



April 29, 2026

# End-Use Load Research Commercial Energy Metering Study – Final Report

Prepared For NEEA:

David Clement, Sr. Program Manager

Aaron James, Survey Data Analyst

Ben Spearing, Survey Program Manager

Prepared By:

Christopher Williams, Senior Engineer

Brad Hoover, Principal Consultant

Kevin Cracknell, Principal Consultant

DNV

1999 Harrison Street, Suite 2150

Oakland, CA 94612

*By accessing or downloading any Content from NEEA's Sites, you acknowledge and agree you read, understand, and will comply with NEEA's [Privacy and Terms of Use](#) and further understand NEEA retains all rights of ownership, title, and interests in the Sites and Content. You may not share, sell, or use the Content except as expressly permitted by NEEA's [Privacy and Terms of Use](#) without NEEA's prior written consent of its [legal counsel](#).*

©2026 Copyright NEEA

Northwest Energy Efficiency Alliance

PHONE

503-688-5400

EMAIL

[info@neea.org](mailto:info@neea.org)



## Table of contents

1	A NEW GENERATION OF LOAD RESEARCH .....	1
2	THE DATA .....	3
2.1	Rooftop unit (RTU) load .....	3
2.2	Heat pump (HP) load .....	5
2.3	Electric resistance heat (ERH) load .....	5
2.4	More ways to visualize loads .....	6
3	PUTTING CEMS DATA TO WORK .....	8
3.1	Increasing efficiency .....	8
3.2	Forecasting future demand .....	8
3.3	Managing peak demand today and tomorrow .....	9

## List of figures

Figure 2-1. RTU summer vs. winter average weekday .....	4
Figure 2-2. RTU temperature sensitivity.....	4
Figure 2-3. HP summer vs. winter average weekday.....	5
Figure 2-4. HP temperature sensitivity .....	5
Figure 2-5. ERH summer vs. winter average weekday .....	6
Figure 2-6. ERH temperature sensitivity .....	6
Figure 2-7. Example of EnergyPrints visualizing actual and normalized HP loads .....	7

## List of tables

Table 1. CEMS participant building type, square footage, and HVAC type totals .....	2
Table 2. CEMS data analysis outputs .....	3



## 1 A NEW GENERATION OF LOAD RESEARCH

For over 30 years utility planners in the Northwest have relied on the load shapes of electric end uses developed through the pioneering End-Use Load and Consumer Assessment Program (ELCAP). ELCAP was conceived in 1983 and conducted over the subsequent decade. The project metered hundreds of homes and commercial buildings, tracking over three years the consumption of specific building end uses and pairing that data with building characteristics to define load shapes for a number of types of buildings in different circumstances. ELCAP was initiated to support “conservation assessment and load forecasting missions.” Knowing how appliances and systems are being commissioned and operated in the real world—the shape of the load they place on the electric grid—provides the necessary baseline from which to design effective energy efficiency programs or accurately predict future grid demands. The load shapes derived from ELCAP data informed utility planning for decades.

Indeed, in the decades since the ELCAP research, those load shapes have been used for a growing number of planning efforts. Utility and regulators are pursuing more energy efficiency programs. Demand response has created a new class of energy programming, one which relies heavily on assumptions about end uses. Load forecasting and planning has become both more critical and more complex as the Northwest, the country, and the world shift transportation and heating load onto the electric grid. At the same time, end uses have undergone vast technological change, market interventions have changed the way energy is consumed, and climate change has altered weather patterns and, in turn, heating and cooling load. Weather-dependent load shapes from three decades ago do not reliably reflect today’s climate.

In short, the need for utility planning has become more pronounced, and the data we use for that planning less and less accurately reflects contemporary electricity consumption.

In the face of this growing disconnect, a collection of public and private utilities, research firms, and federal agencies<sup>1</sup> partnered with the Northwest Energy Efficiency Alliance (NEEA) in 2016 to launch a successor to ELCAP. The \$12.5 million End-Use Load Research (EULR) project collected data on selected electric end uses in both residential and commercial buildings from 2020 – 2025.

The commercial component of the EULR, the Commercial Energy Metering Study (CEMS), collected representative high frequency energy consumption data for key heating, ventilation, and air-conditioning (HVAC) end uses in commercial office and retail buildings. Specifically, CEMS collected 1-minute interval energy data for rooftop units (RTUs<sup>2</sup>), heat pumps (HPs), and electric resistance heating (ERH). CEMS also monitored and collected 15-minute indoor temperature, heat pump supply air temperature, and whole building advanced metering infrastructure (AMI) data. To complement CEMS data, NEEA conducted four Commercial Building Stock Assessments (CBSA) between 2003 and 2020, collecting detailed information on building characteristics and installed equipment. While CEMS collected data from a sample of 70 sites, the CBSA data can help project CEMS data across the region.

CEMS targeted HVAC equipment because of that end use’s dynamic evolution in recent decades, its direct relationship to changing weather patterns, and the expectation that commercial customers will continue to adopt electric HVAC equipment and transition away from gas. Heat pumps, in particular, are increasingly common in the Northwest, representing a generational opportunity to increase efficiency and sustainability and support state climate goals. The increased load on the electric grid, however, poses meaningful challenges for which the ELCAP data of the 1980s is increasingly unsuited. Among its many possible uses, CEMS data allows us to derive new normalized load shapes that illuminate the weather-dependent,

---

<sup>1</sup> This group is: Avista Utilities, Bonneville Power Administration, Building Technologies Office - U.S. Department of Energy, Clark County PUD, Energy Trust of Oregon, Eugene Water & Electric Board, National Renewable Energy Laboratory, Northwest Power & Conservation Council, PacifiCorp, Portland General Electric, Puget Sound Energy, Seattle City Light, Snohomish PUD and Tacoma Power

<sup>2</sup> For the purposes of CEMS, RTUs include packaged systems that use direct expansion for space cooling but do not include an electric space heating load i.e., circuits designated “RTU” do not include heat pumps. RTU space heating is typically served by a gas furnace but RTUs may also include cooling only units.



commercial electric HVAC loads of the future. CEMS-derived load shapes offer utility planners an essential upgrade as they embrace the opportunity and mitigate the potential challenges of increased electrification.

Table 1 presents the final CEMS building participant count by HVAC type and building size across the office and retail sectors, respectively. Note that some sites utilize more than one type of HVAC system. As a result, the sum of the different HVAC type columns is greater than the total participant column.

**Table 1. CEMS participant building type, square footage, and HVAC type totals**

Building type & site sq. ft.	Sites w/ RTU	Sites w/ ERH	Sites w/ Heat Pumps	Total Participants
<b>Office</b>				
<10,000 sq. ft.	2	2	6	7
10,001 – 20,000 sq. ft.	5	7	7	10
20,001 – 100,000 sq. ft.	13	16	10	18
>100,000 sq. ft.	3	7	4	8
<b>Retail</b>				
<10,000 sq. ft.	3	2	0	4
10,001 – 20,000 sq. ft.	6	6	7	10
20,001 – 100,000 sq. ft.	10	6	2	11
>100,000 SQ. FT.	2	0	0	2
<b>Office and retail totals</b>	<b>44</b>	<b>46</b>	<b>36</b>	<b>70</b>

## 2 THE DATA

DNV analyzed the CEMS data to produce actual and weather-normalized load profiles for each sampled site, and for each region of the Northwest, by year and for the entire metering period, and for each end use by building type. In short, DNV’s Load Research System can produce any custom analysis and output, producing broadly or narrowly defined load shapes: the load shape for RTUs in retail buildings or the load shape for RTUs in retail buildings of less than 100,000 square feet in Idaho between the hours of 12:00pm and 8:00pm.

Once derived, these load shapes can be visualized in various ways. Table 2 presents a list of analysis outputs (8,760 or metering period) for individual sites and for aggregate load profiles by sector and technology. Aggregate profiles are provided by building type as well as study-wide. We weather normalized the individual site-level data and the aggregate sector-level data.

**Table 2. CEMS data analysis outputs**

Analysis data streams	Site analysis	Across sample analysis	Weather-normalized
Individual channel data	•		•
Whole facility load <sup>3</sup>	•		•
<b>Technology loads (metered only)</b>			
Electric resistance heating	•		•
Heat pump heating	•		•
Heat pump cooling	•		•
RTU	•		•
<b>Technology expanded<sup>4</sup> loads</b>			
Electric resistance heating	•	•	•
Heat pump heating	•	•	•
Heat pump cooling	•	•	•
RTU	•	•	•
Overall heating load	•	•	•
Overall cooling load	•	•	•
Technology normalized to sq. ft.	•	•	•
Technology normalized to Dd	•	•	•
Technology as percent of total	•	•	•
Achieved statistical error		•	•

The next three sections offer examples of broad load shapes, charting mean averages for the three primary end uses metered by CEMS, reflecting summer versus winter demand and demand relative to outdoor temperature.

### 2.1 Rooftop unit (RTU) load

While an RTU has some base winter ventilation load, its primary electric load is cooling, with gas heating, so the peak electric load occurs during summer months. This seasonal shift is visible in Figure 2-1 which charts average RTU weekday demand for summer and winter, actual and weather normalized. As is common with cooling loads, demand peaks in the late afternoon.

That same late afternoon peak is visible in Figure 2-2, which presents average RTU demand by various temperature gradients, starting with temperatures up to 25°F (Bin 25), then between 26 and 35°F (Bin 35), and so on up to temperatures

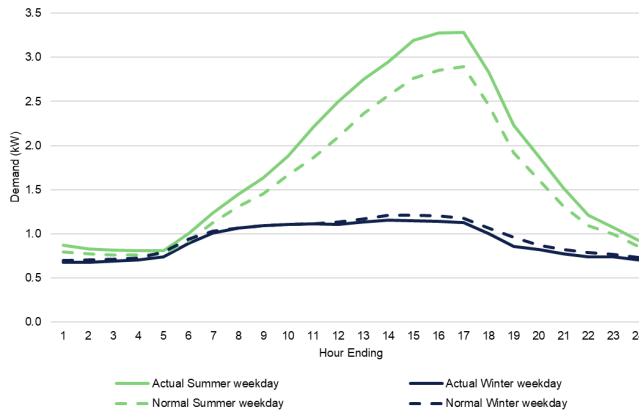
<sup>3</sup> Whole facility load analysis uses a different expansion approach (weight set is different from technologies) because DNV was unable to obtain whole facility loads for all sample points

<sup>4</sup> “Expanded” includes estimating the full load for each technology at a site when within-site sampling was used and estimating the regional technology load.

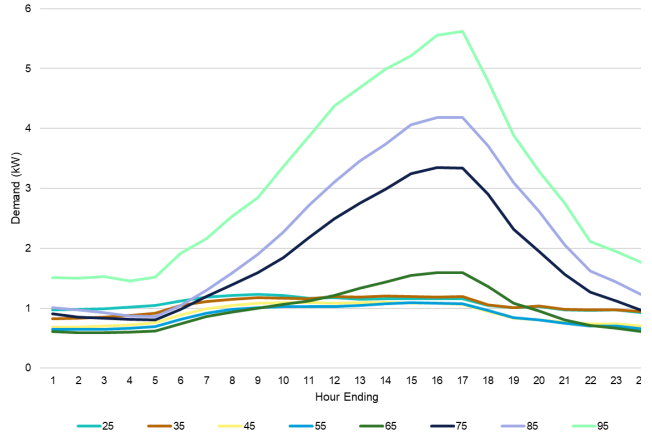


over 85°F in Bin 95. This chart illustrates how higher temperatures increase demand, but also how weather clustering across the CEMS data set can refine peak demand estimates.

**Figure 2-1. RTU summer vs. winter average weekday**



**Figure 2-2. RTU temperature sensitivity**

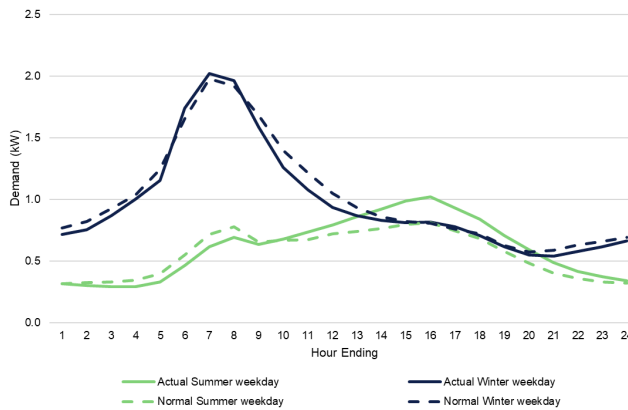


## 2.2 Heat pump (HP) load

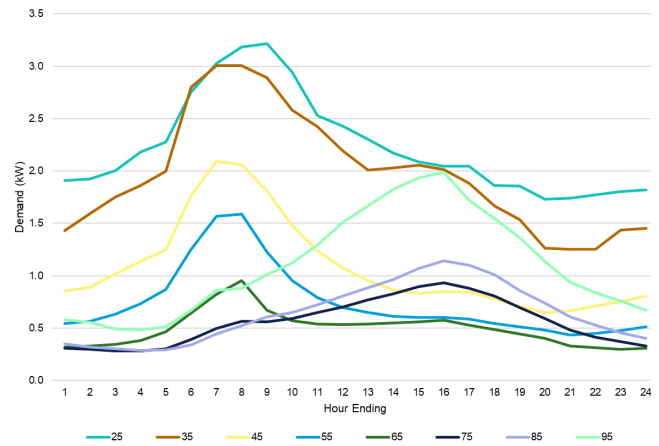
HPs are used for heating and cooling, and load is highest on cold mornings with late afternoon summer load about half to two-thirds that of winter. Figure 2-3 presents a comparison of the average HP weekday demand during the summer and winter months. HP load is greatest in winter morning hours, where the peak is more than double the off-peak demand. Summer weekday demand sees an early morning bump and a late afternoon peak.

Figure 2-4 presents the change in HP load by temperature gradients, starting with up to 25°F (Bin 25) and continuing to greater than 85°F (Bin 95). Again, demand peaks on cold mornings, but also swells on hot afternoons. Comparing to the RTU load shape, the HP summer peak is two-thirds less than the respective peak for RTU. Both figures show the winter heating demand and temperature sensitivity starts to drop briefly between five and nine PM, when many retail and office buildings go into setback temperature mode.

**Figure 2-3. HP summer vs. winter average weekday**



**Figure 2-4. HP temperature sensitivity**

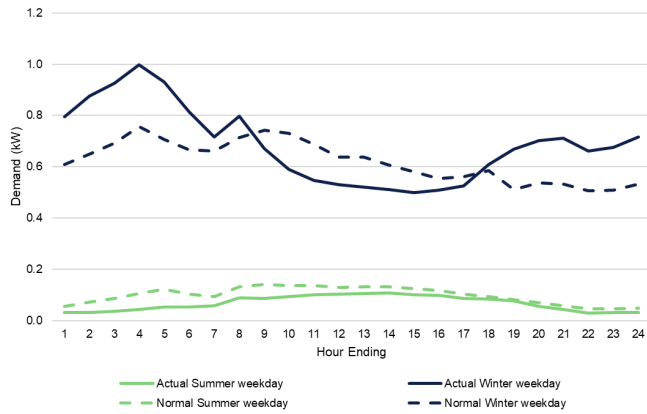


## 2.3 Electric resistance heat (ERH) load

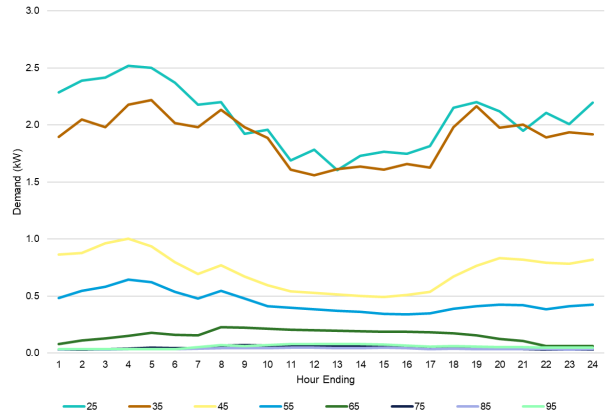
Since ERH does not provide cooling, it has a very modest load in the summer, with demand increasing in the colder winter months, as seen in Figure 2-5, which charts the average ERH weekday demand during summer and winter months, actual and weather normalized.

Figure 2-6 presents the actual average ERH by temperature gradient. Load grows steadily as temperatures drop into the mid-thirties but doubles at the lowest temperatures. A semidiurnal pattern with a morning and evening peak is also present.

**Figure 2-5. ERH summer vs. winter average weekday**



**Figure 2-6. ERH temperature sensitivity**



## 2.4 More ways to visualize loads

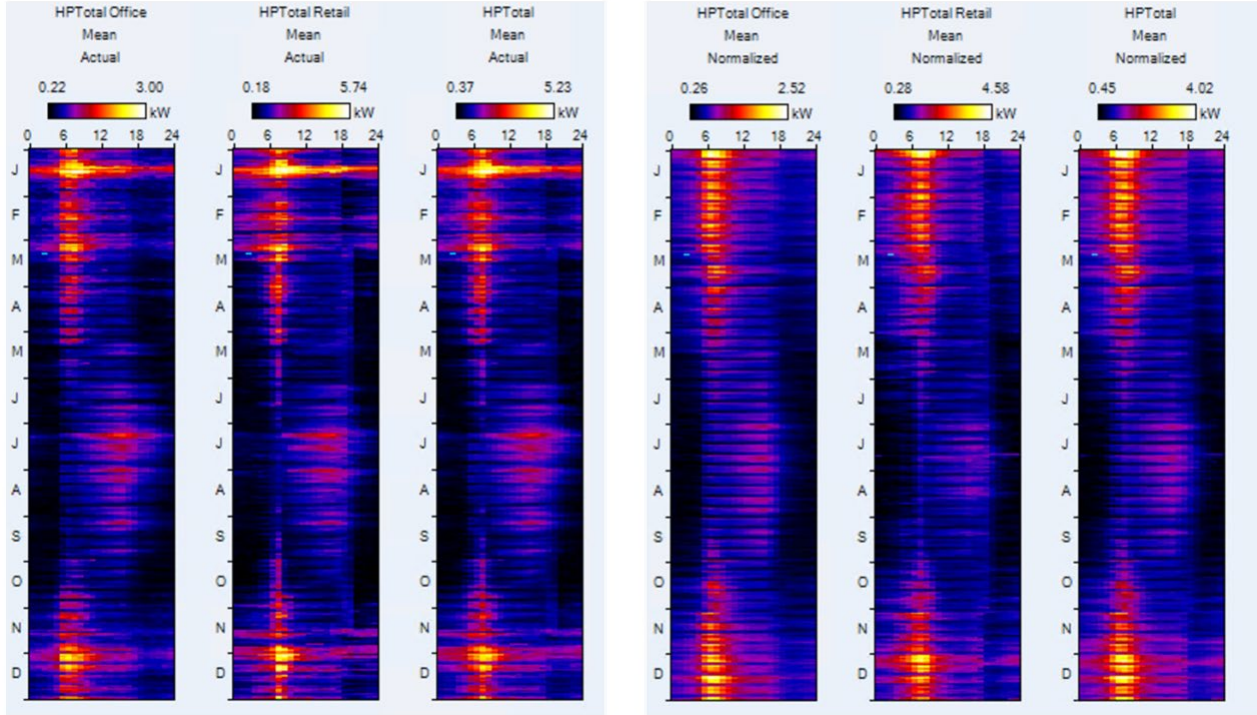
An EnergyPrint like the example shown in Figure 2-7 uses a color gradient to show granular load data. The day of year is presented on the y-axis with the earliest date on the top of the figure. The time is on the x-axis with the 24 hours of the day broken into 6-hour intervals. Low levels of demand are shown in the black-blue spectrum, and high levels of demand in the yellow-white spectrum. The brighter the color, the higher the demand. Each EnergyPrint has a scale at the top or to the far left. The EnergyPrint provides an overarching perspective on the data and time-differentiated usage.

This example shows HP load data from 2023 – 2024. HPs, which provide both heating and cooling, show activity throughout the year, though in warmer months use is highest in the afternoon and during cold months demand typically peaks in the morning, a trend visible as you look down the EnergyPrint, which starts in July. A cold snap in January 2024 shows up in the EnergyPrints of actual load as a stark yellow line—heating demand persisting around the clock even in commercial spaces for several days. EnergyPrints of normalized load are less crisp, reflecting the intentional generalizing inherent in normalizing the data.

Figure 2-7. Example of EnergyPrints visualizing actual and normalized HP loads

### Actual Load

### TMYx Normalized Load



### 3 PUTTING CEMS DATA TO WORK

Utilities and other stakeholders can use the wealth of data captured by CEMS to prepare for and facilitate an increasingly electrified future. While CEMS was conducted for the primary benefit of stakeholders in the Northwest, its 15-minute end-use data is available free to the public and can support energy efficiency and load forecasting goals around the country and the world. One-minute end-use data is available to project funders and others who pay for access.

Accurately estimating energy efficiency impacts requires real-world data showing how different technologies are used at different times of day, in different weather, in different building types, and in different contexts. CEMS data allows a high-resolution assessment of the load shapes of key HVAC technologies in common commercial buildings, empowering planners to more confidently identify and pursue efficiencies, providing a more reliable forecast of the future load on the grid, and helping design programs that can manage and mitigate the challenges posed to the grid by increasing electrification.

#### 3.1 Increasing efficiency

CEMS data provides high-resolution load shapes of key HVAC end uses, the kind of load shapes that energy efficiency programs rely on to predict energy efficiency impacts. Updating the Northwest's decades-old data allows program planners to pursue efficiency opportunities with more confidence and clarity. A program could more confidently and pragmatically design a HP rebate, for example, using contemporary, real-world load shapes than outdated or theoretical data.

The wealth of data from CEMS's 70 sample sites also provides ground-truth load shapes that can be used to identify new and specific efficiency and retro-commissioning opportunities among much larger populations. Utility planners could, for example, identify a load shape correlated with a specific end-use scenario, search for that load shape across their entire service area using widely-available AMI data, and then verify and refine their model's accuracy using CEMS-derived load shapes. Using CEMS data to facilitate both broad and narrow searches in this way, program staff can better target recruitment and, ultimately, help meet state-mandated and other sustainability and resiliency targets.

One targeted example: The residential component of the EULR project (Home Energy Metering Study [HEMS]) found that some HP controls are programmed to minimize customer callbacks instead of energy performance, with inefficient back-up heaters set to cycle on during mild weather, undermining expectations of HP efficiency. Following up on this HEMS finding, we found evidence of a similar issue at commercial sites. Program staff could use CEMS data to serve as ground truth data to help refine a model that, using available AMI data from their larger commercial customer base, efficiently identifies customers with this issue—customers to whom program staff could offer retro-commissioning to increase the efficiency of their HPs.

On a broader scale, CEMS data can illuminate efficiency opportunities that are currently invisible. Utilities often do not know, for example, which end uses commercial buildings of less than 100,000 square feet are using for heating and cooling. With the signatures developed with CEMS data, program staff could more confidently identify customers using gas end uses or less efficient ERH and recruit those customers for conversion to electric and/or more efficient measures.

With years of load data, CEMS provides a rare opportunity to efficiently and confidently pursue electrification at a critical moment. Of course, as we succeed in shifting more heating demand onto the grid, we increase the demands on and risks to that grid—another serious challenge for which CEMS data provides a powerful tool.

#### 3.2 Forecasting future demand

As increased electrification adds strain to the grid, load forecasters and planners preparing for the future need to understand how load shapes will persist or change in the coming years and decades. HVAC loads are especially dynamic, as new technologies are fundamentally shifting the way we heat and cool our buildings. HVAC load tomorrow will look very different



than it does today. Using CEMS data, forecasters and planners can more accurately project the effects of large-scale changes across their service areas. For example, CEMS did not meter gas use, but the study did collect ventilation and cooling equipment for gas-heated buildings. Comparing those load shapes to similar buildings that are heated electrically can provide load planners with a picture of the increased electric demand if one, ten, or a hundred such buildings switched from gas to electric heat. Combined with the Commercial Building Stock Assessment NEEA has collected over the previous two decades, planners can prepare for the grid impacts of this kind of electrification.

As load planners prepare for an increasingly electrified future, they are also preparing for increasingly frequent and extreme peak demand events. Demand response programs that help blunt the impact of peak events will also be able to make use of the powerful CEMS data.

### **3.3 Managing peak demand today and tomorrow**

As more HVAC load shifts onto the electric grid, the nature, timing, and extremity of peak demand also shifts. Increasingly frequent extreme weather events are already producing costly surges in demand, straining the grid and driving up expenses for utilities and ratepayers. While CEMS was gathering data, in January 2024, the Northwest experienced these impacts directly. During the extreme cold snap, wholesale rates increased dramatically as utilities in the region faced adequacy and fuel shortages, importing power and resorting to all back-up supplies. This event is starkly visible in the CEMS data.

While the more reliable HVAC load data provided by CEMS gives forecasters and planners increased confidence as they project and prepare for the next extreme weather event, that same data can also help refine demand response programs that can more actively manage peak events. These programs incentivize customers to allow utilities to adjust their HVAC equipment during a peak event—cycling a cooling unit off, for example, to shed demand during a heat wave. Relatively new, demand response programs are still discovering how their projected demand impacts match up to their actual impacts. The rich portrait of actual use provided by CEMS data can help refine the accuracy of those forecasts and also guide program design. Understanding how customers are programming their HP thermostats, the setpoints they are using for ERH, how they are adjusting their use during extreme events like the January 2024 cold snap, can all help identify demand response opportunities. Lowering peak demand protects our increasingly critical electric grid and reduces costs for everyone.

The more effective demand response programs become, the more load planners can trust that the grid will not be overwhelmed by peak events. Indeed, the effects of improved efficiency program, load planning, and demand response programs are complementary and fundamentally linked. CEMS data can strengthen every link in that chain.

The CEMS-derived load shapes are a powerful tool, but the full CEMS data set is an unmatched resource for future analyses.



## **About DNV**

DNV is an independent assurance and risk management provider, operating in more than 100 countries, with the purpose of safeguarding life, property, and the environment. Whether assessing a new ship design, qualifying technology for a floating wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to manage technological and regulatory complexity with confidence. As a trusted voice for many of the world's most successful organizations, we use our broad experience and deep expertise to advance safety and sustainable performance, set industry standards, and inspire and invent solutions.



# Commercial Energy Metering Study (CEMS) - 2025 Analysis Report

Northwest Energy Efficiency Alliance (NEEA)

Report No.: Final

Date: December 31, 2025





## Table of contents

1	INTRODUCTION.....	1
2	METHODOLOGY.....	2
2.1	Load data sources	3
2.1.1	On-site metering	3
2.1.2	AMI data collection	5
2.2	Metering sample	5
2.3	Assumed population	6
2.4	The EnergyPrint	9
3	LOAD ANALYSIS.....	10
3.1	Site-level analysis	10
3.1.1	An example of site-level analysis	11
3.1.2	Within-site sampling and expansion	13
3.1.3	Site-level end use summary	14
3.1.4	More site-level observations	17
3.2	Weather normalization	22
3.3	Across facility analysis	25
3.3.1	Case weights	25
3.3.2	Site-level events influence extrapolated results	26
3.4	12-month analysis	29
3.4.1	ERH load	30
3.4.2	HP load	39
3.4.3	RTU Load	49
4	LOAD SHAPE OUTPUT SUMMARY.....	57
4.1	Load shape outputs	57
	APPENDIX A. WEATHER NORMALIZATION OF RESULTS.....	A-1
	APPENDIX B. RATIO ESTIMATION FRAMEWORK.....	B-1
	APPENDIX C. TECHNOLOGY END-USE ASSIGNMENT.....	C-1
	APPENDIX D. CAPACITY ASSIGNMENT.....	D-1
	APPENDIX E. WITHIN-SITE EXPANSION.....	E-1
	APPENDIX F. FIELD METER QUALITY CONTROL AND COMMISSIONING.....	F-1
	APPENDIX G. SITE ANALYSIS QUALITY CONTROL AND ASSURANCE.....	G-1
	APPENDIX H. ACTUAL AND NORMAL WEATHER STATION SELECTION.....	H-1
	APPENDIX I. KEY ENERGY AND DEMAND CHARACTERISTICS PER FACILITY.....	I-1
	APPENDIX J. KEY ENERGY AND DEMAND CHARACTERISTICS – TOTALS.....	J-1



## List of tables

Table 2-1. Final achieved sample .....	6
Table 2-2. Office and retail population estimates .....	7
Table 2-3. Office and retail square footage estimates .....	8
Table 3-1. Analysis outputs .....	10
Table 3-2. Site 18080, HVAC unit detail .....	11
Table 3-3. Office sector case weight development .....	26
Table 3-4. Retail sector case weight development .....	26
Table 3-5. Key energy & demand characteristics: office ERH .....	37
Table 3-6. Key energy & demand characteristics: retail ERH .....	38
Table 3-7. Key energy & demand characteristics: office HPs .....	47
Table 3-8. Key energy & demand characteristics: retail HPs .....	48
Table 3-9. Key energy & demand characteristics: office RTUs .....	55
Table 3-10. Key energy & demand characteristics: retail RTUs .....	56
Table C-1. RTU end use descriptions .....	C-1
Table C-2. HP end use descriptions .....	C-2
Table C-3. ERH end use descriptions .....	C-3
Table C-4. Other end use descriptions .....	C-4
Table C-5. non-HVAC end use descriptions .....	C-5
Table H-1. Weather stations by Site ID .....	H-1
Table I-1. Aggregate electric resistance heat – means .....	I-1
Table I-2. Office electric resistance heat – means .....	I-2
Table I-3. Retail electric resistance heat – means .....	I-3
Table I-4. Aggregate heat pump – means .....	I-4
Table I-5. Office heat pump – means .....	I-5
Table I-6. Retail heat pump – means .....	I-6
Table I-7. Aggregate roof top units – means .....	I-7
Table I-8. Office roof top units – means .....	I-8
Table I-9. Retail roof top units – means .....	I-9
Table J-1. Office + Retail RTU totals .....	J-1
Table J-2. Office + Retail HP overall totals .....	J-2
Table J-3. Office + Retail HP Cool totals .....	J-3
Table J-4. Office + Retail HP Heat totals .....	J-4
Table J-5. Office + Retail ERH totals .....	J-5
Table J-6. Office + Retail Other totals .....	J-6
Table J-7. Office RTU totals .....	J-7
Table J-8. Retail RTU totals .....	J-8
Table J-9. Office HP Overall totals .....	J-9
Table J-10. Retail HP Overall totals .....	J-10
Table J-11. Office HP Cool totals .....	J-11
Table J-12. Office HP Heat totals .....	J-12
Table J-13. Retail HP Cool totals .....	J-13
Table J-14. Retail HP Heat totals .....	J-14
Table J-15. Office ERH totals .....	J-15
Table J-16. Retail ERH totals .....	J-16
Table J-17. Office Other totals .....	J-17
Table J-18. Retail Other totals .....	J-18

## List of figures

Figure 2-1. Overview of analysis approach .....	2
Figure 2-2. Complex metering site .....	3
Figure 2-3. Installations by quarter.....	5
Figure 2-4. Full final sample locations.....	6
Figure 2-5. EnergyPrint example.....	9
Figure 3-1. RTU EnergyPrints for Site 18080.....	12
Figure 3-2. DHP EnergyPrints for Site 18080 .....	12
Figure 3-3. Individual HVAC unit loads: average weekday .....	13
Figure 3-4. Within site expansion – RTU example .....	14
Figure 3-5. ERH: Office sector .....	15
Figure 3-6. ERH: Retail sector .....	15
Figure 3-7. HP total load: office sector .....	16
Figure 3-8. HP total load: retail sector.....	16
Figure 3-9. Roof top unit loads: offices.....	17
Figure 3-10. Roof top units: retail sector .....	17
Figure 3-11. Backup strip heat on HP during mild weather (site 19036, green = HP load, blue = backup ERH, orange = outdoor temperature) .....	18
Figure 3-12. Building HVAC response to COVID “shutdown” (medium office site 18080 in Oregon).....	19
Figure 3-13. Building HVAC response to COVID “shutdown” (medium office site 21241 in Washington).....	20
Figure 3-14. Building HVAC response to COVID “shutdown” (small office site 22697 in Washington).....	21
Figure 3-15. Example of weather normalization.....	23
Figure 3-16. Actual versus normal temperature: Portland International Airport.....	24
Figure 3-17. Extreme temperature swings in actuals .....	25
Figure 3-18. Small Retail RTU profiles; site specific .....	28
Figure 3-19. Small Retail RTU Aggregate, Mean .....	28
Figure 3-20. Medium office site D_20167 and medium office RTU mean aggregate.....	29
Figure 3-21. ERH: actual across facility (actual load in orange, actual weather in red) .....	30
Figure 3-22. ERH: normalized to TMYx (load in blue, weather in red) .....	31
Figure 3-23. ERH: average weekday by month (actual in blue, normal in orange) .....	32
Figure 3-24. ERH: office sector (actual in orange, normal in blue).....	33
Figure 3-25. ERH: retail sector (actual in orange, normal in blue) .....	33
Figure 3-26. ERH average load .....	34
Figure 3-27. ERH summer vs winter average weekday .....	35
Figure 3-28. ERH temperature sensitivity .....	36
Figure 3-29. ERH: average weekday load (actual in orange, normal in blue).....	39
Figure 3-30. HP: actual across facility (actual load in orange, actual weather in red).....	39
Figure 3-31. HP: normalized to TMYx (load in blue, weather in red).....	40
Figure 3-32. HP summer vs winter average weekday.....	41
Figure 3-33. HP temperature sensitivity.....	42
Figure 3-34. HP: zoomed-in total demand versus temperature (actual load in orange, normal load in blue, actual weather in red).....	43
Figure 3-35. HP: average weekday by month (actual in orange, normal in blue).....	44
Figure 3-36. HP load duration curve .....	44
Figure 3-37. HP total load: office sector (actual load in orange, normal load in blue).....	45
Figure 3-38. HP total load: retail sector (actual load in orange, normal load in blue).....	45
Figure 3-39. RTU: actual across facility (actual load in orange, actual weather in red).....	49
Figure 3-40. RTU: normalized to TMYx (normal load in blue, normal weather in red).....	50
Figure 3-41. RTU actual and normalized: estimated total load .....	50
Figure 3-42. RTU actual versus normal: estimated mean load .....	51
Figure 3-43. RTU summer vs winter average weekday .....	52
Figure 3-44. RTU demand by temperature bin.....	52
Figure 3-45. RTU: Difference between summer and winter loads (actual load in orange, normal load in blue, actual weather in red).....	53
Figure 3-46. RTU load: office sector (actual load in orange, normal load in blue).....	53
Figure 3-47. RTU load: retail sector (actual load in orange, normal load in blue) .....	54
Figure G-1. Data processing workflow: Script interactions and support functions* .....	G-1
Figure K-1. Aggregate ERH average weekday (actual in orange, normal in blue).....	K-1



Figure K-2. Aggregate ERH average weekend (actual in orange, normal in blue).....	K-2
Figure K-3. Office ERH average weekday (actual in orange, normal in blue).....	K-3
Figure K-4. Office ERH average weekend (actual in orange, normal in blue).....	K-4
Figure K-5. Retail ERH average weekday (actual in orange, normal in blue).....	K-5
Figure K-6. Retail ERH average weekend (actual in orange, normal in blue).....	K-6
Figure K-7. Aggregate heat pump average weekday (actual in orange, normal in blue).....	K-7
Figure K-8. Aggregate heat pump average weekend (actual in orange, normal in blue).....	K-8
Figure K-9. Office heat pump average weekday (actual in orange, normal in blue).....	K-9
Figure K-10. Office heat pump average weekend (actual in orange, normal in blue).....	K-10
Figure K-11. Retail heat pump average weekday (actual in orange, normal in blue).....	K-11
Figure K-12. Retail heat pump average weekend (actual in orange, normal in blue).....	K-12
Figure K-13. Aggregate RTU average weekday (actual in orange, normal in blue).....	K-13
Figure K-14. Aggregate RTU average weekend (actual in orange, normal in blue).....	K-14
Figure K-15. Office RTU average weekday (actual in orange, normal in blue).....	K-15
Figure K-16. Office RTU average weekend (actual in orange, normal in blue).....	K-16
Figure K-17. Retail RTU average weekday (actual in orange, normal in blue).....	K-17
Figure K-18. Retail RTU average weekend (actual in orange, normal in blue).....	K-18



## 1 INTRODUCTION

This report summarizes the remarkable depth of information that is available in the CEMS dataset. From the initial meter deployment in November 2019 to the official closure of data collection in June 2025, the CEMS database accumulated over 3.1 billion readings of electrical circuit power and space and supply temperature measurements from 70 commercial office and retail buildings. The project was hampered by an unprecedented pandemic, in the early stages of implementation as COVID-19 paused the world economy. The project team re-staged recruiting and installation of end-use metering in July 2021 and completed the 70<sup>th</sup> and final installation in the second quarter of 2023. The project sponsors deserve credit for allowing the project to be paused and then renewed following the pandemic.

This final analysis report discusses the following aspects of the study:

1. Data sources – on-site metering, AMI data collection, and actual and normal weather collection
2. Methodology for within-site sampling and expansion
3. Methodologies to establish an assumed population and develop sample weighting for expansion
4. Site-level and across-facility analysis of rooftop unit (RTU), electric resistance heat (ERH), and heat pump (HP) technologies
5. Load shape analysis, producing:
  - a. Regional coincident system peak day 1x24-hour generalized load shapes for metered end-use equipment for both winter and summer
  - b. Weekday 1x24-hour generalized load shapes in each month for metered end uses
  - c. 1x8,760 hourly (annual) data and generalized load shapes for metered end uses
  - d. Confidence intervals for the 1x24 load shapes referenced above
6. Characterization and statistical properties (e.g., mean, standard deviation, variance, etc.) of the weather-normalized load shapes, by technology, building type, and climate zone.

This project purposely focused on three HVAC technologies— RTUs, HPs, and ERH—in two business sectors. Important considerations were made during the study to categorize and define these three HVAC technologies as follows:

- Rooftop units (RTU). Circuits metered in this study were categorized as RTU if they generally met the technical definition as a self-contained HVAC system providing heating, cooling and ventilation. The important distinction of “self-containment” means that the RTU system is “packaged”, typically found on rooftops, installed on a skid, and energized with a single circuit breaker. Systems categorized as “RTU” do not have heat pumps – they supply mechanical cooling using air-source direct expansion air conditioning. They may provide heating using gas furnaces<sup>1</sup>.
- Heat pumps (HP). Circuits metered in this study were categorized as HP if they were components of or HVAC systems that provided space heating and cooling using heat pumps. “Packaged” systems installed on rooftops – which colloquially may be considered RTUs or RTU HPs – that provide space heating using heat pumps are defined as HPs. Built-up HP systems can contain dozens of electric circuits – condenser fans, compressors, fan coils, auxiliary/backup boilers, pumps, etc. All these components in built-up systems were categorized as HP in order to aggregate electric loads that make up built-up HP systems.

---

<sup>1</sup> An RTU system at a site may have no heating or electric heating, but in the case of electric heating, the systems we encountered had a separate circuit energizing the electric furnace. In these cases, the electric furnace circuit was designated as “ERH” because the electric furnace circuit powered the electric resistance heater.



- Electric resistance heat (ERH). Circuits whose primary electric load was electric resistance heat were categorized as ERH. Circuits that powered the electric furnace component in a packaged RTU would be designated ERH. As would auxiliary electric strip heat for heat pumps.

The focus on these three HVAC technologies was done to provide the basis for returning to end-use data development in support of various utility planning functions, including but not limited to:

- **Forecasting** – support bottom-up forecasting efforts and determine the impacts of promoting alternative HVAC technologies
- **Energy efficiency planning** – better define the impacts of energy efficiency measures on an interval basis and across specific performance periods
- **Load management** – evaluate the demand reduction value of measures across specific performance hours
- **Cost-effectiveness testing** – support the performance of time-of-use cost-effectiveness analysis based on the end-use profile and arbitrary bins
- **Integrated resource planning** – update the energy utilization intensities associated with various HVAC system configurations to support the region's resource planning efforts with updated HVAC end-use load profiles

The COVID-19 pandemic forced adjustments to this project's metering scope and project timeline. DNV adjusted its analysis plan to account for these changes and is confident that the final data sets achieve the study's primary research objectives to secure high-quality data on the HVAC systems predominant in the office and retail sectors.

## 2 METHODOLOGY

Figure 2-1 presents an overview of the framework and approach implemented for the CEMS analysis. The population framework is primarily derived from the Commercial Building Stock Assessment (CBSA), and the analysis uses that framework to weight the sampled site data for expansion to the representative population.

**Figure 2-1. Overview of analysis approach**



## 2.1 Load data sources

The foundational sub-hourly interval data comes from end-use metering and the data collected at each sample site. The team metered as much of the HVAC load as possible given the time and cost constraints associated with each site visit. For many of the small and medium sites, all HVAC loads were metered. For the larger or more complex sites, within-site sampling and extrapolation was necessary. Load extrapolation was based on total installed rated capacity of like HVAC technologies.<sup>2</sup> DNV successfully metered approximately 73% of all targeted HVAC loads across the 70 sample sites, weighted by building square footage. Aside from the targeted HVAC loads, DNV collected “other” HVAC and non-HVAC loads whenever possible.<sup>3</sup> These other, non-targeted loads, while not prioritized in the load shape development, provide stakeholders with a rich dataset for future analyses.

CEMS data collection	MMBtu/h	
	Cooling	Heating
229 RTU circuits	45.8	N/A
235 HP circuits	14.9	16.8
353 ERH circuits	N/A	28.5
140 other circuits	31.7	
59 non-HVAC circuits		
55 whole building loads		
70 buildings = 4.4 million sq. ft.		
204 meters	276 wireless sensors	2100 wired current transducers

### 2.1.1 On-site metering

DNV’s engineering team conducted the field installation of the metering equipment. Figure 2-2 presents a collage of several of the metering sites.

**Figure 2-2. Complex metering site**



<sup>2</sup> If rated capacity could not be determined, capacity was estimated using voltage configuration and circuit breaker ampacities (e.g., 50A 3-pole 480V)

<sup>3</sup> “Other” HVAC loads include HVAC technologies that were not categorized as RTU, HP, or ERH. Some examples include split-system air conditioners, PTACs, CRAH/CRAC units, ERV/HRVs, and CHW/HHW loads. Most non-HVAC loads that were collected were electric-resistance DHW.



The scope and continuity of the data collection is immensely valuable and is the main underpinning of the analysis. Ensuring that each data stream is properly defined and assigned appropriate attributes was extremely important for the validity of the load shapes and analysis. The validation, processing, and assignment protocols are described in this report's appendices, specifically APPENDIX C, APPENDIX D, APPENDIX F, and APPENDIX G. The completeness and quality of the on-site meter data is overwhelmingly high, with DNV estimating 98% of on-site meter data both available and of good quality.



DNV was installed whole building meters for 19 sites where we knew AMI-compatible utility meters were not installed. This was a difficult undertaking for several reasons but the most pertinent being that most buildings did not allow de-energizing (i.e., a power outage) to install meters.

### 2.1.2 AMI data collection

The recruiting and data collection effort did not stop with end-use metering. We strived to get written agreement from participants to release whole building electric consumption (i.e., AMI) data so that utilities with AMI meters could share hourly or sub-hourly interval data with DNV. We received AMI data for 36 participating sites, with data completeness estimated to be 97%. For most sites, data covers the entirety of the metering study. Together with the DNV-deployed whole building meters, the study collected hourly or sub-hourly whole building electric consumption data for 55 of the 70 sites.

## 2.2 Metering sample

Figure 2-3 summarizes the completed installations by quarter. Eight sites were installed before the COVID shutdown period, which lasted five quarters. New sites were recruited and installed beginning in the third quarter of 2021, with an additional fifty sites installed by the end of 2022. The DNV field engineering team completed the 70<sup>th</sup> installation in the second quarter of 2023. To achieve at least two years of data for all sites, data collection continued through June 2025.

**Figure 2-3. Installations by quarter**

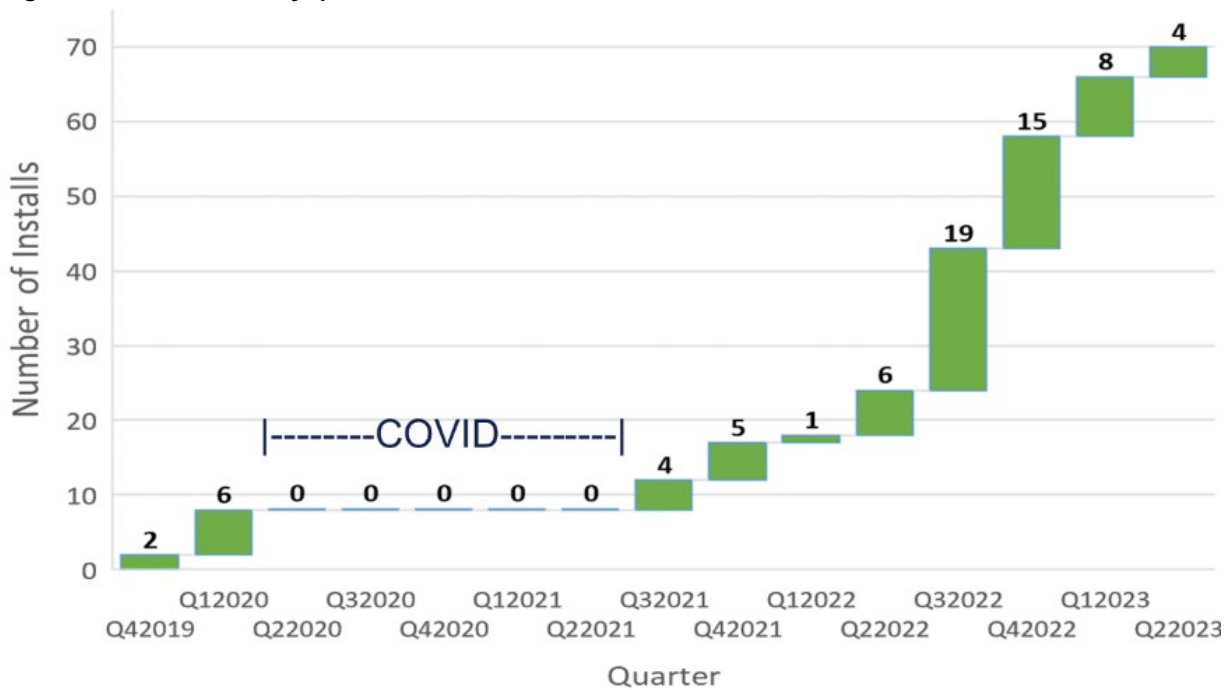


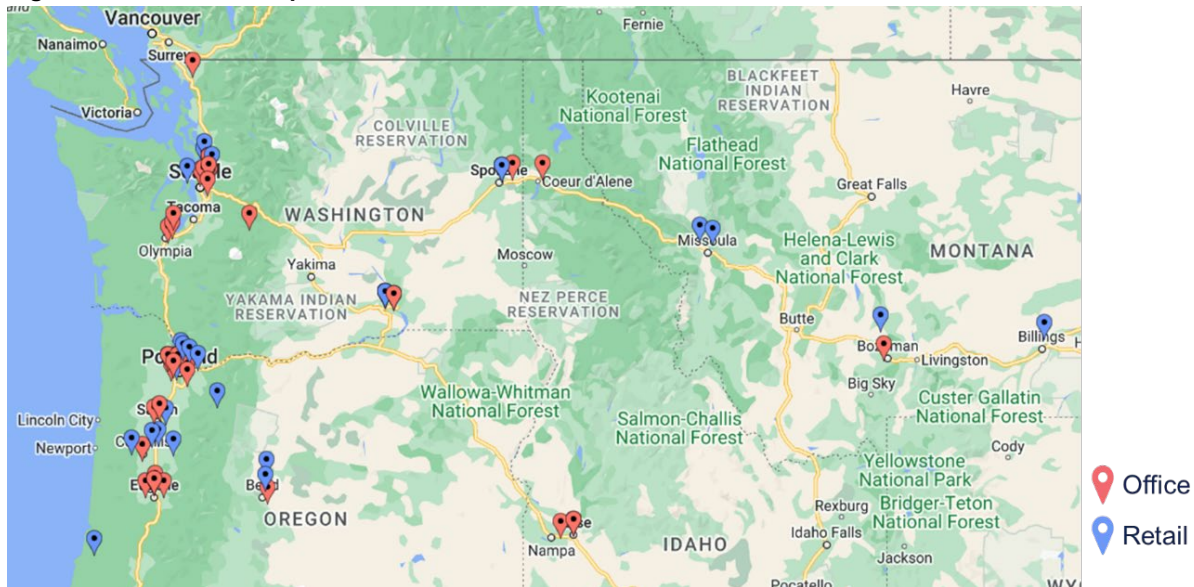
Table 2-1 presents the distribution of the final metering sample by building size and sector.

**Table 2-1. Final achieved sample**

Building type & site sq. ft.	Sample
<b>Office</b>	<b>43</b>
<10,000 sq. ft.	7
10,001 – 20,000 sq. ft.	10
20,001 – 100,000 sq. ft.	18
>100,000 sq. ft.	8
<b>Retail</b>	<b>27</b>
<10,000 sq. ft.	4
10,001 – 20,000 sq. ft.	10
20,001 – 100,000 sq. ft.	11
>100,000 SQ. FT.	2

Figure 2-4 shows a geographical map of the full final sample, reflecting a distribution of office and retail sites across the Pacific Northwest.

**Figure 2-4. Full final sample locations**



### 2.3 Assumed population

Table 2-2 summarizes the office and retail population across the Northwest by square footage.<sup>4</sup> Table 2-3 summarizes the total square footage estimates of the office and retail sectors. Recall, the primary end-use targets include HPs, ERH, and RTUs.

<sup>4</sup> These populations are based on the 2019 CBSA. <https://neea.org/commercial-building-stock-assessment/>

A total of 24,839 sites accounting for 231.9 million square feet of offices have RTUs installed. Similarly, there were 11,689 office sites with ERH, accounting for 16.9 million square feet. Finally, there were 16,377 offices with HPs, accounting for 92.5 million square feet.

The retail sector has 53,956 sites with RTUs, accounting for 592.8 million square feet. There were 48,468 retail sites with ERH, covering 160.5 million square feet. Finally, there were just 4,543 retail establishments with HPs, covering 39 million square feet. We used these population frames to construct the case weights needed to extrapolate site level analysis results to sector representations.

**Table 2-2. Office and retail population estimates**

Building type	Square footage	Sites w/ RTU	Sites w/ ERH	Sites w/ HP heat	Sites w/ HP cool	Sites w/ HP total	Sites w/ other	Total sites
Office	<10,000	18,843	10,948	9,861	11,025	11,088	136	26,924
Office	10,001 – 20,000	3,518	462	3,575	3,575	3,575	141	5,535
Office	20,001 – 100,000	2,268	244	786	1,650	1,650	146	2,474
Office	>100,000	209	35	35	64	64	229	336
<b>Office total</b>		<b>24,839</b>	<b>11,689</b>	<b>14,257</b>	<b>16,314</b>	<b>16,377</b>	<b>651</b>	<b>35,269</b>
Retail	<10,000	40,788	40,242	-	-	-	-	59,874
Retail	10,001 – 20,000	7,534	3,876	2,723	2,971	2,971	0	8,412
Retail	20,001 – 100,000	4,875	4,350	1,572	1,572	1,572	42	4,875
Retail	>100,000	759	-	-	-	-	-	759
<b>Retail total</b>		<b>53,956</b>	<b>48,468</b>	<b>4,295</b>	<b>4,543</b>	<b>4,543</b>	<b>42</b>	<b>73,919</b>
<b>Grand total</b>		<b>78,796</b>	<b>60,158</b>	<b>18,552</b>	<b>20,856</b>	<b>20,919</b>	<b>693</b>	<b>109,188</b>



Table 2-3. Office and retail square footage estimates

Building type	Square footage	RTU sq. ft.	ERH sq. ft.	HP heat sq. ft.	HP cool sq. ft.	HP total sq. ft.	Other sq. ft.	Total sq. ft.
Office	<10,000	84,910,494	11,792,535	29,017,458	35,618,294	36,159,754	0	160,162,097
Office	10,001 – 20,000	48,014,693	1,388,119	6,328,900	23,602,027	23,664,815	6,119,291	102,958,049
Office	20,001 – 100,000	77,829,344	2,275,258	11,798,931	31,037,034	32,194,945	4,632,744	119,368,831
Office	>100,000	21,140,650	1,423,760	207,661	491,301	505,389	87,639,837	76,188,556
<b>Office total</b>		<b>231,895,180</b>	<b>16,879,673</b>	<b>47,352,949</b>	<b>90,748,656</b>	<b>92,524,903</b>	<b>98,391,872</b>	<b>458,677,533</b>
Retail	<10,000	198,504,451	96,294,521	-	-	-	-	355,411,689
Retail	10,001 – 20,000	85,871,040	15,839,302	4,086,859	6,292,428	7,005,566	0	122,075,841
Retail	20,001 – 100,000	162,928,328	48,347,756	29,744,363	8,238,380	32,009,830	555,496	234,119,121
Retail	>100,000	145,557,779	-	-	-	-	-	139,264,500
<b>Retail total</b>		<b>592,861,598</b>	<b>160,481,579</b>	<b>33,831,222</b>	<b>14,530,808</b>	<b>39,015,396</b>	<b>555,496</b>	<b>850,871,151</b>
<b>Grand total</b>		<b>824,756,778</b>	<b>177,361,252</b>	<b>81,184,171</b>	<b>105,279,464</b>	<b>131,540,299</b>	<b>98,947,367</b>	<b>1,309,548,684</b>

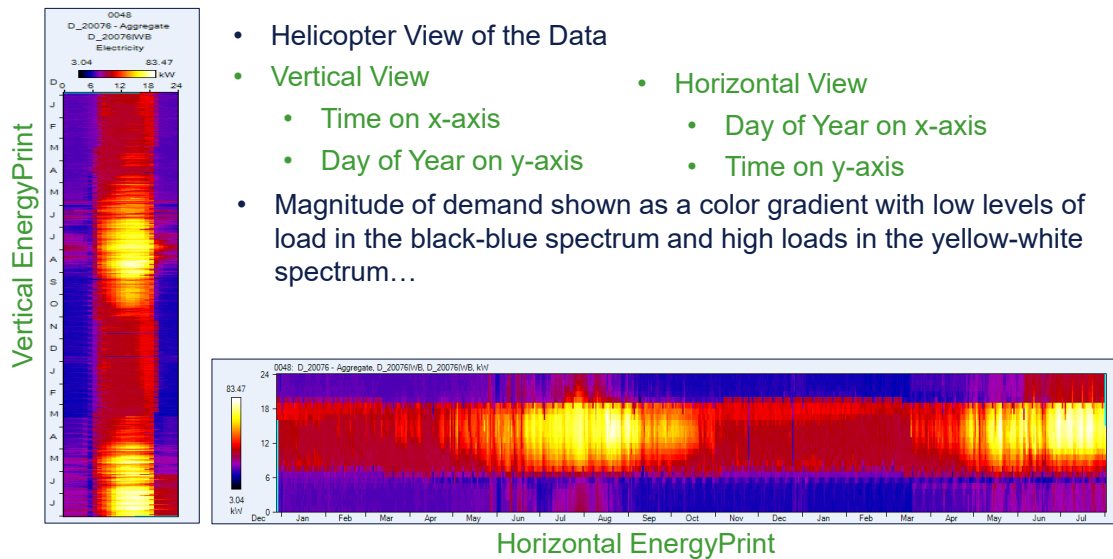
## 2.4 The EnergyPrint

This document uses a graphical representation called an “EnergyPrint” to highlight the time-differentiated characteristics of the end uses in question.

