BUILDINGS BASELINE STUDY

SVCE Territory

September 2020

About Silicon Valley Clean Energy

Silicon Valley Clean Energy (SVCE), a Community Choice Energy agency, is redefining the local electricity market and providing our residents and businesses with new clean energy choices—renewable and carbon–free electricity at competitive rates and innovative programs. SVCE was formed as a Joint Powers Authority in 2016, and now serves approximately 270,000 residential and commercial electricity customers across a service area comprised of the following thirteen communities: Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Morgan Hill, Mountain View, Saratoga, Sunnyvale and Unincorporated Santa Clara County. 97% of electricity customers in SVCE's service area receive their electricity from SVCE. For general information on SVCE, please visit: https://www.svcleanenergy.org/.

SVCE's Board of Directors adopted our Decarbonization Strategy & Programs Roadmap in December 2019. Clean electricity from SVCE's carbon-free sources has already contributed to a dramatic 21% reduction in area-wide carbon emissions from 2015 levels. The Roadmap sets ambitious goals to further reduce greenhouse gas emissions from 2015 baseline levels to 30% by 2021, 40% by 2025 and 50% by 2030, and programs are anticipated to play a major role in achieving these goals. Six program focus areas were identified: power supply, transportation, built environment, energy efficiency & grid integration, education & outreach, and innovation. For more information on SVCE's overarching program strategy and current program portfolio, please visit: https://www.svcleanenergy.org/programs/.

About this Report

SVCE performed a data-driven assessment of energy and emissions in the built environment in SVCE service territory with dual objectives: 1) to develop a comprehensive understanding of energy usage and associated greenhouse gas emissions for buildings (residential and commercial), and 2) to identify opportunities for targeted decarbonization policies and programs. Multiple data sources were used for this analysis, including specifically premise-level energy consumption and building information (age, square footage, etc.). This report summarizes key results. For more information on the analysis and report, please e-mail innovation@svcleanenergy.org.

Acknowledgements

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Executive Summary

Decarbonizing buildings is crucial for meeting science-based greenhouse gas emission reduction targets. However, developing informed strategies and programs to decarbonize the built environment requires in-depth analysis of building stock, building attributes, and energy consumption. A detailed energy and emissions analysis was carried out for SVCE service territory covering both the residential and commercial building sectors, in aggregate and by end-use. The dual objectives of the analysis were to develop a comprehensive understanding of energy usage and associated greenhouse gas emissions trends in buildings, and to identify opportunities for targeted decarbonization policies and programs. Impacts on energy consumption patterns from electric vehicle (EV) charging infrastructure deployment and behind-the-meter (BTM) solar adoption were evaluated. Territory-wide deployment of BTM solar, EVs, BTM storage, and fuel cells was also assessed.

As shown in Figure ES 1, in SVCE service territory, buildings accounted for 33% of emissions[1] in 2018. Electricity and natural gas contribute 16% and 84% to buildings emissions, respectively. Other sources of energy-related emissions include the industrial,[2] utilities,[3] and agricultural sectors, which make up 7%, 5%, and 1% of emissions, respectively.[4]

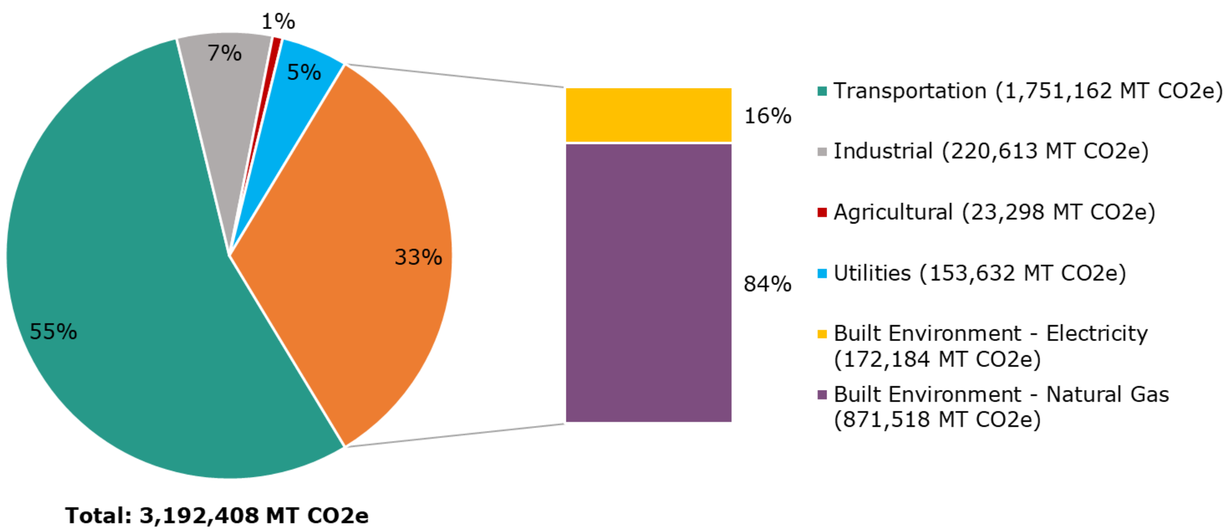

FIGURE ES 1. EMISSIONS BY SECTOR IN SVCE TERRITORY (2018)

Figure ES 2 shows that the residential and commercial building sectors contribute equally to overall building emissions in SVCE territory. Residential buildings are responsible for a higher fraction of natural gas emissions due to proportionally higher natural gas consumption. On the other hand, commercial buildings are responsible for a higher fraction of electricity emissions. This is due to both greater electricity consumption in the commercial sector (2.2 times higher) and the fact that the electricity supply for typical large commercial customers has a higher carbon intensity compared to that powering most buildings in the territory.

[1] Emissions from waste and wastewater represent a small fraction of overall emissions and are not included in this analysis.
[2] Includes emissions from manufacturing and mining.
[3] Includes emissions from electricity generation, water supply, sewage treatment, and natural gas distribution.
[4] Electricity emissions include T&D losses. Natural gas emissions do not include fugitive emissions.

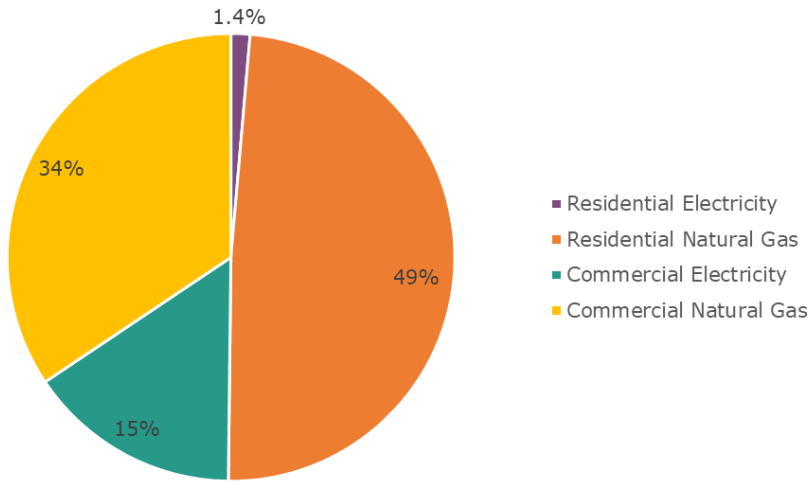

FIGURE ES 2. BUILDINGS EMISSIONS BREAKDOWN BY SECTOR AND FUEL SOURCE IN SVCE TERRITORY (2018)

For residential buildings, electricity and natural gas consumption was analyzed by housing type (single-family homes, condos, multi-family units). The majority of energy consumption and associated emissions are from single-family homes, 95% of which are mixed fuel, meaning they have both electricity and natural gas utility connections. As shown in Figure ES 3, on average, older single-family homes tend to have higher annual electricity and gas energy use intensities (EUIs), which is energy usage (electricity, natural gas, or both) of a building normalized by its square footage. This suggests there is significant potential for both building envelope and appliance efficiency improvements. In older single-family homes — especially those built before 1960 — efficiency and electrification retrofits could yield significant emissions reductions.

For commercial buildings, electricity and natural gas consumption was analyzed by sector. The predominant commercial sectors with respect to energy consumption include: management of companies and enterprises (electricity); professional, scientific, and technical services (electricity); accommodation and food services (natural gas); and health care and social assistance (natural gas). Commercial sector electricity and gas EUIs were found to be generally lower than the regional averages. Commercial EUI was also analyzed in terms of both sector and building square footage - parcels under 10,000 ft^2 in the accommodation and food services sector were found to have the highest energy EUIs, likely due to high gas usage at food service establishments such as restaurants.

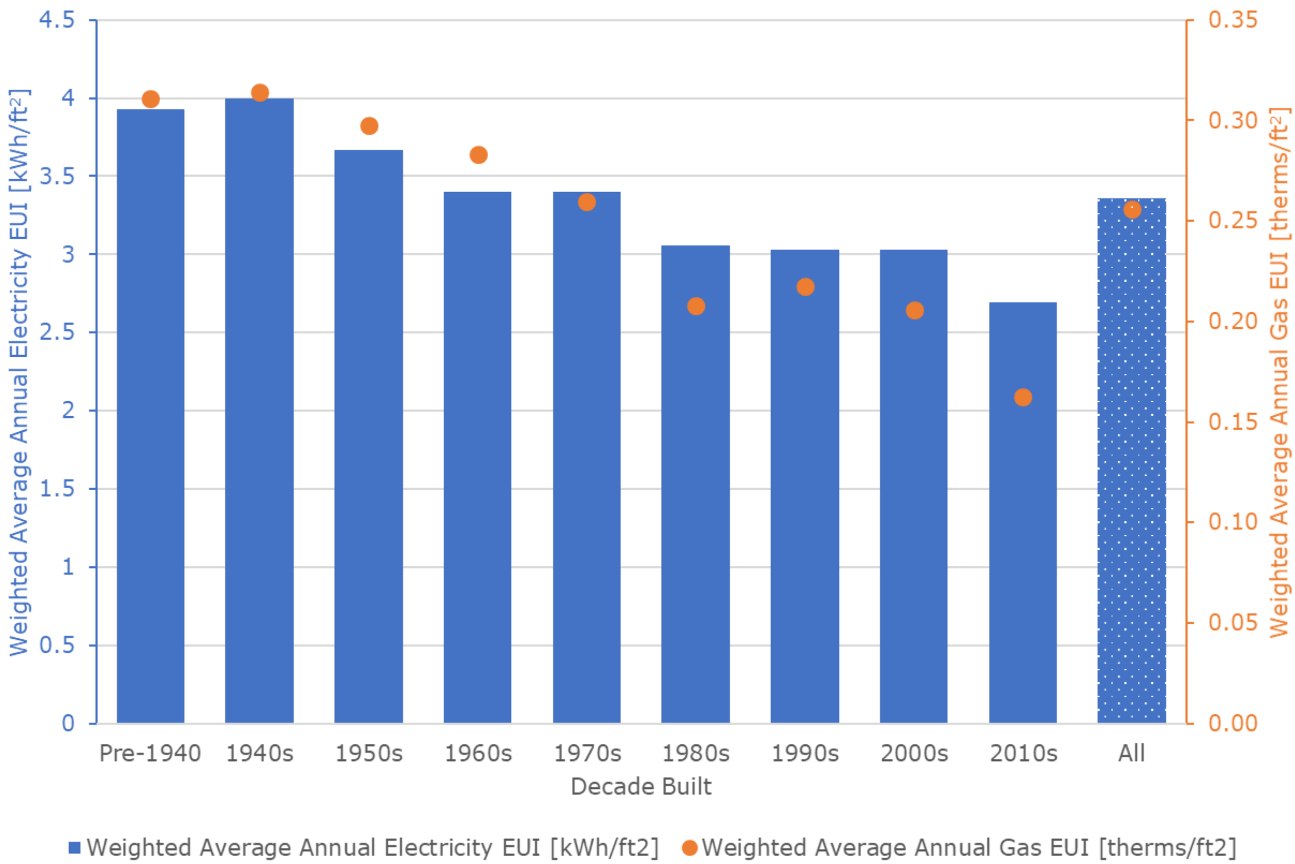

FIGURE ES 3. ANNUAL ELECTRICITY AND GAS EUI FOR SINGLE-FAMILY HOMES[5] IN SVCE TERRITORY (2018)

To gain a more detailed understanding of how energy is used within buildings, retail energy consumption[6] and associated emissions were disaggregated by end-use. As shown in Figure ES 4, electricity and natural gas consumption contribute nearly equally to energy consumption in the built environment. However, as shown in Figure ES 5, emissions from natural gas consumption are five times greater than those from electricity consumption, with water heating, space heating, and cooking being the most emissions-heavy end-uses. This contrast highlights the need to transition from an energy efficiency to an emissions paradigm when developing building decarbonization policies, given traditional energy efficiency measures applied to electricity usage do not have commensurate climate benefits as they once did.

[5] This analysis was carried out only on mixed fuel single-family homes without solar PV/EV/PHEV to isolate the impact of building vintage on EUI.
[6] For electricity consumption, 4.23% T&D losses are included. EV charging is excluded and is instead accounted for in the transportation sector.

