To BE or not to BE? Market Potential and Feasibility of Commercial Building Electrification (BE)

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ABSTRACT

Despite ambitious goals for decarbonization and electrification options being readily available, fuel conversion rates remain low. This paper summarizes the results from a study that set out to develop a better understanding of the market for commercial electrification in Southern California Edison's territory. This type of market characterization can inform the decision-making process of a utility's program planners, such as which building types and electric end uses are the most promising for building electrification, and which face the greatest barriers.

The study used a combination of data sources and analysis approaches. It starts with secondary data to quantify and rank the potential and feasibility of electrification across building segments. We compiled metrics including energy usage intensity (EUI), gas consumption, market size, forecasted growth, and customer adoption preferences. The top five segments with the highest potential and feasibility of electrification based on this assessment were restaurants, health, lodging, multifamily, and schools.

Next, we created a series of energy simulation models to estimate the impact of converting natural gas HVAC, water heating, and cooking to electricity in the three highest priority segments. This paper presents the annualized impacts of each electrification scenario in terms of energy usage, long-term carbon emissions, customer utility bill costs, and on-peak demand all relative to a baseline scenario of continued natural gas usage. Retrofit hotels and new construction fast food restaurants had the highest potential carbon emissions benefits from electrification, with only small increases in utility bills.

Introduction

As electricity generation shifts toward cleaner sources of electricity, strategic building electrification presents a new opportunity to reduce greenhouse gas (GHG) emissions and work toward achieving zero net energy goals. Despite electrification options being readily available, fuel conversion rates remain low. Potential market barriers include a lack of cohesive market development for electrification technologies, higher operating costs, lack of awareness, and structural barriers posed by the existing gas and electric infrastructure. While some researchers have addressed the topic of residential building electrification, there are few studies on the market potential for electrification in the commercial sector.

Southern California Edison scoped this study to provide information about the building electrification market size and potential to support its efforts to meet corporate decarbonization goals in the commercial sector. The study's primary objective was to identify the potential drivers and barriers for building electrification across different building types and operators.

Background

The U.S. joined forces with 195 other nations in 2015 to create the Paris Climate Agreement (the U.S. later withdrew in 2020 and then rejoined in 2021), joining a global effort to fight climate change and its negative impacts. The Paris Agreement includes a call to action for all countries to level off GHG emissions, working to achieve GHG neutrality by 2050. The U.S. committed to cutting GHG emissions to 28 percent below 2005 levels by 2025, enacting the Clean Power Plan (setting limits on fossil-fueled power plants), and setting more stringent fuel economy standards (NRDC 2021). Beyond these national efforts, the state of California has taken action to reduce its GHG emissions. For example, Chapter 249 of the Statutes of 2016 directs the state to achieve a reduction in the emissions of GHGs of 40 percent below 1990 levels by 2030 and 80 percent by 2050.

In 2016, building energy use was responsible for 26 percent of California's statewide GHG emissions (Building Decarbonization Coalition 2019). Decarbonizing California's buildings is essential to achieve the state's GHG emission reduction goals. There are two pathways to decarbonization that have received the most attention in California:[1]

Pathway 1: Natural gas energy efficiency combined with extensive use of renewable natural gas (RNG), and
Pathway 2: Electrification of regulated fossil fuel end uses in buildings.

The Building Decarbonization Coalition's *Roadmap to Decarbonize California Buildings* argues for the importance of electrification (pathway #2). They argue that it is imperative that we "stop digging the hole" by ensuring newly constructed buildings adopt technologies with very low or no GHG emissions. The roadmap also notes significant potential for decarbonization of existing commercial buildings (Building Decarbonization Coalition, 2019). Decarbonization technologies currently have minimal market penetration in California. Near-zero emissions technologies that are acceptable alternatives for many of California's building end uses are already commercially available, but the market conditions need much more development.

To achieve California's stated goals, the roadmap identifies two key building components that traditionally rely on natural gas: HVAC and water heating equipment. While there are many other natural gas end uses in the commercial sector, HVAC and water heating are ubiquitous; many other measures are segment-specific and therefore comprise a smaller proportion of the sector's GHG emissions. The roadmap encourages California businesses to switch from natural gas HVAC and water heating equipment to heat pump-based technologies such as ducted heat pumps, ductless heat pumps, and heat pump water heaters (Building Decarbonization Coalition, 2019).