Figure 2-5 displays an EnergyPrint, oriented both vertically and horizontally. In the vertical orientation, the day of year is presented on the y-axis with the earliest date on the top of the figure. The time is on the x-axis with the 24 hours of the day broken into 6-hour intervals. For the horizontal orientation, time is on the y-axis, and day of year is on the x-axis, with the earliest date to the far left.

**Figure 2-5. EnergyPrint example**

### EnergyPrints



In both orientations, the demand is shown in a color gradient with low levels of demand in the black-blue spectrum and high levels of demand in the yellow-white spectrum. Each EnergyPrint has a scale at the top or to the far left. The EnergyPrint provides an overarching perspective on the data and time-differentiated usage.



### 3 LOAD ANALYSIS

DNV’s analysis provides site- and regional-level outputs, for both the metering period (July 2023 through June 2025) and with the weather normalized to typical weather (in this case, TMYx). In terms of the analysis of load shapes, the LRS+ System<sup>5</sup> provides all the traditional analysis outputs required to feed various applications for planning, rate-setting, DSM program evaluation, and other uses. For this study, we have included load interval estimates of totals, means, error bounds, specific ratios, and relative precisions.

Table 3-1 presents a list of analysis outputs (8,760 or metering period) for individual sites and for aggregate load profiles by sector and technology. Aggregate profiles are provided by building type as well as study-wide. We weather normalized the individual site-level data and the aggregate sector-level data. Currently all the analysis outputs, with the exception of the analysis of whole-facility load data, are available to the sponsors.

The hourly data allows project sponsors to examine demand and energy estimates for any ad hoc period, such as different constructs of on-peak and off-peak periods. If future studies call for additional insights that rely on the load shapes being produced by CEMS, LRS+ has the flexibility and capability to produce any custom analysis and outputs needed.

**Table 3-1. Analysis outputs**

Analysis data streams	Site analysis	Across sample analysis	Weather-normalized
Individual channel data	●		●
Whole facility load <sup>6</sup>	●		●
<b>Technology loads (metered only)</b>			
Electric resistance heating	●		●
Heat pump heating	●		●
Heat pump cooling	●		●
RTU	●		●
<b>Technology expanded<sup>7</sup> loads</b>			
Electric resistance heating	●	●	●
Heat pump heating	●	●	●
Heat pump cooling	●	●	●
RTU	●	●	●
Overall heating load	●	●	●
Overall cooling load	●	●	●
Technology normalized to sq. ft.	●	●	●
Technology normalized to Dd	●	●	●
Technology as percent of total	●	●	●
Achieved statistical error		●	●

#### 3.1 Site-level analysis

The first step of the analysis starts at the site level, using collected circuit-level data to estimate load for each metered end use over the metering period and normalized to weather. For within-site sampling, DNV used rated heating or cooling capacity of the metered units along with the estimated total heating or cooling capacity in the building to estimate total energy for each end use.

<sup>5</sup> DNV’s Load Research System (LRS) is used by several major utilities, including Portland General, Puget Sound Energy, Pacific Gas & Electric, Consolidated Edison of New York, American Electric Power, and Dominion Energy.

<sup>6</sup> Whole facility load analysis uses a different expansion approach (weight set is different from technologies) because DNV was unable to obtain whole facility loads for all sample points

<sup>7</sup> “Expanded” includes estimating the full load for each technology at a site when within-site sampling was used and estimating the regional technology load.



Employing quality assurance/quality control (QA/QC) steps, our post-installation commissioning process used equipment type, equipment capacity, and other building level data points to ensure that the received building data aligns with the range of expected values for each metered circuit and can be trusted as valid. The post commissioning QA/QC steps we took include:

- Confirm current transducer (CT) size rating
- Reference voltage check
- Individual circuit register configuration check
- CT direction check
- Measured current check
- Maximum kW flag
- Timestamp accuracy check

Because meters were remotely accessible, we took opportunities post-installation to re-configure circuit registers. The need to re-configure was a rare occurrence but would occur with circuits that were not energized during the site visit, so were unable to go through typical on-site spot measurement checks. The in-field and post-field commissioning and quality control procedures are detailed in CEMS User Guide, APPENDIX F, and APPENDIX G.

### 3.1.1 An example of site-level analysis

Table 3-2 provides an example of the equipment metered within each site. For this 7,068 sq. ft. office building, the team metered all HVAC loads at the facility.

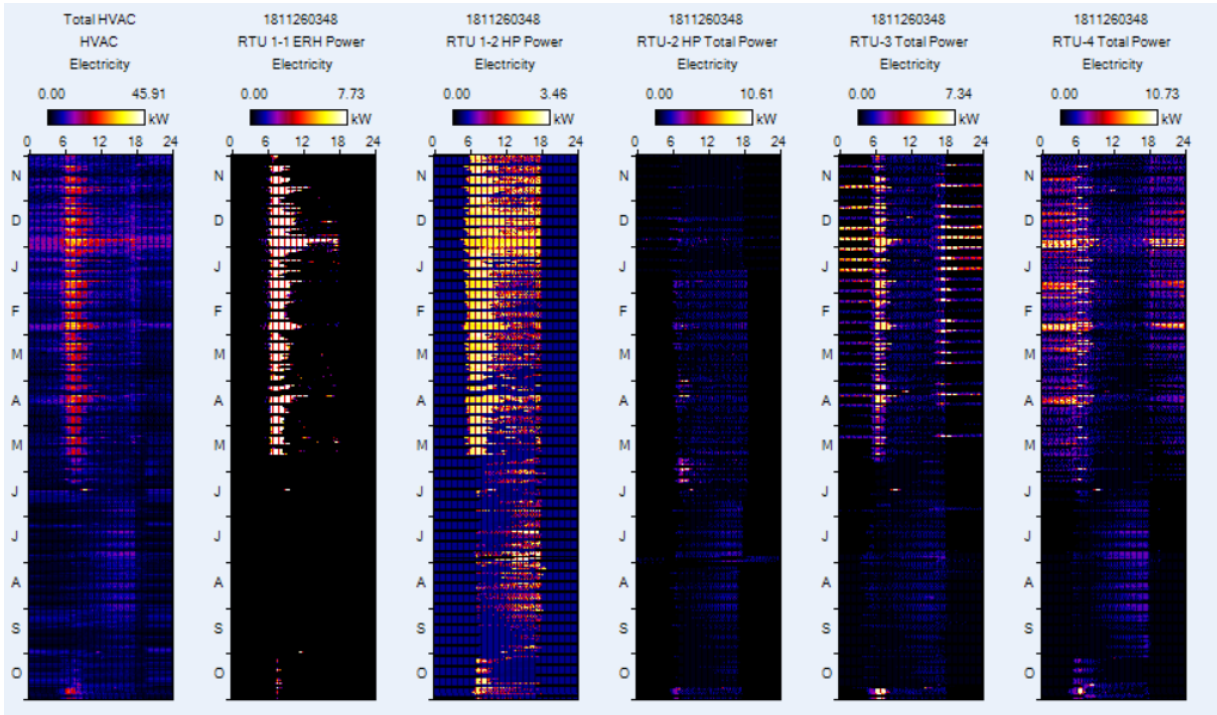
**Table 3-2. Site 18080, HVAC unit detail**

Unit name	Unit type	Capacity [tons]	Zone served
RTU 1	RTU HP	2.9	Office space
RTU 2	RTU HP	2.4	Office space
RTU 3	RTU HP	2.4	Office space
RTU 4	RTU HP	2.4	Office space
FC-5	Ductless mini-split HP combined loads	2.5	Office space
FC-6	Ductless mini-split HP combined loads	2.5	Office space
FC-7	Ductless mini-split HP combined loads	3.0	Office space
FC-8	Ductless mini-split HP combined loads	1.0	Office space
FC-9	Ductless mini-split HP combined loads	1.0	Office space
FC-10	Ductless mini-split HP combined loads	1.3	Office space
FC-IT	Ductless mini-split HP combined loads	2.0	IT room

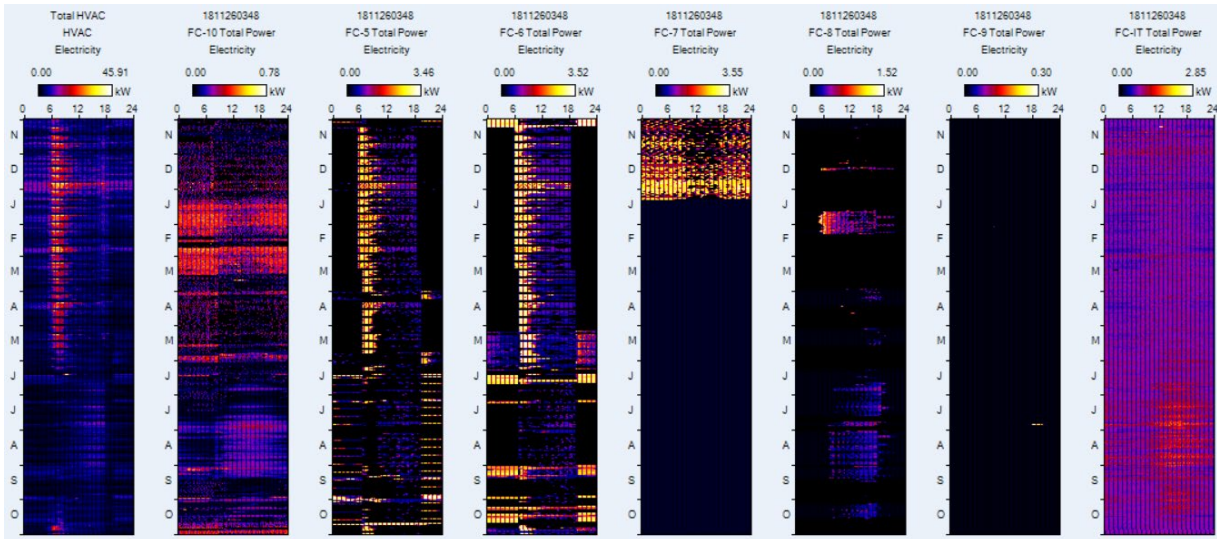
Our site-specific analysis developed EnergyPrint and average profiles for each metered unit. These visuals were used during data cleaning and data quality reviews to identify possible issues requiring deeper review. Figure 3-1 and Figure 3-2 display the EnergyPrints for the total HVAC load of the facility as well as the various components listed in Table 3-2. The vertical EnergyPrints display the time of day on the x-axis, the day of the year on the y-axis, and present the load as a color gradient with low levels of load in the black-blue spectrum and high levels of load in the yellow-white spectrum. The data are presented for a 12-month period, with November 1, 2021 at the top and October 31, 2022 at the bottom. There is an individual scale at the top of each EnergyPrint. The total HVAC load ranges from a low of 0 to a high of 45.91 kW.

- Figure 3-1 presents the total HVAC load, followed by the individual RTU channels, with RTU1 split between ERH and HP load. Each has a unique scale.
- Figure 3-2 also presents the total HVAC load, followed by the seven individual mini-split systems. Each has a unique scale.
- Figure 3-3 shows the average weekday demand profile for all the HVAC units for the site.

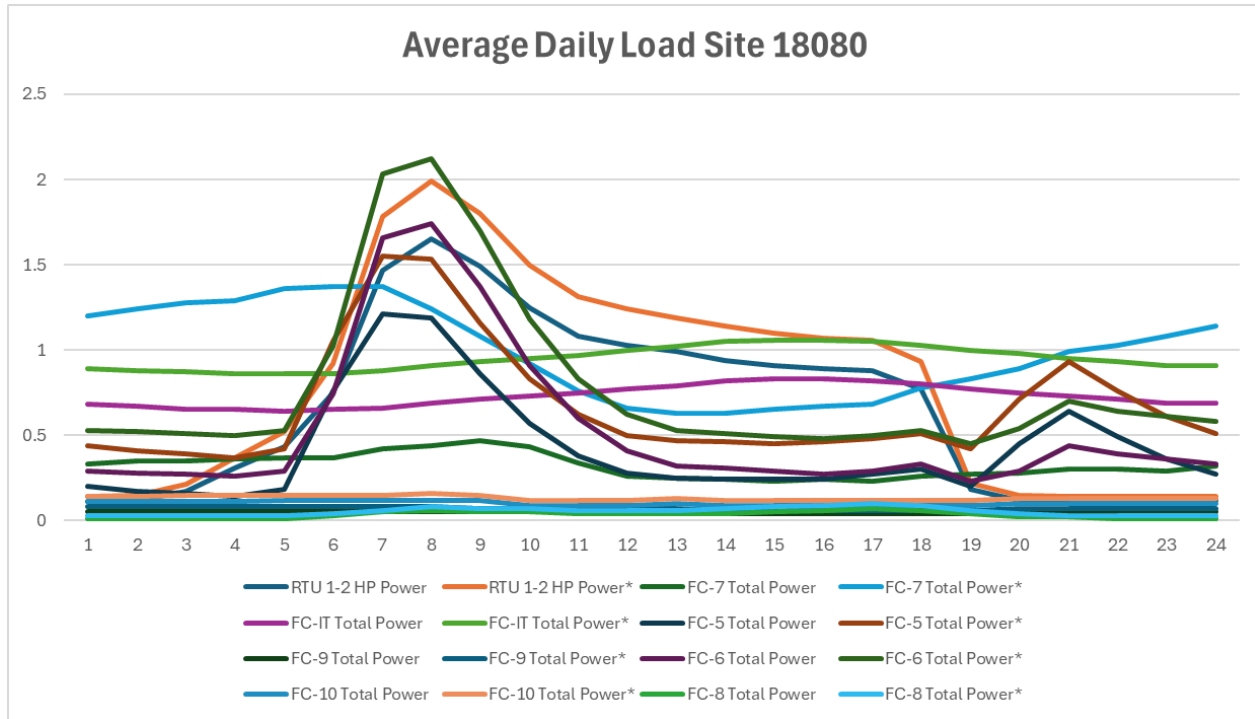
**Figure 3-1. RTU EnergyPrints for Site 18080**



**Figure 3-2. DHP EnergyPrints for Site 18080**



**Figure 3-3. Individual HVAC unit loads: average weekday<sup>8</sup>**



We used our site-level analysis to construct technology (RTU, HP, and/or ERH) profiles at the site level that, in turn, we used to create the aggregate load profiles by sector.

### 3.1.2 Within-site sampling and expansion

In some cases, it was not possible to meter all targeted technologies at a given site, when, for example, the number of units to be metered exceeded the capacity of the maximum equipment deployment or the time allotted for a site.

Within-site sub-samples were drawn during pre-metering plan development, based on the CBSA site visit or other preliminary data collection. In either case, the protocols and tools used were the same. A list of all eligible units, together with a measure of size—ideally equipment capacity but possibly only floorspace served—provided the basis for the sub-sample. We took the following approach:

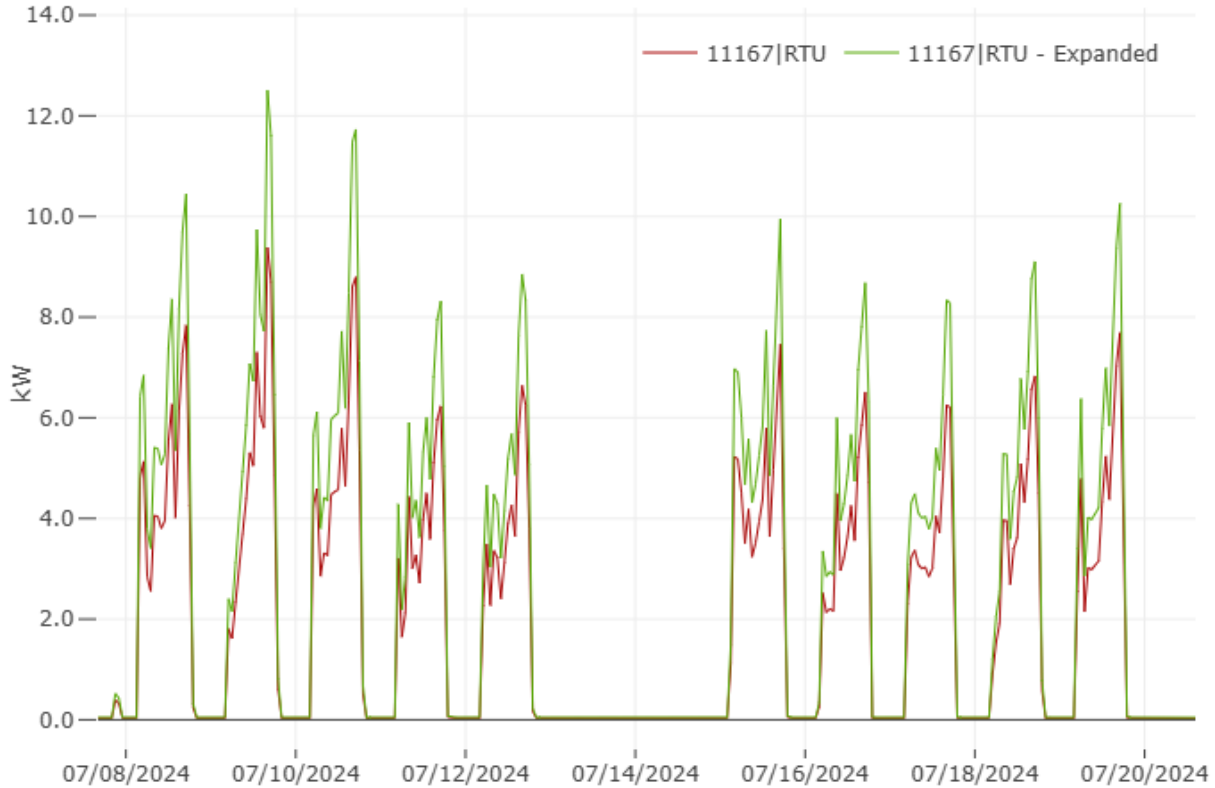
- We stratified eligible units by technology type and size. Capacity is the preferred size measure, as floorspace served is more difficult to define for ERH and mini-split HPs, and some space may be served by multiple units.
- We metered at least one of each eligible technology present, selected with probability proportional to size within each technology type.
- If additional sample units were allocated within the site after selecting the first of each technology, the remaining units were selected with probability proportional to size across all technology types.

The goal was to construct the end uses of interest from the site-level data for every site with a particular end use. Figure 3-4 presents an example that leverages the available end use channel data to project the full within-site level of demand. In the example, the within-site expansion raised the metered RTU demand (the red line – 11167|RTU) to the expanded site-level

<sup>8</sup> HVAC circuit loads with “\*” designate apparent power readings for that circuit.

RTU demand (the green line – 11167|RTU – Expanded) by a factor of four-thirds. See APPENDIX E for further detail on within-site expansion criteria and methodology.

**Figure 3-4. Within site expansion – RTU example**



### 3.1.3 Site-level end use summary

This section highlights end use load estimates for each sample point. To allow for a common basis for comparison, the period selected for final analysis is July 1, 2023 through June 30, 2025 (a period when all 70 sample points were being metered). However, for most illustrations and figures within the report, the period is just one year: July 1, 2023 through June 30, 2024.

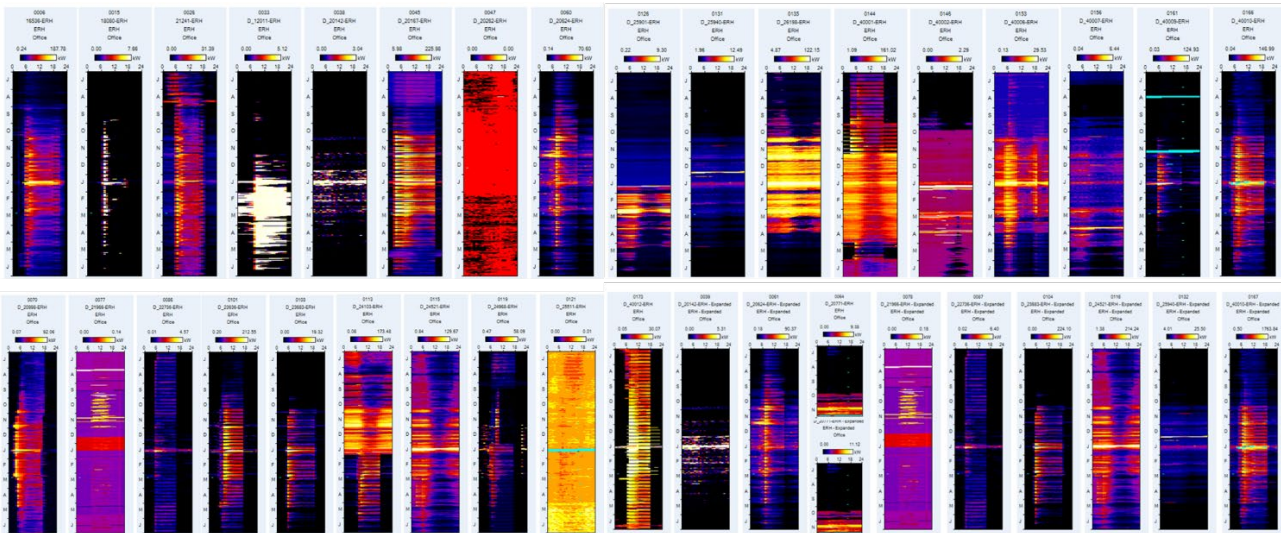
Figure 3-5 through Figure 3-10 summarize the technology (ERH, HP, and RTU) loads for the retail and office sector sites. The figures are collages of individual site EnergyPrints. While the details and text of each site EnergyPrint are not important in these illustrations, the figures show:

- The diversity in load shapes among the sample sites, as seen by the differences across EnergyPrints; and
- The number of site-specific load shapes for each technology and sector.

Figure 3-5 illustrates ERH load shapes in the office sector sites, and Figure 3-6 highlights the ERH loads for the retail sector sites. In those figures, most office ERH loads appear to show a scheduled and seasonal magnitude where ERH turns on in the early morning and turns off in the evening. The magnitude of ERH demand increases in the winter months as outdoor temperature drops and decreases in the summer months when temperatures rise. However, there are some sample sites

where their ERH loads appear less consistent, likely because they are not dominant forms of heating in the building and serve as supplemental heating for smaller zones. In these cases, the ERH load shapes less predictable and may show little to no load (e.g., a baseboard heater in a bathroom or utility closet that is never used) or a consistent, relatively flat load (e.g., a utility closet baseboard heater that is never turned off).

**Figure 3-5. ERH: Office sector**



There were far fewer sampled ERH loads in the retail space where the majority (five of the nine) were effectively off during the period. The other four showed some level of scheduling and control, with all four showing peak intensity during the January 2024 cold snap. At least one of the retail sites (D\_22086) scheduled the ERH off during weekends.

**Figure 3-6. ERH: Retail sector**

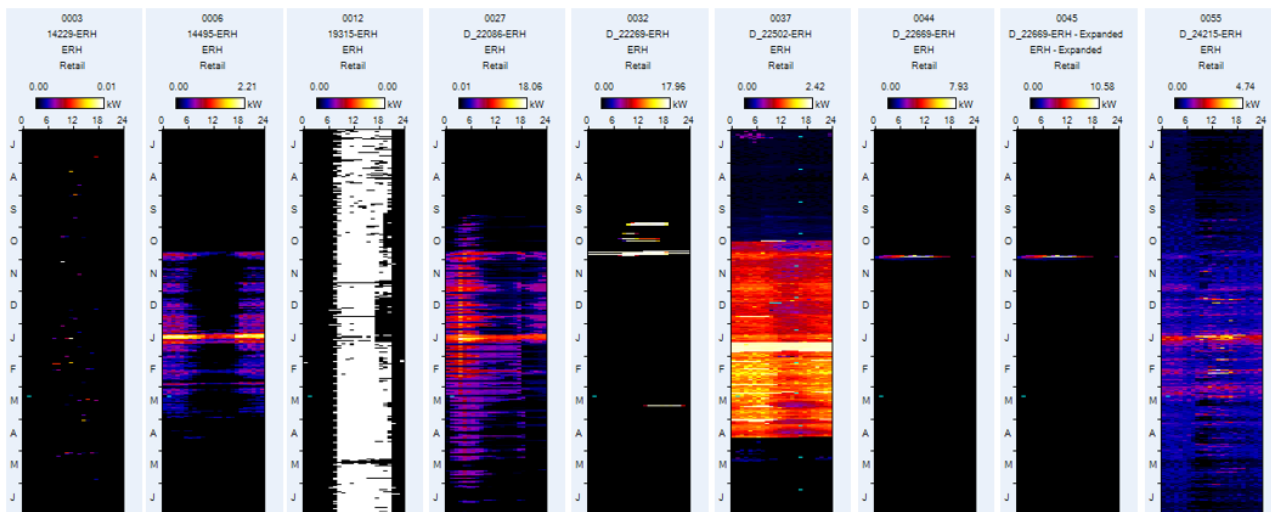
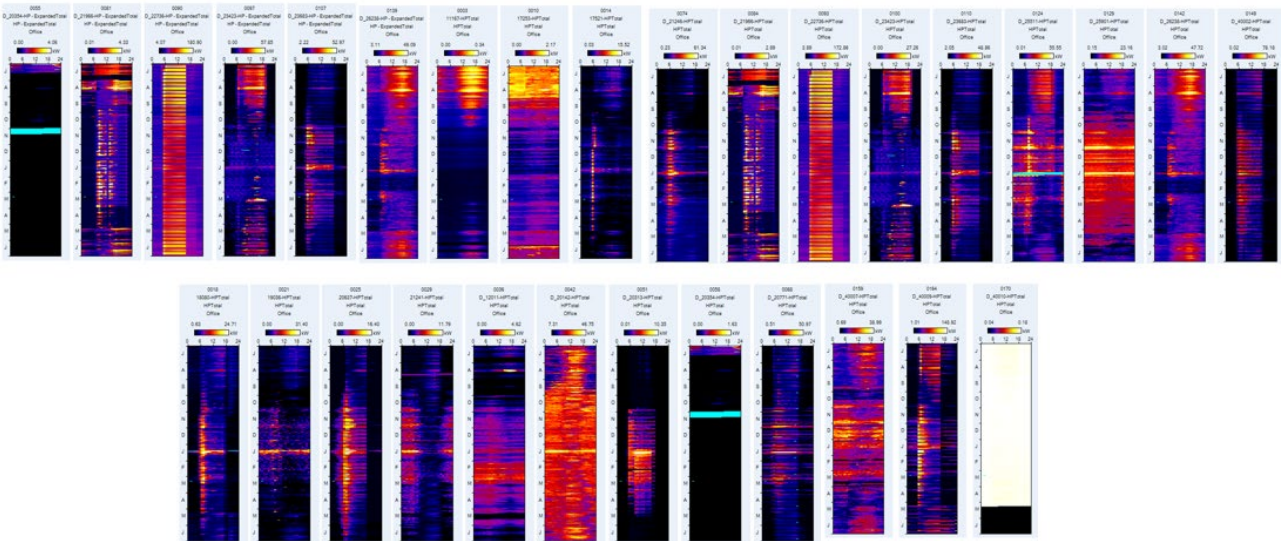


Figure 3-7 presents the HP total end use load for the office sector sites, and Figure 3-8 highlights the HP total load in the retail sector sites. Again, there is significant diversity in patterns across the sites, which reflects how these systems are

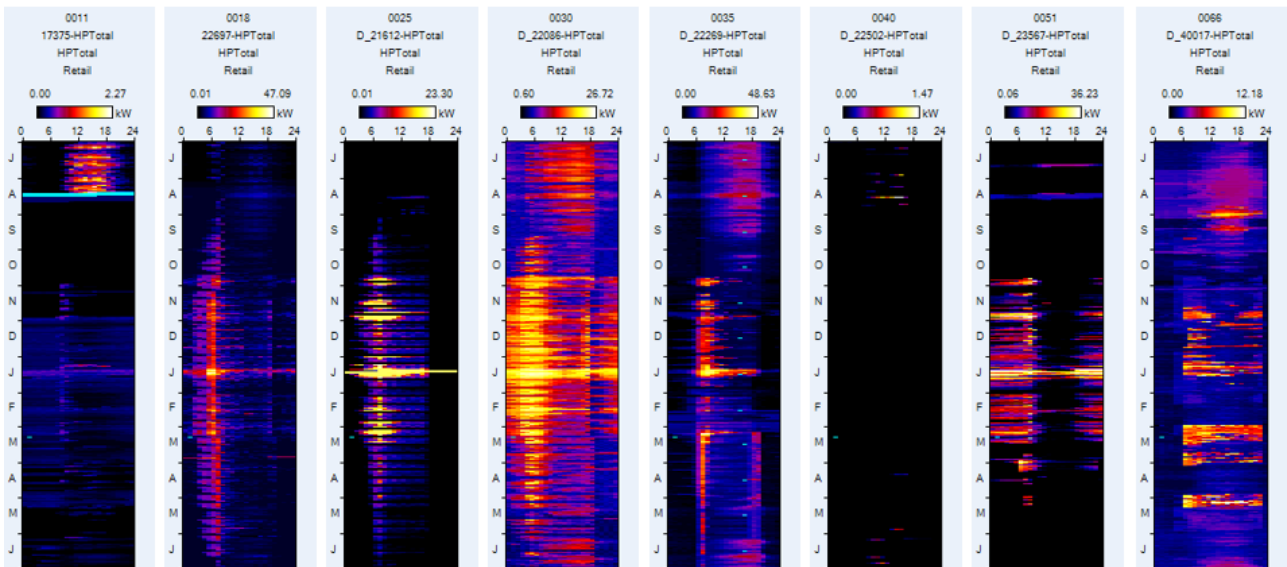
utilized within each building. However, most office HPs appear scheduled around typical office hours, ramping up in the mornings and down in the evenings. For offices that appear to use their HPs for primary heating, morning warm up appears as the most intense periods while heat pumps that are used as supplemental heat are not as active during colder periods and show their highest intensity during summer afternoon and evenings, much like RTU air conditioning.

Retail HPs saw their most intense demand in winter mornings. Some sites appeared to show negligible summer use because the buildings had RTU AC serving the primary cooling load. The HP shapes generally tell the story of higher winter peaking loads relative to their summer peaks.

**Figure 3-7. HP total load: office sector**



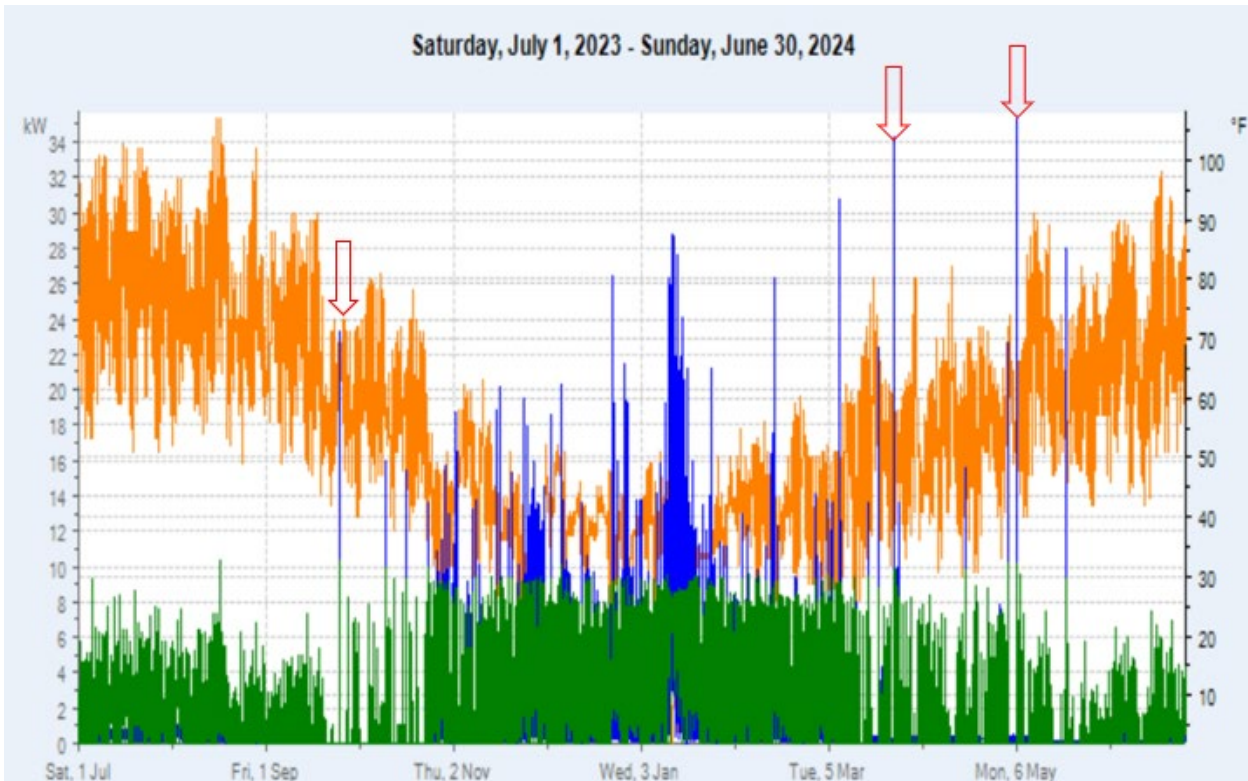
**Figure 3-8. HP total load: retail sector**





higher demand during the winter period when presumably the heat pumps cannot meet the building heating load. However, there are spikes in backup strip heat use during periods of relatively mild weather, where the three red arrows show spikes when temperatures were between 40 and 60 degrees °F. This type of HP operation represents opportunities for re-commissioning controls to prevent backup heat from operating during periods where the heat pump can adequately satisfy the building's heating load.

**Figure 3-11. Backup strip heat on HP during mild weather (site 19036, green = HP load, blue = backup ERH, orange = outdoor temperature)**



While eight sites technically had end-use meters installed prior to the COVID shutdown in March 2020, only a few provided enough pre-COVID data to reasonably illustrate the impact that the shutdown had on their building's HVAC energy consumption. The three examples below show a sharp contrast of the responses that building operators had on HVAC schedules when their states implemented "stay-at-home" orders. The first example site responded aggressively by effectively turning HVAC off for the building while the other two appeared to have not responded, with changes in HVAC consumption presumably attributed to reduced occupancy.

Figure 3-12 shows a medium-sized office building (site 18080) EnergyPrint from February 2020 (the top of the figure) through February 2021 (the bottom of the figure). Oregon issued a statewide stay-at-home order on March 23 (highlighted by a green bar across the EnergyPrints). The building responded almost immediately by setting back thermostats or completely turning off systems and returned to "normal" schedules in late October 2020.

A medium-sized office building in Washington state, shown in Figure 3-13, did not appear to adjust its HVAC schedules or controls in response to the (presumed) building closure. The state issued a stay-at-home order on March 25, 2020,

highlighted by a green bar across the RTU, ERH, and HP EnergyPrints, from left to right. The teal color in the EnergyPrints are periods where data gaps exist.

**Figure 3-12. Building HVAC response to COVID “shutdown” (medium office site 18080 in Oregon)**

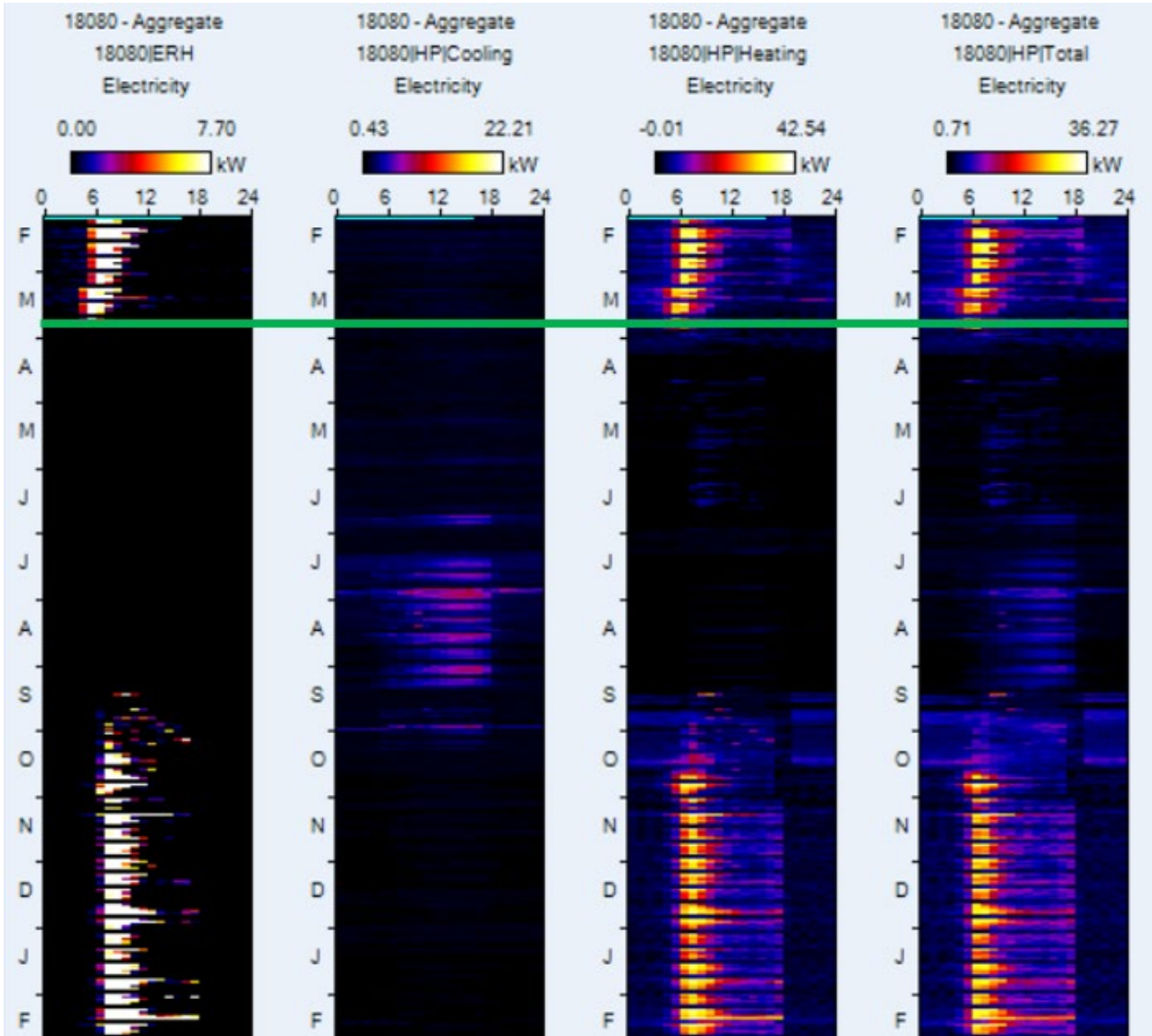
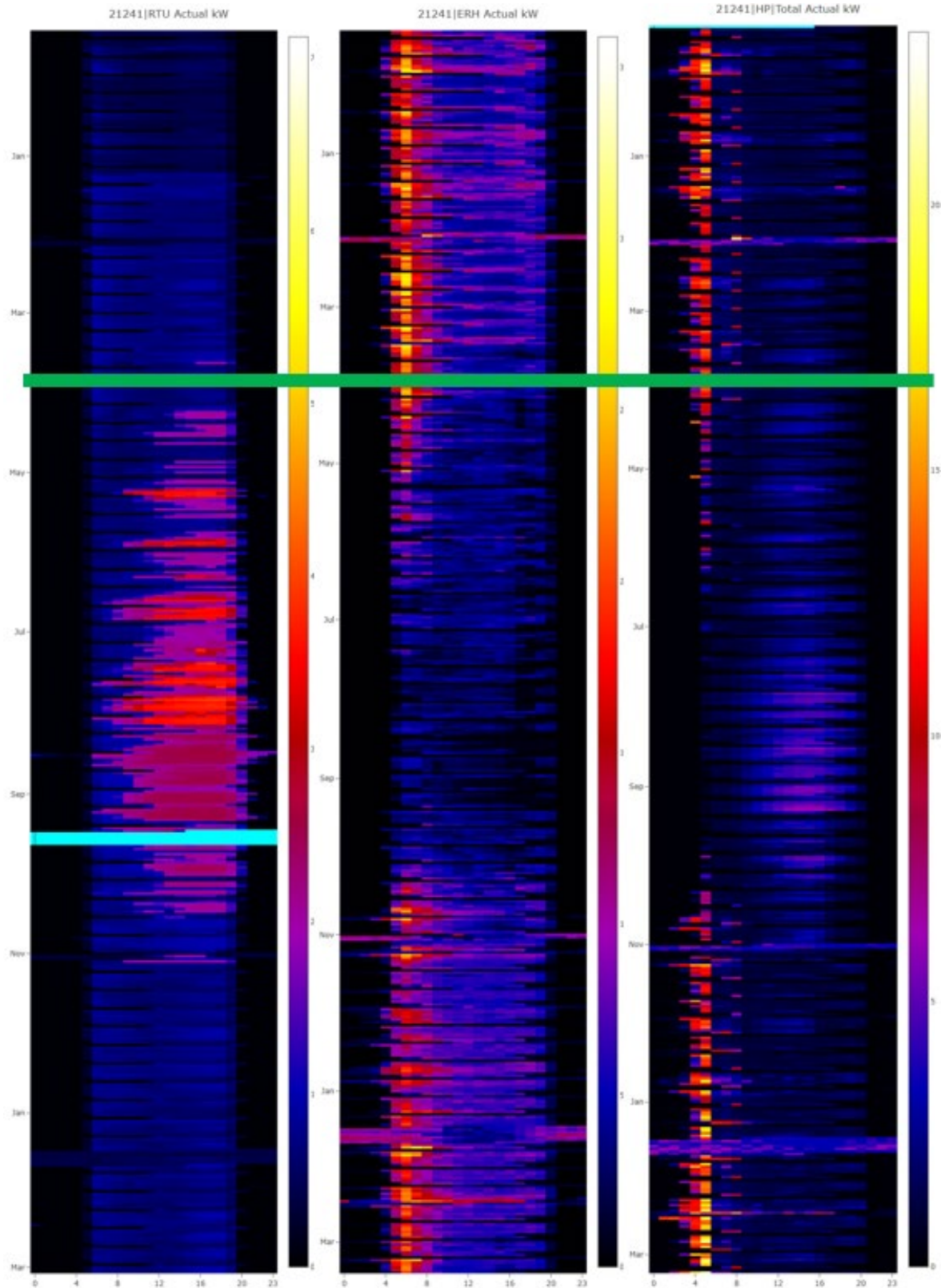
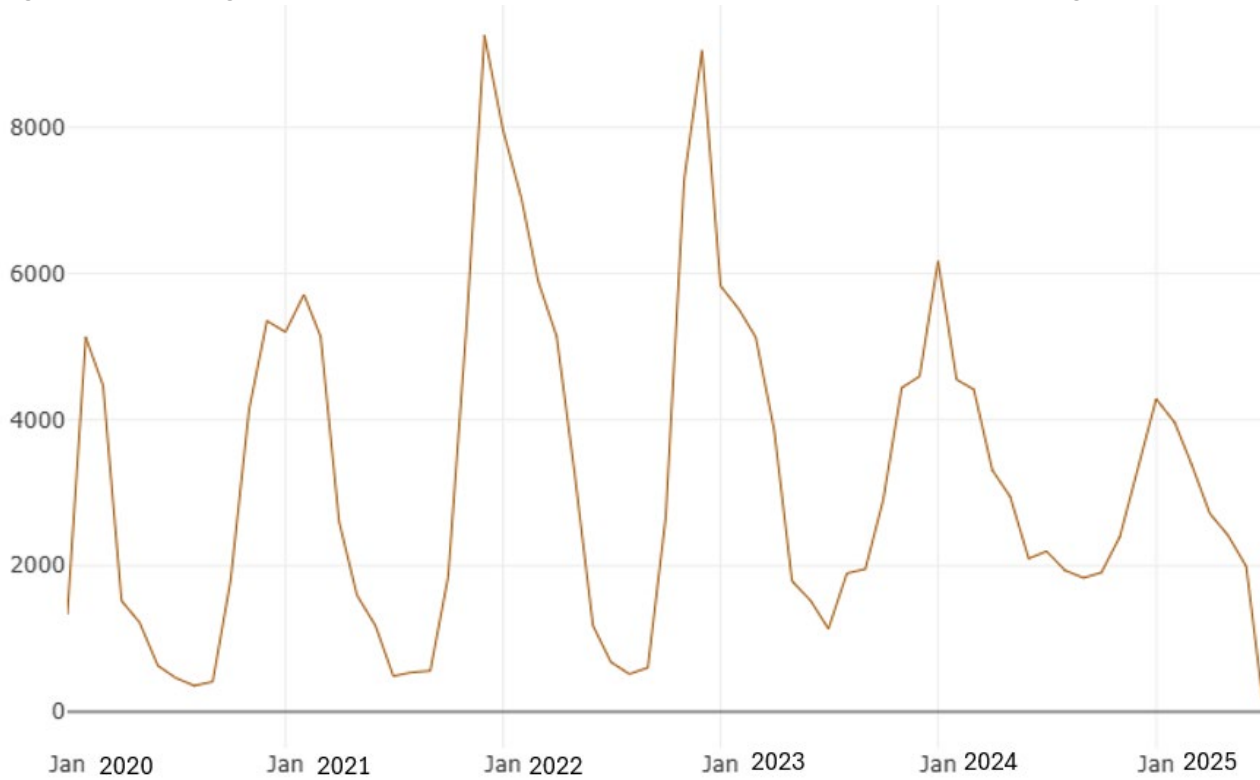


Figure 3-13. Building HVAC response to COVID “shutdown” (medium office site 21241 in Washington)



A third site, a small physical therapy office in Washington, appeared to respond like the medium office in Washington – with minimum to no change to operating schedules. The actual energy consumption of the HVAC equipment may have been affected by the lack of internal loads, as suggested by the slightly lower monthly consumption (kWh) shown year-over-year on the y-axis in Figure 3-14. The figure shows the building’s HP monthly consumption (in kWh) that peaks in colder months. Consumption in 2020 is lower than other years and can be seen by the narrow period relative to the other years.

**Figure 3-14. Building HVAC response to COVID “shutdown” (small office site 22697 in Washington)**





## 3.2 Weather normalization

Weather modeling and normalization served multiple purposes, including the creation of individual site-level models that were used to estimate load, i.e., fill gaps in the data. In addition, this approach allowed DNV to normalize metering sites with different start and end dates and to provide typical-year results. For example, once the technology profiles were developed and normalized, the load shapes could then be projected to any predefined weather conditions.

The generalized model is presented in Equation 1:

### Equation 1. Weather Normalization<sup>9</sup>

$$yvar_{sdi} = b_o + b_1 * \max(0, (heatref - temp_{sdi})) + b_2 * \max(0, (temp_{sdi} - coolref)) + \varepsilon$$

Where,

- **s** represents the sample site/end use
- **d** represents day of week
- **i** represents the interval

We calculated a weather-normalized model for every site/end use by day-of-week and interval. To select the optimal models, we tested a range of potential reference points and selected based on minimizing root means square error. Once selected, the normalized load was estimated using normal TMYx temperatures. However, any normal weather data sets could be used.

This approach has been used by the load research community for decades. As such, the time-temperature regression (i.e., weather normalization routine) is a standard component of DNV's validation, editing, and estimation (VEE) algorithms, which we used to ensure high quality data was available for each site. A more detailed discussion of the general methodology is presented in APPENDIX A.

The DNV team mapped various NOAA and TMYx weather stations to each of the identified sites based on proximity and other considerations. APPENDIX H contains the method used to select weather stations and a table of selected weather stations.

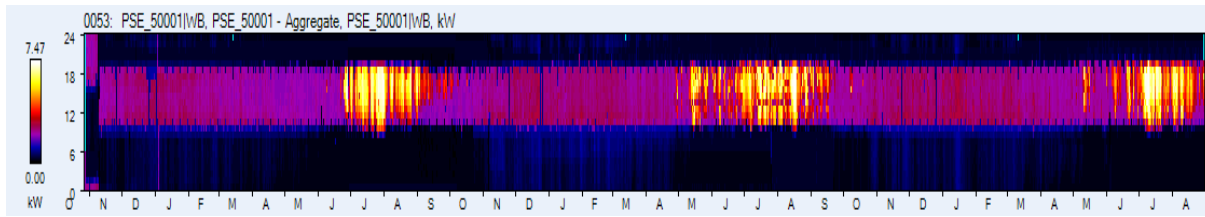
Figure 3-15 presents a comparison of actual aggregate whole-facility load and weather-normalized whole-facility load. In this instance, over two years of data informed this model.

---

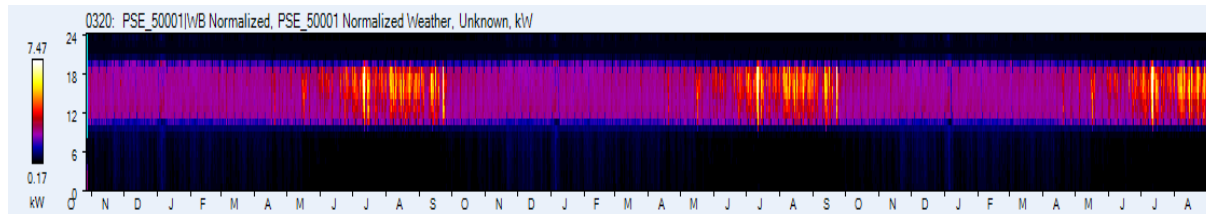
<sup>9</sup> Heatref and coolref are the inflection points where the base load becomes sensitive to changes in temperature. Individual heatref and coolref are created for each site and end use weather normalized.

**Figure 3-15. Example of weather normalization**

**Aggregate Load**



**Normalized Load**



To appreciate the normalization more fully, Figure 3-16 shows the average daily temperature for the Portland International Airport weather station. The actual temperature is in blue with the normal TMYx temperatures shown in orange. For these weather data, the TMYx temperatures were consistently lower in the July, August, and December.

**Figure 3-16. Actual versus normal temperature: Portland International Airport**

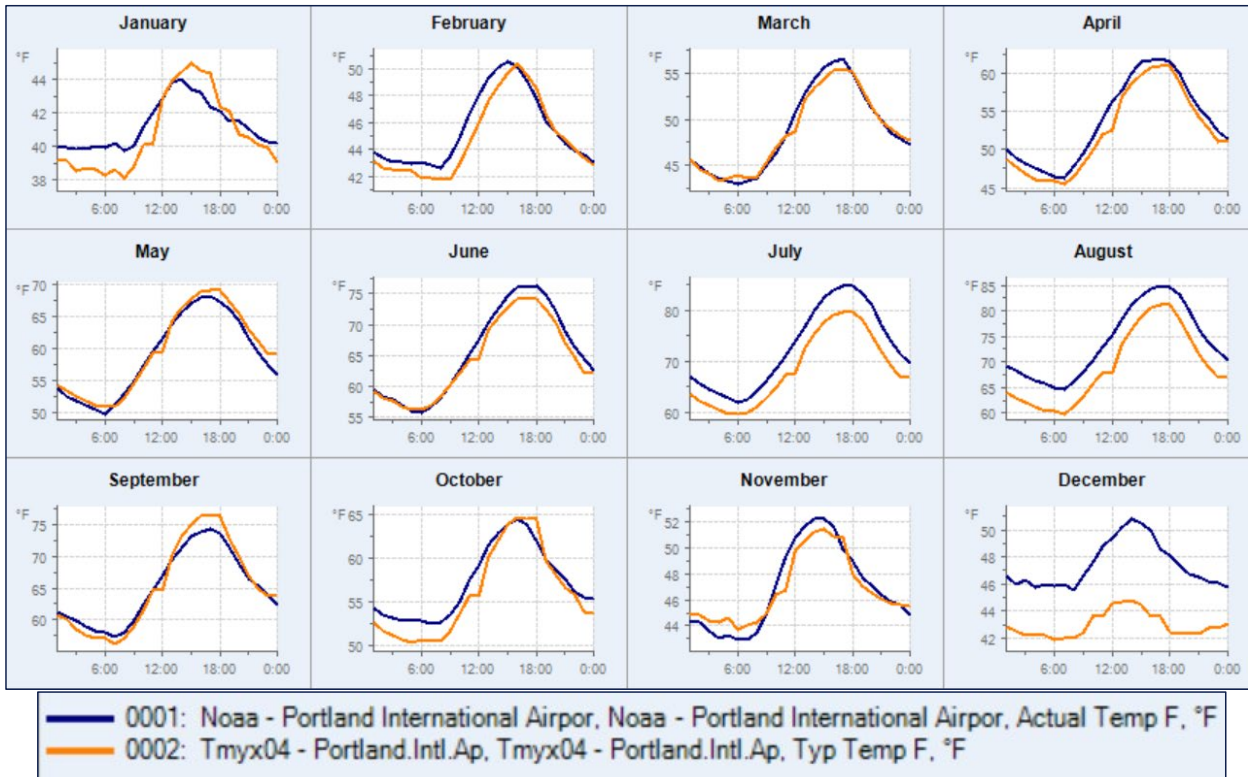
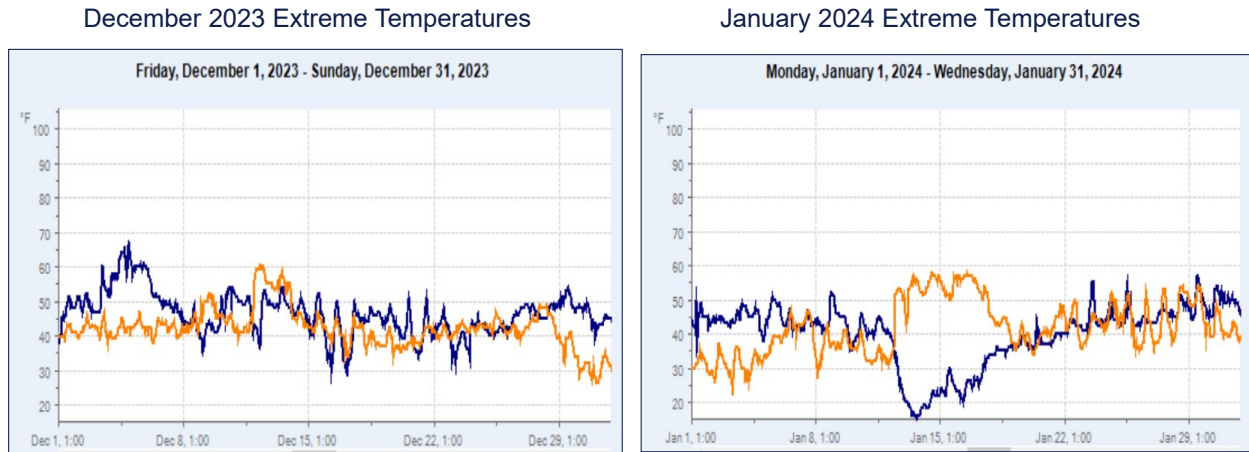


Figure 3-17 shows that actual temperatures can swing significantly compared to the TMYx profiles. Actual temperatures (blue line) were considerably higher in early December but markedly lower during mid-January. Capturing these types of actual weather swings—and the resulting HVAC usage—improves the accuracy of the weather-normalized models. The extended metering period of CEMS was selected with the expectation that some extreme weather data would be captured over the metering period. Figure 3-17 is evidence that the plan succeeded. Several extreme weather events occurred and the data from those events now gives stakeholders the opportunity to model loads using normal weather data besides TMYx.

