CALIFORNIA ENERGY COMMISSION

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix A: Project Challenges and Course Corrections

March 2024 | CEC-500-2024-014-APA-E

APPENDIX A: Project Challenges and Course Corrections

While the project intended go through the process of designing, developing, and deploying zero net energy communities with an eye toward low carbon/zero carbon communities, on all communities, it is important to note that all the communities experienced technical, financial, and timing considerations to align with project timelines. As a result, the project made pivots considering these challenges while ensuring that overall project requirements were achieved. See Table A-1.

Table A-1: Project Challenges and Course Corrections

Challenge	Challenge Description	Ways that Project met Project Requirements
Delays found in typical residential construction	During construction, there are inevitable delays due to challenges when it comes to utility interconnection, permitting, funding, and space limitations.	Used delay down time to investigate additional technologies and envelope measures to further improve energy and non-energy benefits. This additional investigation helped to reduce costs, work alongside trades, and decrease build timeframe. If certain additions were not able to get permitting in a timely manner, those additions were removed from consideration for each of the communities.
Minimizing impact between community developer/builder and its current contractors and supply chain.	As this project was a combination of a technology project, a construction project, and a deployment project, it was important to understand there was considerable pushback from the developer and trades in adopting electric technologies. Some communities had troubles finding trained trade allies to install more energy efficient equipment. Quotes received were also very high for those willing to install the equipment. Lastly, there was challenges with selling all-electric communities, which stalled community occupancy.	Project team and developer/builder explored alternative building envelope measures. The project educated the developer/builder and current contractors on the benefits of electrification. The project also worked with other construction representatives to increase likelihood of adopting electric technologies. Due to supply chain delays, certain technologies planned to be utilized had to be replaced with more readily available ones.

Challenge	Challenge Description	Ways that Project met Project Requirements
Delays Attributed to COVID-19.	Construction of ZNE communities during COVID-19 created unique challenges. Shelter in place ordinances resulted in construction delays, lack of ability and access to install technology and data monitoring devices, increased permitting delays, and slowed occupancy rates. Post COVID-19 also impacted global supply chains, leading to increased cost and material lead times.	As a result of COVID-19 and subsequent supply chain delays, the project did not consider some technologies. Certain data could not be obtained due to state/local access restrictions due to COVID-19.
Limited technology choices due to project requirements.	Grant requirements such as the need to use labor that pays California prevailing wage limited the contractor pool willing to install certain advanced technologies. In addition, advanced technologies typically carry additional upfront costs.	Identified aspects of the community development/construction where prevailing wage were mandatory. Leveraged and identified aspects of the project could be a financial burden of electrification and determined what could be offset by various available incentives. Identified contractors through project team strategic relationships that could assist with finding a trained workforce who were willing to work under prevailing wage.
Data Collection Limitations	California Data Privacy Laws were changed in the middle of the project.	Project team worked with the property manager or homebuilder to have a California Customer-Centric Demand Management Demonstration Program Participation Enrollment Agreement.

Source: EPRI

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Appendix B: Technologies Considered and Implemented as Part of Project's Zero Net Energy Communities

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APPENDIX B: Technologies Considered and Implemented as Part of Project's Zero Net Energy Communities

Table B-1 summarizes the emerging technologies considered and the corresponding lessons learned from all sites when considering these building technologies.

Table B-1: Assessed Building Technologies and Lessons Learned

End-Use Technology	Example Technologies/ Product Assessed	Project Use	Main Lessons Learned
Insulation and Framing			
High Performance Insulation	Aerobarrier Spray Foam Insulation	Used in Fresno, Nightingale, and Mosaic Gardens	Trades familiar if someone pays for costs. With improved insulation needs improved ventilation. Tenants view this as a safety measure "I can't hear what's going on outside."
High Performance Roofs and Attics	Technologies to place ducts in conditioned spaces	Used in Pomona, Nightingale and Belmont	Trades also familiar with this approach. But needs to be designed into architectural plans.
Advanced Stucco	U-Stucco or other products to increase R-value	None	All sites were leery of technology measures that would impact aesthetics.
Advanced Framing Practices	Steel framing and/or 2x6 frames	Used in Pomona; considered in Belmont	Product costs (lumber and steel) were both highly volatile during this project period. Plans of steel were changed back to lumber in Belmont due to steel costs.
Efficient Electrification			
Heat Pumps and Other Advanced HVAC Systems	VRF, central chillers, mini-splits, ductless systems	Used in Belmont, Nightingale, Fresno, Pomona	Trade buy-in still nascent but trades available. Advanced insulation buys down the costs/efficiency needs of advanced HVAC systems. Architects specify advanced HVAC systems in multifamily housing.

