Electrify My Home: Guide to Good Electrification

Final Report
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1. Project Background

1.1 History & Context

Under Senate Bill (SB) 100, the State of California has set a goal to produce 100% carbon-free electricity by 2045 [1]. One critical step in reaching this goal is electrifying existing residential buildings that use natural gas appliances for a variety of applications including heating, cooking, and laundry. The California legislature has already paved a clear path towards advancing building electrification by implementing an electric friendly building code starting in 2023, and allocating over $435 million through electrification programs such as TECH Clean California and the BUILD program [2].

Electrifying residential buildings has a variety of benefits including better air quality, lower energy bills due to more efficient appliances, and improved comfort. Burning natural gas causes harmful toxins to be released into the living environment. Children living in a home with a gas stove are 42% more likely to have asthma, making them particularly vulnerable [3]. Additionally, replacing gas appliances with electric ones can greatly reduce your electricity bill due to more efficient appliances and eliminate gas bills. A heat pump can transfer up to 300% more energy than it consumes under optimal conditions. High-efficiency gas furnaces are only approximately 95% efficient [4]. Food being cooked with induction will receive 90% of the heat generated instead of only 40 to 55% for gas [5]. Using these more efficient appliances leads to less energy being consumed to achieve the same results. Although these statistics sound great, some worry the comfort of their home will be sacrificed. This is a misconception because using heat pump technology does a better job of controlling temperature and humidity compared to traditional HVAC units [6]. Additionally, heat pumps are quieter than conventional alternatives, adding further benefits to comfort levels.

Electrify My Home (EMH), an innovative HVAC contractor based out of Vacaville, California, was created in 2020. This is a unique HVAC contractor in that they've built a business around replacing dirty gas appliances with clean electric heat pumps. Their distinctive sales approach stands out by focusing on education and consultation rather than face-paced, high pressure sales. They've proven they take electrification seriously by being one of three HVAC contractors

in California certified to train other contractors about TECH Clean California, a statewide program designed to accelerate the adoption of clean space and water heating technology across California homes [7]. With over 300 electrification projects under their belt and a growing market for residential electrification, Electrify My Home has become a leader in the sector.

1.2 Problem Description

Electrify My Home is seeking guidance and tools on ways to simplify their customers' home electrification journey. Electrification is a confusing process that includes many moving components, ever-changing incentive programs, and large costs. Historically, homeowners choosing to electrify their homes have had prior knowledge on the process and have disposable income to support the project. But, to reach California's SB 100, more homeowners who may not have prior knowledge on the subject will have to be educated.

To address the knowledge gaps that these homeowners may have, Electrify My Home has seeked help from a group of students at the University of California, Davis to develop a "roadmap" graphic along with an accompanying manual. The team of engineers and energy specialists is well equipped to assist by pairing their knowledge with Electrify My Home's current sales approach.

1.3 Literature Review

To gain a greater understanding of residential electrification, the opportunities and barriers in the sector, as well as customer psychology, the team first conducted a literature review. Although a more extensive literature review was conducted, the following are most relevant to the project.

1. "Status Report on Electrification Policy: Where to Next?" by Rachel Gold [8] highlights the current state of electrification in all sectors, but for the purpose of this summary only the building sector was analyzed. Heat pump technology is identified as the largest opportunity for electrification in the building sector. Buildings in warmer regions of the country will be the most economically beneficial. Additionally, new all-electric construction is economic because of the avoided costs associated with gas connections. Barriers such as up-front costs, cold climate, and structural challenges are addressed. The current policy landscape is described as transitional. Goals and incentives need to be redefined to promote adoption. Two opportunities identified are building performance and appliance standards, and supply-side pricing.

   This journal is relevant to the project because it describes barriers that will inevitably affect the future of EMH. Electrification will need to be incentivized further in legislation to promote further adoption especially for disadvantaged and underserved communities. This journal explains that EMH is on the right path by specializing in heat pump technology and predicts the next biggest opportunity could be appliance replacements.

2. “Review of Adoption Status of Sustainable Energy Technologies in the US Residential Building Sector.” by Emily Schwartz and Moncef Krarti [9] analyzes the pace at which new energy efficient technology products are being adopted, and the reasoning behind why some are being integrated faster than others. For heat pumps the main reasons for adoption are financial incentives, environmental morals, electrification, and health. The reasons against adoption are lack of code, lack of knowledge, financial cost, compatibility, and no social norm. For efficient appliances the reasons for adoption are IECC code, certification incentives, financial incentives, and social norms. The reason against adoption is slow code adoption.