**Figure 3-17. Extreme temperature swings in actuals**



### 3.3 Across facility analysis

After site level analysis was completed, the project team used technology load profiles from each of the sample points to extrapolate across all facilities to create aggregate load profiles for the populations of interest. This was performed for both the individual time-differentiated demands, i.e., the y-variables of interest, and the associated square footage, i.e., our x-variable used in the extrapolation.

#### 3.3.1 Case weights

The extrapolation was accomplished by applying case weights developed from the final population frames and the available samples. Case weights take the form presented in Equation 2.

**Equation 2. Calculating case weights**

$$w_i = N_h/n_h$$

Where customer *i* is in strata *h*.

Case weights are, effectively, the number of sites in the population represented by each sample point. The case weights were calculated using the final population frames and the sample points.

Table 3-3 and Table 3-4 lay out the case weight development used in the final analysis for the office and retail sectors, respectively. The population counts are extracted from the 2019 CBSA data streams, and the sample counts are the sample points selected with the respective end uses. Case weights are used to follow the ratio estimation approach outlined in APPENDIX B. The case weights are applied to the interval load estimates ( $y_i$ ) and the square footage estimates ( $x_i$ ). Next, a ratio is created based on the weighted  $y_i$  divided by the weighted  $x_i$  across the sample. This creates a demand intensity ratio of watts per square foot. Next, the ratio is multiplied by the “known” or “estimated” total square footage to derive the estimate of total demand. Next, the total demand is divided by the population of sites to derive the means.

**Table 3-3. Office sector case weight development**

Population bin	Sites w/ RTU	Sites w/ ERH	Sites w/ HP heat	Sites w/ HP cool	Sites w/ HP total	Total sites
<b>Office sector – population counts</b>						
<10,000 Sq. ft.	18,843	10,948	9,861	11,025	11,088	26,924
10,001 - 20,000 Sq. ft.	3,518	462	3,575	3,575	3,575	5,535
20,001 - 100,000 Sq. ft.	2,268	244	786	1,650	1,650	2,474
>100,000 Sq. ft.	209	35	35	64	64	336
<b>Office sector – sample counts</b>						
<10,000 Sq. ft.	2	2	6	6	6	7
10,001 - 20,000 Sq. ft.	5	7	7	7	7	10
20,001 - 100,000 Sq. ft.	13	16	10	10	10	18
>100,000 Sq. ft.	3	7	4	4	4	8
<b>Office sector – case weights</b>						
<10,000 Sq. ft.	9,422	5,474	1,643	1,838	1,848	3,846
10,001 - 20,000 Sq. ft.	704	66	511	511	511	553
20,001 - 100,000 Sq. ft.	174	15	79	165	165	137
>100,000 Sq. ft.	70	5	9	16	16	42

**Table 3-4. Retail sector case weight development**

Population bin	Sites w/ RTU	Sites w/ ERH	Sites w/ HP heat	Sites w/ HP cool	Sites w/ HP total	Total sites
<b>Retail sector – population counts</b>						
<10,000 Sq. ft.	40,788	40,242	-	-	-	59,874
10,001 - 20,000 Sq. ft.	7,534	3,876	2,723	2,971	2,971	8,412
20,001 - 100,000 Sq. ft.	4,875	4,350	1,572	1,572	1,572	4,875
>100,000 Sq. ft.	759	-	-	-	-	759
<b>Retail sector – sample counts</b>						
<10,000 Sq. ft.	3	2	-	-	-	4
10,001 - 20,000 Sq. ft.	6	6	7	7	7	10
20,001 - 100,000 Sq. ft.	10	6	2	2	2	11
>100,000 Sq. ft.	2	-	-	-	-	2
<b>Retail sector – case weights</b>						
<10,000 Sq. ft.	13,596	20,121	-	-	-	14,968
10,001 - 20,000 Sq. ft.	1,256	646	389	424	424	841
20,001 - 100,000 Sq. ft.	488	725	786	786	786	443
>100,000 Sq. ft.	379	-	-	-	-	379

### 3.3.2 Site-level events influence extrapolated results

Over the course of any five-year period involving commercial building energy consumption, many “non-routine” events occur that can have a profound effect on typical operating patterns. Examples of these events include change of occupancy in leased retail or office spaces, temporary vacancies and closures, change of ownership, and change of HVAC equipment or maintenance schedules.



During the metering period and load shape analysis, DNV identified site-specific events that had significant impact on typical operating patterns and HVAC loads. We also acknowledge that events likely occurred in the metering period that were not identified but influenced the across-facility load shapes.

The impact that site-specific changes have on extrapolated results are also intrinsically tied to the site's case weight and its sample strata size within the total study sample. For example, three of the 70 buildings recruited for the study were categorized as small retail. These buildings' technology-specific load shapes, when expanded to the population, represent tens of thousands of small retail buildings in the Pacific Northwest.

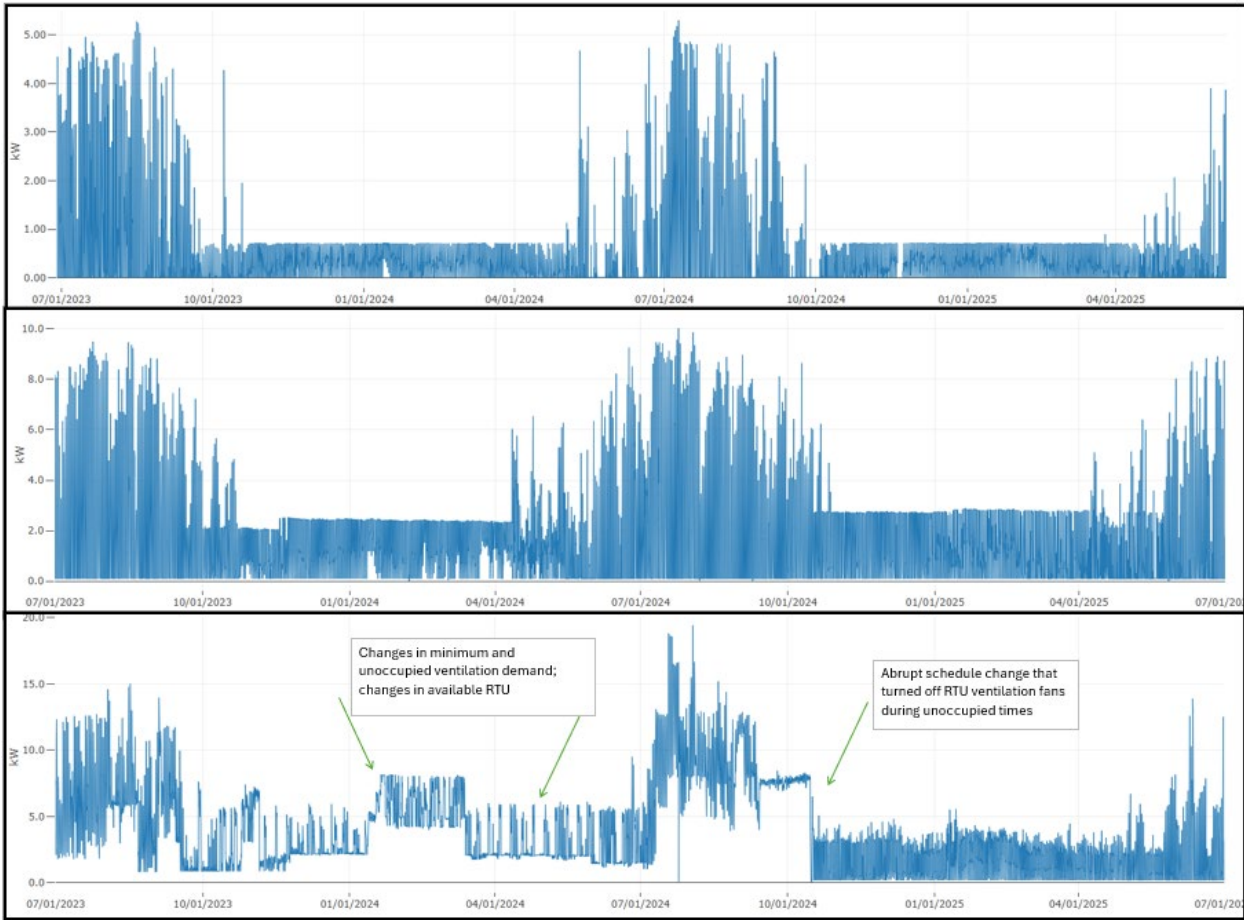
To illustrate how site-specific patterns can propagate into the aggregate expanded shapes, Figure 3-18 shows the site-specific aggregate load shapes for RTUs across the three small retail sites. The top two building profiles have a similar pattern, with controls appearing to turn ventilation fans off during unoccupied periods, consistent ventilation demand during occupied periods, and summer-peaking demand. The bottom building profile (site D\_14229) has inconsistent operating patterns throughout the 2-year period. Load shape patterns indicate changes in minimum and unoccupied ventilation demand, changes in available and operable RTU units, and an abrupt schedule change in the fall of 2024 where the facility began turning off ventilation fans during unoccupied times. At the conclusion of the CEMS metering period DNV contacted the site about the irregularities and the site reported they replaced all the RTU units serving the building in October 2024. The site further shared that the HVAC replacement project was requested by the existing tenant and a stipulation in their lease renewal agreement.

When these individual profiles are rolled up and expanded to represent the mean aggregate small retail RTU load profile, the irregular operating pattern of site D\_14229 carries through, as shown in Figure 3-19. While the mean aggregate profile has been somewhat smoothed out by the other "regular" site specific profiles, the abrupt adjustments in operating schedule across the period persist.<sup>10</sup>

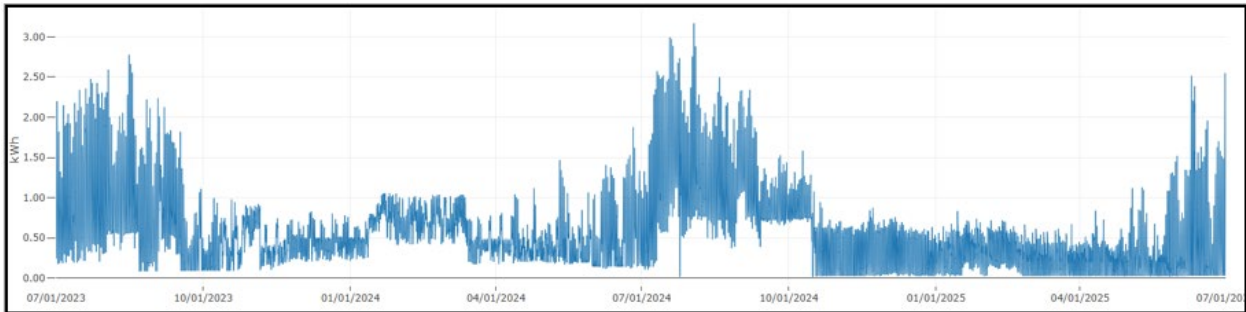
---

<sup>10</sup> For the small retail RTU strata, site D\_14229, it is near double the square footage of the two other sites in the same stratum. The site falls into stratum 1 which has a weight of 13,956 which is to say that this site represents almost 14,000 sites in the population. Strata 2 and 3 sites have weights of 1,256 and 488 respectively. Due to size of the site compared to the others within the same strata and the weighting across strata, this site's profile has strong leverage in the overall retail RTU profile.

**Figure 3-18. Small Retail RTU profiles; site specific**

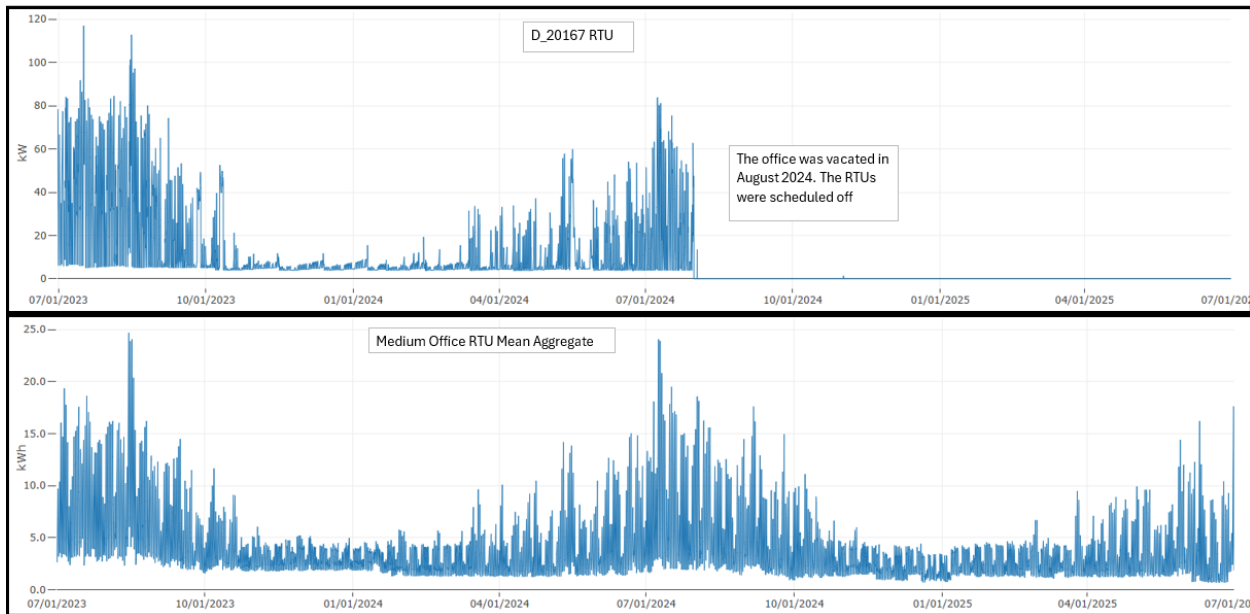


**Figure 3-19. Small Retail RTU Aggregate, Mean**



Another example, this time within the medium office RTU stratum, illustrates the smoothing effect that a larger stratum sample size and consistent load patterns have on the mean aggregate load shape. This stratum included 13 buildings where one of the buildings was vacated in August 2024.<sup>11</sup> As seen in the upper profile in Figure 3-20, the load shape indicates that building operators scheduled the RTUs off when the building was vacated (they kept ERH scheduled on to maintain a minimum setpoint and prevent freezing). However, the mean aggregate profile (the lower profile in Figure 3-20) for this building technology stratum was not significantly influenced by this one building’s abrupt drop in demand. In this case, the site’s weight constituted only 8% of the expanded profile.

**Figure 3-20. Medium office site D\_20167 and medium office RTU mean aggregate**



DNV sought to develop load shapes that are representative of both electric demand patterns of HVAC technologies in commercial buildings but also representative and inclusive of turnover, vacancies, and other events that could be construed as “normal” when extrapolated out to large populations of buildings. It is not uncommon for buildings to undergo disruptive changes that affect their HVAC energy consumption. We believe that the distribution of events, both disruptive and non-disruptive, that occurred within the sample set during the metering period is representative of events that occurred within the population—and that an abrupt vacancy like the one at site D\_20167 is more representative than anomalous. However, we thoroughly documented our methodology and analysis to ensure others can take a different approach and generate alternate load shapes if desired.

### 3.4 12-month analysis

This section examines 12 months of data (July 2023 through June 2024) using the full sample. The study produced time-differentiated, end use load shape data representative of rooftop units (RTUs), heat pumps (HPs), and electric resistance heating (ERH) in office and retail buildings in Idaho, Oregon, Washington, and western Montana. DNV generated 1x8760 actual and normalized profiles for each end use by building type. In turn, the 1x8760 can be used to generate all the desired

<sup>11</sup> The vacancy was not discovered until early 2025. DNV and NEEA decided to retain the participant in the study because there was a chance that the office would be leased to another tenant.

outputs outlined in Table 3-1. The population frames detailed in section 2.3 were used to generate the estimates of total demand.

### 3.4.1 ERH load

Figure 3-21 presents the estimated total demand for ERH across the office and retail segments. The figure to the left is the vertical EnergyPrint, and the two-dimensional graph to the right shows the hourly demand from July 1, 2023 through June 30, 2024. The actual load is represented in orange. The red line represents the average hourly temperature using the Portland weather station. The actual load is highest during periods of extreme cold and decreases as temperature increases.

The actual load shows an extreme peak of nearly 180 MW, which was mostly from the retail sector. Upon examination, this resulted from one of the smaller stratum’s retail sites having high demand during the extreme January 2024 cold snap and carrying a weight of over 20,000. The normalized profile reduces the peak to just over 70 MW. Here again, this is dominated by the retail sector.

**Figure 3-21. ERH: actual across facility (actual load in orange, actual weather in red)**

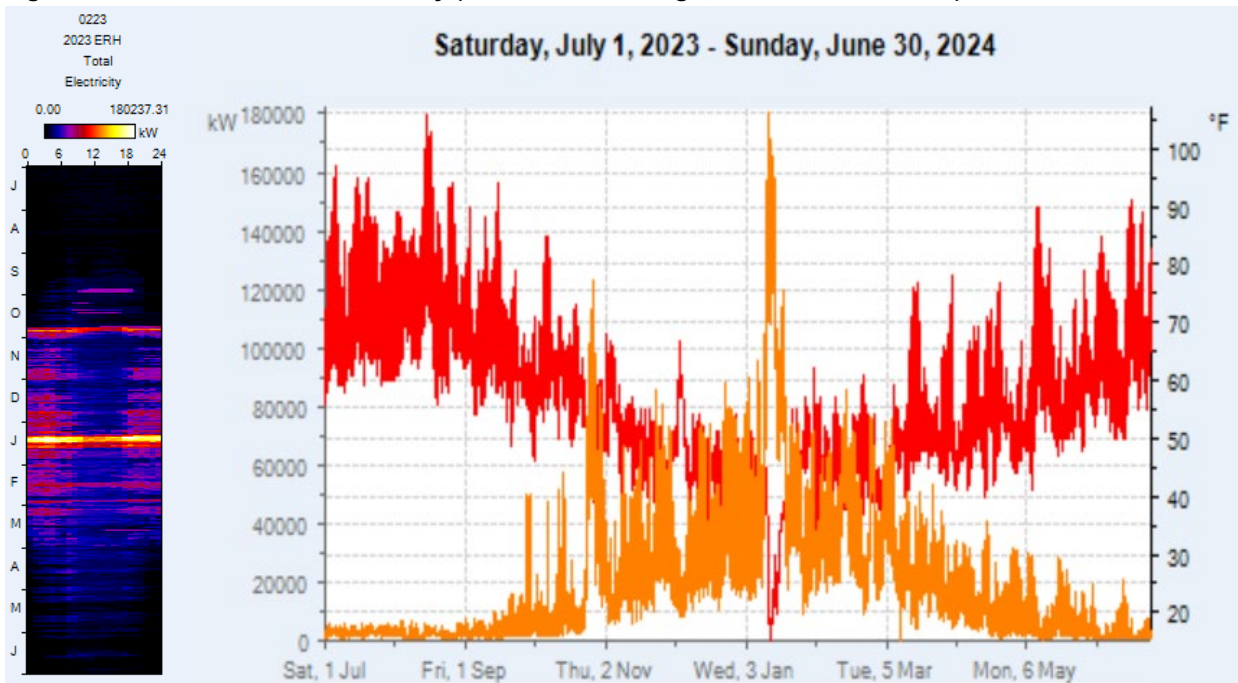
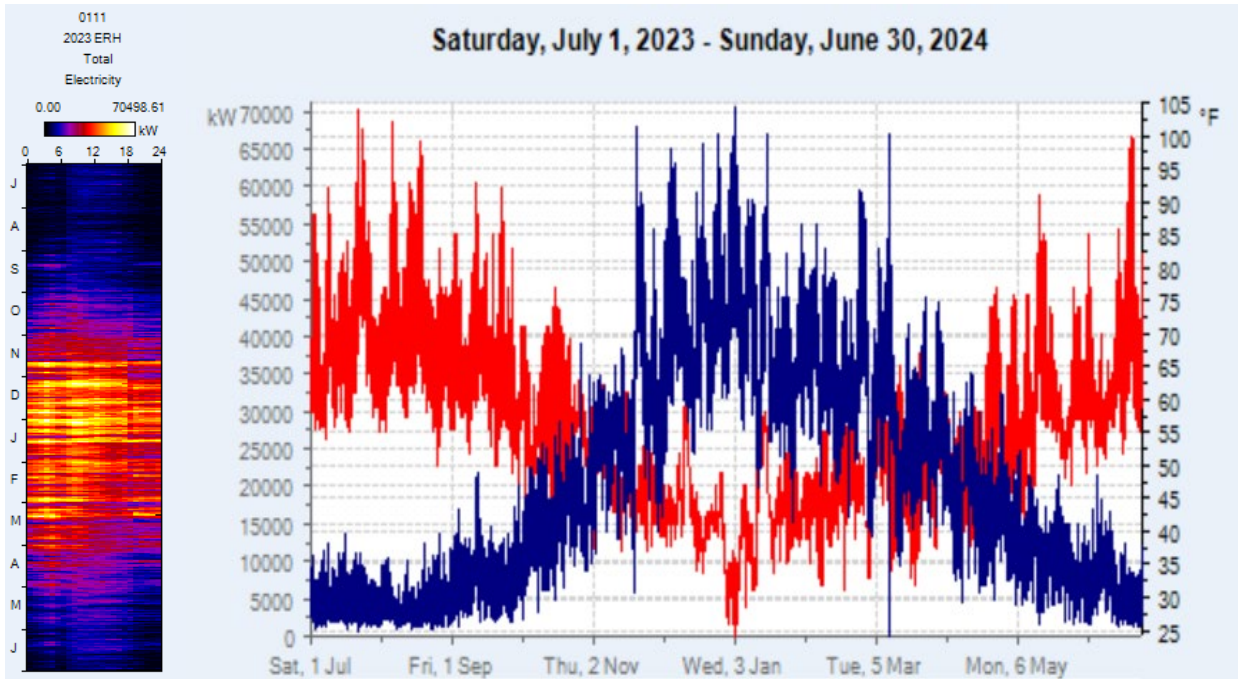


Figure 3-22 presents the load profile for ERH normalized using TMYx normal weather. The normalized load is shown in blue and the TMYx normal weather is shown in red.

Figure 3-22. ERH: normalized to TMYx (load in blue, weather in red)



The end-use data allows us to better understand the temperature response of the buildings and HVAC equipment represented by the load shapes. This can be an effective tool for both demand side management and general energy forecasting.

Figure 3-23 presents the average actual and normal ERH profiles by month. As expected, the ERH load is highest in the winter months. A considerable magnitude of ERH loads measured in the study represented fan-powered boxes (VAV boxes) with electric reheat. Those reheat loads are observable in the summer months (June through August) during hours of typical occupancy (e.g., 6 a.m. to 6 p.m.).

Figure 3-23. ERH: average weekday by month (actual in blue, normal in orange)

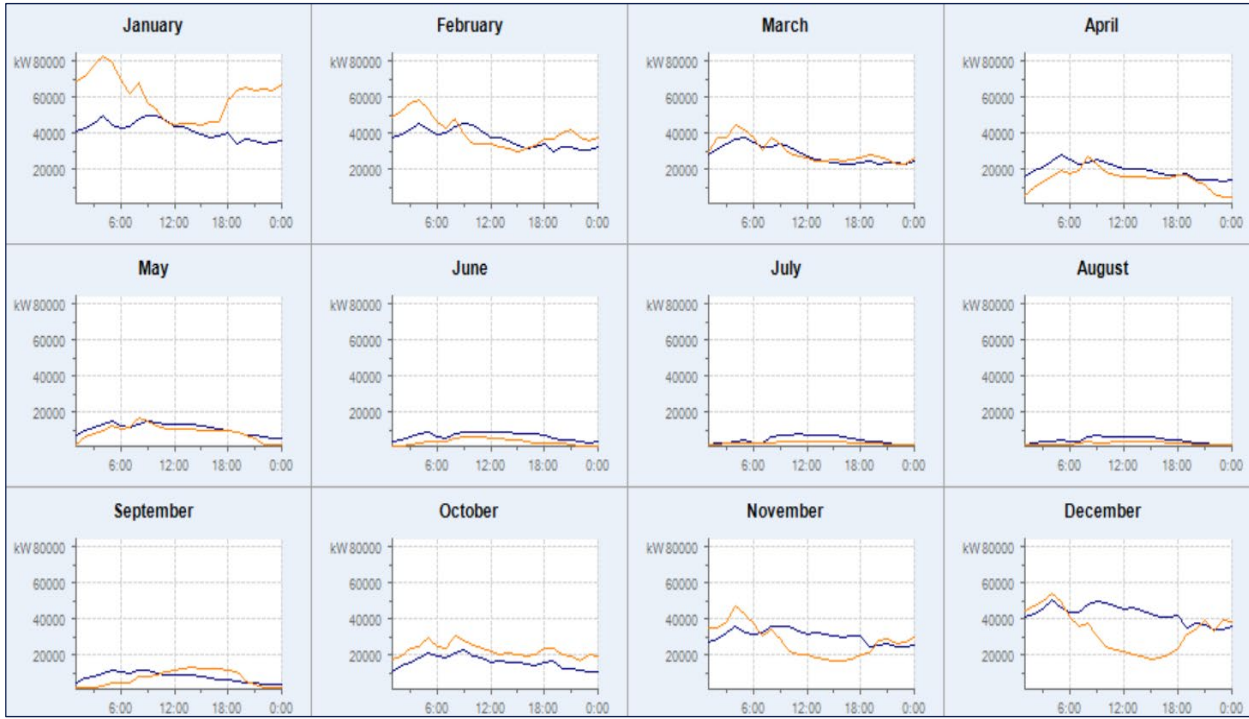
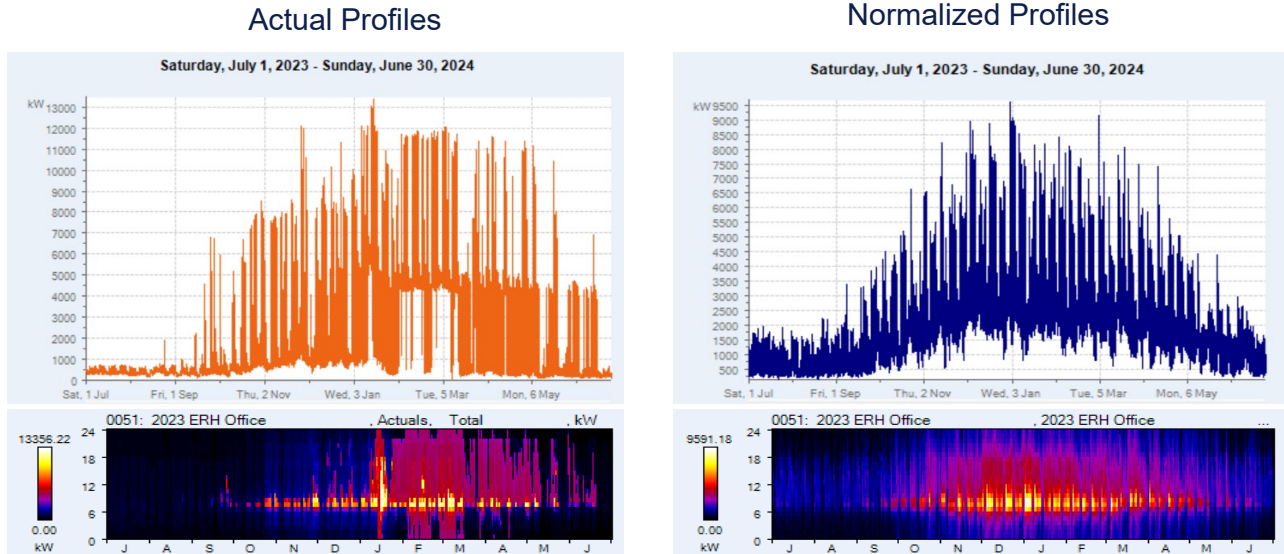
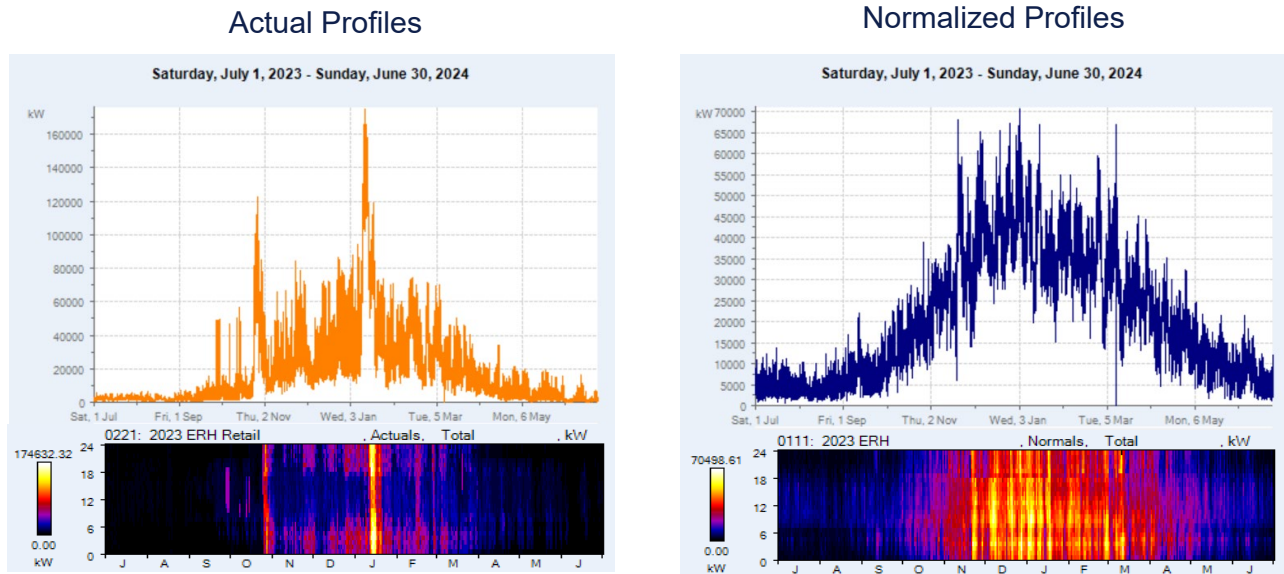


Figure 3-24 and Figure 3-25 highlight the ERH load by sector, i.e., office and retail. The actual load is shown on the left-hand side in orange and the normalized load on the right-hand side in blue. The ERH is dominated by the retail segment. The actual office load peaks at just under 13 MW with the normal load below 10 MW. The actual retail load is dominant peaking at over 174 MW during January’s extreme cold.<sup>12</sup> Normalized to TMYx, the peak ERH load reduces to just 70 MW.

**Figure 3-24. ERH: office sector (actual in orange, normal in blue)**



**Figure 3-25. ERH: retail sector (actual in orange, normal in blue)**



<sup>12</sup> The ERH retail sector load was strongly influenced by two small retail sample sites with conventional ERH loads (e.g., baseboard). The small retail sector has a “heavy” weight for ERH relative to other retail sizes. In other words, the ERH load experienced by the small retail sample sites was multiplied by a large weighting value to extrapolate to the population-level ERH load.

Figure 3-26 presents the average ERH load per facility. Here the average across both sectors is estimated to be 3.0 kW, with the retail sector estimates at 3.6 kW. On a normalized basis, the aggregate peak demand is lowered to 1.17 kW and the retail demand to 1.35 kW.

**Figure 3-26. ERH average load**

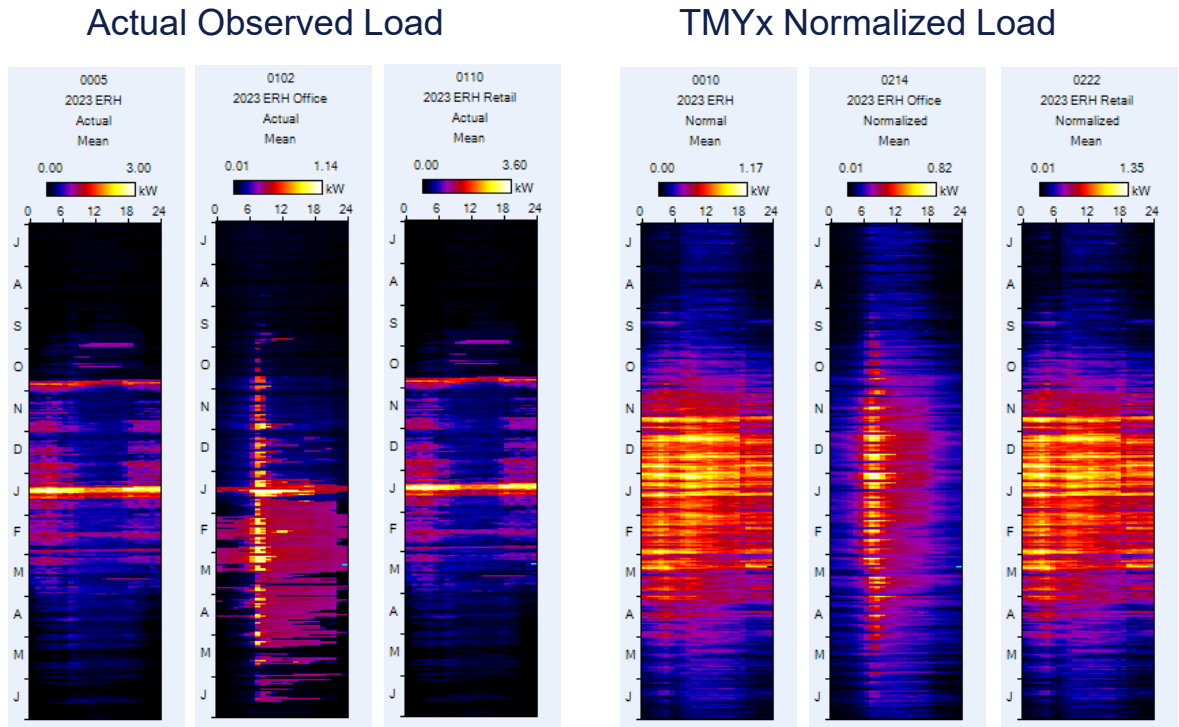


Figure 3-27 presents the summer versus winter average weekday for the actual and normal loads. The actual winter average weekday shape shows a semi-diurnal pattern with higher loads during hours aligning with typical morning warm up and a smaller peak in the evening. The demand stays relatively consistent through colder winter nights. ERH has a modest load in the summer period.

Figure 3-27. ERH summer vs winter average weekday

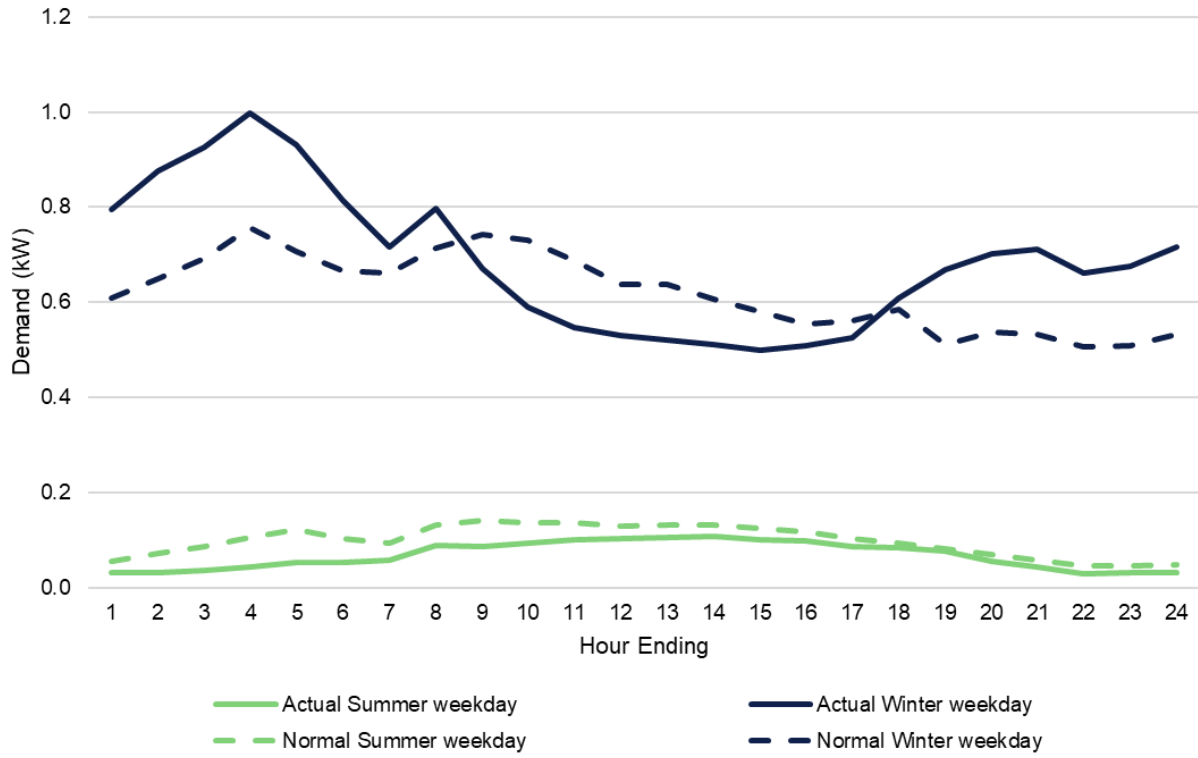


Figure 3-28 presents the actual average ERH load's response to temperature gradients. Here again, 10° gradients are used starting with up to 25°F (Bin 25) and continuing to greater than 85°F (Bin 95). The ERH load shows a significant increase of 1.5 kW per facility at the lowest temperatures.

**Figure 3-28. ERH temperature sensitivity**

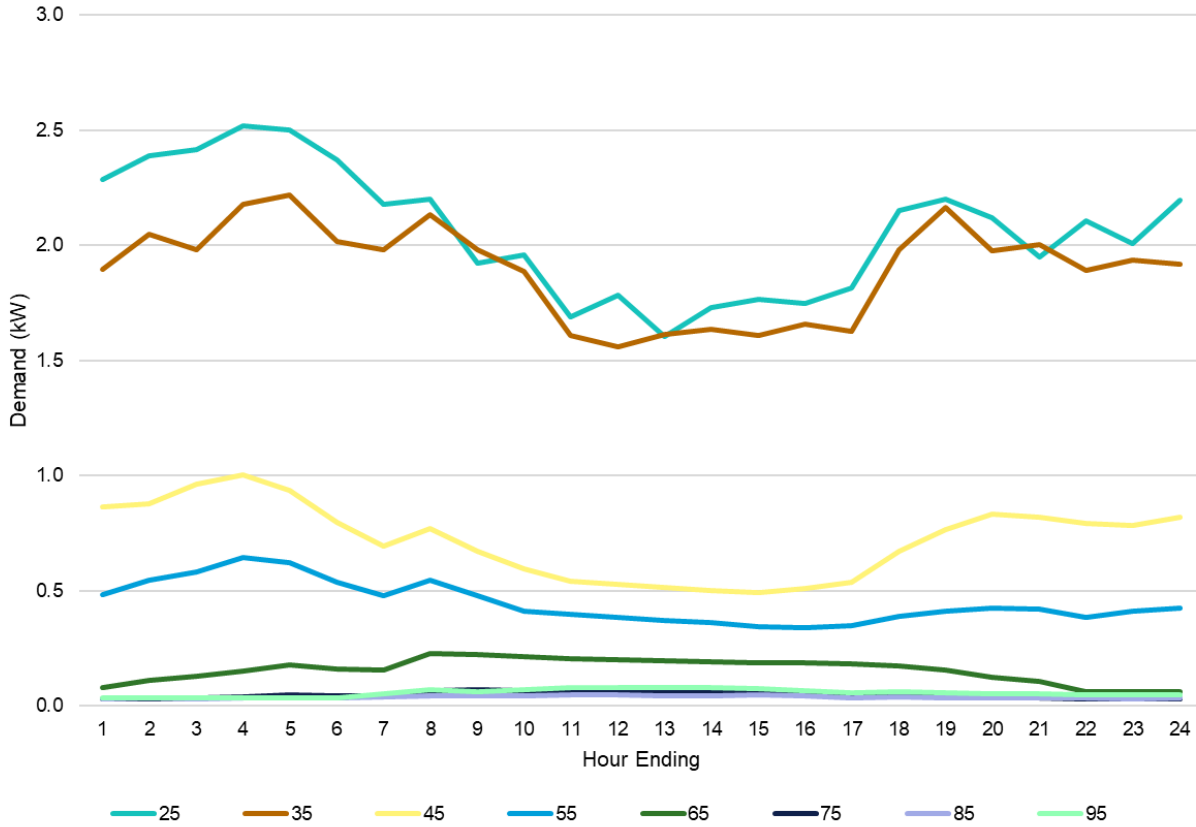


Table 3-5 and Table 3-6 present key energy usage and demand characteristics<sup>13</sup> for the ERH technology in office and retail sectors both on an actual and normalized basis. The tables present the following characteristics:

- Monthly use in kWh
- Non-coincident peak demand in kW
- The date and hour of the non-coincident peak demand
- The average demand in kW
- The load factor (%)

The left-hand side of the table presents the actual observed load, and the right-hand side presents the normalized load. For both sectors, the actual and normalized annual energy (kWh) is relatively equal, but the actual peak demand is dramatically larger than the normalized peak demand across nearly all months, especially the winter months. This underscores the effect that normal weather can have on modeled loads.

<sup>13</sup> APPENDIX I contains similar information but on an average per facility basis, i.e., means. APPENDIX J contains other technology and sector totals



**Table 3-5. Key energy & demand characteristics: office ERH**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	322,383	743	Tue, Jul 11, 2023 07:00	433	58.3%	543,449	1,952	Tue, Jul 11, 2023 08:00	730	37.4%
<b>Aug-23</b>	300,680	1,882	Thu, Aug 24, 2023 09:00	404	21.5%	541,768	2,242	Tue, Aug 22, 2023 08:00	728	32.5%
<b>Sep-23</b>	360,659	6,777	Mon, Sep 25, 2023 13:00	501	7.4%	717,688	3,979	Fri, Sep 29, 2023 09:00	997	25.1%
<b>Oct-23</b>	663,179	8,541	Mon, Oct 30, 2023 10:00	891	10.4%	1,260,244	6,651	Mon, Oct 23, 2023 09:00	1,694	25.5%
<b>Nov-23</b>	1,157,794	12,122	Mon, Nov 27, 2023 09:00	1,608	13.3%	1,822,804	8,232	Tue, Nov 14, 2023 08:00	2,532	30.8%
<b>Dec-23</b>	1,323,950	11,342	Mon, Dec 25, 2023 09:00	1,779	15.7%	2,429,701	8,942	Mon, Dec 04, 2023 08:00	3,266	36.5%
<b>Jan-24</b>	2,775,328	13,356	Tue, Jan 16, 2024 11:00	3,730	27.9%	2,377,025	9,591	Mon, Jan 01, 2024 09:00	3,195	33.3%
<b>Feb-24</b>	3,302,945	11,899	Tue, Feb 27, 2024 08:00	4,745	39.9%	1,996,998	8,404	Mon, Feb 05, 2024 08:00	2,869	34.1%
<b>Mar-24</b>	2,871,125	12,047	Wed, Mar 06, 2024 08:00	3,859	32.0%	1,835,015	9,145	Mon, Mar 04, 2024 08:00	2,466	27.0%
<b>Apr-24</b>	2,121,125	11,602	Mon, Apr 08, 2024 08:00	2,946	25.4%	1,529,943	7,481	Mon, Apr 01, 2024 09:00	2,125	28.4%
<b>May-24</b>	1,139,482	11,156	Mon, May 06, 2024 09:00	1,531	13.7%	1,098,139	4,410	Mon, May 13, 2024 09:00	1,476	33.5%
<b>Jun-24</b>	540,524	6,912	Mon, Jun 17, 2024 08:00	749	10.8%	725,644	2,951	Mon, Jun 10, 2024 09:00	1,005	34.0%
<b>Annual</b>	16,879,174	13,356	Tue, Jan 16, 2024 11:00	1,927	14.4%	16,878,417	9,591	Mon, Jan 01, 2024 09:00	1,926	20.1%

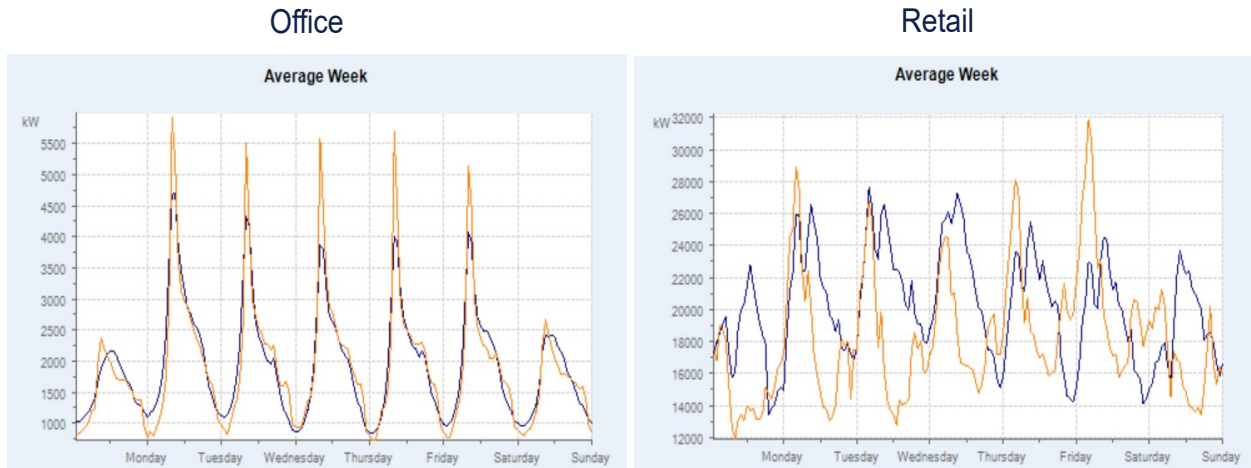


**Table 3-6. Key energy & demand characteristics: retail ERH**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	1,817,877	5,581	Fri, Jul 28, 2023 13:00	2,443	43.8%	2,955,888	12,924	Sat, Jul 15, 2023 17:00	3,973	30.7%
<b>Aug-23</b>	1,481,934	6,326	Tue, Aug 08, 2023 13:00	1,992	31.5%	2,763,203	12,792	Sat, Aug 26, 2023 16:00	3,714	29.0%
<b>Sep-23</b>	3,912,507	49,640	Fri, Sep 29, 2023 18:00	5,434	11.0%	4,712,228	21,293	Tue, Sep 12, 2023 05:00	6,545	30.7%
<b>Oct-23</b>	15,187,871	122,383	Fri, Oct 27, 2023 03:00	20,413	16.7%	10,052,190	37,431	Fri, Oct 27, 2023 05:00	13,511	36.1%
<b>Nov-23</b>	17,786,657	84,523	Fri, Nov 24, 2023 04:00	24,703	29.2%	19,243,911	65,439	Tue, Nov 21, 2023 04:00	26,728	40.8%
<b>Dec-23</b>	22,851,304	86,598	Mon, Dec 25, 2023 03:00	30,713	35.5%	28,226,123	65,032	Wed, Dec 27, 2023 03:00	37,939	58.3%
<b>Jan-24</b>	42,854,117	174,632	Fri, Jan 12, 2024 19:00	57,598	33.0%	26,753,480	64,851	Wed, Jan 17, 2024 04:00	35,959	55.5%
<b>Feb-24</b>	23,053,999	74,059	Fri, Feb 16, 2024 08:00	33,123	44.7%	23,150,047	57,146	Wed, Feb 28, 2024 03:00	33,262	58.2%
<b>Mar-24</b>	17,335,253	70,309	Thu, Mar 07, 2024 04:00	23,300	33.1%	18,889,371	64,840	Mon, Mar 11, 2024 03:00	25,389	39.2%
<b>Apr-24</b>	7,601,516	34,300	Thu, Apr 18, 2024 06:00	10,557	30.8%	12,404,122	42,000	Mon, Apr 01, 2024 05:00	17,228	41.0%
<b>May-24</b>	4,869,729	21,120	Wed, May 01, 2024 07:00	6,545	31.0%	7,174,050	23,330	Tue, May 07, 2024 05:00	9,643	41.3%
<b>Jun-24</b>	1,719,555	16,281	Mon, Jun 17, 2024 10:00	2,381	14.6%	4,136,006	20,374	Mon, Jun 10, 2024 05:00	5,727	28.1%
<b>Annual</b>	160,472,319	174,632	Fri, Jan 12, 2024 19:00	18,318	10.5%	160,460,619	65,439	Tue, Nov 21, 2023 04:00	18,316	28.0%

Figure 3-29 presents the average weekday load of ERH in the office and retail sectors. Actual load is shown in orange and normalized load is shown in blue. The actual office profile suggests a consistent scheduled operating pattern, while the actual retail profile suggests ERH operation is much more erratic, potentially influenced by manual intervention or customer occupancy, as higher ingress/egress leads to higher infiltration.

**Figure 3-29. ERH: average weekday load (actual in orange, normal in blue)**



### 3.4.2 HP load

Figure 3-30 presents the HP total load across both office and retail sectors. In contrast to the ERH load, this load has a much higher consistency, i.e., load factor, throughout the period. The HP total load is highest in the early morning periods, with a significant increase in load during January's extreme cold.

**Figure 3-30. HP: actual across facility (actual load in orange, actual weather in red)**

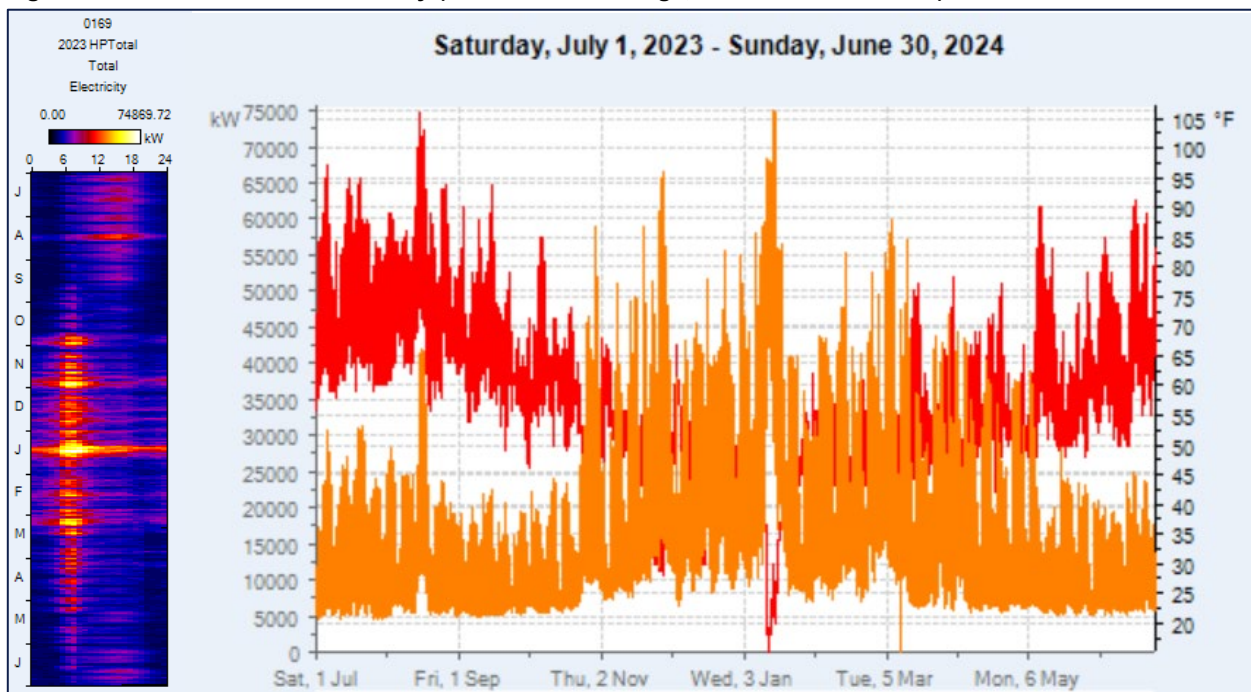


Figure 3-31 shows the impact of adjusting the actual load (in blue) to the normal TMYx temperature set (in red). The demand is dramatically reduced: the actual peak around 75 MW drops to a normal peak around 60 MW.

**Figure 3-31. HP: normalized to TMYx (load in blue, weather in red)**

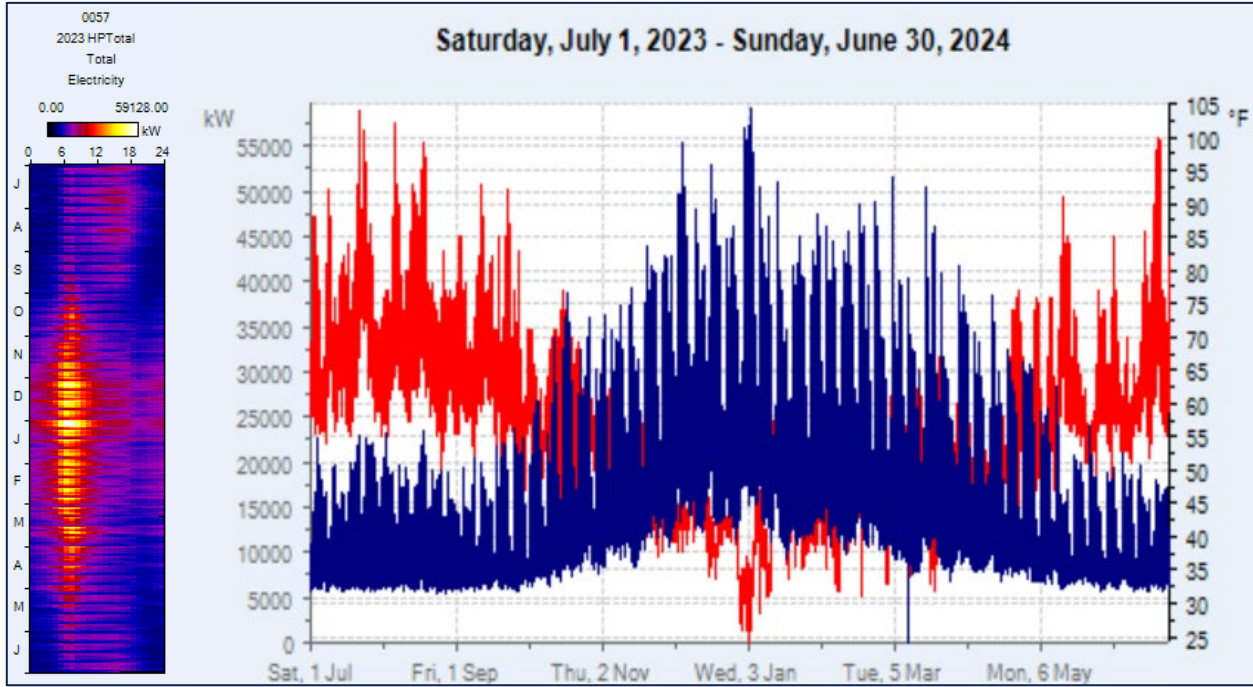


Figure 3-32 presents a comparison of the average weekday load during the summer and winter months. The HP load is more dominant in the winter morning hours, with an average demand of 2.0 kW per customer. However, the average winter shape appears to suggest that the HPs have more setback controls than ERH to curtail demand during off-peak hours. The ERH winter weekday shape in Figure 3-27 has a peak roughly twice the demand of base demand while the HP has a peak of nearly four times the base demand.

