SILICON VALLEY CLEAN ENERGY

Buildings Baseline Study

City of Mountain View

December 2019

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 the City of Mountain View 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 contact SVCE. A similar assessment is currently being carried out for all SVCE service territory.

Acknowledgements

Robert Spragg, Erin Brewster

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, city-wide energy and emissions analysis was carried out for the City of Mountain View 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 such as EV charging infrastructure deployment and rooftop solar adoption were also evaluated.

As shown in Figure ES1, in the City of Mountain View, buildings accounted for 35% of emissions in 2018. Electricity and natural gas contribute 21% and 79% to buildings emissions, respectively.

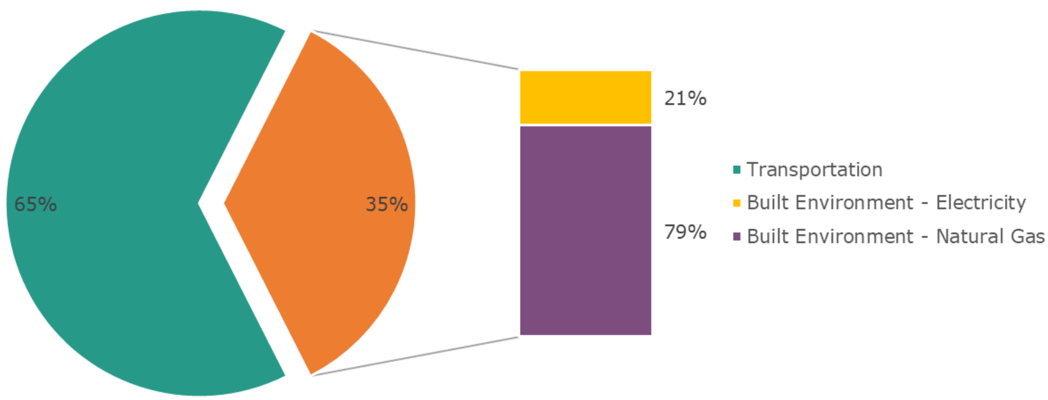

FIGURE ES1. MOUNTAIN VIEW'S 2018 EMISSIONS BY SECTOR

Figure ES2 shows natural gas consumption and associated emissions are split evenly between residential and commercial building sectors. However, electricity emissions from commercial buildings are significantly greater than those of residential buildings. This is due to both greater electricity consumption in the commercial sector (4 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 city.

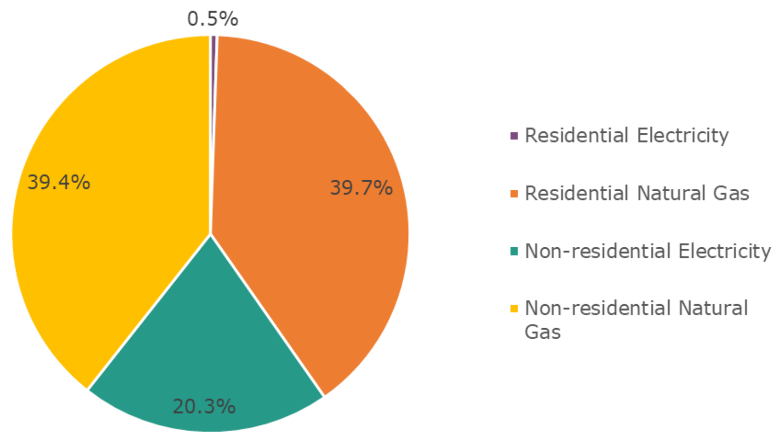

FIGURE ES2. MOUNTAIN VIEW'S 2018 BUILDINGS EMISSIONS BREAKDOWN BY SECTOR AND FUEL SOURCE

For commercial buildings, electricity and natural gas consumption was analyzed by industry. The predominant industries with respect to energy consumption include management of companies and enterprises (electricity and natural gas), health care and social assistance (natural gas), and accommodation and food services (natural gas). Electricity energy usage intensity (EUI) statistics were calculated on a building-by-building basis by industry, which can be leveraged in future analysis to benchmark Mountain View's buildings across the region and state. Commercial properties were also analyzed in terms of building size. The ratio of total electricity consumption to total building square footage is greatest for buildings in commercial parcels over 50,000 ft^2, suggesting larger commercial buildings may benefit the most from energy efficiency policies and programs.

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. As shown in Figure ES3, on average, older single-family homes tend to have higher electricity and gas EUIs, as well as higher gas EUIs in the winter months. In older single-family homes — especially those built before 1960 — efficiency and electrification retrofits could yield significant emissions reductions. This suggests there is significant potential for both building envelope and appliance efficiency improvements.

To gain a more detailed understanding of how energy is used within the buildings, energy consumption and associated emissions from 2018 were disaggregated by end use. As shown in Figure ES4, natural gas and electricity consumption contribute nearly equally to energy consumption in the built environment.

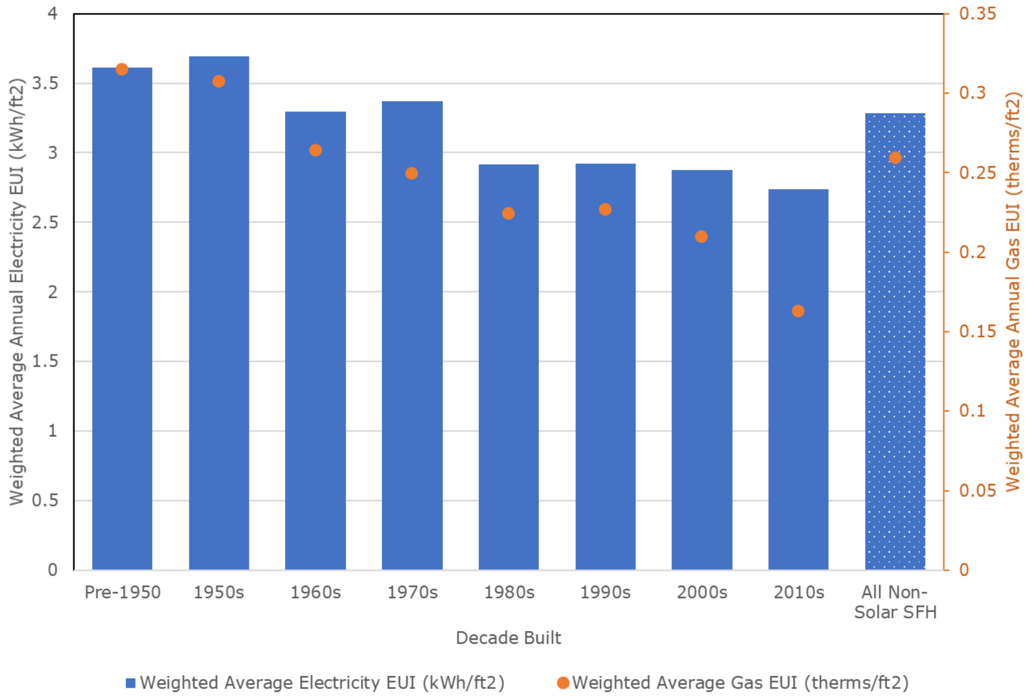

FIGURE ES3. ANNUAL ELECTRICITY AND GAS EUI FOR NON-SOLAR SINGLE-FAMILY HOMES

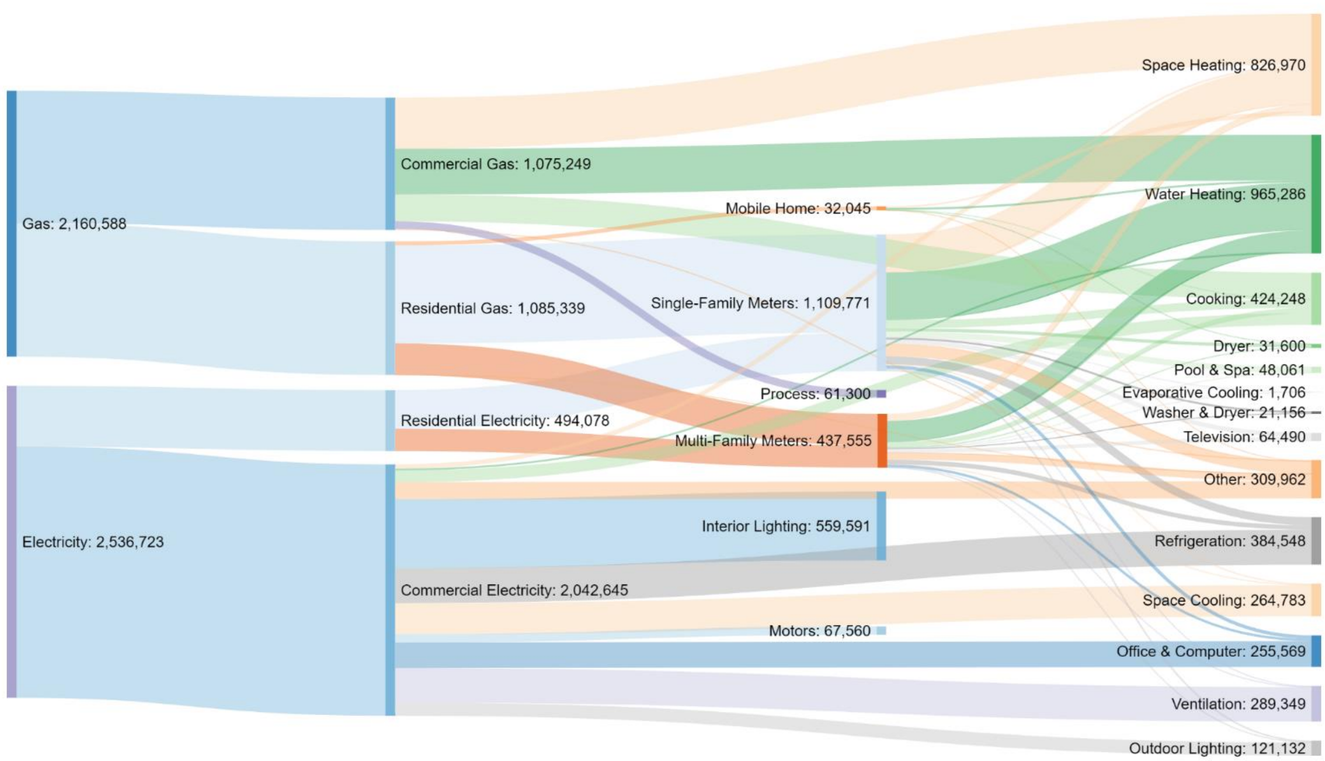

FIGURE ES4: ENERGY DISAGGREGATION BY END USE (2018) (UNIT: MMBTU)

However, as shown in Figure ES5, emissions from natural gas consumption are nearly four 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.