   This paper highlights the reasons that EMH may want to highlight to convince their customers to adopt. Understanding the barriers some may have and anticipating how to best overcome them will benefit EMHs sales. Social norms are an interesting aspect to residential electrification and EMH mentioned that most of their customers are attained through word of mouth. So it can be anticipated that as heat pump installation becomes more prevalent that it will create a positive feedback loop leading to an exponential increase in sales.

3. “Advancing Equity in Access to Distributed Energy Resources in California.” by Tricia Light et. al. [10] addressed equity in the sector. Equity is an extremely important consideration in residential building electrification because currently those who benefit are most often wealthy and white households. Effective policies need to be implemented to address barriers associated with DERs rather than exacerbate them. The author describes several policy scenarios and the advantages and disadvantages of each. The author concludes that the best scenario is to require the CPUC to prioritize DER programs that provide the greatest non-energy benefits to communities instead of only looking at a cost-benefit analysis.

   This journal is important to the project because it outlines how policy plays a role in the future of residential building electrification. DERs are continuing to become a large aspect that needs to be considered in the electrification process so anticipating how policy may affect the adoption of DERs is crucial. Furthermore, Electrify My Home focuses mainly on heat pump technology but is already expanding to include more DER services such as solar panel installation and EV charging stations. Policy will guide how fast these products are implemented at the residential level so it’s important EMH has an understanding of these trends.

2. Methodology

2.1 Major Considerations

The major deliverables for this project included creating a “roadmap” graphic, accompanying manual, and a web-based application for gas appliance replacements. Due to time constraints the web-based application was left out of the scope. A “Customer Archetype” sheet was added to the scope because the team felt it was helpful information to be used during the consultation process.

Major considerations the team addressed included making all information inclusive and easy to understand for a diverse demographic of customers. Additionally, the deliverables must be visually appealing and interesting to read to capture the customers attention.

2.2 Procedure

To inform the deliverables, the team conducted a homeowner survey to identify knowledge gaps and better understand potential customer needs. The survey was administered via Google Forms and consisted of 10 questions:

1. What are the first three things that come to mind when you read the term “home electrification?”
2. Which gas appliances do you currently have in your home?

Before further questions were asked the following definition of electrification was provided to educate the homeowners before continuing: *Electrification is the process of transitioning a home to all electric appliances and doing away with fossil-fuel based energy.*

3. What are some differences between your previous understanding and our definition?
4. Have you heard of home electrification before? If so, how did you hear about it?
5. What advantages would you assume home electrification offers?
6. What would motivate you to switch from gas to electric?
7. Have you taken steps to electrify your home already? If so, what steps have you taken?
8. Are you comfortable with the heating and cooling system in your home? Are there any “pain points?” (i.e. constantly changing thermostat, loud noises, dramatically different temperatures between rooms or floors)
9. What about home electrification might you not find appealing? (i.e. cost, gas vs. electric cooktop)
10. What are some questions you would like answered before (hypothetically) starting the process of electrifying your home?

The survey was taken by 17 homeowners all located in Northern California.

Several reference materials were found to give the team a starting point on what materials would be effective for homeowners. For the roadmap graphic Figure 1 and 2 were referenced. Both figures provide a clean understanding of what steps can be taken to electrify a home in a visually appealing way.