**Figure 3-32. HP summer vs winter average weekday**

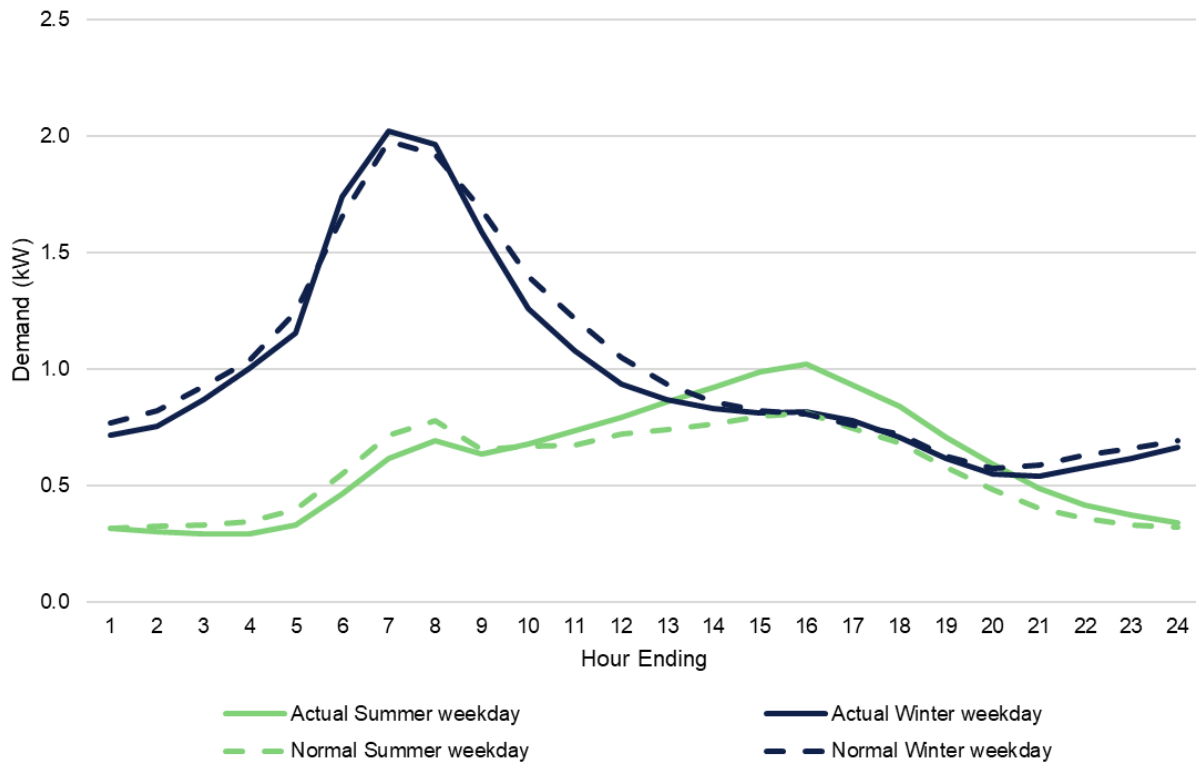


Figure 3-33 presents the change in HP load by temperature gradients. Once again, 10°F gradients are used starting with up to 25°F (Bin 25) and continuing to greater than 85°F (Bin 95). The heat pump load shows an increase in early morning winter load with lower temperatures and an increase in late afternoon load with the highest temperatures.

**Figure 3-33. HP temperature sensitivity**

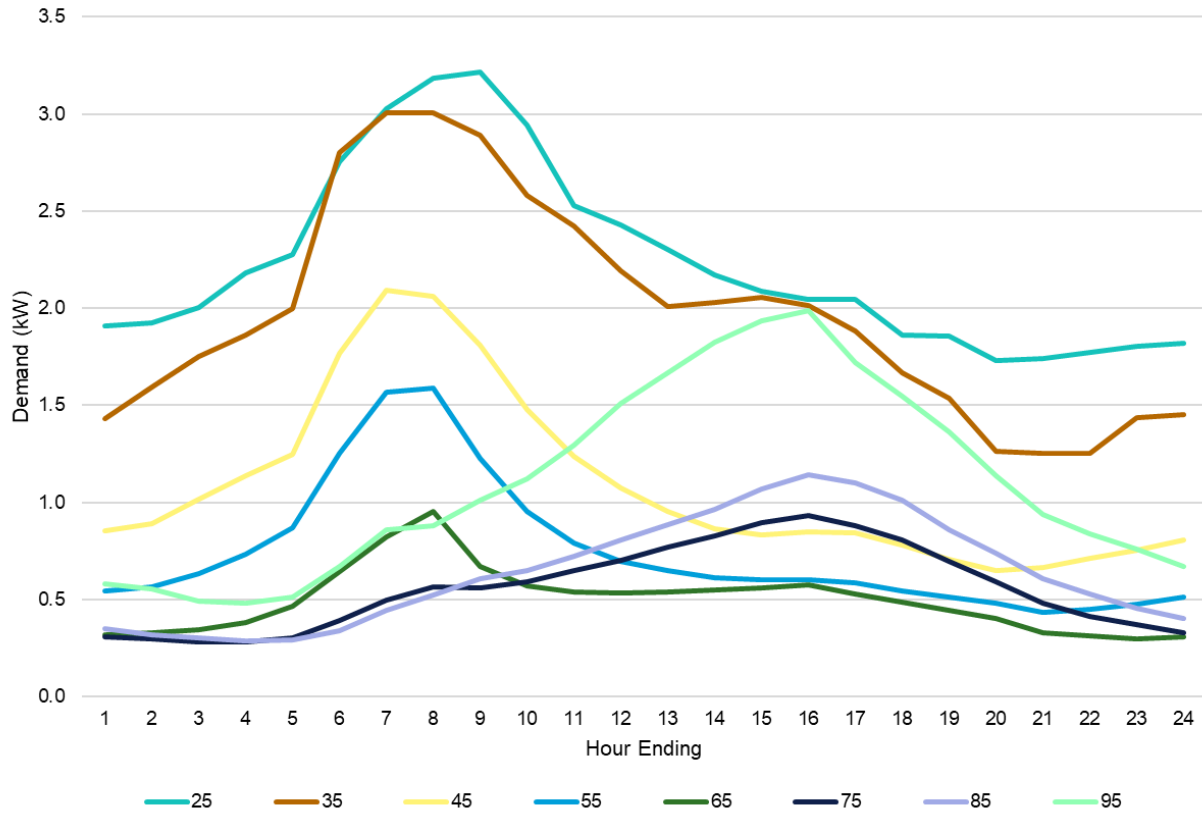


Figure 3-34 zooms in on the very cold mid-January 2024 period, when actual temperature (in red) dropped below 20°F. The figure shows that the actual HP load (in orange) steadily increases with the colder temperatures. The normal profile (in blue) shows a dampened load in anticipation of less extreme temperatures.

**Figure 3-34. HP: zoomed-in total demand versus temperature (actual load in orange, normal load in blue, actual weather in red)**

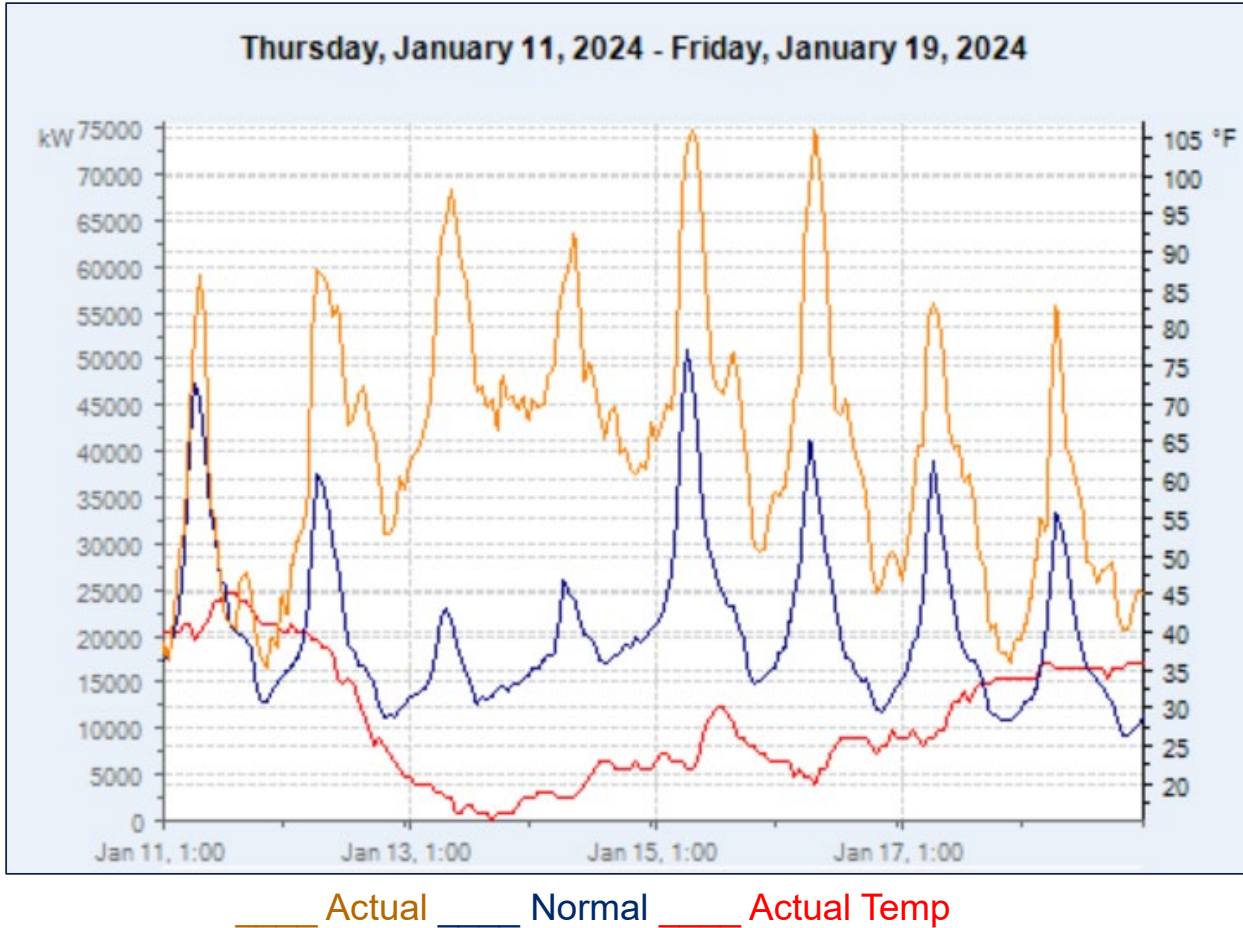
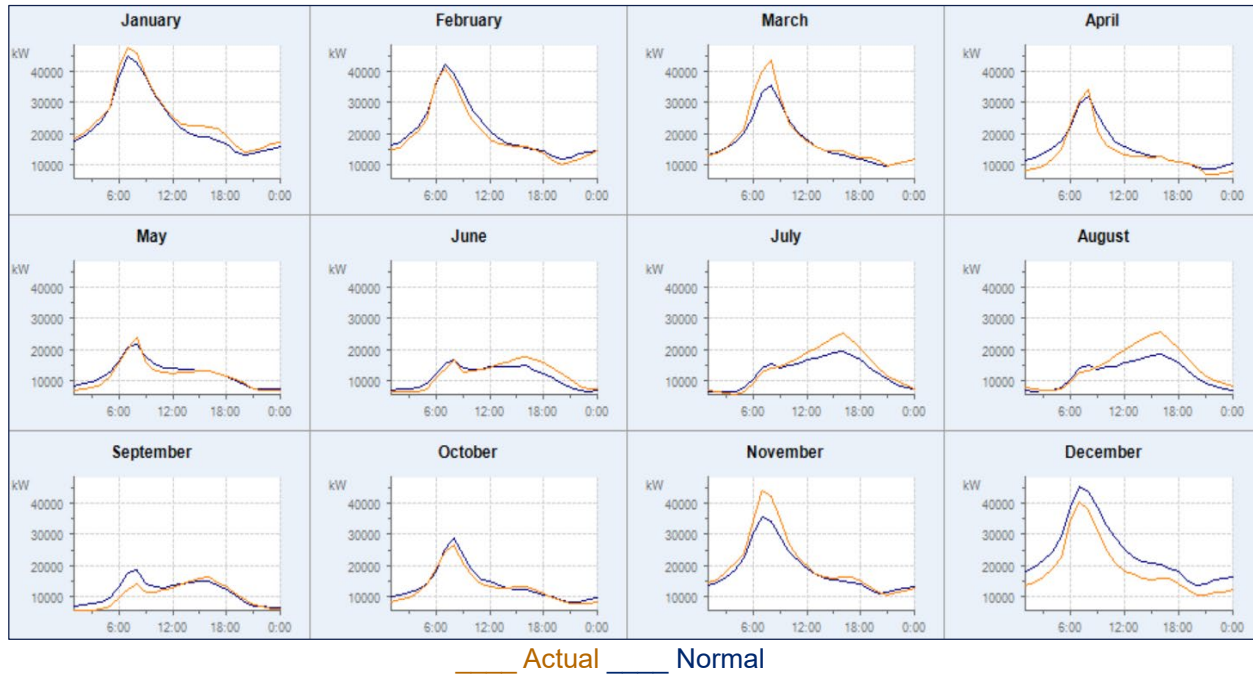


Figure 3-35 presents the average weekday actual and normal load profiles for HP total by month. The charts show that the primary peak demand for HPs occurs in the winter.

**Figure 3-35. HP: average weekday by month (actual in orange, normal in blue)**



The load duration curve shown in Figure 3-36 summarizes the amount of time the HP load is at or below a particular value. The maximum observed demand was 75 MW. At the 99<sup>th</sup> percentile, the load falls to 51 MW which means that there are approximately 90 hours (1% of 8,760 hours) where load management might be an effective tool to access approximately 24 MW of HP load.

**Figure 3-36. HP load duration curve**

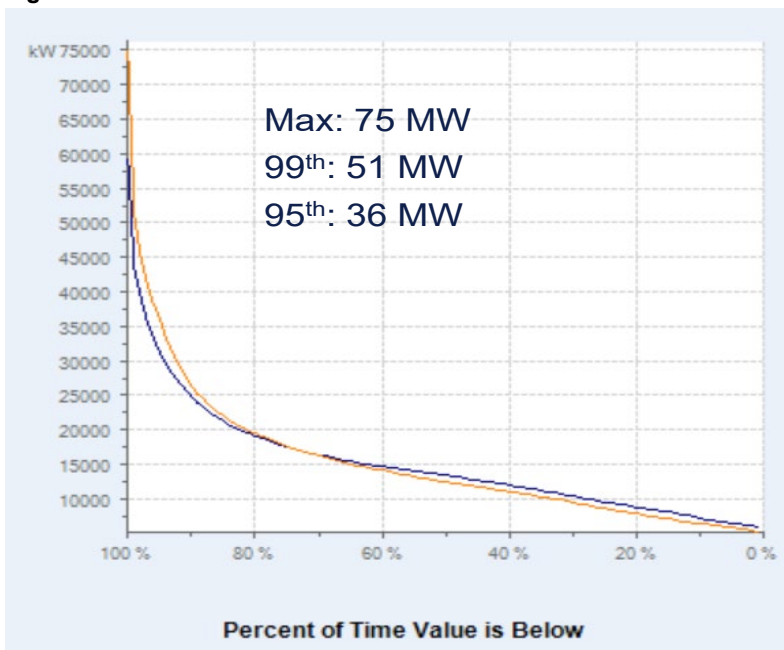
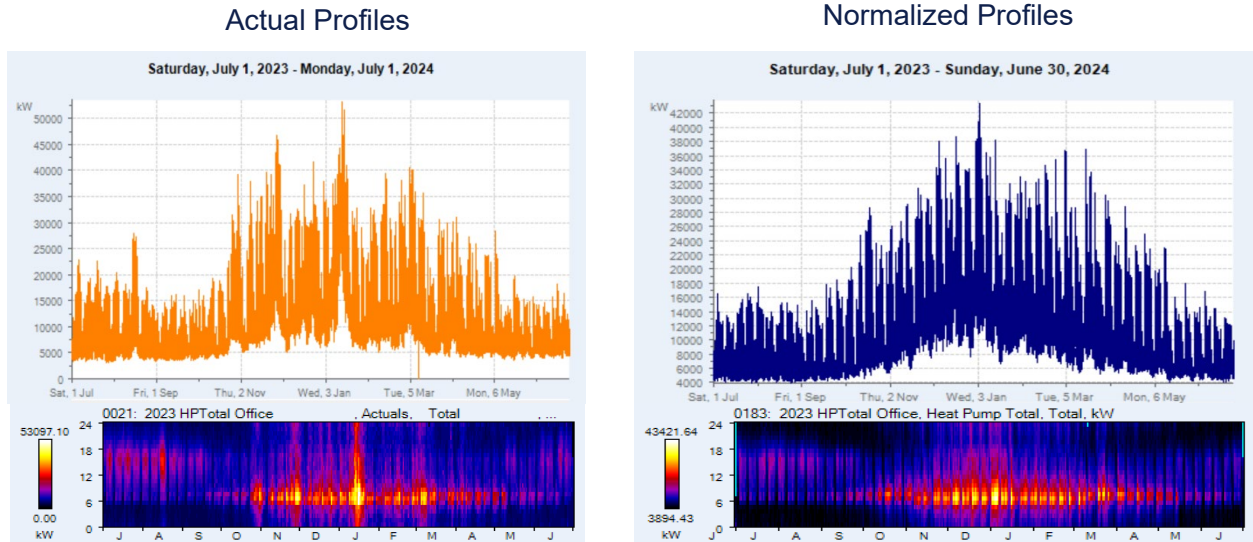
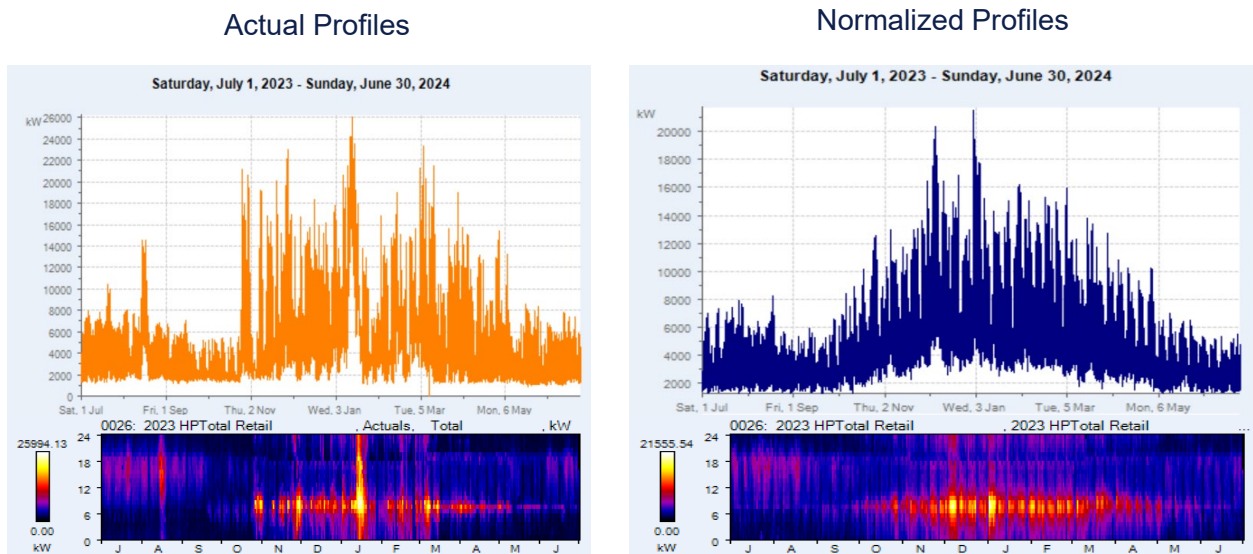


Figure 3-37 and Figure 3-38 present the HP total load for the office and retail sectors. The figures display the actual (in orange) and normal (in blue) loads. While the office sector shows a demand roughly twice that of the retail sector, the load characteristics of HPs used in the two sectors seems more similar than different. As expected, the normal weather data smooths out the extreme cold, mid-January peaks of the actual loads.

**Figure 3-37. HP total load: office sector (actual load in orange, normal load in blue)**



**Figure 3-38. HP total load: retail sector (actual load in orange, normal load in blue)**



Similar to the ERH tables presented in 3.4.1, Table 3-7 and Table 3-8 display key energy and demand characteristics for the HP load of the office and retail sectors, respectively<sup>14</sup>. The HP normal peak demands appear more stable (with smaller differences between actual and normal peaks) than the ERH end use normal peak demands. Note that most HP systems with auxiliary electric heating are designated as HPs—however, there are some HP systems (mainly split system HPs or

<sup>14</sup> APPENDIX J contains other technology and sector totals



packaged HPs with strip heat kits) where the auxiliary electric circuits are categorized as ERH. Normal HP peaks may be more stable than normal ERH peaks because at extremely low temperatures, it is possible that the HP systems lock out compressors, and the buildings use other heating systems to compensate for the heating load.



**Table 3-7. Key energy & demand characteristics: office HPs**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	6,647,119	22,785	Wed, Jul 05, 2023 16:00	8,934	39.2%	6,095,927	16,567	Mon, Jul 24, 2023 15:00	8,194	49.5%
<b>Aug-23</b>	6,763,877	28,003	Tue, Aug 15, 2023 16:00	9,091	32.5%	5,968,979	17,528	Tue, Aug 01, 2023 16:00	8,023	45.8%
<b>Sep-23</b>	4,977,957	16,270	Fri, Sep 15, 2023 15:00	6,913	42.5%	5,372,853	18,407	Mon, Sep 25, 2023 08:00	7,463	40.5%
<b>Oct-23</b>	6,565,745	39,324	Mon, Oct 30, 2023 08:00	8,824	22.4%	6,584,091	28,704	Wed, Oct 18, 2023 08:00	8,850	30.8%
<b>Nov-23</b>	9,770,561	46,708	Tue, Nov 28, 2023 07:00	13,569	29.1%	8,799,354	31,449	Tue, Nov 21, 2023 07:00	12,222	38.9%
<b>Dec-23</b>	10,071,086	41,587	Mon, Dec 25, 2023 07:00	13,535	32.6%	11,771,352	38,690	Mon, Dec 18, 2023 07:00	15,823	40.9%
<b>Jan-24</b>	12,470,647	53,097	Mon, Jan 15, 2024 07:00	16,760	31.6%	11,395,322	43,422	Thu, Jan 04, 2024 07:00	15,318	35.3%
<b>Feb-24</b>	8,674,758	39,477	Fri, Feb 16, 2024 07:00	12,463	31.6%	9,464,937	35,471	Mon, Feb 26, 2024 07:00	13,600	38.3%
<b>Mar-24</b>	8,637,369	40,457	Mon, Mar 04, 2024 07:00	11,609	28.7%	8,367,376	36,956	Mon, Mar 18, 2024 08:00	11,247	30.4%
<b>Apr-24</b>	6,458,934	30,963	Mon, Apr 08, 2024 07:00	8,970	29.0%	7,248,571	30,488	Mon, Apr 01, 2024 08:00	10,068	33.0%
<b>May-24</b>	5,820,223	28,438	Mon, May 06, 2024 08:00	7,822	27.5%	6,119,427	23,023	Mon, May 13, 2024 07:00	8,226	35.7%
<b>Jun-24</b>	5,660,633	18,071	Thu, Jun 20, 2024 16:00	7,783	43.1%	5,329,131	16,858	Mon, Jun 10, 2024 07:00	7,325	43.5%
<b>Annual</b>	92,518,908	53,097	Mon, Jan 15, 2024 07:00	10,554	19.9%	92,517,320	43,422	Thu, Jan 04, 2024 07:00	10,556	24.3%



**Table 3-8. Key energy & demand characteristics: retail HPs**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	2,963,034	10,387	Thu, Jul 20, 2023 16:00	3,982	38.3%	2,539,939	7,921	Tue, Jul 25, 2023 17:00	3,414	43.1%
<b>Aug-23</b>	3,179,812	14,525	Mon, Aug 14, 2023 16:00	4,274	29.4%	2,422,323	8,206	Thu, Aug 17, 2023 17:00	3,256	39.7%
<b>Sep-23</b>	1,945,376	7,078	Fri, Sep 15, 2023 17:00	2,702	38.2%	2,082,252	6,578	Thu, Sep 28, 2023 08:00	2,892	44.0%
<b>Oct-23</b>	2,463,492	21,148	Thu, Oct 26, 2023 09:00	3,311	15.7%	2,740,102	12,536	Fri, Oct 27, 2023 08:00	3,684	29.4%
<b>Nov-23</b>	3,732,540	23,026	Wed, Nov 29, 2023 08:00	5,184	22.5%	3,792,891	13,607	Mon, Nov 27, 2023 08:00	5,269	38.7%
<b>Dec-23</b>	4,035,599	18,286	Mon, Dec 18, 2023 08:00	5,424	29.7%	5,187,504	20,380	Wed, Dec 06, 2023 08:00	6,974	34.2%
<b>Jan-24</b>	6,020,964	25,994	Mon, Jan 15, 2024 09:00	8,092	31.1%	4,891,671	21,556	Mon, Jan 01, 2024 08:00	6,576	30.5%
<b>Feb-24</b>	4,002,189	18,975	Fri, Feb 16, 2024 09:00	5,750	30.3%	4,330,482	16,233	Thu, Feb 01, 2024 08:00	6,223	38.3%
<b>Mar-24</b>	3,833,700	23,318	Thu, Mar 07, 2024 08:00	5,152	22.1%	3,674,087	15,957	Mon, Mar 04, 2024 08:00	4,939	31.0%
<b>Apr-24</b>	2,573,546	18,975	Mon, Apr 01, 2024 08:00	3,574	18.8%	2,948,511	12,746	Mon, Apr 01, 2024 09:00	4,096	32.1%
<b>May-24</b>	2,127,217	15,419	Wed, May 01, 2024 08:00	2,859	18.5%	2,376,776	10,260	Wed, May 01, 2024 08:00	3,195	31.1%
<b>Jun-24</b>	2,135,647	7,771	Mon, Jun 17, 2024 08:00	2,927	37.7%	2,024,271	5,520	Fri, Jun 28, 2024 17:00	2,769	50.2%
<b>Annual</b>	39,013,115	25,994	Mon, Jan 15, 2024 09:00	4,450	17.1%	39,010,810	21,556	Mon, Jan 01, 2024 08:00	4,450	20.6%

### 3.4.3 RTU Load

Figure 3-39 shows the load for RTUs across the office and retail sectors. This load shows a significant increase in load during the late August heat dome that resulted in a temperature of approximately 105°F. Since systems designated as RTUs used natural gas for their heating component, there was virtually no response to the extremely cold temperatures in mid-January that reached 15°F.

**Figure 3-39. RTU: actual across facility (actual load in orange, actual weather in red)**

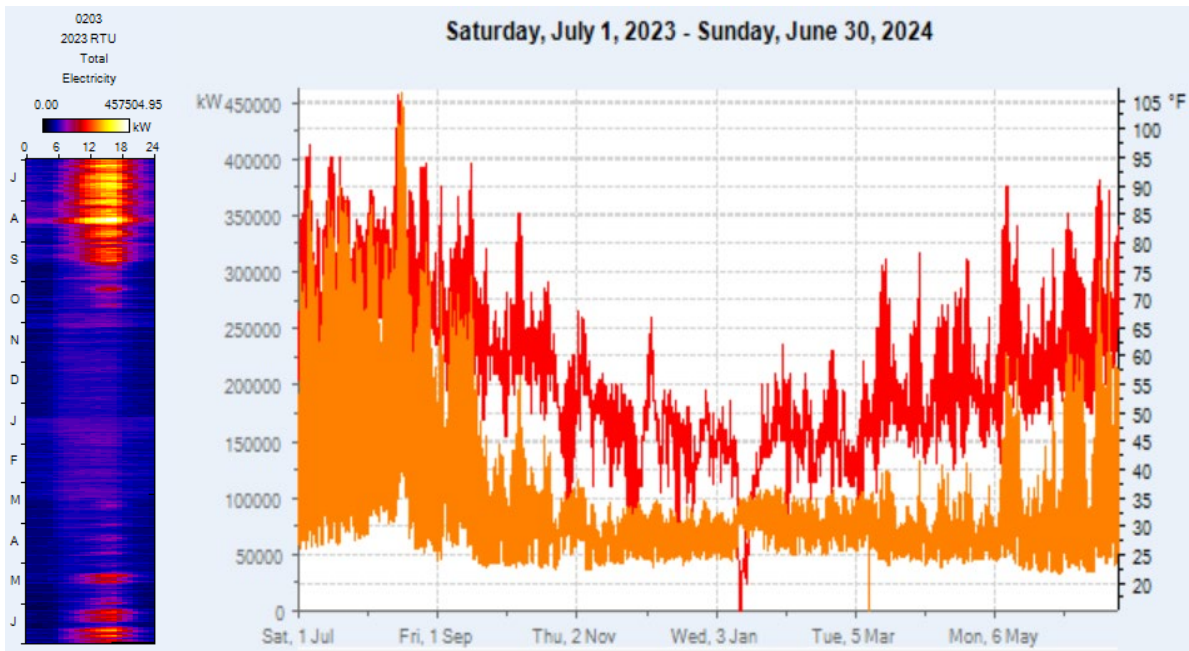


Figure 3-40 presents the results after normalizing the RTU load to the TMYx normal weather. The normalization produces a slightly smoother load profile with less extreme swings in load, particularly in the hotter summer months. The normal peak is approximately 12 MW lower than the actual peak.

**Figure 3-40. RTU: normalized to TMYx (normal load in blue, normal weather in red)**

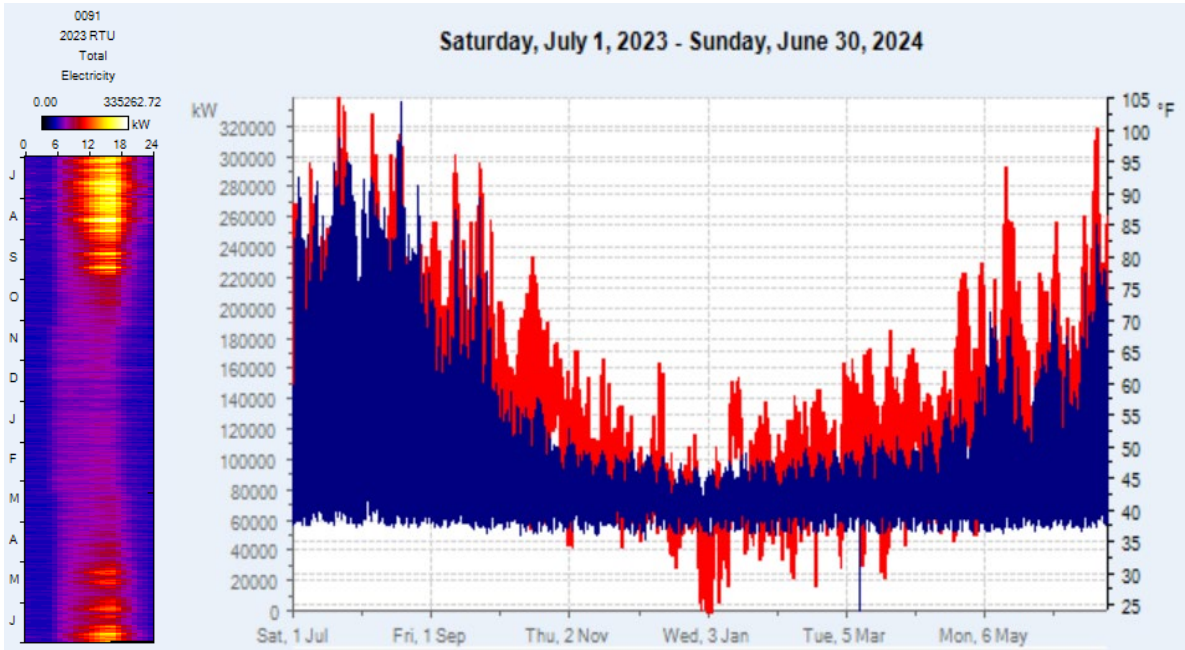


Figure 3-41 presents another angle of the above figures and summarizes the 1 x 8760 profiles of the estimated total RTU load. The figure presents the actual observed load on the left-hand side and the TMYx normalized on the right-hand side of the figure. Three vertical EnergyPrints are presented for each set, reflecting the combined office and retail, office only, and retail only loads. The estimate of aggregate RTU load peaked at 457 MW with the majority associated with the retail sector. On a normalized basis, the combined RTU load was estimated at 335 MW.

**Figure 3-41. RTU actual and normalized: estimated total load**

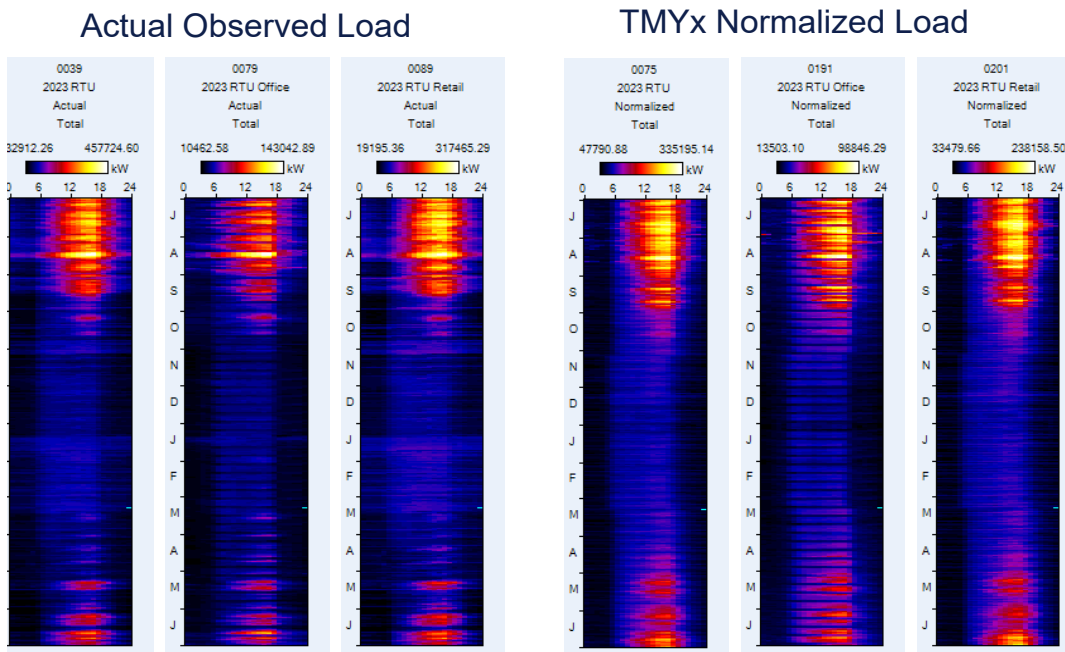


Figure 3-42 depicts the same load on a per-customer basis. The mean actual load peaks at 5.81 kW per customer and is nearly identical between the office (5.76 kW) and retail (5.88 kW) sectors. On a normalized basis, the aggregate RTU load is estimated at 4.25 kW, with the office estimated at 3.98 kW and the retail sector at 4.41 kW. The RTU is primarily a summer load with the greatest intensity in June through September.

**Figure 3-42. RTU actual versus normal: estimated mean load**

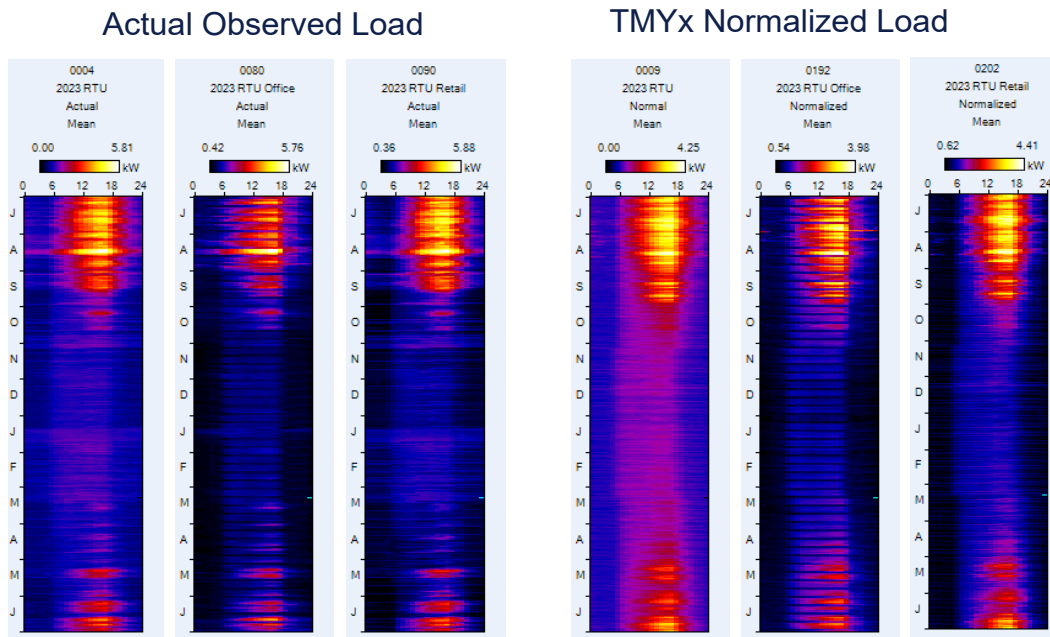


Figure 3-43 presents a comparison of the RTU mean average weekday profiles on an actual and normalized basis for summer versus winter. While there is some base winter load, summer encompasses the vast majority of load. The summer weekday peak is around three times the base load. However, the demand grows gradually over the typical workday, starting to increase at 6 a.m. and dropping to base in the late evening.

**Figure 3-43. RTU summer vs winter average weekday**

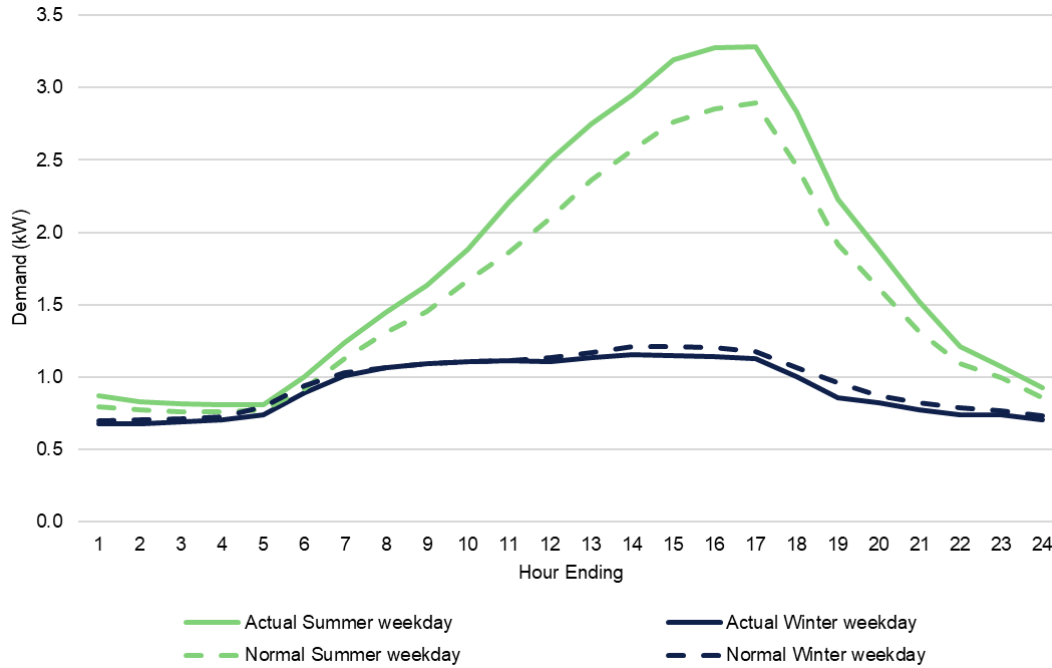


Figure 3-44 presents the average customer RTU demand by various temperature gradients. The gradients are in 10°F increments starting with temperatures up to 25°F (Bin 25), then between 25 and 35°F (Bin 35), and so on up to temperatures over 85°F in Bin 95. The RTU end use is primarily air conditioning with gas heating, so warmer temperatures clearly result in significant electric load increases while cooler temperatures rely on gas heating.

**Figure 3-44. RTU demand by temperature bin**

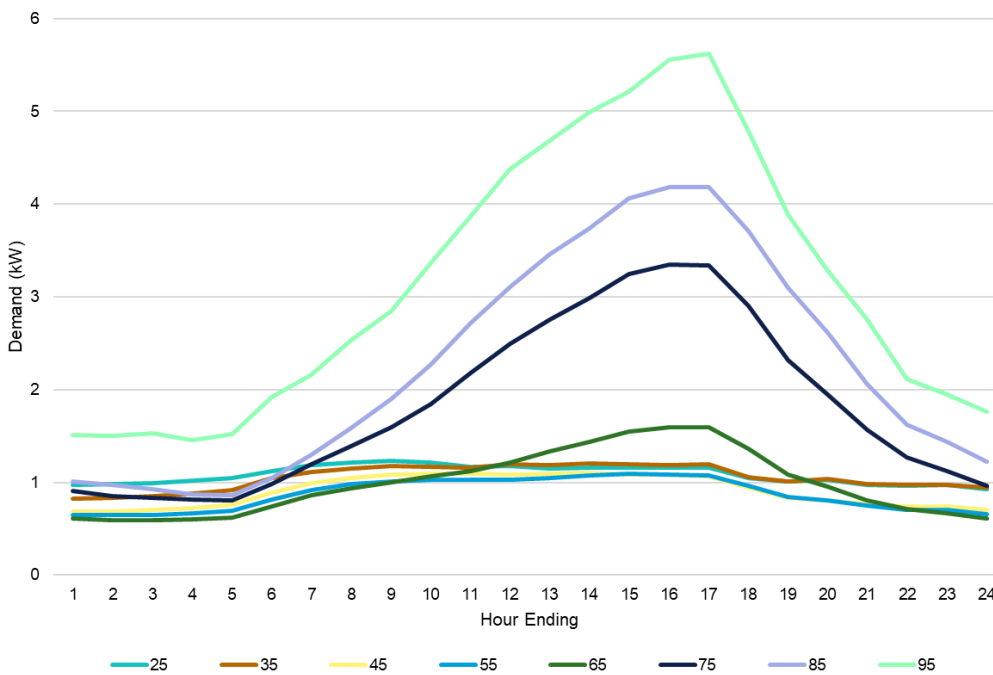


Figure 3-45 compares the RTU demand during the cold snap period in mid-January and a hot mid-August week. From a technology perspective, small and medium-sized (< 15 tons) rooftop HPs ought to have a similar load shape (see Figure 3-35) to their equivalently sized RTUs in cooling seasons. In the heating seasons, the difference between RTU and HP loads is primarily due to the compressor and/or auxiliary heating demand. The CEMS data offers stakeholders the ability to investigate potential fuel substitution scenarios for existing RTUs.

**Figure 3-45. RTU: Difference between summer and winter loads (actual load in orange, normal load in blue, actual weather in red)**

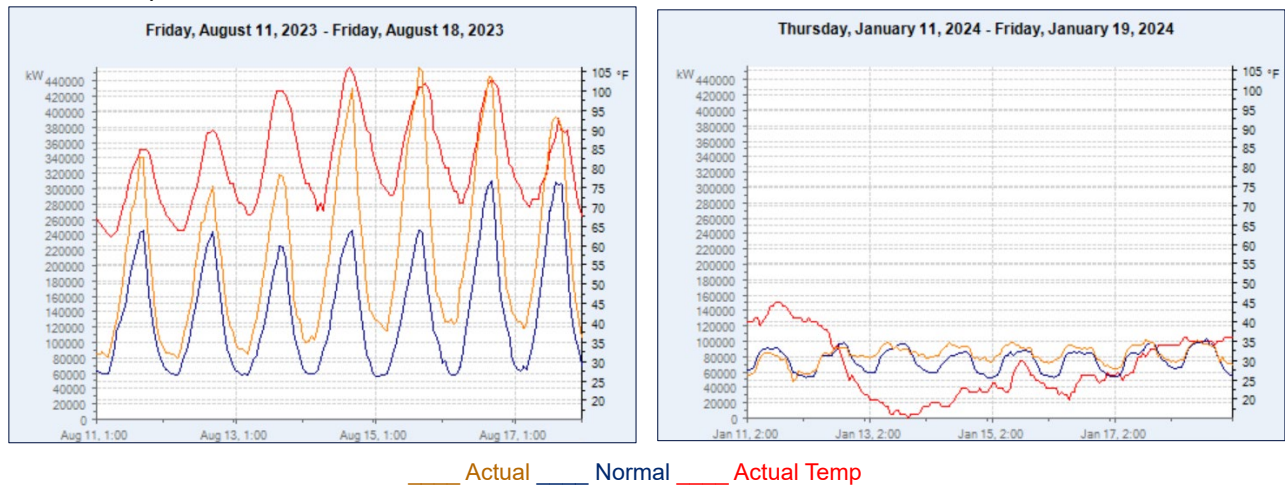


Figure 3-46 and Figure 3-47 show the actual (in orange) and normal (in blue) loads for the office and retail sectors, respectively.

**Figure 3-46. RTU load: office sector (actual load in orange, normal load in blue)**

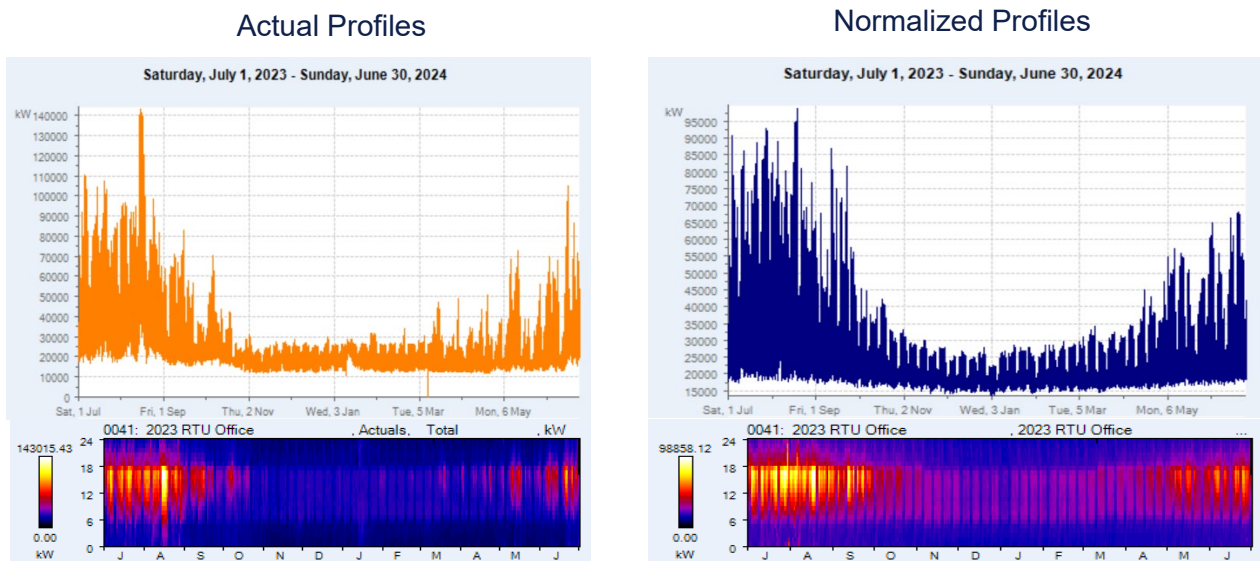


Figure 3-47. RTU load: retail sector (actual load in orange, normal load in blue)

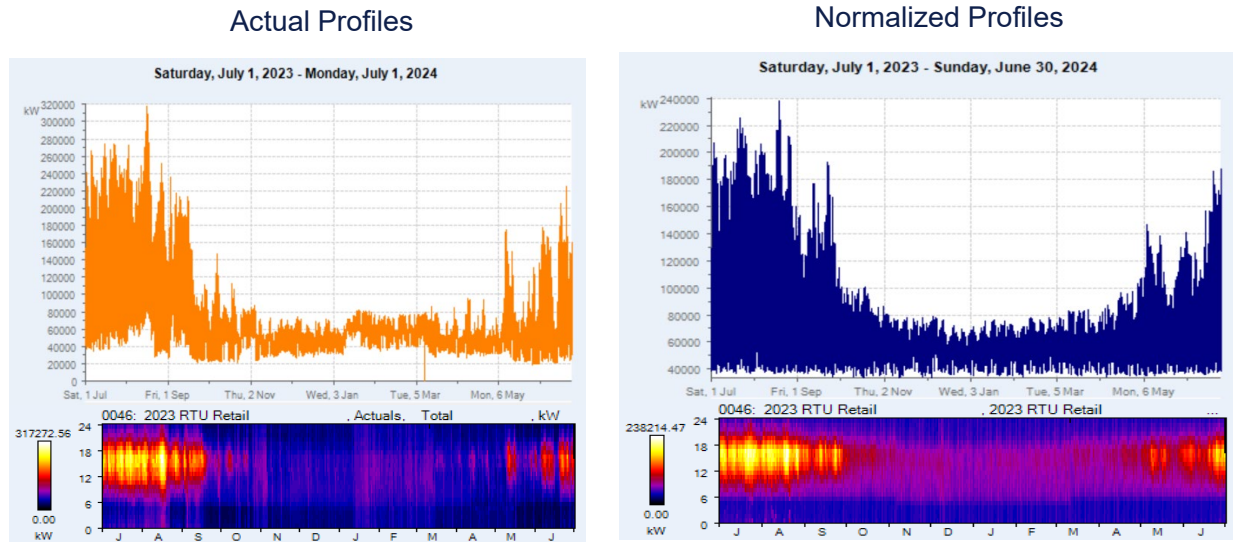


Table 3-9 and Table 3-10 present key energy and demand characteristics for RTUs across both sectors<sup>15</sup>. The tables present the month, energy use, non-coincident peak demand, date/time of non-coincident peak demand, average demand, and load factor. Results are presented for both the actual and TMYx normalized loads. As with the ERH and HP energy characteristics presented in the previous sections, actual and normal annual consumptions are very similar. However, for RTUs, normal winter peak demands are also very similar to actual winter peak demands. The summer peak demands are noticeably different, with the summer peaks dampened by the normal weather.

<sup>15</sup> APPENDIX J contains other technology and sector totals



**Table 3-9. Key energy & demand characteristics: office RTUs**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	33,151,403	110,579	Wed, Jul 05, 2023 17:00	44,550	40.3%	29,201,102	92,755	Thu, Jul 27, 2023 17:00	39,253	42.3%
<b>Aug-23</b>	36,243,213	143,015	Mon, Aug 14, 2023 17:00	48,705	34.1%	28,644,733	98,858	Fri, Aug 18, 2023 17:00	38,506	39.0%
<b>Sep-23</b>	20,826,656	83,190	Fri, Sep 15, 2023 16:00	28,920	34.8%	22,324,499	86,897	Mon, Sep 11, 2023 17:00	31,010	35.7%
<b>Oct-23</b>	17,309,617	70,253	Fri, Oct 06, 2023 16:00	23,261	33.1%	18,024,964	45,299	Mon, Oct 02, 2023 16:00	24,230	53.5%
<b>Nov-23</b>	13,524,853	31,079	Thu, Nov 02, 2023 15:00	18,781	60.4%	15,446,504	33,234	Wed, Nov 01, 2023 16:00	21,456	64.6%
<b>Dec-23</b>	14,363,591	29,873	Fri, Dec 29, 2023 15:00	19,302	64.6%	14,408,308	27,740	Thu, Dec 28, 2023 08:00	19,368	69.8%
<b>Jan-24</b>	15,289,173	31,797	Mon, Jan 29, 2024 15:00	20,546	64.6%	14,789,423	28,427	Thu, Jan 18, 2024 16:00	19,881	69.9%
<b>Feb-24</b>	13,379,376	34,094	Fri, Feb 23, 2024 16:00	19,220	56.4%	14,256,858	29,715	Thu, Feb 22, 2024 16:00	20,486	68.9%
<b>Mar-24</b>	14,730,418	47,154	Mon, Mar 18, 2024 17:00	19,795	42.0%	16,042,906	34,022	Fri, Mar 15, 2024 17:00	21,566	63.4%
<b>Apr-24</b>	14,204,159	50,483	Tue, Apr 23, 2024 17:00	19,724	39.1%	16,792,145	44,886	Fri, Apr 19, 2024 16:00	23,325	52.0%
<b>May-24</b>	17,260,655	72,864	Wed, May 15, 2024 17:00	23,195	31.8%	20,335,333	57,101	Fri, May 10, 2024 16:00	27,336	47.9%
<b>Jun-24</b>	21,598,980	105,129	Fri, Jun 21, 2024 17:00	29,648	28.2%	21,610,979	68,015	Mon, Jun 24, 2024 17:00	29,673	43.6%
<b>Annual</b>	231,882,094	143,015	Mon, Aug 14, 2023 17:00	26,437	18.5%	231,877,75	98,858	Fri, Aug 18, 2023 17:00	26,445	26.8%



**Table 3-10. Key energy & demand characteristics: retail RTUs**

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
<b>Jul-23</b>	92,764,096	273,783	Sat, Jul 22, 2023 17:00	124,607	45.5%	74,180,937	225,343	Fri, Jul 21, 2023 16:00	99,729	44.3%
<b>Aug-23</b>	90,059,916	317,273	Tue, Aug 15, 2023 16:00	120,975	38.1%	71,676,238	238,214	Fri, Aug 18, 2023 16:00	96,362	40.5%
<b>Sep-23</b>	58,761,079	235,675	Sat, Sep 02, 2023 16:00	81,563	34.6%	54,728,126	192,626	Fri, Sep 22, 2023 16:00	76,029	39.5%
<b>Oct-23</b>	39,563,541	146,394	Sat, Oct 07, 2023 16:00	53,145	36.3%	44,505,478	100,938	Mon, Oct 02, 2023 16:00	59,833	59.3%
<b>Nov-23</b>	35,006,140	87,409	Sat, Nov 04, 2023 17:00	48,590	55.6%	40,280,654	86,388	Wed, Nov 01, 2023 17:00	55,959	64.8%
<b>Dec-23</b>	34,639,727	73,693	Thu, Dec 07, 2023 11:00	46,531	63.1%	40,322,899	78,876	Wed, Dec 06, 2023 14:00	54,210	68.7%
<b>Jan-24</b>	42,011,722	82,589	Mon, Jan 22, 2024 09:00	56,433	68.3%	40,047,336	76,019	Fri, Jan 19, 2024 16:00	53,840	70.8%
<b>Feb-24</b>	38,973,123	77,307	Fri, Feb 02, 2024 14:00	55,962	72.4%	38,240,359	78,268	Thu, Feb 15, 2024 14:00	54,956	70.2%
<b>Mar-24</b>	38,488,403	86,494	Sat, Mar 16, 2024 16:00	51,700	59.8%	41,658,980	83,911	Wed, Mar 27, 2024 17:00	56,006	66.7%
<b>Apr-24</b>	32,878,470	95,802	Fri, Apr 12, 2024 17:00	45,637	47.6%	41,714,052	96,979	Sat, Apr 27, 2024 16:00	57,950	59.8%
<b>May-24</b>	38,912,564	174,971	Sat, May 11, 2024 16:00	52,270	29.9%	49,901,541	146,883	Wed, May 08, 2024 17:00	67,088	45.7%
<b>Jun-24</b>	50,777,906	224,878	Tue, Jun 25, 2024 17:00	69,632	31.0%	55,564,433	187,834	Sun, Jun 30, 2024 16:00	76,083	40.5%
<b>Annual</b>	592,836,687	317,273	Tue, Aug 15, 2023 16:00	67,565	21.3%	592,821,034	238,214	Fri, Aug 18, 2023 16:00	67,598	28.4%



## 4 LOAD SHAPE OUTPUT SUMMARY

DNV provided to NEEA quarterly exports of the “raw” meter-level interval data through June 30<sup>th</sup>, 2025.<sup>16</sup> The final data delivery to NEEA also includes the load shapes developed through the methodologies described in this report.

