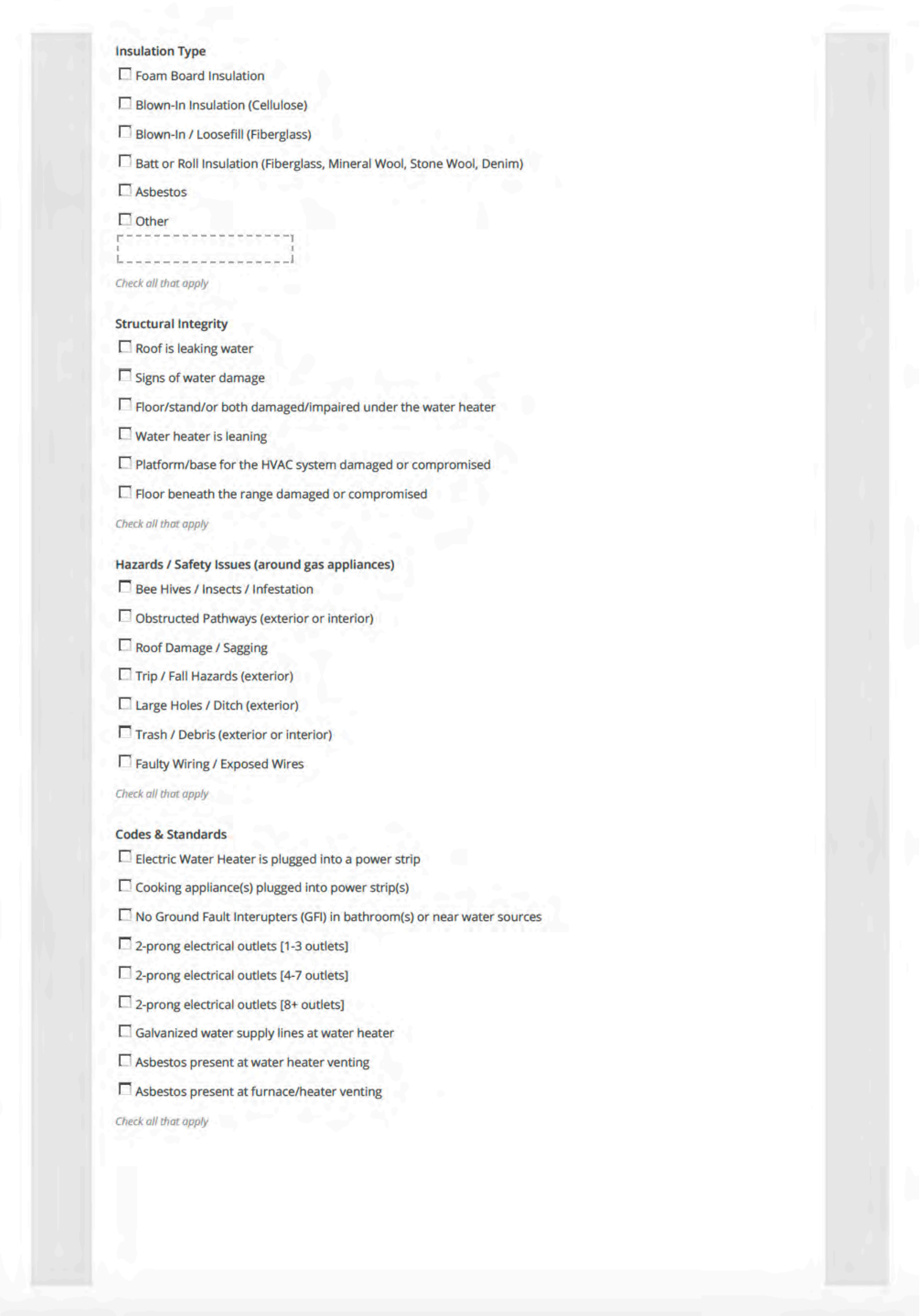
☐ Ceiling

☐ Floor

☐ Basement (Crawl space)

☐ Walls

Check all that apply



Insulation Type

☐ Foam Board Insulation

☐ Blown-In Insulation (Cellulose)

☐ Blown-In / Loosefill (Fiberglass)

☐ Batt or Roll Insulation (Fiberglass, Mineral Wool, Stone Wool, Denim)

☐ Asbestos

☐ Other

Check all that apply

Structural Integrity

☐ Roof is leaking water

☐ Signs of water damage

☐ Floor/stand/or both damaged/impaired under the water heater

☐ Water heater is leaning

☐ Platform/base for the HVAC system damaged or compromised

☐ Floor beneath the range damaged or compromised

Check all that apply

Hazards / Safety Issues (around gas appliances)

☐ Bee Hives / Insects / Infestation

☐ Obstructed Pathways (exterior or interior)

☐ Roof Damage / Sagging

☐ Trip / Fall Hazards (exterior)

☐ Large Holes / Ditch (exterior)

☐ Trash / Debris (exterior or interior)

☐ Faulty Wiring / Exposed Wires

Check all that apply

Codes & Standards

☐ Electric Water Heater is plugged into a power strip

☐ Cooking appliance(s) plugged into power strip(s)