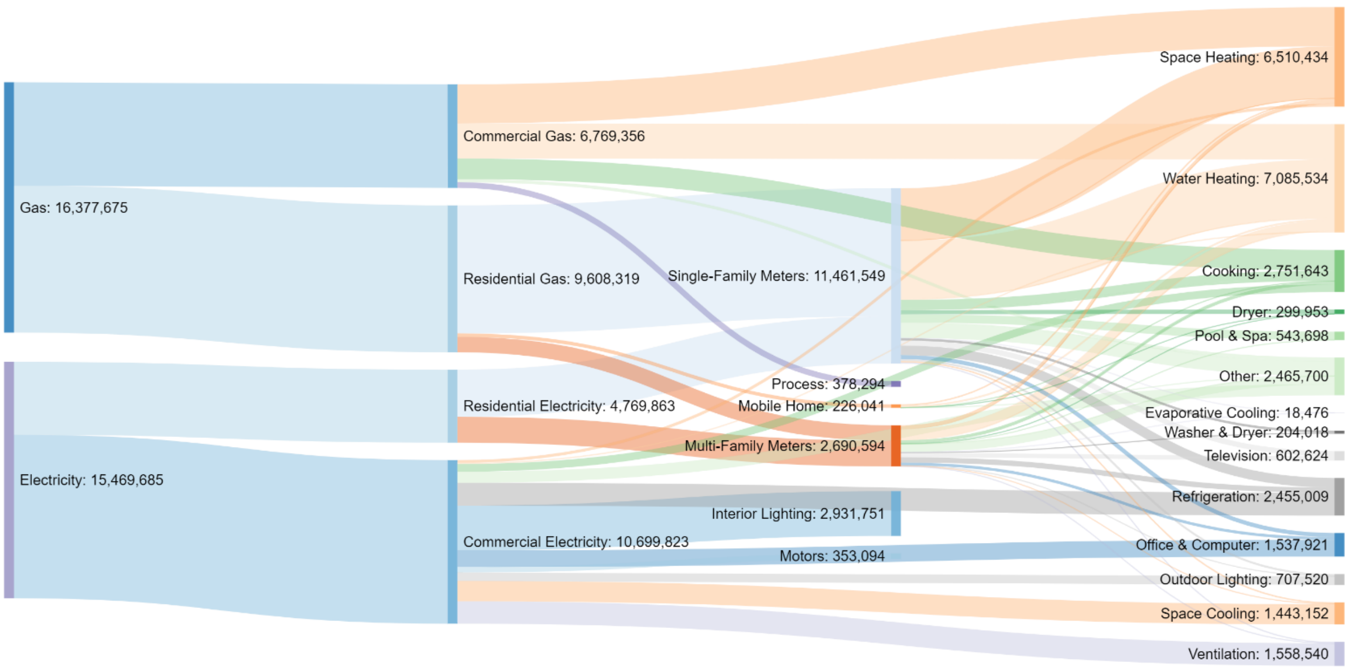

FIGURE ES 4. RESIDENTIAL AND COMMERCIAL BUILDING ENERGY DISAGGREGATION BY END-USE (2018) [MMBTU]

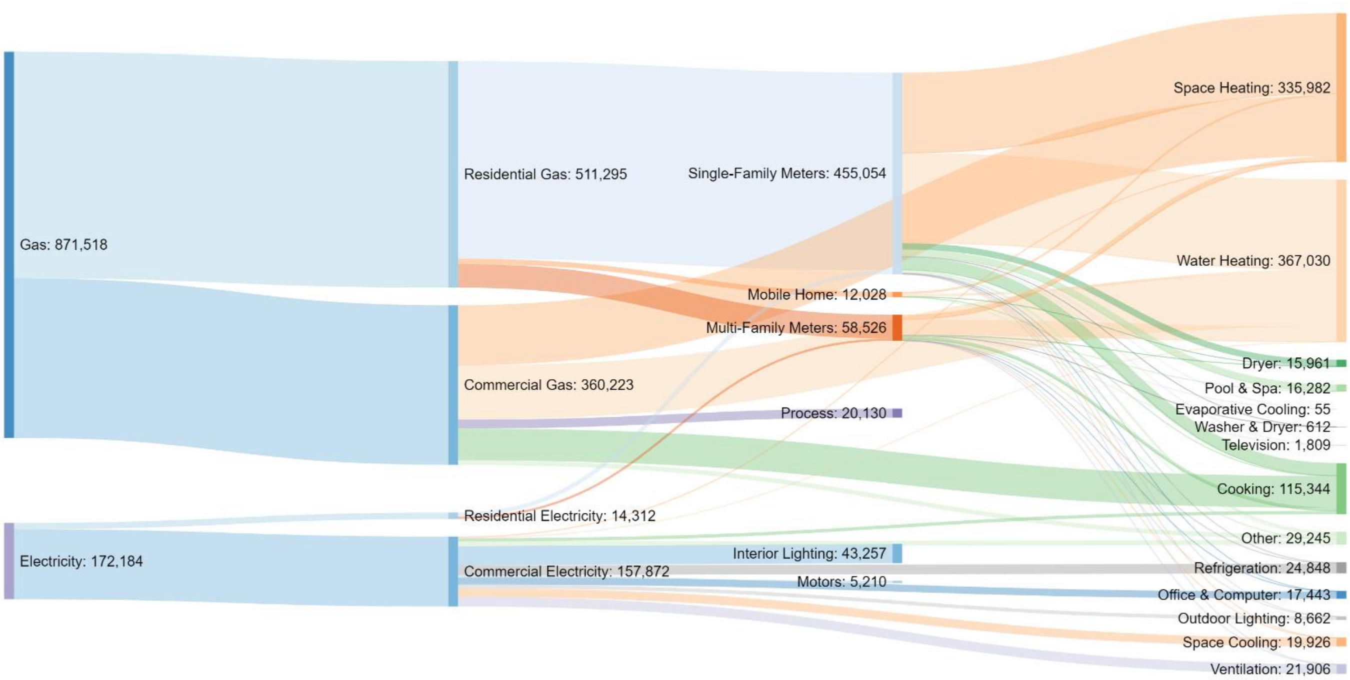

FIGURE ES 5. RESIDENTIAL AND COMMERCIAL BUILDING EMISSIONS DISAGGREGATION BY END-USE (2018) [METRIC TONS CO_2]

Electric vehicle (EV) charging and BTM solar impact the electricity consumption and load shape of a building. Homes with a plug-in hybrid electric vehicle (PHEV) or battery electric vehicle (BEV) have an electricity EUI that is 14-20% higher than non-EV homes, respectively.[7] There are over 15,000 BEVs and over 9,000 PHEVs registered in SVCE territory as of November 2018, and 190 MW of BTM solar as of August 2019. Although current adoption levels are relatively low, EV and solar adoption are the two biggest trends impacting building energy usage and should be tracked and analyzed as their respective markets mature.

In light of recent public safety power shutoff events, BTM battery storage as a source of backup power has become increasingly pertinent to community resilience efforts. There are an estimated 41 commercial/industrial customers and 449 residential customers with BTM battery storage in SVCE territory.[8] Over 90% of BTM storage installations in SVCE territory are paired with rooftop solar.

Natural gas fuel cells are deployed to provide baseload power, but they have associated greenhouse gas emissions and typically operate 24/7 once installed. There are approximately 40 fuel cells in SVCE territory, the majority of which are located at commercial and industrial sites.[9]

SVCE is developing effective ways to understand decarbonization trends through an equity lens, with the purpose of applying these findings to provide more equitable access to clean energy through its programs. In SVCE territory, census tracts that are socioeconomically worse off tend to have lower rates of EV/PHEV, solar, and storage adoption, as well as lower rates of home[10] electrification.

With an increasingly decarbonized electricity supply and advancements in heat pump electric appliances, building electrification will play a significant role in reducing emissions from the built environment. Ensuring that all new construction is energy efficient and all-electric through reach codes reduces building energy consumption and emissions, and reduces the need for costly retrofits in the future. For existing buildings, investing in energy efficiency and electrification retrofits will reduce energy consumption as well as emissions from natural gas usage, which contributes 84% of building emissions in SVCE territory. Lastly, ensuring that buildings support vehicle electrification will lower emissions from the transportation sector, the largest contributor to greenhouse gas emissions in California.

SVCE will continue to monitor and analyze energy and emissions in the built environment across its service territory on behalf of our customers and community. This report will serve to inform a Building Decarbonization Joint Action Plan, which will guide regional and local strategies and action.

[7] Based on homes without solar.
[8] Data is current as of August 2019.
[9] Data is current as of August 2019.
[10] Single-family homes

TABLE OF CONTENTS

1 Introduction

Decarbonizing buildings is crucial for meeting science-based greenhouse gas emission reduction targets. Across the state of California, the built environment is responsible for over a quarter of greenhouse gas emissions.[11] In SVCE territory, buildings accounted for **33%** of emissions in 2018, a higher percentage of overall emissions than the statewide trend.[12,13] As shown in Figure 1, the majority of emissions in the built environment is from natural gas usage from appliances, such as space and water heaters.

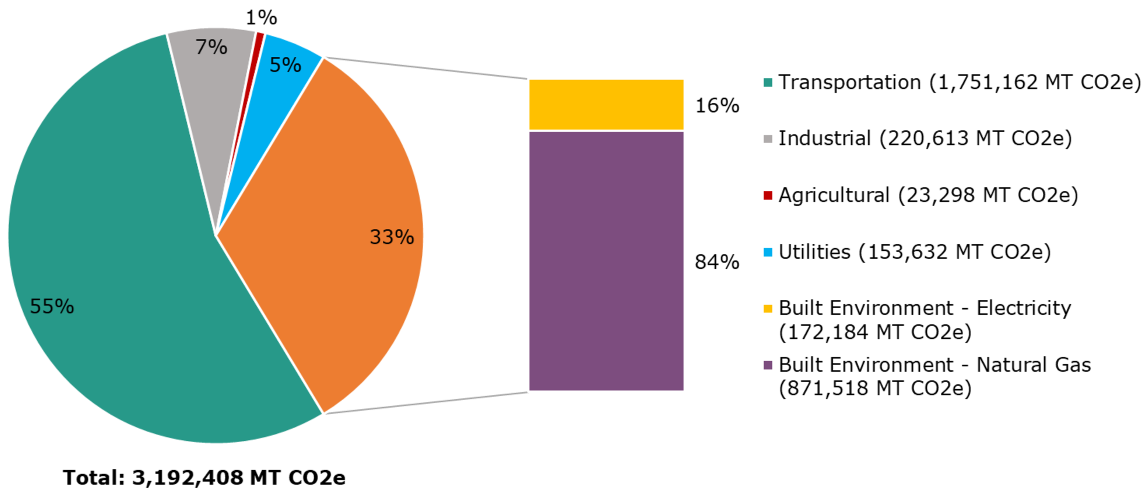

FIGURE 1. ENERGY AND TRANSPORTATION-RELATED EMISSIONS BY SECTOR IN SVCE TERRITORY (2018)

Although there is a half-century long track record of action in the state of California on building *efficiency*, there has been little policy and program activity focused explicitly on building *decarbonization* to date, until very recently.[14] With an increasingly decarbonized electricity supply and advancements in the technology and market of heat pump electric appliances, building electrification will play a significant role in reducing emissions from the built environment. However, developing informed strategies and programs to decarbonize the built environment requires in-depth analysis of building stock, building attributes, and energy consumption in residential and commercial building sectors.

This report lays out a detailed, territory-wide energy and emissions analysis for SVCE service territory.[15] By utilizing over half a dozen datasets, this report presents key metrics for assessing and benchmarking electricity and natural gas consumption and resultant emissions for both the residential and commercial building sectors, both in aggregate and by end-use. Impacts on energy consumption patterns such as EV charging infrastructure deployment and BTM solar PV adoption are evaluated. Territory-wide adoption of BTM solar, EVs, BTM storage, and fuel cells is also assessed.

[11] https://ww2.arb.ca.gov/research/research-green-buildings
[12] 2018 emissions data from SVCE annual GHG inventory
[13] Emissions from waste and wastewater represent a small fraction of overall emissions and are not included in this analysis.
[14] In 2018, SB1477 and AB3232 were adopted into law and the Building Decarbonization Coalition was established. In 2019, the CPUC's three-prong test was modified to allow public benefits funds to be used for electrification programs and a wave of municipal natural gas bans and building decarbonization building codes were passed in 2019.
[15] This study covers all buildings in SVCE service territory, including customers not enrolled with SVCE.

2 Overview of Territory-wide Energy & Emissions

This chapter provides an overview of annual building energy consumption in SVCE territory, by energy source and building sector. Specific energy usage trends in the residential and commercial building sectors are covered in sections 3 and 4, respectively.

First, to provide a visual overview, the boundaries of SVCE service territory are shown in Figure 2 below.

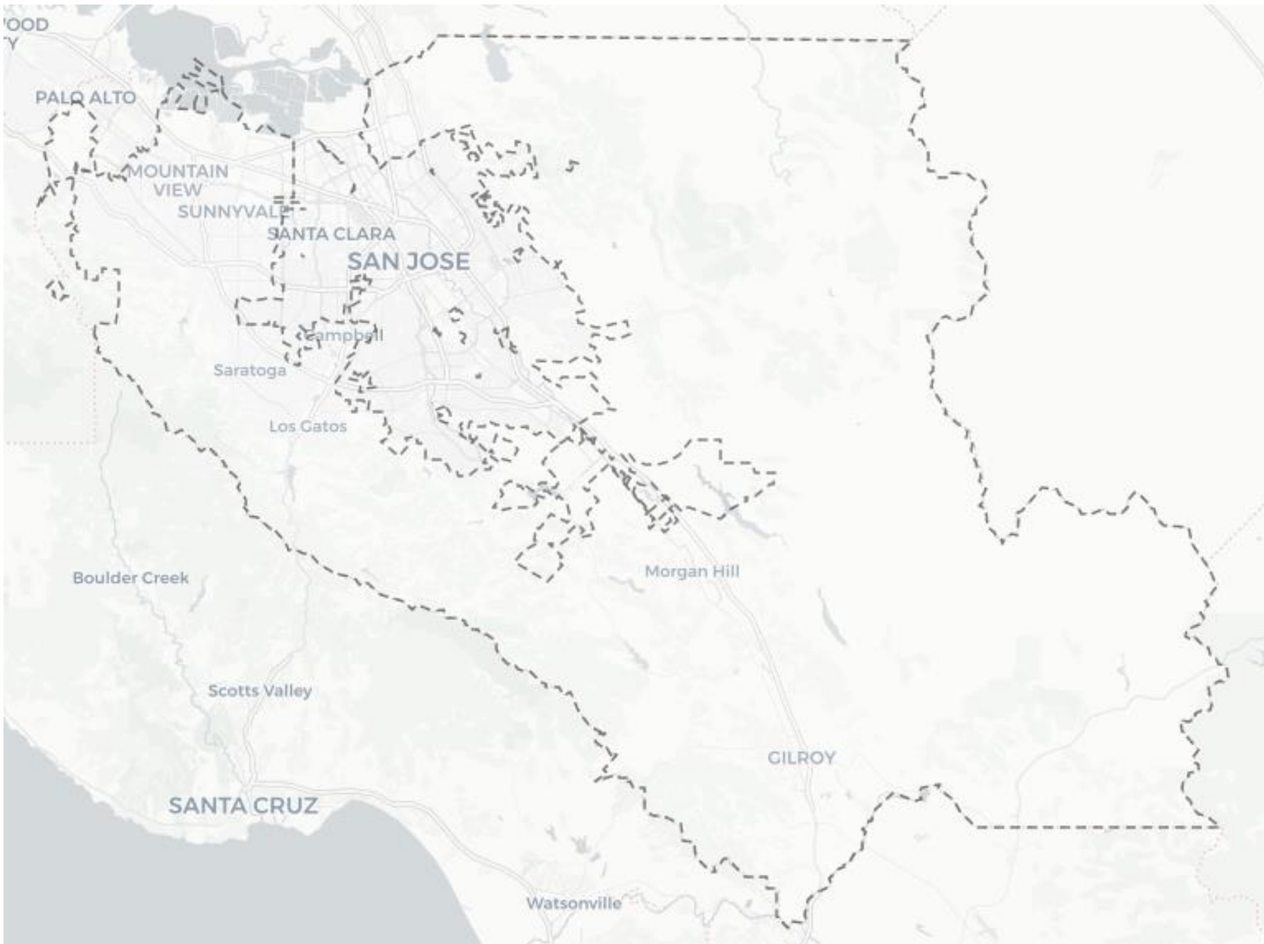

FIGURE 2. BOUNDARIES OF SVCE SERVICE TERRITORY

	Electricity Consumption [GWh][16]	Electricity Emissions [MT CO_2e][17]	Natural Gas Consumption [million therms][18]	Natural Gas Emissions [MT CO_2e][19]	Total Emissions [MT CO_2e]
Residential	1,398	14,312	96.1	511,295	525,607
Commercial	3,136	157,872	67.7	360,223	518,095
Total	**4,534**	**172,184**	**163.8**	**871,518**	**1,043,702**

TABLE 1. BUILDING ENERGY CONSUMPTION AND EMISSIONS BY CUSTOMER CLASS IN SVCE TERRITORY (2018)

In 2018, emissions from building electricity and gas consumption SVCE territory totaled **1.04 million metric tons CO_2e.** As shown in Figure 3, residential and commercial buildings contribute nearly equally to overall building emissions. Residential natural gas emissions are 42% higher than commercial natural gas emissions due to proportionally higher natural gas consumption.