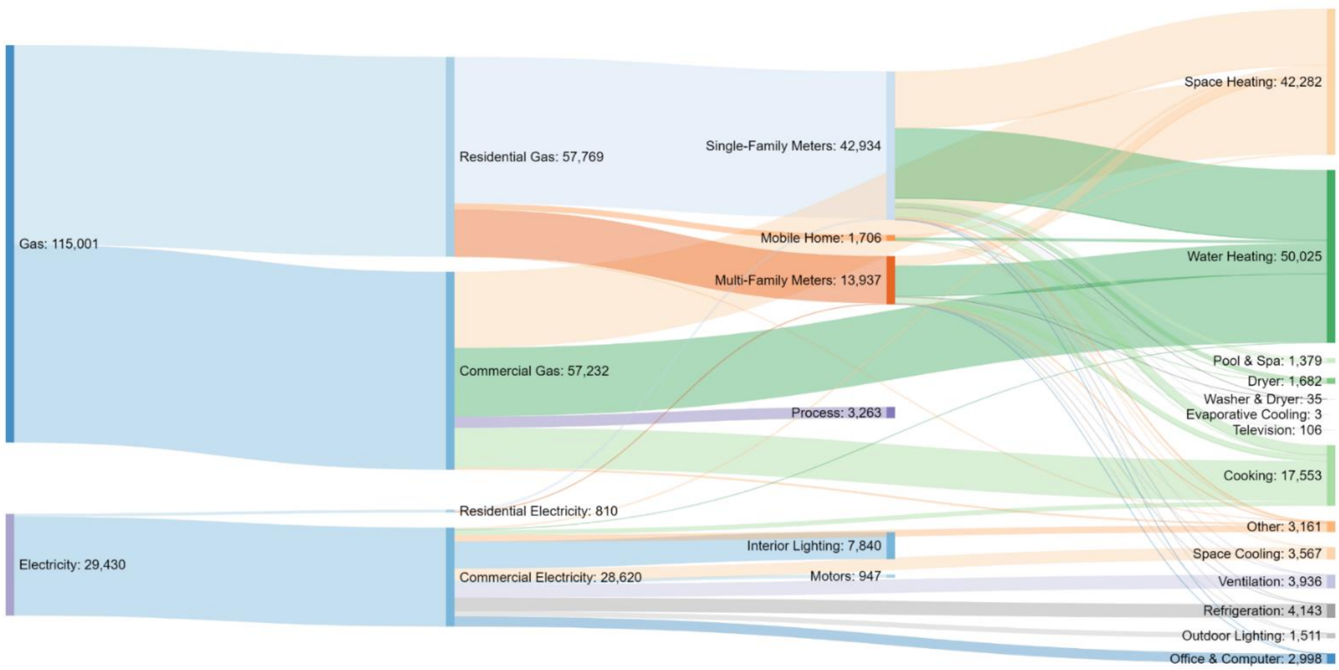

FIGURE ES5: EMISSIONS DISAGGREGATION BY END USE (2018) (UNIT: MT CO2)

Electric vehicle (EV) charging and rooftop solar impact the electricity consumption and load shape of a building. Homes with an EV or plug-in hybrid electric vehicle (PHEV) have an energy use intensity that is 15-20% higher than non-EV homes, respectively. There are approximately 3,000 electric vehicles in Mountain View, and 11.4 MW of rooftop solar. Although current adoption levels are relatively low, EVs and solar adoption are the two biggest trends impacting building energy usage and should be tracked and analyzed as their respective markets mature.

By analyzing Mountain View's energy use patterns, building stock, and other metrics, there are three specific focus areas to underpin a decarbonization roadmap for the built environment:

- Focus Area 1: Zero emissions new construction
- Focus Area 2: Decarbonizing existing buildings
- Focus Area 3: Supporting electric vehicle charging infrastructure

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. Mountain View adopted an all-electric reach code in late 2019, and is leading the state by example. For existing buildings, investing in energy efficiency and electrification retrofits will reduce energy consumption as well as emissions from natural gas usage, which contributes 79% of building emissions in Mountain View. Lastly, ensuring that buildings support vehicle electrification will lower emissions from the transportation sector, the largest contributor to greenhouse gas emissions in California. As a part of its recently adopted reach code, Mountain View included some of the most ambitious requirements in the state for EV charging infrastructure deployment for new construction. A variety of other programs and activities to support EV charging build-out are currently underway, as described in SVCE and its member agency's EV Infrastructure Joint Action Plan.

As discussed in the report, there are limitations in the analysis. The primary one is the lack of information and resultant insight on residential multi-family buildings, which makes up the majority of housing units in the city. And second, this analysis did not delve into identifying a suite of policy and programmatic recommendation for supporting building decarbonization. Both limitations are being addressed in ongoing work for the entire service territory.

SVCE will continue to monitor and analyze energy and emissions in the built environment in Mountain View and across the service territory on behalf of our customers and community. Building on this work, a buildings baseline assessment for all of SVCE service territory is currently underway to inform a building decarbonization joint action plan, which will guide regional and local strategies and action.

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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.[1] In the City of Mountain View, buildings accounted for 35% of emissions in 2018, largely consistent with the statewide trend.[2,3] 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.

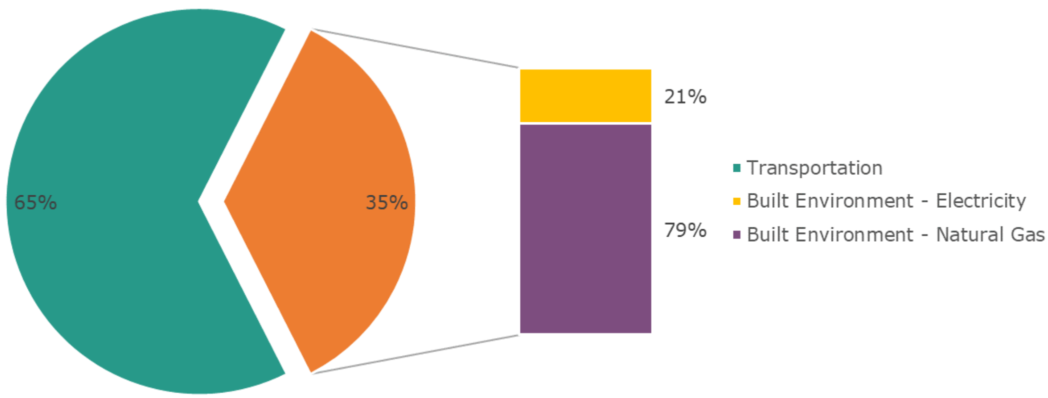

FIGURE 1. MOUNTAIN VIEW'S 2018 EMISSIONS BY SECTOR

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.[4] 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 – the Buildings Baseline Study – lays out a detailed, city-wide energy and emissions analysis for the City of Mountain View. 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 future city growth, EV charging infrastructure deployment, and rooftop solar PV adoption are also evaluated. The final chapter provides a preliminary set of policy and program options to advance decarbonization of the built environment for further analysis and consideration.

[1] https://ww2.arb.ca.gov/research/research-green-buildings
[2] 2017 emissions data from DNV-GL emissions inventory
[3] Emissions from waste and wastewater represent a small fraction of overall emissions and are not included in this analysis.
[4] 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.

2 Overview of Citywide Energy & Emissions

This chapter provides an overview of annual building energy consumption in Mountain View, by energy source and sector. Specific energy usage trends in the non-residential and residential building sectors are covered in sections 2.1 and 2.2.

First, to provide a visual overview of Mountain View's building stock, the distribution of commercial[5] and residential parcels[6] is shown in Figure 2 below.[7]

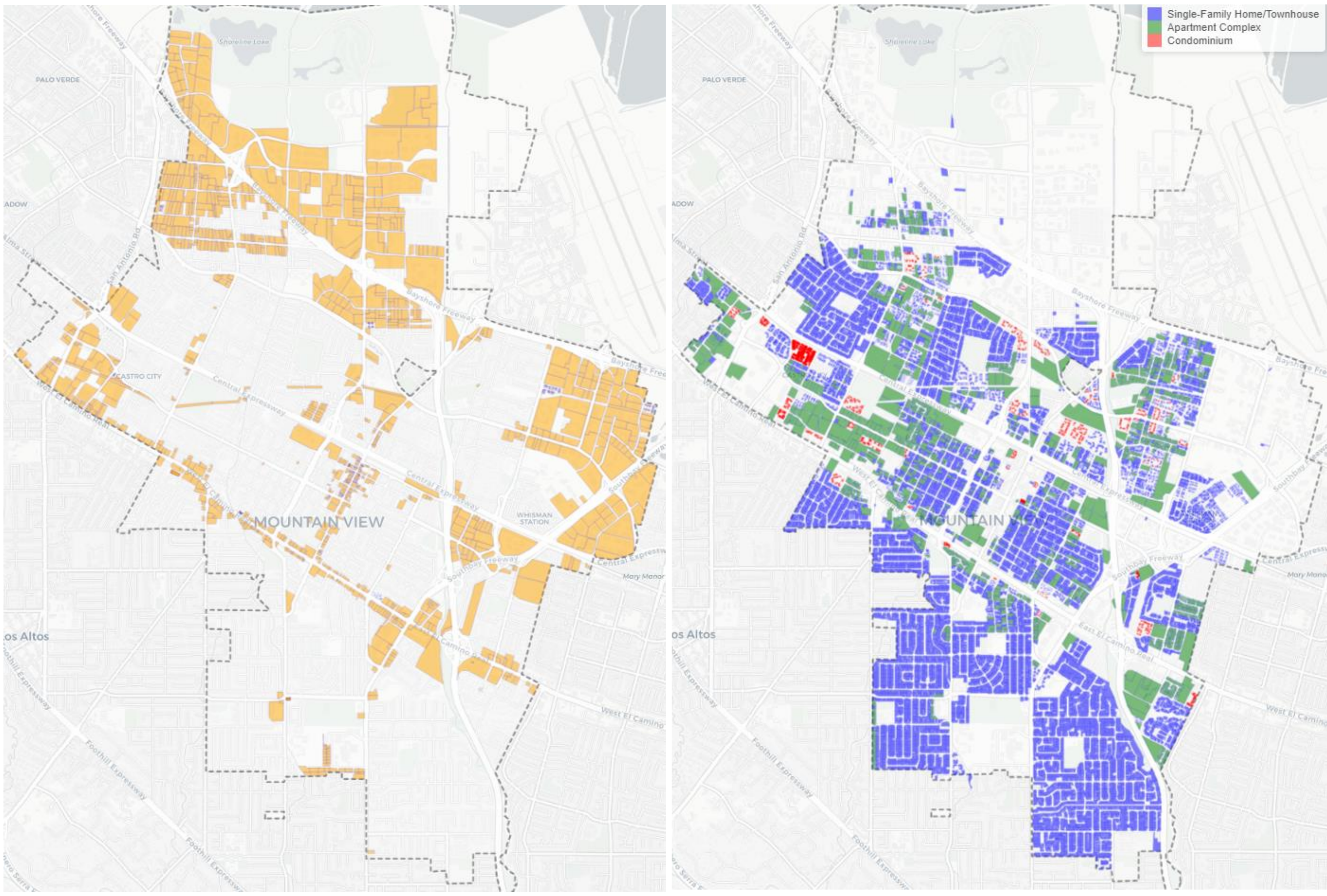

FIGURE 2. MAP OF COMMERCIAL PARCELS (LEFT) AND RESIDENTIAL PARCELS (RIGHT) IN MOUNTAIN VIEW

As shown in Figure 3, non-residential buildings contribute 60% to overall buildings emissions, while residential buildings contribute 40%. Although residential and non-residential natural gas consumption contribute a similar percentage to total buildings emissions, emissions from non-residential electricity consumption are over 30 times higher than emissions from residential electricity consumption. Although non-residential buildings consume around 4 times as much electricity as residential buildings, the disproportionate contribution to emissions is primarily due to the carbon

[5] Most non-residential buildings in Mountain View are commercial.
[6] One parcel can contain one or more buildings, one or more active addresses, and one or more utility accounts.
[7] Please see Appendix A for a map of building age

intensity of the electricity supply, which is higher for PG&E customers and assumed to be significantly higher for direct access customers.[8]

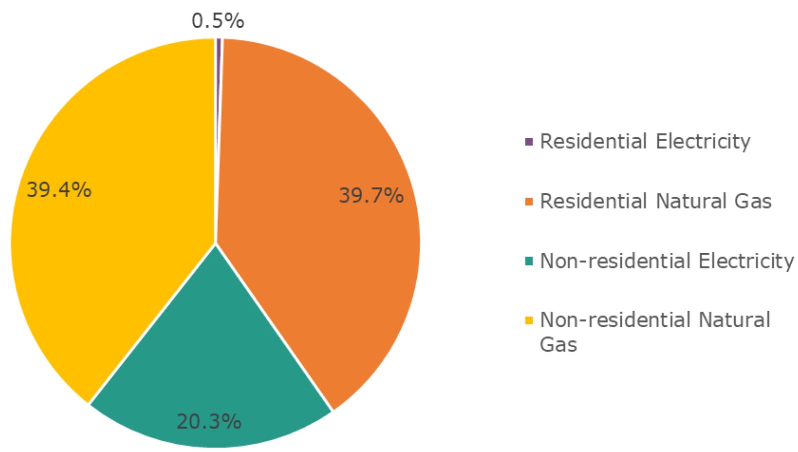

FIGURE 3. MOUNTAIN VIEW'S 2018 BUILDINGS EMISSIONS BREAKDOWN BY SECTOR AND FUEL SOURCE

Electricity: In 2018, the total emissions associated with electricity consumption in Mountain View were approximately **30,327 metric tons**.[9] In the summer months, non-residential electricity consumption is approximately 15% higher, due to cooling loads. On the other hand, residential electricity consumption is approximately 25% lower in the summer months, due to residential rooftop solar PV offsetting the increase in cooling loads.[10] However, given the non-residential building sector's large share of total electricity consumption, Mountain View's overall electricity consumption remains highest during the summer.