☐ No Ground Fault Interupters (GFI) in bathroom(s) or near water sources

☐ 2-prong electrical outlets [1-3 outlets]

☐ 2-prong electrical outlets [4-7 outlets]

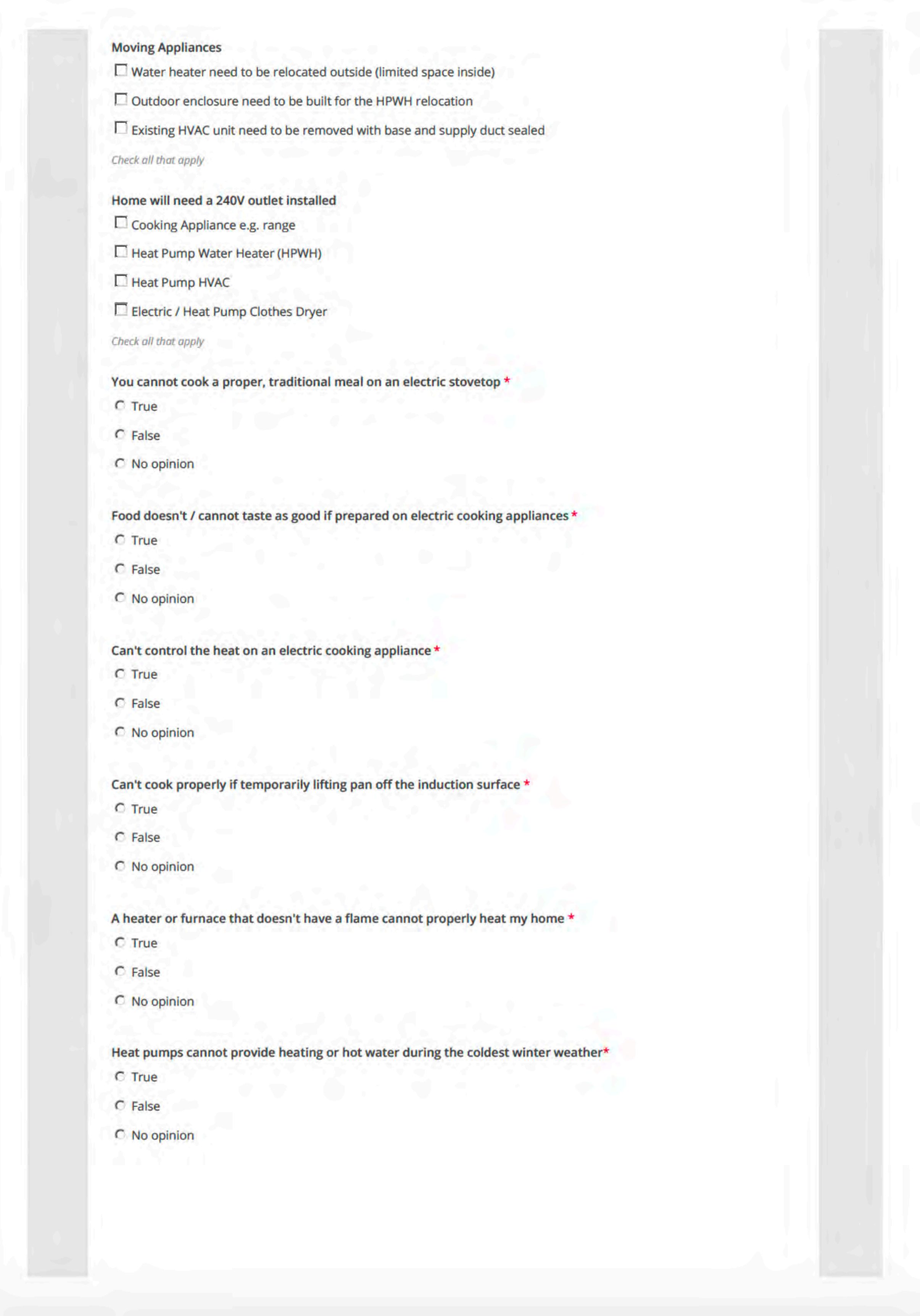
☐ 2-prong electrical outlets [8+ outlets]

☐ Galvanized water supply lines at water heater

☐ Asbestos present at water heater venting

☐ Asbestos present at furnace/heater venting

Check all that apply



Moving Appliances

☐ Water heater need to be relocated outside (limited space inside)

☐ Outdoor enclosure need to be built for the HPWH relocation

☐ Existing HVAC unit need to be removed with base and supply duct sealed

Check all that apply

Home will need a 240V outlet installed

☐ Cooking Appliance e.g. range

☐ Heat Pump Water Heater (HPWH)