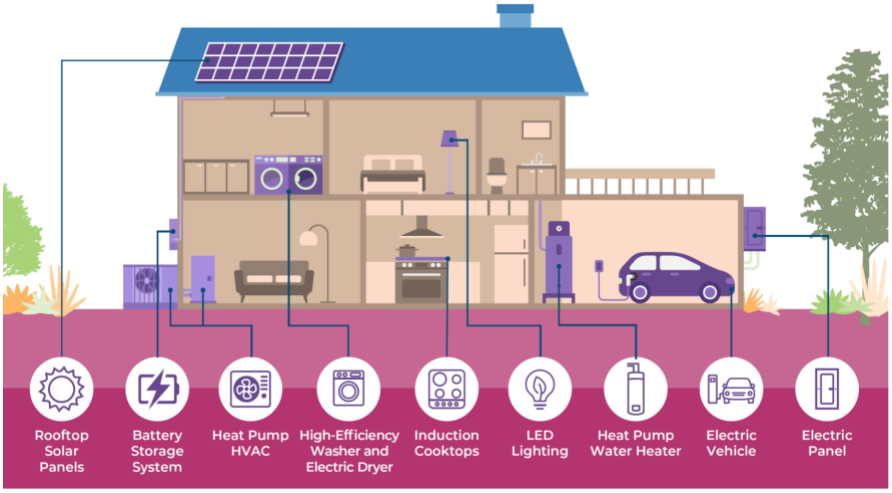

Figure 1: Graphic by City of Palo Alto Utilities

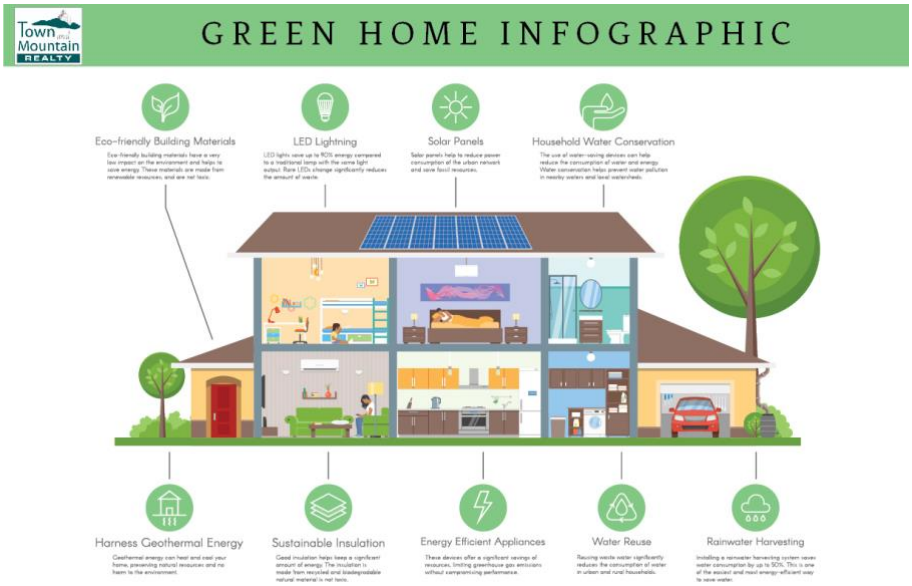

Figure 2: Graphic by Town and Mountain Realty

The creation of a customer archetype sheet was inspired by National Grid's customer types [Figure 3]. National Grid formed this resource as a way to better understand the needs of different types of customers, acknowledging that they serve a diverse demographic and need to serve each differently. The team felt it was important to include something similar in the deliverables so Electrifying My Home can continue towards inclusivity.

Figure 3: National Grid Customer Types

2.3 Analysis

The homeowner surveys were analyzed to give the team a greater understanding of what needs to be addressed when educating a potential customer about home electrification. The survey found that over half of customers surveyed had never heard of electrification in any sense, and only 3 were confident in their definition. This shows that the deliverables should include basic information on what electrification is and why it's important. When asked what benefits they assume electrification offers, half mentioned environmental benefits, while some mentioned lower electric bill costs, and it being a safer option than using gas appliances. This confirmed the team's research, and showed these as compelling selling points. Similarly, when asked what may motivate them to electrify their home, cost was the number one answer, whether it be lower energy bills, lower installation costs, or incentives. Other motivations included increased reliability and independence from utilities. These answers fed directly into informing the "Customer Archetype" sheet to give sales consultants insight to homeowner motivation. Another informative question was about the unappealing factors of home electrification. These answers were fairly evenly split between high cost, switching cooking appliances, and uncertainty about electric equipment. To address these concerns, points are added to the manual to debunk any myths associated with electrification.

2.4 Addressing Equity

The team took several steps to address equity. Every deliverable was intentionally made using easy to understand language and addressed knowledge gaps that customers who aren't familiar with electrification may have. The survey was sent to a diverse group of people that come from different backgrounds, demographics, and income levels. This was done so the team could capture a comprehensive understanding of potential customers Electrify My Home could serve.

3. Results & Discussion

3.1 Main Results

Based on the findings from the homeowner surveys, research, and previous experience in the industry, the team developed several deliverables that broke down the electrification process. To properly educate homeowners on the various pathways and associated components, EMH wanted the team to produce an electrification roadmap. This roadmap would be used as a resource for the EMH representative and the customer during consultations or on-site visits. For it to achieve success as a helpful tool, it would need to provide simple, clear, and compelling information about electrification. After reviewing examples sent over by the client and doing our own research on similar existing resources, the team created a home electrification roadmap and supporting manual. The team decided to include the documents that make up the manual after identifying areas in which homeowners may need further clarification and information that is not outlined in the roadmap.