End-Use Technology	Example Technologies/ Product Assessed	Project Use	Main Lessons Learned
Heat Pump Water Heaters	Unitary, clustered, or central systems	Belmont (unitary) and Fresno (clustered)	Additional design guides for central systems still needed. Education and training are a barrier.
Cooking	High efficiency electric and induction	Fresno is doing a pilot of induction cooktops. Only Belmont doesn't have electrified cooking.	Strong emotional attachment to gas cooktops caused Belmont to stay with gas cooking as an option even though additional cost for running gas lines to the community would be incurred. Lack of cost-effective ADA compliant products and specialized induction pans were deterrents for rental communities.
Dryers	Heat pump dryers	Irvine	High efficiency condensing or heat pump dryers were not used as dryers for all communities are either: (1) not provided or (2) rented from a supplier.
Distributed Energy Resources and Connected Technologies			
Solar	Rooftop solar, building integrated PV	All sites	Roof space is a main challenge of ZNE. Other advanced solar options (for example, BIPV) deemed to be not very cost effective. Community solar allocation not driven by tax credit or financing requirements in Fresno.
Storage	Battery storage	Pomona and Belmont	Interconnection and storage allocation main challenges in Pomona site. Evaluating CA Title 24 JA12 compliance of battery storage systems in Belmont
Connected HVAC Systems	Smart thermostats and building management systems	Belmont and Fresno	Of high interest in Fresno as VRF system energy

End-Use Technology	Example Technologies/ Product Assessed	Project Use	Main Lessons Learned
			consumption is paid for by FHA
Smart Panels	Lumin, SPAN, or Atom Power	None	Cost effectiveness, trade familiarity, and access to circuit data all deterrents
Other			
Lighting	LED lights, lighting control	All	LED lighting is common and standard.
Windows	High-efficiency double-paned windows	All	Triple-paned windows were not cost-effective. Double paned fairly standard. Tech-nology considered health measure by tenants (less condensation on windowsill).
Refrigerator	ENERGY STAR Refrigerator	All	Some refrigerators that were more efficient excluded from consideration as they were not ADA compliant. Sites preferred single style refrigerator.
Laundry	High efficiency washers	None	Same as Dryer. Washers either: (1) not provided or (2) rented from a vendor. So, influence on washer efficiency is limited.
Plug Loads	Smart plugs/strips/circuit splitters	Considered in Fresno	Fresno is considering procuring circuit splitters during peak times to minimize energy use attributed to washers/dryers.
Circuit Level Monitoring	Sense, or other current transformer-based monitoring	All	Accuracy of data + availability became a challenge because of COVID, lack of reliable wi-fi and occupant privacy concerns.

Source: EPRI

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Appendix C: Monthly Zero Net Energy Community Energy Usage

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APPENDIX C:
Monthly Zero Net Energy Community Energy Usage

Table C-1 shows month over month energy use intensity for the three communities at hand. As described, all three communities exhibit comparable summer and winter energy use numbers, departing from the conventional wisdom that summer electricity use is more important than winter electricity use in California. In Fresno, this pattern is less pronounced than in Pomona and Compton, likely due to differences in climate between the Central Valley and the Los Angeles Basin. The month of highest energy consumption is highlighted for the three communities. Again, Pomona and Compton show substantial similarity, whereas Fresno reveals itself to be an outlier. Pomona and Compton data is derived from circuit monitoring equipment installed by EPRI, while Fresno data is downloaded from the Pacific Gas and Electric (PG&E) website through Green Button. The primary takeaway from observing the energy use intensity (EUI) numbers is the extent to which the Fresno's energy use is an outlier in comparison to the Pomona and Compton communities. Reasons as to why Fresno differs so starkly from Pomona and Compton are currently being investigated.