☐ Heat Pump HVAC

☐ Electric / Heat Pump Clothes Dryer

Check all that apply

You cannot cook a proper, traditional meal on an electric stovetop *

○ True

○ False

○ No opinion

Food doesn't / cannot taste as good if prepared on electric cooking appliances *

○ True

○ False

○ No opinion

Can't control the heat on an electric cooking appliance *

○ True

○ False

○ No opinion

Can't cook properly if temporarily lifting pan off the induction surface *

○ True

○ False

○ No opinion

A heater or furnace that doesn't have a flame cannot properly heat my home *

○ True

○ False

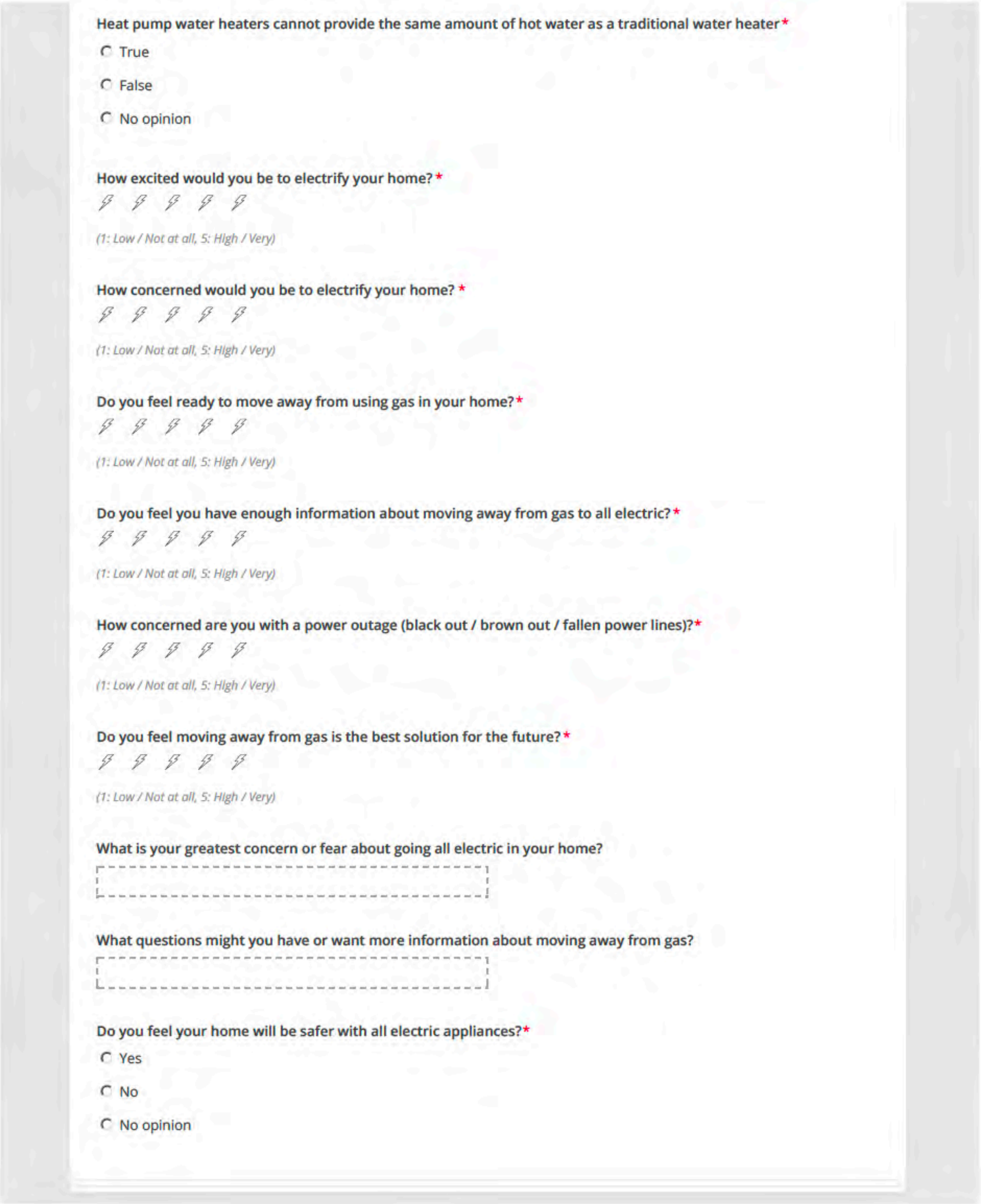
○ No opinion

Heat pumps cannot provide heating or hot water during the coldest winter weather*

○ True

○ False

○ No opinion



Heat pump water heaters cannot provide the same amount of hot water as a traditional water heater*

○ True

○ False

○ No opinion

How excited would you be to electrify your home?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

How concerned would you be to electrify your home?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

Do you feel ready to move away from using gas in your home?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

Do you feel you have enough information about moving away from gas to all electric?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

How concerned are you with a power outage (black out / brown out / fallen power lines)?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

Do you feel moving away from gas is the best solution for the future?*

⚡ ⚡ ⚡ ⚡ ⚡

(1: Low / Not at all, 5: High / Very)

What is your greatest concern or fear about going all electric in your home?

What questions might you have or want more information about moving away from gas?

Do you feel your home will be safer with all electric appliances?*

○ Yes

○ No

○ No opinion

Appendix B: Additional Survey Results

Figure 54: Distribution of occupant status.