One of the unappealing factors for going all-electric that was emphasized in survey responses was the associated costs. Addressing this factor wouldn't fit within the context of the

electrification roadmap and elaboration on electrification components. The obvious importance of including information and available resources on the costs of electric equipment and appliances led to creating an additional deliverable not originally included in the scope of the project. Initially, the deliverables centered around being utilized by the EMH representatives during the consultation process. However, throughout the duration of the project the team determined that there needed to be deliverables that were specifically for the customers. Being able to supply homeowners with documents that highlighted the benefits of electrification, listed incentive programs, and provided average costs would accentuate EMHs thorough services.

3.1.1 Roadmap Graphic [Appendix A]

The electrification roadmap acts as a visual aid during a consultation with a customer. This graphic points out the different components that contribute to an all-electric home. Many of the customers that EMH has worked with are seeking heat pump installations for space or water heating. While the homeowners know about electrifying their HVAC or water heater, they may not know about other areas that are included in the electrification roadmap. EMH has specialized in heat pump installations but wants to build their business to include services that can provide a customer with full-home electrification The electrification graphic can be used with customers to map out different pathways that work towards an all-electric home. Since the roadmap points out all of the components to electrify a home, it gives the customer options for taking on the process one step at a time.

3.1.2 Manual

The team decided that the electrification roadmap would be a visual element only. Adding words to this deliverable would steer the roadmap away from its desired simplicity. A deliverable that dives into details on each component outlined in the home electrification graphic was essential for supporting the visual element.

As previously mentioned, homeowner specific deliverables felt vital to the effectiveness of the roadmap and manual. These resources can provide customers with a sense of trust in EMH, as it goes a step or two further than the average HVAC contractor. Rather than being fixated on making the sale, it conveys that EMH values transparency and educating the customer on the reality of what the electrification process entails.

3.1.2.1 Home Electrification Components [Appendix B]

The home electrification components outlined in this deliverable match up to the numbers that are specified in the roadmap. In addition to stating what exactly was pointed out, relevant details were provided on each component.

3.1.2.2 Homeowner Fact Sheet [Appendix C]

Adding the homeowner fact sheet to the manual was an unprompted decision by the team. The home electrification roadmap and components deliverables could carry out the purpose of being used as a bridge between EMH representatives and customers. However, there is additional information that should be known to the homeowners that could be helpful in the process of electrifying their home. This deliverable provides an overview of the benefits of electrification along with incentive programs that could contribute to a lower cost for electrifying.

3.1.2.3 Available Technologies [Appendix D]

Providing customers with the average costs of electric equipment and appliances can assist in the decision making process for home electrification. Having these prices readily available can establish the homeowner's preferred path forward based on what is most cost-effective and beneficial for the residence. Additionally, the available technologies deliverable can be referred to when looking at the listed incentive programs and the associated eligible upgrades in the homeowner fact sheet. This can give the homeowner a more accurate idea of which technologies they can receive rebates for and may be persuasive for pursuing certain electrification components.

3.1.3 Customer Archetype Sheet [Appendix E]

The client informed the team early on about the interest of incorporating customer psychology into their future consultation approach. After reviewing the general homeowner fact sheet, the client suggested making multiple versions that contained specific information based on the type of customer. It was determined that managing the proper execution of the final deliverables would be best carried out by creating a customer archetype guiding document. Existing resources were utilized to assist in generating three customer archetypes that EMHs customers may fall under.

Existing resources were utilized to assist in generating three customer archetypes that EMHs customers may fall under: the environmentalist, the saver, and the analyst. Each archetype has its own particular motivation for pursuing home electrification and supporting key selling points to integrate into the consultation process. The Environmentalist, for example, is motivated to electrify their home because they want to reduce their carbon footprint. While the Saver is motivated by reducing expenses, the Analyst's motivation is rooted in having clear technical specifications that yield the accurate numbers associated with home electrification. When an EMH representative is consulting a customer, they may recognize certain characteristics that are outlined in the customer archetype sheet. They can then approach the consultation with the motivation and key selling points that are specific to the customer archetype.