Natural Gas: In 2018, the total emissions associated with natural gas consumption in Mountain View were approximately **115,000 metric tons** from 21 million therms of consumption, split nearly equally between residential and non-residential sectors. Note this is nearly four times higher than emissions associated with electricity consumption for the same year.[11] Natural gas consumption in Mountain View is highly seasonal for both residential and non-residential sectors, peaking in the winter months and dropping in the summer months due to increased natural gas usage for heating purposes. The residential sector experiences greater seasonality than the non-residential sector — in 2018, residential consumption was approximately three times higher in winter than in the summer.

[8] The actual carbon intensity of direct access customers in Mountain View is not known due to lack of disclosure requirements.
[9] PG&E emissions factor based on 2017 values. PG&E's emissions have continued to decrease. 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.
[10] See analysis in Appendix B.
[11] https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

3 Commercial Buildings

This chapter focuses on Mountain View's non-residential building sector.[12] For reference, commercial parcels in Mountain View are shown in orange in Figure 4 below. The total commercial building square footage is approximately 28 million square feet, across 1,285 unique parcels.

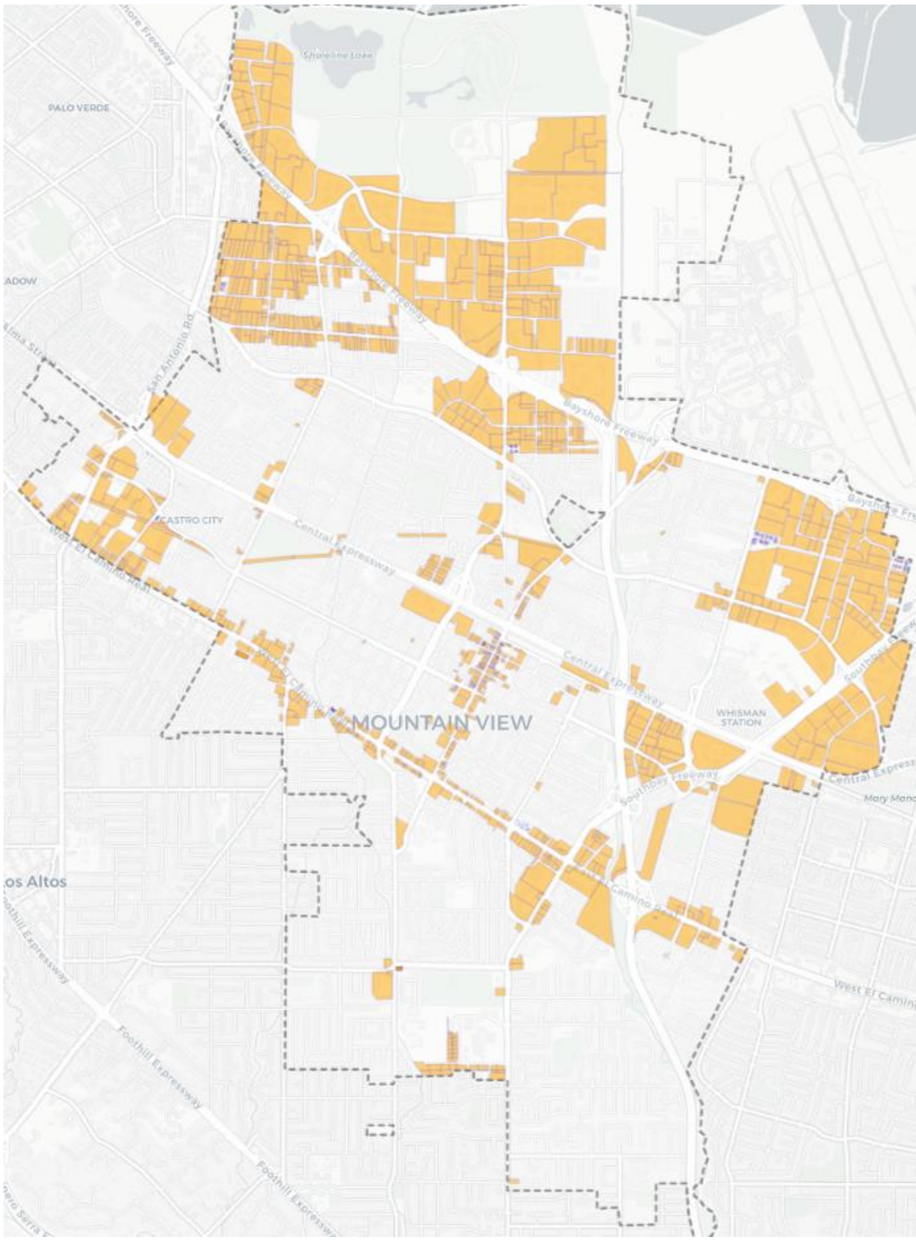

FIGURE 4. MAP OF COMMERCIAL PARCELS IN MOUNTAIN VIEW

[12] Most non-residential buildings in Mountain View are commercial.

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

Figure 5 shows commercial electricity consumption by industry, using the North American Industry Classification System (NAICS) codes.[13] The largest industry electricity consumer is by far the "Management of Companies and Enterprises," which consists of corporate, subsidiary, and regional managing offices.[14]

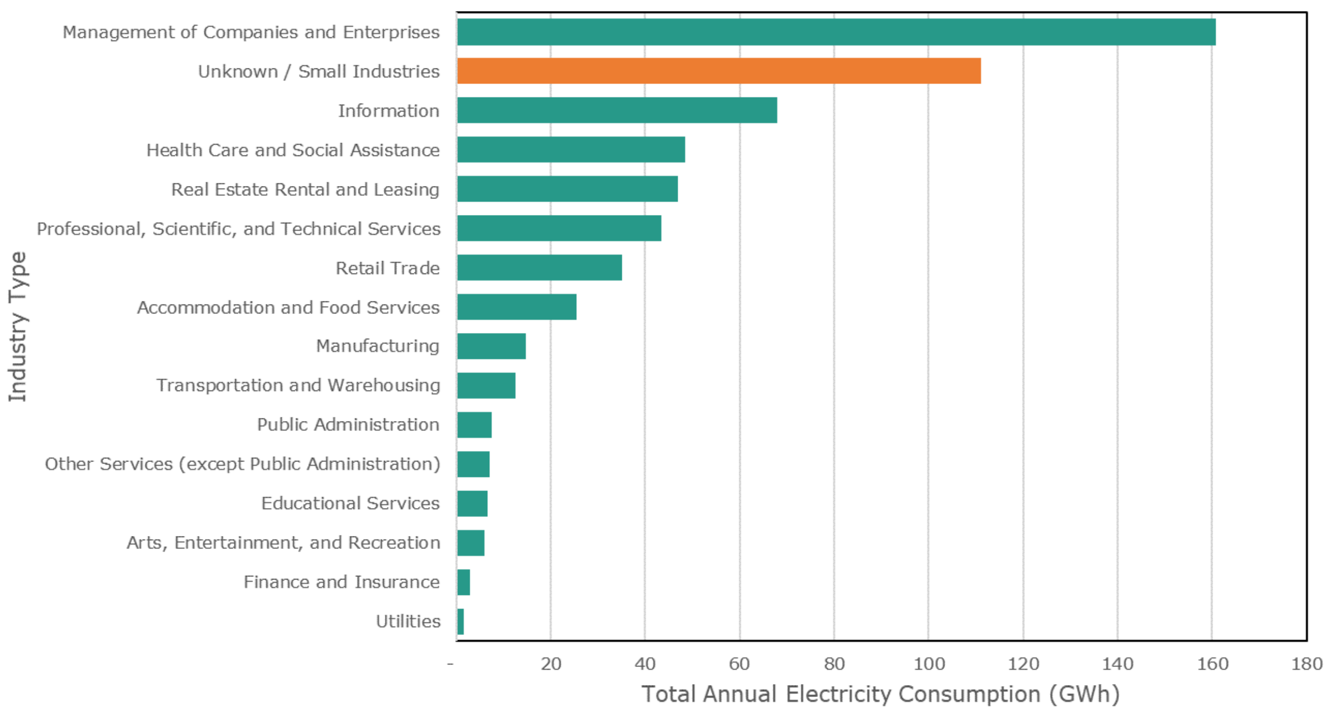

FIGURE 5. COMMERCIAL ELECTRICITY USE BY INDUSTRY FOR MOUNTAIN VIEW (2018)

Energy use intensity (EUI) is the energy usage (electricity, natural gas, or both) normalized by square footage, which allows for comparisons across properties independent of building size. Figure 6 shows the summary statistics of a building-level electricity EUI assessment for commercial buildings by industry for 2018. The black line inside each box represents the median of the annual electricity EUI for each industry. 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. These results can be used to benchmark buildings by industry relative to regional and state standards, to identify the potential for energy efficiency programs. A benchmarking assessment for buildings across SVCE service territory is the subject of current analysis.

[13] For information on sector definitions, please visit https://www.census.gov/programs-surveys/economic-census/guidance/understanding-naics.html
[14] https://classcodes.com/lookup/sector-55/

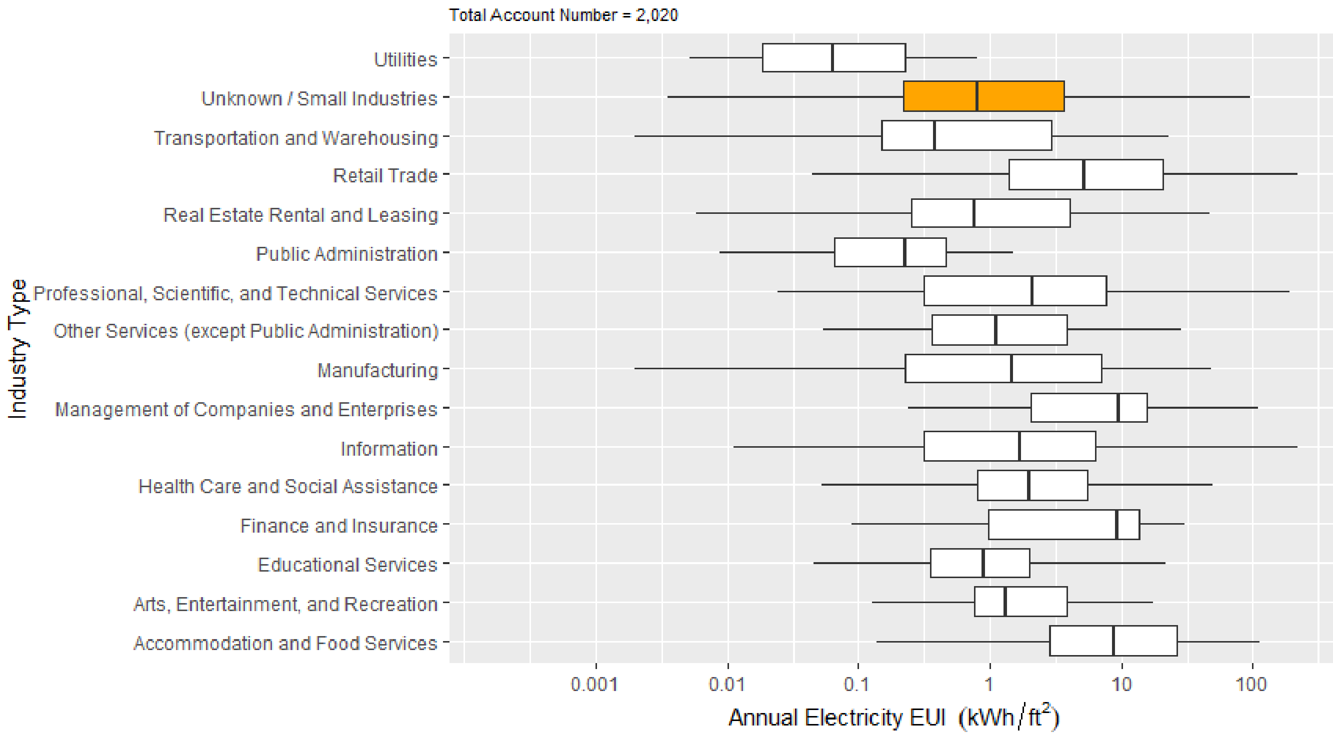

FIGURE 6. ELECTRICITY EUI BY INDUSTRY FOR COMMERCIAL BUILDINGS IN MOUNTAIN VIEW (2018)

To refine our understanding of electricity consumption trends by property type, commercial buildings were categorized by size across all industries. To do so, the total building square footage on each commercial parcel was used to match the parcel based on the four thresholds shown in the first column of Table 1[15]. The electricity EUI was then calculated. Almost 18 million square feet of commercial building space was matched for 836 parcels, totaling over 283 GWh of annual electricity consumption.