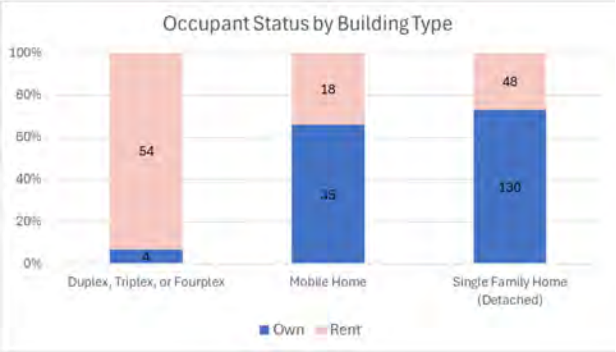


Figure 55: Distribution of occupancy status by building type.

Figure 56: Distribution of English-speaking respondents.

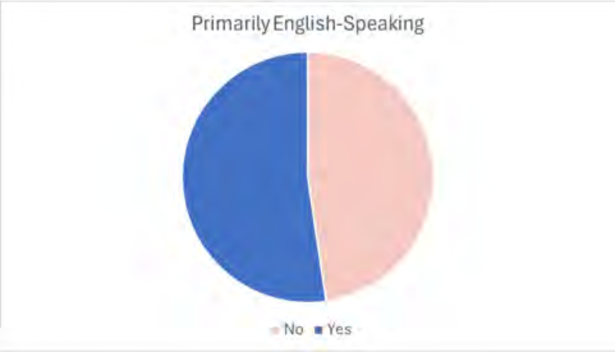


Figure 57: Distribution of primarily English-speaking respondents.

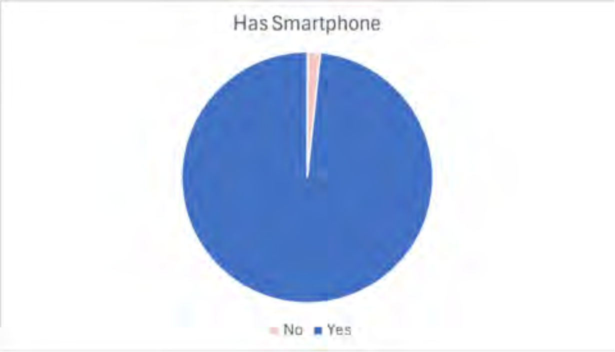


Figure 58: Distribution of smartphone ownership.

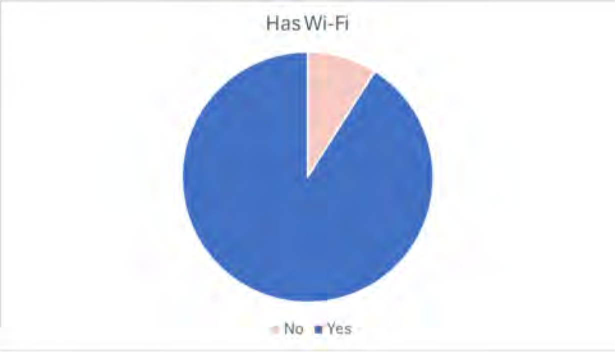


Figure 59: Distributions of homes with Wi-Fi.

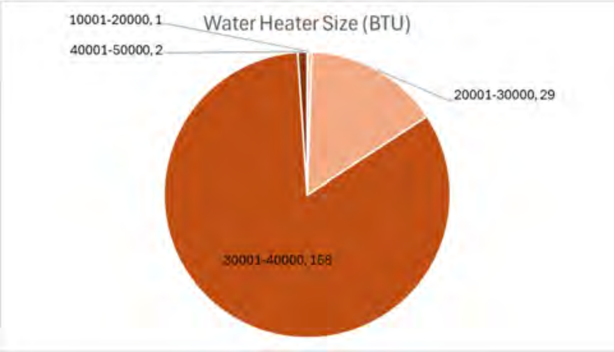


Figure 60: Distribution of water heater sizes.

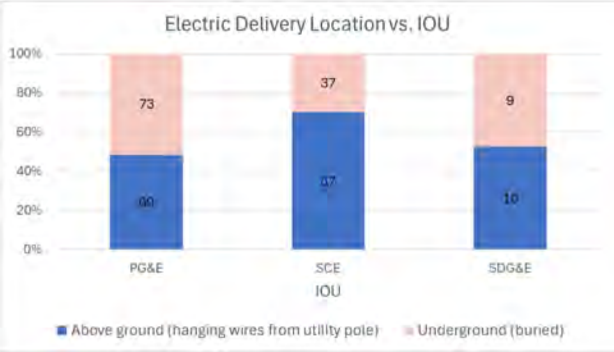


Figure 61: Distribution of electric service location by IOU.

