CHUMASH VILLAGE ELECTRIFICATION IMPACTS STUDY

San Luis Obispo, CA

PREPARED BY
Greg Pfotenhauer

artemisia energy

Executive Summary

As infrastructure at Chumash Village (San Luis Obispo, CA) ages, it provides an opportunity to upgrade and electrify that existing infrastructure. This provides many possible benefits, including substantial reductions in greenhouse gas emissions, long-term lifecycle cost savings, increased safety and indoor air quality, improved comfort and building performance, the benefit of summer cooling, and possible reliability and resilience through the addition of solar+storage.

However, electrification does present a challenge as in the early years it will increase costs to tenants simply due to expensive PG&E electricity compared to relatively cheap gas under SoCal Gas. On a normalized energy basis, current PG&E rates are approximately 5-10x higher than SoCalGas. Even with substantial efficiency gains with heat pumps and heat pump water heaters, bill increases for residents are expected to go up 30-50% (depending on rate schedules) in the first year after electrification. Those with older carriages and higher winter heating loads would be most impacted, resulting an inequitable distribution of impacts to residents. Further, most of these older carriages do not support solar and the ability to reduce overall costs is further hindered.

There are a few possible solutions to help mitigate these issues:

- Transitioning to individual metered structure (as opposed to master/submeter) will allow for more resident choice. Different rate structures will provide cost savings in different ways for different residents, and E-ELEC or TOU-C rates will overall be cheaper than master metered rates for >95% of residents.
- 3CE rates will save an additional 10-20% beyond equivalent PG&E rates E-ELEC or TOU-C.
- Weatherization of older carriages can reduce these cost increases by up to 35-45%.
- Depending on capital availability and whether master/submeter or individually metered structures are pursued, there is enough solar onsite to offset costs incurred by electrification, even without weatherization. This is likely a cheaper option than weatherization in most cases but is highly dependent on funding. Possible options:
    - **Power Purchase Agreement (PPA)**: Chumash Village should solicit new proposals for PPAs or similar.
    - **NEM (Net Energy Metering) / VNEM (Virtual Net Energy Metering):** Chumash Village should explore the cost of NEM (master meter) or VNEM (individual meters) with solar+storage. The up-front costs will be greater than with a PPA, but it will provide more flexibility and greater operational benefit.
    - **Self-Consumption:** A less attractive path forward (or as an initial step) may be to pursue self-consumption with no or limited battery storage. This eliminates the cost for battery storage under NEM/VNEM, and is of greater value than a PPA, but somewhat limited in capacity as it would be sized to summer peak loads. Particularly if individual meters are implemented, this would limit PV sizing for self-consumption by approximately 80% (only 20% of load is common load).

The first 16 residences are being considered for a case study as of the writing of this document. These residences should be studied in detail, and resident engagement (i.e., surveys, audits, and other engagement) is crucial. Further, ongoing education, monitoring, and engagement is crucial for positive resident outcomes.

Background

Chumash Village has aging gas and electrical infrastructure and is faced with the question of whether to replace like with like for fuels or utilize this opportunity to fully electrify. The benefits of electrification are well-known and include:

- Substantial reductions in greenhouse gas emissions.
- Long-term cost savings, as gas prices are set to rise much more quickly than electricity rates over the coming decades.
- Avoidance of necessary future upgrades as ultimately gas infrastructure will have to be removed/replaced.
- Increased safety through removal of gas appliances.
- Improved indoor air quality:
    - Air sealing as an ancillary measure will reduce smoke infiltration during wildfire season as well as outdoor pollutants in general.
    - Electric cooktops will reduce a substantial number of pollutants released by cooking gas.
- Improved comfort and building performance when paired with appropriate energy efficiency measures.
- Improved resilience to future heat waves through added cooling.
- Possible independence and reliability through the addition of solar + storage.

However, in addition to substantial up-front costs, a well-known challenge of electrifying in PG&E (and California in general) territory is the possibility of increased operational costs from fuel switching due to the high price of electricity. The city of San Luis Obispo (SLO) has been tasked with evaluating possible bill impacts to residents and providing a preliminary analysis of those impacts. In general, the goals of this study are:

1. Quantify resident bill impacts using utility bill data.
2. Identify opportunities to reduce impacts, including weatherization and solar + storage.
3. Provide a set of recommendations to help guide future work.

Methods

Submeter data collected from monthly ongoing billing data was used to estimate resident heating and cooling loads to assess bill impacts of potential electrification,

Methods for Energy Disaggregation and Calculating Bill Impacts

Due to uncertainty induced by low-resolution data and lack of audit/site assessment, a few different methods/levels of rigor were used to estimate impacts which are described in some detail in Appendix A. In general, disaggregation of utility bill data was favored over calibrated building energy models, though the latter were utilized to estimate possible energy deltas for weatherization measures.

Challenges and Uncertainty

Potential bill impacts of electrification were challenging to estimate for several reasons:

- Lack of site audits (vintages, equipment, etc.) mean that we cannot build specific models for each home but must rely on various bill disaggregation methods and assumed efficiencies for pre/post-retrofit.
- Monthly data from submeters provides adequate, but lacking, data for which to estimate heating and cooling loads compared to daily or hourly data. Additionally, not having hourly data makes proper solar sizing challenging.
- Resident turnover is not known and a couple vacancies are noted.
- It is assumed that domestic hot water (DHW), space heating, and cooking are fueled by gas for all tenants, but this is an unknown. There could be electric appliances in some units.
- Residents may have ancillary gas appliances like outdoor fireplaces, grills, etc. While laundry services are centralized, it is possible that some residents have their own gas dryers. This leads to uncertainty in the model. Heating loads are relatively easy to extract, and cooking loads are usually small. The remainder is assumed to be DHW but there may be other loads present.
- Gas and electric prices are increasingly more volatile. This is true especially with gas prices; the winter of 2022-23 saw substantially higher procurement rates and in January 2023 these rates more than tripled compared to normal winter costs.
- Common loads induce some uncertainty. Unless otherwise mentioned, bill impacts were calculated from tenant gas/electric data excluding common loads, but since all residents pay for a share of common load utilities, fluctuating common loads under different rate structures will impact their fractional increases in monthly bills.

Housing Characterization

Chumash Village (see Figure 1) is a manufactured home park in San Luis Obispo, CA consisting of 237 spaces (235 units; 2 are double lots). Based on analysis of satellite data, at least half of them pre-date 1994 HUD, and it is possible that some of them predate 1976 HUD manufactured building code standards. Roughly 25% appear to have been built in the 1990s, and another 25% later than 2000.[1] Most (196 spaces) appear to be double-wide, and there are 2 larger double-lot homes on the property.

[1] These are rough estimates based on construction design.

Figure 1: Map of property (left) and aerial view (right)

Energy Usage Characteristics

Chumash Village is in California building climate zone 5 which generally comprises the coastal area west of the Santa Lucia Mountains and is primarily a heating climate zone. As it is a relatively mild zone, many do not have air conditioning and building performance standards are somewhat less stringent. General design practices in this zone center around insulation, reducing infiltration, and encouraging shade and natural ventilation to limit necessary cooling. SLO sits further from the coast than other cities in this zone and has slightly more heating and cooling degree days than more coastal cities in this climate zone (2,954 HDD, 894 CDD).

Based on billing data, approximately 80% of gas usage and 78% of electricity usage is from direct resident (submeter) loads. Figure 2 shows resident (non-common) gas and electric usage at Chumash Village averaged from 2020-2023. Year-on-year trends are remarkably consistent, owing to the relatively mild climate and large number of residents that smooths out anomalies.