3.2 Sources of Uncertainty

The team conducted only a small number of homeowners surveys that might lead to some bias and uncertainty. Large variations in prices of available technologies might need to be updated frequently in the deliverable sheet created by our team. A consulting web page when created

would need to be updated regularly as well based on the variation in the prices of electrification technologies. Given that our manual and the accompanying documents are available only in English right now, non-English speaking customers will not be able to understand the contents of the documents completely. Another aspect of the electrification process that requires overcoming is the cultural uncertainties, including concerns about safety and aesthetics of using appliances that run on electricity. Because the members of this category feel that domesticating electricity calls for attention to the large number of accidents caused by electricity and it makes a convincing case for a resulting fear that provides a significant obstacle to electrification [11].

3.3 Equity Challenges

The small number of homeowners surveyed by our team is not completely inclusive and misses out on various other diverse communities and households. The costs associated with electrification is one of the equity challenges. Language is another equity challenge where people speak a different language other than English. According to the data from the 2000 U.S. Census, 60.5% of Californians speak only English, while 39.5% speak another language (either instead of, or in addition to, English). Spanish and Spanish Creole compose the second most popular language grouping in the state, being spoken by 25.8% of Californians [12]. Given the vast economical and geographical diversity of California, EMH will need to create an exhaustive set of electrification solutions in the future that are tailored to meet the different needs of different communities and families which needs to be inculcated/updated in our current deliverables too. Another equity challenge while conducting homeowner surveys was to assess how much people already knew about electrification and who had access to this information. In order to know about this the team posed relevant questions in the survey questions.

4. Recommendations & Conclusions

4.1 Future Work

There are several areas that Electrify My Home could improve in order to continue their goal of simplifying the electrification journey for customers. First, the web-based application that was left out of the scope due to time constraints could be developed. This web-based application would allow customers to input their current gas appliances and would receive recommendations for electric appliance alternatives with a cost estimate. Furthering automation would give customers a simplistic alternative to consulting with contractors and streamline the process to give Electrify My Home more freedom to focus on expanding business.

Another recommendation would be for Electrify My Home to expand their holistic retrofit services to give customers more options to make their home efficient without spending large amounts of money. Holistic retrofit services include those that don’t electrify a home but rather increase efficiency to lessen reliance on natural gas and lower costs. Electrify My Home already offers insulation services to increase home comfort and lower energy bills. They could offer

more services such as HVAC sealing, lighting replacements, and installation of smart home devices.

Future work could be done on the “Customer Archetype” sheet as well. There are many motivations for people to electrify their home and because the survey included 17 people, not all motivations have been discovered. For example, someone may be motivated to electrify to decrease their reliance on investor-owned utilities and the rising cost of electricity and natural gas. This motivation is not currently represented on the sheet and this type of customer would be compelled by vastly different selling points.

4.2 Addressing Equity in Future Work

A web-based application could address equity challenges by allowing customers to get through more of their electrification journey from the comfort of their home. Because Electrify My Home is only open during normal business hours, some working homeowners may find it burdensome to go through the consultation process during the work day. Allowing for those customers to receive electric appliance replacement recommendations along with cost estimates gives them a greater understanding of the process while fitting it into their schedule. Also for the web-based application, attention must be paid that the created webpage is ADA compliant and is easily accessible to people with disabilities since there was a 14% increase in lawsuits in 2021 against organizations whose websites were not ADA compliant.

Holistic retrofits address equity challenges because it offers options to lower income customers who may not be able to afford whole home electrification. Increasing optionality for customers to choose how big or small the project starts puts power into their hands. They may have goals to reduce their carbon footprint or save money on their energy bills, which Electrify My Home could help them achieve. This is mutually beneficial because Electrify My Home would gain a greater customer base, increasing inclusivity, while customers save money.

Adding additional archetypes to the “Customer Archetype” sheet would address equity challenges because it expands the consultants' knowledge of their customer base to be more inclusive. Historically, those who choose to electrify have had very similar motivations but as the market expands a more diverse set of customers will appear. Because of this, Electrify My Home should continue to work towards more inclusion in their sales and consultation process.