In addition to heating and water heating, gas cooking equipment accounts for a significant portion of natural gas usage in the commercial sector. For example, *The California Commercial End-Use Survey* found that approximately 22 percent of natural gas usage in Southern California's commercial sector was from cooking end uses (Itron, 2019). Electric and induction cooking equipment will be a key driver for California's electrification efforts in restaurants, healthcare facilities, hotels, food production facilities, and other commercial segments that may utilize traditional gas cooking equipment.

Recent developments in decarbonization efforts include the release of a California Energy Commission (CEC) report that highlights building decarbonization and local municipalities banning natural

[1] Such as California SB1477, which incentivizes low-emissions technologies for affordable housing.

gas hookups for new construction.[2] The CEC Integrated Energy Policy Report highlights that these efforts must be focused on zero-emission buildings in order to meet 2030 and 2050 climate goals. It is recommended that electrification of HVAC and water heating is an effective strategy to meet zero-emission building goals (CEC 2019). In August 2019, the CPUC voted to alter the three-prong test, a policy from the 1990s that prevented investor-owned utilities (IOUs) from offering incentives for fuel substitution. The changes make it easier to establish the cost effectiveness of electrification technologies and establish carbon dioxide emissions reductions as the metric to determine environmental impact.

Southern California Edison (SCE) has aligned its corporate goals around GHG reduction with its Pathway 2045 (SCE 2019). Despite ambitious goals for decarbonization and electrification options being readily available, fuel conversion rates remain low. In preparation for market transformation activities, SCE set out to develop a better understanding of the current market for electrification within their service territory.

Methodology

Evergreen Economics and BrightLine Group were hired by SCE to investigate the potential impact, drivers, and barriers to both partial and full building electrification in high priority commercial building types. The Evergreen team used a combination of approaches to conduct this study:

1. **Market Data:** Summarizing secondary source data to estimate and rank the market size and potential for electrification by commercial business segment within SCE's service territory.
2. **Building Simulations:** Creating building simulations of the top three most promising business segments (fast food restaurants, hotels, and mid-rise multifamily)—considering both retrofit and new construction scenarios for two climate zones—then using the simulation outputs to estimate the impacts of electrification on carbon emissions, customer utility bills, and grid stability.
3. **Interviews:** Assessing drivers of and barriers to electrification for the top five most promising business segments through primary research (n=29 telephone interviews).

SCE's definition of the commercial sector for this study also includes mid- and high-rise multifamily, industrial, and agricultural sectors. In other words, this study was intended to capture all the utility's non-residential customers.

Market Data. Evergreen compiled secondary market data and qualitative information on adoption acceptance from a variety of sources for this assessment, including:[3]

1. Total gas usage, measure usage intensity, and floor stock per segment from the 2006 Commercial End Use Survey (CEUS) and the 2009 Residential Appliance Saturation Survey (RASS)
2. California Commercial Saturation Survey (CSS), 2014
3. GHG emissions from natural gas usage from the Environmental Protection Agency (EPA) GHG Equivalencies Calculator, 2019
4. New construction growth forecast from McGraw Hill Dodge, Q2 2019-2023
5. Commercial ownership/adoption data from the U.S. Energy Information Administration (EIA) Commercial Building Energy Consumption Survey (CBECS), 2012

[2] There have also been local efforts to meet zero-emission goals for buildings. Berkeley, California became the first city in the nation to ban the installation of natural gas lines for new low-rise residential buildings starting January 1, 2020 (Gerdes 2019). Many other cities in California (San Jose, Mountain View, Santa Rosa, and Brisbane) and across the country (Brookline, MA) have followed suit.

[3] This task was completed in 2019, prior to the release of the updated 2019 RASS, 2018 CBECS, or 2019 CEUS.