Commercial electricity emissions are over 11 times higher than residential electricity emissions for two reasons: 1) commercial buildings in aggregate consume around 2.2 times more electricity than residential buildings, and, more importantly, 2) the carbon intensity of the electricity supply is assumed to be significantly higher for direct access electricity providers.[20]

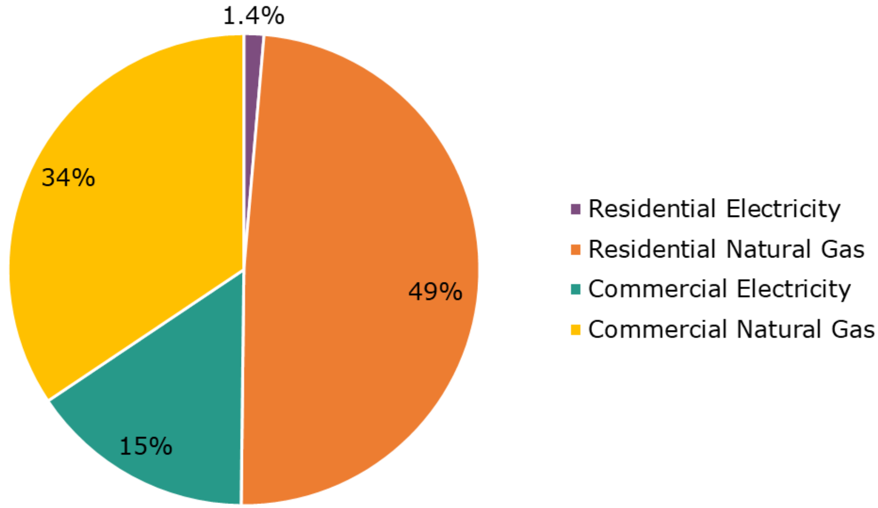

FIGURE 3. BUILDINGS EMISSIONS BREAKDOWN BY SECTOR AND FUEL SOURCE IN SVCE TERRITORY (2018)

[16] Includes T&D losses and excludes electric vehicle charging.
[17] Ibid.
[18] Excludes fugitive emissions.
[19] Ibid.
[20] Direct access emissions calculated using state-level data from CARB and adjusted based on the knowledge that SVCE territory has several large direct access electricity customers that publicly report purchasing 100% carbon-free electricity. The actual carbon intensity of direct access customers in SVCE territory is not known due to lack of disclosure requirements.

Electricity: In 2018, the total emissions associated with building electricity consumption in SVCE territory were approximately **172,184 metric tons,** broken out as 8% residential / 92% commercial.[21,22] In the summer months, commercial electricity consumption is approximately 24% higher than in the winter months, presumably due to cooling loads. On the other hand, residential electricity consumption is relatively stable throughout the year, peaking slightly in the winter months. It is possible that the expected residential summer peak due to cooling loads is offset by rooftop solar PV.[23]

Given the commercial building sector's large share of total electricity consumption, SVCE territory's overall electricity consumption remains highest during the summer.

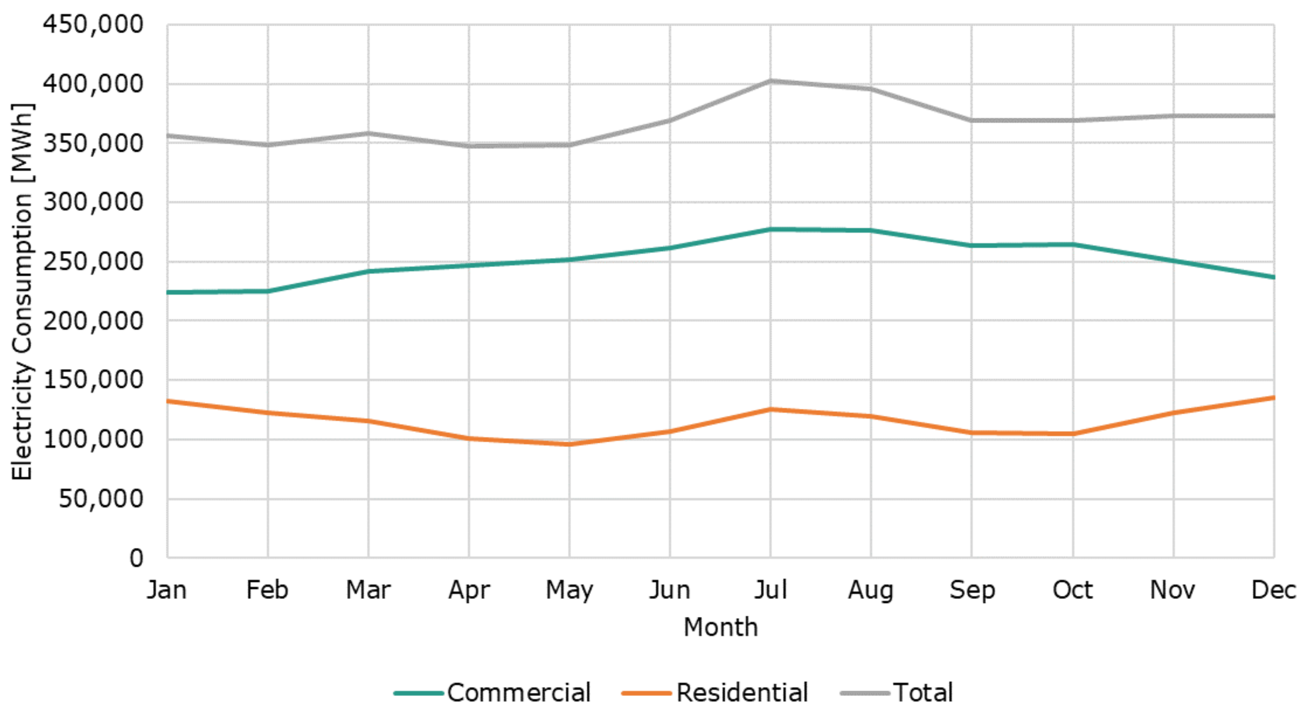

FIGURE 4. MONTHLY BUILDING ELECTRICITY CONSUMPTION FOR SVCE TERRITORY (2018)

[21] Ibid., 16.
[22] PG&E emissions factor based on 2017 values. PG&E's emissions have continued to decrease.
[23] See analysis in Appendix A.

Natural Gas: In 2018, the total emissions associated with building natural gas consumption in SVCE territory were approximately **871,518 metric tons**, broken out as 59% residential / 41% commercial. Note this is five times higher than emissions associated with electricity consumption for the same year.[24]

As shown in Figure 5, natural gas consumption is highly seasonal for the residential sector, peaking in the winter months due to increased natural gas usage for space heating purposes. In 2018, residential consumption was nearly four times higher in winter than in the summer.

Commercial natural gas consumption experiences a much milder winter peak, still presumably driven by increased natural gas usage for space heating purposes. Residential and commercial natural gas consumption begin to converge in the spring, and then diverge again in the fall, highlighting the seasonality of residential natural gas consumption.

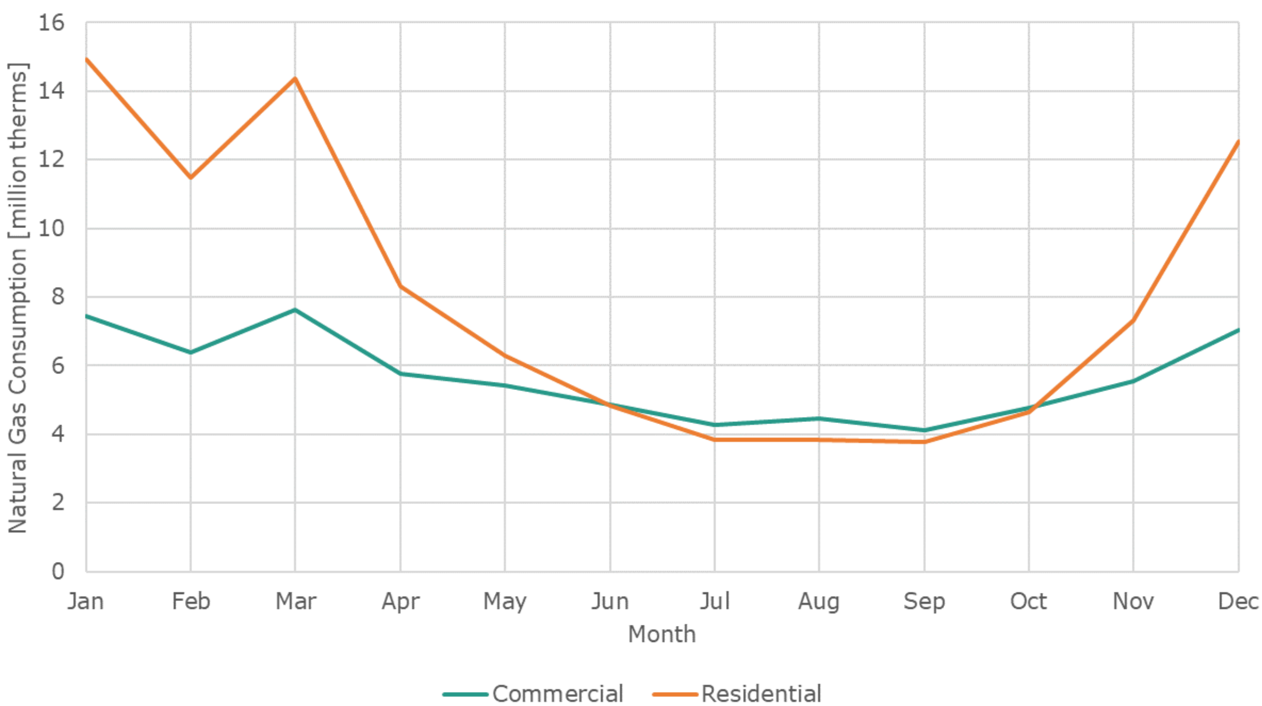

FIGURE 5. MONTHLY BUILDING NATURAL GAS CONSUMPTION FOR SVCE TERRITORY (2018)

[24] https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

3 Residential Buildings

This chapter focuses on SVCE territory's residential building sector. For reference, residential parcels in SVCE territory are shown in Figure 6 below, categorized by single-family homes,[25] apartments (multi-family), and condos. The total residential building square footage is approximately 377 million square feet, across over 166,000 unique parcels.

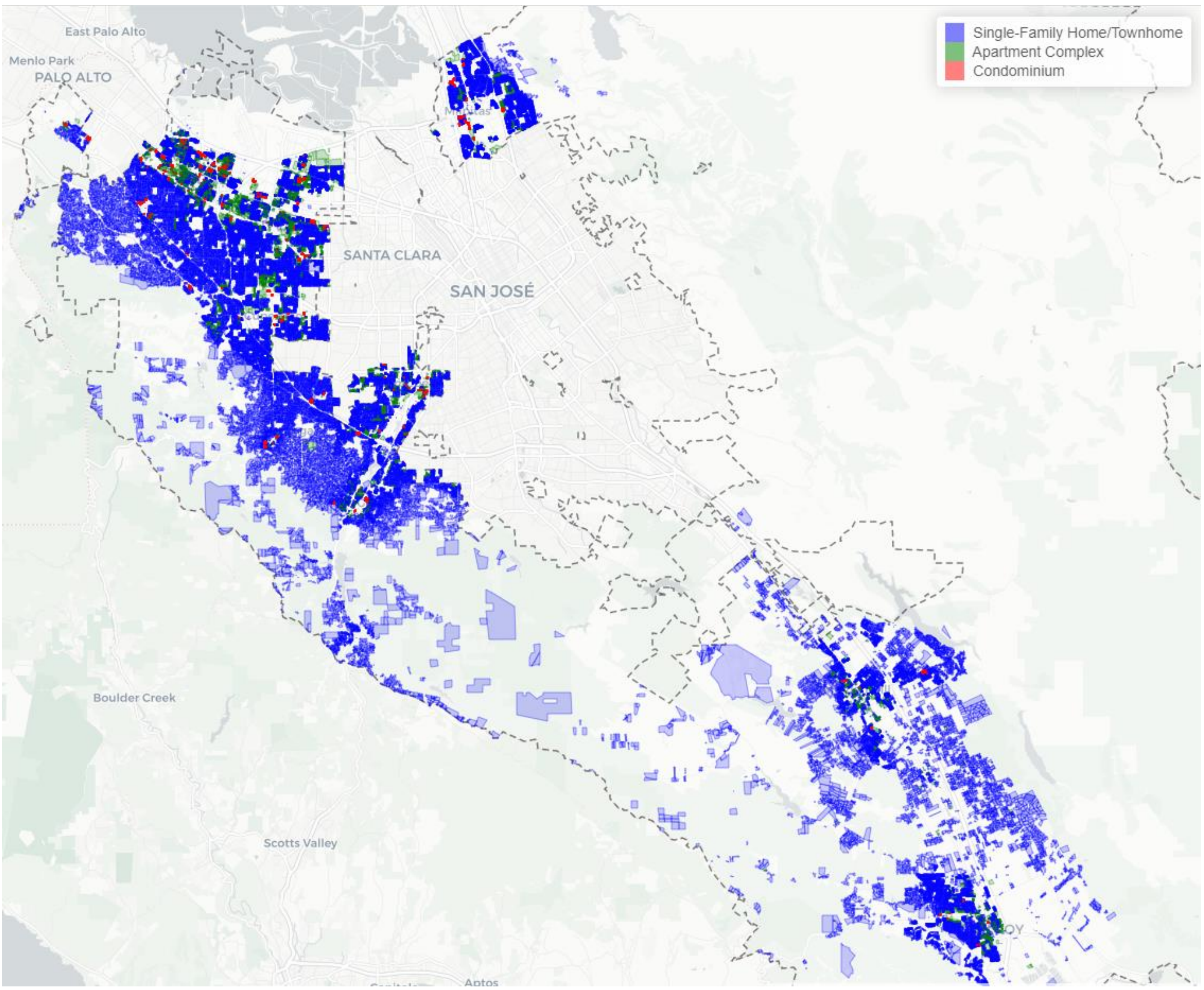

FIGURE 6. MAP OF RESIDENTIAL PARCELS IN SVCE TERRITORY

[25] Townhomes are categorized as single-family homes in this report.

Residential Parcel Analysis

Table 2 shows residential property characteristics, categorized into single-family homes, condos, and multi-family. Condos differ from multi-family units in that each unit in a condominium is separately owned and typically owner-occupied, whereas multi-family units are often leased by tenants. This distinction should be considered when implementing building decarbonization programs, as ownership can affect an occupant's ability and willingness to retrofit their home.