5. Bibliography & Appendices

5.1 Bibliography

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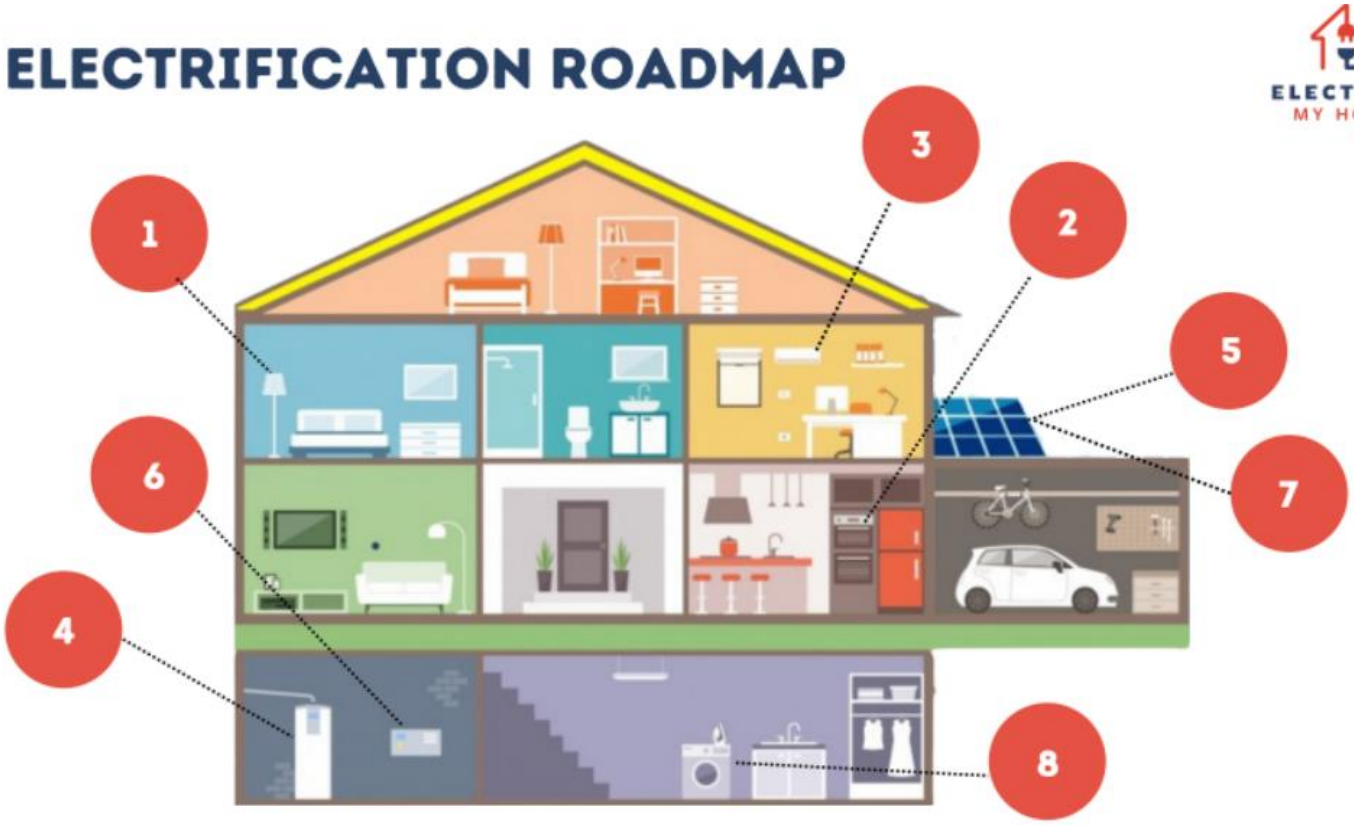
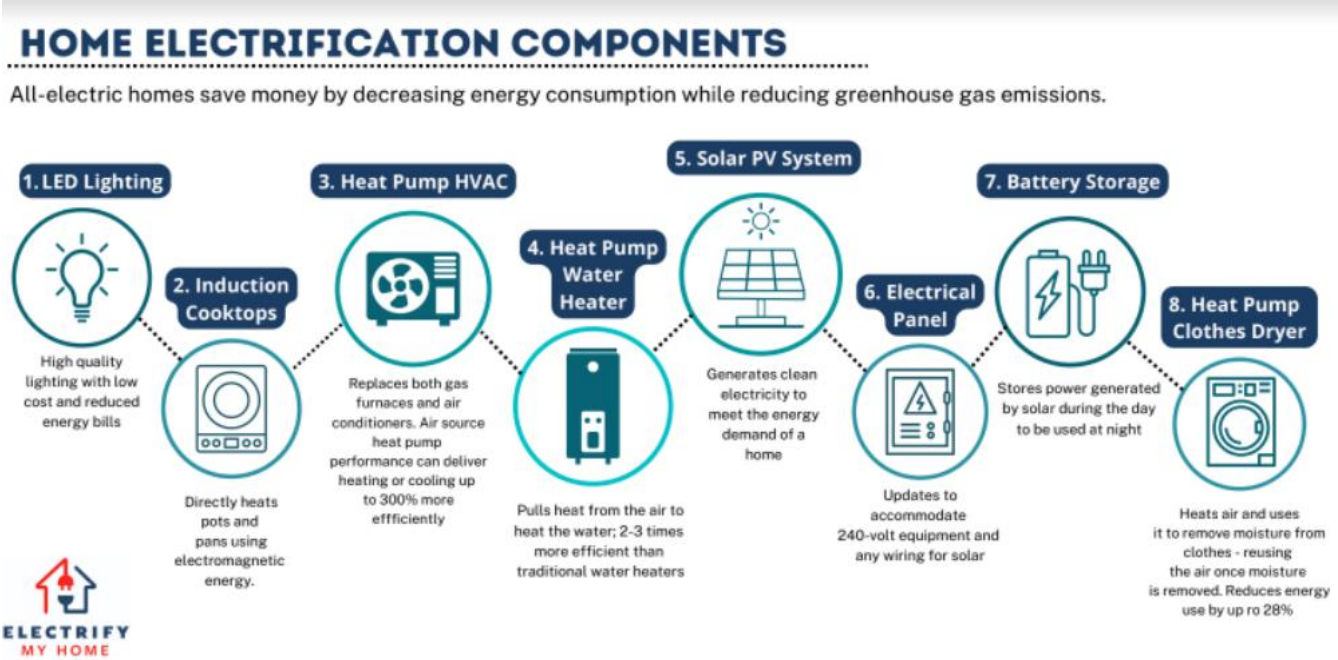
5.2 Appendices