Building square footage by parcel	Number of Parcels	% of Total Matched Square Footage	% of Total Matched Electricity Consumption	Annual Electricity EUI (kWh/ft^2)[16]
< 10,000	457	10%	10%	16.34
10,000 – 25,000	211	18%	11%	9.37
25,000 – 50,000	79	15%	16%	16.87
> 50,000	89	56%	63%	17.67
Total	**836**	**100%**	**100%**	**15.88**

TABLE 1. COMMERCIAL ELECTRICITY CONSUMPTION BY PARCEL BUILDING SQUARE FOOTAGE

[15] Only includes accounts that have a non-residential electricity rate and are located on a commercial parcel. Note that one parcel can consist of one or more buildings. Analysis was conducted on a parcel-level due to limitations of assessor parcel data for building characterization.

[16] The combined EUI of multiple buildings is calculated using the weighted average (by square footage) of the EUIs of each building.

The electricity EUI shown in the right column of Table 1 is greatest for buildings in commercial parcels over 50,000 ft^2, which represent 56% of total commercial building area and 63% of total commercial electricity consumption.[17] Though this analysis was conducted on a parcel-level and further analysis is required, these results suggest that larger commercial buildings may benefit the most from energy efficiency retrofits and benchmarking programs.

Commercial Natural Gas Consumption by Industry

Figure 7 shows non-residential natural gas consumption by industry type for Mountain View. Although over 80% of commercial gas consumption was successfully aggregated, note that commercial meters belonging to small industries or commercial meters with no NAICS data consume more gas than any specific NAICS category. The largest single industry gas consumers are the "Management of Companies and Enterprises", "Health Care and Social Assistance", and "Accommodation and Food Services".

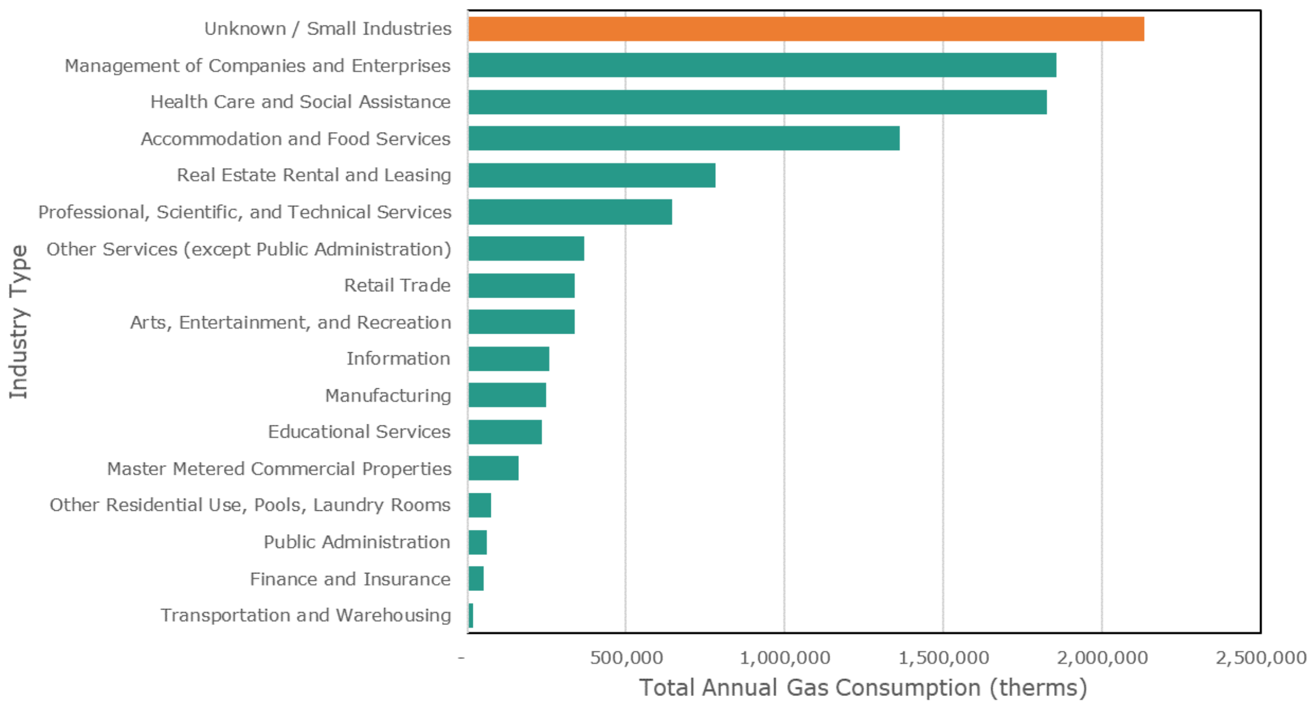

FIGURE 7. COMMERCIAL NATURAL GAS USE BY INDUSTRY FOR MOUNTAIN VIEW (2018)

Figure 8 shows the summary statistics of a building-level electricity EUI assessment for commercial buildings by industry for 2018. These results can be used to benchmark buildings by industry relative to regional and state standards, to identify the potential for energy efficiency programs. A benchmarking assessment for buildings across SVCE service territory is the subject of current analysis.

[17] Based on commercial parcels that were successfully matched to non-residential electricity consumption data.

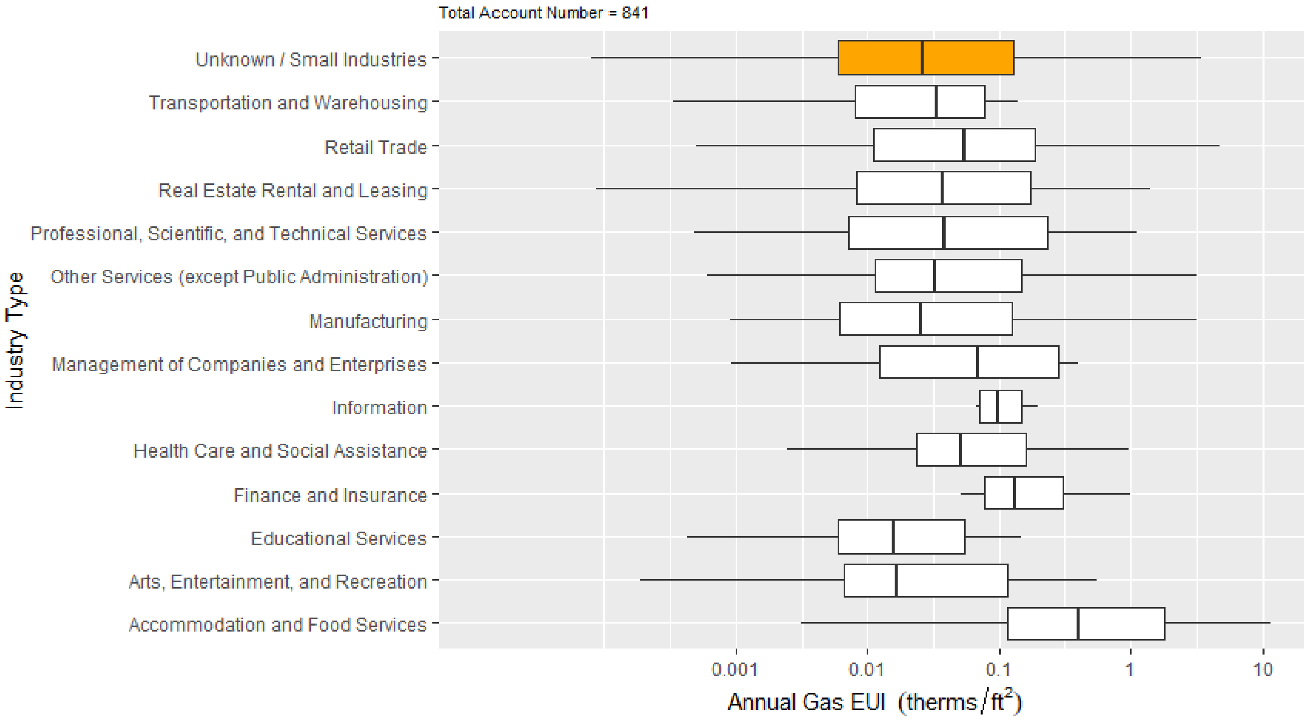

FIGURE 8. GAS EUI BY INDUSTRY FOR COMMERCIAL BUILDINGS IN MOUNTAIN VIEW (2018)

4 Residential Buildings

This chapter focuses on Mountain View's residential building sector. For reference, residential parcels in Mountain View are shown in Figure 9 below, categorized by single-family homes,[18] apartments, and condos. The total residential building square footage is approximately 42 million square feet, across over 18,000 unique parcels.