Building Simulations. BrightLine created whole-building energy simulation models with EnergyPlus for the top three commercial segments (fast food restaurants, hotels, and mid-rise multifamily). The objective of this task was to estimate the impact of converting natural gas HVAC, water heating, and cooking to electricity. We tested multiple scenarios to assess the level of electrification achievable for new construction versus retrofits of existing building and across varied climate zones (9 Burbank-Glendale to represent SCE's primary population centers and 13 Fresno to highlight electrification impacts in colder areas), accounting for differences in the building codes (Title 24 2008, 2016, and 2019). SCE provided the original prototype models from SCE's Benchmarking Database and a mid-rise multifamily model developed in CBECC-Com 2019 (California building energy code compliance for commercial/non-residential buildings). We simulated the impacts of electrifying gas HVAC, water heating, and cooking end uses in these buildings, as well as interactive effects on other building systems (e.g., cooling).

For each scenario, the building simulation outputs provided 8,760 hourly weather-normalized energy use load shapes for both electricity and natural gas. Evergreen used the annualized impacts of each electrification scenario to estimate each building's long-term carbon emissions, utility bill costs, and increased peak demand, relative to the baseline scenario of continued natural gas usage. The combination of these three metrics provides a holistic view of how electrification would impact the environment, utility customers, and regional grid stability.

Interviews. Evergreen conducted in-depth interviews with 29 market actors between September and November 2019. We used a combination of SCE-supplied contacts (trade allies, participants of previous programs, and commercial account representatives), our own lists of trade allies from prior similar research, and online trade organization lists (such as the California Association of Building Energy Consultants) to identify potential interview targets. Each contact was associated with electrification efforts within the top five most promising business segments (restaurants, health, lodging, multifamily, and schools). The overarching goal of the primary qualitative research efforts was to gather direct input from market actors within SCE's commercial market that inform potential drivers and barriers for commercial building electrification.

Results

This section presents the results of our market characterization for building electrification in the commercial sector, which for the purposes of this study includes the multifamily (with five or more residential units), industrial, and agricultural sectors.

Market Potential

The study included the development of a potential score, which is a multiplicative score based on each segment's proportion of total gas usage and intensity (relative to all commercial), measure usage intensity (for cooking, heating, and water heating), and forecasted new construction growth as shown below.

$$
\begin{aligned}
&Potential\ Score_i \\
&\quad = \left[\left(\%\ Existing\ Floor\ Stock_i * 100 * \frac{Segment\ Gas\ Consumption_i}{\sum Commercial\ Gas\ Consumption}\right.\right. \\
&\quad * \frac{Gas\ Intensity_i}{\sum Commercial\ Gas\ Intensity} \\
&\quad \left. * \frac{Cooking +\ Heating + WaterHeating\ Intensity_i}{Gas\ Intensity_i}\right) \\
&\quad \left. + \left(\%\ NewConstruction * \frac{Forecasted\ Growth_i}{\sum Forecasted\ Growth}\right)\right] / 100
\end{aligned}
$$

A feasibility score was calculated based on an average across the four feasibility categories: ease of electrification for existing buildings, ease of electrification for new construction, business structure, and ownership structure (where 1=low feasibility for electrification, 2=medium, and 3=high). The potential score was normalized and combined with the feasibility score using a 3:1 weighted average to inform the final rankings (i.e., potential given a weight of 3, and feasibility a weight of 1).

Table 1 highlights key potential and feasibility results for the top 10 commercial segments within SCE's service territory, ranked by highest priority for electrification. Restaurants yielded the highest potential score and ranked first in priority for electrification.[4] They have the highest total gas usage, largely due to cooking and water heating. Even with removing the cooking component of gas consumption, the restaurant segment still ranks high. Multifamily properties have the second highest gas consumption and large projected growth. The multifamily segment had a higher potential score than lodging but was demoted in its rank due to low feasibility marks, resulting from challenges in adoption of electrification measures for existing buildings and ownership structure. While industrial and agricultural sectors have some potential for electrification efforts, neither was identified as one of the top segments for further consideration given that most of their gas usage and GHG emissions come from end uses outside of the current scope, which focuses on heating, water heating, and cooking.

[4] We did not differentiate between fast food and sit-down restaurants in the potential assessment, as this was not a distinction made in the source data.