Table C-1: Monthly Energy Use Intensity (in kWh/sq. ft.) Largest Energy Use Intensity is Highlighted in Yellow

Month	Pomona Community EUI (kWh/sq. ft.)	Compton Community EUI (kWh/sq. ft.)	Fresno EUI (kWh/sq. ft.)
1	0.59	0.62	3.18
2	0.56	0.46	2.97
3	0.49	0.49	2.80
4	0.48	0.38	2.32
5	0.44	0.31	2.35
6	0.42	0.41	2.29
7	0.47	0.47	3.49
8	0.47	0.37	3.35
9	0.46	0.34	2.39
10	0.46	0.36	
11	0.46	0.41	
12	0.57	0.59	

Source: EPRI

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Appendix D: Utility Bill Analysis

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APPENDIX D: Utility Bill Analysis

Table D-1: Net Electricity Bill Statistics by Community

Month	Average Utility Bill, CA Residential Customer	Average Natural Gas Bill, CA Residential Customer	Weighted Average Electricity Bill, Pomona	Weighted Average Electricity Bill, Compton	Common Load Electricity Bill, Normalized by Apartments, Fresno
January	$152	$ 103	$46	$74	$324
February	$123	$ 78	$45	$34	$259
March	$122	$ 60	($13)	$20	$183
April	$126	$ 43	($16)	($15)	$93
May	$117	$ 40	($33)	($39)	$74
June	$131	$ 35	($60)	($19)	$75
July	$176	$ 30	($52)	($13)	$68
August	$215	$ 28	($57)	($42)	$224
September	$204	$ 29	($34)	($28)	$214
October	$129	$ 34	($13)	($14)	
November	$125	$ 75	$10	$16	
December	$131	$ 117	$48	$69	

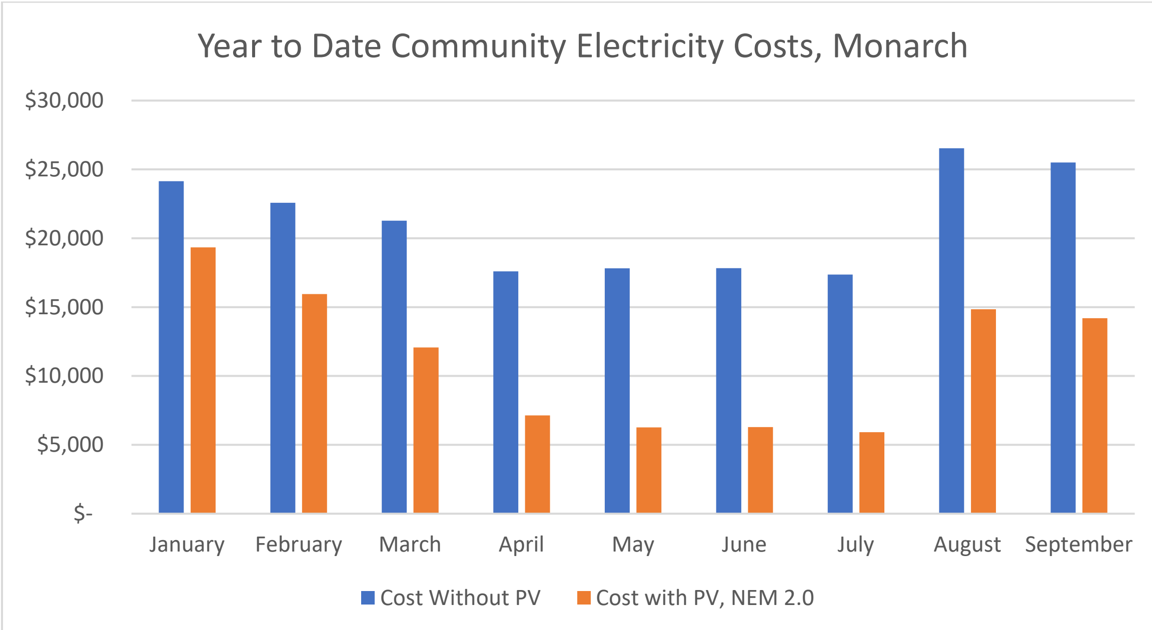
Source: EPRI

For Fresno, only common area loads are considered. Average utility bills are based on electricity and natural gas residential sales data from the Energy Information Administration.[1]

Table D-1 shows month over month utility bill numbers for three of the communities within the study. As a benchmark, the average electricity bill for a residential customer in California is also listed in the first column (U.S. Energy Information Administration, 2023). Note that this average bill likely skews high for a typical apartment, as single-family homes remain the most common housing unit type in California. Therefore, the average bill for apartments is likely lower than what is shown.