<table>
<tr><th>Property Type</th><th>Number of Parcels</th><th>Number of Units[26]</th><th>Total Building Area [ft^2][27]</th><th>Electricity Consumption [GWh][28]</th><th>Natural Gas Consumption [million therms][29]</th></tr>
<tr><td>Single-Family Home</td><td>151,899</td><td>154,945</td><td>310,023,893</td><td>903.8</td><td rowspan="2">83.8</td></tr>
<tr><td>Condo</td><td>7,382</td><td>9,181</td><td>7,938,004</td><td rowspan="2">494.1</td></tr>
<tr><td>Multi-Family[30]</td><td>6,722</td><td>63,711</td><td>59,250,244</td><td>10.0</td></tr>
<tr><td>Total</td><td>166,003</td><td>227,837</td><td>377,212,141</td><td>1,397.9</td><td>96.1[31]</td></tr>
</table>

TABLE 2. EXISTING RESIDENTIAL PROPERTY CHARACTERISTICS FOR SVCE TERRITORY[32]

As shown in Appendix D, a large percentage of residential square footage was constructed in the 1960s, and residential development trends vary by building type. As shown in Appendices E and F, a large percentage of single-family homes were built in the 1950s; most condos were built after 1960; and, a large percentage of multi-family parcels and units were developed in the 1960s.

Single-family homes are typically significantly larger than multi-family units and condos. In SVCE territory, the average square footage of single-family homes is 2,043 ft^2, compared to 1,075 ft^2 for condos and 974 ft^2 for multi-family units. This makes single-family homes on average 90% larger than condos and 110% larger than multi-family units.

As shown in Table 3 below, approximately 83% of condos have utility gas service, compared to 92% of multi-family units and 95% of single-family homes that have utility gas service.[33]

[26] Only counts units with non-zero/non-null square footage.
[27] Based on total building square footage, not total lot size.
[28] Includes T&D losses. Breakdown by property type estimated based on census data and residential energy consumption survey data, which categorize condos as multi-family.
[29] Excludes fugitive emissions. Most condos have the same rate code as single-family homes (G1).
[30] Includes duplexes, triplexes, etc. as well as large apartment buildings.
[31] Also includes natural gas consumption in mobile homes, which was identified through the GT gas rate code.
[32] Only includes unique parcels with non-zero/non-null square footage that could be matched to energy consumption data.
[33] All-electric and mixed fuel estimates are based on matching of electricity and gas accounts. SVCE plans to carry out follow-up research to further validate these values.

Property Type	Number of Units	Total Building Area [ft²]	Fuel Type	% by Unit	% by Square Footage
Single-Family Home	154,945	310,023,893	All-electric	5%	5%
			Mixed fuel	95%	95%
Condo	9,181	7,938,004	All-electric	17%	16%
			Mixed fuel	83%	84%
Multi-Family	63,711	59,250,244	All-electric	8%	5%
			Mixed fuel	92%	95%

TABLE 3. BREAKDOWN OF FUEL TYPE IN RESIDENTIAL PROPERTIES IN SVCE TERRITORY[34]

Residential EUI by Building Type

Energy use intensity (EUI) is the energy usage (electricity, natural gas, or both) of a building normalized by its square footage, which allows for comparisons across properties independent of building size. Figure 7 shows the monthly electricity EUIs of all-electric and mixed fuel single-family homes, condos, and multi-family units.[35] Electricity EUI patterns are similar across mixed fuel property types, with a summer peak due to cooling loads and a winter peak due to higher active occupancy during colder seasons.[36] On the other hand, all-electric properties experience a more significant winter peak, likely due to electric space heating. On average, all-electric condos have the highest monthly electricity EUI, followed by all-electric single-family homes and all-electric multi-family units.[37] Electricity EUI across all property and fuel types converge in the summer months, likely due to similar cooling needs.

Figure 8 shows the monthly gas EUIs of mixed fuel single-family homes, condos, and multi-family units. In the winter months, single-family homes have the highest gas EUI, possibly due to building envelope efficiency issues, especially in older single-family homes. Gas EUI across all property types converge in the non-winter months, likely due to the relative consistency of energy usage from cooking and water heating across seasons.

[34] A home is deemed "all-electric" if its electricity account could not be matched with an individually metered or master-metered gas account. The actual number of all-electric residential units may be lower than what is reported in this table.
[35] The combined EUI of multiple buildings is calculated using the weighted average (by square footage) of the EUIs of each building.
[36] Amir Fazeli, Mark Gillott, Analysing the effects of seasonal variation on occupancy in an electricity demand model, International Journal of Low-Carbon Technologies, Volume 8, Issue 4, December 2013, Pages 282–288, https://doi.org/10.1093/ijlct/cts032
[37] SVCE plans to carry out follow-up research to ground truth these results.

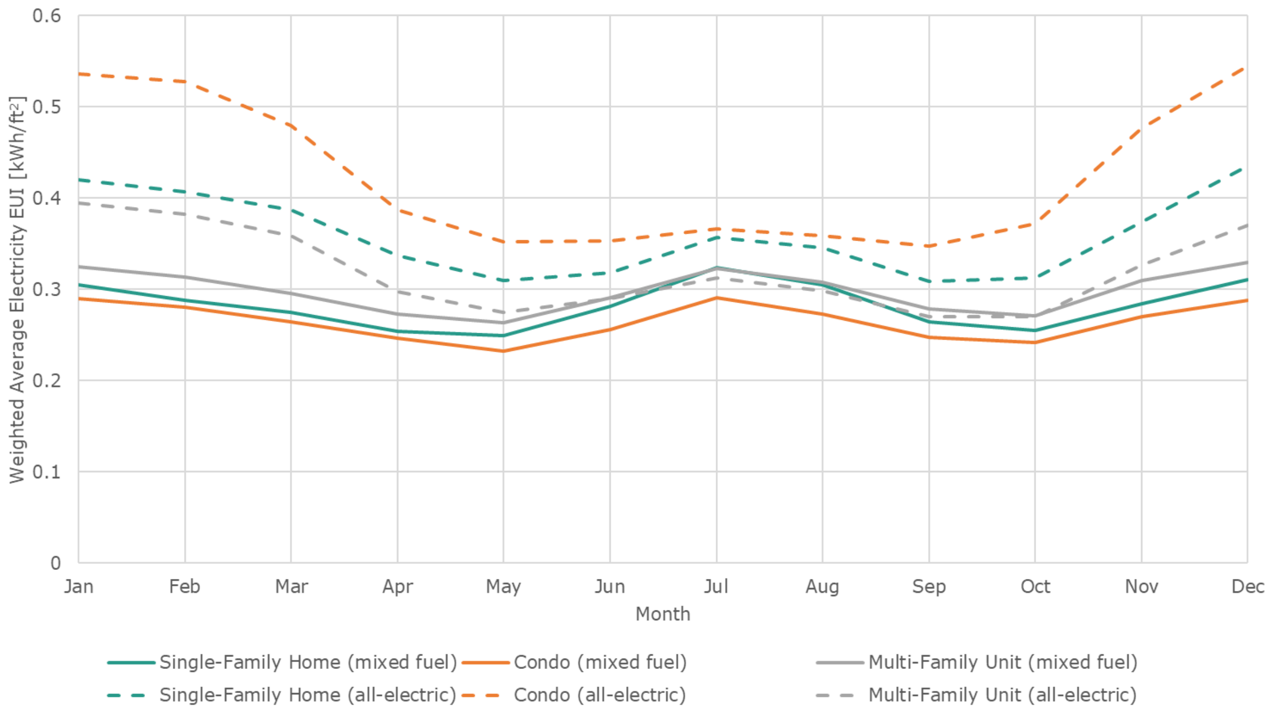

FIGURE 7. ELECTRICITY EUI OF ALL-ELECTRIC VS. MIXED FUEL RESIDENTIAL PROPERTIES IN SVCE TERRITORY[38]

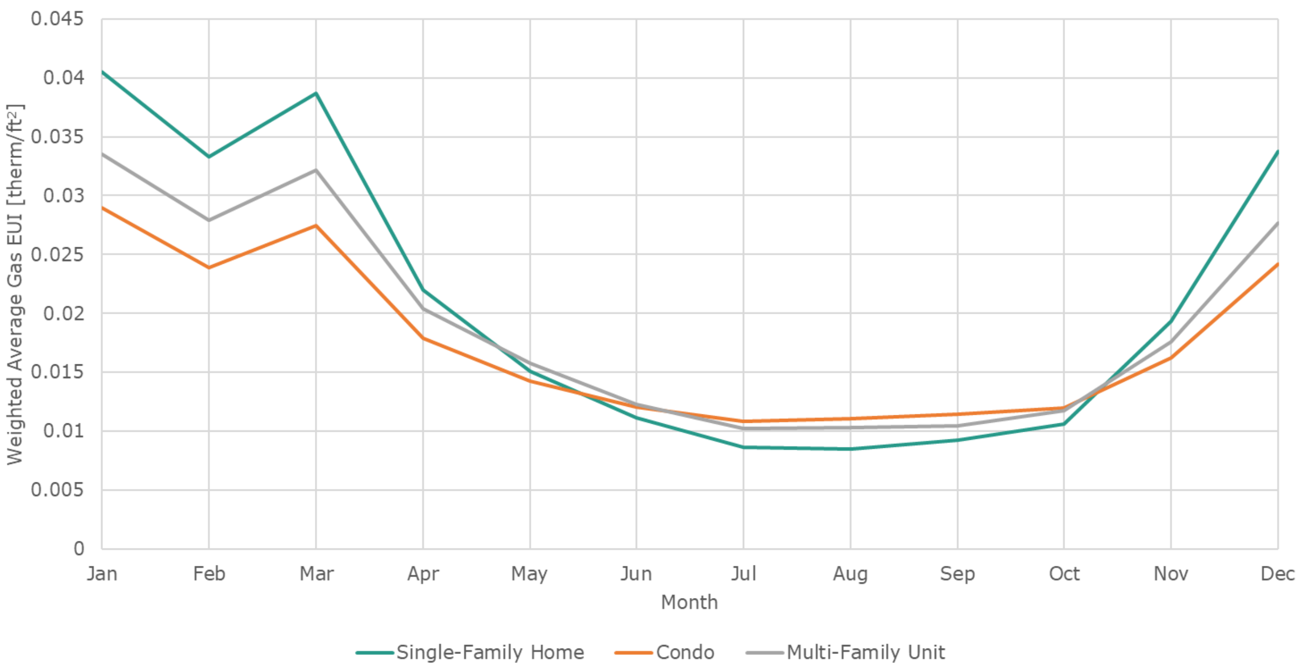

FIGURE 8. GAS EUI OF MIXED FUEL RESIDENTIAL PROPERTIES IN SVCE TERRITORY

[38] Includes the electricity consumption of both all-electric and mixed fuel properties.

Residential Energy Consumption by Building Vintage

To better understand the relationship between building age and efficiency, the electricity and gas EUIs of single-family homes were analyzed by building vintage. To focus on building vintage as the variable affecting home energy usage, only **mixed-fuel, non-solar, non-EV single-family homes** were included in this analysis.

Figure 9 shows the number of mixed fuel, non-solar, non-EV single-family homes by building vintage in SVCE territory. Since single-family homes built between 1890 and 1940 represent a small percentage of total square footage, these decades were combined into a "Pre-1940" category for the purposes of this analysis.

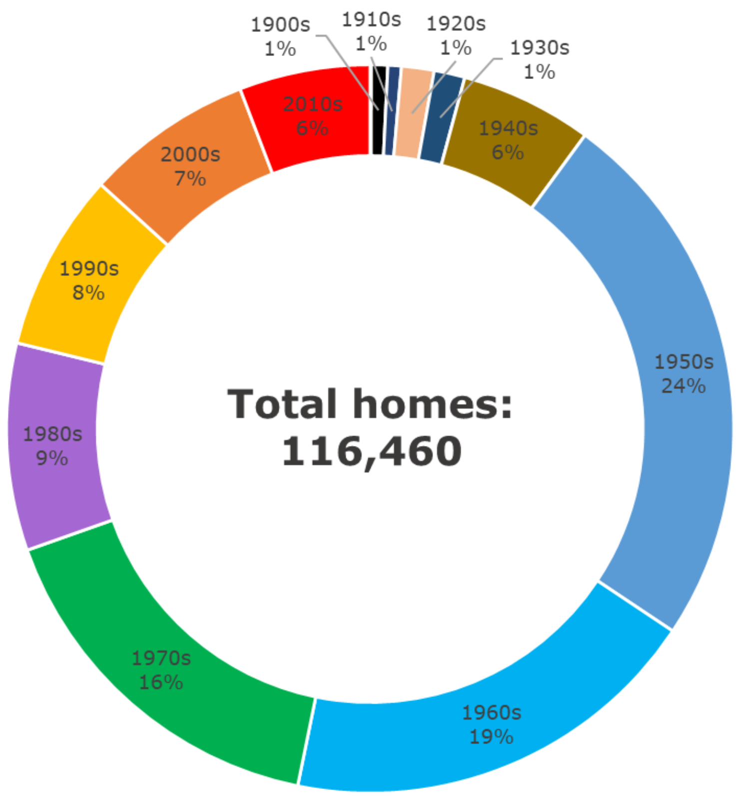

FIGURE 9. VINTAGE DISTRIBUTION OF SINGLE-FAMILY HOMES[39] IN SVCE TERRITORY

Figure 10 below shows that on an annual basis, newer single-family homes tend to have lower electricity EUI and gas EUI compared to older vintages. Homes built between 1980 and 2010 share similar gas and electricity EUI patterns.

[39] This analysis was carried out only on mixed fuel single-family homes without solar PV/EV/PHEV to isolate the impact of building vintage on EUI.