Appendix A: Roadmap Graphic



Appendix B: Manual: Home Electrification Components



Appendix C: Manual: Homeowner Fact Sheet

HOMEOWNER FACT SHEET

Building Electrification Benefits

Reduces Energy Use

- Efficient electric technologies can lower energy use by over **40%** and carbon emissions by over **75%**
- Lower energy use = lower monthly utility bills = lower annual cost spent on utilities

Creates Healthy Homes and Living Environments

- Gas appliances emit air pollutants that can lead to indoor air having more pollutants than outdoor air.
- Children living in homes with gas stoves are **42% more likely** to suffer asthma systems than homes with electric stoves

Increasing Costs of Gas

- Cost of maintaining gas infrastructure is **increasing** with added costs falling onto ratepayers, while the cost of efficient electric appliances is **decreasing**

Incentive Program	Eligible Upgrades	Administrator
Energy Efficiency Upgrades Rebates	Heat pump water heater, induction cooktop, service panel upgrades, solar + storage	Community Choice Aggregators (CCAs)
Residential Energy Efficiency Rebates	High efficiency heat pump water heater	Pacific Gas & Electric
SMUD Energy Efficiency	Heat pump water heater, ductless mini-split, HVAC replacement	SMUD
Home+ BayREN	Heat pump water heater, induction cooktop, heat pumps, heat pump dryer	Bay Area Regional Energy Network (BayREN)