[1] 2022. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. U.S. Energy Information Administration (EIA) State Energy Data System. U.S. Energy Information Administration.

Figure D-1: Community Electricity Costs (per Month) Without and With Solar



Source: EPRI

The Fresno community's result highlights the importance of matching on-site PV generation or rates to reduce elevated electricity costs due to electrification (Figure 4). With substantial reductions observed, especially in the summertime, interconnection of the 170-kW rooftop PV system is estimated to result in a 56 percent reduction in electricity bills.

Table D-2: Estimated Annual Electricity Bill at Fresno. Actual Bill in Yellow

PG&E Tariff	Estimated Annual Electricity Bill, Monarch
E-1	$195,990.00
E-TOU-C	$189,670.00
E-TOU-D	$173,500.00

Source: Pacific Gas and Electric

Results from this project also emphasize the importance of tariff selection to energy burdened customers (Table D-2). At the Fresno community, an 11 percent reduction in annual electricity bill is feasible through tariff optimization. In addition, as NEM 3.0 is adopted, it will be more and more important to consider ways to use a system approach – matching efficiency and building electrification benefits with right-sized solar and battery storage. Electrical and thermal storage enabled through batteries as well as connected HVAC and heat pump water heating systems can also maximize local renewable energy.

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Appendix E: Community Load Shape Analysis

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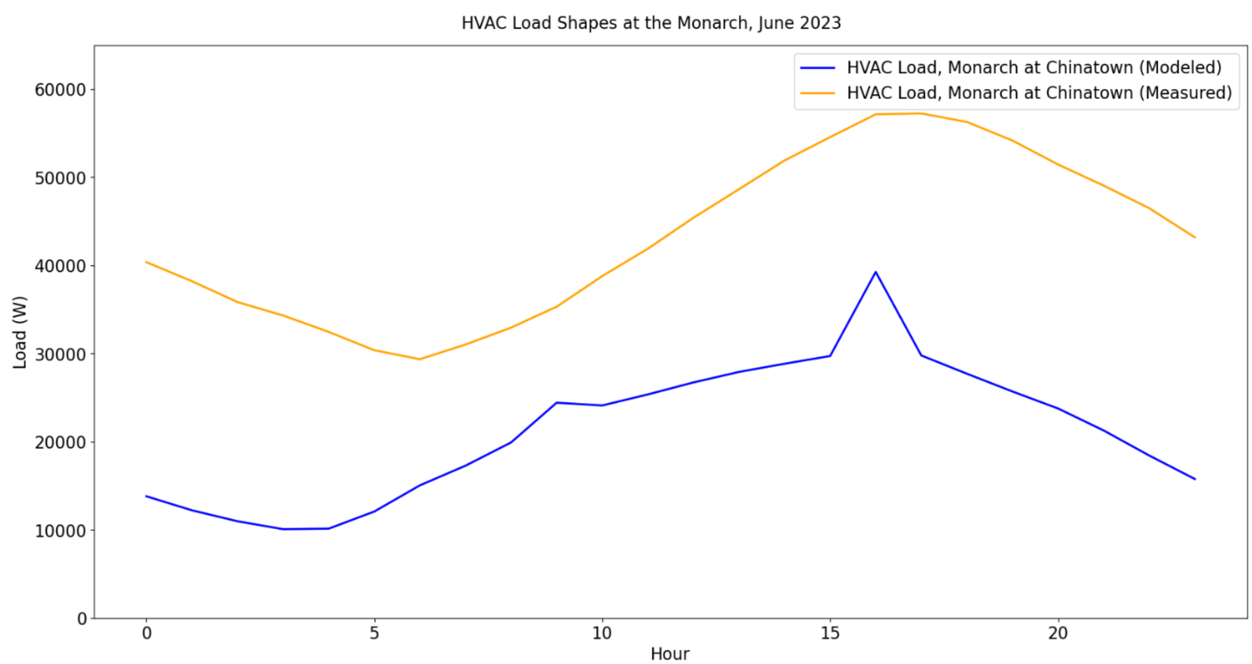
APPENDIX E:
Community Load Shape Analysis