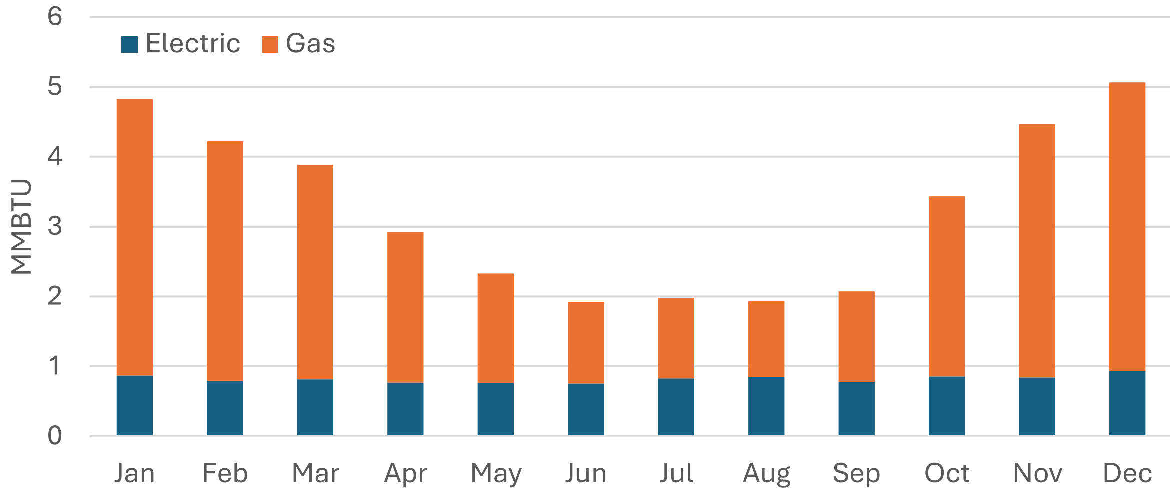

Figure 2: Average per-Unit Energy Consumption, 2020-2023 at Chumash Village

The following was determined from analysis of aggregated electric and gas data (excluding common loads):[2]

- Per-resident annual energy is 75% gas (29.2MMBTU) and 25% electricity (9.8MMBTU).
- Annual average electricity usage is 2,887 kWh per resident.
  - In aggregate, electricity usage is very consistent, and despite small seasonal changes only varies +/-5% from month to month.
  - 84.2% of total electricity is non-space conditioning load.
  - Models estimate 10.5% of electricity usage to be electric heating[3]
  - Models estimate 5.3% of electricity usage to be cooling.
- Annual average gas usage is 292 therms per resident.
  - In aggregate, non-heating gas usage is consistent; +/-5% from month to month.[4]
  - Models estimate 55% of gas usage (162 therms) goes towards heating.

An analysis of individual resident usage suggests at most 17% of residents utilize summer cooling. Winter space heating is estimated to be utilized frequently by approximately 20%. Note that these are very rough estimates based on billing level data.

Individual gas and electric usage is shown in Figure 3 and Figure 4. Gas loads in winter are highly variable, ranging from 0-150 therms per month, suggesting either very high thermostat setpoints or room for building efficiency improvements. Electric loads are relatively constant throughout the

[2] CalTRACK methods using eemeter were used to disaggregate heating and cooling loads. Overall regression results were very clean with low error.
[3] Model uncertainty is greater in electric disaggregation due to the greater amount of noise (more things plugged in than dedicated end uses for gas) and covariance of other winter loads (ie, lighting also increases in the winter due to shorter days).
[4] Seasonal changes in water heating use due to colder water temperatures cannot be disaggregated from this level of data.

year on a site basis (excluding those that appear to have cooling or are seasonally vacant) and overall variance across residents is substantially less than with gas usage.

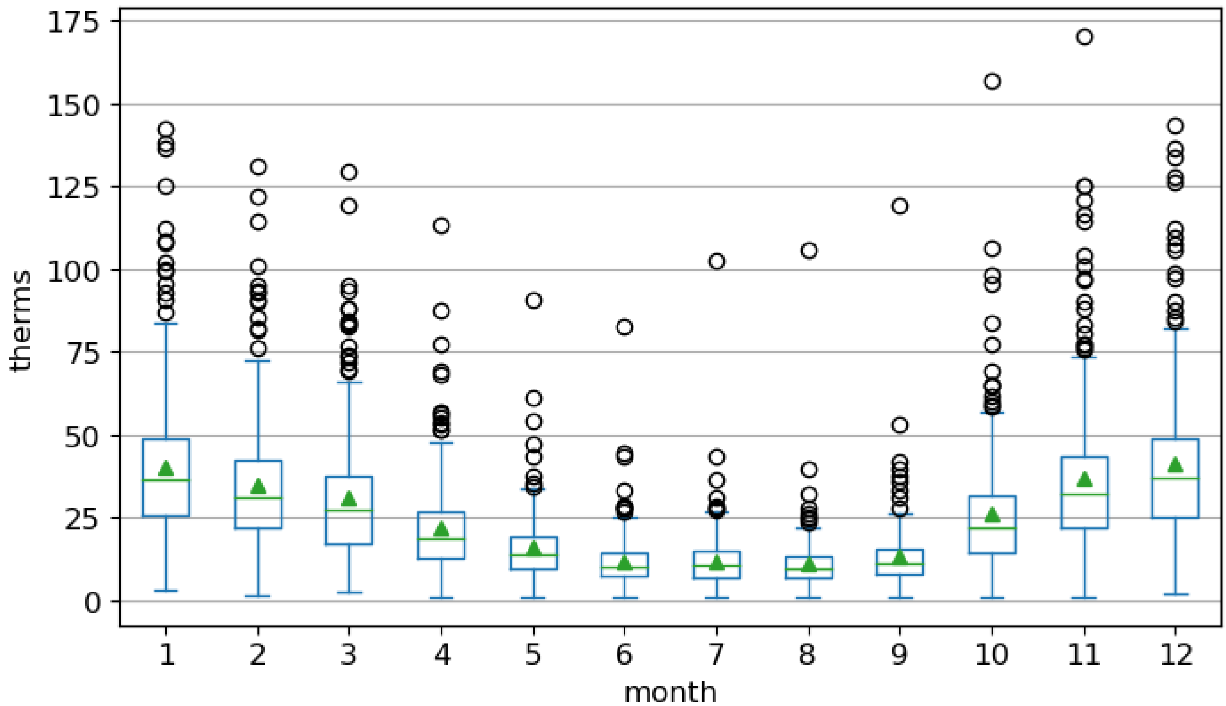

Figure 3: Monthly gas usage per resident for 2022.

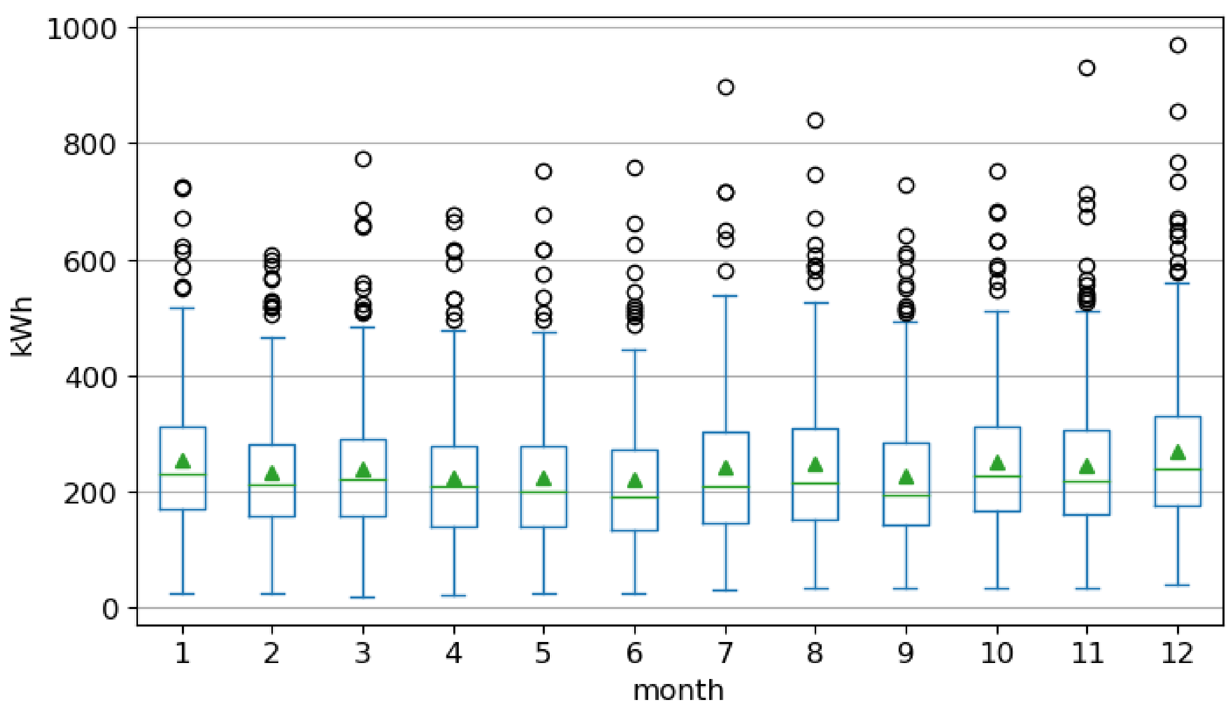

Figure 4: Monthly electric usage per resident for 2022.