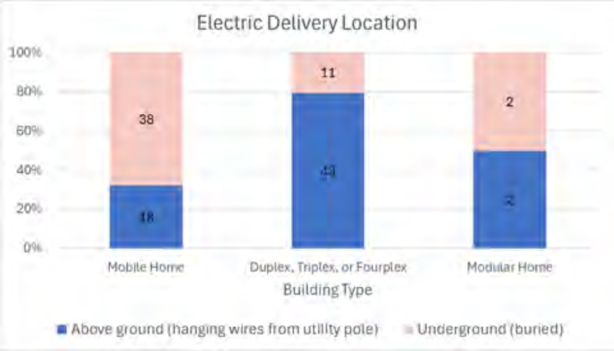


Figure 62: Distribution of electric service location by building type.

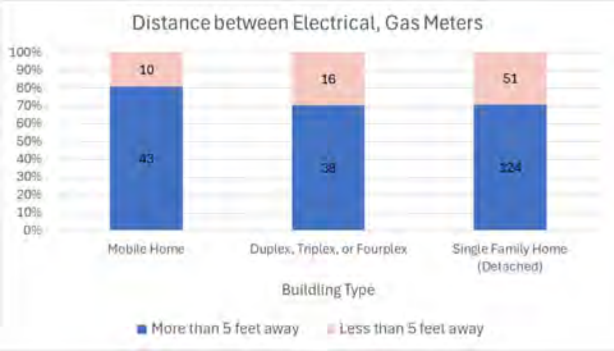


Figure 63: Distribution of electrical and gas meter proximity by building type.

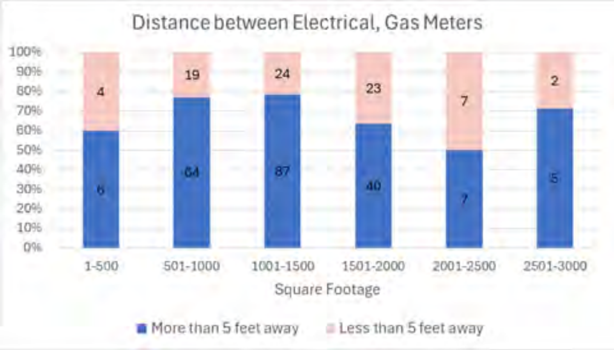


Figure 64: Distribution of electrical and gas meter proximity by building area.

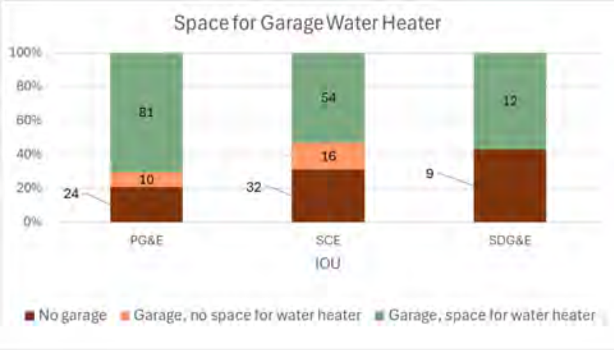


Figure 65: Distribution of potential for garage water heater by IOU.

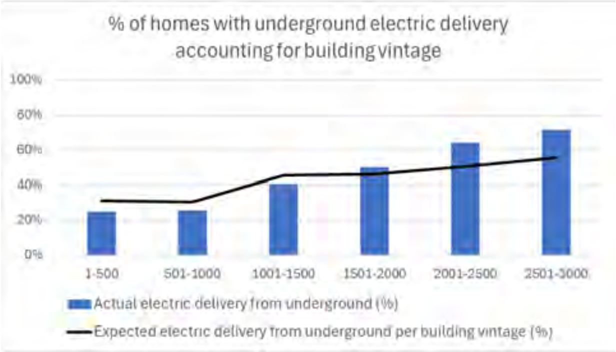


Figure 66: Graph showing electric delivery location/building area correlation independent of building vintage.

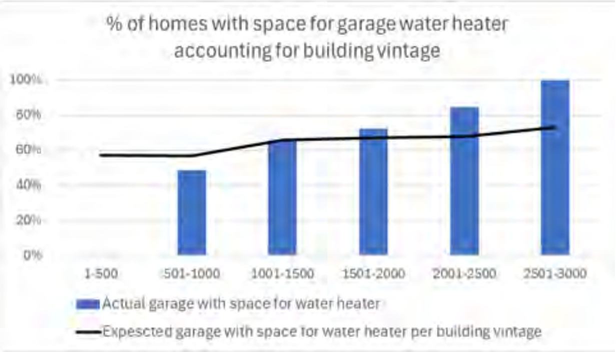


Figure 67: Graph showing potential for garage water heater/building area correlation independent of building vintage.