### 4.1 Load shape outputs

Section 3.4 illustrates the wide array of data outputs available from the CEMS. Some stakeholders will want to examine the high-resolution (1-minute) data at the individual metering point to assess subtleties in equipment controls and the true maximum demand of the equipment. Others will be interested in normalized population-level results at the technology level.

The data products are at three levels:

1. Meter-level results – provided to NEEA at the frequency of data collection (i.e., 1-minute), 15-minute, and 1-hour (for a small subset of AMI data); however, the frequency can be processed to different intervals, e.g., hourly, daily, seasonal.
2. Site-level results – focused on hourly levels of aggregation and available at the technology and whole facility level
3. Sector-level results – focused on hourly levels of across sample aggregation at the technology and whole facility level

The data streams include the observed “actual” technology performance during the measurement period and weather “normalized” profiles. The weather normalization was conducted collectively across the two-year period July 2023 through June 2025.<sup>17</sup>

Focusing on a single study year, e.g., July 2023 through June 2024, we can create a variety of additional data products for use by the stakeholders. These include, but are not limited to:

- 1x8760 hourly (yvar1-yvar24)
- 1x8760 normalized (norm1-norm24)
- 1x24 coincident peak
- 12x24 average weekday<sup>18</sup>
- 12x24 average weekend<sup>11</sup>
- 1x24 summer average weekday
- 1x24 summer average weekend
- 1x24 winter average weekday
- 1x24 winter average weekend

Data for the sector level results will be provided to NEEA and project funders in the following formats:

- Hourly sector level load shapes for both aggregate and normalized profiles will be provided in a text file for each building type and technology combination including totals, means, ratios, and relative precisions.
- All other results files will be provided in separate excel workbooks containing each building type and technology combination for totals and means including: Average weekday/weekend by season and overall, coincident peak day

<sup>16</sup> “Raw” data means that DNV has not validated or edited data or estimated data to fill gaps. Metadata and context to each circuit profile and a timestamp list that provides a basis for interpreting “bad” data is included

<sup>17</sup> Recall that the last recruited site of the sample began metering in Q2 of 2023 so the metering period with the full n=70 sample began Q2 of 2023. However, dynamic weighting may be performed to include more than 2 years for sites that had meters installed prior to Q2 of 2023.

<sup>18</sup> Graphical representations of the monthly average weekday and weekend days are presented in APPENDIX J.

## APPENDIX A. WEATHER NORMALIZATION OF RESULTS

The development of the tie-temperature regression models follows an eight-step procedure:

4. **Identify Holidays:** First, the hourly load data will be read in and checked for completeness. Holidays have a unique load pattern when compared to similar days in the same season. Accordingly, these dates will be excluded from the analysis. The typical holidays include the “Big 6” New Year’s Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.
5. **Determine the Base Load:** The next step will be to determine the base loads. The demands for each analysis group will be by day of the week and time of day. The median of the lowest five non-zero loads by day of the week and time will be designated as the base load for the group.

**Output 1:** 7 x 24 array of baseload estimates (168 unique estimates).

6. **Determine the Variable Load:** The third step will be to determine the variable load. For each test group the base load will be matched to the total load by day of the week and time. The variable load will be calculated as the difference between the total load and the base load. If the variable load is less than zero, the variable load was set equal to zero.

**Output 2:** Estimate of Variable for every non-holiday hour metered (Min. value = 0).

7. **Merge Load Information with Temperature Data:** The next step will be to match the test group loads to the temperature file. Based on the location and the temperature sites that are available, each site will be mapped to a representative temperature station.

**Output 3:** Temperature data for every hour metered.

8. **Initial Regression Analysis:** For each analysis group an initial regression analysis will be performed. The results of this model will be used to identify outliers. Typically, any data with a studentized residual greater than 3 is omitted from the analysis data set. The initial model is:

$$VL_{dow,time} = b_0 + b_1 * HDD + b_2 * CDD$$

Where:

VL<sub>dow,time</sub> is the Variable Load for customer ‘LRID’, on day of the week ‘DOW’ at hour ending ‘Time’.

HDD are the heating degree-days (60<sup>0</sup> base)

CDD are the cooling degree-days (70<sup>0</sup> base)

9. **Final Regression Analysis:** Using the trimmed dataset, we will conduct the final regression analysis. For each day of the week and hour of the day, a model will be developed.

A family of models will be examined for each test group by day of the week, by time of day. These models will include only cooling degree-days, models that include heating degree-days and models that include both heating and cooling degree-days.

To further optimize the selection of the models, a range of degree-day set points will be considered for each analysis group model. For heating degree-days, the considered set points will range from 50<sup>0</sup> to 70<sup>0</sup>. For cooling degree-days, the considered set points will range from 64<sup>0</sup> to 78<sup>0</sup>. Mathematically, the models under consideration can be expressed as follows:

$$VL_{dow,time} = b_0 + b_1 * HDD(t_1) + b_2 * CDD(t_2)$$

Where,



$VL_{dow,time}$  is the same as above

HDD( $t_1$ ) are the heating degree-days with a  $t_1$  base

CDD( $t_2$ ) are the cooling degree-days with a  $t_2$  base

For each test group, for each day of the week for each hour 351 models will be considered. To determine the optimal model amongst the 351 alternatives will be based on the minimization of the mean squared error of the residuals ( $MS_E$ )<sup>19</sup>. Using this selection method, 168 optimal models are chosen for each customer.

**Output 4:** 168 (7 x 24) coefficient sets used to estimate the variable load for any hour on any day of the week using temperature.

10. **Verify the Models:** Several different methods will be used to check the veracity of the models. First, for each test group, the actual temperatures from the data collection period will be applied to the models to predict the demands. The comparison of the actual observed demands to the predicted demands will be used to identify any anomalies in the modeling process.
11. **Predict “Normal” Data:** Finally, we will estimate the demand and energy for a “normal” year. Applying the appropriate TMYx temperatures, or regional “normal” temperature data, we will calculate the predicted variable demands. Then, the base load by day of the week and hour will be added to the variable load component. Lastly, the unadjusted holidays will be included, with the dates being correctly calendarized for Memorial Day, Labor Day, and Thanksgiving. Finally, we perform a final check on each analysis group by comparing the actual energy to the predicted energy.

**Output 5:** 1 x 8,760 profiles for a normal (e.g., TMYx, TMY3) year.

---

<sup>19</sup> Alternative models, with different numbers of independent variables, introduce a challenge to choosing an optimal model. One approach would rely on the maximization of  $R^2$  to indicate the optimal model. However, in building mathematical regression models, the  $R^2$  statistic has a tendency to increase as the number of independent variables increases. Therefore, when comparing models with different numbers of regressors, the maximum  $R^2$  criteria may not lead to choosing the optimal model between alternative models. To avoid this possibility, an alternative method to determine the optimal model was used, the minimization of the mean squared error of the residuals ( $MS_E$ ). The  $MS_E$  accounts for the decrease in the degrees of freedom when an additional regressor is added to the equation. Therefore, the model that minimized the  $MS_E$  was chosen as the optimal model to represent the temperature versus demand relationship.

## APPENDIX B. RATIO ESTIMATION FRAMEWORK

In the ratio estimation framework, there are alternative variables to consider for use in the across facility expansions. This includes both variables of interest, i.e., the y-variables, and variables used to expand the variables of interest to sector representations, the x-variables. The x-variables should be highly correlated to the variables of interest and should either be known or can be estimated with reasonable certainty to the respective populations of interest.

The generalized ratio estimation analysis is presented in Equation 3 and Equation 4. The y-variables are effectively any variable of analytical interest that can be calculated from the available sample data. These variables can include hourly demand, on-peak use, off-peak use, seasonal use, annual use, etc. The x-variables will be any variable “known” for the populations of interest that are expected to be highly correlated to the y-variables. Examples include square footage, whole facility sector data, weather sensitive energy, etc. In Equation 3, the case weights are applied to each of the sample points to generate a ratio,  $\beta$ . Here again, this can be an aggregate y-variable like on-peak use, or the hourly demands of the technology. The estimate of total Y is calculated by applying the “known” X for the population to the individual betas ( $\beta$ ).

### Equation 3 – Estimating the Ratios

$$\hat{\beta} = \frac{\sum_{i=1}^n w_i y_i}{\sum_{i=1}^n w_i x_i}$$

### Equation 4 – Estimating Totals

$$\hat{Y} = \hat{\beta} X$$

Finally, one of the deliverables involves the calculation of the achieved statistical error associated with the load estimations. We start by calculating the residual  $e_i$  for each site. This is highlighted in Equation 5. Next, we use the residual to calculate the standard error of  $\beta$  as presented in Equation 6.

### Equation 5 – Calculating Residual

$$e_i = y_i - \hat{\beta} x_i$$

### Equation 6 – Standard Error of $\beta$

$$se(\hat{\beta}) = \left( \frac{1}{\hat{X}} \right) \sqrt{\sum_{i=1}^n w_i (w_i - 1) e_i^2}$$

With X-hat calculated from the sample using Equation 7.

### Equation 7 – Substitution of X-hat

$$\hat{X} = \sum_{h=1}^L N_h \bar{x}_h$$

Then the standard error of the estimate of total Y is derived from Equation 8.

### Equation 8 – Standard Error of Y

$$se(\hat{Y}) = se(\hat{\beta}) X$$

Finally, the error bounds, confidence intervals, and relative precision are derived from the equations in Equation 9 through Equation 11.

### Equation 9 – Error Bound

$$eb(\hat{Y}) = z se(\hat{Y})$$

### Equation 10 – Confidence Interval

$$\hat{Y} \pm eb(\hat{Y})$$



### Equation 11 – Relative Precision

$$rp = \frac{eb(\hat{Y})}{\hat{Y}}$$

Fortunately, the project team has software that automates the above calculations. The planned output includes the following attributes for each y-variable of interest:

- Ratios
- Means
- Totals
- Relative Precision
- Error Bound of Means
- Error Bound of Totals

## APPENDIX C. TECHNOLOGY END-USE ASSIGNMENT

This section documents the logic characterizing end use assignment. Each physical circuit that was metered is assigned one of the following end uses:

- RTU – rooftop unit
- HP – heat pump
- ERH – electric resistance heat
- Other
- Non-HVAC
- WB – whole building

Each of these end uses is defined in more detail in the subsequent subsections. Note that only RTU, ERH, and HP end uses are analyzed and described in this report. The other end uses are necessary to define the meter-level interval data not included in the site-level and sector-level analysis.

There are also “aggregated loads” which are described in its own subsection. They are a collection of end use circuits that were metered in aggregate. For example, if the metering plan was unable to meter all circuits individually (because the number of sensors or meters necessary was not feasible), the circuits were metered just upstream at an electrical distribution panel.

### RTU

Rooftop unit (RTU) end use is defined as a “traditional” packaged roof top air conditioning unit with a DX coil for cooling and optional heating. Since this end use covers traditional packaged systems, the metered circuits are overwhelmingly packaged meaning one single circuit powers one singular RTU system. Sometimes the auxiliary strip heat is powered with a separate circuit breaker. The circuit/register is assigned End use category “RTU” when:

12. The circuit powers a component of an RTU system.
13. Separate circuits powering auxiliary strip heat for RTU ACs **are not assigned as RTU. They are assigned as ERH.** Even though the circuit itself is a subcomponent to a RTU system, the load shape will resemble traditional ERH loads. Also, the end use assignment is used to estimate capacity.
14. The circuit is an aggregated load of RTUs. No isolation or subtraction to arrive to the aggregated RTU load is required. **If isolation is required, then the aggregated circuit is assigned “Other.”**

Capacity is assigned to the circuit containing the compressor. For RTUs there is typically only one circuit per RTU system.

**Table C-1. RTU end use descriptions**

End use	Detailed equipment type	Description
RTU	RTU-AS-AC-gas	Rooftop air source AC unit with gas heat
RTU	RTU-AS-AC-ERH	Rooftop air source AC unit with electric heat
RTU	RTU-AS-AC-noheat	Rooftop air source AC unit with no heat

### HP

Heat pump (HP) end use is defined as any type of heat pump system. A traditional packaged rooftop unit HP is very similar to a traditional packaged RTU with DX coil and optional heating, especially with the way the systems are energized. There is

typically 1 circuit breaker per traditional RTU HP system. If the RTU HP has auxiliary strip heat, the strip heat is normally powered using another circuit breaker.

The circuit/register is assigned end use category HP when:

1. The circuit powers a component of a HP system. Common components are outdoor units, indoor fan coil units, indoor fan coil + compressor units, pumps, tower fans, branch circuitry (powers multiple fan coils + control electronics).
2. Separate circuits powering auxiliary strip heat for RTU HPs **are not assigned as HP**. Even though the circuit itself is a subcomponent to a HP system, the load shape will resemble traditional backup ERH loads. Also, the end use assignment is used to estimate capacity.
3. A single circuit powering all the components of the HP system + the backup auxiliary heat is assigned as HP.
4. The circuit is an aggregated load of HP. No isolation or subtraction to arrive to the aggregated HP load is required. **If isolation is required, then the aggregated circuit is assigned “Other.”**

Capacity is assigned to the circuit containing the compressor. A list of common examples is below.

- Water source heat pumps using cooling towers, boilers and pumps that have zonal fan coils packaged with compressors. The zonal units are assigned capacity (rated or via circuit size and COP assumptions). Other components are assigned 0 capacity.
- Packaged RTU HPs with no backup ERH (1 circuit). Capacity is assigned to the packaged system circuit.
- Packaged RTU HPs with backup ERH (2 circuits). HP capacity is assigned to the RTU HP circuit. ERH capacity is assigned to the backup ERH circuit.

**Table C-2. HP end use descriptions**

End use	Detailed equipment type	Description
HP	RTU-AS-HP	Rooftop air source HP unit with no aux ERH heat
HP	RTU-AS-HP-ERH	Rooftop air source HP unit with aux ERH heat
HP	RTU-AS-HP-gas	Rooftop air source HP unit with aux gas heat
HP	SS-AS-HP-Combined	Split System Air Source HP unit with no aux ERH heat – 1 circuit (IDU + ODU)
HP	SS-AS-HP-ERH-Combined	Split System Air Source HP unit with aux ERH heat – 1 circuit (IDU + ODU)
HP	SS-AS-HP-gas-Combined	Split System Air Source HP unit with aux gas heat – 1 circuit (IDU + ODU)
HP	SS-AS-HP-ODU	Split System Air Source HP, ODU
HP	SS-AS-HP-IDU	Split System Air Source HP, IDU, no aux heat (e.g., the metered circuit is just the IDU and not the IDU + aux ERH)
HP	SS-AS-HP-IDU-ERH	Split System Air Source HP, IDU, aux ERH heat
HP	SS-AS-HP-IDU-gas	Split System Air Source HP, IDU, aux gas heat
HP	WSHP-IDU	Water Source Heat Pump, IDU e.g., compressor, HX fan, and controls
HP	WSHP-ODU	Water Source Heat Pump, ODU e.g., compressor, integrated pump
HP	WSHP-AHU	Water Source Heat pump, only the indoor fan
HP	WSHP-Pump	WSHP condenser pump
HP	WSHP-Tower	WSHP cooling tower (fans, sump pump, basin heaters)
HP	WSHP-Boiler	WSHP backup boiler (gas or electric)
HP	GSHP-IDU	Ground Source Heat pump, IDU e.g., compressor, HX fan, controls

End use	Detailed equipment type	Description
HP	GSHP-Pumps	GSHP well pump
HP	GSHP-Boiler	GSHP backup boiler (gas or electric)
HP	DL-HP-Combined	Ductless HP, combined circuit
HP	DL-HP-ODU	Ductless HP, outdoor unit
HP	DL-HP-IDU	Ductless HP, indoor branch circuit
HP	VRF-HP-Combined	Variable refrigerant flow HP, combined circuit
HP	VRF-HP-ODU	VRF HP, outdoor unit
HP	VRF-HP-IDU	VRF HP, indoor branch circuits
HP	PTHP	Packaged Terminal Heat pump

## ERH

Electric resistance heat (ERH) end use is defined as any type of electric resistance heat “system” or auxiliary heat to a system. ERH circuits were predominantly three categories.

1. Primary or auxiliary back up strip heat for a RTU AC, RTU HP, split system HP, or WSHP system
2. Fan powered VAV boxes with electric reheat
3. Stand-alone baseboard or box heaters. (1) and (3) are likely purely ERH loads while (2) is a mix of fan motors, controls (e.g., electronically actuated dampers), and ERH. Recall that while the ERH circuit may be dependent on overall system control (e.g., the HP or RTU controls the backup ERH circuit and the backup ERH circuit cannot operate independently from the HP/RTU), the load shape itself will be an isolated or predominantly ERH load.

The circuit/register is assigned end-use category ERH when:

- The circuit powers any sort of ERH component. Examples include back up auxiliary ERH for RTUs and HPs, fan-powered boxes, VAV boxes, terminal units, baseboard heaters, unit heaters, etc.
- Separate circuits powering auxiliary strip heat for HPs are assigned as ERH. This means the circuit is controlled by the HP thermostat and control board.
- The circuit is an aggregated load of ERH. No isolation or subtraction to arrive at the aggregated ERH load is required. If isolation is required, then the aggregated circuit is assigned “Other.”
- If it is known that a singular RTU or HP circuit also includes auxiliary ERH, that circuit is assigned to the end use controlling the “sub-circuit” ERH. For example, if there is a 90A 2-pole breaker powering a RTU with AC and electric heat, that circuit is assigned “RTU”.

**Table C-3. ERH end use descriptions**

End use	Detailed equipment type	Description
ERH	SS-AS-AC-auxERH	Split System Air Source AC, aux ERH circuit for IDU
ERH	RTU-AS-HP-auxERH	Rooftop air source HP unit aux ERH circuit
ERH	SS-AS-HP-auxERH	Split System Air Source HP, aux ERH circuit (secondary IDU circuit)
ERH	ERH	General Electric Resistance Heat (e.g., stand-alone ERH, baseboard, unknown)
ERH	ERH-Duct	ERH, Duct Heater
ERH	ERH-FPB	Fan power box (e.g., VAV, TU) with electric heat



End use	Detailed equipment type	Description
ERH	ERH-auxheat	Aux/backup ERH for RTU or HPs not covered under other categories (i.e., basically auxERH for WSHPs)

## Other

Other end use is defined as any other HVAC than the three primary end uses described above. A few highlights are mentioned below:

- Water source heat pump systems that utilize supplemental ventilation units (i.e., HRV/ERV) have those circuits assigned as “Other”. It could be argued that the WSHPs would never be installed without an HRV/ERV (because ventilation code requires outside air that isn’t provided by the WSHP components) and so the HRV/ERV should be assigned as “HP” end use. However, DNV chose to assign these units as “Other” and whenever possible, grouped them under system assignments to their appropriate built-up system.
- ERV/HRVs are not grouped with systems unless there is high confidence that the ERV/HRV is intentionally paired with an RTU/HP. ERV/HRVs are typically standalone packaged systems that do not require feedback or input from other systems. They may require input for schedules and pressure set points, but they aren’t reliant on the systems that they’re “providing” ventilation for. For example, many of the ERV/HRV we metered were in buildings that had built up WSHP systems. ERV/HRVs were installed because they are needed for code ventilation, not because they are part of the HP system.
  - They may be associated with a system via the primary equipment ID (e.g., ERV1 is associated with HP-1) or System Grouping ID
- Any type of air-conditioning unit that is not a traditional RTU is assigned as “Other”. The metering plans generally avoided these systems and does not count them in the total building capacity. The instances where we metered these systems were due to mistake. Example – we thought they were HPs, but they turned out to be a split AC or ductless AC. They served IT closets. Usually Ductless AC
- Built-up systems that are not HP systems and are not ERH circuits were assigned as “Other”. These were typically CHW/HHW components (chillers, boilers, pumps, towers, fans/AHUs)
- Computer room air conditioners and air handling units (CRAC/CRAH/CRUs)

**Table C-4. Other end use descriptions**

End use	Detailed equipment type	Description
Other	SS-AS-AC-gas-Combined	Split system air source AC, gas heat, combined circuit
Other	SS-AS-AC-ERH-Combined	Split system air source AC, ERH heat, combined circuit
Other	SS-AS-AC-noheat-Combined	Split system air source AC, no heat, combined circuit
Other	SS-AS-AC-ODU	Split system air source AC, outdoor unit
Other	SS-AS-AC-IDU-noheat	Split system air source AC, indoor unit, no heat
Other	SS-AS-AC-IDU-gas	Split system air source AC, indoor unit, gas heat
Other	SS-AS-AC-IDU-ERH	Split system air source AC, indoor unit, ERH heat
Other	DL-AC-Combined	Ductless AC combined circuit
Other	DL-AC-ODU	Ductless AC outdoor unit

End use	Detailed equipment type	Description
Other	DL-AC-IDU	Ductless AC, indoor branch circuit
Other	PTAC	Packaged terminal AC
Other	ERV-HRV-noheat	Energy recovery unit / heat recovery unit with no aux heat
Other	ERV-HRV-ERH	Energy recovery unit / heat recovery unit with aux ERH
Other	ERV-HRV-gas	Energy recovery unit / heat recovery unit with aux gas heat
Other	ERV-HRV-unknown	Energy recovery unit / heat recovery unit when aux heating is unknown
Other	Boiler-gas	Central plant boiler, gas
Other	Boiler-electric	Central plant boiler, electric
Other	Chiller	Central plant chiller
Other	CHWP	Central plant chilled water pump
Other	HHWP	Central plant heating hot water pump
Other	CWP	Central plant condenser water pump
Other	Tower	Central plant cooling tower (includes CT fans, sump pumps, basin heaters)
Other	Fan-SF	Central plant air handler supply fans
Other	Fan-RF	Central plant air handler return/relief fans
Hp or Other	Aggregated-HP	Aggregated loads determined to be only HP (once aggregated load is isolated by subtracting other loads)
RTU or Other	Aggregated-RTU	Aggregated loads determined to be only RTU (once aggregated load is isolated by subtracting other loads)
ERH or Other	Aggregated-ERH	Aggregated loads determined to be only ERH (once aggregated load is isolated by subtracting other loads)
Other	Aggregated-Mixed	Aggregated loads determined to be mix of HP, RTU, ERH (once aggregated load is isolated by subtracting other loads)
Other	CRAC/CRAH	Computer room AC/AH
Other	WS-AC	Water source AC (any component e.g., compressors, fans, pumps, cooling towers)
Other	RTU-CHW-no heat	Rooftop fan coil with CHW
Other	Other	

## Non-HVAC

The non-HVAC category is assigned to any load determined to not be HVAC-related. non-HVAC circuits that the team metered are plug loads, domestic water heating, lighting, compressed air, and sub panels not containing HVAC.

**Table C-5. non-HVAC end use descriptions**

End use	Detailed equipment type	Description
<b>Non-HVAC</b>	HWT	Hot water tank
<b>Non-HVAC</b>	InstaWH	Tankless water heater
<b>Non-HVAC</b>	OTHER	
<b>Non-HVAC</b>	CA	Air Compressor circuit
<b>Non-HVAC</b>	Lighting	Lighting panel metered to sub-meter HVAC
<b>Non-HVAC</b>	GUH	Gas unit heater



## **Whole Building (WB)**

When possible, DNV metered the main distribution panel serving the building. We performed visual checks to assess with greater confidence whether the utility meter served more than the main distribution panel.



## APPENDIX D. CAPACITY ASSIGNMENT

---

“Capacity assignment” relates to what specific circuits were assigned rated cooling and/or heating capacities. For most single circuit HVAC systems, there was no need to have “rules” for capacity assignment. For example, a single circuit powers a typical DX RTU named RTU1 and RTU1 has a nameplate model that, when looked up, has a nominal cooling capacity of 10 tons. That 10-ton cooling capacity is assigned to the metering point measuring the RTU1 power.

For built up systems that have multiple components and multiple circuits, capacity assignment is performed according to protocol. The assignment protocol followed the rules below:

- Only HP and ERH end uses are assigned heating capacity. HP heating capacity is estimated based on rated cooling capacity.
- ERH circuits are generally treated as standalone circuits and assigned standalone heating capacity. The majority of ERH circuits were given a heating capacity estimate based on the circuit breaker size and voltage configuration. If mechanical or panel schedules gave information on ERH size (e.g., “100 kW Duct heat”) then the schedule’s capacity was used.
- Capacities were assigned to circuits that energize outdoor units or compressors. For example, for a simple split HP unit that is rated 5 tons, that 5-ton capacity is assigned to the ODU circuit, and the IDU circuit is assigned “0” capacity.
- Gas systems, if metered, are not assigned a capacity

The purpose of this protocol is to simplify for capacity bookkeeping and to avoid double counting capacity. Capacity assignment was attempted as best as possible to work as a bottom-up assignment. Also, nameplate lookup is generally easier from the equipment that has the compressor.

Capacity assignment was limited to circuit-level profiles and aggregated technology profiles. *Square footage conditioned by individual circuits could not be allocated.* DNV uses a simplified method to break out square footage served by each HVAC technology. Square footage served by each HVAC technology is proportional to the total estimated output capacity of that technology. For example, site “ABC” has a total of 1,000 square feet of conditioned space and is served by a 2-ton RTU and 2-ton HP for a total of 4 tons. To break down square footage served by technology, RTU serves 1,000 square feet x (2-ton RTU / 4-ton total), or 500 square feet. The same calculation is performed for the HP technology (500 square feet served by HP).



## APPENDIX E. WITHIN-SITE EXPANSION

DNV made its best attempt to meter all HVAC end uses at sampled sites. Key criteria were followed when developing site-specific metering plans:

- Whenever possible, measure and collect power (kW and kVA) readings for individual HVAC circuits.
- If measuring all HVAC circuits (individually) at a site is not possible:
  - If multiple technology end uses (RTU, HP, and ERH) are present at a site, develop a plan to capture each technology type
  - Aggregate HVAC circuits by measuring upstream (e.g., measure the feed to the HVAC sub-panel rather than individual circuits on the sub-panel).
  - Meter target sub-panel circuits downstream of the aggregate circuit such that targeted non-HVAC circuits or targeted HVAC circuits of similar technology can be subtracted from the aggregate measurement. With this method, an aggregate HVAC end use can be isolated from the aggregate sub-panel load<sup>20</sup>.
  - HVAC circuits were prioritized over other end uses (refrigeration, IT, lighting, plug load)

Of the 70 sampled sites, the team was able to meter with high confidence 100% of HVAC end uses for 46 sites. For all sites, however, the team made best efforts to document:

- The total # of circuits belonging to an HVAC technology (RTU, HP, ERH, other)
- The # of metered circuits belonging to an HVAC technology
- The rated output capacity (cooling if RTU or HP, heating if ERH) of each circuit

Using the above information, within site expansion was performed on 24 sites using the following linear expansion:

$$SitekW = MeterkW \times \frac{SiteCap}{MeterCap}$$

Where,

SitekW = Expanded site-level kW for a HVAC technology type

MeterkW = Sum of metered kW for a HVAC technology type

SiteCap = Total estimated output capacity of all equipment categorized under a HVAC technology type

MeterCap = Total estimated output capacity of all metered equipment categorized under a HVAC technology type

In this case, the meter to site-level expansion factor is a simple multiplier  $\geq 1$ .

<sup>20</sup> For example, if there is a sub-panel with 20 circuits, 15 of which are ERH circuits, 2 are RTU, and the rest are nonHVAC. In this example, metering all 14 ERH and 2 RTU circuits individually is not possible. Instead, the feed to the sub-panel is metered, including the 2 RTU circuits and 3 nonHVAC circuits. From the load shape standpoint, if we subtract the 2 RTU circuits and 3 nonHVAC circuits from the sub-panel circuit, we are left with an aggregate load shape of 15 ERH circuits.

## **APPENDIX F. FIELD METER QUALITY CONTROL AND COMMISSIONING**

---

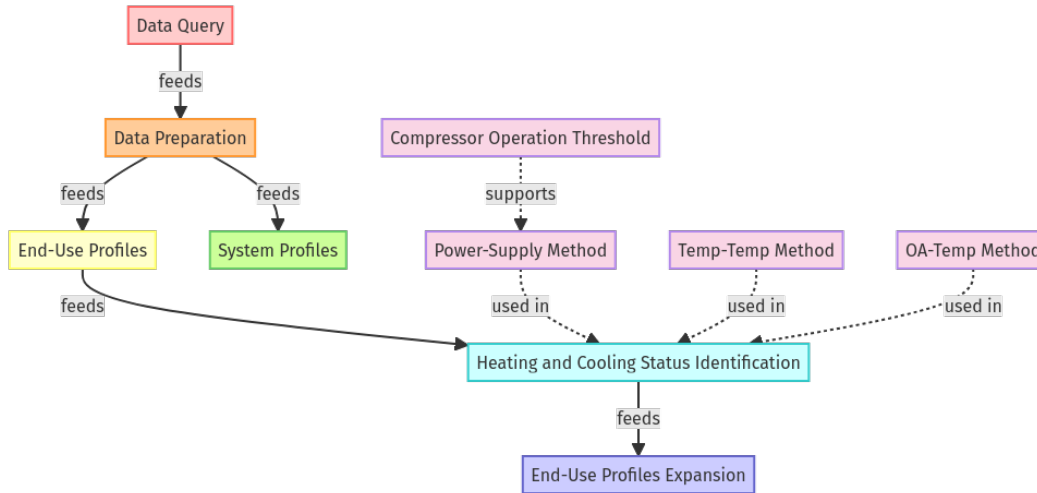
A pre-site and onsite field metering procedure manual was developed to assist field staff maintain consistent and documented installation techniques. Some of the key quality control steps taken during field installs were:

- Voltage configuration and correct “phasing.” This step ensured the meter’s voltage reference was accurate.
- Current transducer (CT) sizing, direction, lid closure, and wiring.
  - Physical and rated CT sizes were chosen based on wire gauge and circuit breaker ampacity.
  - CT direction was checked for consistency by making sure measured power was positive.
  - Lid closure on split core CTs were double checked by electricians and inspected by DNV staff, both visually and via the power meter’s “spot checker.”
  - CT wires sometimes needed to be spliced and lengthened. Field staff took care in ensuring an electrically conductive and robust splice. The CT signal was shielded using either twisted pair or twisted pair + shielded wiring.
- Voltage and current spot power measurements. Reference voltage was measured using handheld meters and compared to the voltage measured by the power meters. When possible, handheld amp probes were used to measure circuit current and compared to current measured by CTs
- CT and circuit labelling. With up to 30 CTs being installed in a sub-panel and wired to a single power meter, organization and labelling was critical to ensure that CT channels were matched up to the expected circuit. Both ends of the CTs were very commonly labelled with number stickers before installation.
- Power meter date and time. The eGauge power meters use an internet connection to check in daily with a time (NTP) server. If for some reason the meter’s clock is off (from the time server) by more than 1 minute, the meter sends an alert. DNV staff typically fixed meter clock issues within 1 day of receiving alert. Time clock issues are extremely rare, and the most common difference from the time server clock was 1-2 minutes. If it’s suspected that the time clock was different from the time server by more than 10 minutes, the range of data suspected to have inaccurate timestamps are flagged as “bad”.

## APPENDIX G. SITE ANALYSIS QUALITY CONTROL AND ASSURANCE

DNV used Python programs to perform automated and systematic quality control and initial site analysis. The following figure shows a simplified workflow with scripts performing quality control, data flagging, and aggregation steps.

**Figure G-1. Data processing workflow: Script interactions and support functions\***



\*Each box represents a specific script.

The following nomenclature should be known:

- LRS data server. The DNV server housing the CEMS database. Contains all raw circuit and temperature data, weather data, and post-processed and analysis outputs e.g., “clean” profiles, normal load shapes, aggregate load shapes, etc.
- Master Data File. A workbook containing circuit-level metadata and QC information

### Data query

#### Overall purpose

This script pulls the data from the LRS data server for each site available in the Master Data File.

#### Main components

1. Authentication: It starts by setting up connections to the LRS data server using credentials, ensuring secure access.
2. Data Loading: Then, it loads the Master Data File containing information like site IDs and installation dates.
3. Data Querying: The script queries data for each service site, focusing on individual profiles within each site. It adopts an iterative approach, retrieving data month-by-month with a one-hour timestep. After obtaining each month's data, the script appends these monthly datasets to construct a comprehensive profile covering the entire available period. Next, it concatenates these profiles to create a Python DataFrame. This DataFrame encompasses all available profiles and their corresponding timestamps at the current site, excluding those related to reactive power. The rationale behind this month-by-month querying strategy stems from server limitations, as attempts to query the entire period at once previously resulted in server crashes.
4. Data Storage: Finally, the queried data is saved in an organized format for each site.

#### Inputs and outputs

- Input: Master Data File with site information and server access for querying data.



- Output: The script generates Excel files containing data for each site, presented in hourly intervals and adjusted to the UTC time zone. Additionally, it provides an optional summary file detailing any data issues encountered during the querying process.

An equivalent script is used to query NOAA weather dry bulb temperature data for each site.

## Data preparation

### Overall purpose

The script loads the queried data and applies a series of transformations dictated by the Master Data File to prepare it for aggregated profiles calculations and HVAC status identification.

### Main components

1. Data Loading: Loads the Master Data File and the queried data.
2. Timestamp Alignment: The script ensures all profiles within a site share the same timestamps, despite some profiles (Monnit sensors) initially having its own unique timestamp.
3. Data Conversion: It adjusts certain profiles using a multiplier defined in the Master Data File, such as converting currents to power.
4. Handling 'Bad Data': Segments labeled as 'bad data' in the Master Data File are excluded by the script, resulting in gaps in the final data representation.
5. Outliers Removal: Values greater than the max kW value indicated in the Master Data File are replaced by NaN.
6. Negatives Handling: Negative values that their absolute value is less than 0.2 kW are replaced by zero and those greater than 0.2 kW are replaced by NaN.
7. Data Resampling: For timestamps that don't align with a regular 1-hour interval, the script resamples and averages the data to align as closely as possible with the nearest hour.
8. Data Storage: Finally, the transformed data is saved in a CSV file for each site.

### Inputs and outputs

- Input: Master Data File containing site information and rules for data conversion and queried data.
- Output: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

An equivalent script is used to prepare NOAA dry bulb temperature data for each site.

## Aggregate end use profiles

### Overall purpose

The script loads the prepared data and sums profiles together that belong to the same end use category as directed by the Master Data File.

### Main components

1. Data Loading: Loads the Master Data File and the prepared data.
2. End Use Categorization: Puts the profiles into categories with same end use described in the Master Data File. Profiles belonging to end use 'Other' receives a special treatment according to the Master file when the profile's corresponding 'Detailed Equipment Type' includes the term 'Aggregated'.

3. Profiles Aggregation: The profiles belonging to the same end use category are summed up together to create a new aggregated profile. Profiles elected to be ignored according to the Master Data File are left out from the summation (profile already accounted for in a different profile).
4. Data Storage: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site in addition to the aggregated profiles, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

## Inputs and outputs

- Input: Master Data File containing site and end use information, and prepared data.
- Output: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site in addition to the aggregated profiles, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

## Heat pump heating and cooling mode identification

### Overall purpose

The script loads aggregated data by end use and identifies the heat pump status for each profile belonging to the HP end use according to the Master File data.

### Main components

1. Data Loading: Loads the Master Data File and the aggregated data by end use.
2. Status identification method: It checks whether it is possible to reasonably identify the status of the HP profiles within current site and identifies the appropriate method to do so. This is done based on information provided in the Master Data File.

Power-Supply method: It identifies the power profiles and supply temperature profiles that will be used to deduce status at each given timestamp. Sites using this method have a one-to-one correspondence between power profiles and supply temperatures. The description of the algorithm used to identify status according to this method is described in sections below. This method requires identifying when the HP compressor is in operation, the function used to identify compressor operation is described in sections below, too.

Power-Supply-Indirect method: The script identifies the power profiles and supply temperature profiles that will be used to deduce status at each given timestamp. Sites using this method do not have a one-to-one correspondence between power profiles and supply temperatures. The profiles that don't have a corresponding temperature will follow the same status of profiles with one-to-one match as directed by the Master Data File. The description of the algorithm used to identify status according to this method is described in sections below. This method requires identifying when the HP compressor is in operation, the function used to identify compressor operation is described in sections below, too. Some sites using this method have "cool only profiles." These profiles are added to the identified HP profiles in cooling mode.

Temp-Temp method: When no match exists between power and temperature profiles the script identifies the supply temperature and space temperature that will be used to identify HP profiles status according to the Master file. The description of the algorithm used to identify status according to this method is described in sections below.

OA-Temp method: When there is neither a match between a power and a temperature profile nor between a space and a supply temperature profile, the algorithm uses the available space temperature directed by the Master Data File to identify the HP status. The description of the algorithm used to identify status according to this method is described in sections below.

3. Status profiles aggregation: The script sums the profiles belonging to the HP end use in heating mode together and the ones in cooling mode together.
4. Data Storage: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site in addition to the HP aggregated profiles with status, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

## Inputs and outputs

- Input: Master Data File containing site system information, and the aggregated data by end use.
- Output: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site in addition to the HP aggregated profiles with status, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

## Heat pump compressor operation threshold

### Overall purpose

This script calculates the average values of a signal over periods where the signal is constant or nearly constant, groups these averages into clusters based on a defined threshold, and then computes the summary statistics for each cluster to deduce the level of power below which the compressor is considered off.

### Main components

1. Data Transformation: It calculates the difference between consecutive rows in the power column and identifies periods where the signal is nearly constant.
2. Grouping and Filtering: The script groups periods of near-constant signal and filters out groups that are not sustained for a minimum duration.
3. Average Calculation: For each group, it calculates the average signal value (i.e., kW).
4. Clustering: The script sorts these average values and clusters them based on a threshold. Differences between adjacent average values are used to determine cluster membership. Each cluster represents a candidate for the threshold determining when the compressor will be considered On or Off.
5. Summary Statistics: For each cluster, it computes the number of groups and the average of average values.
6. Final Computation: The script calculates the maximum average value from clusters with significant contributions, adjusts this value, and then scales it by a factor for the final output.

### Inputs and outputs

- Input: A DataFrame with a column representing compressor power.
- Output: The script outputs a scaled maximum average value from significant clusters, which represents the threshold beyond which the compressor will be considered in operation. This value is likely to be the ventilation power, too.

## Power supply method

### Overall purpose

This script is designed to analyze heating and cooling cycles in a dataset. It processes power and temperature data to identify periods of heating or cooling based on predefined thresholds and temperature comparisons. The script also integrates outdoor temperature data for more accurate mode determination.

### Main components

1. Data Loading and Preparation: Loads outdoor temperature for the site of interest and prepares the DataFrame for analysis.



2. **Cycle Detection:** Identifies cycles where power exceeds a given threshold, indicating the start of a heating or cooling cycle.
3. **Temperature Analysis:** Calculates average temperatures during, before, and after each cycle, and incorporates outdoor temperature data for mode determination.
4. **Mode Determination:** Based on temperature trends and comparisons, the script determines if a cycle is for heating or cooling. If the start of the cycle index is 0, it checks if the average dry-bulb temperature is above or below a threshold. Depending on this, it compares the average temperature during a cycle with the temperature after the cycle (or before, if start is not 0) to decide if the mode should be set to 'cooling' or 'heating'. A difference of more than 10 degrees triggers a 'heating' mode if the temperature has increased, or 'cooling' mode if it has decreased. If the temperature change is less than 10 degrees, the system defaults to 'cooling' unless the average dry-bulb temperature is below the threshold, in which case it defaults to 'heating'.
5. **Status Assignment:** Assigns a status ('heating', 'cooling', or 'unchanged') for each data point based on the identified mode.
6. **Handling Unchanged Intervals:** Processes intervals between cycles, handling missing data and assigning appropriate modes.
7. **Data Enhancement:** Adds columns to the original DataFrame to indicate heating or cooling power based on the identified status for each cycle.



## Inputs and outputs

- Input: A DataFrame containing power and temperature data, a threshold value for cycle detection, and additional parameters like site number and end-use type.
- Output: The enhanced DataFrame, with additional columns indicating the status (heating, cooling) for each period and separate columns for heating and cooling power.

The Power-Supply method uses the same script.

## Temp-temp method

### Overall purpose

The script is designed to analyze the difference between supply and space temperatures signals and classify each data point as either 'heating', 'cooling', or 'unknown' based on a predefined threshold. This algorithm is particularly focused on handling scenarios where the signal is not clearly defined, which is a common challenge in data analysis of fluctuating signals.

### Main components

1. Status Calculation: The script iterates through the signal data, assigning a status based on the value relative to the threshold.
2. Handling 'NaN' Values: If a signal value is missing (NaN), the corresponding status is set as 'NaN'.
3. Threshold Comparison: For each data point, the script checks if the signal is above or below the threshold to determine 'heating' or 'cooling' status, respectively.
4. First Entry Special Handling: For the first data point, the script looks ahead to the next status to determine the current status if the signal is within the threshold range.
5. Subsequent Entries Handling: For subsequent data points, the script assigns the same status as the previous point if the signal is within the threshold range.

### Inputs and outputs

- Input: An array or list of temperature difference signal values and a threshold value for classification.
- Output: A list of statuses ('heating', 'cooling') corresponding to each signal value.

## OA-temp method

### Overall purpose

The script is designed to analyze outdoor air (OA) temperature to identify HVAC profiles status in a given site by categorizing periods as either 'heating', 'cooling'. It does so by smoothing the data, computing slopes for daytime and nighttime segments, and assigning statuses based on these slopes.

### Main components

1. Data Smoothing: The script smooths the OA data using a rolling window, which helps in identifying trends more clearly.
2. Time Adjustment: Shifts the DataFrame by 7 hours to account for UTC-7 time zone differences.
3. Slope Calculation: A custom function is used to calculate the slope of a regression line, which is key to determining the status.
4. Daytime and Nighttime Analysis: The script separates the data into daytime and nighttime segments for each day and calculates their respective slopes.
5. Status Assignment: Based on the slopes calculated for daytime and nighttime, the script assigns a status of 'heating', 'cooling'. If the nighttime slope is positive and the daytime slope is negative, the system is considered to be in 'cooling'.



mode. Conversely, if the nighttime slope is negative and the daytime slope is positive, it's in 'heating' mode. If neither condition is met, the code checks the previous day's status during the daytime hours of 5 am to 6 pm; if it finds data, it assigns the last known 'status' to the current day. If there is no previous day data, it defaults to 'heating' if the daytime slope is positive or 'cooling' if otherwise.

6. Time Re-adjustment: Finally, the DataFrame is shifted back to its original time.

## Inputs and outputs

- Input: A DataFrame containing time-indexed space temperature.
- Output: The enhanced DataFrame, with additional columns indicating the status (heating, cooling), the slope of the data, and the time period (daytime or nighttime).

## End-Use profiles expansion

### Overall purpose

The script is designed to process and expand aggregated profiles data for all sites using expansion coefficients provided in the Meta data file.

### Main components

1. Data Loading: Loads the Master Data File and the CSV file that includes all processed profiles for current site including HP aggregated profiles with mode.
2. Within site expansion coefficient calculation: A function is used to retrieve expansion coefficients for different end uses for each site.
3. Within site profile expansion: For each end-use profile in the time-series data (like ERH, HP, Other, RTU), the script applies the corresponding expansion coefficient to create an expanded data column.
4. Data Storage: The script saves the expanded time-series data into CSV files, one for each site.

### Inputs and outputs

- Input: The Master Data File and the CSV file that includes all processed profiles including HP aggregated profiles with status.
- Output: The script generates a CSV file for each site, with data presented in hourly intervals standardized to the UTC time zone. Each CSV file includes all processed profiles for that site in addition to the aggregated profiles with status expanded, as directed by the Master Data File, and features a single, shared timestamp column for all profiles.

## AMI Data Intake and Processing

The data processing workflow begins by loading the dataset and converting all timestamps to UTC, ensuring consistency across time zones. Key column, power, datetime, and ID, are extracted, with the power values initially assumed to be in kilowatt-hours (kWh). Any ambiguous or non-existent times are handled by converting them to NaT (Not a Time). In the second step, the energy values are converted from kWh to kilowatts (kW), adjusted by a multiplier if available. Missing datetime entries are removed, and both negative values and statistical outliers are replaced with NaN to maintain data integrity. The third step involves merging profiles that share the same meter ID, resampling them to the most common timestep, and marking data as NaN when the frequency falls below this threshold. In the fourth step, profiles with the same meter ID but from different data sharing rounds are combined and similarly resampled. Finally, the fifth step loads the data, identifies overlapping periods, and aggregates profiles belonging to the same site by summing their values.

## APPENDIX H. ACTUAL AND NORMAL WEATHER STATION SELECTION

This appendix explains the basic logic for weather station selection during the weather normalization analysis routine. Each of the 70 sample points is associated with an actual (NOAA) weather station and a normal (TMYx) weather station. The logic listed below applies for both the actual and normal weather station selections. DNV uses [WeatherHub](#), an internal API querying tool to access public weather stations.

1. For each service delivery (sample) point the zip code is used to search for the 5 closest weather stations sorted by distance away.
2. Starting with the closest weather station a request is made to retrieve two days of data. Two days is an arbitrary amount to speed up the query process and serves as a quality control means i.e., does the weather station have valid data
3. If there are valid records, the weather station is mapped to the sample point. This continues until the closest weather station with valid data is saved and mapped as that sample point's weather station.

Table C-1 lists all the actual (NOAA) and normal (TMYx) weather stations used in the CEMS analysis, by Site ID.

**Table H-1. Weather stations by Site ID**

SiteID	NOAA weather station	TMYx weather station
21241	Noaa - Renton Municipal Airport	Tmyx04 - Renton.Muni.Ap
17521	Noaa - Aurora State Airport	Tmyx04 - Aurora.State.Ap-Lematta.Field
22697	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - West.Point.Lighthouse
17375	Noaa - Portland-Troutdale Airport	Tmyx04 - Portland-Troutdale.Ap
17253	Noaa - McNary Field Airport	Tmyx04 - Salem.Muni.Ap-Mcnary.Field
18080	Noaa - Portland-Hillsboro Airport	Tmyx04 - Portland-Hillsboro.Ap
19315	Noaa - Portland International Airpor	Tmyx04 - Portland.Intl.Ap
19407	Noaa - Pearson Field Airport	Tmyx04 - Vancouver-Pearson.Field.Ap
11141	Noaa - Richland Airport	Tmyx04 - Pasco-Tri.Cities.Ap
19036	Noaa - Tri-Cities Airport	Tmyx04 - Pasco-Tri.Cities.Ap
20637	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_12011	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
21846	Noaa - Bellingham Intl Airport	Tmyx04 - Bellingham.Intl.Ap
PSE_50001	Noaa - Snohomish Co (Paine Fd) Ap	Tmyx04 - Everett-Paine.Field-Snohomish.County.Ap
D_20076	Noaa - Richland Airport	Tmyx04 - Pasco-Tri.Cities.Ap
11167	Noaa - Richland Airport	Tmyx04 - Pasco-Tri.Cities.Ap
D_22385	Noaa - Tri-Cities Airport	Tmyx04 - Pasco-Tri.Cities.Ap
D_23636	Noaa - McNary Field Airport	Tmyx04 - Salem.Muni.Ap-Mcnary.Field
D_21913	Noaa - Portland-Troutdale Airport	Tmyx04 - Portland-Troutdale.Ap
D_20262	Noaa - Portland-Troutdale Airport	Tmyx04 - Portland-Troutdale.Ap
D_21919	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field

SitelD	NOAA weather station	TMYx weather station
D_25511	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field
D_26331	Noaa - Aurora State Airport	Tmyx04 - Aurora.State.Ap-Lematta.Field
D_20998	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field
D_20446	Noaa - Corvallis Municipal Aprt	Tmyx04 - Corvallis.Muni.Ap
D_24968	Noaa - Snohomish Co (Paine Fd) Ap	Tmyx04 - Everett-Paine.Field-Snohomish.County.Ap
D_40001	Noaa - Snohomish Co (Paine Fd) Ap	Tmyx04 - Everett-Paine.Field-Snohomish.County.Ap
D_23683	Noaa - Pierce County Airport Thun Fi	Tmyx04 - Puyallup-Pierce.County.Ap-Thun.Field
D_23879	Noaa - Felts Field Airport	Tmyx04 - Spokane-Felts.Field
D_20354	Noaa - Felts Field Airport	Tmyx04 - Spokane-Felts.Field
D_20313	Noaa - Felts Field Airport	Tmyx04 - Spokane-Felts.Field
D_26339	Noaa - Bend Municipal Airport	Tmyx04 - Bend.Muni.Ap
D_25901	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field
D_23567	Noaa - Roberts Field Airport	Tmyx04 - Redmond.Muni.Ap-Roberts.Field
D_23423	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_24521	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_22669	Noaa - Corvallis Municipal Aprt	Tmyx04 - Corvallis.Muni.Ap
D_25757	Noaa - Corvallis Municipal Aprt	Tmyx04 - Corvallis.Muni.Ap
D_26238	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field
D_21246	Noaa - Gray Aff Airport	Tmyx04 - Tacoma-Jb.Lewis-Mcchord-Gray.Aaf
D_40002	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_20167	Noaa - Olympia Airport	Tmyx04 - Olympia.Rgnl.Ap
D_20771	Noaa - Mahlon Sweet Field Airport	Tmyx04 - Eugene.Ap-Sweet.Field
D_22736	Noaa - Boise Air Terminal/Gowen Fd A	Tmyx04 - Boise.Ap-Gowen.Field.Angb
D_40007	Noaa - Nampa Municipal Airport	Tmyx04 - Nampa.Muni.Ap
D_40010	Noaa - Portland International Airpor	Tmyx04 - Portland.Intl.Ap
D_20624	Noaa - Corvallis Municipal Aprt	Tmyx04 - Corvallis.Muni.Ap
D_25940	Noaa - Portland-Troutdale Airport	Tmyx04 - Portland-Troutdale.Ap
16536	Noaa - Portland-Hillsboro Airport	Tmyx04 - Portland-Hillsboro.Ap
D_40009	Noaa - Boise Air Terminal/Gowen Fd A	Tmyx04 - Boise.Ap-Gowen.Field.Angb
D_40006	Noaa - Coeur D'alene Air Term Apt	Tmyx04 - Coeur.Dalene.Ap-Boyington.Field
14229	Noaa - Missoula International Airpor	Tmyx04 - Missoula.Intl.Ap
D_22086	Noaa - Missoula International Airpor	Tmyx04 - Missoula.Intl.Ap
D_20142	Noaa - Gallatin Field Airport	Tmyx04 - Bozeman.Yellowstone.Intl.Ap-Gallatin.Field
D_22502	Noaa - Gallatin Field Airport	Tmyx04 - Bozeman.Yellowstone.Intl.Ap-Gallatin.Field
14495	Noaa - Powell Muni	Tmyx04 - Billings.Logan.Intl.Ap



Siteld	NOAA weather station	TMYx weather station
D_21966	Noaa - Portland International Airpor	Tmyx04 - Portland.Intl.Ap
D_40012	Noaa - Portland International Airpor	Tmyx04 - Portland.Intl.Ap
D_26198	Noaa - Olympia Airport	Tmyx04 - Olympia.Rgnl.Ap
D_21612	Noaa - Snohomish Co (Paine Fd) Ap	Tmyx04 - Everett-Paine.Field-Snohomish.County.Ap
D_22269	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_24215	Noaa - Pearson Field Airport	Tmyx04 - Vancouver-Pearson.Field.Ap
D_40004	Noaa - Boeing Fld/King Co Intl Ap	Tmyx04 - Seattle
D_24103	Noaa - Aurora State Airport	Tmyx04 - Aurora.State.Ap-Lematta.Field
D_23306	Noaa - Portland-Hillsboro Airport	Tmyx04 - Portland-Hillsboro.Ap
D_23008	Noaa - McNary Field Airport	Tmyx04 - Salem.Muni.Ap-Mcnary.Field
D_24948	Noaa - Snohomish Co (Paine Fd) Ap	Tmyx04 - Everett-Paine.Field-Snohomish.County.Ap
D_40017	Noaa - North Bend Municipal Arpt	Tmyx04 - North.Bend-Southwest.Oregon.Rgnl.Ap
D_33545	Noaa - Corvallis Municipal Aprt	Tmyx04 - Corvallis.Muni.Ap
D_21484	Noaa - Bend Municipal Airport	Tmyx04 - Bend.Muni.Ap



## APPENDIX I. KEY ENERGY AND DEMAND CHARACTERISTICS PER FACILITY

Table I-1. Aggregate electric resistance heat – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	36	0.10	Fri, Jul 28, 2023 13:00	0.05	47.4%	58	0.23	Sat, Jul 15, 2023 17:00	0.08	34.4%
Aug-23	30	0.11	Tue, Aug 08, 2023 13:00	0.04	35.2%	55	0.23	Sat, Aug 26, 2023 16:00	0.07	32.5%
Sep-23	71	0.83	Fri, Sep 29, 2023 17:00	0.10	11.8%	90	0.36	Tue, Sep 12, 2023 05:00	0.13	34.4%
Oct-23	263	2.05	Fri, Oct 27, 2023 03:00	0.35	17.3%	188	0.65	Fri, Oct 27, 2023 05:00	0.25	39.0%
Nov-23	315	1.43	Fri, Nov 24, 2023 04:00	0.44	30.6%	350	1.13	Tue, Nov 21, 2023 04:00	0.49	43.0%
Dec-23	402	1.46	Mon, Dec 25, 2023 03:00	0.54	37.0%	510	1.11	Wed, Dec 27, 2023 04:00	0.68	61.4%
Jan-24	759	3.00	Fri, Jan 12, 2024 19:00	1.02	34.0%	484	1.17	Wed, Jan 03, 2024 09:00	0.65	55.5%
Feb-24	438	1.43	Fri, Feb 16, 2024 08:00	0.63	44.1%	418	0.99	Tue, Feb 27, 2024 04:00	0.60	60.9%
Mar-24	336	1.26	Thu, Mar 07, 2024 04:00	0.45	36.0%	345	1.11	Mon, Mar 11, 2024 03:00	0.46	41.7%
Apr-24	162	0.68	Thu, Apr 18, 2024 08:00	0.22	32.9%	232	0.74	Mon, Apr 01, 2024 05:00	0.32	43.5%
May-24	100	0.51	Wed, May 01, 2024 08:00	0.13	26.6%	138	0.41	Tue, May 07, 2024 05:00	0.18	45.2%
Jun-24	38	0.35	Mon, Jun 17, 2024 10:00	0.05	15.1%	81	0.36	Mon, Jun 10, 2024 05:00	0.11	31.5%
Annual	2,948	3.00	Fri, Jan 12, 2024 19:00	0.34	11.2%	2,948	1.17	Wed, Jan 03, 2024 09:00	0.34	28.8%