An analysis of vintages and estimated winter heating loads showed that overall, there is a substantial difference between older and newer homes in terms of winter heating load. From pre-1990s to 1990 there is a 20% drop in winter heating use for double-wide homes, and from pre-1990s to post-2000s there is a 38% drop in winter heating load (see Figure 5). With many obvious caveats, this is large enough to be significant. Further, among these same double-wides, there is *no* change in non-heating site (electric and gas) energy across vintages. This suggests room for improvement either in weatherization or equipment performance.[5] Prior to retrofit, more information should be collected on vintage and exact building characteristics.

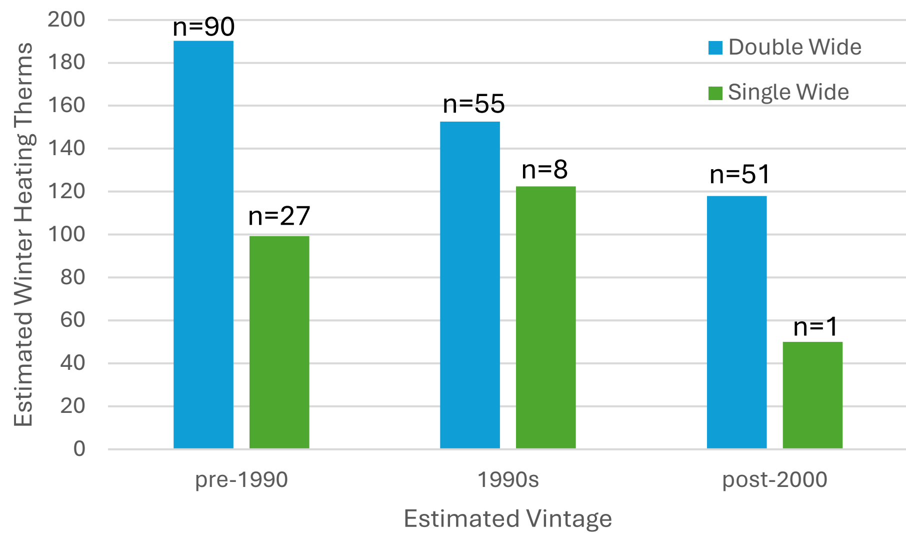

Figure 5: Average estimated gas heating loads by vintage category. Note that the relatively small number of single-wide homes leads to less certainty, but a clear trend is present. Additionally, square-footage can vary particularly among older single-wides, which may account for lower heating loads overall. Finally, trends in apparent electric heating could not be verified but it is possible that older homes utilize this more frequently as well.

Bill Characteristics

Chumash Village is on a SCG GS and PG&E ET rate schedules. These are both rate schedules specifically for master-metered mobile/manufactured home parks with a two-tier (baseline and above-baseline) structure. Both gas and electric rate schedules include non-trivial submeter credits. 15% of residents are on CARE.

Including common loads, approximately 10% of gas usage and 23% of electric usage is above-baseline on an annual basis. Electric above-baseline usage is reasonably evenly distributed across the year, but most above-baseline gas usage appears to be during shoulder months (particularly October/November, when heating usage goes up, but baseline allocations are still low). With

[5] It is well-known that older manufactured homes, particularly pre-HUD code, are less energy efficient, though few studies actually documenting this are available. EIA data (EIA, 2013) shows an 8% drop from pre-1970 to 2000s era mobile homes, but this refers to total site energy. A recent CalNext Study also shows similar differences between 1976 HUD and 1994 HUD manufactured homes (CalNext 2023).

credits and surcharges applied, average gas and electric rates[6] are $1.18/therm and $0.42/kWh. While this average electric rate is up from $0.35/kWh in early 2023, the average gas rate has declined substantially from a high of $4.00/therm in January 2023.

Resident electricity costs are 75% of their non-common load bill despite only making up 25% of their energy usage. An analysis of gas and electric bills at Chumash Village for 1976 HUD and 1994 HUD (estimated vintages) shows that newer homes (1994 HUD) pay 30% less on an annual basis for gas, driven largely by heating loads.

Results - Bill Impacts of Electrification

Possible bill impacts of electrification were analyzed from several different angles, described in the Methods section. Results are presented under several scenarios:

1. Residents remain on a single master/sub meter agreement on PG&E electric rate ET
2. Residents transition to individual meters and switch to an individual rate such as E-ELEC, TOU-C, or 3CE equivalent.

Some form of the latter is generally recommended, but there are pros and cons to both scenarios. Note also that while impacts may vary slightly for residents on CARE, these are not covered here as only 15% of residents are on CARE and the identity of these specific residents was not originally shared for this analysis.

End-Use Specific Impacts

A high-level look at rate schedules and possible costs of specific end-uses is useful when actual usage patterns of individuals are subject to uncertainty. Table 1 shows proportional change in cost by end use for switching from SCG gas to PG&E electric for Chumash Village residents for two rate schedules.[7]

Table 1: Estimated range of fractional increases in cost on a per-end-use basis under two scenarios: 1) if residents kept the PGE ET rats schedule on a Master/Sub agreement, or 2) if they transitioned to an individually-metered framework on E-ELEC. For instance, space heating would increase 1.4 to 2.3 times (40-130% increase) under the existing master meter agreement, and 1.5-1.9 times (50-90%) under an E-ELEC individually metered rate. Note that similar ratios are present under other TOU rate schedules; these data are meant primarily to illustrate the substantial difference in cost between SCG gas and PG&E electricity.

	ET Master/Sub		**E-ELEC Individual Metered**	
	Low	High	Low	High
Cooking	5.7	9.2	5.8	7.5
DHW	1.3	2.1	1.3	1.7
Space Heating	1.4	2.3	1.5	1.9

[6] Non-CARE. Based on current electric and gas rates, using 2023-24 gas commodity rates.
[7] Note that this range is approximate and subject to many factors, including actual equipment efficiencies, fractional baseline/above baseline usage, fixed charges, actual time of use and seasonal usage, changes in occupant behavior etc.

While these increases are large, note that this only represents fuel-switched loads, which on average will represent approximately half the energy usage of a fully electrified residence at Chumash Village. Overall impacts on bills are therefore proportionally lower (see subsequent results). This ratio is of course not static; if January 2023 rates were used in this calculation, fully electrified homes would have spent less on space heating and water heating due to exorbitantly high gas commodity prices.

Average Resident Impacts

Baseline results from the aggregate model are listed in the Energy Usage Characteristics section. Based on these data and assumed post-retrofit efficiencies (see Appendix B), we can estimate an average impact to residents. The benefit to modeling in aggregate is that resident variance is smoothed out and we can achieve an average estimate of post-electrification resident load with a high degree of confidence. However, as previously noted, this approach does not cover the spread of usage among residents (covered in the following section) and particularly ignores outliers.