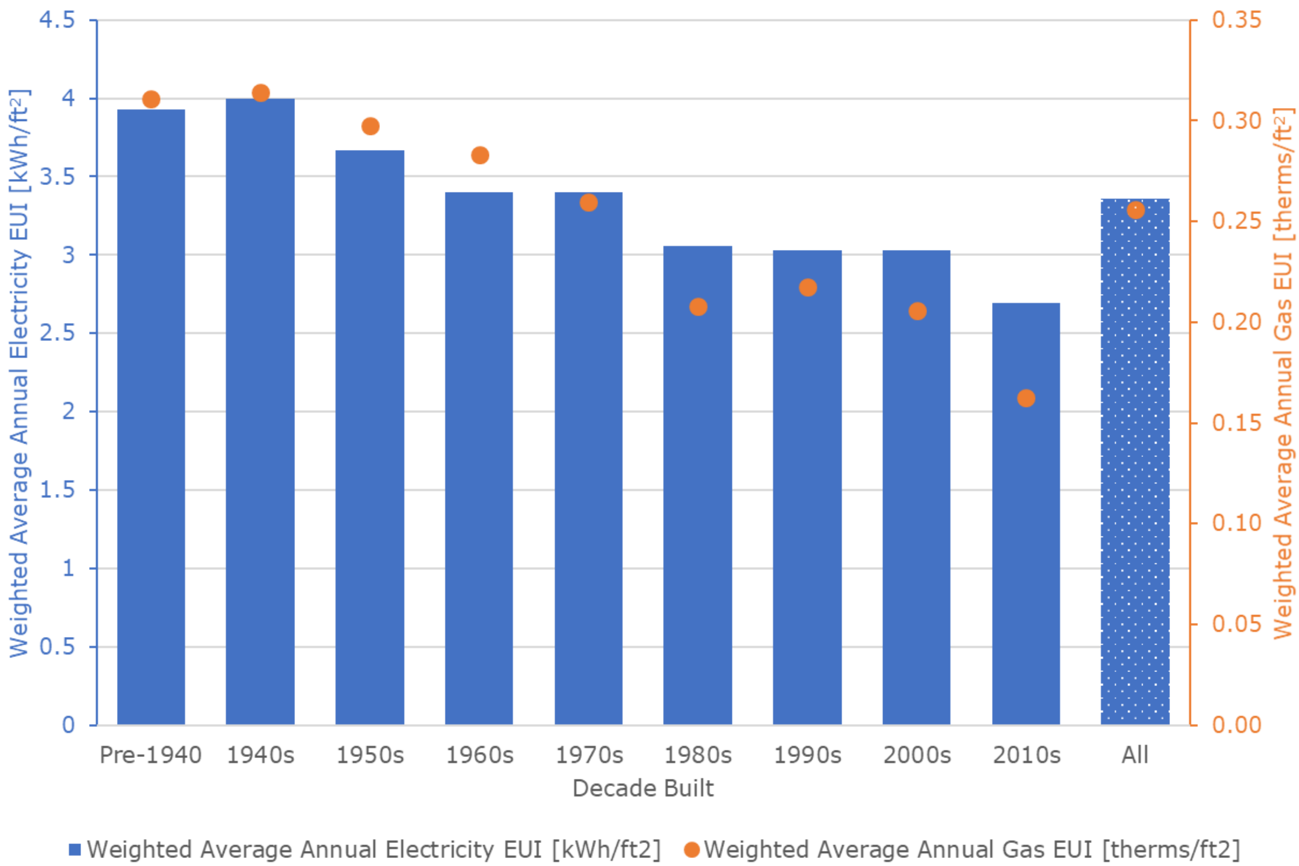

FIGURE 10. ANNUAL ELECTRICITY AND GAS EUI FOR SINGLE-FAMILY HOMES[40] IN SVCE TERRITORY (2018)

Figure 11 shows the monthly breakdown of electricity EUI by building vintage. Homes of all vintages experience a summer peak in electricity EUI due to increased cooling loads. The summer peak is apparent because this analysis excludes homes with rooftop solar, which otherwise might shave the summer peak. Older mixed fuel homes experience a more pronounced winter peak in electricity EUI, which could be caused by increased energy usage due to people staying indoors more often. Another potential cause could be more electric space heaters being used in older, less insulated homes.

Figure 12 shows the monthly breakdown of gas EUI by building vintage. Homes of all vintages peak in the winter months due to higher natural gas usage for heating purposes; however, newer homes experience noticeably lower winter peaks, indicating improvements in space heating and building envelop efficiency.

Both figures demonstrate a general increase in building efficiency in single-family homes built in the 1980s and thereafter. This trend is not unexpected, given increasing efficiency measures incorporated into California's building code over the past several decades.

[40] Ibid., 5.

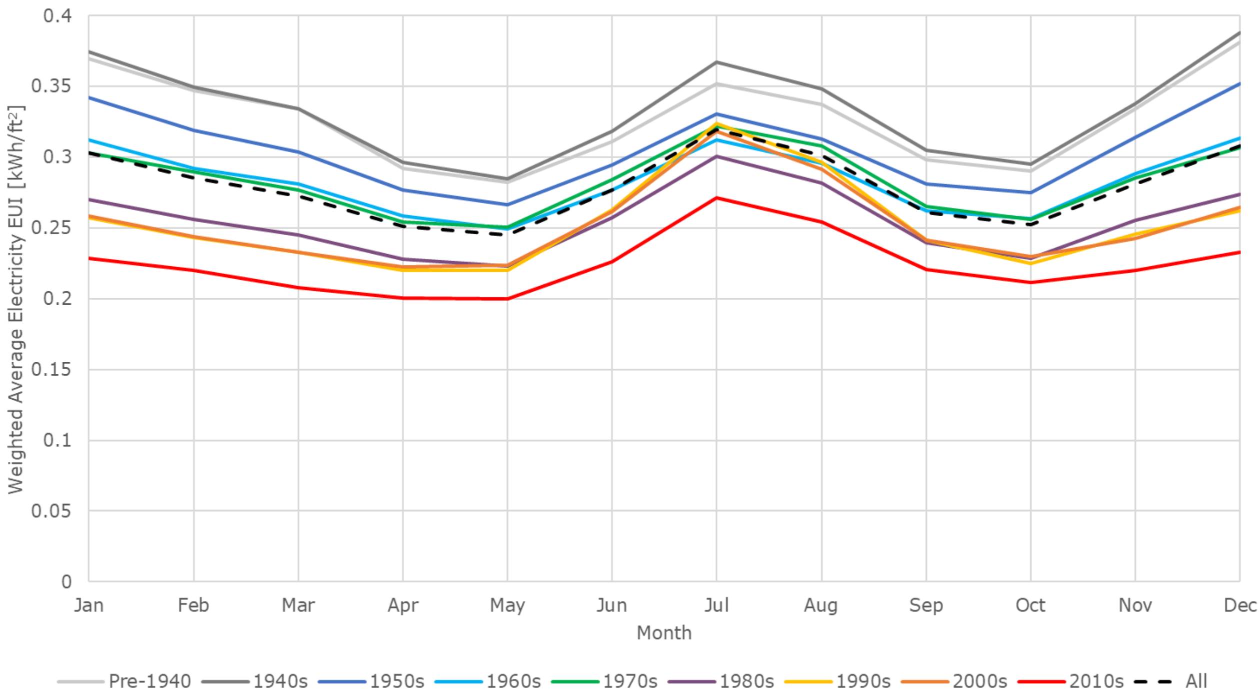

FIGURE 11. MONTHLY ELECTRICITY EUI FOR SINGLE-FAMILY HOMES[41] IN SVCE TERRITORY (2018)

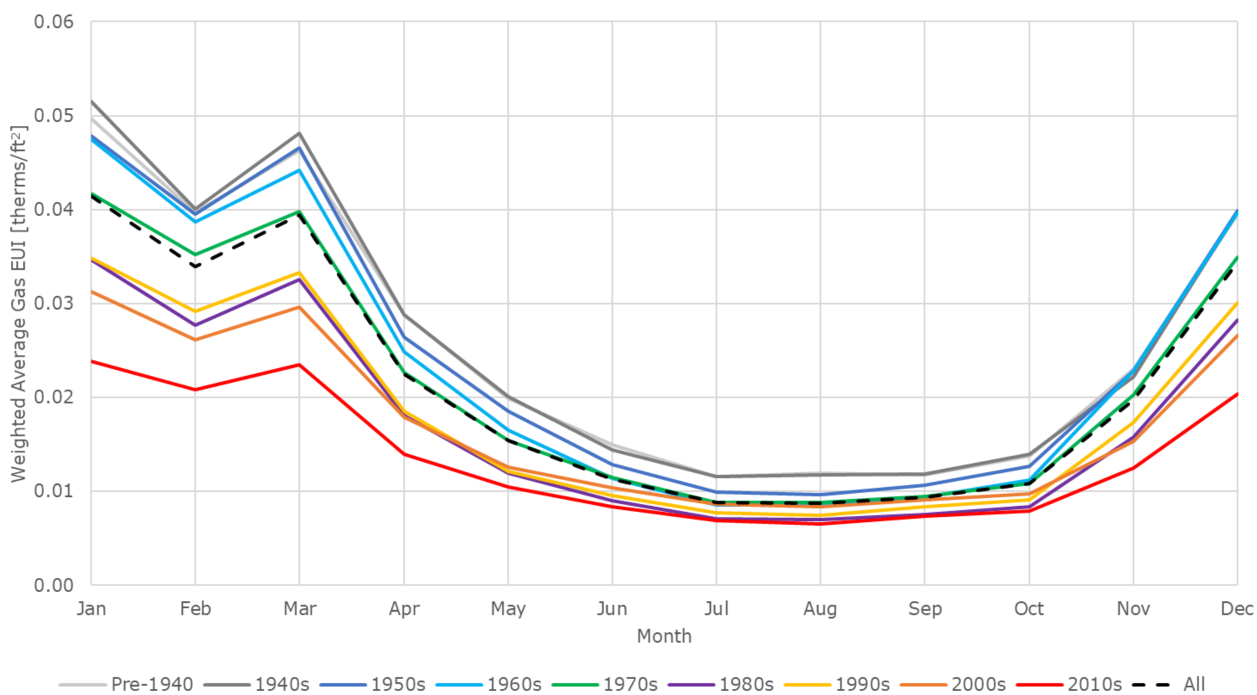

FIGURE 12. MONTHLY GAS EUI FOR SINGLE-FAMILY HOMES[42] IN SVCE TERRITORY (2018)

[41] Ibid., 5.
[42] Ibid., 5.

4 Commercial Buildings

This chapter focuses on SVCE territory's commercial building sector. For reference, commercial parcels in SVCE territory are shown in Figure 13 below. The total commercial building square footage is approximately 129 million square feet, across over 5,500 unique parcels.

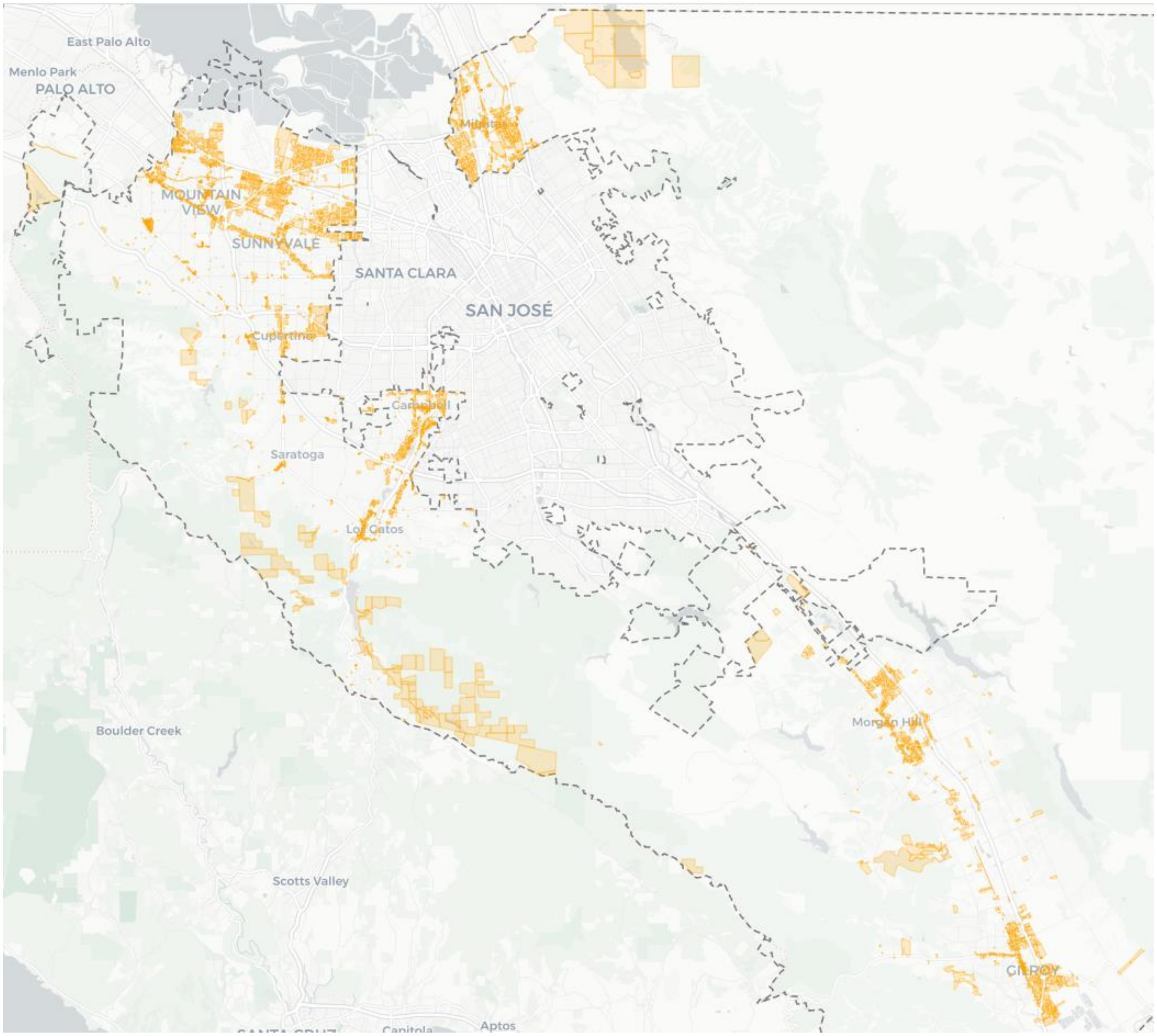

FIGURE 13. MAP OF COMMERCIAL/INDUSTRIAL[43] PARCELS IN SVCE TERRITORY

[43] Most non-residential parcels in SVCE territory are commercial.

Commercial Parcel Analysis

Table 4 shows commercial parcel and energy consumption characteristics, binned into four square footage categories. Buildings smaller than 10,000 ft^2 represent approximately 60% of all commercial parcels, but only 10% of total commercial building square footage. Buildings greater than 50,000 ft^2 only represent 12% of all commercial parcels, but they make up 63% of total commercial building square footage.

There are over 5,500 commercial parcels consisting of over 13,600 commercial units in SVCE territory. Between 25% and 40% of commercial units are all-electric.[44]

Building Square footage by Parcel	Number of Parcels	Number of Units	% of Total Building Square Footage	Electricity Consumption [GWh][45]	Natural Gas Consumption [million therms][46]
< 10,000 ft^2	3,319	5,927	10%	190.5	4.2
10,000 ft^2 – 25,000 ft^2	1,077	3,548	13%	180.7	3.7
25,000 ft^2 – 50,000 ft^2	509	1,618	14%	258.7	2.7
50,000 ft^2 +	646	2,605	63%	1,429.3	11.0
Total	**5,551**	**13,698**	**100%**	**2,059.1**	**21.7**

TABLE 4. EXISTING COMMERCIAL PROPERTY CHARACTERISTICS FOR SVCE TERRITORY[47]

[44] All-electric and mixed fuel estimates are based on matching of electricity and gas accounts on a unit-level and parcel-level. SVCE plans to carry out follow-up research to further validate these values.
[45] Excludes T&D losses.
[46] Excludes fugitive emissions.
[47] Only includes unique parcels with non-zero/non-null square footage that could be matched to energy consumption data. Around 128.6 million ft^2 of commercial building space was matched for 5,551 parcels.