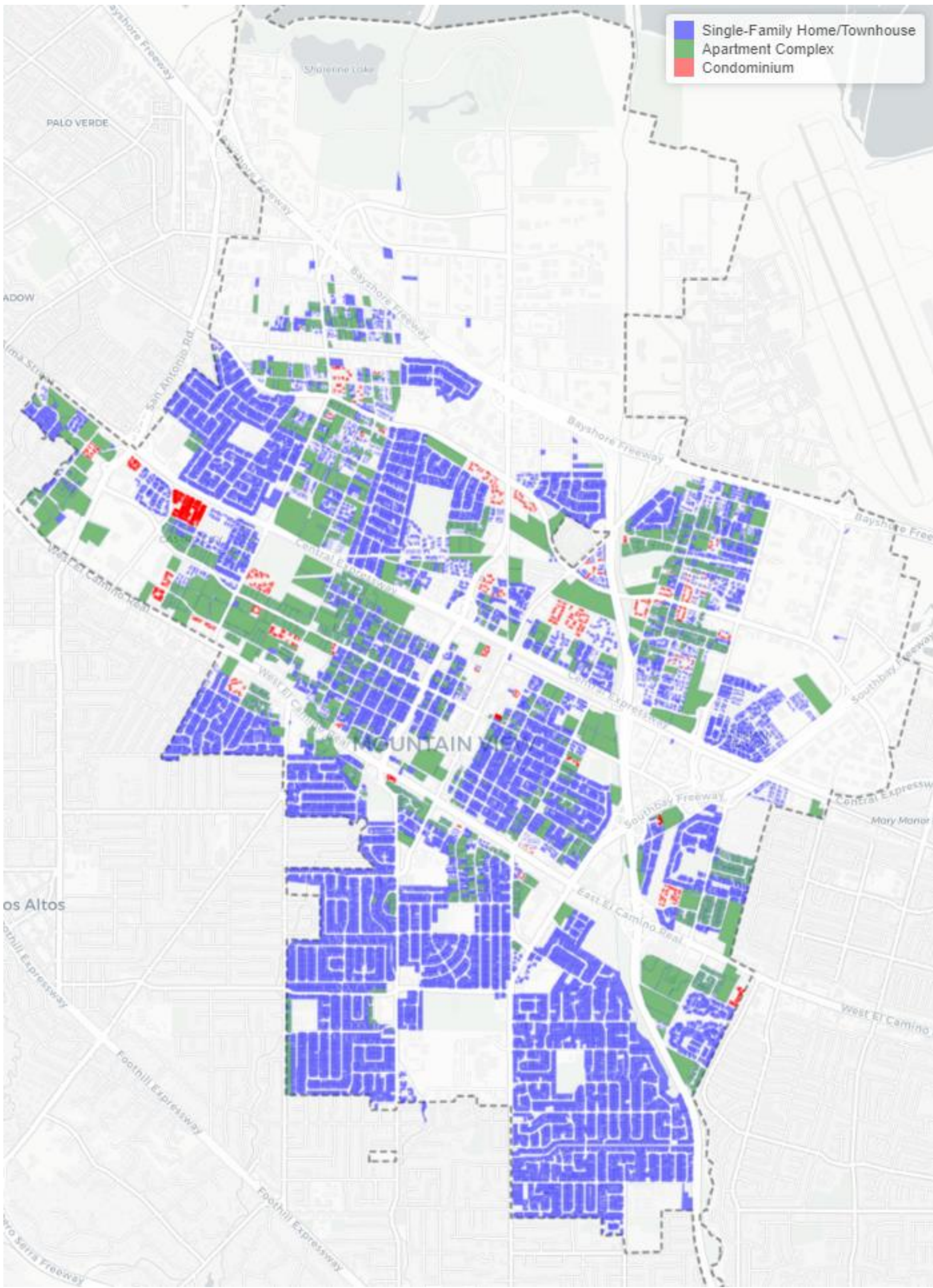

FIGURE 9. MAP OF RESIDENTIAL PARCELS IN MOUNTAIN VIEW

[18] 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 Unique Parcel IDs</th><th>Number of Units</th><th>Total Building Area (ft^2)[19]</th><th>Electricity Consumption (MWh)[20]</th><th>Natural Gas Consumption (MMBTu)[21]</th></tr>
<tr><td>Single-Family Home</td><td>13,536</td><td>13,536</td><td>22,070,353</td><td>91,667</td><td rowspan="2">796,990</td></tr>
<tr><td>Condo</td><td>2,941</td><td>2,941</td><td>3,018,748</td><td rowspan="2">53,133</td></tr>
<tr><td>Multi-Family[22]</td><td>1,540</td><td>22,799</td><td>17,340,389</td><td>256,258</td></tr>
<tr><td>Total</td><td>18,017</td><td>39,276</td><td>42,429,490</td><td>144,800</td><td>1,053,248</td></tr>
</table>

TABLE 2. EXISTING RESIDENTIAL PROPERTY CHARACTERISTICS FOR MOUNTAIN VIEW

As shown in Appendix F, a large percentage of residential square footage was constructed in the 1960s, and residential development trends vary by building type. A large percentage of single-family homes were built in the 1950s; most condos were built in the 1960s and 1970s; 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 Mountain View, the average square footage of single-family homes is 1,630 ft^2, compared to 760 ft^2 for multi-family units and 1,026 ft^2 for condos. This makes single-family homes on average 100% larger than multi-family units and 50% larger than condos. Not surprisingly, as shown in Appendices I and J, on an annual basis, condo units typically have lower electricity and gas consumption than single-family homes.

Residential EUI by Building Type

Figure 10 and Figure 11 show the monthly electricity and gas EUIs, respectively, of condos and single-family homes.[23] Multi-family homes were excluded from the EUI analysis due to lack of reliable unit-level square footage data.[24]

In summer months, condos have an electricity EUI similar to that of single-family homes, whereas in winter months, condos have a higher electricity EUI and a lower gas EUI. This suggests most condos are using electric resistance heating. Gas EUI across building type is similar for the remainder of the year, likely due to the relative consistency of energy usage from cooking and water heating across seasons. Note that only approximately 20% of condos have an individual gas meter.

[19] Based on total building square footage, not total lot size.
[20] Values estimated based on census data and residential energy consumption survey data
[21] One MMBTu equals 10 Therms. Most condos have the same rate code as single-family homes (G1)
[22] Includes duplexes, triplexes, etc. as well as large apartment buildings
[23] The combined EUI of multiple buildings is calculated using the weighted average (by square footage) of the EUIs of each building.
[24] Given the number of multi-family units in Mountain View and elsewhere in SVCE service territory, more research and analysis are currently underway to glean more insight into this residential sub-sector.

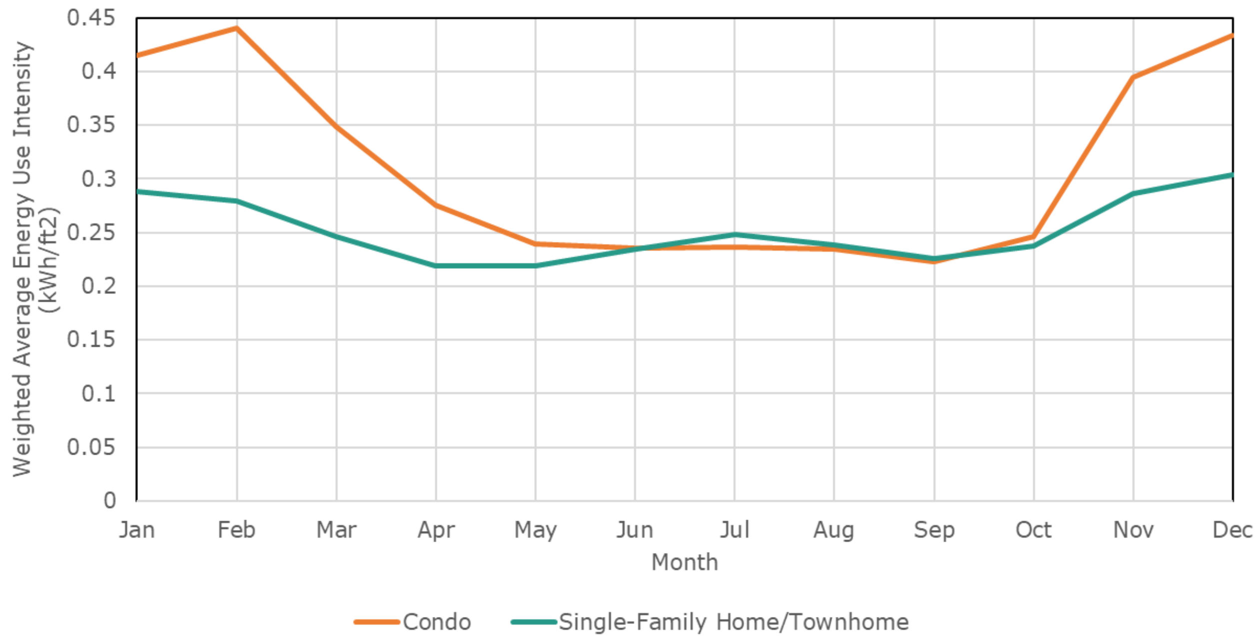

FIGURE 10. ELECTRICITY EUI OF SINGLE-FAMILY HOMES VERSUS CONDOS IN MOUNTAIN VIEW[25]

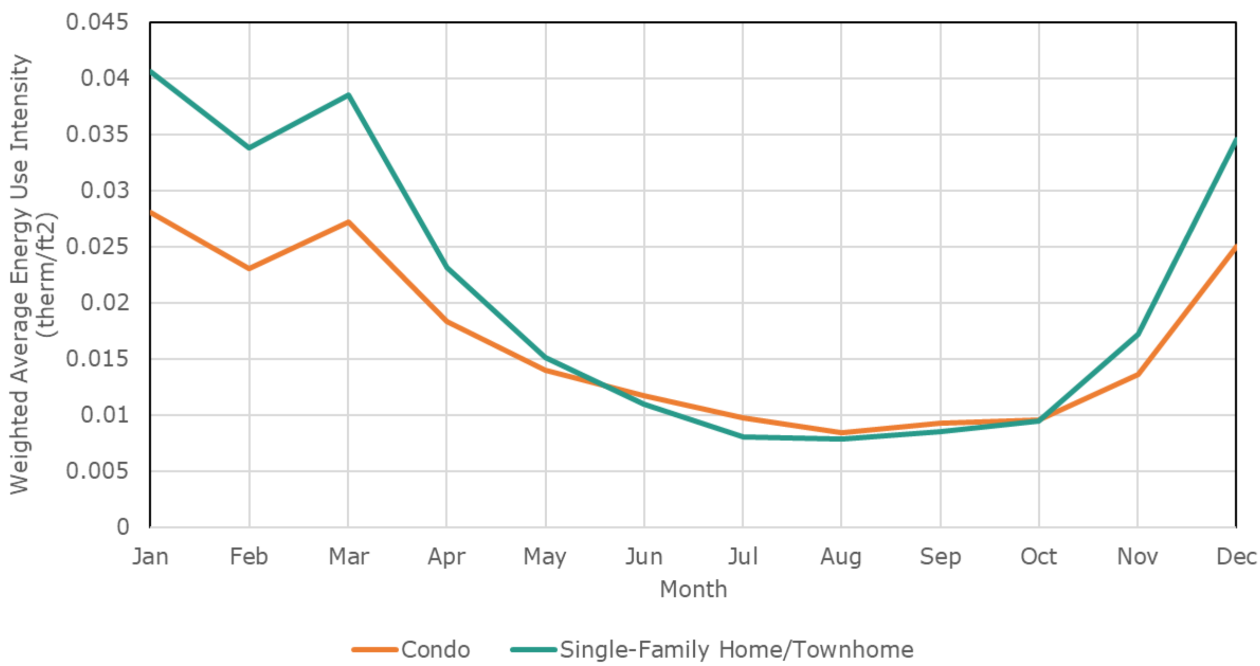

FIGURE 11. GAS EUI OF SINGLE-FAMILY HOMES VERSUS CONDOS IN MOUNTAIN VIEW

[25] Includes the electricity consumption of both all-electric and mixed fuel single-family homes/condos.

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. For the purposes of this analysis, only non-solar homes were considered.

Figure 12 shows the distribution of building area for non-solar single-family homes by building vintage. Since single-family homes built between 1890 and 1950 represent a small percentage of total square footage, these decades were combined into a "Pre-1950" category for the purposes of this analysis.

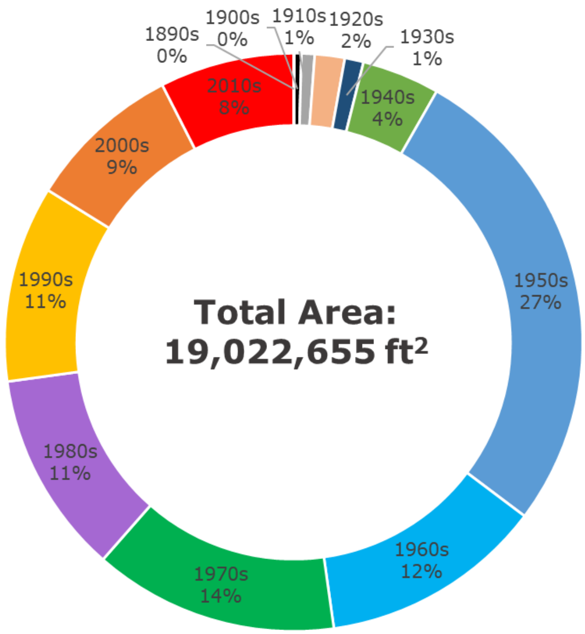

FIGURE 12. TOTAL AREA OF NON-SOLAR SINGLE-FAMILY HOMES BY VINTAGE IN MOUNTAIN VIEW

Figure 13 below shows that on an annual basis, newer single-family homes tend to have lower electricity EUI and gas EUI compared to older vintages. Figure 14 shows the monthly breakdown of electricity EUI. 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.