There are several impacts limiting the cost-effectiveness of electrification even with substantial efficiency gains:

- **Induced above-baseline load**: On an annual basis, baseline (Tier 1) electricity consumption allocation under PG&E's ET rate scheduleis 2,615 kWh. Currently, 47% of Chumash Village residents use less than this amount and their average rate is therefore reasonably low. Most fall close to this threshold and therefore on their current rate schedules some of the added load would be above-baseline usage even with greater all-electric baseline usage allowances. This problem is partially solved by switching rates on an individually metered basis.
- **Fixed rates:** Switching utilities/rates could incur other issues. Currently under SoCalGas, each resident sees approximately $131 in discounts per year due to the submeter credit, or a 21% reduction in annual gas cost (not including common loads). Switching fuels would remove this credit, and if residents moved to an individual metered schedule, they would also lose their current PG&E $0.12 per-dwelling daily credit. Under E-ELEC, this would also incur a $0.49 per-customer daily charge ($15/month). Functionally, this leads to an increase in annual fixed rate charges of approximately $130 (if remaining on master/submeter rate ET) or $340 (individual meters on E-ELEC) per resident. Changes in fixed rate charges/credits would make up half of the increase in resident bills if switching to E-ELEC.

  Under TOU-C, residents would get a baseline credit of $0.11/kWh (up to $41.42/month), which would help offset comparatively higher rates on TOU-C to a degree.

- **Commodity rates:** Current SGC commodity gas prices are quite low both historically and relative to PG&E. Since their peak in 2022-2023, natural gas commodity rates have fallen substantially while electric rates have continued to rise, and so the current cost tradeoff for fuel-switching from SCG to PG&E is not attractive. Substantial increases in gas commodity rates would have to be present for first-year benefits to be positive.

All the above compound the electrification cost-effectiveness challenges for manufactured homes in general within SLO,[8] and Chumash Village has historically paid comparatively little for gas. This set of problems is perhaps particularly unique simply due to SLO's utilities' service territories.

Enrolling in 3CE to achieve slightly lower generation rates will reduce overall cost some. Total bundled rates under 3CE generation charges end up being 17% cheaper (E-ELEC) or 10% cheaper (TOU-C) during the summer. Winter rates are roughly equal. Since Chumash Village does not have substantial cooling loads and ostensibly low peak usage, the effect of switching to 3CE rates is somewhat muted.

Disaggregation of totaled resident data (excluding common loads) suggests that 55% of gas usage is used for space heating, 40% for water heating, and 5% for cooking. Based on assumed efficiencies (referenced in Appendix B), this increases resident electricity usage (excluding common loads) by 81% (an additional 2,350 kWh/year) after full electrification.[9] See Figure 6.

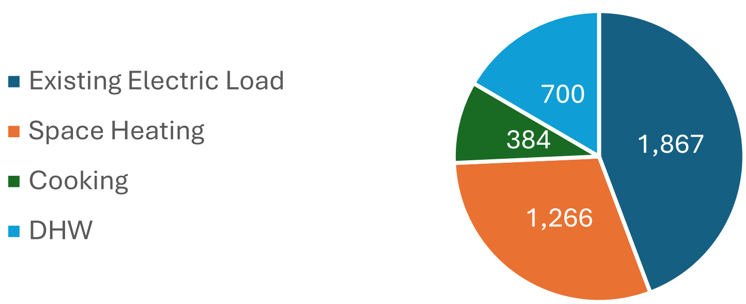

Figure 6: Average electric load composition (kWh) on a per-resident basis post-electrification.

In aggregate, these upgrades would reduce resident site energy consumption from 39.0 MMBTU to 17.7 MMBTU, a reduction of 55%. Under current rate schedules (PG&E rate ET and SCG rate GS) this would increase costs by 45% ($714 on average, annually).[10] Under an E-ELEC rate schedule, with individual meters, overall cost increases are lower ($650 increase, or 41%) since the average rate is somewhat lower than the above-baseline ET rate. Increases in cost are lessened somewhat under comparative 3CE plans ($522 / 33% increase under 3CE E-ELEC; $572 / 36% increase under 3CE TOU-C). Figure 7 shows cost breakdowns of costs under these different rate schedules. Actual cost increases will vary based on time of use.[11]

---

[8] Commodity rates are perhaps more transient and subject to change, but as of early 2024 the CPUC's fixed rate proposal would also have impacts on this calculus (CPUC, 2024).

[9] Note that this estimate is conservative and assumes no induced cooling load because of this addition and doesn't assume any electric space heating energy (of which there appears to be some) is reduced because of retrofits. This also assumes no weatherization work to improve overall efficiency. Finally, this model is most sensitive to cooking energy estimates as there are not efficiency gains to be made here.

[10] This calculation and related calculations in this document include all relevant surcharges and credits and is based off current 2024 PG&E and SCG generation and transmission rates.

[11] As of this writing, current load shapes are unknown and induced load shapes are estimated based on typical DHW, cooking, and space heating load profiles. While impacts to resident loads under an ET rate schedule is straightforward, the impacts under a time-of-use rate schedule like E-ELEC are subject to much more uncertainty.

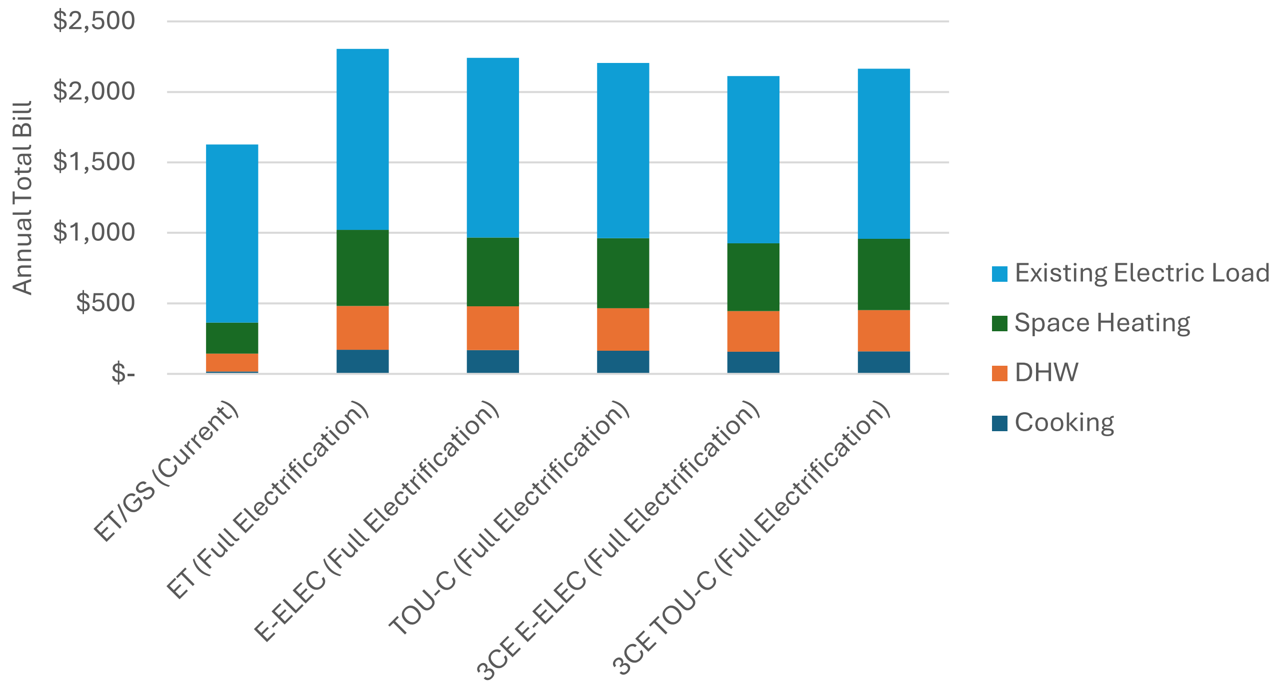

Figure 7: Average per-resident cost breakdown by load for current ET and GT rate schedule, and fully electrified residences (excludes common loads), under both ET and E-ELEC rates. Base charges were applied proportionally across end uses.

Figure 8 shows how these costs would vary seasonally. E-ELEC rates smooth out bill impacts over the course of the year due to the reduced cost of winter off-peak heating. Under a fully electrified ET rate schedule, bill impacts are much more acutely felt in the winter. Above-baseline usage is felt more greatly under higher TOU-C rates in the summer, but winter rates are somewhat lower compared to ET.