Electrification Sentiment Score Results

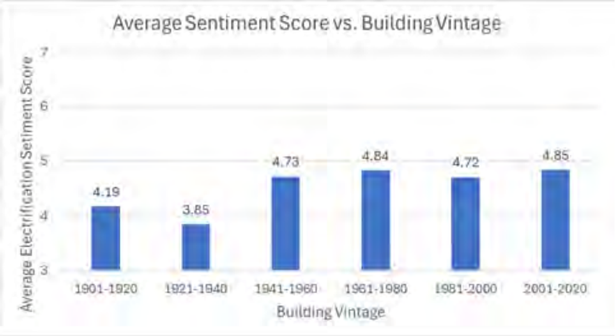


Figure 68: Distribution of sentiment score by vintage

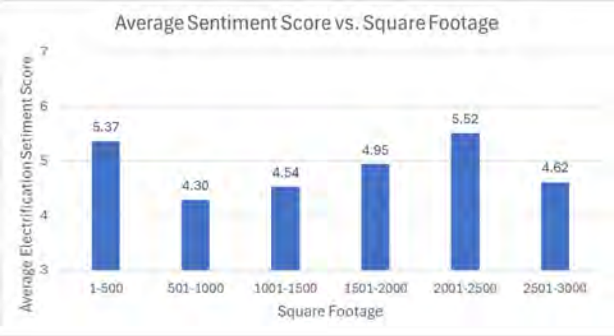


Figure 69: Distribution of sentiment score by size

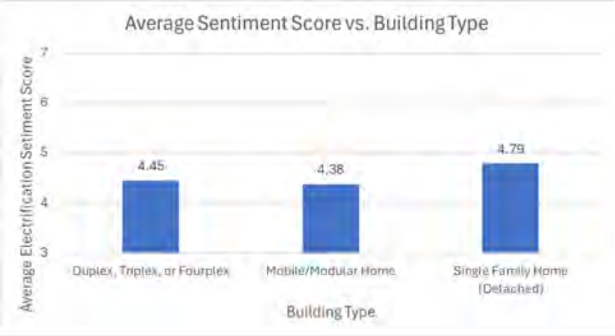


Figure 70: Distribution of sentiment score by building type

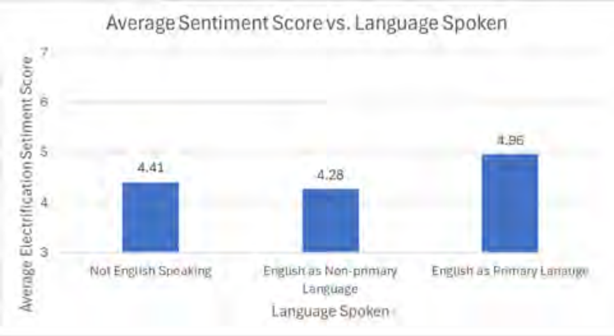


Figure 71: Distribution of sentiment score by language

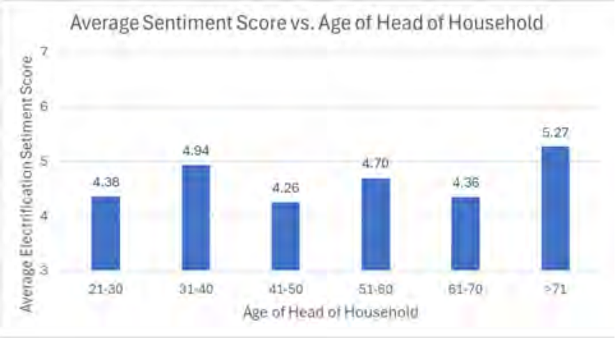


Figure 72: Distribution of sentiment score by age

Figure 73: Distribution of sentiment score by occupant status

Electrification Score Results

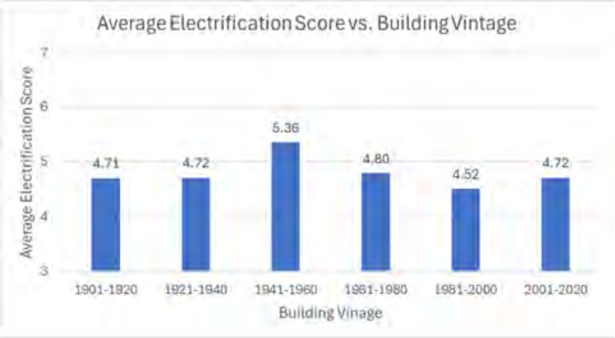


Figure 74: Distribution of electrification score by vintage

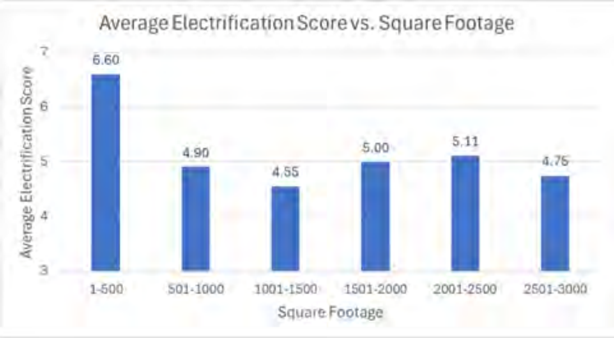


Figure 75: Distribution of electrification score by size

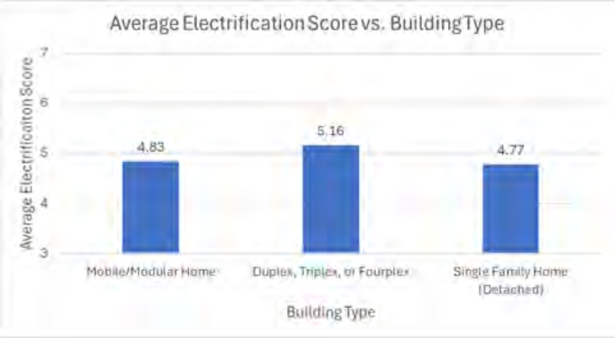


Figure 76: Distribution of electrification score by building type

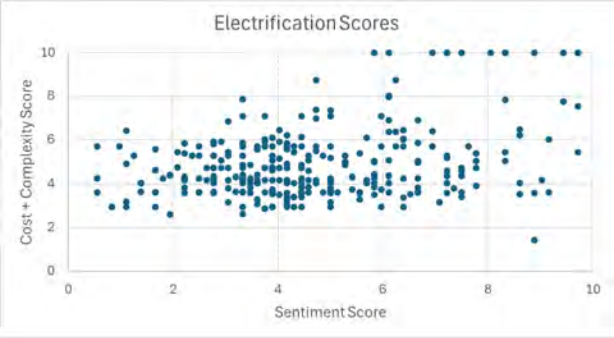


Figure 77: Electrification scores vs. sentiment scores

Appendix C: Electrification Costs

Category	Measure	Amps	Average Cost	TECH LI BE	PG&E Pilot	SER	Contractor	Notes
Electrical Infrastructure	150A - Overhead Electric Service Upgrade		$ 6,000.00		$ 6,000.00			Assume above ground service wires
	200A - Overhead Electric Service Upgrade		$ 6,000.00		$ 6,000.00			Assume above ground service wires
	150A - Underground Electric Service Upgrade		$ 10,000.00		$ 10,000.00			Assume underground service wires
	200A - Underground Electric Service Upgrade		$ 10,000.00		$ 10,000.00			Assume underground service wires
	Electric Panel Upgrade		$ 3,924.84	$ 3,300.00	$ 2,674.52		$ 5,800.00	Parts, labor, permit^^
	Adder for relocating electrical panel away from gas meter		$ 350.00	$ 350.00				~ 5 feet relocation distance; 2 hours $175 electrician rate
	Electrical Sub-Panel		$ 2,416.51	$ 1,800.00	$ 2,074.52		$ 3,375.00	Parts, labor, permit^^^