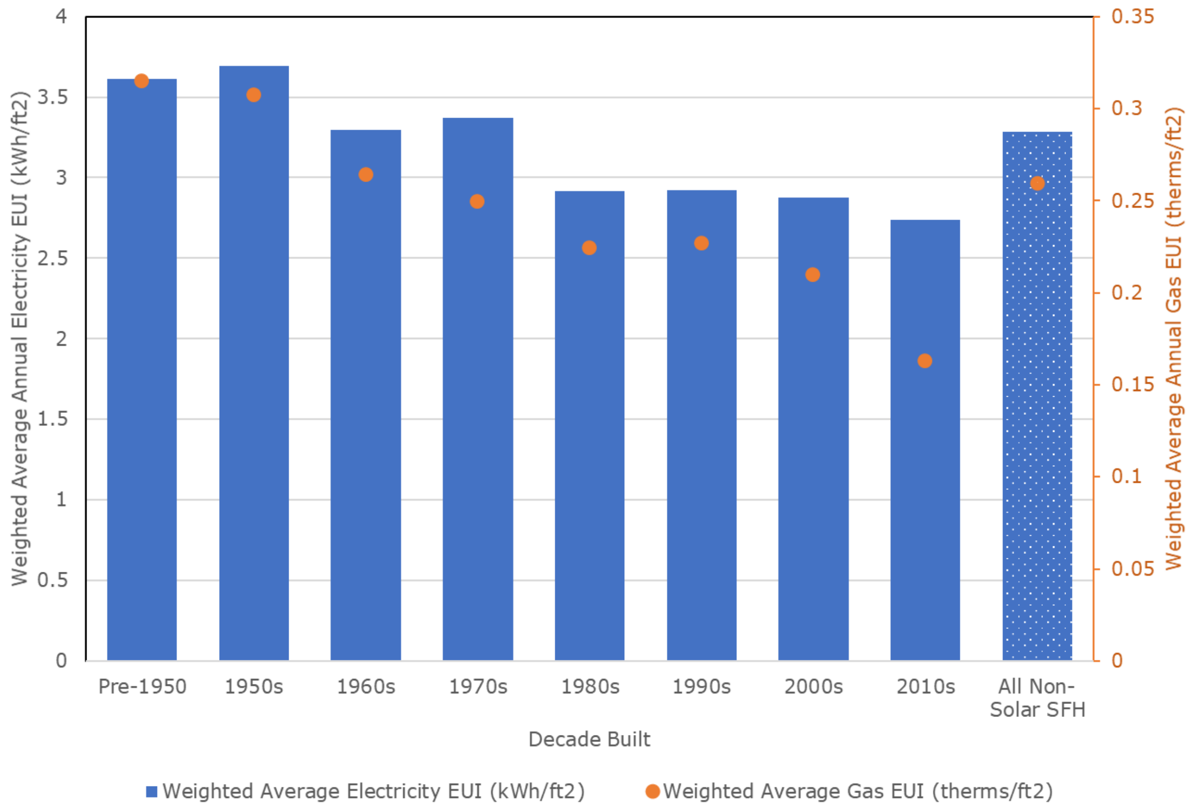

FIGURE 13. ANNUAL ELECTRICITY AND GAS EUI FOR NON-SOLAR SINGLE-FAMILY HOMES IN MOUNTAIN VIEW

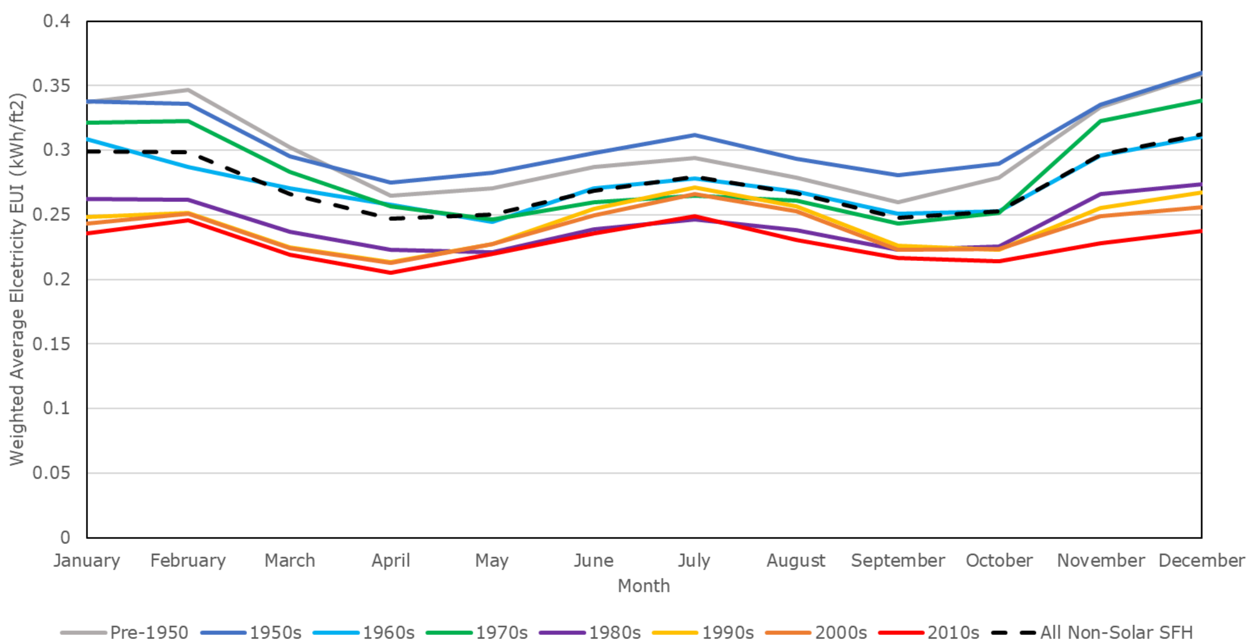

FIGURE 14. MONTHLY ELECTRICITY EUI FOR NON-SOLAR SFHS IN MOUNTAIN VIEW

The monthly breakdown of gas EUI in Figure 15 below shows that the most significant difference in gas EUI between older and newer single-family homes occurs during winter months. There is a consistent trend in decreasing winter gas EUI as decade built increases, suggesting that newer homes have more efficient building envelopes and gas heating appliances.

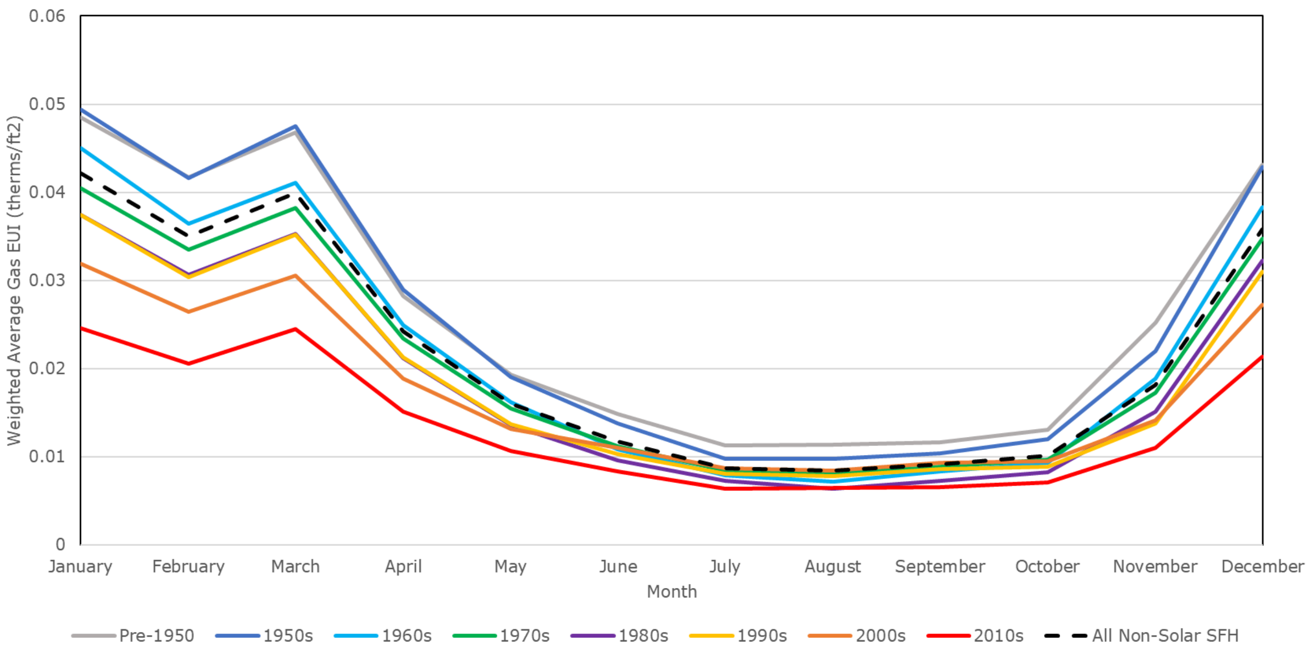

FIGURE 15. MONTHLY GAS EUI FOR NON-SOLAR SFHS IN MOUNTAIN VIEW

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, industry, 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.[26,27,28]

Figure 16 and Figure 17 show energy consumption and emissions, respectively, disaggregated by end use.[29] As observed in the first figure, natural gas and electricity consumption contribute nearly 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 nearly four times greater than those from electricity consumption, with water heating, space heating, and cooking being the most emissions-heavy end-uses. These three end uses make up approximately 94% 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.

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

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

[28] 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 March 2020 and March 2021, respectively—therefore, there will likely be significant changes in end-use fractions after the next survey update.

[29] Individual disaggregation charts for Mountain View's building electricity consumption and natural gas consumption are located in Appendices C and D.

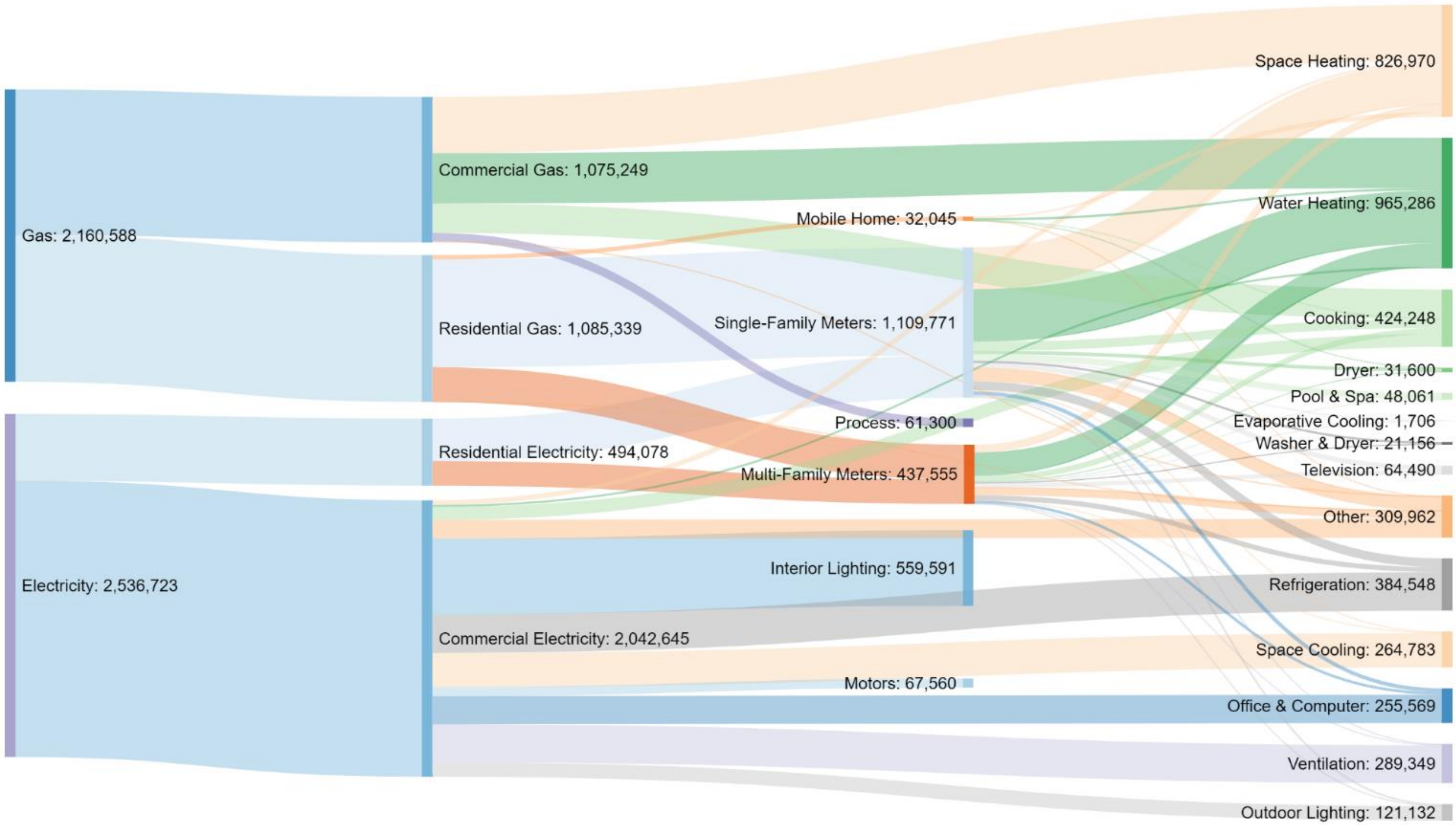

FIGURE 16: ENERGY DISAGGREGATION BY END USE (2018) (UNIT: MMBTU)