Table 1. Top ten commercial segments for building electrification

Segment	Existing Stock (1,000 sqft)	New Construction Growth (1,000 sqft)	Total Gas Usage (annual GBtu)	Potential Score	Feasibility Score*	Overall Score	Rank
Restaurant	61,623	2,181	15,349	202	1.5	3.8	1
Health	106,471	11,115	7,272	27	2	1.4	2
Lodging	112,405	16,125	4,601	11	2.75	1.3	3
Multifamily (5+ units)	901,000**	109,416	14,648	15	2.25	1.3	4
School	176,999	21,790	2,146	2	3	1.3	5
College	64,809	7,979	1,556	2	2.75	1.2	6
Small Office	157,884	8,975	1,270	1	2.75	1.1	7
Large Office	227,225	12,916	2,949	2	2	1.0	8
Grocery	63,820	2,259	1,392	2	2	1.0	9
Warehouse	383,796	62,247	1,111	1	1.75	0.9	10

* 1=low, 2=medium, 3=high

** Floor stock was unavailable in CEUS for multifamily. We took the midpoint of the RASS and Census estimates for the number of households within the service territory (Cadmus 2013), and then applied an average of 916 square-feet per unit (RASS 2009) to produce a rough estimate.

The **restaurant** segment has the highest gas usage intensity in the commercial market, primarily stemming from cooking equipment and water heating. Installation cost barriers are lower for electrical heating and induction cooking equipment than for other electrification measures; however, commercial heat pump water heaters are not cost effective in many applications (NREL 2017). Feasibility concerns occur because of the professional preference for gas cooking equipment within the restaurant segment and the potential lack of sufficient electrical infrastructure in retrofit applications.

The **health** segment has the second highest gas usage intensity and one of the highest rates of new construction within SCE's service territory, with a high percentage of owner-operated, multi-building and campus applications that can realize this potential for long-term energy savings. Hospitals and other large in-patient facilities may account for most of the overall usage but may be more difficult to absorb electrification efforts due to potential downtime associated with retrofits. Conversely, smaller healthcare facilities that are easier to target and implement electrification efforts may only have limited technical potential based on their lower overall gas usage.

Similar to the health segment, all of the electrification measures that this study is targeting may be applicable to a subgroup of businesses within the **lodging** segment, notably heat pump water heaters because of the relatively high water heating gas usage intensity and simultaneous demand for cooling and water heating. However, because commercial heat pump water heater applications are not currently cost effective in many applications (NREL 2017), this may be a potential barrier in the lodging segment.

The **multifamily** segment—defined as multifamily buildings with five or more units—has very high total gas usage and an average gas usage intensity. Usage typically comes from heating, water heating, and cooking, presenting an opportunity for multiple electrification measures like the other high-interest segments. The multifamily segment has a significant amount of new construction opportunities compared to other commercial segments. Building owners and managers typically oversee multiple sites, which may be an opportunity to lower the amount of outreach efforts on behalf of SCE with strategic targeting.

The **school** segment, mostly comprised of elementary and secondary schools, does not have significant overall usage (approximately 4 percent of commercial usage) but does have relatively high overall gas usage intensity stemming primarily from heating and water heating requirements, with some cooking. Unlike other segments such as office and retail, the school segment is much more clearly defined with a consistent ownership structure, which may make it easier for SCE to target this segment with specific electrification measures . The timing of the school year schedule may allow for flexibility on larger retrofit projects.

Simulated Impacts of Electrification

Following the ranking of the most promising commercial segments for electrification, BrightLine developed building simulation models and then Evergreen analyzed the results to estimate the impacts of electrification on customer bills, the utility electricity grid, and carbon emissions from three of the top five priority segments: fast food restaurants, hotels, and mid-rise multifamily.

Impact on Carbon Emissions. SCE provided CO2 emissions multipliers for both electricity and gas consumption (NORESCO 2018).[5] These multipliers were developed by SCE with the intent of meeting the CEC's objectives for sending a strong GHG signal to the market. SCE's engineers used the Integrated Energy Policy Report (IPER) as a guideline when forecasting emissions, assuming that California will meet its goal of 100 percent renewable electricity generation by 2025 (consistent with Senate Bill 100). However, this does not mean that all electricity supplied by California's grid will be carbon-free, as capacity of existing generators will reduce over time and be supplemented with increased imports from outside the region, which are not always renewable.[6] These 8,760 hourly CO2 emissions multipliers developed by SCE provide the best available estimate for the forecasted fuel generation mix for each fuel over the course of the next 15- or 30-year span (i.e., average over the next 15 years, not annual impacts).