Performance of Centralized Energy Systems in Fresno

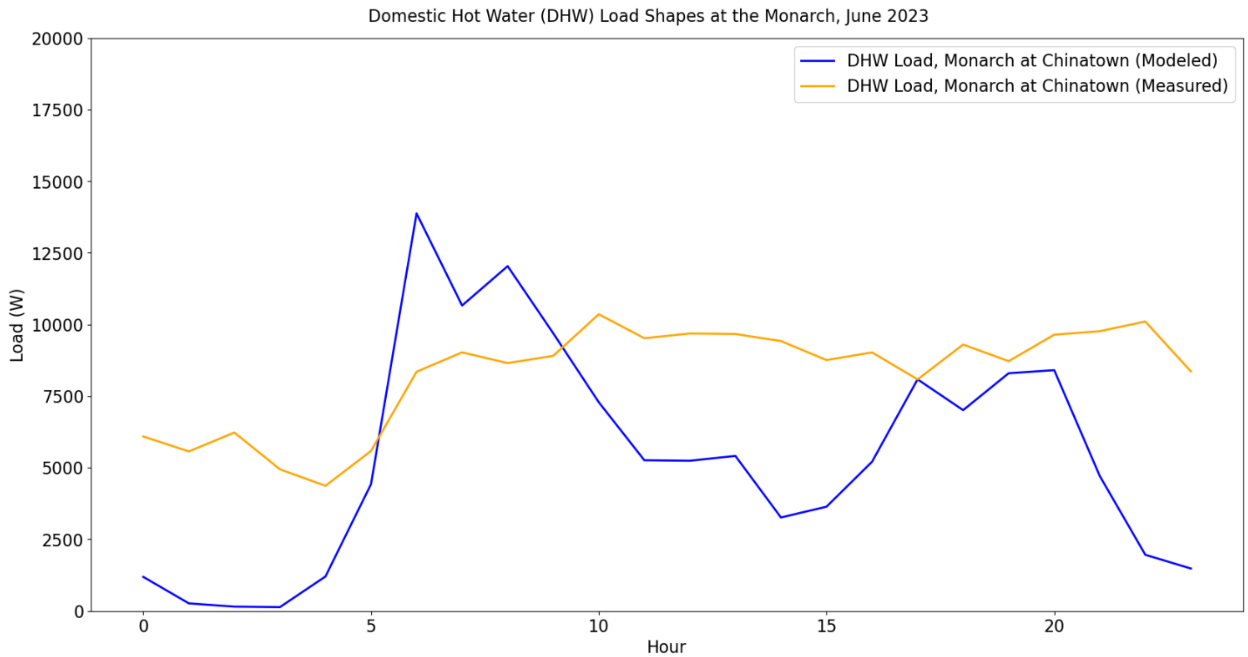
Figure E-1 shows the average HVAC modeled and measured load shapes in Fresno for June 2023. The most notable conclusion from this graph is that the model significantly underestimates actual HVAC energy use. The team is currently investigating this inconsistency. So far, possible reasons for this inconsistency include (a) limitations of physics based energy models when it comes to modeling VRF operation under certain conditions such as low-load and overload conditions, (b) the inherent inability of models to properly capture behaviorally driven loads, such as HVAC, (c) differences in thermostat setpoints between the model and actual operation, and (d) differences in ventilation requirements between 2017 (year the model was developed) and 2023 (year of operation).

Figure E-1: HVAC Load Shapes at Fresno for June 2023, Estimates versus Actual



Source: EPRI

Figure E-2: Water Heating Load Shapes at Fresno for June 2023, Estimates Vs. Actual