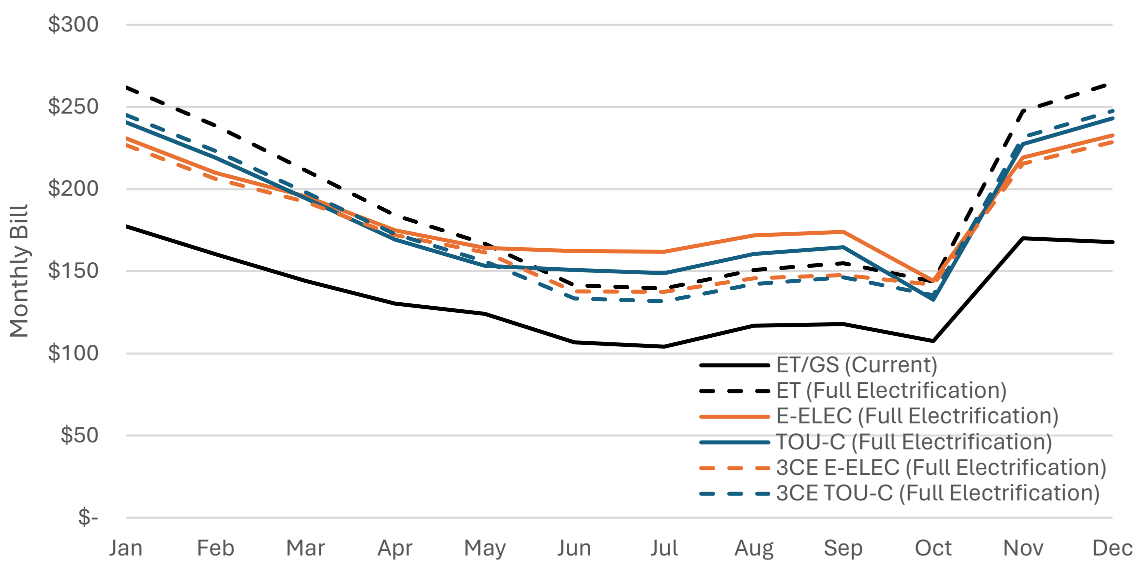

Figure 8: Monthly average per-resident non-common load costs under current dual fuel ET and GT rates, and monthly bill impacts under ET and E-ELEC given a full electrification.

Variance of Resident Impacts

A "traditional" bill analysis was used as a means of disaggregating monthly per-resident gas and electric data as a means of assessing the spread of impacts.[12] This is particularly important since different rate schedules[13] will yield different results for different residents:

- 3-104% under rate ET ($6-$4,696)
- -5-212% under E-ELEC (-$173-$2,429)
- 4-108% under TOU-C ($36-$4,195)
- -10-194% under 3CE E-ELEC (-$463-$1,710)
- 2-100% under 3CE TOU-C ($22-$3,903)

There are clearly different impacts to different residents that vary across rate schedules, and residents would benefit from at least having choices with individual meters (as opposed to not being able to individually choose their rate schedule on a master/submeter arrangement). Most residents (57%) would see the lowest cost increase under TOU-C, compared to 38% under E-ELEC, and 5% under ET. Residents would also typically see slightly lower rates under equivalent 3CE plans (7% lower than PG&E on TOU-C, 22% lower than PG&E on E-ELEC).

In general, residents who would see the smallest (%) increases in annual cost under an E-ELEC rate, are overwhelmingly high electric consumers of electricity already and would benefit from a lower rate. These same residents that would see the greatest (%) increase on an E-ELEC rate are those who benefit from lower baseline rates due to low overall usage (and are impacted disproportionately by fixed charges) and may fare better on a TOU-C rate schedule. This depends somewhat on their gas usage; large winter heating loads exceeding baseline allocations will see higher costs under TOU-C. Figure 9 shows the spread of increases on a percent basis for 3CE rates.

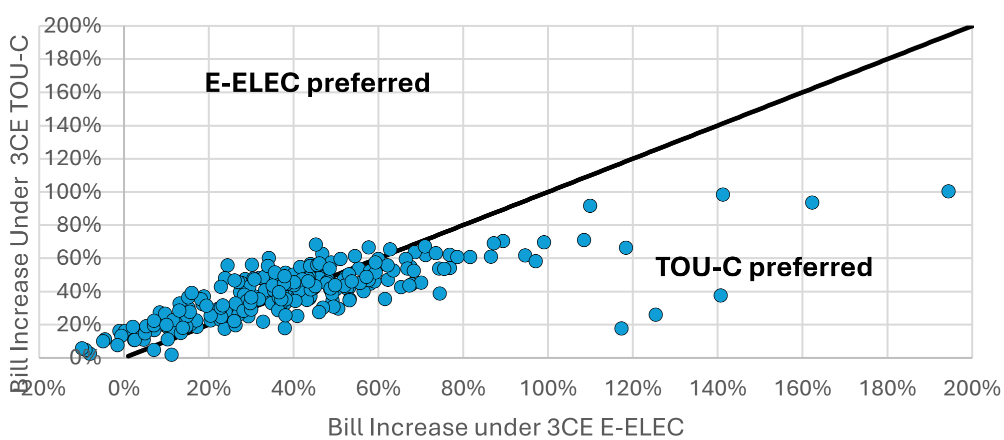

Figure 9: Percent increase in annual bill post-electrification under 3CE rate schedules. Despite different impacts on different rate schedules, most see parity between TOU-C and E-ELEC (or close to it).

---

[12] While there is a high degree of confidence in the spread of results, outliers are present and extremes in both directions should be regarded with less confidence.

[13] Rate schedules like TOU-C (such as TOU-D) were not considered due to their similarity and lack of actual resident load shapes.

Mitigation of Impacts

Two possible strategies should be considered for mitigating bill impacts of electrification: 1) Weatherization of older carriages and 2) Solar to reduce the cost of electrification.

Weatherization of Older and Less Efficient Homes

As previously noted, there is a clear correlation between older carriages (particularly HUD 1976 and pre-HUD) and winter space heating usage for gas. The greatest cost increases are therefore driven in large part by winter gas heating loads, and anything that can be done to mitigate this ahead of time via weatherization will reduce costs, improve comfort and performance, and possibly reduce sizing and up-front costs of equipment. Note that pre-HUD homes may be challenging or impossible to retrofit or weatherize, but this will need to be evaluated on an individual basis.

A market characterization study undertaken by CalNext (CalNext, 2023) showed that proper retrofitting showed consistently greater savings than even new construction replacement and shows 10-20% site savings for weatherization above electrification alone for 1976 HUD homes in hot-dry climate zones.[14]

A calibrated analysis based on prototype models was undertaken to assess the impacts on heating loads at Chumash Village using prototype models from PNNL (PNNL, 2022). These models show a 50% reduction in heating energy for fully electrified homes when comparing 1976 HUD to Tier 2 manufactured home energy conservation standards and represents a reasonable upper limit for weatherization savings. These energy savings would result in up to 623 kWh in savings on average for Chumash Village homes with 1976 HUD or earlier construction (50% of homes). This would reduce added electric load per resident by 27%, and reduce resident energy by 11% annually.

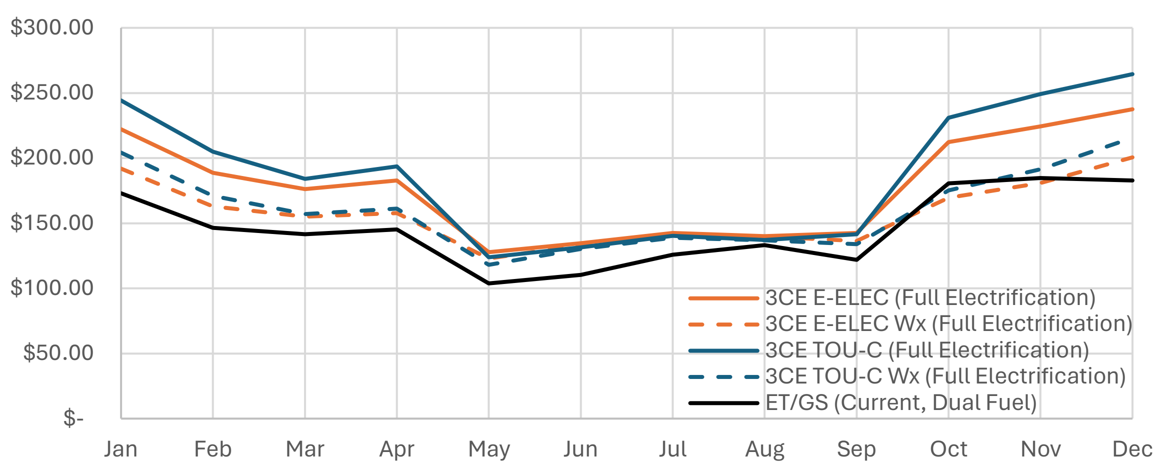

Figure 10: Monthly cost (3CE) with and without weatherization (Wx) based on calibrated models for 1976 HUD homes at Chumash Village. These results were modeled with a reasonable maximum possible weatherization savings.