	Tandem breaker		$ 1,312.00				$ 1,312.00	Parts, labor, permit: Remove existing 120V standard-width breaker, install tandem breaker to maximize use of physical space in panel
	Circuit sharing device		$ 1,018.42		$ 724.84		$ 1,312.00	Parts, labor, permit*****
	Circuit throttling/pausing device		$ 1,293.42		$ 1,324.84		$ 1,262.00	Parts, labor, permit^^^^^
	Level 2 EV charging equipment		$ 1,718.00				$ 1,718.00	Parts, labor, permit^^^^
	Level 1 EV-ready circuit		$ 712.00				$ 712.00	Parts, labor: min. 20A, 129V dedicated circuit complete with outlet in garage or near parking space
	New Electrical Circuit		$ 956.46	$ 960.00	$ 694.84	$ 859.00	$ 1,312.00	Parts, labor, permit***
Water Heater	Install 50 gal HPWH (240V)	30	$ 4,110.43		$ 2,715.00		$ 5,505.86	Include necessary materials, HPWH, condensate line, and permitting; assume location and electrical circuit available.
	Install 65 gal HPWH (240V)	30	$ 4,766.28		$ 3,235.00	$ 5,135.86	$ 5,927.99	Include necessary materials, HPWH, condensate line, and permitting; assume location and electrical circuit available.
	Install 80 gal HPWH (240V)	30	$ 6,096.07		$ 4,015.00	$ 7,536.00	$ 6,737.22	Include necessary materials, HPWH, condensate line, and permitting; assume location and electrical circuit available.
	Install plug-in 65 gal HPWH (120V)		$ 4,834.24		$ 3,188.00		$ 6,480.48	Include necessary materials, HPWH, condensate line, and permitting; assume location and electrical circuit available.
	Install plug-in 80 gal HPWH (120V)		$ 5,256.60		$ 3,618.00		$ 6,895.20	Include necessary materials, HPWH, condensate line, and permitting; assume location and electrical circuit available.
	Emergency loaner cost		$ 2,950.00				$ 2,950.00	
	Water Heater Relocation + New Outside Shed		$ 2,652.50	$ 2,652.50				
	Water Heater Removal		$ 563.33	$ 563.33				
	Water Heater Shed		$ 659.17	$ 768.33		$ 550.00		