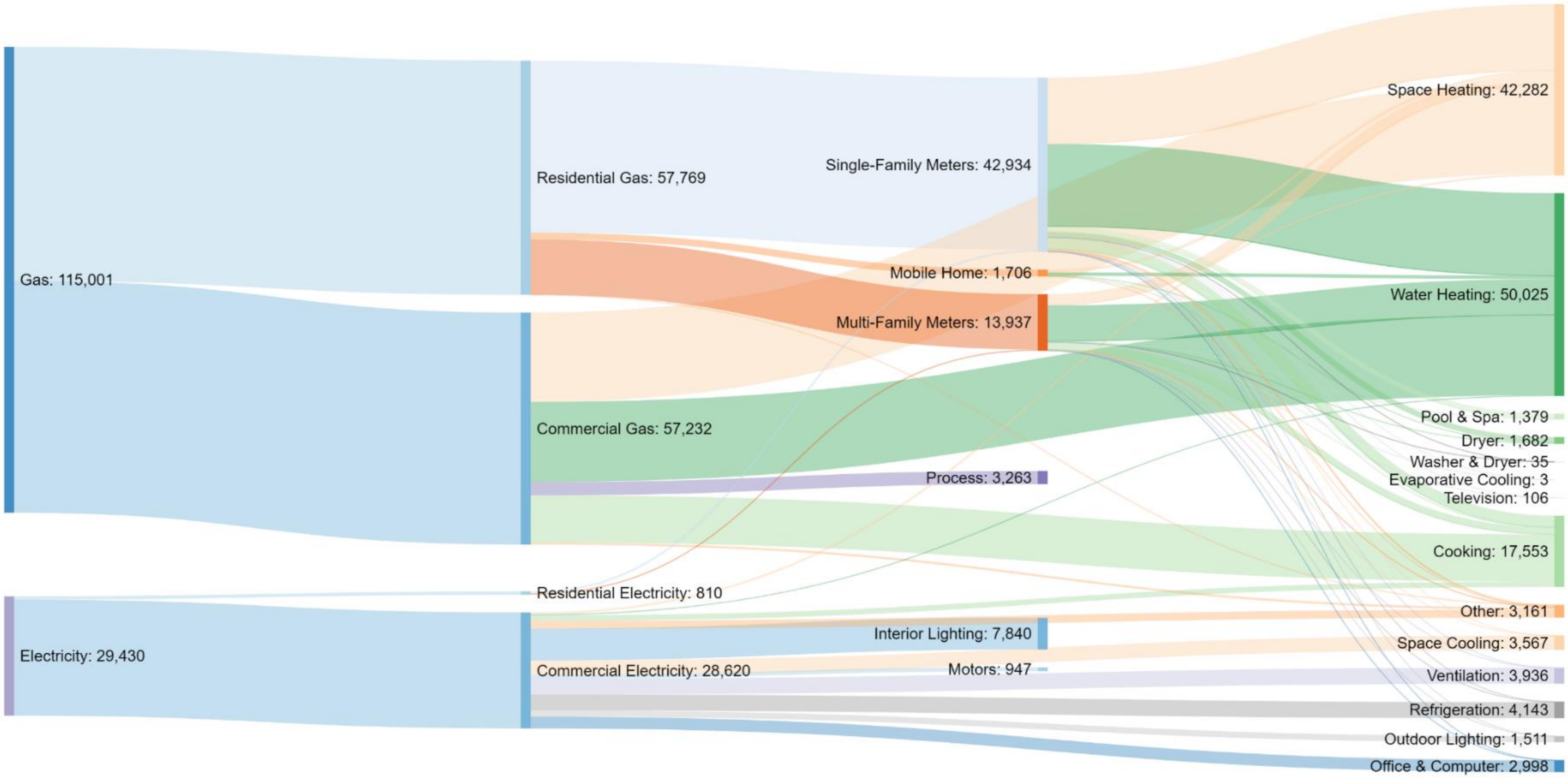

FIGURE 17. EMISSIONS DISAGGREGATION BY END USE (2018) (UNIT: METRIC TONS CO2)

6 Trends in Electric Vehicle and Rooftop Solar Adoption

Two trends merit further analysis given their impact on energy consumption: electric vehicle charging and rooftop solar adoption.

Accounting for Electric Vehicles

For residential households, the presence of an electric vehicle (EV) or plug-in hybrid electric vehicle (PHEV) has a large impact on total energy consumption. Homes with an EV or PHEV have an energy use intensity that is 15-20% higher than non-EV homes, respectively.[30]

According to the most recent DMV data,[31] there are 2,030 electric vehicles and 1,053 plug-in hybrid electric vehicles registered in Mountain View. Figure 18 shows the distribution of EVs and PHEVs across Mountain View. The higher intensity colors on the map indicate areas with higher numbers of EVs. These areas tend to correlate with high-density developments, such as the Whisman station and the neighborhood adjacent to the San Antonio Caltrain station.

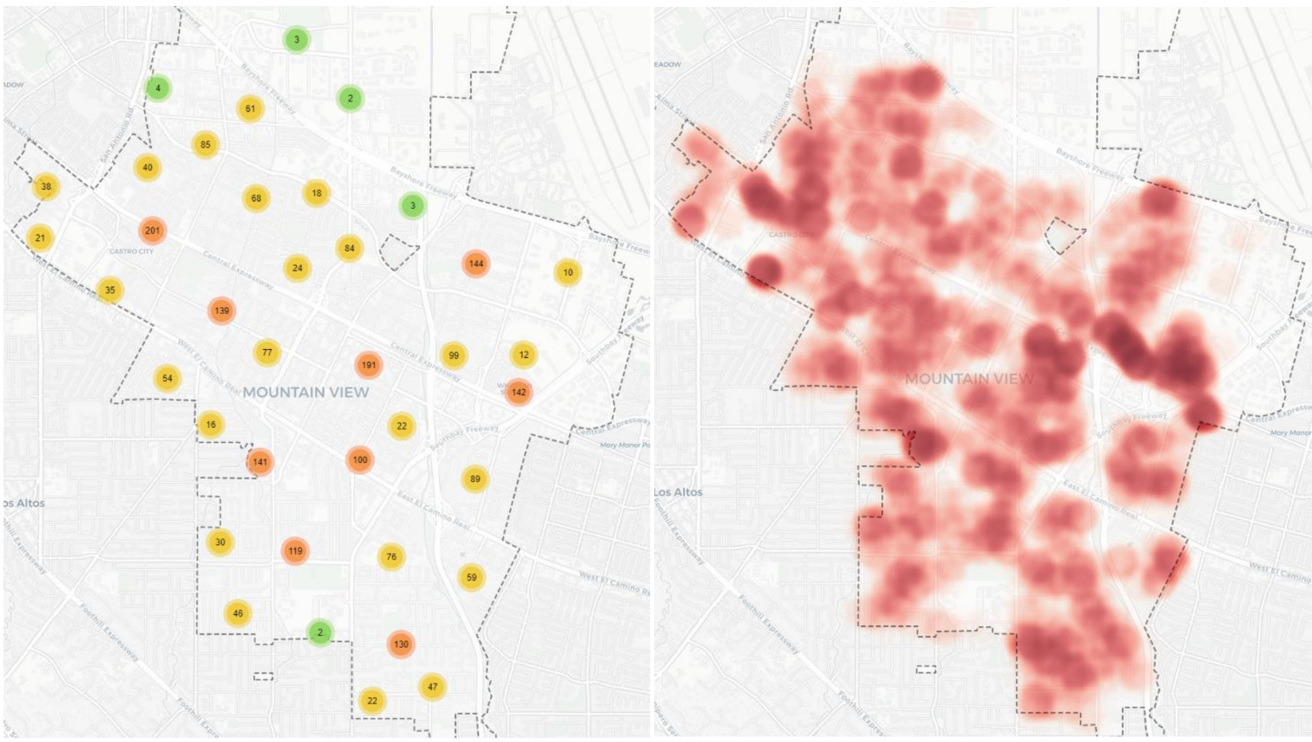

FIGURE 18. MAPS OF EV/PHEV DISTRIBUTION IN MOUNTAIN VIEW

Given current adoption levels are relatively low, the residential analysis presented in chapter 6 did not distinguish between buildings with and without charging infrastructure, although additional analysis of residential EUI of EV households is provided in Appendix B. In future analyses as EV adoption continues to grow exponentially, buildings will likely need to be segmented by presence of charging infrastructure, given it will constitute a larger share of both residential and commercial electricity consumption.

Accounting for Rooftop Solar

[30] Based on homes without solar
[31] Based on vehicle registration data dated December 2018

Like EV and PHEV customers, solar customers have unique load shapes and total energy consumption patterns. There are an estimated 40 commercial and 1,250 residential customers with solar PV in Mountain View, totaling approximately 11.4 MW of installed capacity.[32,33] This is 6.7% of all solar installed in SVCE service territory. Table 3 shows the breakdown of solar PV by building type.

Customer Sector	Install Count	Total kW	Avg. Size (kW)
Commercial	44	4,044	92
Educational	2	51	26
Industrial	5	1,548	310
Non-Profit	1	28	28
Other Government	2	429	215
Residential	1,303	5,301	4

TABLE 3. BREAKDOWN OF SOLAR PV BY BUILDING TYPE IN MOUNTAIN VIEW

Figure 19 provides a visual representation of single-family homes with solar in Mountain View. The neighborhoods with solar on almost every parcel are likely newer developments.