Commercial Electricity Consumption and Energy Use Intensity (EUI) by Sector

Commercial electricity consumption can be categorized by sector using the North American Industry Classification System (NAICS) codes.[48] The largest commercial sector electricity consumer is "Management of Companies and Enterprises," which consists of corporate, subsidiary, and regional managing offices.[49] The second largest sector electricity consumer is "Professional, Scientific, and Technical Services," which can include establishments providing legal, accounting, engineering, consulting, research, and other professional, scientific, and technical services.[50]

Figure 14 shows the summary statistics of sector-level electricity EUI assessment for commercial parcels in SVCE territory. The black line inside each box represents the median of the annual electricity EUI for each sector. The left and right ends of each box represent the first and third quartiles of the results, and each box spans the interquartile range of its respective data. The ends of the so-called "whiskers" attached to each box represent the minimum and maximum values. For benchmarking purposes, the turquoise points in the figure represent the sector's average annual electricity EUI in the PG&E service area.[51]

Median commercial electricity EUIs in SVCE territory are generally equal to or lower than the PG&E service area average. However, it is important to note that the benchmarking data is weather-normalized, while SVCE data is not. Lacking weather normalization likely introduces a small uncertainty to the comparison between SVCE values and regional average values. Furthermore, the benchmarking data is from the 2006 California Commercial End-Use Survey (CEUS). The updated CEUS is expected to be completed in March 2021; therefore, there will likely be significant changes in statewide and regional commercial EUI values after the next survey update. SVCE plans to update our analyses after the updated CEUS is released.

[48] For information on sector definitions, please visit https://www.census.gov/programs-surveys/economic-census/guidance/understanding-naics.html
[49] https://classcodes.com/lookup/sector-55/
[50] https://classcodes.com/lookup/sector-54/
[51] Energy intensity (EI) values for PG&E service territory (Source: 2006 CEUS https://ww2.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF)

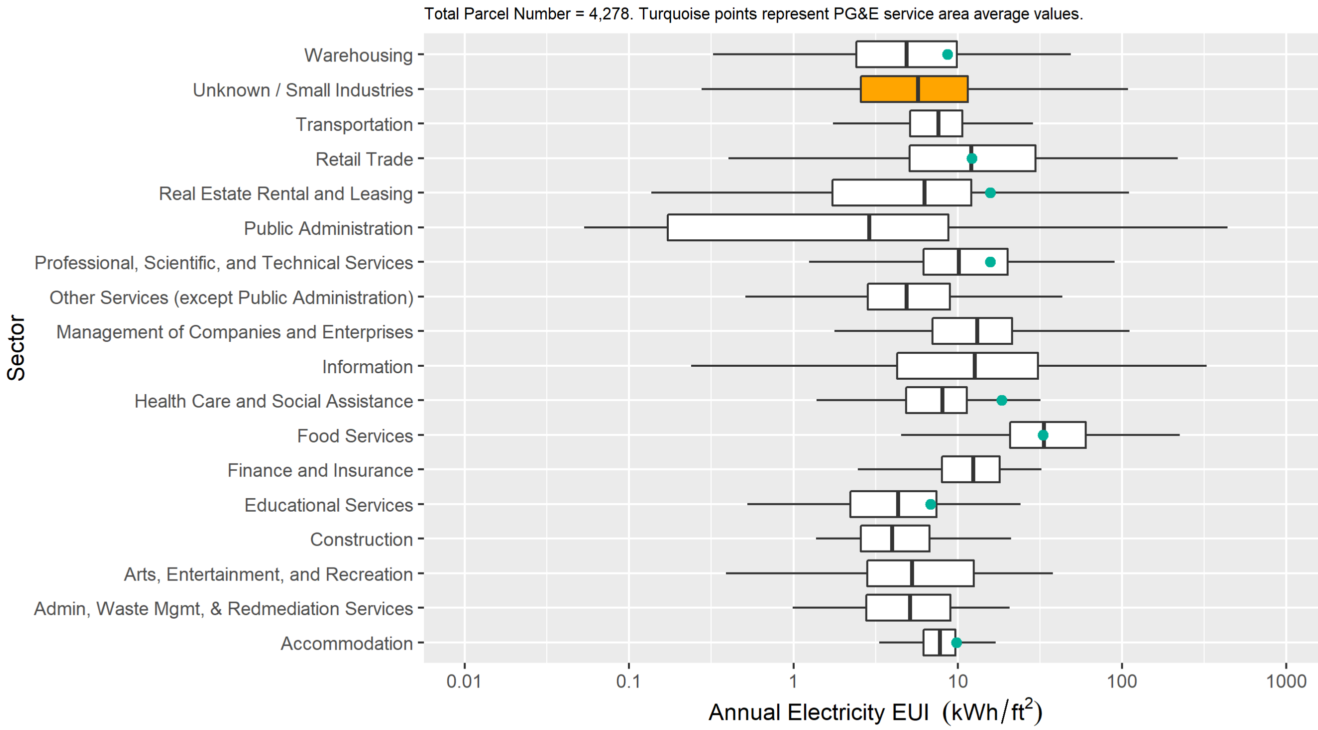

FIGURE 14. ELECTRICITY EUI BY SECTOR FOR COMMERCIAL PARCELS[52] IN SVCE TERRITORY (2018)[53]

To refine our understanding of electricity consumption trends by property type, commercial electricity EUI was also analyzed by building square footage. To do so, each parcel was matched to electricity consumption from one or more accounts, and then the parcel's electricity EUI was calculated. Around 128.6 million square feet of commercial building space was matched for 5,551 parcels,[54] totaling 2,059 GWh of annual electricity consumption.

The highest electricity EUIs tend to belong to commercial parcels with less than 10,000 ft^2 of building square footage, and generally belong to the "Accommodation and Food Services" and "Retail Trade" sectors. This implies that the smallest buildings in these two sectors are the least efficient users of electricity. In other sectors, there is no clear correlation between parcel building square footage and electricity EUI.

[52] Parcels associated with more than one NAICS sector were excluded.
[53] "Unknown / Small Industries" consists of an aggregation of various NAICS sectors that were deemed too small to report individually.
[54] 2,331 all-electric / 3,220 mixed fuel parcels

Commercial Natural Gas Consumption and Energy Use Intensity (EUI) by Sector

The largest commercial sector gas consumer is "Accommodation and Food Services," which includes hotels, restaurants, and establishments that provide food and drink services, among others.[55] The second largest commercial sector gas consumer is "Health Care and Social Assistance," which includes establishments such as hospitals, doctor's offices, medical laboratories, and social assistance services.[56]

Figure 15 shows the summary statistics of a sector-level gas EUI assessment for commercial parcels in SVCE territory. For benchmarking purposes, the turquoise points in the figure represent the sector's average annual gas EUI in the PG&E service area.[57]

Median commercial gas EUIs in SVCE territory are generally equal to or lower than the PG&E service area averages, with the exception of warehousing. Again, it is important to note that the benchmarking data is weather-normalized, while SVCE data is not, and the benchmarking data is from the 2006 CEUS, and that there will likely be significant changes in statewide and regional commercial EUI values after the next survey update.

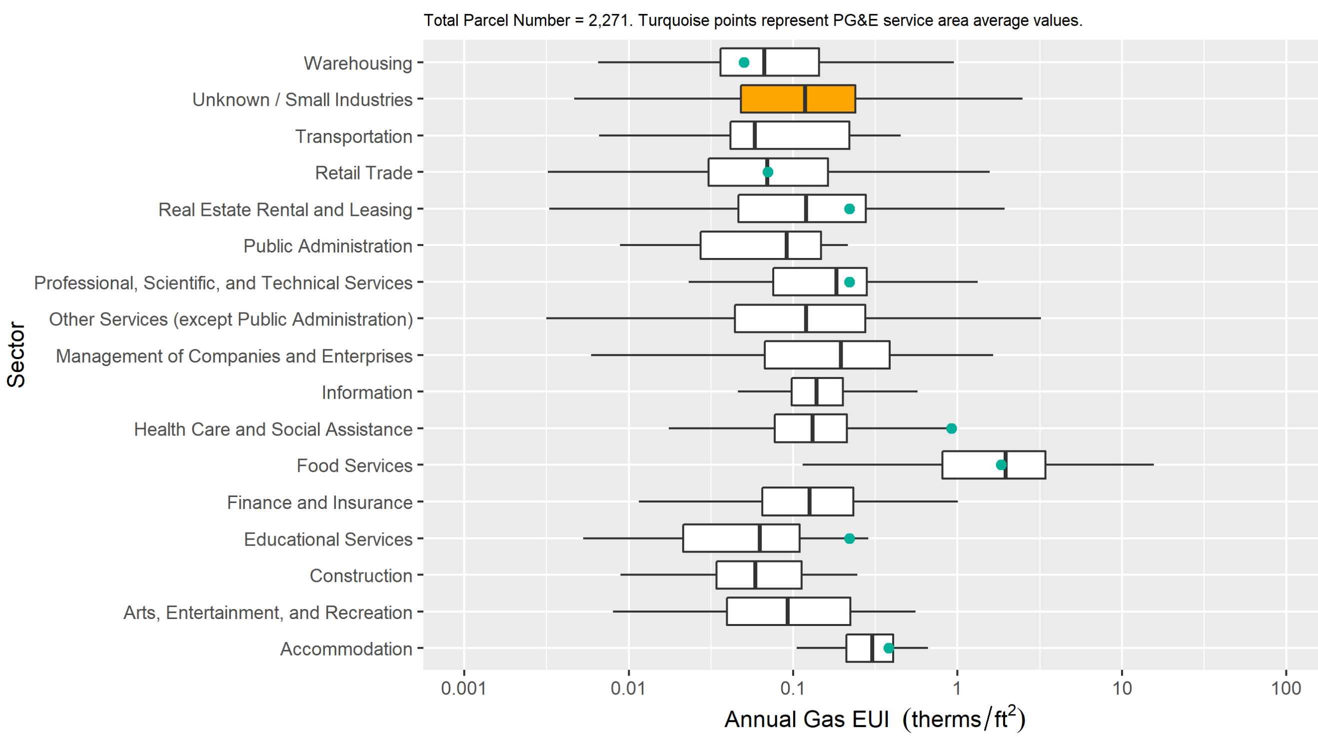

FIGURE 15. GAS EUI BY SECTOR FOR COMMERCIAL PARCELS[58] IN SVCE TERRITORY (2018)[59]

Commercial gas EUI was also analyzed by building square footage. To do so, each mixed fuel parcel was matched to gas consumption from one or more accounts, and then the parcel's gas EUI was

[55] https://classcodes.com/lookup/naics-3-digit-subsector-code-722/
[56] https://classcodes.com/lookup/sector-62/
[57] Energy intensity (EI) values for PG&E service territory (Source: 2006 CEUS https://ww2.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF)
[58] Parcels associated with more than one NAICS sector were excluded.
[59] "Unknown / Small Industries" consists of an aggregation of various NAICS sectors that were deemed too small to report individually.

calculated. Around 79 million square feet of commercial building space was matched for 3,220 mixed fuel parcels, totaling 21.7 million therms of annual gas consumption.

The highest gas EUIs tend to belong to commercial parcels with less than 10,000 ft^2 of building square footage, and generally belong to the "Accommodation and Food Services" sector. This is likely due to the fact that restaurants have high gas usage for cooking purposes. Since the highest gas EUIs belong to the smallest restaurants, this implies that gas usage in restaurants does not scale linearly with square footage. In other sectors, there is no clear correlation between parcel building square footage and gas EUI.

Commercial Combined Energy Use Intensity (EUI) by Sector

To evaluate the combined energy EUIs of commercial parcels, electricity and gas EUIs were converted to a common unit (kBTU/ft^2). While energy EUI for all-electric parcels includes only electricity EUI, energy EUI for mixed fuel parcels includes both electricity EUI and gas EUI.

In terms of parcel building square footage, all-electric commercial parcels tend to cluster below 10,000 ft^2, whereas mixed fuel commercial parcels are more evenly distributed.

The highest annual energy EUIs tend to belong to the "Accommodation and Food Services" and "Retail Trade" sectors, especially in commercial parcels with less than 10,000 ft^2 of building square footage. For these two sectors, energy EUI tends to decrease with increasing parcel building square footage, indicating that smaller properties tend to be less energy efficient. The "Health Care and Social Assistance" sector is highly clustered both in annual energy EUI and parcel building square footage, and is consistently lower in annual energy EUI than the "Accommodation and Food Services" and "Retail Trade" sectors.

There are significantly more mixed fuel parcels with annual energy EUIs greater than 500 kBTU/ft^2, most of which are of the "Accommodation and Food Services" sector and are likely restaurants with high gas usage. This indicates that electrifying food service establishments such as restaurants can result in significant emission reductions.

5 Energy and Emissions Disaggregation by End-Use

Although the prior chapters provide a comprehensive assessment of energy usage categorized by a variety of factors (building type, square footage, commercial sector, vintage, etc.), the above analysis provides limited insight into how energy is actually being used within the buildings. To gain a more detailed understanding of this, energy consumption and associated emissions from 2018 were disaggregated by end-use using the statewide residential and commercial end-use surveys.[60,61,62]

Figure 16 and Figure 17 show residential and commercial energy consumption and emissions, respectively, disaggregated by end-use.[63] As observed in the first figure, natural gas and electricity consumption contribute relatively equally to energy consumption in the built environment in terms of MMBTUs. However, as shown in the second figure, emissions from natural gas consumption are five times greater than those from electricity consumption, with water heating and space heating being the most emissions-heavy end-uses. These two end-uses make up 80% of overall natural gas consumption. This contrast highlights the need to transition from an energy efficiency to an emissions paradigm when developing building decarbonization policies. Given the rapid progress decarbonizing the electricity supply, traditional energy efficiency measures applied to electricity usage do not have commensurate climate benefits as they once did.

[60] https://www.energy.ca.gov/appliances/rass/

[61] https://www.energy.ca.gov/ceus/

[62] Approximately 30% of residential electricity load is not categorized. It is also important to note that the RASS and CEUS predate the widespread adoption of LED lighting. The updated RASS and CEUS surveys are expected to be completed in June 2020 and March 2021, respectively—therefore, there will likely be significant changes in end-use fractions after the next survey update. SVCE plans to update its analyses after the updated RASS and CEUS surveys are released.

[63] Individual disaggregation charts for SVCE territory's building electricity consumption and natural gas consumption are located in Appendices B and C.