Compared to electrification without weatherization, this would reduce average annual first-year cost increases by 34% ($239) under 3CE E-ELEC or by 44% ($312) under 3CE TOU-C. 3CE E-ELEC

[14] While other climate zones, including marine, were modeled, the full results were not listed in this report.

would remain the cheapest on average, but reducing above-baseline heating usage has a larger effect on TOU-C. Note that there is still a sizeable gap between current dual-fuel utility costs and that this excludes the 50% of Chumash Village residences that are 1994 HUD or later construction.

In general, weatherization improvements are much more varied than more predictable equipment efficiency improvements, and it is impossible to know how much current gas heating loads present in the monthly data are a function of poorly weatherized home or behavior. On-site assessments and prescriptive approaches for addressing poorly weatherized homes will ensure positive outcomes. In general, the following measures will have the greatest impact and cost-effectiveness for reducing heating and cooling loads in mobile homes:

- Air sealing of attics and crawl spaces, including duct register boots
- Insulation in attics and crawl spaces
- Weather-stripping on windows and doors where absent[15]
- Duct sealing, repair, or replacement
- Siding replacement and exterior air sealing

Targeting measures with the greatest ROI in this manner will allow dollars to go further and reach a greater number of residents. If already doing on-site audits, it may be valuable to assess other low-hanging fruit to reduce resident costs such as LED lighting upgrades, smart power strips, faucet aerators, etc. at the same time to help further reduce resident costs. While effective, much of this work can be expensive and leveraging funding is key. The ACEEE provides a comprehensive guide to possible funding streams in one of their topic briefs (Aimee Bell-Pasht, ACEEE, 2023).

Solar as a Resource

Depending on funding, PV is almost certainly a less expensive option than weatherization for reducing electrification cost impacts. The approach for solar as a resource will depend on the type of metered structure at Chumash Village. Under the current master meter arrangement, public spaces could be solarized to provide a community benefit and offset overall consumption. However, under NEM3.0, excess production would provide little benefit and battery storage is necessary to maximize solar potential. Some residences may also have the option for rooftop solar.

Solarization of Public Spaces

A 2020 proposal by Shorebreak Energy Developers, LLC suggests a maximum solar resource of 500MWH per year on public spaces within Chumash Village (ShoreBreak Energy Developers, LLC, 2020). A similar analysis shows somewhat less (436 MWH annually), due to smaller solar carpark sizing and elimination of less valuable array locations. Figure 11 shows a high-level map of possible solar arrays, and Figure 12 shows the total annual solar resource for each of these sites. Note that the sizing of these spaces is not exact but meant to provide an estimate of the solar resource.

[15] Window replacement may be applicable in some cases, but since SLO is a primarily heating climate zone, ensuring window leakage is limited is far more effective and important than whether windows are double/single pane or the type of glazing. Window replacement should there be limited to situations where there are structural or water intrusion issues.

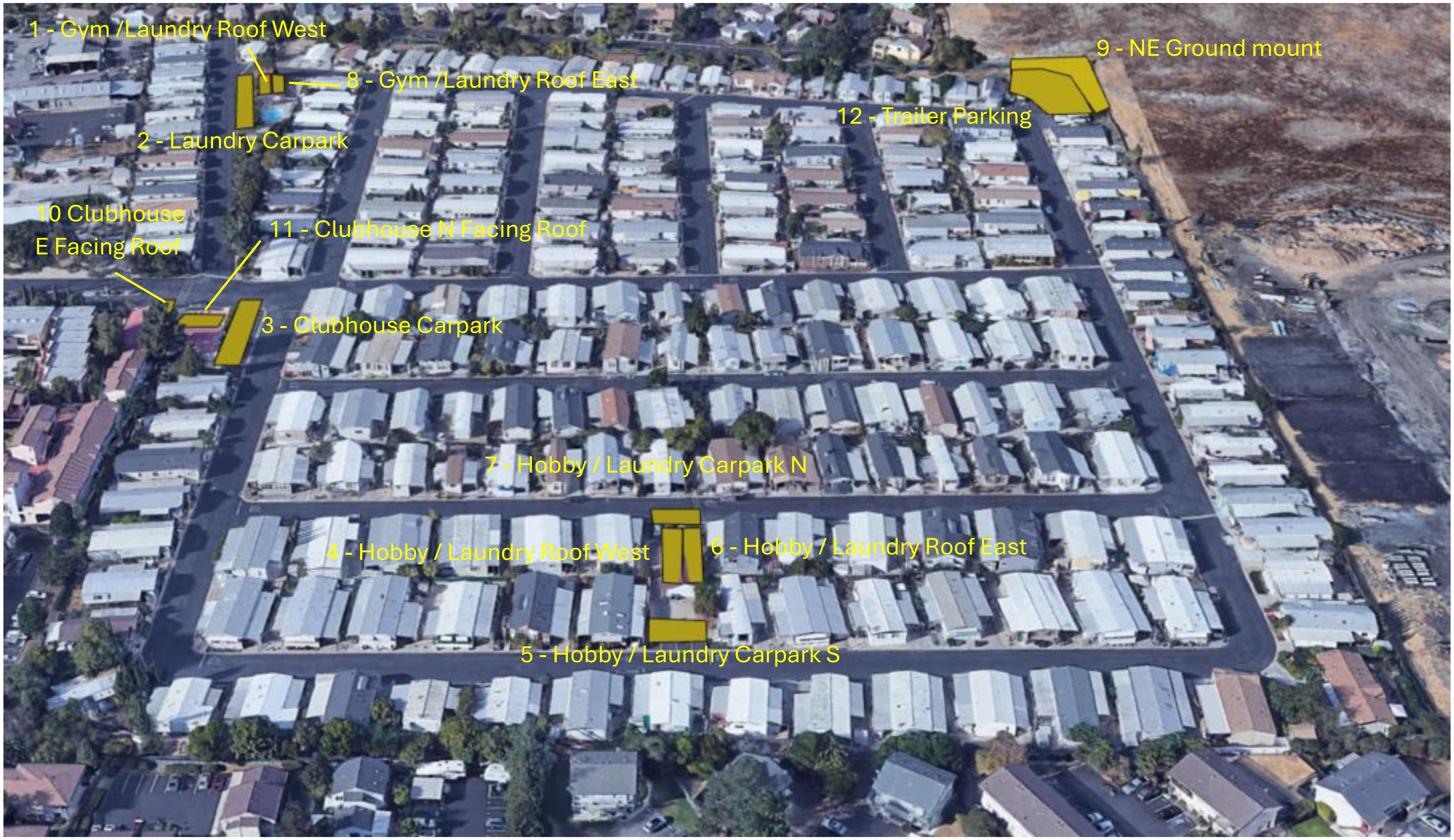

Figure 11: A map of feasible PV arrays in common spaces. The public spaces outlined here are not enough even to meet current site load, but overhead solarization of roadways could be considered as a means of going fully net zero. This would have implications to tenants, but if structures allow for 14 feet of clearance to meet fire code, they should be permissible. Converting certain roads to one-way and perhaps treating these overhead structures as car parks may be an option. This should be further explored to ensure feasibility and support from residents.