Appliances	Heat pump clothes dryer (240V)	30	$ 1,706.33		$ 2,059.00	$ 1,367.00	$ 1,693.00	Includes RETAIL PARTS, labor** [LG 7.8 cu. ft. ventless inverter heat pump clothes dryer]
	Heat pump clothes dryer (120V)		$ 2,109.00		$ 2,109.00			
	Condensing combo washer-dryer		$ 2,394.00				$ 2,394.00	Includes RETAIL PARTS, labor** [GE 4.6 cu. ft. electric all-in-one washer with ventless heat pump dryer combo]
	Electric induction range	40	$ 2,636.28	$ 2,823.56			$ 2,449.00	Includes RETAIL PARTS, labor** [Frigidaire 30in 5.3 cu.ft. 4-element induction range]
	Electric resistance wall oven	25	$ 2,233.08	$ 2,233.08				
	Electric induction cooktop	40	$ 2,286.78		$ 2,575.56		$ 1,998.00	induction cooktop]
HVAC	Package heat pump (2 ton)	25	$ 6,198.00		$ 6,198.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Package heat pump (3 ton)	35	$ 7,418.00		$ 7,418.00	#########		Include necessary materials and permitting; assume location and electrical circuit available.
	Package heat pump (4 ton)	50	$ 8,058.00		$ 8,058.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Split heat pump with new air handler (2 ton)		$ 6,448.00		$ 6,448.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Split heat pump with new air handler (2.5 ton)		$ 7,466.48			$ 7,466.48		Include necessary materials and permitting; assume location and electrical circuit available.
	Split heat pump with new air handler (3 ton)		$ 7,648.00		$ 7,648.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Split heat pump with new air handler (4 ton)		$ 9,258.00		$ 9,258.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 1 head (1 ton)		$ 5,876.92			$ 5,876.92		Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 1 head (1.25 ton)		$ 4,107.00		$ 4,107.00			
	Ductless, mini-split heat pump with 1 head (1.5 ton)		$ 5,338.00		$ 5,338.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 2 heads (1.67 ton)		$ 5,168.00		$ 5,168.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 2 heads (2 ton)		$ 5,878.00		$ 5,878.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 3 heads (2 ton)		$ 6,346.00		$ 6,346.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Ductless, mini-split heat pump with 4 heads (4 ton)		$ 6,598.00		$ 6,598.00			Include necessary materials and permitting; assume location and electrical circuit available.
	Heat pump HVAC, (ducted, inverter-driven)		$ 10,250.00				$ 10,250.00	Includes parts, labor, permit^
	Heat pump mini-split system (Ductless, inverter-driven,) one zone		$ 9,066.00				$ 9,066.00	Includes parts, labor, permit^
	Heat pump mini-split system (Ductless, inverter-driven,) two zone		$ 9,594.00				$ 9,594.00	Includes parts, labor, permit^
	Heat pump mini-split system (Ductless, inverter-driven,) three zone		$ 12,076.00				$ 12,076.00	Includes parts, labor, permit^
	Heat pump mini-split system (Ductless, inverter-driven,) four zone		$ 14,058.00				$ 14,058.00	Includes parts, labor, permit^

Remediation	Repair Damaged Flooring Under Water Heater		$ 190.00	$ 190.00				additional labor (2 hrs @ 95$)
	Remediation (HPWH, Electrical, Cooking, Dryer) - Spend Cap		$ 2,500.00		$ 2,500.00			
	Crawl Space Insulation & Sealing		$ 6.29		$ 6.29			Per square foot (average)
	Ceiling Insulation - Blown in Cellulose (R-60)		$ 2.80		$ 2.80			
	Ceiling Insulation - Blown in Cellulose (R-38)		$ 1.77		$ 1.77			
	Ceiling Insulation - Blown in Cellulose (R-19)		$ 1.70		$ 1.70			
	Ceiling Insulation		$ 2.36	$ 2.36				Per square foot (average)
	Ceiling Insulation (total)		$ 2,569.95	$ 2,446.29		$ 2,693.60		Average total per home
	Duct Sealing		$ 730.67	$ 550.00		$ 911.34		
	A/C Removal		$ 1,260.00	$ 1,260.00				
	Additional Wiring for new circuit		$ 300.00	$ 300.00				Assumed for large homes
	Cap Gas Line		$ 205.80	$ 183.33		$ 228.27		
	Condenser Wall Bracket		$ 680.00	$ 680.00				
	Drywall Repair		$ 190.00	$ 190.00				additional labor (2 hrs @ 95$)
	Replace existing supply ducts		$ 4,561.38	$ 3,620.00		$ 5,502.75		
	Return Duct Platform		$ 250.00	$ 250.00				
	Specialty Drain Pan		$ 161.82	$ 161.82				
	Wall Heater Removal		$ 595.00	$ 595.00				
	Dormer Vents (4)		$ 420.00	$ 500.00		$ 340.00		
	Relocate Dryer Vent & Patch Wall		$ 530.00	$ 530.00				
Other	Electrical Permit		$ 200.00	$ 200.00				
	Load Calculation		$ 648.68			$ 648.68		
	Electrical Panel Calculation		$ 339.00			$ 339.00		
	Smart Thermostat		$ 280.00	$ 280.00				
	CO/Smoke Alarm		$ 111.25	$ 111.25				
	Smoke Alarm		$ 72.50	$ 72.50				
	Smoke Alarms (x3)		$ 217.50	$ 217.50				Typically 3 installed per home
	Technician Labor Rate		$ 95.00	$ 95.00				Per hour
	Crane Rental		$ 800.00	$ 800.00				