Table I-2. Office electric resistance heat – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	28	0.06	Tue, Jul 11, 2023 07:00	0.04	58.3%	46	0.17	Tue, Jul 11, 2023 08:00	0.06	37.4%
Aug-23	26	0.16	Thu, Aug 24, 2023 09:00	0.03	21.5%	46	0.19	Tue, Aug 22, 2023 08:00	0.06	32.5%
Sep-23	31	0.58	Mon, Sep 25, 2023 13:00	0.04	7.4%	61	0.34	Fri, Sep 29, 2023 09:00	0.09	25.1%
Oct-23	57	0.73	Mon, Oct 30, 2023 10:00	0.08	10.4%	108	0.57	Mon, Oct 23, 2023 09:00	0.14	25.5%
Nov-23	99	1.04	Mon, Nov 27, 2023 09:00	0.14	13.3%	156	0.70	Tue, Nov 14, 2023 08:00	0.22	30.8%
Dec-23	113	0.97	Mon, Dec 25, 2023 09:00	0.15	15.7%	208	0.76	Mon, Dec 04, 2023 08:00	0.28	36.5%
Jan-24	237	1.14	Tue, Jan 16, 2024 11:00	0.32	27.9%	203	0.82	Mon, Jan 01, 2024 09:00	0.27	33.3%
Feb-24	283	1.02	Tue, Feb 27, 2024 08:00	0.41	39.9%	171	0.72	Mon, Feb 05, 2024 08:00	0.25	34.1%
Mar-24	246	1.03	Wed, Mar 06, 2024 08:00	0.33	32.1%	157	0.78	Mon, Mar 04, 2024 08:00	0.21	27.0%
Apr-24	181	0.99	Mon, Apr 08, 2024 08:00	0.25	25.4%	131	0.64	Mon, Apr 01, 2024 09:00	0.18	28.4%
May-24	97	0.95	Mon, May 06, 2024 09:00	0.13	13.7%	94	0.38	Mon, May 13, 2024 09:00	0.13	33.5%
Jun-24	46	0.59	Mon, Jun 17, 2024 08:00	0.06	10.9%	62	0.25	Mon, Jun 10, 2024 09:00	0.09	34.2%
Annual	1,444	1.14	Tue, Jan 16, 2024 11:00	0.16	14.5%	1,444	0.82	Mon, Jan 01, 2024 09:00	0.16	20.1%



Table I-3. Retail electric resistance heat – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	38	0.12	Fri, Jul 28, 2023 13:00	0.05	43.8%	61	0.27	Sat, Jul 15, 2023 17:00	0.08	30.7%
Aug-23	31	0.13	Tue, Aug 08, 2023 13:00	0.04	31.5%	57	0.26	Sat, Aug 26, 2023 16:00	0.08	29.0%
Sep-23	81	1.02	Fri, Sep 29, 2023 18:00	0.11	11.0%	97	0.44	Tue, Sep 12, 2023 05:00	0.14	30.7%
Oct-23	313	2.53	Fri, Oct 27, 2023 03:00	0.42	16.7%	207	0.77	Fri, Oct 27, 2023 05:00	0.28	36.1%
Nov-23	367	1.74	Fri, Nov 24, 2023 04:00	0.51	29.2%	397	1.35	Tue, Nov 21, 2023 04:00	0.55	40.8%
Dec-23	471	1.79	Mon, Dec 25, 2023 03:00	0.63	35.5%	582	1.34	Wed, Dec 27, 2023 03:00	0.78	58.3%
Jan-24	884	3.60	Fri, Jan 12, 2024 19:00	1.19	33.0%	552	1.34	Wed, Jan 17, 2024 04:00	0.74	55.5%
Feb-24	476	1.53	Fri, Feb 16, 2024 08:00	0.68	44.7%	478	1.18	Wed, Feb 28, 2024 03:00	0.69	58.2%
Mar-24	358	1.45	Thu, Mar 07, 2024 04:00	0.48	33.2%	390	1.34	Mon, Mar 11, 2024 03:00	0.52	39.2%
Apr-24	157	0.71	Thu, Apr 18, 2024 06:00	0.22	30.8%	256	0.87	Mon, Apr 01, 2024 05:00	0.36	41.0%
May-24	100	0.44	Wed, May 01, 2024 07:00	0.14	31.0%	148	0.48	Tue, May 07, 2024 05:00	0.20	41.3%
Jun-24	35	0.34	Mon, Jun 17, 2024 10:00	0.05	14.7%	85	0.42	Mon, Jun 10, 2024 05:00	0.12	28.2%
Annual	3,311	3.60	Fri, Jan 12, 2024 19:00	0.38	10.5%	3,311	1.35	Tue, Nov 21, 2023 04:00	0.38	28.0%



Table I-4. Aggregate heat pump – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	459	1.50	Thu, Jul 20, 2023 16:00	0.62	41.2%	413	1.10	Fri, Jul 21, 2023 16:00	0.55	50.5%
Aug-23	475	2.00	Tue, Aug 15, 2023 16:00	0.64	31.9%	401	1.12	Thu, Aug 17, 2023 17:00	0.54	48.2%
Sep-23	331	1.07	Fri, Sep 15, 2023 16:00	0.46	42.8%	356	1.14	Mon, Sep 25, 2023 08:00	0.49	43.6%
Oct-23	432	2.81	Mon, Oct 30, 2023 08:00	0.58	20.6%	446	1.86	Wed, Oct 18, 2023 08:00	0.60	32.3%
Nov-23	645	3.17	Wed, Nov 29, 2023 07:00	0.90	28.2%	602	2.10	Tue, Nov 21, 2023 07:00	0.84	39.9%
Dec-23	674	2.66	Mon, Dec 25, 2023 07:00	0.91	34.1%	811	2.64	Wed, Dec 06, 2023 08:00	1.09	41.3%
Jan-24	884	3.58	Mon, Jan 15, 2024 08:00	1.19	33.2%	779	2.83	Thu, Jan 04, 2024 07:00	1.05	37.0%
Feb-24	606	2.64	Fri, Feb 16, 2024 08:00	0.87	32.9%	659	2.33	Mon, Feb 26, 2024 07:00	0.95	40.6%
Mar-24	596	2.86	Thu, Mar 07, 2024 08:00	0.80	28.0%	576	2.46	Mon, Mar 04, 2024 07:00	0.77	31.5%
Apr-24	432	2.23	Mon, Apr 01, 2024 08:00	0.60	26.9%	487	2.00	Mon, Apr 01, 2024 08:00	0.68	33.9%
May-24	380	1.85	Mon, May 06, 2024 08:00	0.51	27.6%	406	1.47	Wed, May 01, 2024 08:00	0.55	37.1%
Jun-24	373	1.19	Thu, Jun 20, 2024 16:00	0.52	43.3%	352	1.01	Mon, Jun 10, 2024 08:00	0.49	48.5%
Annual	6,287	3.58	Mon, Jan 15, 2024 08:00	0.72	20.0%	6,287	2.83	Thu, Jan 04, 2024 07:00	0.72	25.4%



Table I-5. Office heat pump – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	406	1.39	Wed, Jul 05, 2023 16:00	0.55	39.2%	372	1.01	Mon, Jul 24, 2023 15:00	0.50	49.5%
Aug-23	413	1.71	Tue, Aug 15, 2023 16:00	0.56	32.5%	364	1.07	Tue, Aug 01, 2023 16:00	0.49	45.8%
Sep-23	304	0.99	Fri, Sep 15, 2023 15:00	0.42	42.5%	328	1.12	Mon, Sep 25, 2023 08:00	0.46	40.5%
Oct-23	401	2.40	Mon, Oct 30, 2023 08:00	0.54	22.4%	402	1.75	Wed, Oct 18, 2023 08:00	0.54	30.8%
Nov-23	597	2.85	Tue, Nov 28, 2023 07:00	0.83	29.1%	537	1.92	Tue, Nov 21, 2023 07:00	0.75	38.9%
Dec-23	615	2.54	Mon, Dec 25, 2023 07:00	0.83	32.6%	719	2.36	Mon, Dec 18, 2023 07:00	0.97	40.9%
Jan-24	761	3.24	Mon, Jan 15, 2024 07:00	1.02	31.6%	696	2.65	Thu, Jan 04, 2024 07:00	0.94	35.3%
Feb-24	530	2.41	Fri, Feb 16, 2024 07:00	0.76	31.6%	578	2.17	Mon, Feb 26, 2024 07:00	0.83	38.3%
Mar-24	527	2.47	Mon, Mar 04, 2024 07:00	0.71	28.7%	511	2.26	Mon, Mar 18, 2024 08:00	0.69	30.5%
Apr-24	394	1.89	Mon, Apr 08, 2024 07:00	0.55	29.0%	443	1.86	Mon, Apr 01, 2024 08:00	0.61	33.0%
May-24	355	1.74	Mon, May 06, 2024 08:00	0.48	27.5%	374	1.41	Mon, May 13, 2024 07:00	0.50	35.7%
Jun-24	346	1.10	Thu, Jun 20, 2024 16:00	0.48	43.5%	325	1.03	Mon, Jun 10, 2024 07:00	0.45	43.9%
Annual	5,649	3.24	Mon, Jan 15, 2024 07:00	0.64	19.9%	5,649	2.65	Thu, Jan 04, 2024 07:00	0.64	24.3%



Table I-6. Retail heat pump – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	652	2.29	Thu, Jul 20, 2023 16:00	0.88	38.3%	559	1.74	Tue, Jul 25, 2023 17:00	0.75	43.1%
Aug-23	700	3.20	Mon, Aug 14, 2023 16:00	0.94	29.4%	533	1.81	Thu, Aug 17, 2023 17:00	0.72	39.7%
Sep-23	428	1.56	Fri, Sep 15, 2023 17:00	0.59	38.2%	458	1.45	Thu, Sep 28, 2023 08:00	0.64	44.0%
Oct-23	542	4.66	Thu, Oct 26, 2023 09:00	0.73	15.7%	603	2.76	Fri, Oct 27, 2023 08:00	0.81	29.4%
Nov-23	822	5.07	Wed, Nov 29, 2023 08:00	1.14	22.5%	835	2.99	Mon, Nov 27, 2023 08:00	1.16	38.7%
Dec-23	888	4.03	Mon, Dec 18, 2023 08:00	1.19	29.7%	1,142	4.49	Wed, Dec 06, 2023 08:00	1.53	34.2%
Jan-24	1,325	5.72	Mon, Jan 15, 2024 09:00	1.78	31.1%	1,077	4.74	Mon, Jan 01, 2024 08:00	1.45	30.5%
Feb-24	881	4.18	Fri, Feb 16, 2024 09:00	1.27	30.3%	953	3.57	Thu, Feb 01, 2024 08:00	1.37	38.3%
Mar-24	844	5.13	Thu, Mar 07, 2024 08:00	1.14	22.1%	809	3.51	Mon, Mar 04, 2024 08:00	1.09	31.0%
Apr-24	566	4.18	Mon, Apr 01, 2024 08:00	0.79	18.8%	649	2.81	Mon, Apr 01, 2024 09:00	0.90	32.1%
May-24	468	3.39	Wed, May 01, 2024 08:00	0.63	18.5%	523	2.26	Wed, May 01, 2024 08:00	0.70	31.1%
Jun-24	470	1.71	Mon, Jun 17, 2024 08:00	0.65	38.2%	446	1.26	Sun, Jun 30, 2024 18:00	0.62	49.3%
Annual	8,588	5.72	Mon, Jan 15, 2024 09:00	0.98	17.1%	8,587	4.74	Mon, Jan 01, 2024 08:00	0.98	20.7%



Table I-7. Aggregate roof top units – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	1,598	4.76	Wed, Jul 19, 2023 16:00	2.15	45.1%	1,312	3.95	Fri, Jul 21, 2023 16:00	1.76	44.6%
Aug-23	1,603	5.81	Tue, Aug 15, 2023 16:00	2.15	37.1%	1,273	4.25	Fri, Aug 18, 2023 16:00	1.71	40.2%
Sep-23	1,010	3.77	Fri, Sep 15, 2023 17:00	1.40	37.3%	978	3.46	Fri, Sep 22, 2023 17:00	1.36	39.2%
Oct-23	722	2.65	Sat, Oct 07, 2023 16:00	0.97	36.6%	794	1.86	Mon, Oct 02, 2023 16:00	1.07	57.5%
Nov-23	616	1.46	Thu, Nov 02, 2023 15:00	0.86	58.6%	707	1.52	Wed, Nov 01, 2023 17:00	0.98	64.8%
Dec-23	622	1.25	Thu, Dec 07, 2023 11:00	0.84	66.9%	695	1.29	Fri, Dec 08, 2023 14:00	0.93	72.1%
Jan-24	727	1.39	Mon, Jan 29, 2024 13:00	0.98	70.1%	696	1.32	Fri, Jan 19, 2024 16:00	0.94	71.1%
Feb-24	664	1.36	Fri, Feb 23, 2024 16:00	0.95	70.3%	666	1.35	Thu, Feb 15, 2024 14:00	0.96	70.9%
Mar-24	675	1.57	Mon, Mar 18, 2024 17:00	0.91	57.7%	732	1.47	Fri, Mar 15, 2024 17:00	0.99	66.9%
Apr-24	598	1.68	Tue, Apr 02, 2024 17:00	0.83	49.3%	743	1.76	Wed, Apr 24, 2024 17:00	1.03	58.6%
May-24	713	2.90	Fri, May 10, 2024 15:00	0.96	33.0%	891	2.49	Wed, May 08, 2024 17:00	1.20	48.0%
Jun-24	919	3.94	Tue, Jun 25, 2024 17:00	1.28	32.4%	979	3.23	Mon, Jun 24, 2024 17:00	1.36	42.2%
Annual	10,467	5.81	Tue, Aug 15, 2023 16:00	1.19	20.6%	10,467	4.25	Fri, Aug 18, 2023 16:00	1.19	28.1%



Table I-8. Office roof top units – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	1,335	4.45	Wed, Jul 05, 2023 17:00	1.79	40.3%	1,176	3.73	Thu, Jul 27, 2023 17:00	1.58	42.3%
Aug-23	1,459	5.76	Mon, Aug 14, 2023 17:00	1.96	34.1%	1,153	3.98	Fri, Aug 18, 2023 17:00	1.55	39.0%
Sep-23	839	3.35	Fri, Sep 15, 2023 16:00	1.16	34.8%	899	3.50	Mon, Sep 11, 2023 17:00	1.25	35.7%
Oct-23	697	2.83	Fri, Oct 06, 2023 16:00	0.94	33.1%	726	1.82	Mon, Oct 02, 2023 16:00	0.98	53.5%
Nov-23	545	1.25	Thu, Nov 02, 2023 15:00	0.76	60.4%	622	1.34	Wed, Nov 01, 2023 16:00	0.86	64.6%
Dec-23	578	1.20	Fri, Dec 29, 2023 15:00	0.78	64.6%	580	1.12	Thu, Dec 28, 2023 08:00	0.78	69.8%
Jan-24	616	1.28	Mon, Jan 29, 2024 15:00	0.83	64.6%	595	1.14	Thu, Jan 18, 2024 16:00	0.80	69.9%
Feb-24	539	1.37	Fri, Feb 23, 2024 16:00	0.77	56.4%	574	1.20	Thu, Feb 22, 2024 16:00	0.82	68.9%
Mar-24	593	1.90	Mon, Mar 18, 2024 17:00	0.80	42.0%	646	1.37	Fri, Mar 15, 2024 17:00	0.87	63.5%
Apr-24	572	2.03	Tue, Apr 23, 2024 17:00	0.79	39.1%	676	1.81	Fri, Apr 19, 2024 16:00	0.94	52.0%
May-24	695	2.93	Wed, May 15, 2024 17:00	0.93	31.8%	819	2.30	Fri, May 10, 2024 16:00	1.10	47.9%
Jun-24	870	4.23	Fri, Jun 21, 2024 17:00	1.21	28.5%	870	2.74	Mon, Jun 24, 2024 17:00	1.21	44.1%
Annual	9,336	5.76	Mon, Aug 14, 2023 17:00	1.07	18.5%	9,336	3.98	Fri, Aug 18, 2023 17:00	1.07	26.8%



Table I-9. Retail roof top units – means

Month	Actuals					Normals				
	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)	Total use (kWh)	Peak demand (kW)	Occurrence date & time	Average demand (kW)	Load factor (%)
Jul-23	1,719	5.08	Sat, Jul 22, 2023 17:00	2.31	45.5%	1,375	4.18	Fri, Jul 21, 2023 16:00	1.85	44.3%
Aug-23	1,669	5.88	Tue, Aug 15, 2023 16:00	2.24	38.1%	1,328	4.41	Fri, Aug 18, 2023 16:00	1.79	40.5%
Sep-23	1,089	4.37	Sat, Sep 02, 2023 16:00	1.51	34.6%	1,014	3.57	Fri, Sep 22, 2023 16:00	1.41	39.5%
Oct-23	733	2.71	Sat, Oct 07, 2023 16:00	0.99	36.3%	825	1.87	Mon, Oct 02, 2023 16:00	1.11	59.3%
Nov-23	649	1.62	Sat, Nov 04, 2023 17:00	0.90	55.6%	747	1.60	Wed, Nov 01, 2023 17:00	1.04	64.8%
Dec-23	642	1.37	Thu, Dec 07, 2023 11:00	0.86	63.1%	747	1.46	Wed, Dec 06, 2023 14:00	1.00	68.7%
Jan-24	779	1.53	Mon, Jan 22, 2024 09:00	1.05	68.3%	742	1.41	Fri, Jan 19, 2024 16:00	1.00	70.8%
Feb-24	722	1.43	Fri, Feb 02, 2024 14:00	1.04	72.4%	709	1.45	Thu, Feb 15, 2024 14:00	1.02	70.2%
Mar-24	713	1.60	Sat, Mar 16, 2024 16:00	0.96	59.9%	772	1.55	Wed, Mar 27, 2024 17:00	1.04	66.8%
Apr-24	609	1.78	Fri, Apr 12, 2024 17:00	0.85	47.6%	773	1.80	Sat, Apr 27, 2024 16:00	1.07	59.8%
May-24	721	3.24	Sat, May 11, 2024 16:00	0.97	29.9%	925	2.72	Wed, May 08, 2024 17:00	1.24	45.7%
Jun-24	941	4.17	Tue, Jun 25, 2024 17:00	1.31	31.3%	1,030	3.61	Sun, Jun 30, 2024 17:00	1.43	39.6%
Annual	10,987	5.88	Tue, Aug 15, 2023 16:00	1.25	21.3%	10,987	4.41	Fri, Aug 18, 2023 16:00	1.25	28.4%



## APPENDIX J. KEY ENERGY AND DEMAND CHARACTERISTICS – TOTALS

Table J-1. Office + Retail RTU totals

Month	RTU (Office + Retail)									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	129,196,866	385,730	Wed, Jul 19, 2023 16:00	173,652	45.02%	100,182,437	292,983	Fri, Jul 21, 2023 16:00	134,654	45.96%
Aug-23	128,527,650	467,245	Tue, Aug 15, 2023 16:00	172,752	36.97%	97,762,055	319,167	Fri, Aug 18, 2023 16:00	131,401	41.17%
Sep-23	81,555,925	301,514	Fri, Sep 15, 2023 17:00	113,272	37.57%	77,262,675	260,953	Fri, Sep 22, 2023 16:00	107,309	41.12%
Oct-23	58,254,514	211,538	Sat, Oct 07, 2023 16:00	78,299	37.01%	63,619,612	146,535	Mon, Oct 02, 2023 16:00	85,510	58.35%
Nov-23	49,915,323	115,975	Thu, Nov 02, 2023 15:00	69,327	59.78%	55,719,479	120,095	Wed, Nov 01, 2023 16:00	77,388	64.44%
Dec-23	50,337,672	100,348	Thu, Dec 07, 2023 11:00	67,658	67.42%	53,913,377	101,105	Wed, Dec 13, 2023 15:00	72,464	71.67%
Jan-24	58,979,320	112,282	Mon, Jan 29, 2024 13:00	79,273	70.60%	54,435,858	103,353	Fri, Jan 19, 2024 14:00	73,166	70.79%
Feb-24	53,867,634	108,718	Fri, Feb 23, 2024 16:00	77,396	71.19%	52,411,907	108,852	Wed, Feb 28, 2024 15:00	75,304	69.18%
Mar-24	54,621,421	123,814	Mon, Mar 18, 2024 17:00	73,515	59.38%	58,609,215	125,919	Fri, Mar 15, 2024 17:00	78,882	62.64%
Apr-24	48,130,904	131,090	Tue, Apr 02, 2024 17:00	66,848	50.99%	59,756,086	147,067	Fri, Apr 19, 2024 17:00	82,995	56.43%
May-24	57,384,693	230,847	Fri, May 10, 2024 15:00	77,130	33.41%	71,378,121	195,096	Wed, May 08, 2024 16:00	95,938	49.18%
Jun-24	73,991,311	316,431	Tue, Jun 25, 2024 17:00	102,766	32.48%	77,511,238	234,711	Mon, Jun 24, 2024 17:00	107,655	45.87%
Jul-24	139,611,613	453,557	Tue, Jul 09, 2024 17:00	187,650	41.37%	101,798,197	299,116	Wed, Jul 24, 2024 17:00	136,826	45.74%
Aug-24	122,446,764	452,677	Fri, Aug 02, 2024 16:00	164,579	36.36%	97,406,039	299,589	Sat, Aug 17, 2024 16:00	130,922	43.70%
Sep-24	95,683,166	387,282	Thu, Sep 05, 2024 17:00	132,893	34.31%	77,463,326	277,235	Wed, Sep 11, 2024 16:00	107,588	38.81%
Oct-24	62,147,249	190,191	Mon, Oct 07, 2024 17:00	83,531	43.92%	63,890,320	152,685	Wed, Oct 02, 2024 16:00	85,874	56.24%
Nov-24	43,679,287	100,599	Fri, Nov 22, 2024 11:00	60,666	60.30%	55,681,340	119,701	Fri, Nov 01, 2024 16:00	77,335	64.61%
Dec-24	44,742,849	98,188	Tue, Dec 03, 2024 09:00	60,138	61.25%	54,040,233	99,130	Thu, Dec 12, 2024 10:00	72,635	73.27%
Jan-25	47,082,467	105,975	Tue, Jan 28, 2025 10:00	63,283	59.71%	54,528,710	106,700	Wed, Jan 29, 2025 16:00	73,291	68.69%
Feb-25	43,735,612	106,929	Tue, Feb 11, 2025 09:00	65,083	60.87%	50,545,252	107,756	Fri, Feb 28, 2025 16:00	75,216	69.80%
Mar-25	42,326,309	132,108	Wed, Mar 26, 2025 16:00	56,967	43.12%	58,635,449	123,520	Mon, Mar 24, 2025 16:00	78,917	63.89%
Apr-25	40,531,010	136,680	Tue, Apr 15, 2025 17:00	56,293	41.19%	59,792,437	142,080	Fri, Apr 18, 2025 17:00	83,045	58.45%
May-25	51,167,374	238,477	Wed, May 28, 2025 17:00	68,773	28.84%	71,142,341	188,386	Fri, May 09, 2025 16:00	95,621	50.76%
Jun-25	71,524,340	389,812	Mon, Jun 09, 2025 17:00	99,339	25.48%	81,916,571	261,501	Mon, Jun 30, 2025 17:00	113,773	43.51%



**Table J-2. Office + Retail HP overall totals**

Month	HP Overall Total (Office + Retail)									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	10,153,574	32,750	Wed, Jul 05, 2023 16:00	13,647	41.67%	8,719,528	23,629	Fri, Jul 21, 2023 16:00	11,720	49.60%
Aug-23	10,164,203	43,301	Mon, Aug 14, 2023 16:00	13,662	31.55%	8,578,168	24,391	Thu, Aug 17, 2023 16:00	11,530	47.27%
Sep-23	6,963,906	23,193	Fri, Sep 15, 2023 15:00	9,672	41.70%	7,860,859	21,895	Mon, Sep 25, 2023 07:00	10,918	49.87%
Oct-23	9,027,850	56,621	Mon, Oct 30, 2023 08:00	12,134	21.43%	9,680,737	33,220	Wed, Oct 18, 2023 08:00	13,012	39.17%
Nov-23	13,506,000	64,486	Wed, Nov 29, 2023 08:00	18,758	29.09%	12,612,772	42,620	Tue, Nov 21, 2023 07:00	17,518	41.10%
Dec-23	14,038,140	52,889	Mon, Dec 25, 2023 07:00	18,868	35.68%	16,202,349	51,977	Wed, Dec 06, 2023 07:00	21,777	41.90%
Jan-24	18,312,986	72,847	Mon, Jan 15, 2024 09:00	24,614	33.79%	15,774,454	55,038	Thu, Jan 04, 2024 07:00	21,202	38.52%
Feb-24	12,562,055	54,325	Fri, Feb 16, 2024 08:00	18,049	33.22%	13,396,976	45,636	Thu, Feb 01, 2024 08:00	19,249	42.18%
Mar-24	12,333,071	59,180	Fri, Mar 08, 2024 08:00	16,599	28.05%	11,955,026	46,268	Mon, Mar 04, 2024 07:00	16,090	34.78%
Apr-24	8,939,160	44,794	Mon, Apr 01, 2024 08:00	12,416	27.72%	10,307,192	39,288	Mon, Apr 01, 2024 08:00	14,316	36.44%
May-24	7,832,637	37,815	Mon, May 06, 2024 08:00	10,528	27.84%	8,830,886	26,681	Wed, May 01, 2024 08:00	11,869	44.49%
Jun-24	7,858,086	25,402	Thu, Jun 20, 2024 16:00	10,914	42.96%	7,714,496	20,893	Mon, Jun 10, 2024 08:00	10,715	51.28%
Jul-24	11,299,379	42,667	Tue, Jul 09, 2024 16:00	15,187	35.60%	8,959,330	23,694	Wed, Jul 03, 2024 16:00	12,042	50.82%
Aug-24	9,345,932	35,448	Thu, Aug 01, 2024 16:00	12,562	35.44%	8,488,319	22,268	Thu, Aug 01, 2024 16:00	11,409	51.23%
Sep-24	7,557,770	32,423	Thu, Sep 05, 2024 16:00	10,497	32.37%	7,892,544	28,507	Mon, Sep 30, 2024 08:00	10,962	38.45%
Oct-24	7,937,653	35,008	Wed, Oct 30, 2024 08:00	10,669	30.48%	9,646,197	32,324	Mon, Oct 21, 2024 08:00	12,965	40.11%
Nov-24	12,501,047	52,997	Fri, Nov 29, 2024 08:00	17,363	32.76%	12,456,676	46,197	Mon, Nov 25, 2024 07:00	17,301	37.45%
Dec-24	15,862,654	58,559	Mon, Dec 02, 2024 09:00	21,321	36.41%	16,408,379	56,759	Tue, Dec 17, 2024 07:00	22,054	38.86%
Jan-25	18,975,439	66,303	Mon, Jan 27, 2025 08:00	25,505	38.47%	15,712,881	54,736	Fri, Jan 03, 2025 08:00	21,119	38.58%
Feb-25	15,816,297	63,706	Wed, Feb 12, 2025 07:00	23,536	36.95%	12,946,909	48,130	Mon, Feb 03, 2025 08:00	19,266	40.03%
Mar-25	10,729,365	44,068	Mon, Mar 31, 2025 08:00	14,441	32.77%	12,023,380	44,450	Mon, Mar 03, 2025 07:00	16,182	36.41%
Apr-25	7,491,843	34,799	Fri, Apr 04, 2025 08:00	10,405	29.90%	10,297,321	35,531	Tue, Apr 01, 2025 08:00	14,302	40.25%
May-25	6,640,816	23,107	Mon, May 05, 2025 07:00	8,926	38.63%	8,782,963	26,804	Thu, May 01, 2025 08:00	11,805	44.04%
Jun-25	7,212,499	31,526	Mon, Jun 30, 2025 16:00	10,017	31.77%	7,805,046	22,234	Mon, Jun 30, 2025 16:00	10,840	48.76%



**Table J-3. Office + Retail HP Cool totals**

Month	HP Cool Total (Office + Retail)									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	18,288,798	66,260	Thu, Jul 20, 2023 16:00	24,582	37.10%	15,440,280	48,672	Tue, Jul 25, 2023 16:00	20,753	42.64%
Aug-23	17,173,085	80,125	Mon, Aug 14, 2023 15:00	23,082	28.81%	14,796,527	52,674	Tue, Aug 01, 2023 16:00	19,888	37.76%
Sep-23	9,188,964	40,493	Mon, Sep 11, 2023 16:00	12,762	31.52%	10,610,668	38,217	Tue, Sep 12, 2023 16:00	14,737	38.56%
Oct-23	5,588,984	25,750	Fri, Oct 06, 2023 16:00	7,512	29.17%	7,673,108	22,349	Mon, Oct 02, 2023 15:00	10,313	46.15%
Nov-23	3,757,998	14,635	Mon, Nov 20, 2023 07:00	5,219	35.66%	5,903,208	12,380	Wed, Nov 01, 2023 14:00	8,199	66.23%
Dec-23	4,497,060	12,431	Mon, Dec 18, 2023 06:00	6,044	48.63%	5,407,889	11,509	Fri, Dec 01, 2023 06:00	7,269	63.16%
Jan-24	3,916,754	13,383	Mon, Jan 15, 2024 13:00	5,264	39.34%	5,517,278	13,158	Thu, Jan 18, 2024 06:00	7,416	56.36%
Feb-24	4,071,380	15,709	Fri, Feb 23, 2024 06:00	5,850	37.24%	5,486,744	12,618	Thu, Feb 22, 2024 06:00	7,883	62.48%
Mar-24	5,032,796	17,744	Thu, Mar 14, 2024 06:00	6,774	38.17%	6,618,018	13,965	Fri, Mar 15, 2024 15:00	8,907	63.78%
Apr-24	5,382,623	18,965	Thu, Apr 18, 2024 06:00	7,476	39.42%	7,040,214	21,081	Fri, Apr 19, 2024 16:00	9,778	46.38%
May-24	6,894,018	30,976	Fri, May 10, 2024 16:00	9,266	29.91%	9,538,699	33,821	Wed, May 15, 2024 16:00	12,821	37.91%
Jun-24	11,706,058	51,332	Thu, Jun 20, 2024 16:00	16,258	31.67%	11,051,864	34,548	Fri, Jun 28, 2024 16:00	15,350	44.43%
Jul-24	21,323,984	89,594	Tue, Jul 09, 2024 16:00	28,661	31.99%	15,981,374	50,897	Tue, Jul 23, 2024 16:00	21,480	42.20%
Aug-24	16,826,889	73,243	Thu, Aug 01, 2024 16:00	22,617	30.88%	14,631,901	48,091	Thu, Aug 01, 2024 16:00	19,667	40.89%
Sep-24	11,520,812	64,039	Thu, Sep 05, 2024 16:00	16,001	24.99%	10,701,156	42,553	Wed, Sep 11, 2024 16:00	14,863	34.93%
Oct-24	5,995,059	28,024	Tue, Oct 08, 2024 16:00	8,058	28.75%	7,742,502	23,139	Tue, Oct 01, 2024 15:00	10,407	44.97%
Nov-24	4,764,151	17,136	Mon, Nov 25, 2024 06:00	6,617	38.61%	5,811,805	12,885	Thu, Nov 07, 2024 06:00	8,072	62.65%
Dec-24	6,148,064	17,722	Tue, Dec 03, 2024 07:00	8,264	46.63%	5,443,153	11,924	Fri, Dec 13, 2024 06:00	7,316	61.36%
Jan-25	7,352,829	23,582	Tue, Jan 28, 2025 03:00	9,883	41.91%	5,526,464	12,224	Fri, Jan 17, 2025 06:00	7,428	60.77%
Feb-25	7,474,770	25,750	Wed, Feb 12, 2025 07:00	11,123	43.20%	5,282,351	12,221	Fri, Feb 28, 2025 06:00	7,861	64.32%
Mar-25	7,473,242	27,385	Mon, Mar 10, 2025 06:00	10,058	36.73%	6,617,336	14,341	Mon, Mar 31, 2025 14:00	8,906	62.10%
Apr-25	6,387,930	24,068	Tue, Apr 15, 2025 16:00	8,872	36.86%	7,058,309	19,484	Mon, Apr 21, 2025 15:00	9,803	50.31%
May-25	7,923,249	42,810	Wed, May 28, 2025 15:00	10,650	24.88%	9,403,796	32,511	Thu, May 15, 2025 16:00	12,640	38.88%
Jun-25	11,858,500	57,415	Mon, Jun 09, 2025 16:00	16,470	28.69%	11,259,775	45,327	Mon, Jun 30, 2025 16:00	15,639	34.50%



**Table J-4. Office + Retail HP Heat totals**

Month	HP Heat Total (Office + Retail)									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	1,648,070	6,254	Mon, Jul 10, 2023 15:00	2,215	35.42%	1,648,070	6,254	Mon, Jul 10, 2023 15:00	2,958	35.42%
Aug-23	1,957,947	7,792	Mon, Aug 14, 2023 16:00	2,632	33.78%	1,957,947	7,792	Mon, Aug 14, 2023 16:00	3,082	33.78%
Sep-23	2,612,009	17,678	Thu, Sep 28, 2023 08:00	3,628	20.52%	2,612,009	17,678	Thu, Sep 28, 2023 08:00	4,487	20.52%
Oct-23	6,244,003	53,509	Mon, Oct 30, 2023 08:00	8,392	15.68%	6,244,003	53,509	Mon, Oct 30, 2023 08:00	8,189	15.68%
Nov-23	11,203,264	62,647	Wed, Nov 29, 2023 08:00	15,560	24.84%	11,203,264	62,647	Wed, Nov 29, 2023 08:00	12,928	24.84%
Dec-23	11,732,972	51,245	Mon, Dec 18, 2023 08:00	15,770	30.77%	11,732,972	51,245	Mon, Dec 18, 2023 08:00	17,126	30.77%
Jan-24	16,097,283	69,474	Mon, Jan 15, 2024 09:00	21,636	31.14%	16,097,283	69,474	Mon, Jan 15, 2024 09:00	16,465	31.14%
Feb-24	10,457,215	51,091	Fri, Feb 16, 2024 08:00	15,025	29.41%	10,457,215	51,091	Fri, Feb 16, 2024 08:00	14,766	29.41%
Mar-24	9,652,990	57,833	Thu, Mar 07, 2024 08:00	12,992	22.46%	9,652,990	57,833	Thu, Mar 07, 2024 08:00	11,582	22.46%
Apr-24	6,196,744	44,060	Mon, Apr 01, 2024 08:00	8,607	19.53%	6,196,744	44,060	Mon, Apr 01, 2024 08:00	9,591	19.53%
May-24	4,478,953	36,028	Wed, May 01, 2024 08:00	6,020	16.71%	4,478,953	36,028	Wed, May 01, 2024 08:00	6,097	16.71%
Jun-24	2,750,111	19,483	Mon, Jun 17, 2024 08:00	3,820	19.61%	2,750,111	19,483	Mon, Jun 17, 2024 08:00	4,033	19.61%
Jul-24	1,723,173	5,998	Fri, Jul 26, 2024 17:00	2,316	38.61%	1,723,173	5,998	Fri, Jul 26, 2024 17:00	2,987	38.61%
Aug-24	1,819,686	10,428	Wed, Aug 28, 2024 08:00	2,446	23.46%	1,819,686	10,428	Wed, Aug 28, 2024 08:00	3,050	23.46%
Sep-24	2,485,291	23,497	Mon, Sep 30, 2024 08:00	3,452	14.69%	2,485,291	23,497	Mon, Sep 30, 2024 08:00	4,494	14.69%
Oct-24	5,096,690	30,585	Thu, Oct 24, 2024 08:00	6,850	22.40%	5,096,690	30,585	Thu, Oct 24, 2024 08:00	8,136	22.40%
Nov-24	9,994,264	47,709	Thu, Nov 28, 2024 08:00	13,881	29.10%	9,994,264	47,709	Thu, Nov 28, 2024 08:00	12,738	29.10%
Dec-24	12,839,212	55,932	Tue, Dec 10, 2024 08:00	17,257	30.85%	12,839,212	55,932	Tue, Dec 10, 2024 08:00	17,396	30.85%
Jan-25	15,235,328	60,363	Wed, Jan 29, 2025 08:00	20,478	33.92%	15,235,328	60,363	Wed, Jan 29, 2025 08:00	16,348	33.92%
Feb-25	12,206,830	54,899	Wed, Feb 12, 2025 07:00	18,165	33.09%	12,206,830	54,899	Wed, Feb 12, 2025 07:00	14,804	33.09%
Mar-25	6,920,772	40,340	Mon, Mar 17, 2025 09:00	9,315	23.09%	6,920,772	40,340	Mon, Mar 17, 2025 09:00	11,644	23.09%
Apr-25	4,348,264	29,960	Fri, Apr 04, 2025 08:00	6,039	20.16%	4,348,264	29,960	Fri, Apr 04, 2025 08:00	9,577	20.16%
May-25	2,865,911	18,889	Mon, May 05, 2025 07:00	3,852	20.39%	2,865,911	18,889	Mon, May 05, 2025 07:00	6,092	20.39%
Jun-25	1,790,166	9,886	Mon, Jun 02, 2025 08:00	2,486	25.15%	1,790,166	9,886	Mon, Jun 02, 2025 08:00	4,051	25.15%



**Table J-5. Office + Retail ERH totals**

Month	ERH Total (Office + Retail)									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	1,536,462	4,461	Fri, Jul 28, 2023 13:00	2,065	46.29%	3,256,347	12,090	Fri, Jul 14, 2023 13:00	4,377	36.20%
Aug-23	1,264,084	4,997	Tue, Aug 08, 2023 13:00	1,699	34.00%	3,415,878	13,948	Thu, Aug 31, 2023 16:00	4,591	32.92%
Sep-23	3,375,267	43,738	Fri, Sep 29, 2023 17:00	4,688	10.72%	5,792,889	23,509	Mon, Sep 11, 2023 05:00	8,046	34.22%
Oct-23	13,534,943	109,834	Fri, Oct 27, 2023 03:00	18,192	16.56%	12,220,335	39,818	Fri, Oct 27, 2023 05:00	16,425	41.25%
Nov-23	15,970,949	76,296	Fri, Nov 24, 2023 04:00	22,182	29.07%	21,350,685	63,963	Tue, Nov 21, 2023 04:00	29,654	46.36%
Dec-23	20,681,186	78,179	Mon, Dec 25, 2023 03:00	27,797	35.56%	30,154,343	65,994	Fri, Dec 08, 2023 04:00	40,530	61.41%
Jan-24	38,960,357	153,834	Fri, Jan 12, 2024 19:00	52,366	34.04%	27,969,130	60,392	Wed, Jan 03, 2024 09:00	37,593	62.25%
Feb-24	22,532,937	73,522	Fri, Feb 16, 2024 08:00	32,375	44.03%	24,498,667	57,216	Tue, Feb 27, 2024 04:00	35,199	61.52%
Mar-24	17,273,025	64,557	Thu, Mar 07, 2024 04:00	23,248	36.01%	20,706,220	57,365	Mon, Mar 11, 2024 03:00	27,868	48.58%
Apr-24	8,313,821	35,228	Thu, Apr 18, 2024 08:00	11,547	32.78%	14,396,500	41,037	Mon, Apr 01, 2024 05:00	19,995	48.72%
May-24	5,092,931	26,122	Wed, May 01, 2024 08:00	6,845	26.21%	9,021,268	25,628	Wed, May 01, 2024 04:00	12,125	47.31%
Jun-24	1,878,520	17,808	Mon, Jun 17, 2024 10:00	2,609	14.65%	5,200,059	19,033	Thu, Jun 13, 2024 16:00	7,222	37.95%
Jul-24	1,454,202	6,938	Wed, Jul 03, 2024 10:00	1,955	28.17%	3,500,402	12,722	Mon, Jul 08, 2024 15:00	4,705	36.98%
Aug-24	1,672,486	9,851	Fri, Aug 23, 2024 12:00	2,248	22.82%	3,363,505	11,205	Wed, Aug 21, 2024 11:00	4,521	40.35%
Sep-24	1,979,988	11,351	Thu, Sep 26, 2024 09:00	2,750	24.23%	5,838,876	26,230	Mon, Sep 30, 2024 05:00	8,110	30.92%
Oct-24	4,362,397	46,186	Thu, Oct 31, 2024 04:00	5,863	12.70%	12,035,568	32,249	Thu, Oct 31, 2024 05:00	16,177	50.16%
Nov-24	25,043,240	113,077	Mon, Nov 25, 2024 04:00	34,782	30.76%	21,002,893	66,330	Thu, Nov 21, 2024 04:00	29,171	43.98%
Dec-24	30,330,002	89,908	Mon, Dec 02, 2024 04:00	40,766	45.34%	29,694,074	65,069	Fri, Dec 27, 2024 04:00	39,911	61.34%
Jan-25	34,101,952	86,696	Mon, Jan 20, 2025 18:00	45,836	52.87%	28,087,671	64,029	Fri, Jan 17, 2025 04:00	37,752	58.96%
Feb-25	52,975,764	184,471	Thu, Feb 13, 2025 04:00	78,833	42.73%	23,499,186	60,586	Thu, Feb 27, 2025 04:00	34,969	57.72%
Mar-25	33,601,403	105,954	Wed, Mar 05, 2025 00:00	45,224	42.68%	20,874,344	56,608	Tue, Mar 11, 2025 05:00	28,095	49.63%
Apr-25	14,488,773	76,974	Fri, Apr 04, 2025 08:00	20,123	26.14%	14,486,613	41,918	Tue, Apr 01, 2025 05:00	20,120	48.00%
May-25	3,792,269	43,071	Wed, May 14, 2025 07:00	5,097	11.83%	9,019,770	26,158	Mon, May 05, 2025 05:00	12,123	46.35%
Jun-25	483,190	10,970	Mon, Jun 23, 2025 05:00	671	6.12%	5,290,979	20,429	Mon, Jun 09, 2025 05:00	7,349	35.97%



**Table J-6. Office + Retail Other totals**

Month	Other Total (Office + Retail)									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	7,344,454	20,089	Wed, Jul 05, 2023 17:00	9,872	49.14%	9,438,762	31,800	Mon, Jul 24, 2023 13:00	12,687	39.89%
Aug-23	8,467,715	29,634	Mon, Aug 14, 2023 17:00	11,381	38.41%	9,742,350	30,739	Wed, Aug 16, 2023 17:00	13,095	42.60%
Sep-23	6,511,529	29,233	Fri, Sep 29, 2023 08:00	9,044	30.94%	8,527,464	28,905	Fri, Sep 22, 2023 15:00	11,844	40.97%
Oct-23	7,493,408	46,656	Mon, Oct 30, 2023 06:00	10,072	21.59%	8,043,100	27,407	Tue, Oct 24, 2023 08:00	10,811	39.45%
Nov-23	8,738,398	48,467	Fri, Nov 24, 2023 07:00	12,137	25.04%	7,629,147	30,599	Tue, Nov 14, 2023 08:00	10,596	34.63%
Dec-23	9,330,874	56,803	Tue, Dec 26, 2023 08:00	12,542	22.08%	7,975,627	35,867	Tue, Dec 12, 2023 08:00	10,720	29.89%
Jan-24	12,281,059	47,328	Tue, Jan 02, 2024 07:00	16,507	34.88%	8,155,521	30,490	Tue, Jan 16, 2024 08:00	10,962	35.95%
Feb-24	8,720,246	47,243	Mon, Feb 05, 2024 06:00	12,529	26.52%	7,555,115	32,309	Tue, Feb 27, 2024 08:00	10,855	33.60%
Mar-24	8,665,883	45,519	Mon, Mar 04, 2024 07:00	11,663	25.62%	7,892,283	34,575	Mon, Mar 04, 2024 06:00	10,622	30.72%
Apr-24	7,886,025	46,444	Mon, Apr 08, 2024 06:00	10,953	23.58%	7,965,850	32,471	Mon, Apr 01, 2024 07:00	11,064	34.07%
May-24	7,276,752	41,662	Mon, May 06, 2024 06:00	9,781	23.48%	8,708,473	31,026	Thu, May 16, 2024 08:00	11,705	37.73%
Jun-24	7,153,708	27,439	Mon, Jun 17, 2024 07:00	9,936	36.21%	8,350,863	32,294	Tue, Jun 25, 2024 12:00	11,598	35.92%
Jul-24	8,929,421	21,231	Wed, Jul 10, 2024 18:00	12,002	56.53%	9,693,774	33,266	Wed, Jul 24, 2024 13:00	13,029	39.17%
Aug-24	7,634,253	20,691	Thu, Aug 08, 2024 17:00	10,261	49.59%	9,564,799	29,950	Mon, Aug 05, 2024 16:00	12,856	42.92%
Sep-24	7,335,306	25,696	Mon, Sep 16, 2024 07:00	10,188	39.65%	8,562,385	29,774	Wed, Sep 11, 2024 15:00	11,892	39.94%
Oct-24	7,832,492	37,110	Thu, Oct 31, 2024 08:00	10,528	28.37%	8,087,921	26,551	Tue, Oct 22, 2024 09:00	10,871	40.94%
Nov-24	8,789,271	48,244	Mon, Nov 18, 2024 06:00	12,207	25.30%	7,480,029	28,611	Mon, Nov 18, 2024 06:00	10,389	36.31%
Dec-24	9,971,190	44,388	Mon, Dec 30, 2024 05:00	13,402	30.19%	8,239,507	36,904	Mon, Dec 09, 2024 06:00	11,075	30.01%
Jan-25	10,664,862	47,521	Thu, Jan 02, 2025 07:00	14,334	30.16%	8,183,007	31,209	Mon, Jan 06, 2025 06:00	10,999	35.24%
Feb-25	10,673,726	48,251	Wed, Feb 05, 2025 07:00	15,884	32.92%	7,251,524	31,906	Mon, Feb 24, 2025 06:00	10,791	33.82%
Mar-25	8,309,002	45,814	Mon, Mar 17, 2025 06:00	11,183	24.41%	8,105,131	32,570	Tue, Mar 04, 2025 08:00	10,909	33.49%
Apr-25	6,368,509	39,160	Mon, Apr 14, 2025 07:00	8,845	22.59%	7,926,971	31,865	Tue, Apr 01, 2025 09:00	11,010	34.55%
May-25	5,094,856	33,097	Mon, May 05, 2025 07:00	6,848	20.69%	8,576,705	30,426	Thu, May 15, 2025 12:00	11,528	37.89%
Jun-25	6,413,344	27,395	Mon, Jun 23, 2025 07:00	8,907	32.51%	6,228,661	25,922	Fri, Jun 06, 2025 15:00	8,651	33.37%



**Table J-7. Office RTU totals**

Month	Office RTU Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	32,853,624	109,810	Wed, Jul 05, 2023 17:00	44,158	40.21%	27,685,391	86,684	Thu, Jul 27, 2023 17:00	37,212	42.93%
Aug-23	34,992,189	140,556	Mon, Aug 14, 2023 17:00	47,033	33.46%	27,226,974	88,663	Wed, Aug 16, 2023 16:00	36,595	41.27%
Sep-23	20,529,905	79,821	Fri, Sep 15, 2023 16:00	28,514	35.72%	21,840,528	75,744	Mon, Sep 11, 2023 16:00	30,334	40.05%
Oct-23	17,168,181	67,201	Fri, Oct 06, 2023 16:00	23,076	34.34%	18,407,712	45,527	Mon, Oct 02, 2023 16:00	24,742	54.34%
Nov-23	13,560,123	28,704	Thu, Nov 02, 2023 15:00	18,834	65.61%	15,911,706	35,985	Wed, Nov 01, 2023 16:00	22,100	61.41%
Dec-23	14,361,804	27,598	Fri, Dec 29, 2023 15:00	19,304	69.95%	14,990,826	29,217	Thu, Dec 28, 2023 09:00	20,149	68.96%
Jan-24	15,347,967	30,107	Mon, Jan 15, 2024 10:00	20,629	68.52%	15,381,306	29,634	Thu, Jan 18, 2024 16:00	20,674	69.76%
Feb-24	13,391,988	32,949	Fri, Feb 23, 2024 16:00	19,241	58.40%	14,843,484	32,429	Thu, Feb 22, 2024 15:00	21,327	65.77%
Mar-24	14,648,882	43,925	Mon, Mar 18, 2024 17:00	19,716	44.89%	16,625,759	36,832	Fri, Mar 15, 2024 17:00	22,377	60.75%
Apr-24	13,984,155	45,554	Tue, Apr 23, 2024 17:00	19,422	42.64%	17,264,540	45,838	Fri, Apr 19, 2024 15:00	23,979	52.31%
May-24	16,971,678	68,993	Wed, May 15, 2024 17:00	22,811	33.06%	20,448,936	59,102	Wed, May 15, 2024 16:00	27,485	46.50%
Jun-24	21,256,544	100,568	Fri, Jun 21, 2024 17:00	29,523	29.36%	21,341,127	64,129	Wed, Jun 19, 2024 16:00	29,640	46.22%
Jul-24	36,223,289	141,981	Tue, Jul 09, 2024 16:00	48,687	34.29%	28,344,036	90,696	Wed, Jul 03, 2024 17:00	38,097	42.00%
Aug-24	30,152,114	132,942	Thu, Aug 01, 2024 16:00	40,527	30.48%	26,908,631	83,662	Mon, Aug 05, 2024 16:00	36,168	43.23%
Sep-24	22,857,114	112,329	Thu, Sep 05, 2024 16:00	31,746	28.26%	21,994,308	83,970	Wed, Sep 11, 2024 16:00	30,548	36.38%
Oct-24	17,087,409	54,432	Mon, Oct 07, 2024 16:00	22,967	42.19%	18,520,952	46,671	Tue, Oct 01, 2024 16:00	24,894	53.34%
Nov-24	14,018,166	29,343	Fri, Nov 08, 2024 15:00	19,470	66.35%	15,816,705	35,073	Fri, Nov 01, 2024 16:00	21,968	62.63%
Dec-24	13,876,548	25,770	Wed, Dec 11, 2024 07:00	18,651	72.38%	15,037,105	27,887	Wed, Dec 25, 2024 09:00	20,211	72.47%
Jan-25	15,216,484	30,140	Mon, Jan 20, 2025 10:00	20,452	67.86%	15,378,900	29,493	Wed, Jan 29, 2025 16:00	20,671	70.09%
Feb-25	14,418,596	36,438	Thu, Feb 27, 2025 16:00	21,456	58.88%	14,273,484	31,307	Wed, Feb 26, 2025 15:00	21,240	67.85%
Mar-25	15,318,759	50,357	Tue, Mar 25, 2025 16:00	20,617	40.94%	16,657,740	36,797	Wed, Mar 12, 2025 16:00	22,420	60.93%
Apr-25	15,191,082	46,752	Thu, Apr 24, 2025 16:00	21,099	45.13%	17,272,999	41,445	Thu, Apr 24, 2025 17:00	23,990	57.88%
May-25	18,056,173	76,050	Wed, May 28, 2025 16:00	24,269	31.91%	20,220,827	57,824	Thu, May 15, 2025 16:00	27,179	47.00%
Jun-25	22,275,113	109,750	Mon, Jun 30, 2025 17:00	30,938	28.19%	21,360,849	63,812	Tue, Jun 24, 2025 17:00	29,668	46.49%



**Table J-8. Retail RTU totals**

Month	Retail RTU Total									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	96,343,243	284,506	Sat, Jul 22, 2023 17:00	129,494	45.52%	72,497,045	219,579	Sat, Jul 22, 2023 17:00	97,442	44.38%
Aug-23	93,535,461	329,695	Tue, Aug 15, 2023 16:00	125,720	38.13%	70,535,082	231,641	Fri, Aug 18, 2023 16:00	94,805	40.93%
Sep-23	61,026,021	244,908	Sat, Sep 02, 2023 16:00	84,758	34.61%	55,422,147	187,483	Fri, Sep 22, 2023 16:00	76,975	41.06%
Oct-23	41,086,333	152,116	Sat, Oct 07, 2023 16:00	55,224	36.30%	45,211,900	102,777	Thu, Oct 19, 2023 15:00	60,769	59.13%
Nov-23	36,355,200	90,825	Sat, Nov 04, 2023 17:00	50,493	55.59%	39,807,772	84,110	Wed, Nov 01, 2023 16:00	55,289	65.73%
Dec-23	35,975,868	76,579	Thu, Dec 07, 2023 11:00	48,355	63.14%	38,922,550	75,077	Sat, Dec 09, 2023 09:00	52,315	69.68%
Jan-24	43,631,353	85,823	Mon, Jan 22, 2024 09:00	58,644	68.33%	39,054,552	75,135	Fri, Jan 19, 2024 14:00	52,493	69.86%
Feb-24	40,475,647	80,334	Fri, Feb 02, 2024 14:00	58,155	72.39%	37,568,423	77,835	Wed, Feb 28, 2024 15:00	53,978	69.35%
Mar-24	39,972,538	89,880	Sat, Mar 16, 2024 16:00	53,799	59.86%	41,983,456	89,316	Sun, Mar 24, 2024 16:00	56,505	63.26%
Apr-24	34,146,749	99,552	Fri, Apr 12, 2024 17:00	47,426	47.64%	42,491,546	102,445	Fri, Apr 19, 2024 17:00	59,016	57.61%
May-24	40,413,015	181,815	Sat, May 11, 2024 16:00	54,319	29.88%	50,929,186	145,386	Wed, May 08, 2024 16:00	68,453	47.08%
Jun-24	52,734,766	233,690	Tue, Jun 25, 2024 17:00	73,243	31.34%	56,170,111	185,502	Sun, Jun 30, 2024 16:00	78,014	42.06%
Jul-24	103,388,324	311,975	Tue, Jul 09, 2024 17:00	138,963	44.54%	73,454,161	216,347	Wed, Jul 24, 2024 17:00	98,729	45.63%
Aug-24	92,294,651	337,079	Fri, Aug 02, 2024 17:00	124,052	36.80%	70,497,408	229,381	Sat, Aug 17, 2024 16:00	94,755	41.31%
Sep-24	72,826,053	276,149	Thu, Sep 05, 2024 17:00	101,147	36.63%	55,469,019	193,266	Wed, Sep 11, 2024 16:00	77,040	39.86%
Oct-24	45,059,840	141,172	Wed, Oct 09, 2024 16:00	60,564	42.90%	45,369,369	108,002	Wed, Oct 02, 2024 16:00	60,980	56.46%
Nov-24	29,661,121	80,536	Fri, Nov 22, 2024 11:00	41,196	51.15%	39,864,634	84,628	Fri, Nov 01, 2024 16:00	55,368	65.42%
Dec-24	30,866,301	76,177	Tue, Dec 03, 2024 09:00	41,487	54.46%	39,003,128	75,905	Sat, Dec 07, 2024 13:00	52,424	69.06%
Jan-25	31,865,984	80,538	Tue, Jan 14, 2025 09:00	42,831	53.18%	39,149,811	77,207	Wed, Jan 29, 2025 16:00	52,621	68.16%
Feb-25	29,317,015	78,689	Tue, Feb 11, 2025 09:00	43,627	55.44%	36,271,768	78,315	Fri, Feb 28, 2025 16:00	53,976	68.92%
Mar-25	27,007,550	85,037	Wed, Mar 26, 2025 16:00	36,349	42.75%	41,977,709	87,973	Mon, Mar 24, 2025 16:00	56,498	64.22%
Apr-25	25,339,927	91,917	Tue, Apr 15, 2025 17:00	35,194	38.29%	42,519,439	102,482	Fri, Apr 18, 2025 17:00	59,055	57.62%
May-25	33,111,201	166,306	Fri, May 30, 2025 16:00	44,504	26.76%	50,921,514	138,870	Sat, May 17, 2025 17:00	68,443	49.29%
Jun-25	49,249,227	285,309	Mon, Jun 09, 2025 17:00	68,402	23.97%	60,555,721	199,341	Mon, Jun 30, 2025 17:00	84,105	42.19%