In most cases, the results confirmed that electrification would lead to a reduction in carbon emissions, relative to the baseline scenario with continued use of natural gas equipment. The most substantial improvement was seen in hotel retrofits, with a 21 percent drop in annual carbon emissions for both climate zones (9 and 13).[7] The fast food restaurant model has a 'breakfast service' load profile with increased occupancy during the early morning hours from cooking load and heating. Because of the time of day, during those specific hours, electrification causes carbon emissions to increase. The increase

[5] This is based on metric 8, the long-run marginal Renewable Portfolio Standard (RPS) constrained GHG impacts per kWh and therm, version 2022.

[6] Renewable or non-fossil fuel generation such as wind, solar, and hydro all operate without CO2 emissions. These sources supply around 50 percent of the electricity for California's grid on summer afternoons, but only 15 percent during the early morning hours. SCE's generation portfolio is predominantly comprised of renewable energy during the midday hours, yet still relies on non-renewable generation during the late night and early morning hours. Due to the variability in types of electric generation by hour and season, a single kWh is associated with between 0 and 0.00104 tons of CO2 emissions. The emissions associated with gas generation are much less varied, with between 0.00541 and 0.00548 tons of CO2 per therm; these emissions vary by climate zone but are consistent across hours of the day.

[7] The retrofit hotel scenario is based on Title 24 2008, whereas the new construction hotel is based on Title 24 2019. The baseline scenario for the retrofit hotel had significantly higher carbon emissions than the new construction hotel. After electrification, the two prototypes have similar carbon emissions. There was more room for improvement in the retrofit hotel.

is higher (worse) for the retrofit model because of its less efficient shell. This increase partially offsets the improvement in carbon emissions during other hours of the day.

The electrified scenario was associated with a small increase in carbon emissions for mid-rise multifamily retrofits (2%) and hotel new construction (1%) in climate zone 9. In these cases, natural gas equipment that operates during the early morning and evening peak hours is being replaced with electric equipment. This leads to substantial increases in electricity usage during the hours when the utility is most reliant on nonrenewable sources of generation, with higher carbon emissions per kWh. These changes are quite small, but suggest that we may see a short term increase in carbon emissions from building electrification in these cases. However, if these buildings were to adopt onsite generation and/or energy storage, they could easily offset this small increase in carbon emissions.

Impact on Peak Demand. Building electrification has the potential for both positive and negative impacts on the utility grid by increasing electricity demand (i.e., load) during the peak and/or off-peak hours. In all but one instance, the building electrification scenario had higher (i.e., worse) demand during summer than the baseline. Hotels have especially large increases in peak demand from electrification of both HVAC and water heating, with new construction increasing from 216 to 370 kW in climate zone 9 and increasing from 222 to 351 kW in climate zone 13. When a building has a large increase in facility peak demand, this can lead to a need for the utility to make upgrades to the electricity delivery and/or transmission infrastructure.

Impact on Load Factors. The load factor is a ratio of a customer's average energy consumption across all hours and days to their consumption during the utility system peak (i.e., summer weekdays from 4:00 p.m. to 9:00 p.m.). Higher load factors are better for grid stability. A low load factor indicates that a high proportion of electricity usage is concentrated in the peak period. This leads to grid instability because the evening ramp-up at the beginning of the system peak requires the utility to dispatch additional generation. Buildings with a high load factor are less 'peaky', leading to more efficient utilization of the electric grid.