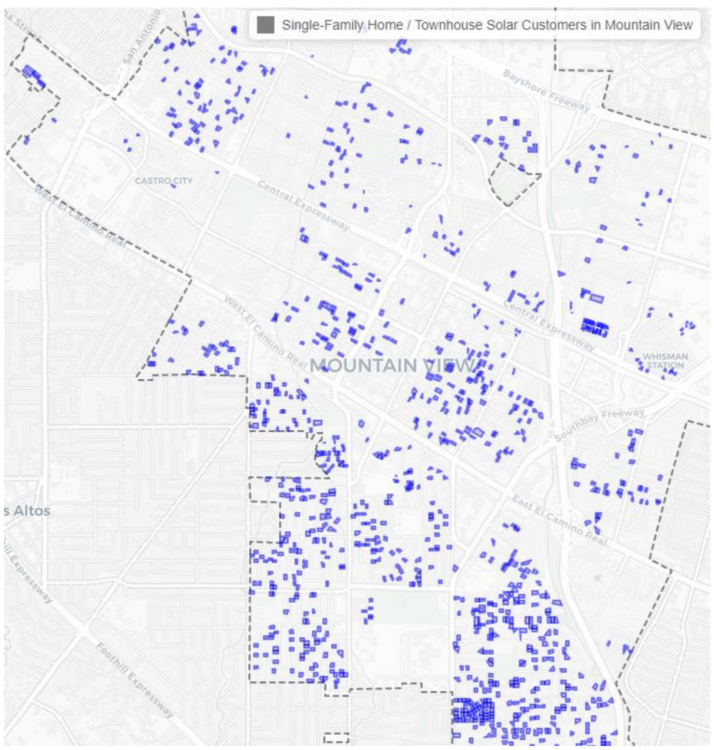

FIGURE 19. MAP OF SINGLE-FAMILY HOME ROOFTOP SOLAR INSTALLATIONS IN MOUNTAIN VIEW

The residential analysis presented in chapter 6 distinguished between buildings with and without rooftop solar, where noted. Additional analysis of residential EUI of solar households is provided in Appendix B.

[32] Commercial estimate found using CDGS dataset. Residential estimate found using the 4013-file received from PG&E (updated March 2019)
[33] https://www.californiadgstats.ca.gov/downloads/#_nem_cids (data updated March 31st, 2019)

7 Decarbonization Roadmap Framework

Leveraging the analysis presented above on Mountain View's built environment and the Building Decarbonization Coalition's "A Roadmap to Decarbonize California Buildings", this chapter presents a decarbonization roadmap framework for the city. While this framework outlines key areas that have been identified as impactful for Mountain View's decarbonization efforts, please note that it does not provide a complete strategic plan.

Focus Area 1: Zero Emissions New Construction

According to 2017 data from the American Community Survey (ACS), Mountain View has added 1,043 housing units from 2015 to 2017.[34] Mountain View is expected to add a total of 2,926 units of housing between 2015 and 2023 to satisfy its Regional Housing Need Allocation (RHNA).[35] Meeting this target would correspond to an 8.6% increase in total housing units from 2015 to 2023. This is slightly lower than the 9.1% growth rate expected for Santa Clara County as a whole, but higher than the 7.1% rate expected for SVCE service territory.

Local jurisdictions should first focus on locking in low emissions in new development, before turning attention toward retrofits of existing buildings. New construction is the most cost-effective time to decarbonize, and can save the community millions of dollars in stranded assets that must be retrofit at a later time. As illustrated in Figure 17 above, given the low average emissions intensity of the electricity sector in SVCE service territory, the largest area of opportunity for building decarbonization is the reduction of natural gas usage. Therefore, ensuring that new housing growth is all-electric and operating on decarbonized electricity will help mitigate a corresponding growth in emissions associated with new buildings.

Statewide, California has already set ambitious targets for both energy efficiency savings and zero net energy (ZNE) buildings which apply to new construction. In 2015, the state set a target to double statewide energy efficiency savings by 2030.[36] In addition, the state has called for all new residential construction to be ZNE by 2020, and all new commercial construction to be ZNE by 2030.[37] However, state policy and building codes have continued to focus on energy efficiency and ZNE, as opposed to emissions and decarbonization. Cities therefore have the opportunity to lead by adopting local amendments to the building code – so-called "reach codes" – that focus on decarbonization.

SVCE and Peninsula Clean Energy (PCE) jointly sponsored and organized technical support and regional stakeholder engagement to develop a set of building electrification and EV charging infrastructure reach codes to reduce greenhouse gas emissions in their service territories.[38] These model codes were developed to encourage all-electric new construction. In late 2019, the City of Mountain View went above and beyond the model codes and adopted reach codes to mandate all-electric buildings in almost every sector and increased EV charging infrastructure requirements for new construction, positioning them as a state leader on taking action to address climate change.[39]

Focus Area 2: Decarbonizing Existing Buildings

Transitioning the thousands of Mountain View's existing residential and commercial buildings to all-electric is also necessary and crucial for meeting climate targets. As illustrated in Figure 17 above, emissions in existing buildings are due to natural gas consumption, predominantly from space and

[34] https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml
[35] https://abag.ca.gov/planning/housingneeds/
[36] Kenney, Michael, Heather Bird, Heriberto Rosales, and Antonio Cano. 2019. *2019 California Energy Efficiency Action Plan*. California Energy Commission. Publication Number: CEC-400-2019-010-SD
[37] https://www.cpuc.ca.gov/ZNE/
[38] https://peninsulareachcodes.org/
[39] https://mountainview.legistar.com/View.ashx?M=A&ID=655822&GUID=19E5E82B-9864-49CC-82E7-0D7ADC9AB130

water heating. Therefore, decarbonizing existing buildings entails reducing natural gas usage through retrofits, with a focus on the following two types of measures.

1. **Building envelope efficiency improvements**. This includes, for instance, improved insulation, air sealing and fenestration. Efficiency measures have the benefit of reducing heating, cooling, and even lighting loads, resulting in lower utility bills. There are also significant non-energy benefits such as improved occupant comfort.

2. **Swapping natural gas appliances for electric**. This entails removing natural gas appliances such as gas furnaces and water heaters and replacing them with high-efficiency, electric alternatives. All-electric buildings can feature electric heat pumps for water heating and space heating. Other end uses such as cooking and clothes drying can also be converted from gas to electric with induction cooktop and heat pump appliances, respectively.

For *commercial buildings* in specific, as shown in Table 1, in the city of Mountain View, the ratio of total electricity consumption to total building square footage is greatest for buildings in commercial parcels over 50,000 ft^2. These results suggest that larger commercial buildings may benefit the most from energy efficiency policies and programs. Furthermore, as supported by Figure 5 through Figure 7, the predominant industries in Mountain View with respect to energy consumption are management of companies and enterprises, health care and social assistance, and accommodation and food services. Dedicated outreach to these industries can help inform policy and programmatic options for retrofitting existing buildings while taking into account specific industry considerations.

For *residential buildings* in specific, in older homes — especially those built before 1960 — efficiency and electrification retrofits could yield significant emissions reductions. As shown in Figure 13 through Figure 15 above, on average, older single-family homes tend to have higher electricity and gas EUIs, and notably much higher gas EUIs in the winter months. This suggests there is significant potential for both building envelope and appliance efficiency improvements. Furthermore, efficiency measures carried out in combination with HVAC electrification can help ensure proper sizing of the HVAC system and lead to improved cost-effectiveness outcomes for the household.

There are a variety of policy and programmatic tools that could be leveraged to support retrofitting buildings, including traditional utility rebate programs, ordinances and codes applied to existing buildings (e.g. energy benchmarking, disclosure, or retrofit at resale), general education and outreach, contractor support, financing support (e.g. on-bill financing, property assessed clean energy (PACE)), and pay-for-performance efficiency or emissions markets. Most of these policy and programmatic tools currently exist and are available to Mountain View homes and businesses specifically for building envelope efficiency improvements, although uptake and efficacy of existing programs are under evaluation. There remain few options to date specifically to support appliance electrification[40].

A deep dive analysis into policy and programmatic tools for decarbonizing existing buildings is the subject of ongoing research and analysis. The approach must be multi-faceted, since different strategies and tactics are needed to tackle the commercial and residential sectors given variation in ownership models, building structures, appliance availability, and occupant needs. In addition to pursuing more traditional measures, dedicating funding and effort to pursue especially innovative but promising approaches to retrofits such as Energiesprong[41] could help Mountain View and SVCE set examples for other cities and regions to follow.

[40] SVCE launched its FutureFit Heat Pump Water Heater program to provide rebates to households for swapping natural gas for heat pump water heaters; however, such programs are not widespread yet.
[41] https://energiesprong.org/

Focus Area 3: Supporting Electric Vehicle Charging Infrastructure

Buildings and transportation are the two largest sources of emissions in Mountain View. Ensuring that building-level measures support vehicle electrification through inclusion of electric vehicle supply equipment (EVSE) can shrink the carbon footprint of both sectors.

SVCE and its thirteen member agencies jointly developed an EV Infrastructure Joint Action Plan (abbv. "EVI Joint Action Plan")[42], which outlines key barriers, strategies and programs underway to support EVSE build-out across the region. SVCE's Board approved $8M in funding over a four-year period, which was leveraged to gain an additional $6M in funding from the California Energy Commission for EVSE incentives. Implementation of the EVI Joint Action Plan will position Mountain View and SVCE to be leaders in supporting transportation electrification in the state.

With respect to *new construction*, the California Green Building Standards Code requires that a certain percentage of newly constructed non-residential parking spaces be EVSE-ready, depending on the total number of parking spaces at the site.[43] Requiring a higher percentage of newly constructed non-residential parking spaces to be EVSE-ready or equipped with EVSE will support EV charging infrastructure development and EV adoption in Mountain View. As mentioned above, the City of Mountain View adopted an EV charging infrastructure reach code that goes above and beyond the statewide requirements.

With respect to *existing buildings*, both single family homes and large commercial properties have experienced significant uptake in EVSE deployment. However, key sectors experiencing significant barriers include multi-family housing and small and medium commercial properties, and incentives are expected to play an important role in supporting deployment. Converting a certain percentage of parking spaces in these sectors to EV charging spaces or EVSE-ready spaces could help encourage EV adoption in these tough-to-reach sectors. This is especially important for drivers living in multi-unit dwellings, as they often lack private parking spaces to install their own EV chargers.

Please see the EVI Joint Action Plan for additional information on programs and activities that are currently under way.

Other Considerations

Key market barriers for the strategies recommended can fall into four main categories: awareness, assurance, availability, and affordability. In order to successfully implement building retrofit programs, residential and commercial customers must first be aware of the possibility of transitioning their buildings from gas to electric. Since all-electric homes are not yet widely adopted, customers must also be assured that new electric appliances will work just as well — or better — than their gas appliances. Making suppliers and contractors more available to customers will make the retrofitting process more convenient and appealing. Lastly, the retrofits must be affordable enough such that cost is not a major deterrent for customers pursuing retrofits.

It will be important to create value propositions for residential and commercial building retrofits, as potential participants will have different priorities. Potential drivers of all-electric retrofits include: bill savings, pollution reduction, health, safety, convenience, and comfort. And for leased buildings, it is expected that tenants will have a low willingness to participate due to lack of ability or incentive to retrofit leased properties.

[42] https://www.svcleanenergy.org/wp-content/uploads/2019/09/EVI-Joint-Action-Plan_Sept-2019.pdf
[43] https://www.documents.dgs.ca.gov/bsc/CALGreen/CALGreen-Guide-2016-FINAL.pdf

8 Conclusions

This report summarizes key results from a data-driven assessment of energy and emissions in the built environment in the City of Mountain View. 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.

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, decarbonizing existing buildings, and supporting EV charging infrastructure deployment. Specific policy and programmatic tools to support decarbonization in the built environment are the subject of further analysis and consideration, but examples include traditional utility rebate programs, ordinances and codes applied to existing buildings (e.g. energy benchmarking, disclosure, or retrofit at resale), general education and outreach, contractor support, financing support (e.g. on-bill financing, property assessed clean energy (PACE)), and pay-for-performance efficiency or emissions markets. Although the proposed focus areas for decarbonizing buildings are based on data specifically from the City of Mountain View, they are consistent with existing literature of statewide decarbonization roadmaps.[44]

As discussed in the report, there are various limitations in the analysis. The primary one is the lack of information and insight on residential multi-family buildings, which makes up the majority of housing units in the city. More research and analysis is needed to accurately match multi-family building characteristics with their energy consumption. This will unlock greater understanding of energy and emissions trends of this sub-sector. That work is currently underway.

SVCE will continue to monitor and analyze energy and emissions in the built environment in Mountain View and across our service territory on behalf of our customers and community. Building on this work, a buildings baseline assessment for all of SVCE service territory is currently underway to inform a building decarbonization joint action plan, which will guide regional and local strategies and action.

[44] See for instance the Building Decarbonization Coalition's *A Roadmap to Decarbonize California Buildings* (2019).