**Table J-9. Office HP Overall totals**

Month	Office HP Total									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	7,194,059	24,843	Wed, Jul 05, 2023 16:00	9,669	38.92%	6,312,014	16,743	Fri, Jul 21, 2023 16:00	8,484	50.67%
Aug-23	7,090,649	29,941	Tue, Aug 15, 2023 16:00	9,530	31.83%	6,235,337	18,153	Tue, Aug 01, 2023 16:00	8,381	46.17%
Sep-23	5,011,318	17,030	Fri, Sep 15, 2023 15:00	6,960	40.87%	5,719,334	17,595	Mon, Sep 18, 2023 07:00	7,944	45.15%
Oct-23	6,524,840	37,024	Mon, Oct 30, 2023 08:00	8,770	23.69%	6,830,602	24,175	Wed, Oct 18, 2023 08:00	9,181	37.98%
Nov-23	9,703,835	43,878	Wed, Nov 29, 2023 07:00	13,478	30.72%	8,771,945	30,760	Tue, Nov 21, 2023 07:00	12,183	39.61%
Dec-23	9,886,984	38,125	Mon, Dec 25, 2023 07:00	13,289	34.86%	11,130,228	35,778	Mon, Dec 18, 2023 07:00	14,960	41.81%
Jan-24	12,179,803	49,074	Mon, Jan 15, 2024 08:00	16,371	33.36%	10,906,116	39,391	Thu, Jan 04, 2024 07:00	14,659	37.21%
Feb-24	8,439,839	37,399	Fri, Feb 16, 2024 08:00	12,126	32.42%	9,115,259	32,303	Tue, Feb 20, 2024 07:00	13,097	40.54%
Mar-24	8,401,154	38,122	Fri, Mar 08, 2024 08:00	11,307	29.66%	8,257,579	33,031	Mon, Mar 04, 2024 07:00	11,114	33.65%
Apr-24	6,284,651	29,070	Fri, Apr 05, 2024 07:00	8,729	30.03%	7,277,154	28,332	Mon, Apr 01, 2024 08:00	10,107	35.67%
May-24	5,660,221	26,685	Mon, May 06, 2024 08:00	7,608	28.51%	6,364,652	18,302	Thu, May 02, 2024 08:00	8,555	46.74%
Jun-24	5,706,864	18,471	Thu, Jun 20, 2024 16:00	7,926	42.91%	5,638,177	15,234	Mon, Jun 10, 2024 08:00	7,831	51.40%
Jul-24	7,977,929	29,244	Tue, Jul 09, 2024 16:00	10,723	36.67%	6,484,531	17,463	Wed, Jul 03, 2024 16:00	8,716	49.91%
Aug-24	6,528,318	23,508	Thu, Aug 01, 2024 16:00	8,775	37.33%	6,160,330	17,115	Tue, Aug 27, 2024 16:00	8,280	48.38%
Sep-24	5,472,780	22,476	Thu, Sep 05, 2024 16:00	7,601	33.82%	5,739,279	20,870	Mon, Sep 30, 2024 08:00	7,971	38.20%
Oct-24	5,610,795	22,402	Thu, Oct 24, 2024 08:00	7,541	33.66%	6,827,001	24,181	Mon, Oct 21, 2024 08:00	9,176	37.95%
Nov-24	8,416,526	34,444	Thu, Nov 28, 2024 07:00	11,690	33.94%	8,696,779	34,828	Mon, Nov 25, 2024 07:00	12,079	34.68%
Dec-24	10,798,496	40,523	Wed, Dec 04, 2024 07:00	14,514	35.82%	11,309,830	41,239	Tue, Dec 17, 2024 07:00	15,201	36.86%
Jan-25	12,862,546	46,346	Mon, Jan 20, 2025 07:00	17,288	37.30%	10,842,628	37,854	Mon, Jan 06, 2025 07:00	14,573	38.50%
Feb-25	10,995,640	44,485	Wed, Feb 12, 2025 06:00	16,363	36.78%	8,805,937	32,564	Mon, Feb 03, 2025 07:00	13,104	40.24%
Mar-25	7,741,647	33,534	Mon, Mar 31, 2025 08:00	10,419	31.07%	8,334,471	33,296	Mon, Mar 03, 2025 07:00	11,217	33.69%
Apr-25	5,748,608	24,605	Tue, Apr 01, 2025 06:00	7,984	32.45%	7,239,927	26,474	Mon, Apr 14, 2025 08:00	10,055	37.98%
May-25	5,316,160	17,284	Mon, May 05, 2025 06:00	7,145	41.34%	6,322,201	19,269	Mon, May 12, 2025 07:00	8,498	44.10%
Jun-25	5,482,603	23,164	Mon, Jun 30, 2025 16:00	7,615	32.87%	5,710,814	16,193	Mon, Jun 30, 2025 16:00	7,932	48.98%



**Table J-10. Retail HP Overall totals**

Month	Retail HP Total									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	2,959,515	10,412	Thu, Jul 20, 2023 16:00	3,978	38.21%	2,407,515	7,100	Thu, Jul 27, 2023 17:00	3,236	45.58%
Aug-23	3,073,554	14,562	Mon, Aug 14, 2023 16:00	4,131	28.37%	2,342,831	7,520	Thu, Aug 17, 2023 16:00	3,149	41.87%
Sep-23	1,952,589	7,090	Fri, Sep 15, 2023 17:00	2,712	38.25%	2,141,526	6,591	Thu, Sep 28, 2023 08:00	2,974	45.13%
Oct-23	2,503,010	21,212	Thu, Oct 26, 2023 09:00	3,364	15.86%	2,850,135	11,253	Thu, Oct 26, 2023 09:00	3,831	34.04%
Nov-23	3,802,165	23,105	Wed, Nov 29, 2023 08:00	5,281	22.86%	3,840,827	13,876	Mon, Nov 27, 2023 08:00	5,334	38.44%
Dec-23	4,151,156	19,089	Mon, Dec 18, 2023 08:00	5,580	29.23%	5,072,121	18,837	Thu, Dec 07, 2023 08:00	6,817	36.19%
Jan-24	6,133,184	26,086	Mon, Jan 15, 2024 09:00	8,244	31.60%	4,868,339	20,827	Mon, Jan 01, 2024 08:00	6,543	31.42%
Feb-24	4,122,217	19,034	Fri, Feb 16, 2024 09:00	5,923	31.12%	4,281,717	16,108	Thu, Feb 01, 2024 08:00	6,152	38.19%
Mar-24	3,931,917	23,398	Thu, Mar 07, 2024 08:00	5,292	22.62%	3,697,447	15,746	Mon, Mar 04, 2024 08:00	4,976	31.60%
Apr-24	2,654,510	19,820	Mon, Apr 01, 2024 08:00	3,687	18.60%	3,030,038	12,787	Mon, Apr 01, 2024 09:00	4,208	32.91%
May-24	2,172,416	16,257	Wed, May 01, 2024 08:00	2,920	17.96%	2,466,234	9,424	Wed, May 01, 2024 08:00	3,315	35.17%
Jun-24	2,151,222	8,459	Mon, Jun 17, 2024 08:00	2,988	35.32%	2,076,318	6,014	Mon, Jun 17, 2024 08:00	2,884	47.95%
Jul-24	3,321,450	13,543	Tue, Jul 09, 2024 17:00	4,464	32.96%	2,474,800	7,041	Thu, Jul 25, 2024 16:00	3,326	47.24%
Aug-24	2,817,614	12,052	Fri, Aug 02, 2024 16:00	3,787	31.42%	2,327,989	6,476	Fri, Aug 16, 2024 16:00	3,129	48.32%
Sep-24	2,084,990	11,454	Mon, Sep 30, 2024 08:00	2,896	25.28%	2,153,264	7,637	Mon, Sep 30, 2024 08:00	2,991	39.16%
Oct-24	2,326,858	14,541	Tue, Oct 29, 2024 08:00	3,128	21.51%	2,819,196	10,138	Fri, Oct 25, 2024 09:00	3,789	37.38%
Nov-24	4,084,521	21,525	Thu, Nov 28, 2024 08:00	5,673	26.35%	3,759,896	14,972	Mon, Nov 04, 2024 08:00	5,222	34.88%
Dec-24	5,064,157	23,920	Thu, Dec 12, 2024 09:00	6,807	28.46%	5,098,549	18,368	Thu, Dec 05, 2024 08:00	6,853	37.31%
Jan-25	6,112,892	27,448	Wed, Jan 29, 2025 08:00	8,216	29.93%	4,870,253	19,972	Mon, Jan 06, 2025 09:00	6,546	32.78%
Feb-25	4,820,657	24,626	Mon, Feb 03, 2025 09:00	7,174	29.13%	4,140,971	17,009	Mon, Feb 03, 2025 08:00	6,162	36.23%
Mar-25	2,987,718	20,632	Mon, Mar 17, 2025 09:00	4,021	19.49%	3,688,908	14,699	Tue, Mar 04, 2025 08:00	4,965	33.78%
Apr-25	1,743,235	12,453	Fri, Apr 04, 2025 08:00	2,421	19.44%	3,057,394	11,616	Tue, Apr 01, 2025 09:00	4,246	36.56%
May-25	1,324,656	6,850	Wed, May 14, 2025 07:00	1,780	25.99%	2,460,763	9,524	Thu, May 01, 2025 09:00	3,307	34.73%
Jun-25	1,729,896	8,362	Mon, Jun 30, 2025 16:00	2,403	28.73%	2,094,232	6,437	Mon, Jun 16, 2025 08:00	2,909	45.19%



**Table J-11. Office HP Cool totals**

Month	Office HP Cool Total									
	Actuals					Normals				
	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	15,117,638	52,703	Wed, Jul 05, 2023 16:00	20,319	38.55%	13,070,437	41,076	Wed, Jul 26, 2023 15:00	17,568	42.77%
Aug-23	13,807,771	64,283	Tue, Aug 15, 2023 16:00	18,559	28.87%	12,571,599	46,844	Tue, Aug 01, 2023 16:00	16,897	36.07%
Sep-23	7,637,902	33,914	Mon, Sep 11, 2023 16:00	10,608	31.28%	9,108,218	33,479	Tue, Sep 12, 2023 16:00	12,650	37.79%
Oct-23	4,891,329	22,543	Fri, Oct 06, 2023 16:00	6,574	29.16%	6,624,272	20,353	Mon, Oct 02, 2023 15:00	8,904	43.75%
Nov-23	3,425,293	14,448	Mon, Nov 20, 2023 07:00	4,757	32.93%	5,161,844	11,388	Fri, Nov 17, 2023 06:00	7,169	62.95%
Dec-23	4,256,342	12,267	Mon, Dec 18, 2023 06:00	5,721	46.64%	4,834,069	10,872	Tue, Dec 12, 2023 06:00	6,497	59.76%
Jan-24	3,606,808	13,214	Mon, Jan 15, 2024 13:00	4,848	36.69%	4,906,319	12,466	Thu, Jan 18, 2024 06:00	6,595	52.90%
Feb-24	3,652,006	15,397	Fri, Feb 23, 2024 06:00	5,247	34.08%	4,853,416	11,930	Thu, Feb 29, 2024 06:00	6,973	58.45%
Mar-24	4,270,980	17,533	Thu, Mar 14, 2024 06:00	5,748	32.79%	5,763,390	12,509	Fri, Mar 29, 2024 07:00	7,757	62.01%
Apr-24	4,700,852	18,727	Thu, Apr 18, 2024 06:00	6,529	34.86%	6,085,989	18,229	Fri, Apr 19, 2024 15:00	8,453	46.37%
May-24	5,904,066	26,534	Thu, May 16, 2024 16:00	7,936	29.91%	8,181,286	30,405	Wed, May 15, 2024 16:00	10,996	36.17%
Jun-24	10,287,984	45,170	Thu, Jun 20, 2024 16:00	14,289	31.63%	9,445,939	30,908	Thu, Jun 06, 2024 15:00	13,119	42.45%
Jul-24	18,056,245	73,470	Tue, Jul 09, 2024 16:00	24,269	33.03%	13,498,373	44,123	Tue, Jul 23, 2024 16:00	18,143	41.12%
Aug-24	14,115,177	58,903	Thu, Aug 01, 2024 16:00	18,972	32.21%	12,423,564	42,926	Thu, Aug 01, 2024 16:00	16,698	38.90%
Sep-24	10,084,539	54,609	Thu, Sep 05, 2024 16:00	14,006	25.65%	9,193,566	36,083	Wed, Sep 11, 2024 16:00	12,769	35.39%
Oct-24	5,264,381	24,954	Tue, Oct 08, 2024 16:00	7,076	28.36%	6,699,819	21,311	Tue, Oct 01, 2024 15:00	9,005	42.26%
Nov-24	4,063,676	15,768	Wed, Nov 06, 2024 06:00	5,644	35.79%	5,074,321	11,925	Thu, Nov 07, 2024 06:00	7,048	59.10%
Dec-24	5,617,614	17,689	Tue, Dec 03, 2024 07:00	7,551	42.69%	4,858,419	11,382	Fri, Dec 13, 2024 06:00	6,530	57.37%
Jan-25	6,552,896	21,668	Wed, Jan 29, 2025 07:00	8,808	40.65%	4,900,213	11,836	Fri, Jan 17, 2025 06:00	6,586	55.65%
Feb-25	6,870,043	25,719	Wed, Feb 12, 2025 07:00	10,223	39.75%	4,672,562	11,805	Fri, Feb 28, 2025 06:00	6,953	58.90%
Mar-25	6,424,978	24,403	Tue, Mar 25, 2025 15:00	8,647	35.44%	5,761,013	12,954	Mon, Mar 31, 2025 14:00	7,754	59.85%
Apr-25	5,655,679	21,395	Tue, Apr 15, 2025 16:00	7,855	36.71%	6,104,627	16,891	Mon, Apr 21, 2025 15:00	8,479	50.20%
May-25	6,949,249	37,038	Wed, May 28, 2025 15:00	9,340	25.22%	8,043,482	29,081	Thu, May 15, 2025 16:00	10,811	37.18%
Jun-25	10,275,857	49,860	Mon, Jun 30, 2025 17:00	14,272	28.62%	9,647,834	39,168	Mon, Jun 30, 2025 16:00	13,400	34.21%



**Table J-12. Office HP Heat totals**

Month	Office HP Heat Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	1,291,039	4,537	Tue, Jul 04, 2023 16:00	1,735	38.25%	1,490,883	4,322	Mon, Jul 31, 2023 07:00	2,004	46.37%
Aug-23	1,568,759	6,095	Mon, Aug 14, 2023 16:00	2,109	34.60%	1,518,026	4,250	Mon, Aug 28, 2023 07:00	2,040	48.01%
Sep-23	1,806,997	11,763	Thu, Sep 28, 2023 08:00	2,510	21.34%	2,027,302	10,500	Mon, Sep 25, 2023 07:00	2,816	26.81%
Oct-23	3,823,697	29,020	Mon, Oct 30, 2023 08:00	5,139	17.71%	3,520,721	17,464	Wed, Oct 18, 2023 08:00	4,732	27.10%
Nov-23	6,743,923	34,104	Wed, Nov 29, 2023 07:00	9,367	27.46%	5,378,112	22,300	Thu, Nov 23, 2023 07:00	7,470	33.50%
Dec-23	6,718,082	27,813	Mon, Dec 25, 2023 07:00	9,030	32.47%	7,208,957	27,859	Mon, Dec 18, 2023 07:00	9,689	34.78%
Jan-24	8,636,739	38,827	Mon, Jan 15, 2024 08:00	11,609	29.90%	7,051,681	30,487	Wed, Jan 03, 2024 07:00	9,478	31.09%
Feb-24	5,675,077	30,059	Fri, Feb 16, 2024 08:00	8,154	27.13%	5,673,436	24,351	Mon, Feb 12, 2024 07:00	8,151	33.47%
Mar-24	5,500,770	30,365	Wed, Mar 06, 2024 08:00	7,403	24.38%	4,841,148	25,370	Mon, Mar 04, 2024 07:00	6,516	25.68%
Apr-24	3,550,111	22,252	Fri, Apr 05, 2024 08:00	4,931	22.16%	4,070,854	20,794	Mon, Apr 01, 2024 08:00	5,654	27.19%
May-24	2,779,038	20,977	Mon, May 06, 2024 08:00	3,735	17.81%	2,768,742	12,261	Thu, May 02, 2024 08:00	3,721	30.35%
Jun-24	1,557,605	9,184	Mon, Jun 17, 2024 08:00	2,163	23.55%	1,879,222	7,829	Mon, Jun 10, 2024 08:00	2,610	33.34%
Jul-24	991,975	3,207	Thu, Jul 04, 2024 21:00	1,333	41.58%	1,500,170	3,557	Mon, Jul 15, 2024 06:00	2,016	56.68%
Aug-24	1,017,212	3,480	Wed, Aug 28, 2024 07:00	1,367	39.29%	1,504,790	5,242	Mon, Aug 26, 2024 06:00	2,023	38.59%
Sep-24	1,392,789	10,181	Mon, Sep 30, 2024 07:00	1,934	19.00%	2,026,853	14,097	Mon, Sep 30, 2024 08:00	2,815	19.97%
Oct-24	2,951,724	16,828	Thu, Oct 24, 2024 07:00	3,967	23.58%	3,501,886	18,361	Mon, Oct 21, 2024 08:00	4,707	25.63%
Nov-24	5,621,741	26,941	Thu, Nov 28, 2024 07:00	7,808	28.98%	5,338,591	26,413	Mon, Nov 25, 2024 07:00	7,415	28.07%
Dec-24	7,034,233	31,796	Wed, Dec 04, 2024 07:00	9,455	29.74%	7,350,364	30,988	Tue, Dec 17, 2024 07:00	9,880	31.88%
Jan-25	8,397,061	31,496	Mon, Jan 20, 2025 07:00	11,286	35.83%	6,972,884	30,029	Fri, Jan 03, 2025 08:00	9,372	31.21%
Feb-25	6,776,629	31,052	Wed, Feb 12, 2025 06:00	10,084	32.48%	5,470,696	25,300	Mon, Feb 10, 2025 07:00	8,141	32.18%
Mar-25	4,272,969	21,066	Mon, Mar 31, 2025 08:00	5,751	27.30%	4,902,187	25,102	Mon, Mar 03, 2025 07:00	6,598	26.28%
Apr-25	2,961,437	18,797	Tue, Apr 01, 2025 06:00	4,113	21.88%	4,033,065	20,217	Mon, Apr 14, 2025 08:00	5,601	27.71%
May-25	2,259,610	10,655	Mon, May 05, 2025 07:00	3,037	28.50%	2,782,342	12,157	Mon, May 12, 2025 07:00	3,740	30.76%
Jun-25	1,368,273	5,417	Mon, Jun 02, 2025 07:00	1,900	35.08%	1,883,194	6,440	Tue, Jun 10, 2025 08:00	2,616	40.61%



**Table J-13. Retail HP Cool totals**

Retail HP Cool Total										
Actuals						Normals				
Month	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)	Total Use (kWh)	Peak Demand (kW)	Occurrence Date and Time	Average Demand (kW)	Load Factor (%)
Jul-23	3,171,160	14,021	Thu, Jul 20, 2023 16:00	4,262	30.40%	2,369,843	7,931	Fri, Jul 21, 2023 17:00	3,185	40.16%
Aug-23	3,365,315	22,255	Mon, Aug 14, 2023 16:00	4,523	20.32%	2,224,928	8,203	Thu, Aug 17, 2023 16:00	2,991	36.46%
Sep-23	1,551,062	7,306	Fri, Sep 15, 2023 17:00	2,154	29.48%	1,502,451	5,745	Mon, Sep 11, 2023 16:00	2,087	36.32%
Oct-23	697,655	4,758	Sat, Oct 07, 2023 17:00	938	19.71%	1,048,836	2,849	Mon, Oct 09, 2023 16:00	1,410	49.48%
Nov-23	332,705	3,955	Fri, Nov 10, 2023 01:00	462	11.68%	741,364	1,937	Thu, Nov 23, 2023 03:00	1,030	53.17%
Dec-23	240,719	4,378	Thu, Dec 14, 2023 02:00	324	7.39%	573,819	1,589	Thu, Dec 14, 2023 03:00	771	48.55%
Jan-24	309,946	2,290	Wed, Jan 31, 2024 15:00	417	18.19%	610,959	1,616	Thu, Jan 11, 2024 03:00	821	50.81%
Feb-24	419,374	4,519	Wed, Feb 07, 2024 05:00	603	13.33%	633,328	1,700	Wed, Feb 07, 2024 14:00	910	53.54%
Mar-24	761,816	3,760	Mon, Mar 18, 2024 05:00	1,025	27.27%	854,628	2,215	Tue, Mar 12, 2024 16:00	1,150	51.93%
Apr-24	681,771	3,470	Sat, Apr 20, 2024 05:00	947	27.29%	954,226	2,876	Fri, Apr 19, 2024 16:00	1,325	46.08%
May-24	989,953	4,543	Fri, May 10, 2024 17:00	1,331	29.29%	1,357,413	4,592	Thu, May 30, 2024 18:00	1,824	39.73%
Jun-24	1,418,074	6,789	Fri, Jun 21, 2024 17:00	1,970	29.01%	1,605,925	5,896	Fri, Jun 28, 2024 17:00	2,230	37.83%
Jul-24	3,267,739	16,248	Tue, Jul 09, 2024 17:00	4,392	27.03%	2,483,001	12,366	Sun, Jul 21, 2024 23:00	3,337	26.99%
Aug-24	2,711,712	14,662	Fri, Aug 02, 2024 16:00	3,645	24.86%	2,208,337	7,375	Tue, Aug 13, 2024 17:00	2,968	40.25%
Sep-24	1,436,273	9,579	Thu, Sep 05, 2024 17:00	1,995	20.83%	1,507,590	6,470	Wed, Sep 11, 2024 16:00	2,094	32.36%
Oct-24	730,678	4,190	Wed, Oct 23, 2024 06:00	982	23.44%	1,042,683	2,920	Tue, Oct 08, 2024 17:00	1,401	48.00%
Nov-24	700,476	3,653	Fri, Nov 29, 2024 07:00	973	26.63%	737,484	1,776	Fri, Nov 01, 2024 04:00	1,024	57.67%
Dec-24	530,449	6,060	Tue, Dec 24, 2024 04:00	713	11.76%	584,734	1,642	Thu, Dec 26, 2024 03:00	786	47.85%
Jan-25	799,934	5,711	Sun, Jan 26, 2025 09:00	1,075	18.83%	626,251	1,884	Tue, Jan 07, 2025 15:00	842	44.68%
Feb-25	604,727	5,763	Tue, Feb 04, 2025 12:00	900	15.61%	609,789	1,580	Tue, Feb 18, 2025 14:00	907	57.43%
Mar-25	1,048,264	5,338	Mon, Mar 10, 2025 06:00	1,411	26.43%	856,323	2,177	Wed, Mar 12, 2025 16:00	1,153	52.95%
Apr-25	732,251	5,325	Thu, Apr 10, 2025 05:00	1,017	19.10%	953,682	2,720	Mon, Apr 21, 2025 16:00	1,325	48.70%
May-25	974,000	6,537	Wed, May 28, 2025 17:00	1,309	20.03%	1,360,313	4,426	Thu, May 08, 2025 16:00	1,828	41.31%
Jun-25	1,582,642	7,861	Mon, Jun 09, 2025 16:00	2,198	27.96%	1,611,941	6,999	Mon, Jun 30, 2025 17:00	2,239	31.99%



**Table J-14. Retail HP Heat totals**

Month	Retail HP Heat Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	357,031	3,734	Mon, Jul 10, 2023 19:00	480	12.85%	709,580	3,299	Mon, Jul 24, 2023 08:00	954	28.91%
Aug-23	389,187	3,773	Thu, Aug 31, 2023 10:00	523	13.86%	775,174	4,951	Wed, Aug 23, 2023 07:00	1,042	21.04%
Sep-23	805,012	6,649	Fri, Sep 29, 2023 08:00	1,118	16.81%	1,203,346	6,326	Thu, Sep 28, 2023 08:00	1,671	26.42%
Oct-23	2,420,306	26,585	Thu, Oct 26, 2023 09:00	3,253	12.24%	2,571,810	12,581	Fri, Oct 27, 2023 07:00	3,457	27.48%
Nov-23	4,459,341	28,906	Wed, Nov 29, 2023 08:00	6,194	21.43%	3,930,140	15,373	Mon, Nov 27, 2023 08:00	5,459	35.51%
Dec-23	5,014,891	23,885	Mon, Dec 18, 2023 08:00	6,740	28.22%	5,532,847	20,820	Tue, Dec 05, 2023 08:00	7,437	35.72%
Jan-24	7,460,545	32,006	Mon, Jan 15, 2024 09:00	10,028	31.33%	5,198,631	22,383	Mon, Jan 01, 2024 08:00	6,987	31.22%
Feb-24	4,782,138	23,701	Fri, Feb 16, 2024 09:00	6,871	28.99%	4,603,662	17,348	Thu, Feb 01, 2024 08:00	6,614	38.13%
Mar-24	4,152,221	29,285	Thu, Mar 07, 2024 08:00	5,588	19.08%	3,764,547	17,244	Mon, Mar 04, 2024 08:00	5,067	29.38%
Apr-24	2,646,633	24,800	Mon, Apr 01, 2024 08:00	3,676	14.82%	2,834,623	13,690	Mon, Apr 01, 2024 09:00	3,937	28.76%
May-24	1,699,914	20,322	Wed, May 01, 2024 08:00	2,285	11.24%	1,767,409	10,242	Wed, May 01, 2024 08:00	2,376	23.19%
Jun-24	1,192,507	10,298	Mon, Jun 17, 2024 08:00	1,656	16.08%	1,024,268	4,861	Thu, Jun 13, 2024 08:00	1,423	29.27%
Jul-24	731,197	3,842	Fri, Jul 26, 2024 18:00	983	25.58%	722,388	3,406	Tue, Jul 30, 2024 05:00	971	28.50%
Aug-24	802,474	7,116	Wed, Aug 28, 2024 08:00	1,079	15.16%	764,225	4,711	Fri, Aug 23, 2024 06:00	1,027	21.81%
Sep-24	1,092,502	14,011	Mon, Sep 30, 2024 08:00	1,517	10.83%	1,209,169	7,595	Mon, Sep 30, 2024 08:00	1,679	22.11%
Oct-24	2,144,966	18,270	Tue, Oct 29, 2024 08:00	2,883	15.78%	2,551,198	10,969	Fri, Oct 25, 2024 09:00	3,429	31.26%
Nov-24	4,372,523	24,756	Thu, Nov 28, 2024 08:00	6,073	24.53%	3,833,025	16,557	Mon, Nov 04, 2024 08:00	5,324	32.15%
Dec-24	5,804,979	30,072	Thu, Dec 12, 2024 09:00	7,802	25.95%	5,591,960	20,079	Thu, Dec 05, 2024 08:00	7,516	37.43%
Jan-25	6,838,266	34,516	Wed, Jan 29, 2025 08:00	9,191	26.63%	5,189,816	22,122	Wed, Jan 01, 2025 08:00	6,976	31.53%
Feb-25	5,430,201	30,962	Mon, Feb 03, 2025 09:00	8,081	26.10%	4,477,887	18,773	Mon, Feb 03, 2025 08:00	6,664	35.49%
Mar-25	2,647,802	25,931	Mon, Mar 17, 2025 09:00	3,564	13.74%	3,749,396	16,434	Tue, Mar 04, 2025 08:00	5,046	30.71%
Apr-25	1,386,827	15,639	Fri, Apr 04, 2025 08:00	1,926	12.32%	2,862,695	12,815	Tue, Apr 01, 2025 09:00	3,976	31.03%
May-25	606,301	8,501	Wed, May 21, 2025 07:00	815	9.59%	1,749,899	10,020	Thu, May 01, 2025 09:00	2,352	23.47%
Jun-25	421,893	5,129	Mon, Jun 23, 2025 06:00	586	11.43%	1,033,738	4,708	Mon, Jun 16, 2025 08:00	1,436	30.49%



**Table J-15. Office ERH totals**

Month	Office ERH Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	220,108	567	Fri, Jul 21, 2023 11:00	296	52.17%	529,781	1,960	Mon, Jul 24, 2023 12:00	712	36.33%
Aug-23	205,666	1,576	Thu, Aug 24, 2023 09:00	276	17.54%	528,042	1,829	Mon, Aug 21, 2023 13:00	710	38.81%
Sep-23	292,966	5,938	Mon, Sep 25, 2023 13:00	407	6.85%	712,855	3,125	Fri, Sep 29, 2023 08:00	990	31.68%
Oct-23	550,471	7,383	Mon, Oct 30, 2023 10:00	740	10.02%	1,273,460	5,536	Mon, Oct 23, 2023 09:00	1,712	30.92%
Nov-23	977,836	10,545	Mon, Nov 27, 2023 09:00	1,358	12.88%	1,836,317	7,190	Tue, Nov 14, 2023 08:00	2,550	35.47%
Dec-23	1,138,634	9,935	Mon, Dec 25, 2023 09:00	1,530	15.40%	2,439,118	8,057	Mon, Dec 18, 2023 08:00	3,278	40.69%
Jan-24	2,406,630	11,713	Tue, Jan 16, 2024 11:00	3,235	27.62%	2,376,854	8,735	Mon, Jan 01, 2024 08:00	3,195	36.57%
Feb-24	2,882,344	10,392	Tue, Feb 27, 2024 08:00	4,141	39.85%	2,001,640	7,575	Mon, Feb 05, 2024 08:00	2,876	37.97%
Mar-24	2,516,323	10,532	Wed, Mar 06, 2024 08:00	3,387	32.16%	1,845,312	7,642	Mon, Mar 04, 2024 08:00	2,484	32.50%
Apr-24	1,859,767	10,125	Mon, Apr 08, 2024 08:00	2,583	25.51%	1,532,732	6,787	Mon, Apr 01, 2024 09:00	2,129	31.36%
May-24	978,578	9,716	Mon, May 06, 2024 09:00	1,315	13.54%	1,108,678	4,085	Mon, May 27, 2024 09:00	1,490	36.48%
Jun-24	452,391	6,023	Mon, Jun 17, 2024 08:00	628	10.43%	725,057	2,756	Mon, Jun 10, 2024 09:00	1,007	36.54%
Jul-24	134,718	445	Fri, Jul 26, 2024 08:00	181	40.66%	539,119	2,018	Mon, Jul 15, 2024 11:00	725	35.92%
Aug-24	141,237	679	Wed, Aug 28, 2024 07:00	190	27.96%	525,003	1,782	Mon, Aug 19, 2024 16:00	706	39.60%
Sep-24	337,970	4,254	Mon, Sep 30, 2024 09:00	469	11.04%	728,637	4,541	Mon, Sep 30, 2024 09:00	1,012	22.29%
Oct-24	1,544,011	9,851	Wed, Oct 30, 2024 07:00	2,075	21.07%	1,277,122	5,780	Mon, Oct 21, 2024 09:00	1,717	29.70%
Nov-24	2,855,004	11,032	Fri, Nov 29, 2024 06:00	3,965	35.94%	1,839,370	6,805	Thu, Nov 14, 2024 08:00	2,555	37.54%
Dec-24	3,439,194	11,284	Wed, Dec 04, 2024 06:00	4,623	40.97%	2,470,542	8,626	Tue, Dec 17, 2024 08:00	3,321	38.49%
Jan-25	3,599,169	11,315	Mon, Jan 20, 2025 06:00	4,838	42.75%	2,332,392	8,561	Fri, Jan 03, 2025 08:00	3,135	36.62%
Feb-25	3,031,401	11,130	Tue, Feb 04, 2025 06:00	4,511	40.53%	1,916,741	7,816	Mon, Feb 03, 2025 08:00	2,852	36.49%
Mar-25	2,636,104	9,565	Fri, Mar 14, 2025 05:00	3,548	37.09%	1,853,302	7,363	Mon, Mar 03, 2025 08:00	2,494	33.88%
Apr-25	1,111,175	8,682	Tue, Apr 22, 2025 04:00	1,543	17.78%	1,522,584	6,349	Mon, Apr 14, 2025 09:00	2,115	33.31%
May-25	296,703	4,208	Thu, May 01, 2025 08:00	399	9.48%	1,108,985	3,985	Thu, May 01, 2025 09:00	1,491	37.41%
Jun-25	150,142	721	Mon, Jun 23, 2025 07:00	209	28.94%	732,696	2,633	Mon, Jun 16, 2025 11:00	1,018	38.65%



**Table J-16. Retail ERH totals**

Month	Retail ERH Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	1,316,353	4,116	Fri, Jul 28, 2023 13:00	1,769	42.98%	2,726,566	10,594	Fri, Jul 14, 2023 13:00	3,665	34.59%
Aug-23	1,058,418	4,677	Tue, Aug 08, 2023 13:00	1,423	30.41%	2,887,836	12,693	Mon, Aug 28, 2023 05:00	3,882	30.58%
Sep-23	3,082,302	43,286	Fri, Sep 29, 2023 18:00	4,281	9.89%	5,080,034	22,901	Mon, Sep 11, 2023 05:00	7,056	30.81%
Oct-23	12,984,472	109,066	Fri, Oct 27, 2023 03:00	17,452	16.00%	10,946,875	38,398	Fri, Oct 27, 2023 05:00	14,714	38.32%
Nov-23	14,993,113	75,139	Fri, Nov 24, 2023 04:00	20,824	27.71%	19,514,368	61,443	Tue, Nov 21, 2023 04:00	27,103	44.11%
Dec-23	19,542,552	77,121	Mon, Dec 25, 2023 03:00	26,267	34.06%	27,715,225	63,658	Fri, Dec 08, 2023 04:00	37,252	58.52%
Jan-24	36,553,728	148,987	Fri, Jan 12, 2024 19:00	49,131	32.98%	25,592,276	57,055	Mon, Jan 01, 2024 04:00	34,398	60.29%
Feb-24	19,650,593	63,168	Fri, Feb 16, 2024 08:00	28,234	44.70%	22,497,027	54,824	Thu, Feb 29, 2024 04:00	32,323	58.96%
Mar-24	14,756,702	59,942	Thu, Mar 07, 2024 04:00	19,861	33.13%	18,860,908	55,505	Mon, Mar 11, 2024 03:00	25,385	45.73%
Apr-24	6,454,054	29,219	Thu, Apr 18, 2024 06:00	8,964	30.68%	12,863,767	38,550	Mon, Apr 01, 2024 05:00	17,866	46.35%
May-24	4,114,353	17,977	Wed, May 01, 2024 07:00	5,530	30.76%	7,912,590	24,030	Wed, May 01, 2024 04:00	10,635	44.26%
Jun-24	1,426,128	13,832	Mon, Jun 17, 2024 10:00	1,981	14.32%	4,475,002	17,921	Mon, Jun 10, 2024 05:00	6,215	34.68%
Jul-24	1,319,484	6,588	Wed, Jul 03, 2024 10:00	1,774	26.92%	2,961,283	10,883	Mon, Jul 08, 2024 15:00	3,980	36.57%
Aug-24	1,531,250	9,533	Fri, Aug 23, 2024 12:00	2,058	21.59%	2,838,502	9,798	Fri, Aug 23, 2024 05:00	3,815	38.94%
Sep-24	1,642,018	8,919	Mon, Sep 30, 2024 05:00	2,281	25.57%	5,110,239	24,344	Mon, Sep 30, 2024 05:00	7,098	29.15%
Oct-24	2,818,386	45,260	Thu, Oct 31, 2024 04:00	3,788	8.37%	10,758,446	31,490	Thu, Oct 31, 2024 05:00	14,460	45.92%
Nov-24	22,188,235	108,780	Mon, Nov 25, 2024 04:00	30,817	28.33%	19,163,523	64,077	Thu, Nov 21, 2024 04:00	26,616	41.54%
Dec-24	26,890,807	85,080	Mon, Dec 02, 2024 04:00	36,144	42.48%	27,223,532	63,021	Fri, Dec 27, 2024 04:00	36,591	58.06%
Jan-25	30,502,783	82,204	Mon, Jan 20, 2025 18:00	40,998	49.87%	25,755,279	61,901	Fri, Jan 17, 2025 04:00	34,617	55.92%
Feb-25	49,944,364	178,246	Thu, Feb 13, 2025 04:00	74,322	41.70%	21,582,445	58,192	Thu, Feb 27, 2025 04:00	32,117	55.19%
Mar-25	30,965,299	102,073	Wed, Mar 05, 2025 00:00	41,676	40.83%	19,021,041	54,553	Tue, Mar 11, 2025 05:00	25,600	46.93%
Apr-25	13,377,599	72,232	Fri, Apr 04, 2025 08:00	18,580	25.72%	12,964,030	39,677	Tue, Apr 01, 2025 05:00	18,006	45.38%
May-25	3,495,566	42,106	Wed, May 14, 2025 07:00	4,698	11.16%	7,910,786	24,193	Mon, May 05, 2025 05:00	10,633	43.95%
Jun-25	333,048	10,718	Mon, Jun 23, 2025 05:00	463	4.32%	4,558,282	19,678	Mon, Jun 09, 2025 05:00	6,331	32.17%



**Table J-17. Office Other totals**

Month	Office Other Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	7,271,461	19,713	Wed, Jul 05, 2023 17:00	9,773	49.58%	9,366,356	31,697	Mon, Jul 24, 2023 13:00	12,589	39.72%
Aug-23	8,358,961	29,096	Mon, Aug 14, 2023 17:00	11,235	38.61%	9,671,954	30,351	Wed, Aug 16, 2023 17:00	13,000	42.83%
Sep-23	6,472,319	29,176	Fri, Sep 29, 2023 08:00	8,989	30.81%	8,471,668	28,653	Fri, Sep 22, 2023 15:00	11,766	41.06%
Oct-23	7,469,636	46,617	Mon, Oct 30, 2023 06:00	10,040	21.54%	7,999,875	27,368	Tue, Oct 24, 2023 08:00	10,753	39.29%
Nov-23	8,706,193	48,424	Fri, Nov 24, 2023 07:00	12,092	24.97%	7,594,775	30,551	Tue, Nov 14, 2023 08:00	10,548	34.53%
Dec-23	9,310,881	56,793	Tue, Dec 26, 2023 08:00	12,515	22.04%	7,944,458	35,816	Tue, Dec 12, 2023 08:00	10,678	29.81%
Jan-24	12,259,353	47,278	Tue, Jan 02, 2024 07:00	16,478	34.85%	8,121,969	30,429	Tue, Jan 16, 2024 08:00	10,917	35.88%
Feb-24	8,700,442	47,204	Mon, Feb 05, 2024 06:00	12,501	26.48%	7,522,305	32,255	Tue, Feb 27, 2024 08:00	10,808	33.51%
Mar-24	8,649,903	45,519	Mon, Mar 04, 2024 07:00	11,642	25.58%	7,854,529	34,538	Mon, Mar 04, 2024 06:00	10,571	30.61%
Apr-24	7,870,392	46,401	Mon, Apr 08, 2024 06:00	10,931	23.56%	7,926,715	32,428	Mon, Apr 01, 2024 07:00	11,009	33.95%
May-24	7,240,620	41,628	Mon, May 06, 2024 06:00	9,732	23.38%	8,657,845	30,989	Thu, May 16, 2024 08:00	11,637	37.55%
Jun-24	7,119,705	27,428	Mon, Jun 17, 2024 07:00	9,888	36.05%	8,298,585	32,222	Tue, Jun 25, 2024 12:00	11,526	35.77%
Jul-24	8,762,718	20,674	Wed, Jul 10, 2024 18:00	11,778	56.97%	9,619,402	33,112	Wed, Jul 24, 2024 13:00	12,929	39.05%
Aug-24	7,515,447	20,664	Mon, Aug 26, 2024 07:00	10,101	48.88%	9,494,528	29,680	Mon, Aug 05, 2024 16:00	12,761	43.00%
Sep-24	7,253,268	25,676	Mon, Sep 16, 2024 07:00	10,074	39.23%	8,504,459	29,372	Wed, Sep 11, 2024 15:00	11,812	40.21%
Oct-24	7,793,402	37,076	Thu, Oct 31, 2024 08:00	10,475	28.25%	8,043,999	26,494	Tue, Oct 22, 2024 09:00	10,812	40.81%
Nov-24	8,763,839	48,191	Mon, Nov 18, 2024 06:00	12,172	25.26%	7,445,779	28,574	Mon, Nov 18, 2024 06:00	10,341	36.19%
Dec-24	9,934,594	44,344	Mon, Dec 30, 2024 05:00	13,353	30.11%	8,207,730	36,866	Mon, Dec 09, 2024 06:00	11,032	29.92%
Jan-25	10,630,765	47,475	Thu, Jan 02, 2025 07:00	14,289	30.10%	8,149,092	31,165	Mon, Jan 06, 2025 06:00	10,953	35.15%
Feb-25	10,648,887	48,203	Wed, Feb 05, 2025 07:00	15,847	32.87%	7,220,071	31,867	Mon, Feb 24, 2025 06:00	10,744	33.72%
Mar-25	8,287,681	45,779	Mon, Mar 17, 2025 06:00	11,154	24.37%	8,067,080	32,516	Tue, Mar 04, 2025 08:00	10,857	33.39%
Apr-25	6,348,816	39,125	Mon, Apr 14, 2025 07:00	8,818	22.54%	7,887,755	31,809	Tue, Apr 01, 2025 09:00	10,955	34.44%
May-25	5,070,868	33,080	Mon, May 05, 2025 07:00	6,816	20.60%	8,526,873	30,368	Thu, May 15, 2025 12:00	11,461	37.74%
Jun-25	6,335,191	27,380	Mon, Jun 23, 2025 07:00	8,799	32.14%	6,176,255	25,726	Fri, Jun 06, 2025 15:00	8,578	33.34%



**Table J-18. Retail Other totals**

Month	Retail Other Total									
	Actuals					Normals				
	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor	Total Use	Peak Demand	Occurrence	Average Demand	Load Factor
(kWh)	(kW)	Date and Time	(kW)	(%)	(kWh)	(kW)	Date and Time	(kW)	(%)	
Jul-23	72,993	478	Thu, Jul 13, 2023 14:00	98	20.52%	72,406	1,109	Fri, Jul 28, 2023 00:00	97	8.78%
Aug-23	108,755	825	Wed, Aug 16, 2023 16:00	146	17.73%	70,396	534	Wed, Aug 16, 2023 16:00	95	17.72%
Sep-23	39,210	457	Tue, Sep 12, 2023 17:00	54	11.91%	55,796	339	Tue, Sep 12, 2023 16:00	77	22.83%
Oct-23	23,772	252	Fri, Oct 06, 2023 19:00	32	12.70%	43,225	197	Mon, Oct 16, 2023 16:00	58	29.54%
Nov-23	32,206	129	Thu, Nov 02, 2023 17:00	45	34.64%	34,372	178	Fri, Nov 03, 2023 17:00	48	26.79%
Dec-23	19,992	90	Wed, Dec 13, 2023 11:00	27	29.82%	31,169	106	Thu, Dec 14, 2023 16:00	42	39.48%
Jan-24	21,706	81	Mon, Jan 22, 2024 10:00	29	36.13%	33,552	135	Thu, Jan 18, 2024 16:00	45	33.51%
Feb-24	19,803	128	Fri, Feb 23, 2024 16:00	28	22.25%	32,810	129	Thu, Feb 29, 2024 16:00	47	36.57%
Mar-24	15,980	95	Wed, Mar 06, 2024 09:00	22	22.61%	37,755	147	Tue, Mar 19, 2024 17:00	51	34.60%
Apr-24	15,633	121	Thu, Apr 25, 2024 15:00	22	17.94%	39,136	153	Mon, Apr 15, 2024 16:00	54	35.42%
May-24	36,132	358	Wed, May 15, 2024 19:00	49	13.58%	50,627	275	Tue, May 28, 2024 16:00	68	24.73%
Jun-24	34,004	315	Tue, Jun 25, 2024 14:00	47	14.99%	52,278	232	Tue, Jun 11, 2024 16:00	73	31.27%
Jul-24	166,704	1,019	Tue, Jul 09, 2024 16:00	224	21.98%	74,372	433	Wed, Jul 03, 2024 15:00	100	23.11%
Aug-24	118,806	1,038	Thu, Aug 01, 2024 17:00	160	15.38%	70,271	534	Wed, Aug 14, 2024 16:00	94	17.69%
Sep-24	82,039	967	Tue, Sep 24, 2024 16:00	114	11.79%	57,926	465	Wed, Sep 11, 2024 16:00	80	17.29%
Oct-24	39,090	527	Tue, Oct 08, 2024 16:00	53	9.96%	43,922	193	Wed, Oct 16, 2024 16:00	59	30.55%
Nov-24	25,432	71	Thu, Nov 21, 2024 15:00	35	49.47%	34,250	153	Mon, Nov 04, 2024 15:00	48	30.99%
Dec-24	36,596	90	Fri, Dec 06, 2024 04:00	49	54.37%	31,777	106	Thu, Dec 26, 2024 16:00	43	40.25%
Jan-25	34,096	193	Wed, Jan 15, 2025 10:00	46	23.77%	33,915	111	Mon, Jan 20, 2025 15:00	46	40.99%
Feb-25	24,839	119	Mon, Feb 03, 2025 15:00	37	31.14%	31,453	129	Thu, Feb 27, 2025 16:00	47	36.31%
Mar-25	21,321	74	Sun, Mar 09, 2025 05:00	29	38.73%	38,051	179	Mon, Mar 24, 2025 16:00	51	28.63%
Apr-25	19,694	231	Fri, Apr 04, 2025 14:00	27	11.84%	39,216	171	Fri, Apr 18, 2025 16:00	54	31.92%
May-25	23,988	407	Wed, May 07, 2025 16:00	32	7.92%	49,832	293	Wed, May 28, 2025 16:00	67	22.85%
Jun-25	78,152	710	Mon, Jun 30, 2025 18:00	109	15.29%	52,406	234	Tue, Jun 10, 2025 18:00	73	31.12%



## APPENDIX K. AVERAGE WEEKDAY AND WEEKEND PROFILES

In this appendix we present the monthly average weekday and average weekend load profiles per facility. The actual load is displayed in orange, and the normalized load is displayed in blue.

Figure K-1. Aggregate ERH average weekday (actual in orange, normal in blue)

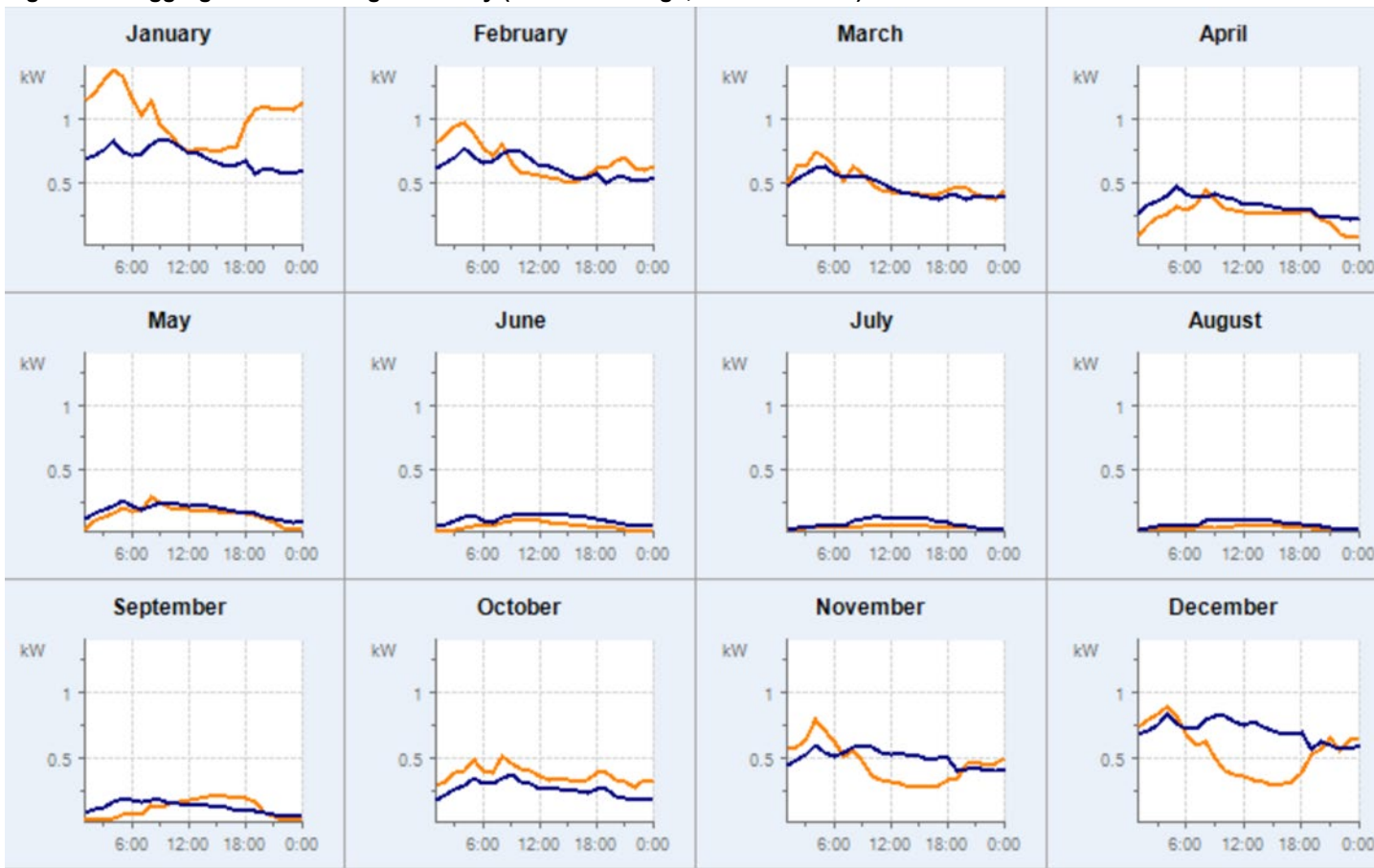




Figure K-2. Aggregate ERH average weekend (actual in orange, normal in blue)





Figure K-3. Office ERH average weekday (actual in orange, normal in blue)

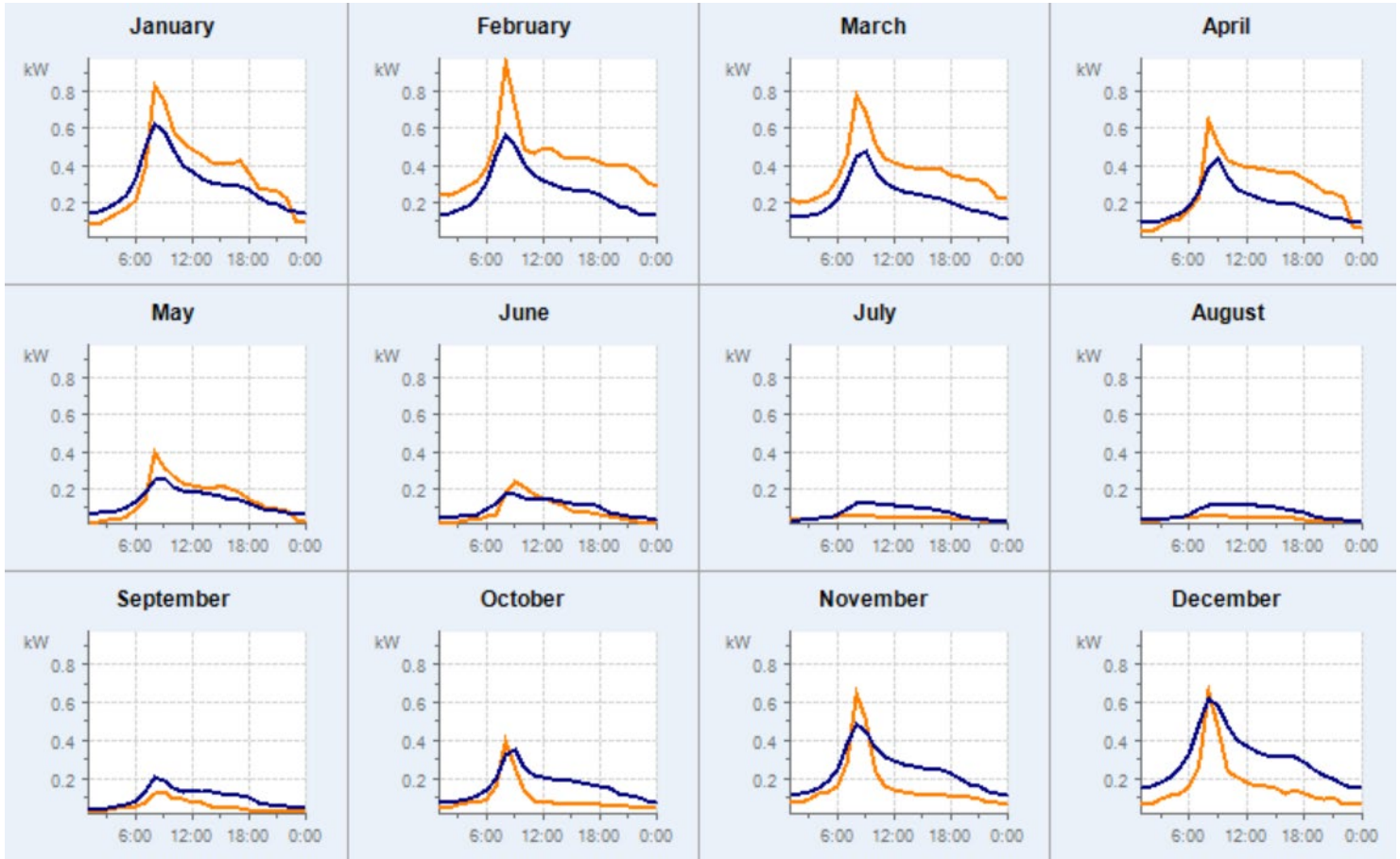




Figure K-4. Office ERH average weekend (actual in orange, normal in blue)

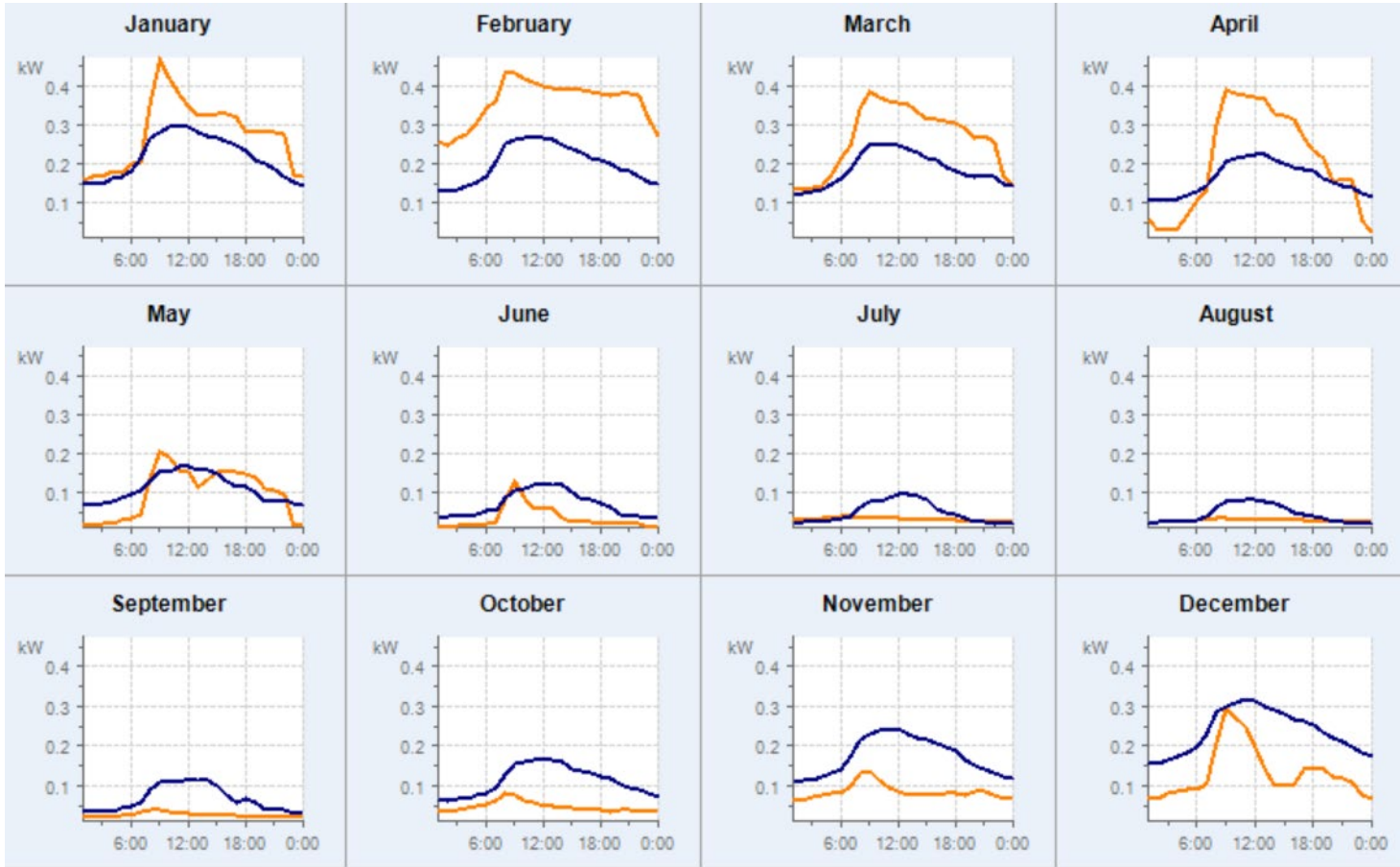




Figure K-5. Retail ERH average weekday (actual in orange, normal in blue)