In each instance, the building electrification scenario had a higher (i.e., improved) load factor score than the baseline. The most extreme example is hotel new construction in climate zone 13, where the load factor increased from 0.46 in the baseline to 0.63 with full electrification, a 37 percent improvement. The fast food restaurant model for climate zone 13 had slightly *higher* load factors with partial electrification (HVAC and water heating only) than full electrification (which also includes cooking) in both climate zones; this was due to a reduction in overall electricity usage between the partial and full electrification scenarios (increasing the numerator more than the denominator). In the full electrification simulation, gas cooking equipment is replaced with electric convection equipment. In addition to being more efficient, convection produces less HVAC than gas cooking, reducing the need for cooling. This results in an overall reduction in electricity usage with only a minor change in peak demand, leading to a reduction in the load factor.

Impact on Customer Utility Bills. SCE was interested in understanding how customers would be impacted by moving from a combination of electric and gas usage to full electric usage for electrification measures (i.e., heat pumps and heat pump water heaters in the simulation scenarios). Evergreen assessed the financial impacts to the customer by applying current SCE and Southern California Gas (SoCalGas) tariffs to the energy consumption estimates produced by the building simulation models.[8]

[8] SCE and SoCalGas tariffs as of August 28, 2019.

For the fast food restaurant scenario, partial electrification (HVAC and water heating only) led to an increase in utility bills because the increase in electricity unit charges was not enough to offset the reduction in natural gas unit charges. However, full electrification does produce bill savings, as the customer is now able to avoid the gas service charges. In the baseline scenario, the fast food restaurant scenario had sufficiently low maximum demand that it qualified for the small business rate schedule (TOU-GS-1). Adding additional electric end uses causes an increase in demand, enough to push them to a different rate schedule (TOU-GS-2). This rate schedule has lower electric unit charges (kWh) by time-of-use but *adds* demand charges (per kW). Despite this shift in the rate schedule, the full electrification retrofit still estimated an overall reduction in utility bills relative to the baseline scenario.

In each hotel scenario, electrification led to a large increase in electricity demand charges. For retrofit hotels, these demand charges offset some of the bill savings from reduced gas unit charges, whereas new construction hotels exhibit a significant increase in both demand and electric unit charges after full electrification, leading to an overall increase in utility bills.

Most multifamily buildings in SCE's service territory are individually metered, with tenants paying the utility directly for the energy usage within their unit. In retrofits and new construction, we found that the utility bills of the common areas and retail units were similar or decreased slightly in the electrified scenario (compared to the baseline), while the bills for residential units decreased dramatically. This dramatic drop in residential unit electric costs is driven by the change from the basic residential rate plan (TOU-D) to a prime rate (TOU-D-PRIME), which is reserved for households with heat pumps, electric vehicles, or behind-the-meter energy storage. The total residential unit bill savings would be distributed across 88 individual residential units, with each customer saving around 20 dollars each month in the electrified scenario.

Summary of Impacts. Table 2 provides the percentage change in building-level carbon emissions, maximum summer on-peak demand, load factor, and customer utility bills for the full electrification scenario relative to the baseline. We have highlighted the best cases and worst cases for each metric.

Retrofit hotels and new construction fast food restaurants have the highest potential carbon emissions benefits (9-21% reduction) from electrification, with only small increases in utility bills of 1 to 6 percent. The worst candidates for electrification among the priority segments were new construction hotels, with very small carbon emissions impacts of ±1 percent, a 17 percent increase in utility bills, and a 58 to 71 percent increase in summer on-peak demand after the electrification of water heating and HVAC (e.g., variable refrigerant-flow system with dedicated outdoor air system).

The small increase in carbon emissions for mid-rise multifamily buildings in climate zone 9 is due to the electrification of equipment that operates in the early morning and evening peak hours. During these hours, the utility is more reliant on non-renewable generation (i.e., more fossil fuels and less solar generation), resulting in higher carbon emissions per kWh. Small increases in carbon emissions from electrification could theoretically be offset by strategic use of on-site battery storage, delaying projects a few years (i.e., waiting for the grid to increase the renewable generation mix to improve the overall 15- or 30-year average impacts), or adjusting the electrification scenario parameters (e.g., require small adjustments to HVAC scheduling to shift more of the increased electricity usage towards hours with a cleaner generation mix).