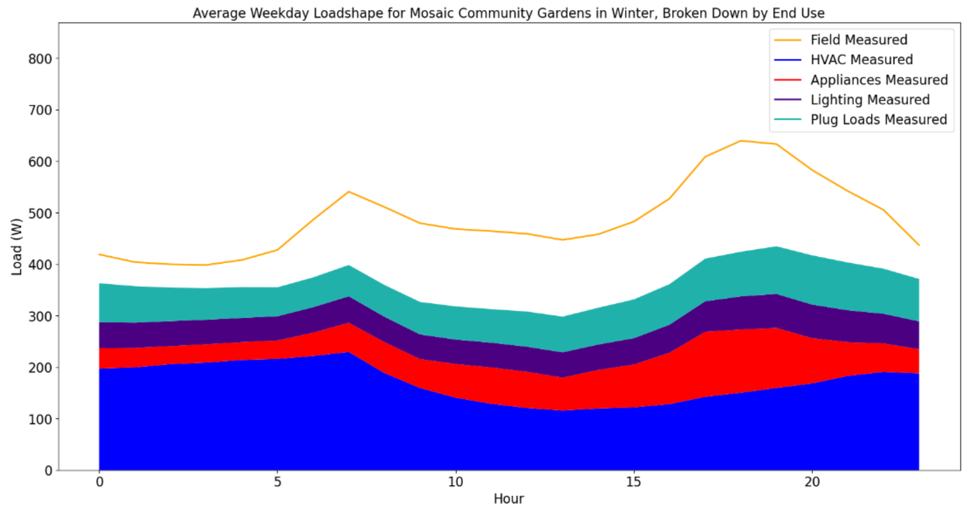
Source: EPRI

The water heating load shape shown in Figure E-2 is more aligned with the HVAC load shape, meaning that for June mismatches in HVAC energy use between modeled and measured explain mismatches in overall energy use. Differences in modeled and measured load profiles can be attributed to limitations of energy models in properly representing load diversity. Although the outcome of this comparison is not as worrisome as that of the HVAC comparison, these conclusions are weakened by the fact that this is summer data. Further winter data would be useful for reinforcing these conclusions.

Peak Drivers

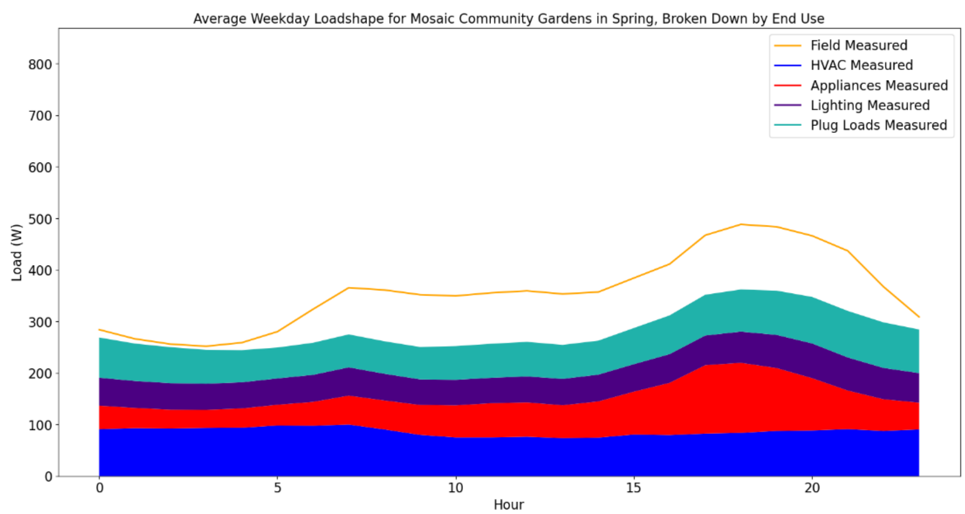
End-use load shapes at Pomona (Figures E-3 through E-6) confirm the previously established trend of peaks driven by heating and cooling depending on the season, with heating driven peaks being more pronounced on average. Interestingly, appliances appear to be secondary peak drivers as well.

Figure E-3: Average Load Shape at Pomona, With end Uses (Winter)