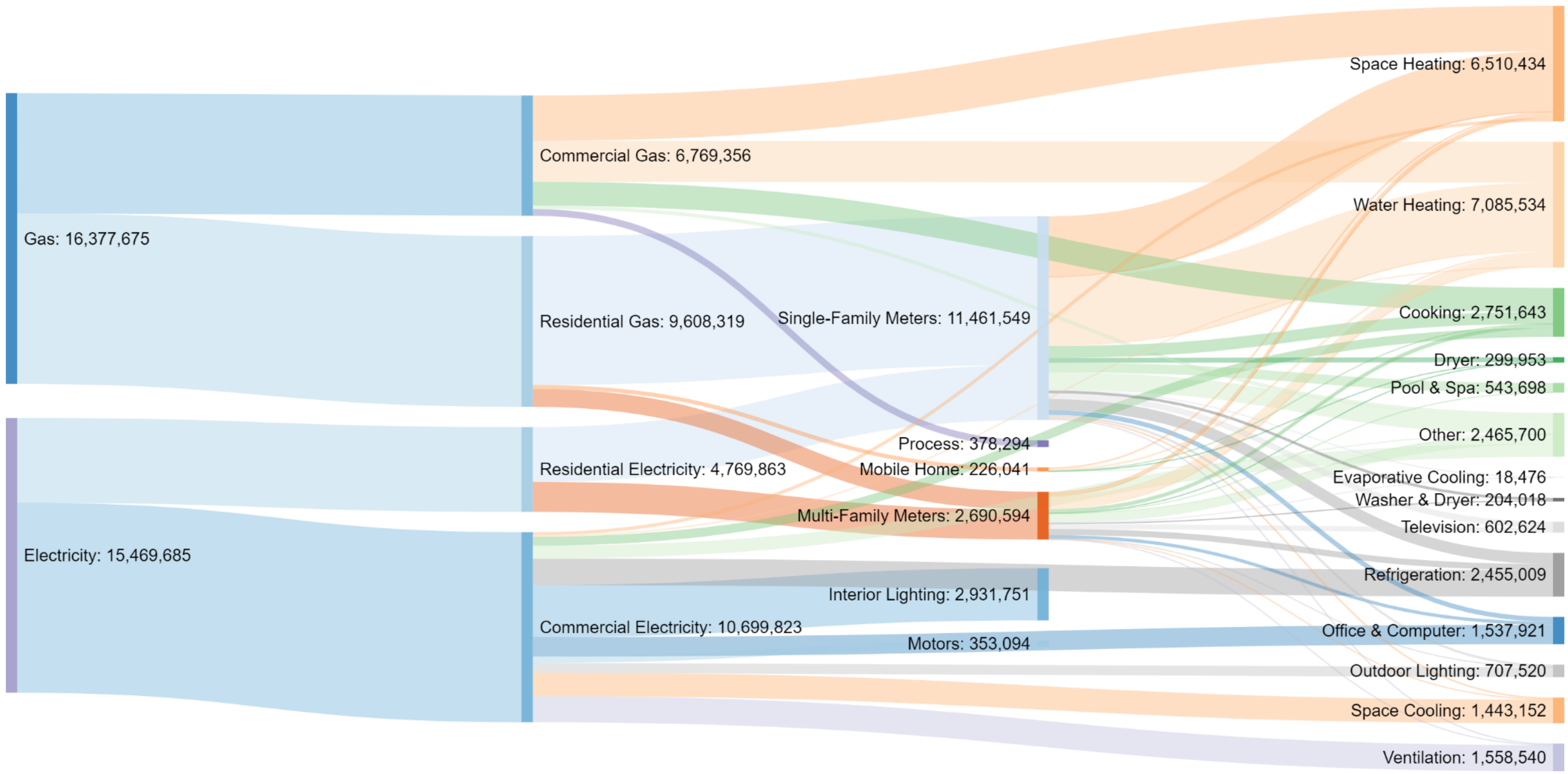

FIGURE 16. RESIDENTIAL AND COMMERCIAL BUIDLING ENERGY DISAGGREGATION BY END-USE (2018) [MMBTU][64]

[64] Includes T&D losses; excludes EV charging and fugitive emissions.

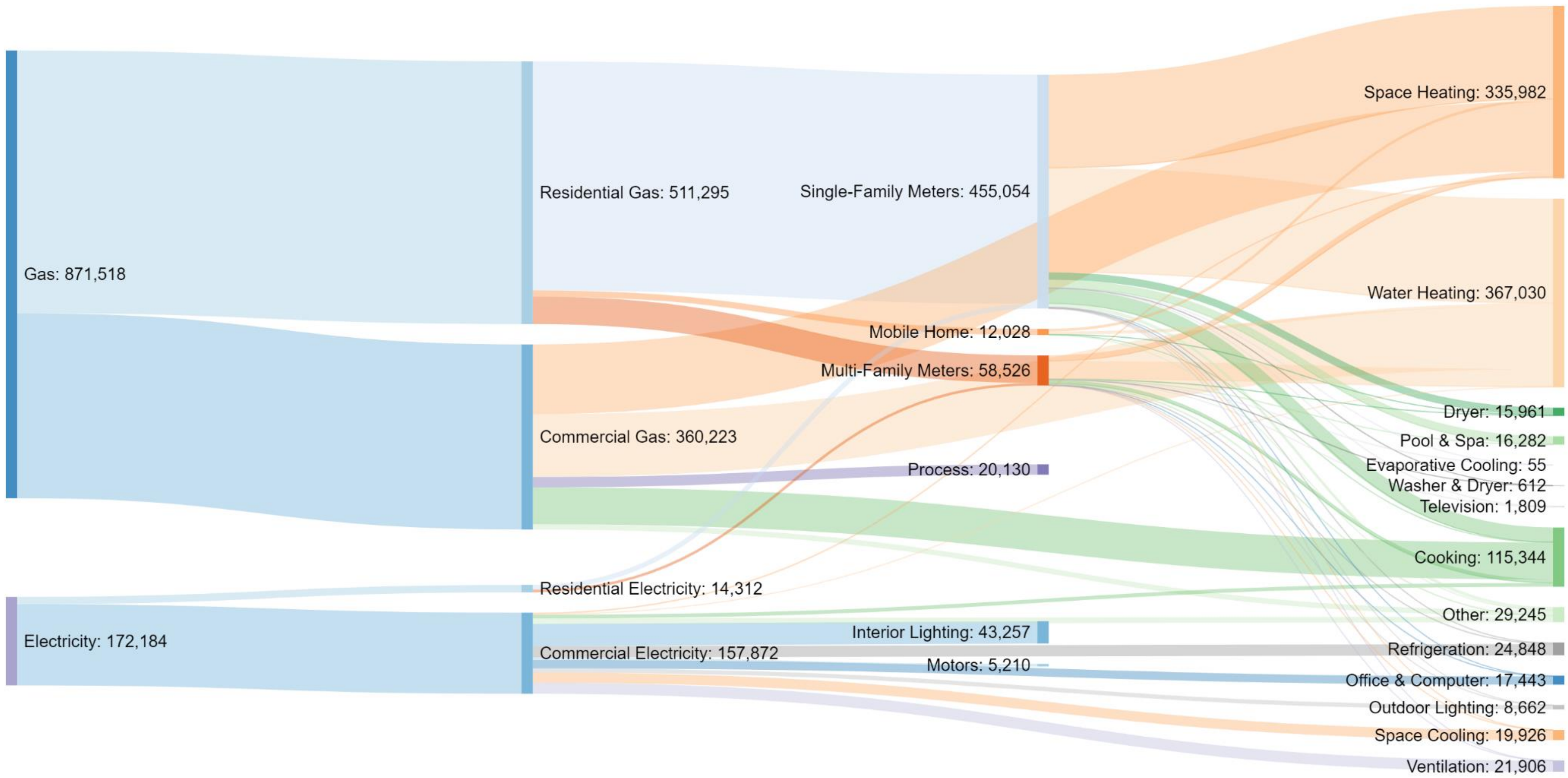

FIGURE 17. RESIDENTIAL AND COMMERCIAL BUILDING EMISSIONS DISAGGREGATION BY END-USE (2018) [METRIC TONS CO_2][65]

[65] Includes T&D losses; excludes EV charging and fugitive emissions.

6 Trends in Distributed Energy Resource (DER) Adoption

Multiple trends in DER adoption merit further analysis. Electric vehicle charging and behind-the-meter (BTM) solar significantly impact energy consumption patterns. Furthermore, in light of recent power shutoff events, BTM battery storage is becoming an increasingly important resource for backup power. Fuel cells, which can provide baseload power but have associated greenhouse gas emissions, should also be tracked alongside BTM battery storage.

Accounting for Electric Vehicles

For residential households, the presence of a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) has a large impact on total energy consumption. Homes with a PHEV or BEV have an energy use intensity that is 14-20% higher than non-EV homes, respectively.[66]

According to vehicle registration data,[67] there are over 15,000 BEVs and over 9,000 PHEVs registered in SVCE territory. Figure 18 shows BEV and PHEV density by census tract in SVCE territory. The darker colors on the map indicate census tracts with higher BEV/PHEV density.

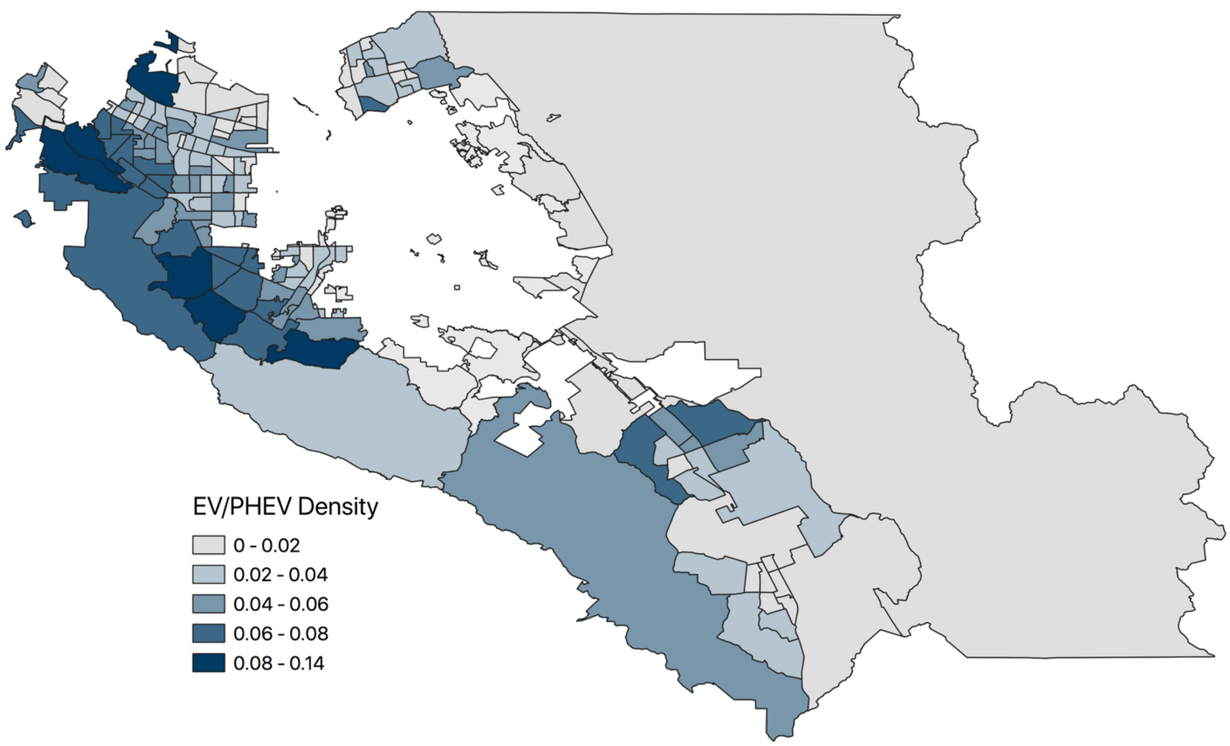

FIGURE 18. BEV/PHEV DENSITY[68] BY CENSUS TRACT IN SVCE TERRITORY (2018)

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[66] This calculation was carried out by analyzing only single-family homes without solar PV to isolate the impact of EV charging on load.
[67] Based on vehicle registration data dated December 2018.
[68] Defined as the number of BEVs/PHEVs divided by census tract population.

Accounting for BTM Solar

Like EV and PHEV customers, rooftop solar customers have unique load shapes and total energy consumption patterns. There are over 20,000 customers with rooftop solar in SVCE territory, totaling approximately 190 MW of installed capacity.[69] Table 5 shows the breakdown of rooftop solar installations in SVCE territory by customer sector.

Customer Sector	Install Count	Total kW	Average Size [kW]
Residential	20,159	102,301	5
Commercial	419	37,228	89
Industrial	74	49,374	667
Agricultural	7	1,275	182
Total	**20,659**	**190,178**	

TABLE 5. ROOFTOP SOLAR INSTALLATIONS IN SVCE TERRITORY BY CUSTOMER SECTOR

Figure 19 below shows rooftop solar adoption by census tract in SVCE territory. The darker colors on the map indicate census tracts with higher rooftop solar density in terms of number of installations.

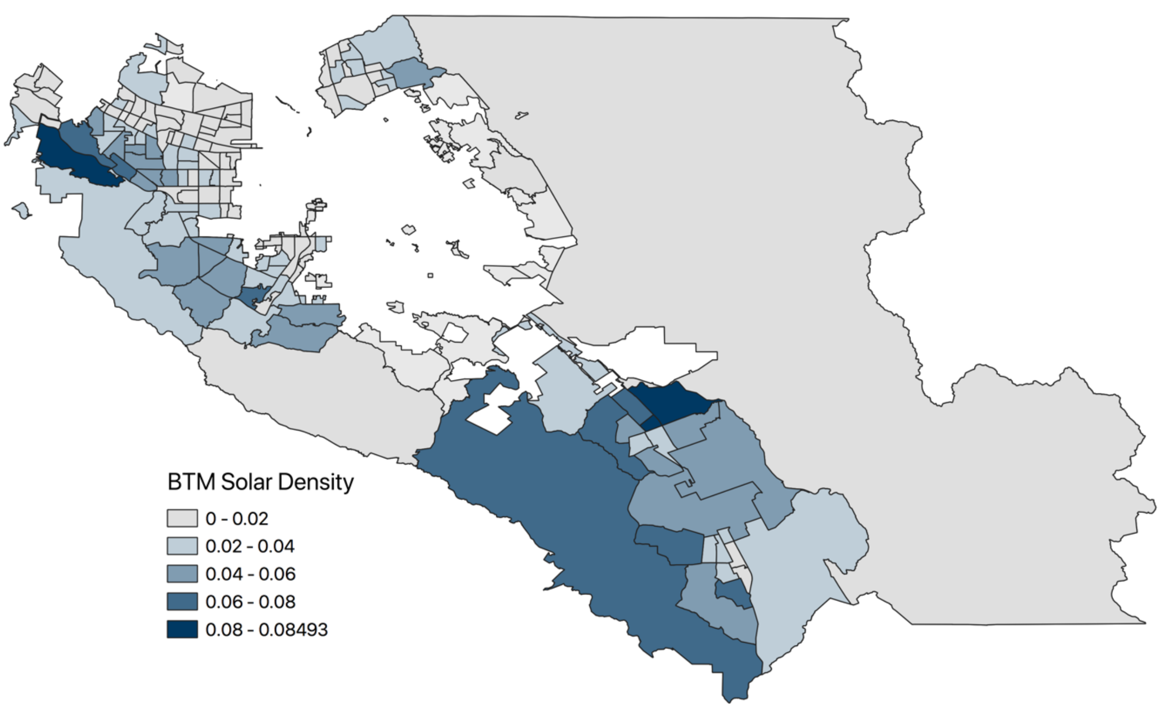

FIGURE 19. ROOFTOP SOLAR DENSITY[70] BY CENSUS TRACT IN SVCE TERRITORY (2019)

[69] Based on interconnection data dated August 2019.