ELECTRIFY MY HOME

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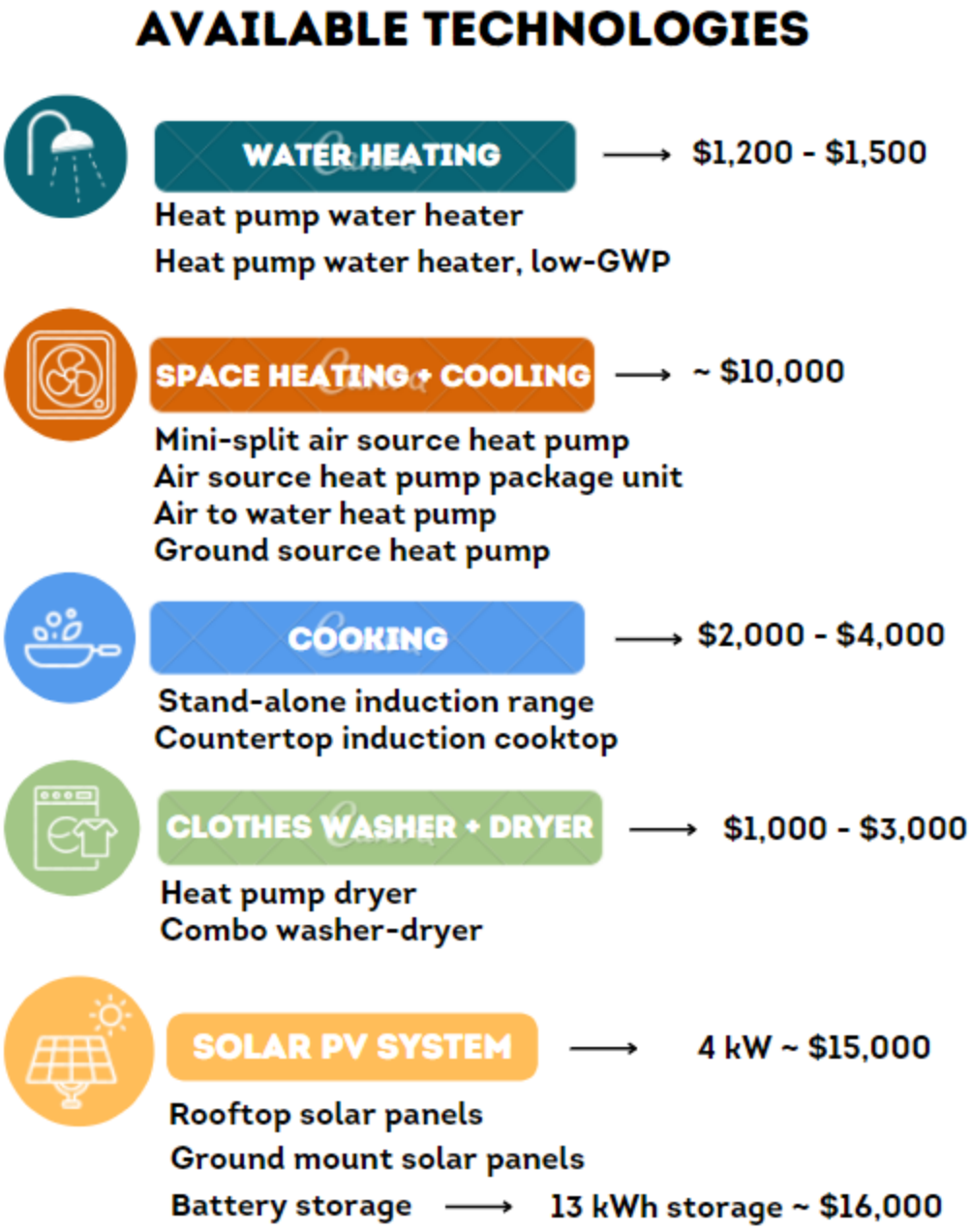
Appendix D: Manual: Available Technologies



Appendix E: Customer Archetype Sheet

CUSTOMER ARCHETYPE

The Environmentalist

Motivation: The environmentalist wants to electrify because of their values. They may have already done research into ways they can reduce their carbon footprint.

Key Selling Points:

- Why choosing electric over gas is better for the environment
- Electrification is a key step in California's journey to zero carbon energy
- Switching to electric appliances reduces toxic pollutants in their home and the environment
- Electrified homes are safer. Electric cooktops, water heaters, and other appliances are less likely to cause fires and explosions than devices powered by gas.

The Saver

Motivation: The saver is motivated by money. They may want to electrify to reduce dependence on volatile natural gas prices or it may be time for them to replace their natural gas appliances.

Key Selling Points:

- Natural gas prices are going to continue to rise while electric appliances like a heat pump are decreasing
- The electrification process is fluid - one appliance can be changed out now and others can be in the future
- All electric homes are cheaper - more efficient appliances and no natural gas bill
- Pairing electrified homes with solar panels decreases electricity bills even further and lessen reliance on the grid

The Analyst

Motivation: The analyst is motivated by numbers. They appreciate straight forward but technical language so they have all of the information to make the right decision for their home.

Key Selling Points:

- Show them the numbers - how much will each individual upgrade cost, how was this cost calculated
- Pull statistics to convince them of the benefits (i.e. children in homes with gas stoves are 42% more likely to develop asthma)
- Discuss costs as well as avoided costs so they can see the full picture of the project