Source: EPRI

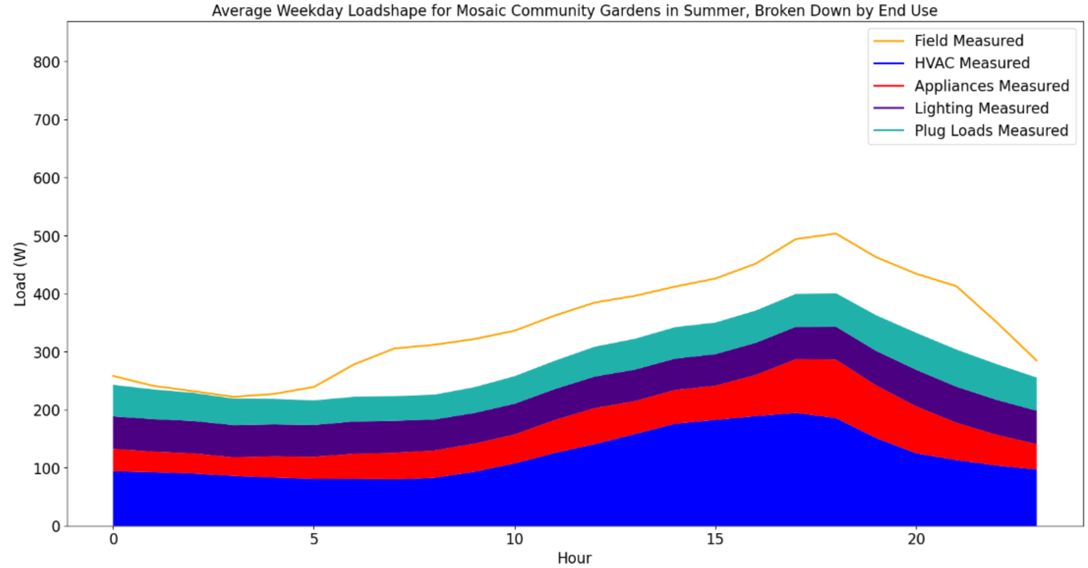
Figure E-4: Average Load Shape at Pomona, With end Uses (Spring)



Source: EPRI

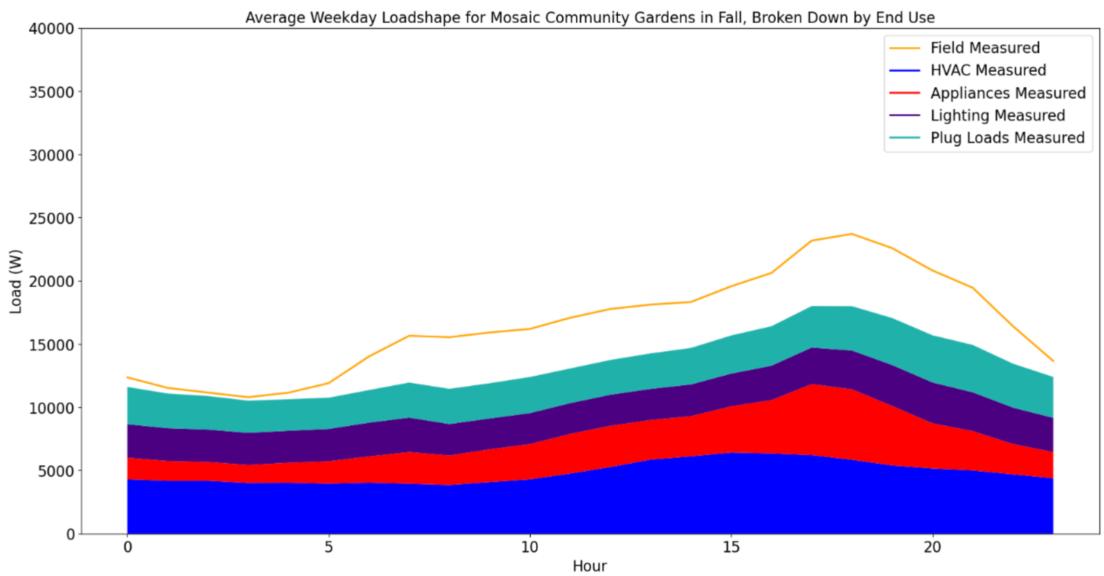
Figure E-5: Average Load Shape at Pomona, With end Uses (Summer)

Figure is a line graph showing field measured, HVAC measured, appliances measured, lighting measured, and plug loads measured. The x axis is hours and the y axis is load in watts