[70] Defined as the number of rooftop solar installations divided by census tract population.

Accounting for BTM Storage

Battery storage is often paired with rooftop solar to reduce a customer's energy bill and to provide backup power. In light of recent public safety power shutoff events, BTM battery storage has become increasingly pertinent to community resilience efforts. There are an estimated 41 commercial/industrial customers and 449 residential customers with BTM battery storage in SVCE territory.[71] Approximately 91% of BTM storage installations in SVCE territory are paired with rooftop solar.

Figure 20 below shows BTM battery storage adoption by census tract in SVCE territory. The darker colors on the map indicate census tracts with higher BTM battery storage density in terms of number of installations.

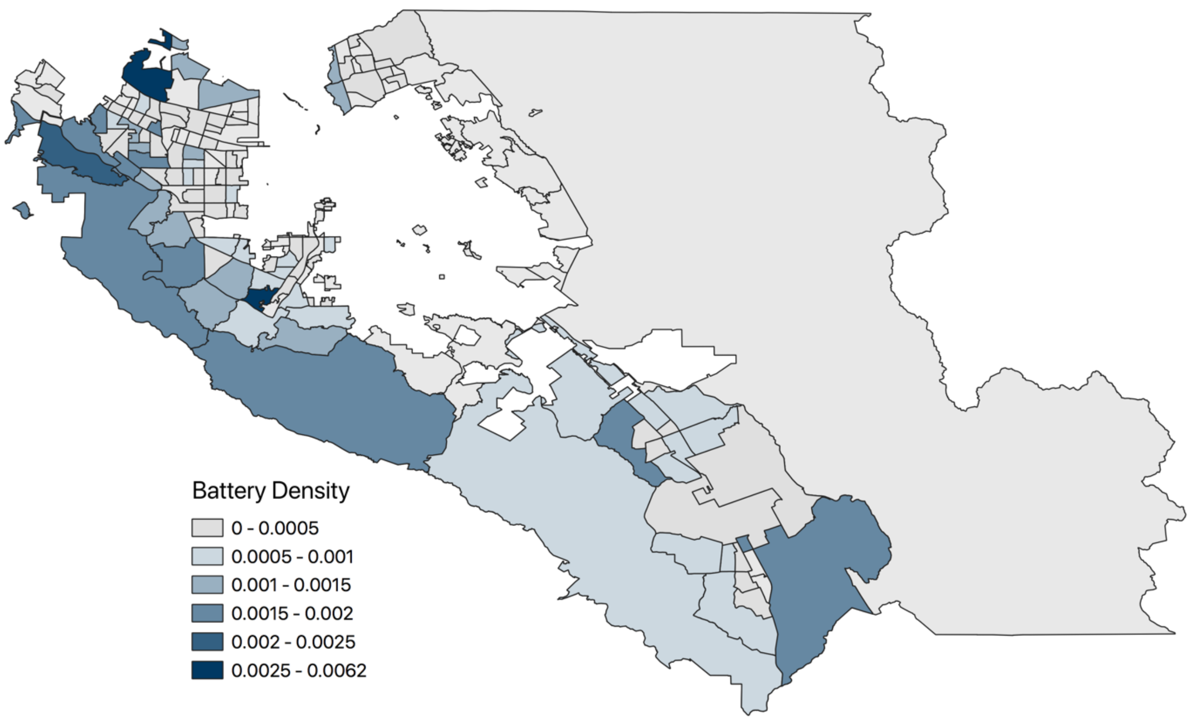

FIGURE 20. BTM BATTERY STORAGE DENSITY BY CENSUS TRACT[72] IN SVCE TERRITORY (2019)

[71] Based on interconnection data dated August 2019.
[72] Defined as the number of storage installations divided by census tract population.

Accounting for Fuel Cells

Fuel cells can be deployed to provide baseload power and typically operate 24/7 once installed. Fuel cells use natural gas to generate electricity and therefore have associated greenhouse gas emissions. SVCE is tracking fuel cell deployment in its service territory to better understand the emissions implications of increased fuel cell adoption.

There are approximately 40 fuel cells in SVCE territory, the majority of which are located at commercial and industrial sites.[73]

7 Disadvantaged Community Assessment

To gain a more nuanced understanding of the findings presented in previous chapters, residential electrification and decarbonization trends were analyzed relative to several equity-focused metrics.

Table 6 below describes different metrics that can be used to segment SVCE customers for equity analysis. CARE, FERA, and DAC are categorical measures: a customer or census tract either qualifies or does not qualify under each definition. Regionalized CES, SEVI, and AMI are comparative: they arrange the census tracts within the service territory along a continuum.

Figure 21 further below shows the census tracts in SVCE territory mapped by the community metrics outlined in Table 6. The darker colors on the maps indicate relatively worse off tracts in terms of each metric.

[73] Based on interconnection data dated August 2019.

Household Metric	**CARE** (California Alternate Rates for Energy)	Customers whose household income is <200% of the Federal Poverty Line and have enrolled to receive a 30-35% discount on their electric bill and a 20% discount on their gas bill.[74] **9%** of SVCE residential customers are enrolled in CARE. CARE customers are distributed across all census tracts and member agencies.
	FERA (Family Electric Rate Assistance Program)	Customers who do not qualify for CARE, but whose household income is <250% of the federal poverty line and have enrolled to receive an 18% electric bill discount.[75] **0.3%** of SVCE residential customers are enrolled in FERA.
Community Metric	**CalEnviroScreen: DAC** (Disadvantaged Community)	CalEnviroScreen (CES) uses environmental, health and socioeconomic data to identify vulnerable communities who are burdened by poor environmental outcomes. On the state level, DACs (Disadvantaged Communities) are commonly defined as the 25% worst-scoring census tracts in the state. **7 census tracts** in SVCE service territory qualify as DACs according to CES.[76] **1%** of residential customers and **7%** of commercial customers are located in these census tracts.
	CalEnviroScreen: Regionalized	CalEnviroScreen scores can be compared within a region to create a regionalized ranking of cumulative social, health and environmental impacts.[77]
	SEVI (SocioEconomic Vulnerability Index): Regionalized	SEVI describes the relative socioeconomic characteristics of communities. SEVI is composed of the five socioeconomic indicators included in CalEnviroScreen (education attainment, housing burden, linguistic isolation, poverty, and unemployment). Similar to CalEnviroScreen, SEVI scores can be used to create a regionalized ranking.[78]
	AMI (Area Median Income): Regionalized	AMI represents income levels as a percentage of the median income within the region of consideration. Census tract median household incomes can be compared the area median income to create a regionalized ranking. 80% AMI is a commonly used cutoff for defining "low income."[79]

TABLE 6. TYPES OF EQUITY METRICS

[74] https://www.cpuc.ca.gov/General.aspx?id=976
[75] https://www.cpuc.ca.gov/General.aspx?id=976
[76] https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

[77] https://caleja.org/wp-content/uploads/2018/08/CEJA-CES-Report-2018_web.pdf, p.24
[78] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M325/K620/325620620.PDF, p.32
[79] https://www.hcd.ca.gov/grants-funding/income-limits/index.shtml

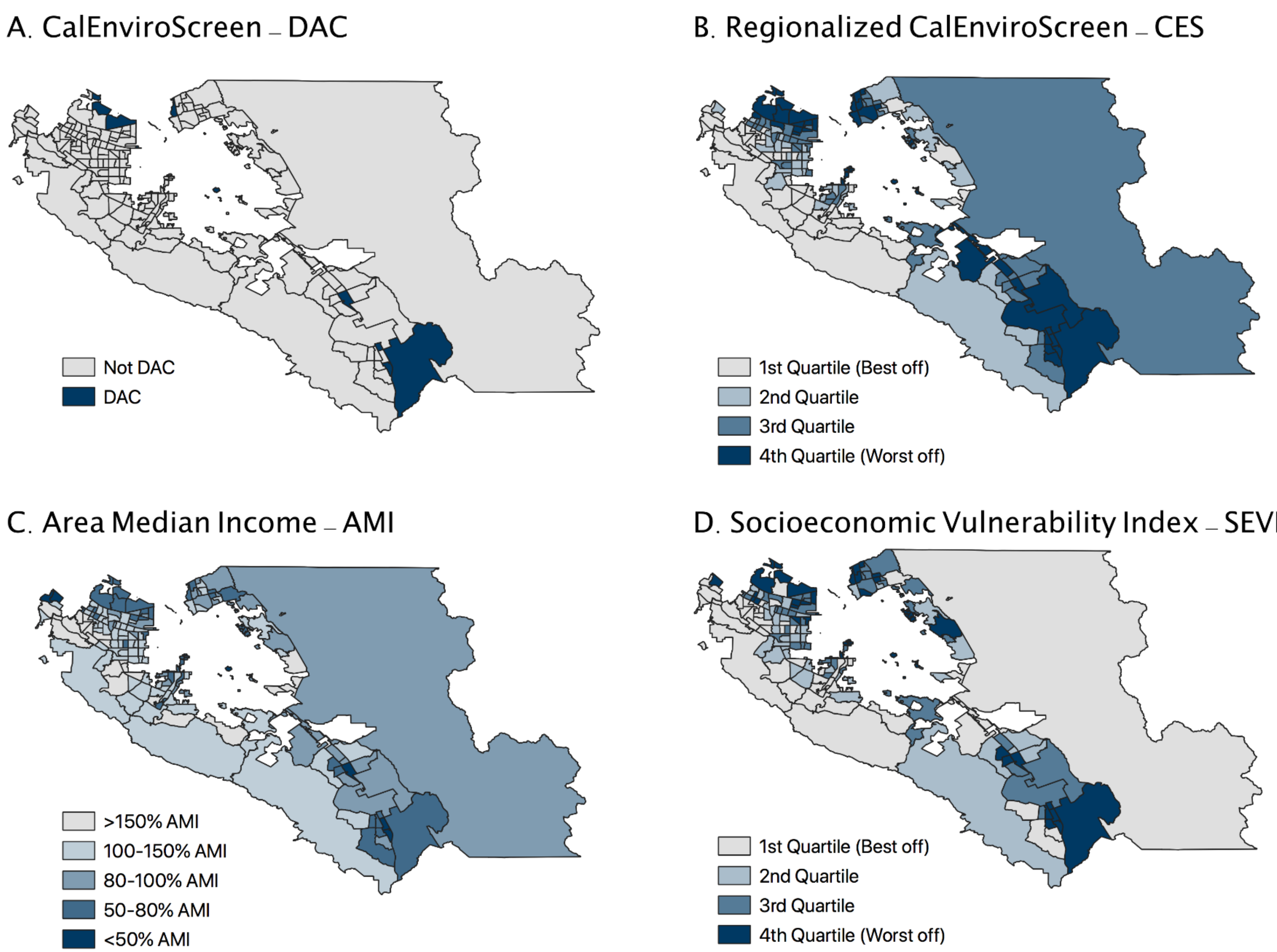

FIGURE 21. SVCE TERRITORY MAPPED BY VARIOUS EQUITY INDICATOR METRICS

To gain a better understanding of building electrification in relation to socioeconomic factors, the composition of residential building types was explored as a function of individual and community metrics. 47% of CARE customers live in multi-family housing compared to 20% of non-CARE customers. Additionally, SEVI and AMI both indicate that socioeconomically worse off census tracts have higher proportions of multi-family housing. In low-income census tracts,[80] 38% of customers live in multi-family units compared to 3% in high income census tracts.[81] Similarly, in the worst-off quartile of SEVI, 39% of customers live in multi-family units compared to 8% in the best-off quartile.

Multi-family units are often leased, which can affect a resident's willingness or ability to electrify their home. Moreover, due to the smaller residence size, those who live in multi-family units are at a higher risk for acute and chronic health impacts caused by air pollutants from natural gas-burning appliances.[82]

Home vintage was also explored as a function of community metrics. As shown in Section 3 of this report, single-family homes built before 1960 are the least efficient consumers of both electricity and natural gas. 25% of pre-1960 single-family homes and condos in SVCE territory are located in low income census tracts.[83] There is also a disproportionate presence of these old homes among the most disadvantaged communities according to SEVI: 47% of single-family homes and condos located in the worst-off tenth of SEVI were built before 1960. These patterns indicate that there may be an opportunity to target old homes for paired electrification and efficiency measures while reducing bills for socioeconomically disadvantaged members of the community.

As shown in Section 3, around 5% of single-family homes in SVCE territory are all-electric. However, these all-electric homes are not distributed evenly across SVCE territory. According to both AMI and SEVI, all-electric single-family homes are concentrated in the socioeconomically best-off census tracts. In low income census tracts,[84] 4% of single-family homes are all-electric compared to 12% in high income census tracts.[85] Similarly, in the worst-off quartile of SEVI, 3% of homes are all-electric compared to 8% in the best-off quartile.

Echoing the trends in single-family home electrification, all community indicator metrics demonstrate a higher per-capita density of EVs/PHEVs, rooftop solar systems, and residential battery systems in better off census tracts, as shown in Table 7.[86]

[80] <80% AMI
[81] >150% AMI
[82] https://ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7, p.6
[83] <80% AMI
[84] <80% AMI
[85] >150% AMI
[86] Density is measured as the occurrence of the technology divided by the total population of the census tract.

	SEVI [count / 1000 residents]		AMI [count / 1000 residents]	
	Worst off quartile	Best off quartile	Low income (<80% AMI)	High income (>150% AMI)
EV/PHEVs	9	48	12	49
BTM Solar	8	38	11	39
BTM Storage	0.1	0.8	0.1	0.9

TABLE 7. PER-CAPITA DENSITY OF DISTRIBUTED ENERGY RESOURCES BY SEVI/AMI QUARTILE

Achieving deep decarbonization requires participation from households in all socioeconomic classes. The territory-level trends presented in this chapter can be used to inform the development of proactive policies and programs that deliver electrification solutions that serve everyone.

8 Conclusions

This report summarizes key results from a data-driven assessment of energy and emissions in the built environment in SVCE service territory. The dual objectives of the analyses were to develop a comprehensive understanding of energy usage and associated greenhouse gas emissions trends in buildings, and to inform a Building Decarbonization Joint Action Plan, which will guide regional and local strategies and action.

The results support the need for a sustained investment in building electrification policies and programs as a pathway for achieving deep decarbonization, with a focus on zero-emissions new construction and decarbonizing existing buildings. The contrast between the emission intensities of electricity and natural gas highlights the need to transition from an energy efficiency to an emissions paradigm when developing building decarbonization policies, given traditional energy efficiency measures applied to electricity usage do not have commensurate climate benefits as they once did.

As discussed in the report, there are various limitations in the analysis. The primary one is the lack of visibility into electrification in the condo, multi-family and commercial sectors. More research and analysis is needed to accurately differentiate between all-electric and mixed fuel buildings in these sectors. This will unlock greater understanding of energy consumption and electrification trends in these sectors. That work is currently underway.

SVCE will continue to monitor and analyze energy and emissions in the built environment across our service territory on behalf of our customers and community.