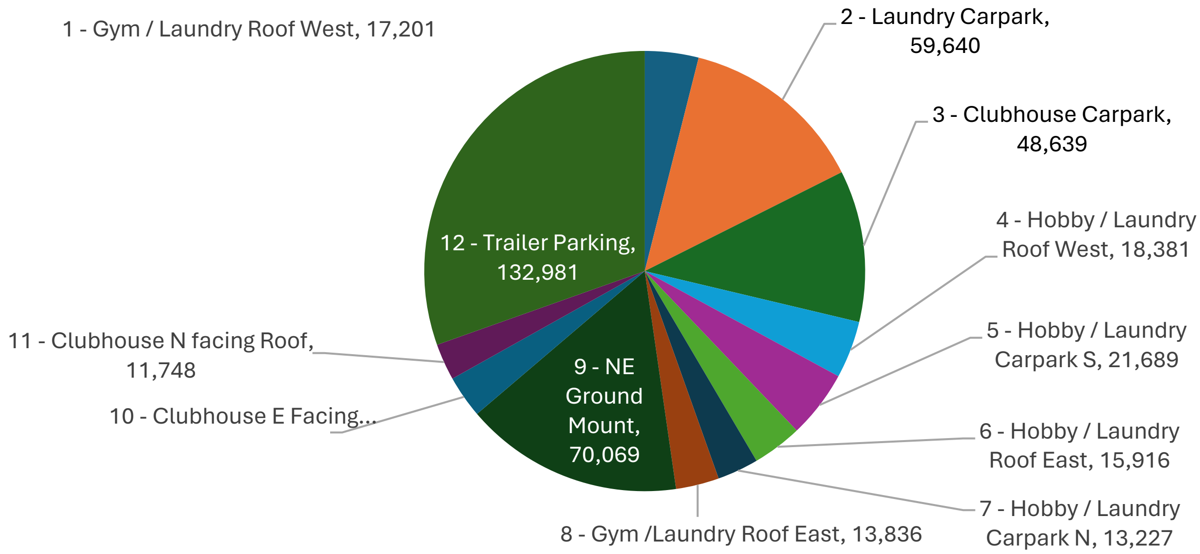

Figure 12: Annual breakdown of PV production (kWh) for various arrays in public spaces.

Cost considerations are highly variable across each of these unique arrays, but the carparks (particularly the larger laundry carpark, #2) and trailer parking area are likely the most attractive due to solar exposure and size of array. Additionally, these provide additional benefits of protection for cars/trailers. Note that arrays #9 and #12 are modeled separately but are functionally one array; the ShoreBreak proposal breaks this out slightly differently but with similar overall sizing. If partial solar development is considered, a staged approach beginning with the lowest cost per watt (installed) is recommended. A full solar proposal should be requested, ideally with cost breakouts by location.[16]

Full buildout of all possible public-space arrays would cover 52% of current electrical loads, or 80% of added load from electrification of residences. This would be sufficient to reduce cost of added load enough to achieve parity with current dual-fuel costs, but recent changes to NEM/VNEM alter the cost-effectiveness of adding solar. A few options should be further explored:

- **Power Purchase Agreement (PPA):** The original proposal from ShoreBreak includes a $0.19/kWh PPA with a good payback period, but this is no longer relevant without battery storage under new legislation. A PPA might be the simplest path forward, and a good fit by reducing upfront costs substantially. Chumash Village should consider getting a new quote from ShoreBreak or another developer to assess if this is a good fit.
- **Self-Consumption:** A second option is to simply size a much smaller array to meet but not exceed demand during peak summer solar hours. This provides the greatest $/kWh of these approaches as it eliminates the need for battery storage but is greatly limited in size. Under a master/submeter arrangement, total loads from both common areas and resident loads could be offset since they feed to the same meter, but with individual meters any self-consumption is limited to common area loads. Appendix C provides a rough analysis of the value of self-consumption given some basic assumptions about load shapes for common load self-consumption. Under an individually metered E-ELEC rate schedule, this analysis

[16] Rooftop solar is often cheaper than ground-mount, but economies of scale associated with these ground-mount systems may outweigh material costs that they incur.

shows an average benefit of $0.41/kWh, with an annual benefit of $19,822 (51 MWh) in the first year (enough to offset the increase in cost from 20 average electrified residences). Under a master/submeter arrangement this value will be much larger, and a time-of-use analysis is recommended to understand the maximum possible sizing of self-consumption.

- **Net Metering (NEM) or Virtual Net Metering (VNEM) 3.0:** Whether NEM or VNEM (now VNBT – Virtual Net Billing Tariff) will apply will depend on the metering structure. Likely, NEM would apply for a master/submeter arrangement like the one currently in place, and the VNBT would apply if a transition to individual meters is realized. In either case, the necessity of battery storage is the same beyond the self-consumption, and overgeneration is credited at the same amount ($0.022/kWh), so the economics are the same. Load-shifting with batteries would increase the $/kWh value (up to over self-consumption by offsetting peak loads, but the exact value will depend on PV and storage sizing.

Ultimately the path forward depends on availability of capital to construct a solar array. Self-consumption is not a permanent solution, but it could be employed prior to future VNEM or a PPA while providing some immediate benefit. It is recommended that Chumash Village get some quotes from developers under both a VNEM and PPA, consider incentives, rebates, and tax credits, and determine if cash flow after any financing is sufficient to offset resident costs incurred by electrification.

Solarization of Resident Roofs

There is limited possible benefit to individual residents via rooftop solar. Nearly all residents have excellent solar exposure with little shade, particularly those with N/S roof faces. Unfortunately, those that would benefit most from solar, due to increased winter heating loads, are likely not good candidates for solar. Pre-1994 HUD homes (estimated to be half of the homes in Chumash Village) do not meet the wind load requirements for solar, may have other structural limitations, and mostly have TPO (Thermoplastic Polyolefin) or other membranous roofs that are challenging to effectively perforate without inducing water leaks.

The remaining homes are likely structurally eligible (see map in Appendix D). Some of these newer carriages have more complex rooflines and perforations (vents, etc) that will make taking full advantage of their solar resource a challenge. Figure 13 shows an example of this.

Figure 13: Example of a newer residence. Despite south-facing aspect and no shade, numerous different rooflines from dormers and other structural elements, as well as numerous vents, significantly limits the space available for rooftop solar

Recommendations and Next Steps

Cost increases in the short term will be incurred if residents pursue electrification, despite the long-term benefits. It is recommended that weatherization for older (1976 HUD and earlier) homes be pursued to limit inequitable cost increases resulting from high winter heating loads. Additionally, since nearly all residents will see cost increases under electrification simply due to the low price of SCG gas, some form of solar generation will need to be utilized to achieve parity with current dual-fuel bills.

Ultimately, there are numerous possible paths forward to get to full electrification, but the ability to absorb operational costs is largely dependent on the availability of current capital since both weatherization and solar will be expensive. In general, a staged approach of phasing out gas on-site may be a viable strategy, but this does limit the ability to absorb costs incurred on electrified residences.

The following recommendations are made based on analysis of the data provided:

- Chumash Village should get a new proposal for a PPA so that capital costs and operational benefits can be accurately understood. Quotes for VNEM (including storage) should be solicited, as this will provide a greater operational benefit than a PPA (but with higher up-front costs).
- Individual metering should be considered, as it provides the lowest cost for residents post-electrification and allows residents to choose rate plans that are cheapest for them. However, this should be balanced with other considerations; giving up master metering limits self-consumption capacity substantially.
- If a master/submetering structure is to be retained in the foreseeable future, exploring self-generation in more detail is recommended. A time-of-use analysis of master meter bills should be undertaken to assess the possible size of PV relying only on self-consumption (with no or limited storage).
- Rooftop solar for individual residents is likely not a viable strategy for most residents but can be pursued for post-1994 HUD homes where cost-effective.
- On-site audits and surveys should be collected to improve information about the site and more adequately assess impacts.
- To limit risk and facilitate learnings, residents participating in the case study should be studied as much as possible. This includes resident surveys, full energy audits, bill analysis, and if possible, submetering of appliances for evaluating performance. Resident education should also be a component of this case study and any future electrification work. This will help encourage good outcomes with residents.
- Chumash Village should pursue funding for weatherization through the IRA or other sources.