Source: EPRI

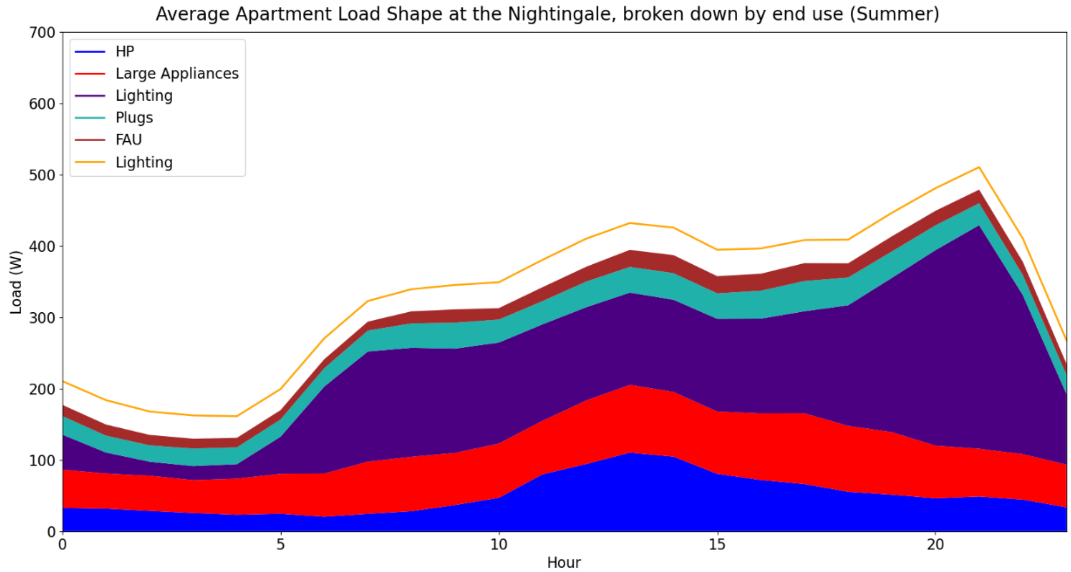
Figure E-6: Average Load Shape at Pomona, With end Uses (Fall)



Source: EPRI

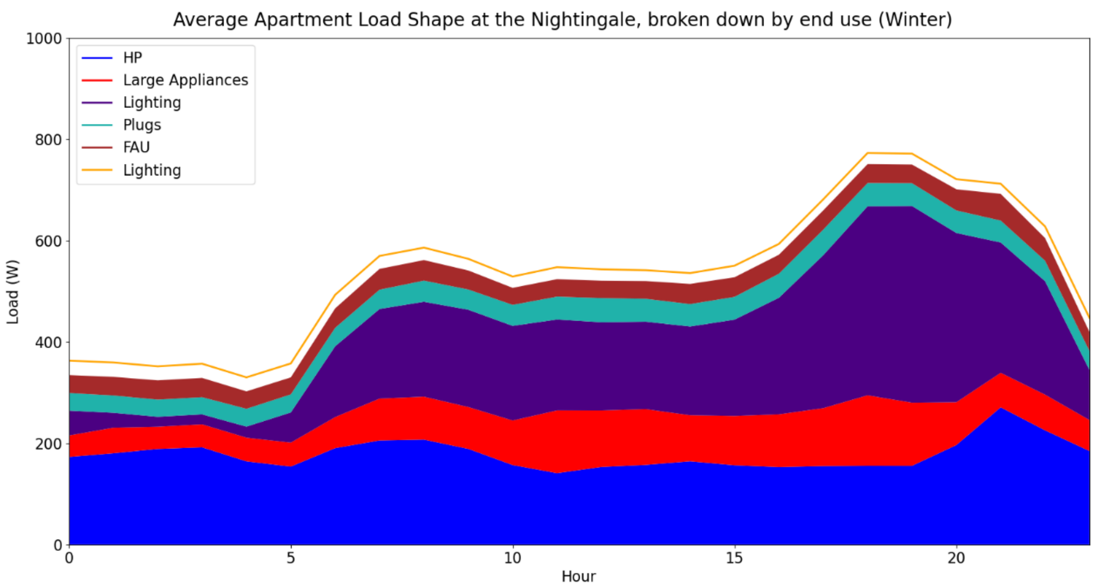
The Compton community's load shape (Figure E-7 and E-8) is notably driven by lighting. This peculiarity may be a result of the demographically unique nature of the Compton community's residents, a portion of whom were formerly unhoused individuals. Thus, generalized models of loads that drive average peaks may not be applicable to all types of subsidized housing. However, an examination of the largest peaks to occur within the representative year reveals that the largest peaks (in absolute terms, not on average) are still primarily driven by heating.

Figure E-7: Average Load Shape at Compton, With end Uses (Summer)



Source: EPRI

Figure E-8: Average Load Shape at Compton, With end Uses (Winter)



Source: EPRI