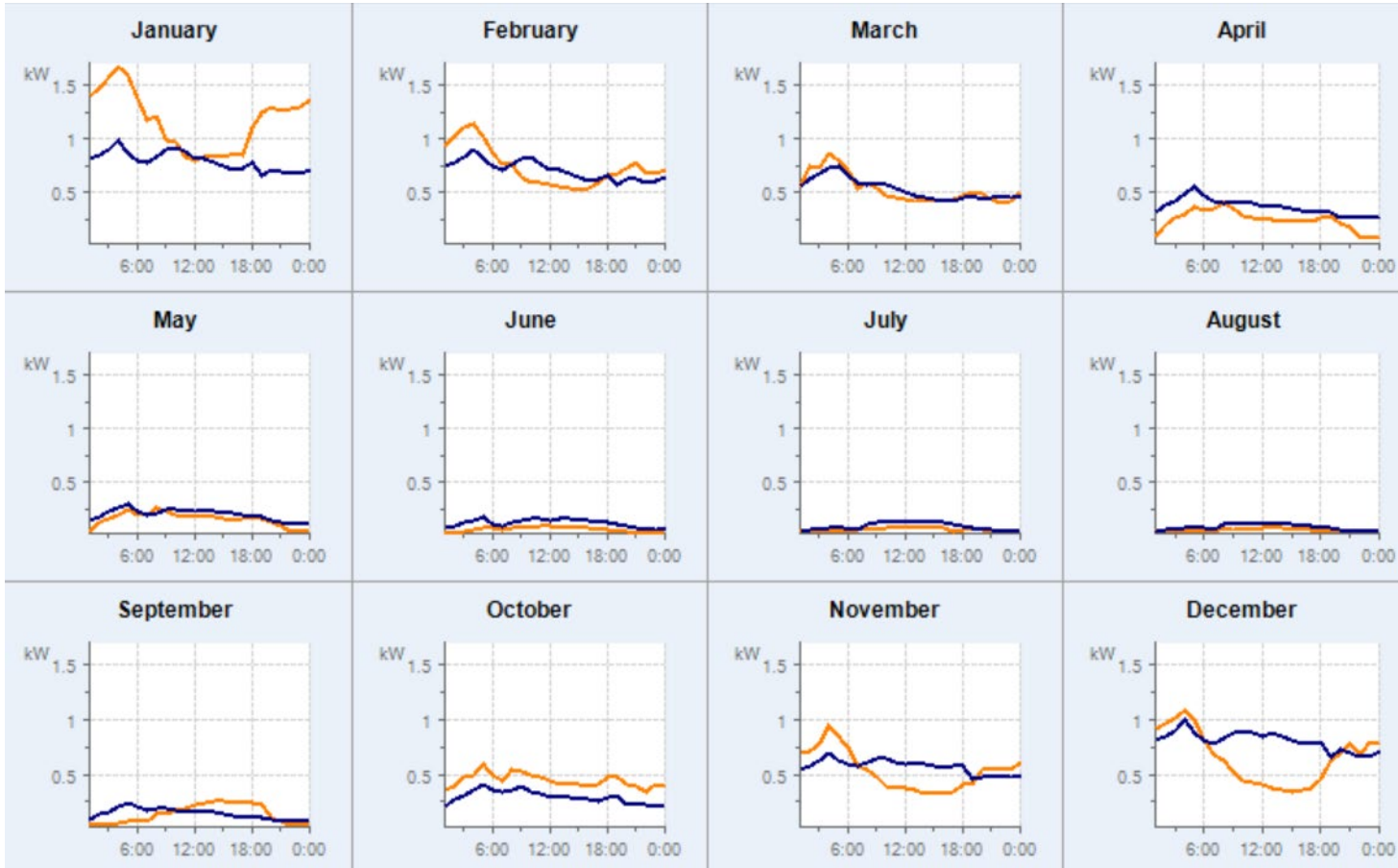




Figure K-6. Retail ERH average weekend (actual in orange, normal in blue)

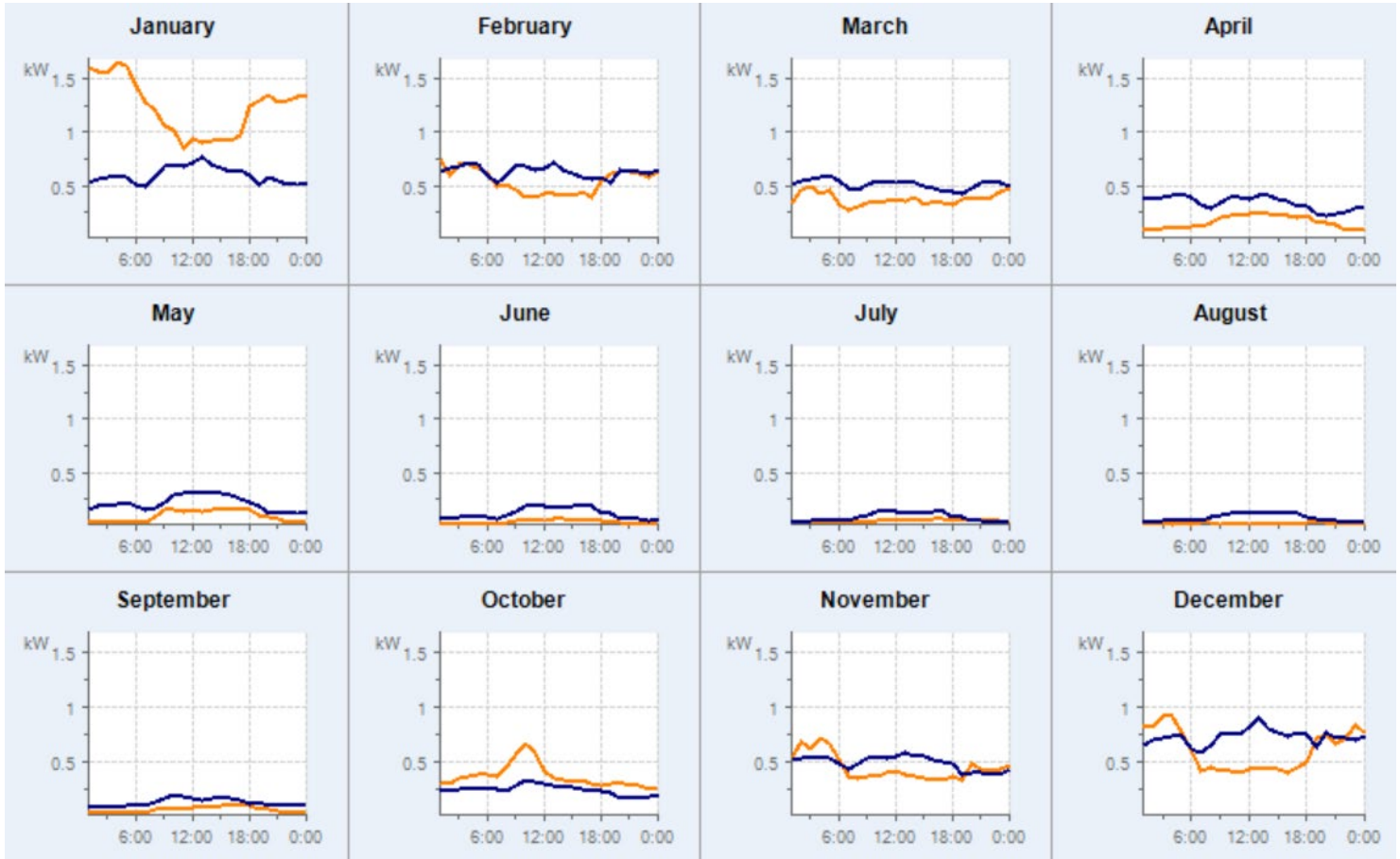


Figure K-7. Aggregate heat pump average weekday (actual in orange, normal in blue)

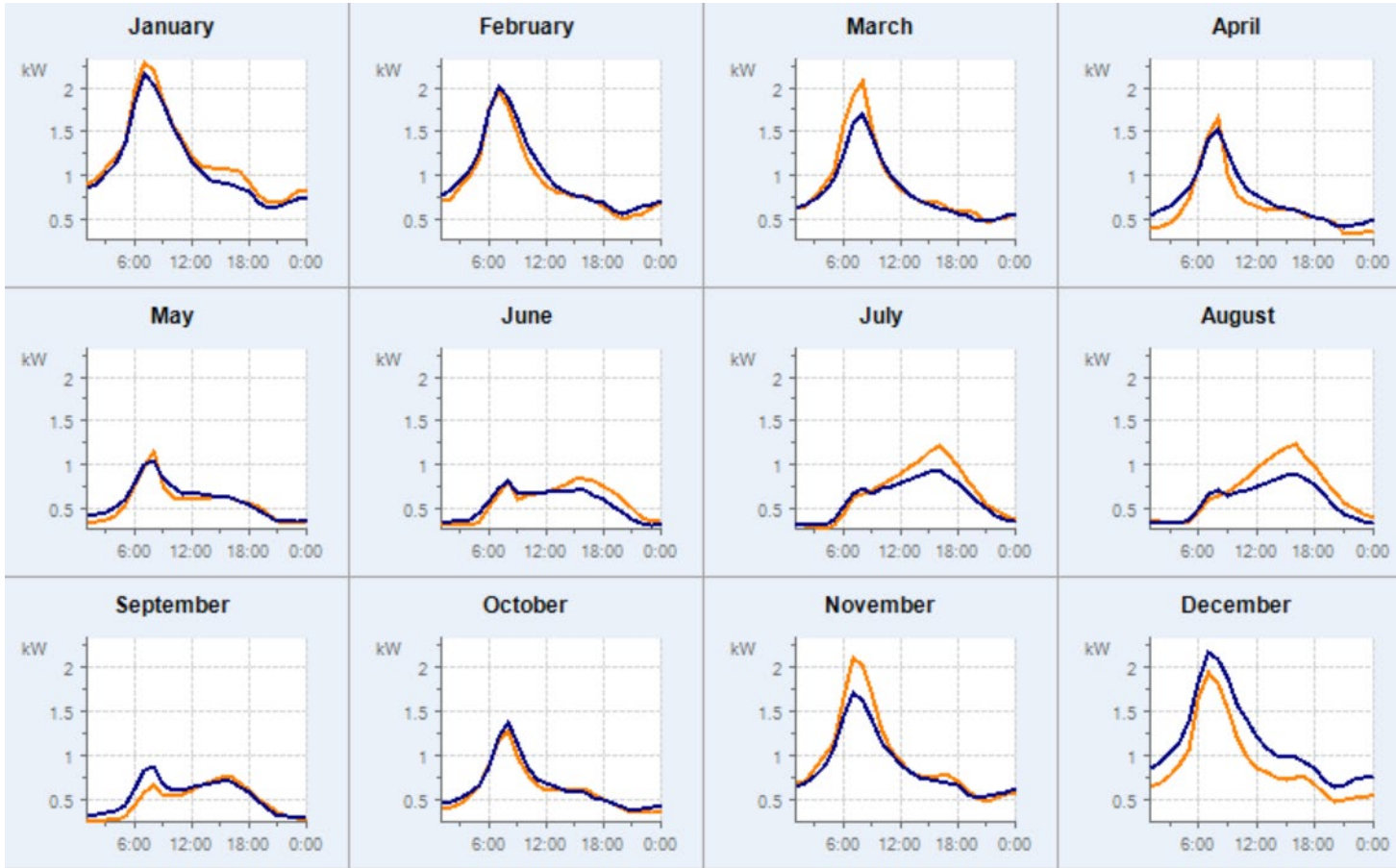




Figure K-8. Aggregate heat pump average weekend (actual in orange, normal in blue)

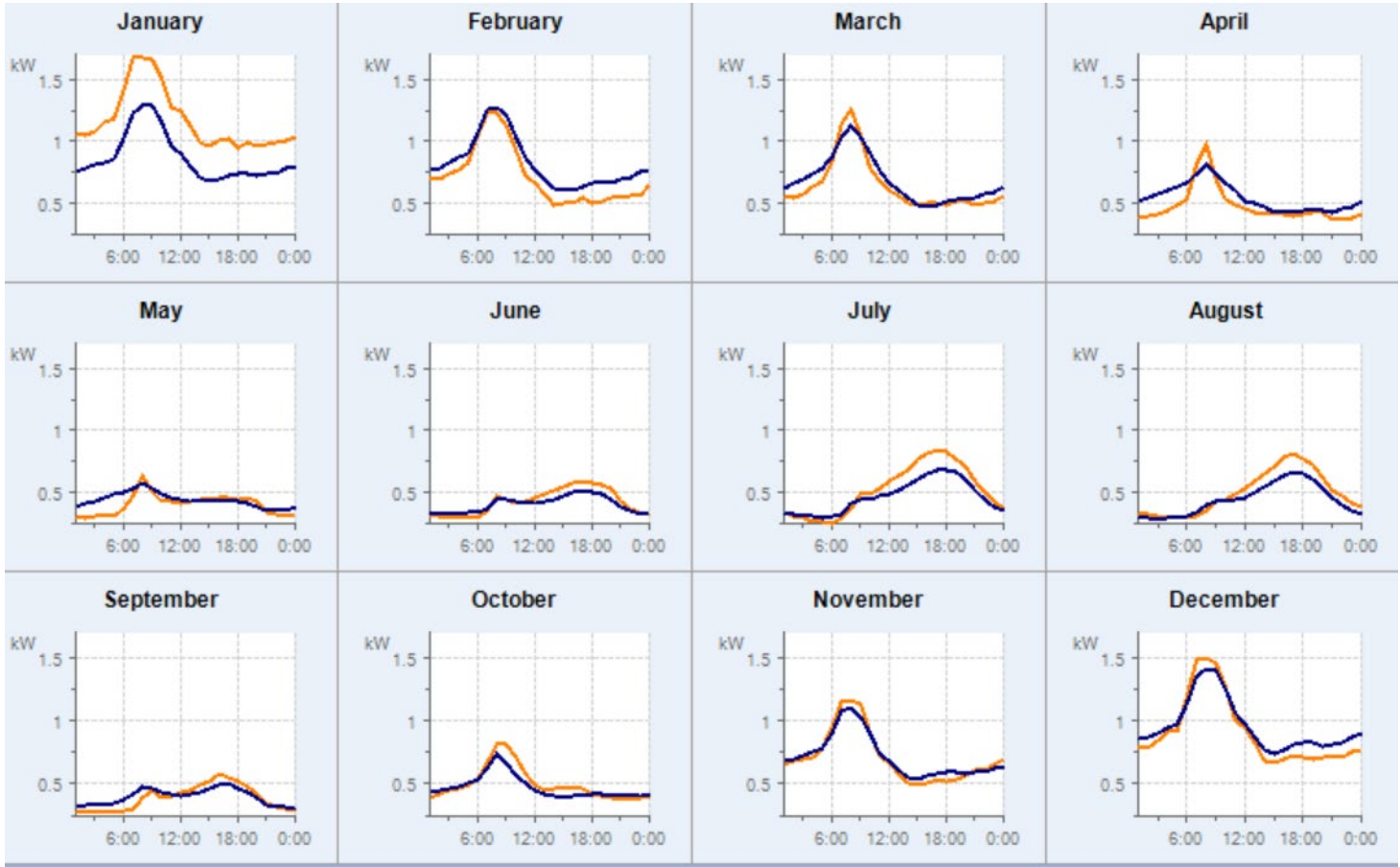




Figure K-9. Office heat pump average weekday (actual in orange, normal in blue)

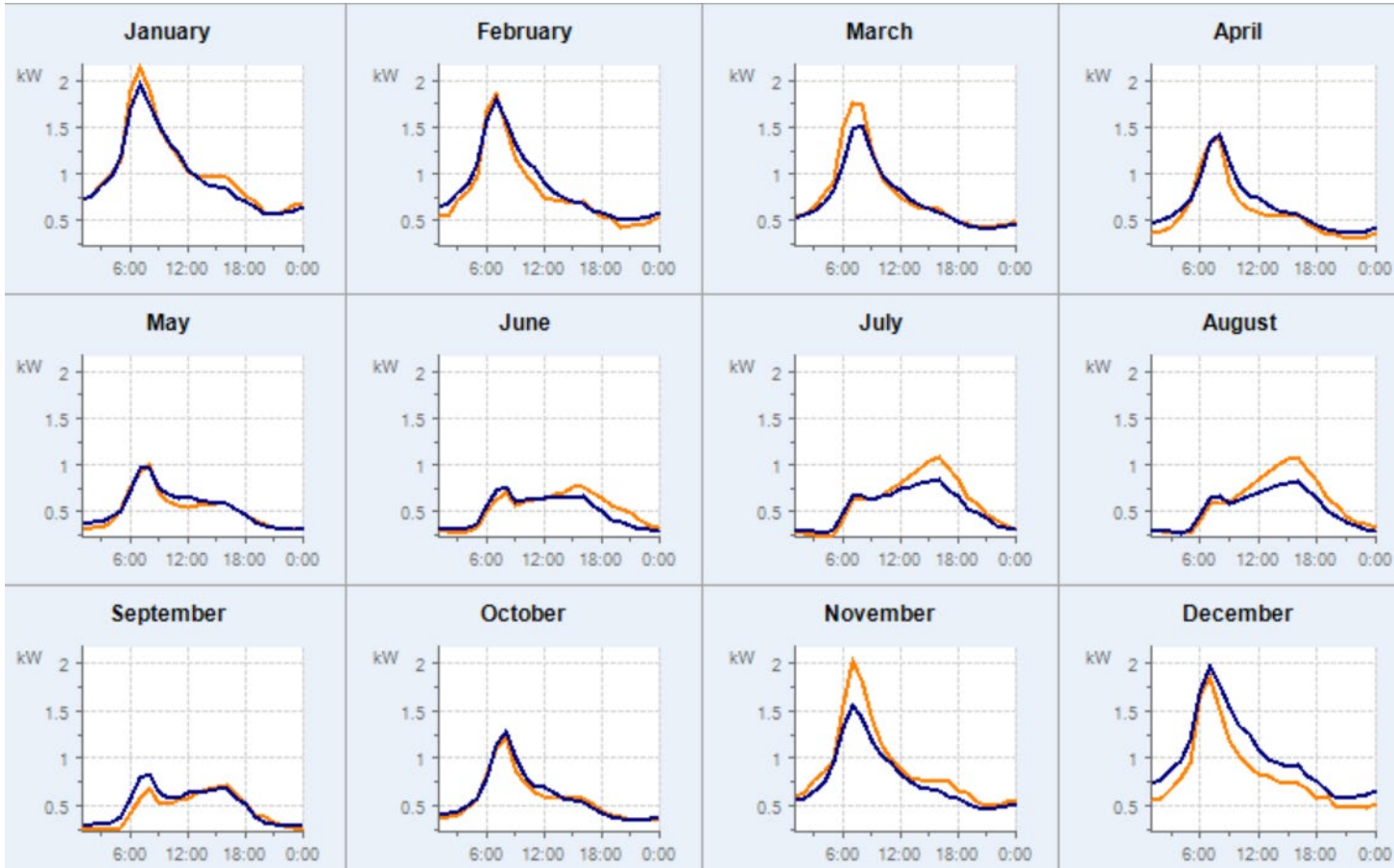




Figure K-10. Office heat pump average weekend (actual in orange, normal in blue)

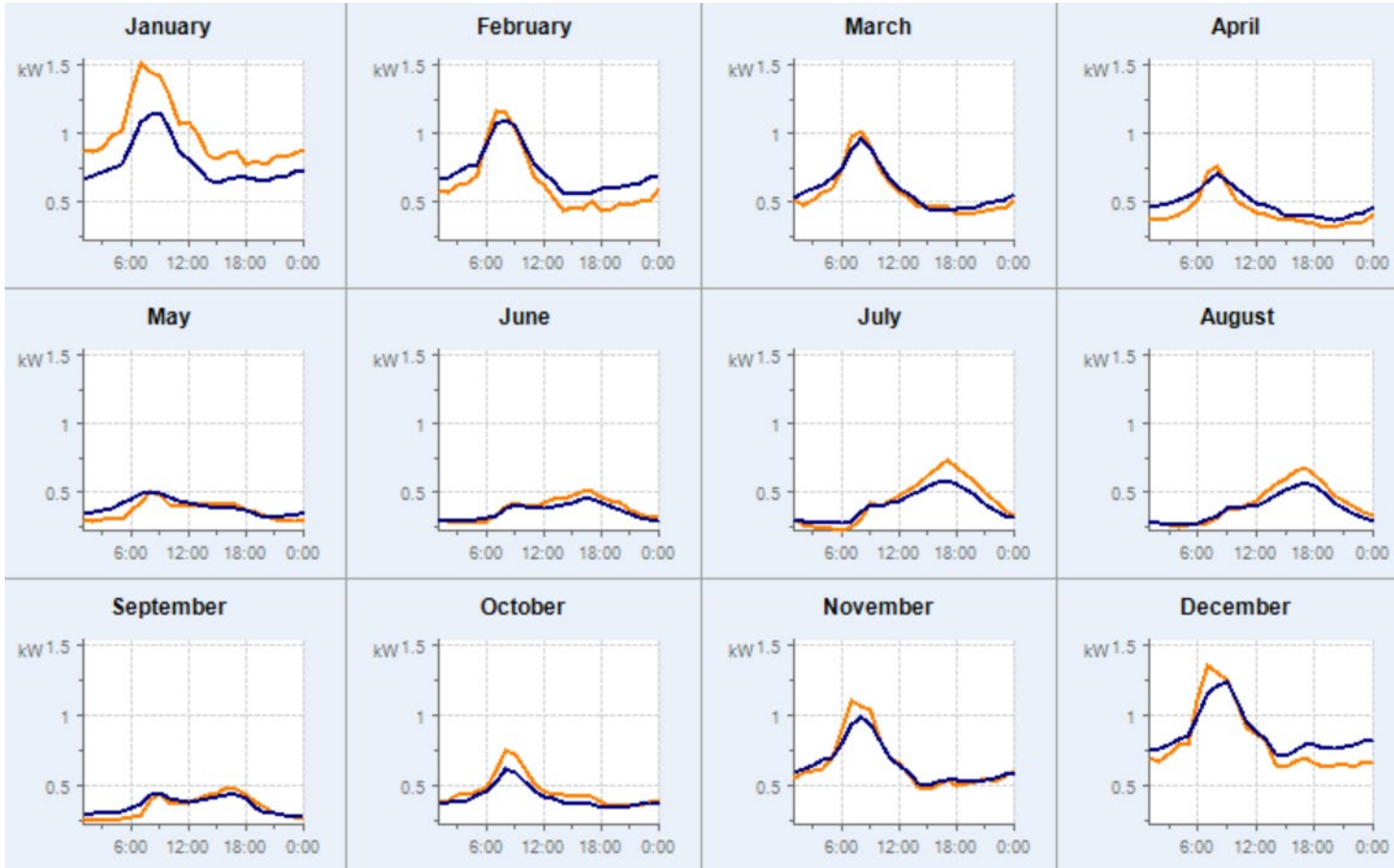


Figure K-11. Retail heat pump average weekday (actual in orange, normal in blue)

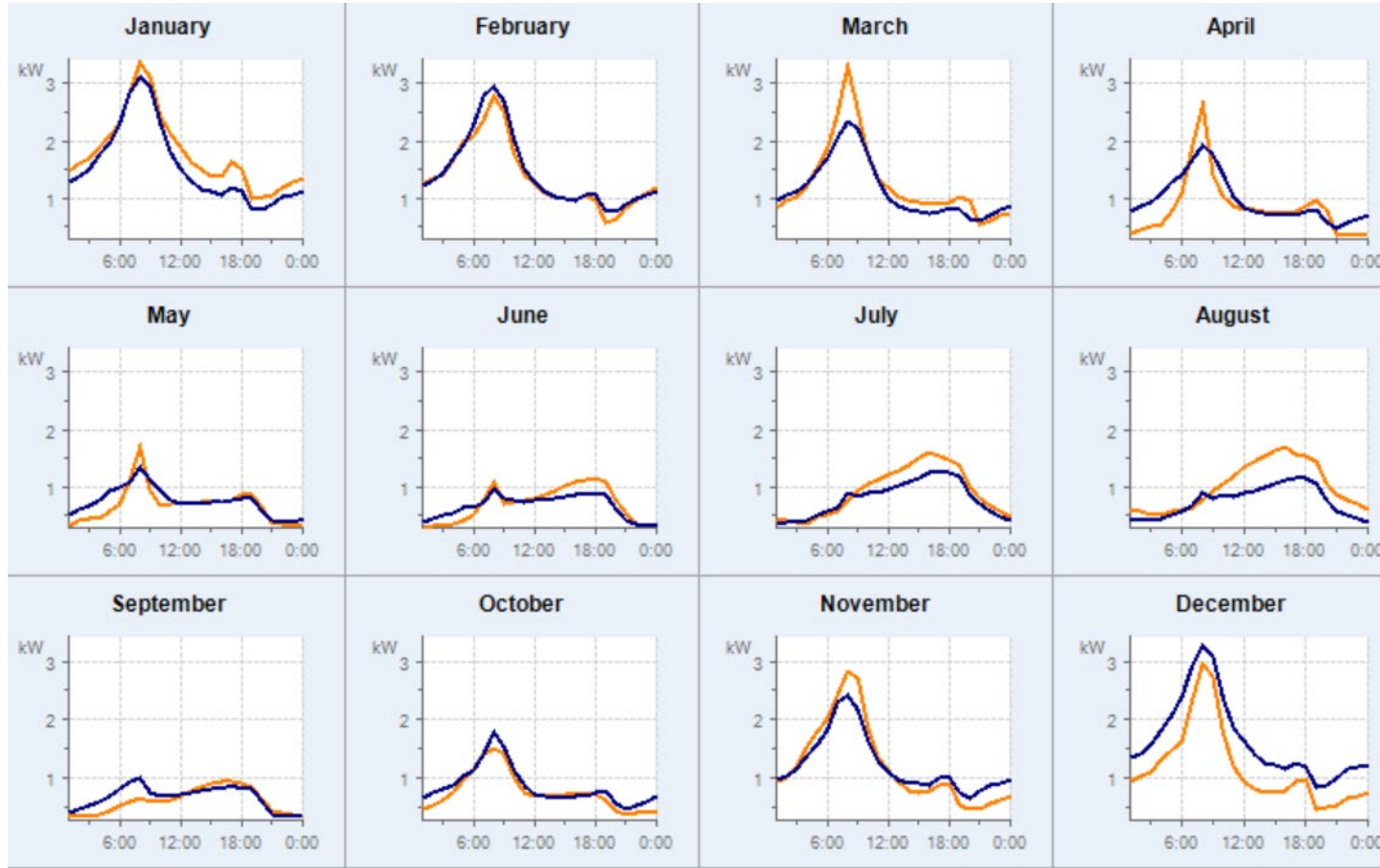




Figure K-12. Retail heat pump average weekend (actual in orange, normal in blue)

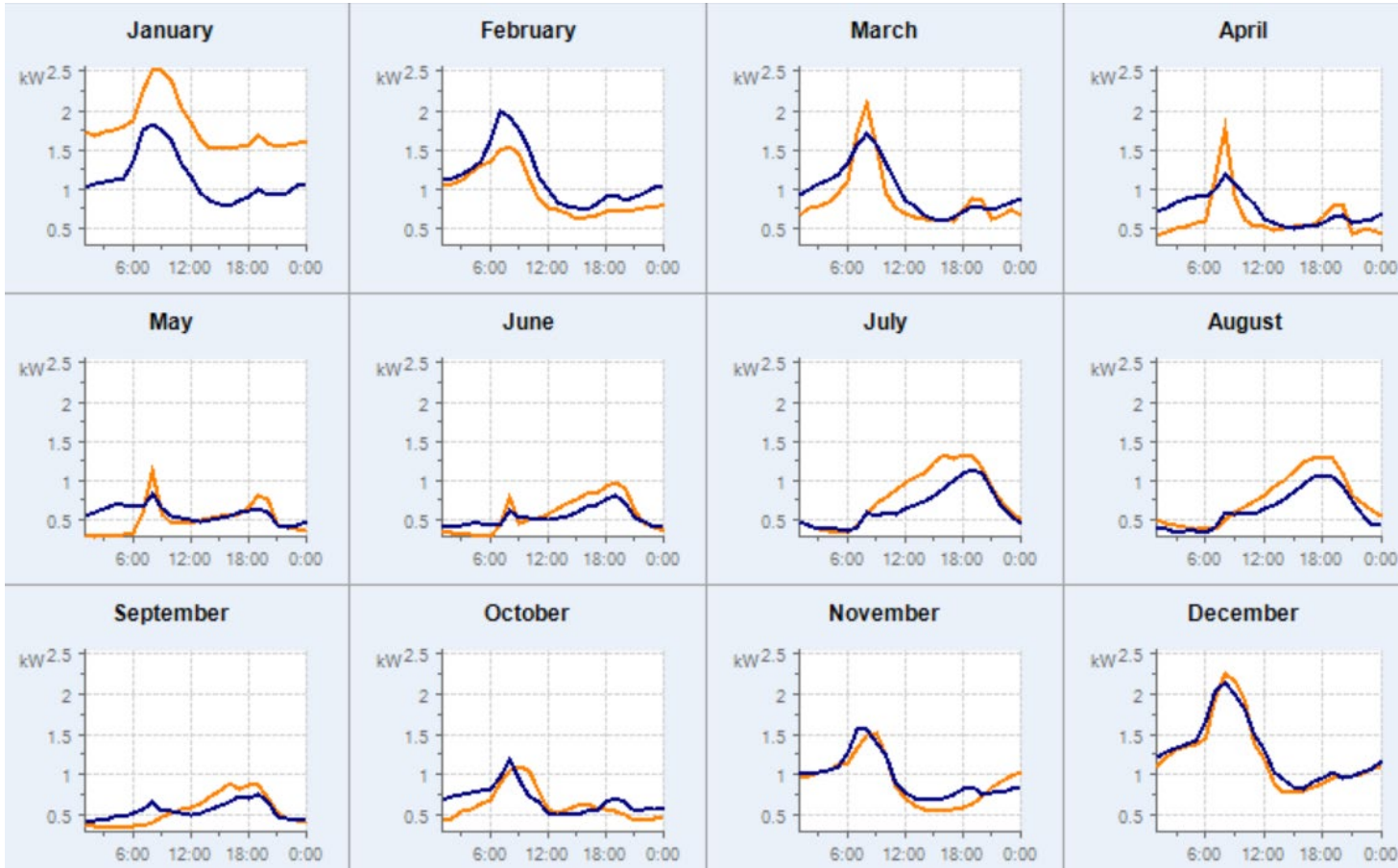




Figure K-13. Aggregate RTU average weekday (actual in orange, normal in blue)

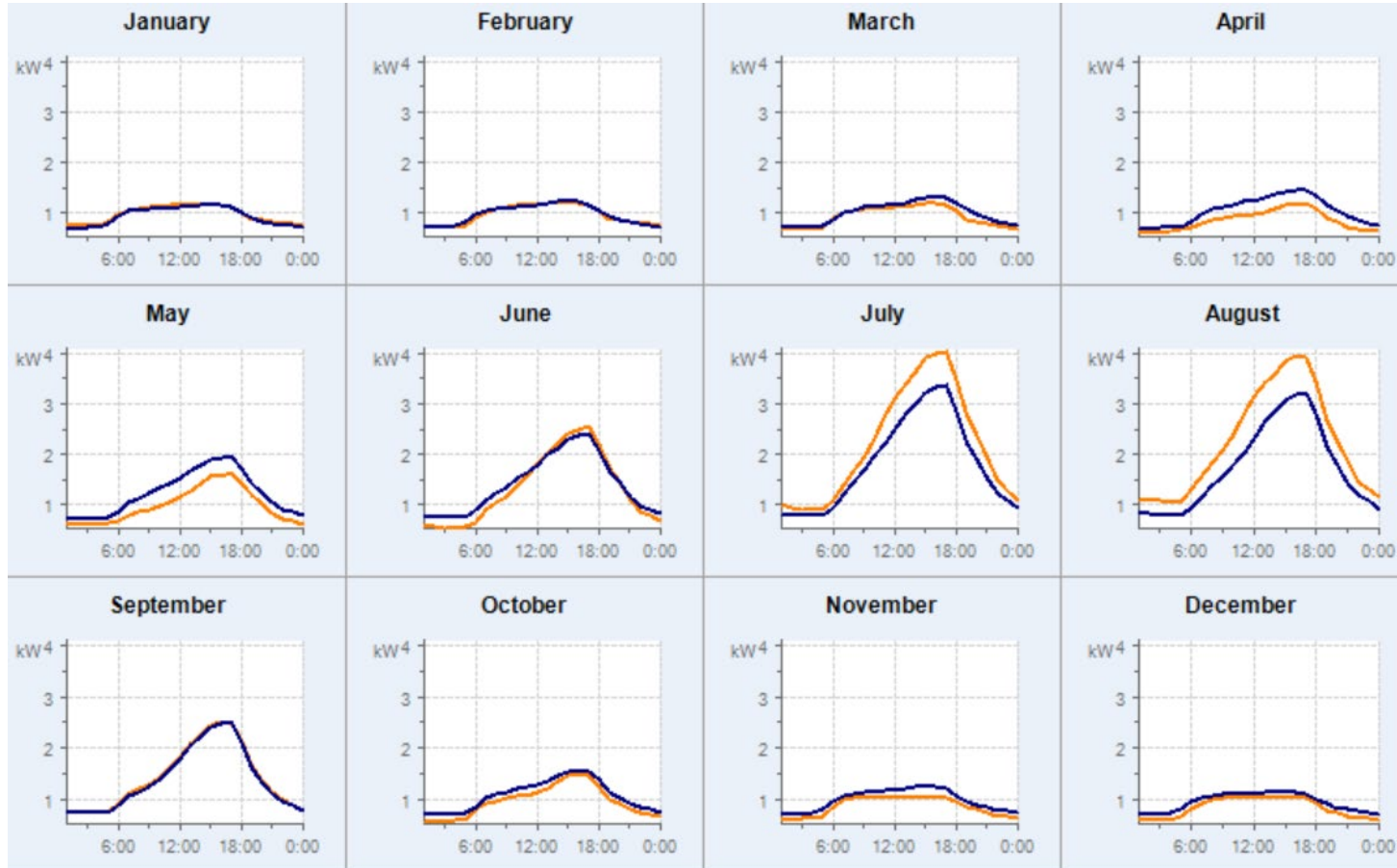




Figure K-14. Aggregate RTU average weekend (actual in orange, normal in blue)

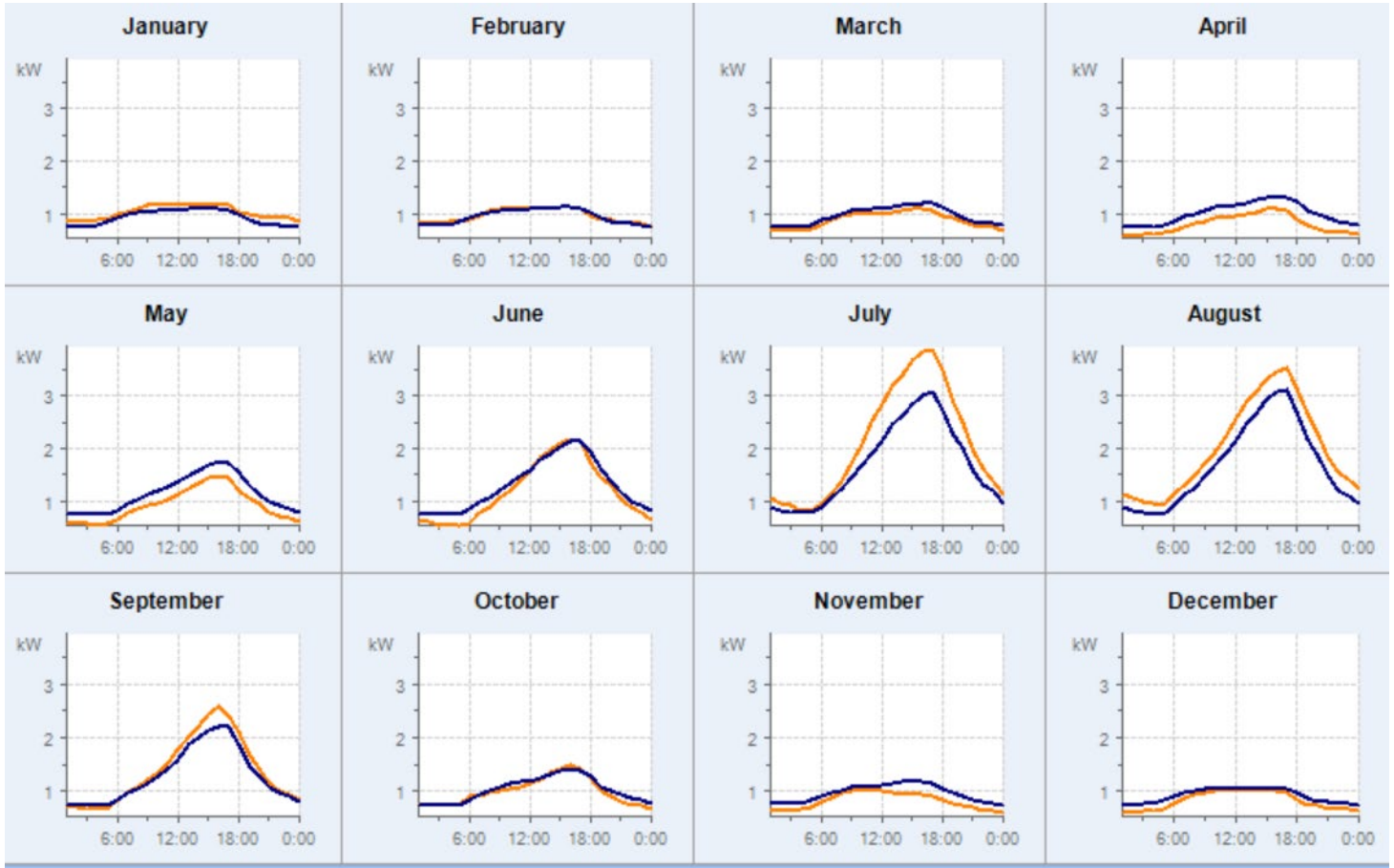




Figure K-15. Office RTU average weekday (actual in orange, normal in blue)

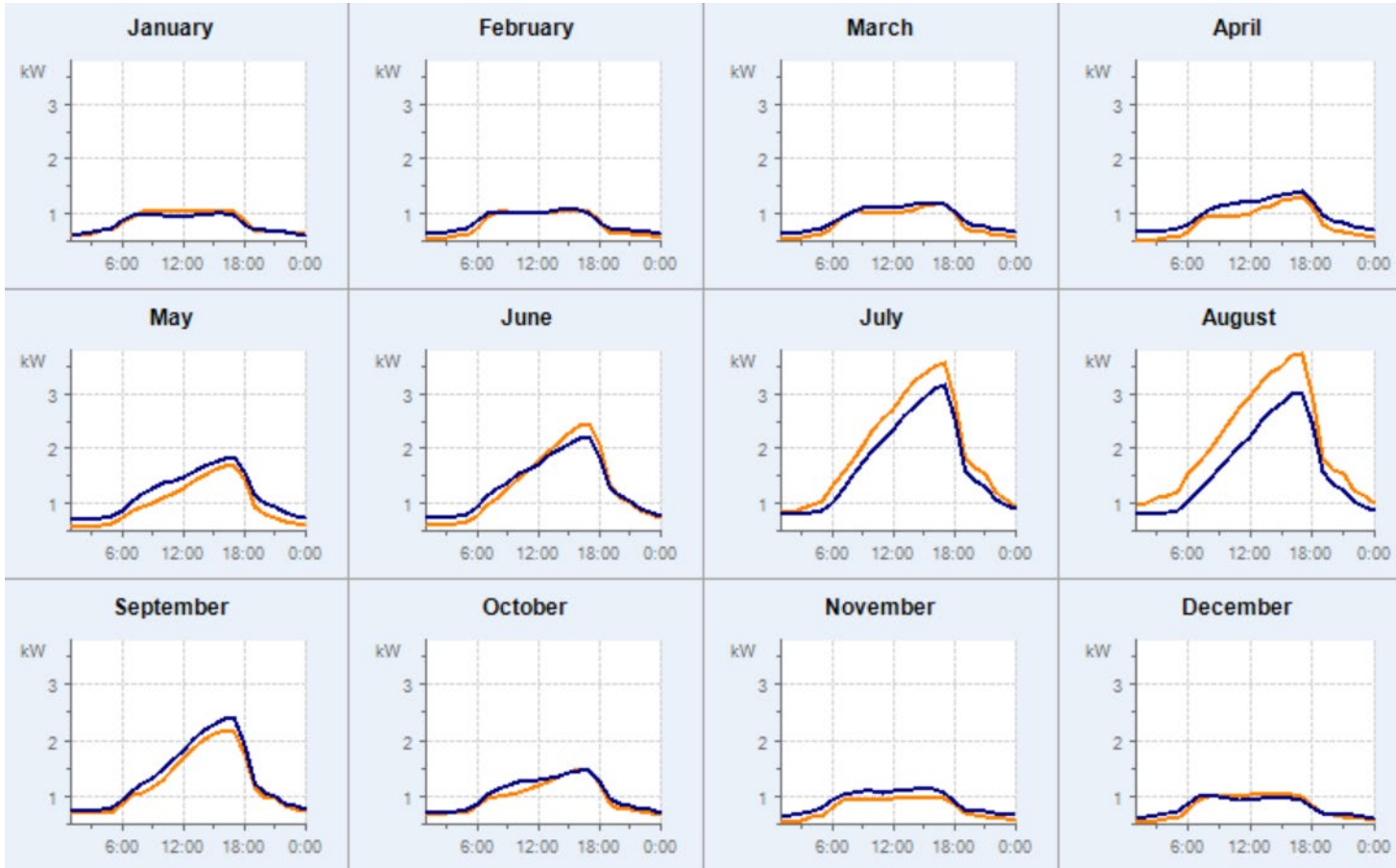




Figure K-16. Office RTU average weekend (actual in orange, normal in blue)

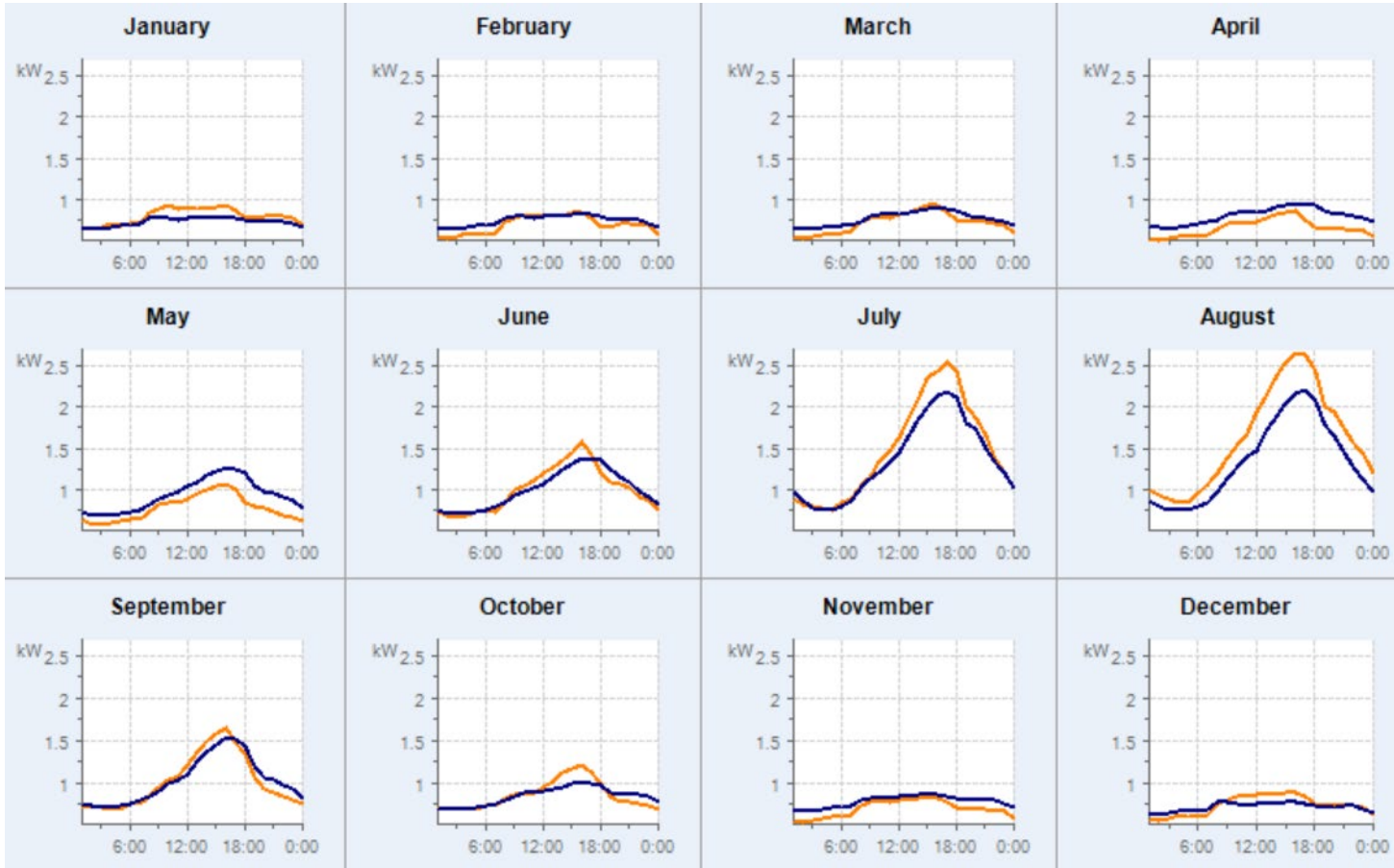




Figure K-17. Retail RTU average weekday (actual in orange, normal in blue)

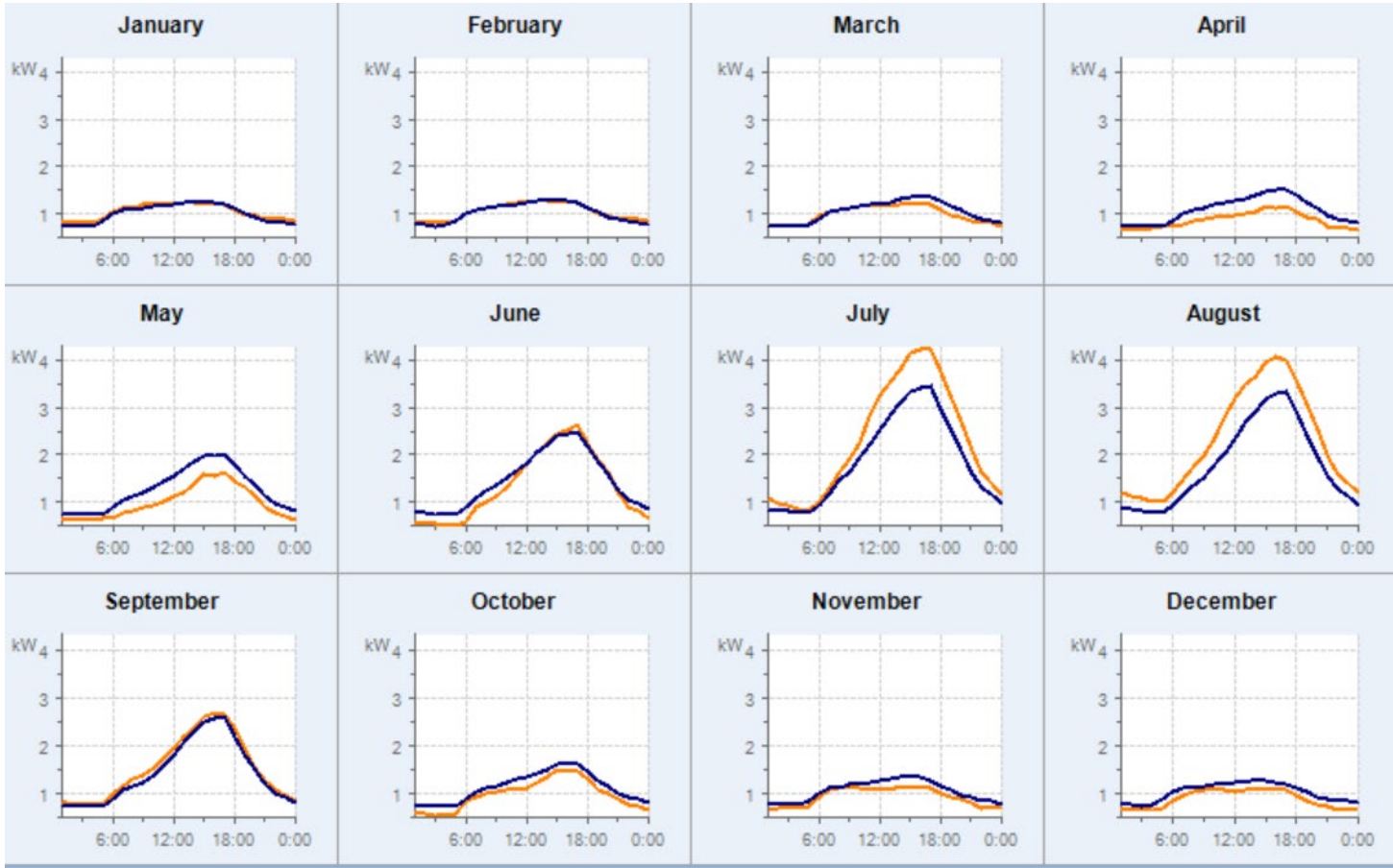
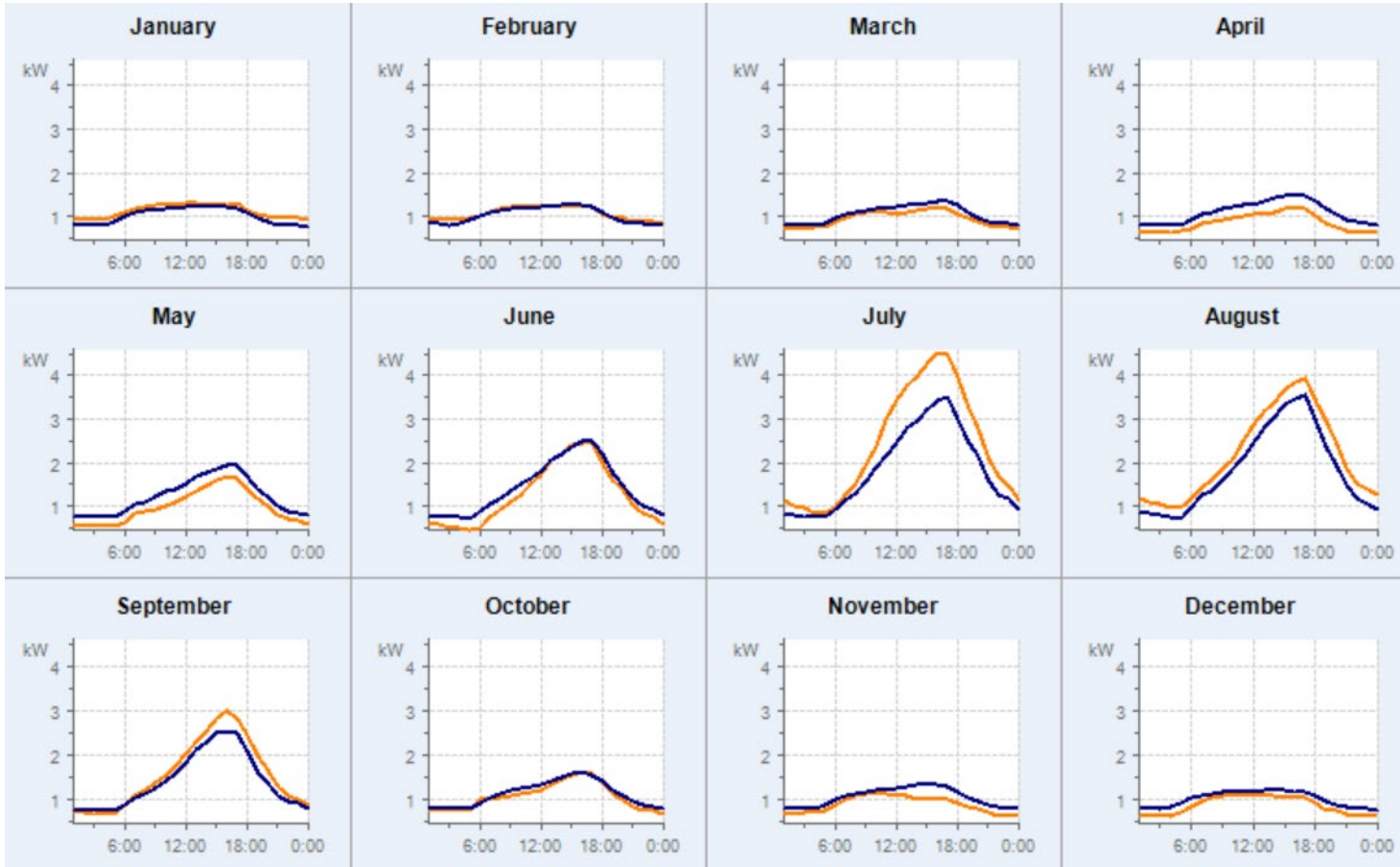




Figure K-18. Retail RTU average weekend (actual in orange, normal in blue)





## **About DNV**

DNV is an independent assurance and risk management provider, operating in more than 100 countries, with the purpose of safeguarding life, property, and the environment. Whether assessing a new ship design, qualifying technology for a floating wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to manage technological and regulatory complexity with confidence. As a trusted voice for many of the world's most successful organizations, we use our broad experience and deep expertise to advance safety and sustainable performance, set industry standards, and inspire and invent solutions.