Appendices

Appendix A: Methods for Estimating Electrification Impacts

Several modeling approaches were used to estimate bill impacts. Pursuing multiple methods of analysis allows us to get a range of values and evaluate impacts from a few different angles. Utility billing-level data is low-resolution and there is an inherent level of uncertainty in these results. Assumptions for equipment efficiencies are stated in Appendix B.

Individual Meter Data Disaggregation Using CalTRACK: CalTRACK models provide a set of standardized methods for disaggregation of heating and cooling loads for hourly, daily, or even billing data. However, billing data, particularly electric data, has too much variation, including periods of vacancy, for adequate estimates of heating loads to be determined. *Note: Models were run but ultimately this methodology was thrown out due to poor fit and is therefore not used for final calculations*.

Aggregate Resident Meter Data Disaggregation Using CalTRACK: In aggregate, resident variance is smoothed out and the sum of all residents' data can be fit much more accurately to a CalTRACK model. The disadvantage to this is that individual impacts cannot be determined. The advantage is that due to good model fit, we have a good understanding of the average heating and cooling loads on site and can therefore determine average impacts with a greater degree of certainty.

"Traditional" Utility Bill Analysis: Traditional utility bill analysis can still be useful as a semi-manual methodology for estimating heating and cooling loads when only billing data is available (DOE, 2012). This is particularly useful in this setting since California's mediterranean climate allows for easy gas disaggregation, and the relative lack of cooling loads can be conservatively ignored if desired since electrification will decrease any already-present cooling loads via more efficient equipment. This methodology was utilized to determine the spread of impacts and applicable mostly to the section "Individual Resident Impacts"

Calibrated Building Model: To determine possible benefits of weatherization or other energy efficiency measures, a parametric analysis of prototype HUD models was undertaken.

Appendix B: Equipment Efficiency Assumptions

The following tables describe assumed efficiencies for modeled energy use.

Table 2: Pre-existing equipment assumed efficiencies.

End Use	Efficiency	Rationale
Water Heater	0.62 EF	Assumed typical EF of tank gas water heater
Furnace	80 AFUE	Standard efficiency of non-condensing furnaces
Cooking	N/A	Assumed typical 5% of annual energy towards cooking

Table 3: Post-electrification assumed efficiencies.

End Use	Efficiency	Rationale
HPWH	2.9 UEF	Field studies confirm a uniform energy factor (UEF) of 2.9 for 120V water heaters, and typical field efficiencies of 240V water heaters have shown similar UEFs (lower than their rated 3.5-3.7 UEF
Heat Pump (Space Conditioning)	HSPF 10	Expected HSPF for variable-speed heat pump
Cooking	N/A	Assume a 10% reduction in cooking energy. Cooking efficiency depends highly on behavior, and studies are somewhat inconclusive. Most studies suggest a possible 10% reduction in energy use for induction cooking.

Appendix C: Sample Calculations for Common Area Self-Consumption Sizing

Load shapes are currently not provided for common areas, so accurately estimating common area offsets (assuming individual meters, which is likely the best scenario for Chumash Village) is a challenge. However, if we assume that various common area solar arrays can be used to offset aggregate common loads[17] and assume a load shape, we can roughly estimate PV sizing and its benefit.[18]

Coincidentally, the optimal PV size is equivalent to one sized for the main clubhouse carport (51MWh/year). The value of this on an annual basis under current E-ELEC rates is $19,822. On a master/submeter arrangement, the size of this array may be up to five times greater (common loads are only 20% of the total) and there are ample other areas for PV. Figure 14 shows peak production in June to illustrate sizing for self-consumption without storage.

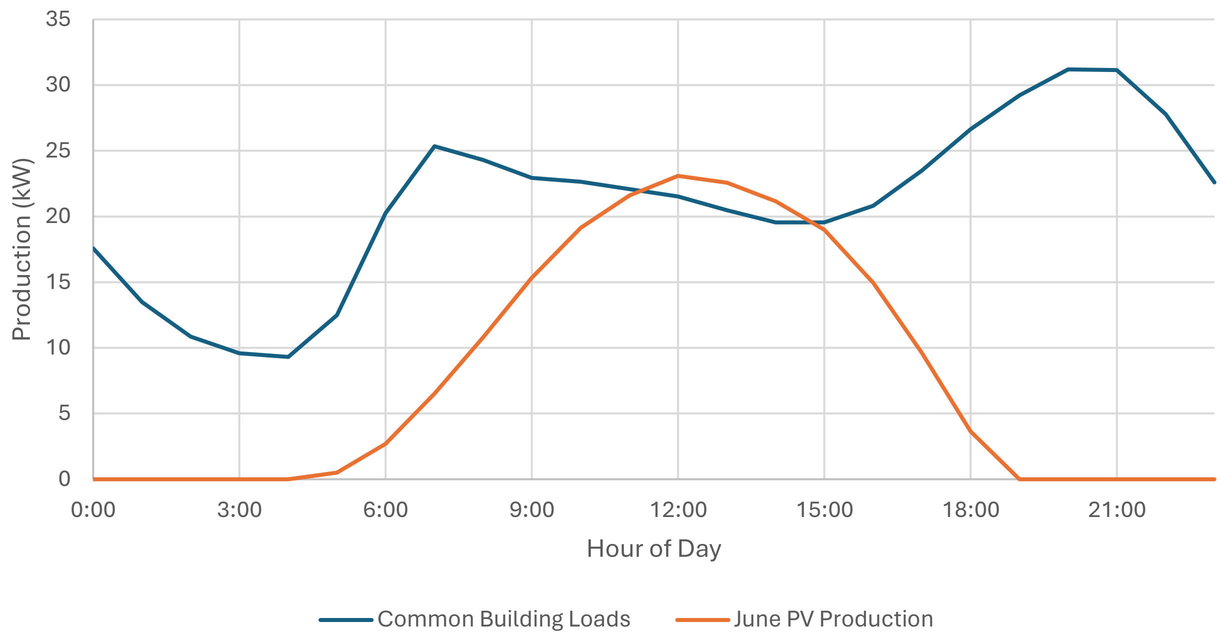

Figure 14: Example consumption and production for an average day in June.

[17] This is a big assumption. Due to the disparate locations of the different buildings, this may be a challenge. The greater the number of common meters, the more arrays that must be constructed and the less benefit they provide by having distinct load shapes.
[18] Note that there are likely operational adjustments that could be made to optimize solar benefit, such as scheduling pool pumps or other equipment around solar peak production.

Appendix D: Rooftop Solar Potential for Individual Residences

The below diagram is a rough identification of homes that may support rooftop solar. It excludes older carriages. All newer carriages identified have adequate solar exposure. Note that an actual evaluation by a solar installer will be required to verify feasibility for rooftop solar.

References

Aimee Bell-Pasht, ACEEE. 2023. *Topic Briefs: Upgrading Manufactured Homes.* https://www.aceee.org/topic-brief/2023/08/topic-briefs-upgrading-manufactured-homes

CalNext. 2023. *"Mobile and Manufactured Housing Market Characterization Study."* https://calnext.com/wp-content/uploads/2023/12/ET23SWE0017_Mobile-and-Manufactured-Housing-Market-Characterization-Study_Final-Report.pdf

CPUC. 2024. "*Proposed Decision Would Cut the Price of Electricity Under New Billing Structure and Accelerate California's Clean Energy Transition.*" https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-flexibility-oir/ab205-pd-032724.pdf

DOE. 2012. *"Weatherization Energy Auditor Single Family Utility Bill Analysis."* https://www.energy.gov/sites/default/files/2016/07/f33/3_utilitybillanalysis_v2.0.pptx

EIA. 2013. *"Residential Energy Consumption Survey."* https://www.eia.gov/todayinenergy/detail.php?id=11731

PNNL. 2022. *Prototype Building Models.* https://www.energycodes.gov/prototype-building-models

Shorebreak Energy Developers. 2020. *"Solar Investment Analysis: Chumash Village HOA."*