Table 2. Summary of electrification impacts based on simulation

Prototype Model	Scenario	Climate Zone	% Change after Electrification: Utility Bills	On-Peak Demand	Load Factor	Carbon Emissions
Fast Food Restaurant	Retrofit	CZ 09	2%	16%	15%	-7%
		CZ 13	-6%	37%	15%	-2%
	New Construction	CZ 09	-1%	24%	10%	-12%
		CZ 13	3%	25%	13%	-9%
Hotel	Retrofit	CZ 09	-4%	27%	9%	-21%
		CZ 13	-6%	19%	17%	-21%
	New Construction	CZ 09	17%	71%	27%	1%
		CZ 13	17%	58%	37%	-1%
Mid-rise Multifamily	Retrofit	CZ 09	-21%	-1%	30%	2%
		CZ 13	-22%	3%	21%	-4%
	New Construction	CZ 09	-22%	3%	35%	2%
		CZ 13	-21%	7%	31%	-2%

Note: Cells have been shaded to highlight the best and worst scenarios.

Market Drivers and Barriers

Evergreen conducted 29 in-depth interviews with direct market actors (4 manufacturers, 10 energy consultants/design teams, and 9 installers) and market observers (5 peer utilities and 1 SCE account representative). The overarching goal of this primary research was to expand upon the findings from the potential assessment by gathering direct input on the drivers and barriers for electrification.

Throughout these interviews, three consistent barriers were raised by the direct market actors and market observers:

1. **Initial Purchase and Installation Costs:** Market actors consistently identified initial purchase price as one of the most important considerations for heating and water heating projects. Several noted increased prices as a direct barrier to fuel substitution technologies. It does not appear that there are increased installation costs for heat pump technologies, but the distinction of equipment and installation charges are not always easy to understand for customers. Another important cost associated with fuel substitution that is important to consider is the business downtime attributed to a large retrofit. This cost is associated with early replacement and replacement on failure. This downtime and potential loss of business may not be feasible for some of the segments identified in the potential and feasibility assessment.
2. **Lack of Awareness:** Manufacturers and energy consultants identified lack of awareness of heat pump technologies as one of the greatest barriers to adoption. Several noted that this lack of

awareness included end users and contractors and other market actors who would be involved in the installation or purchasing process.

3. **Natural Gas Infrastructure Status Quo:** A more indirect barrier that came across in several interviews is that the market views gas as a reliable and inexpensive existing infrastructure that they may be resistant to give up.

Conclusions

The top five segments identified by the study's potential assessment (restaurants, health, lodging, multifamily, and schools) offer the greatest potential and feasibility for electrification initiatives and are a natural starting point for electrification initiatives in Southern California and other jurisdictions with similar commercial sector composition and characteristics. SCE could leverage efforts of peer utilities, such as the Northeast Energy Efficiency Partnerships' Action Plan.

Building electrification is part of a larger decarbonization strategy. As highlighted in our building simulation analysis, there is potential under current conditions for building electrification to slightly increase carbon emissions, given current generation sources. It is critical to approach electrification from a holistic perspective, with GHG emissions as the primary metric of interest. Small projected increases in carbon emissions from electrification measures could theoretically be offset by strategic use of on-site battery storage, delaying projects a few years (i.e., waiting for electricity generation to shift towards cleaner sources), or adjusting the measure parameters (e.g., require small adjustments to scheduling to shift more of the electricity usage to hours with a cleaner generation mix).

The study showed the value of examining the benefits and opportunities of building decarbonization from a number of perspectives, including potential for GHG emission reductions, market feasibility, generation source impacts, customer rate impacts, and grid constraints. There are many existing data resources that may be tapped for jurisdictions to examine their commercial sectors' potential for electrification. In addition to mining secondary data, it proved useful to conduct modeling of how buildings may use electric appliances (simulations), and how customer rates and generation sources will impact net GHG reduction benefits and energy bills (statistical models). Finally, including the input from stakeholders that will be key to achieving electrification goals in the assessment of feasibility is also key—including supply side actors, grid operators, and peer utilities that have lessons learned to offer.

The market potential and barriers highlighted in this paper provide a snapshot of a complex issue, supporting program and regulatory efforts to reduce GHG emissions through building electrification. This type of market characterization is a valuable tool for program administrators, planners, and code officials, informing them of potential and barriers to electrification.

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