

Load research – Beyond the Rate Case

CEMS 2025

Kevin Cracknell

April 2026

Agenda

1. Core objectives and purpose
2. Study timeline
3. Challenges & solutions
4. Capturing the data
5. Flexible Data Model
6. Applying CEMS
7. Load shapes
8. Questions



Objectives

- Updated HVAC end-use load profiles
- Peak day 1 x 24-hour generalized load shapes for metered commercial end use equipment
- Weekday 1 x 24-hour generalized load shapes in each month for metered end use equipment.
- Confidence intervals for the 1 x 24 load shapes above.
- 1 x 8,760 hourly (annual) data and generalized load shapes for metered end use equipment.

Purpose

Forecasting – bottom-up forecasting

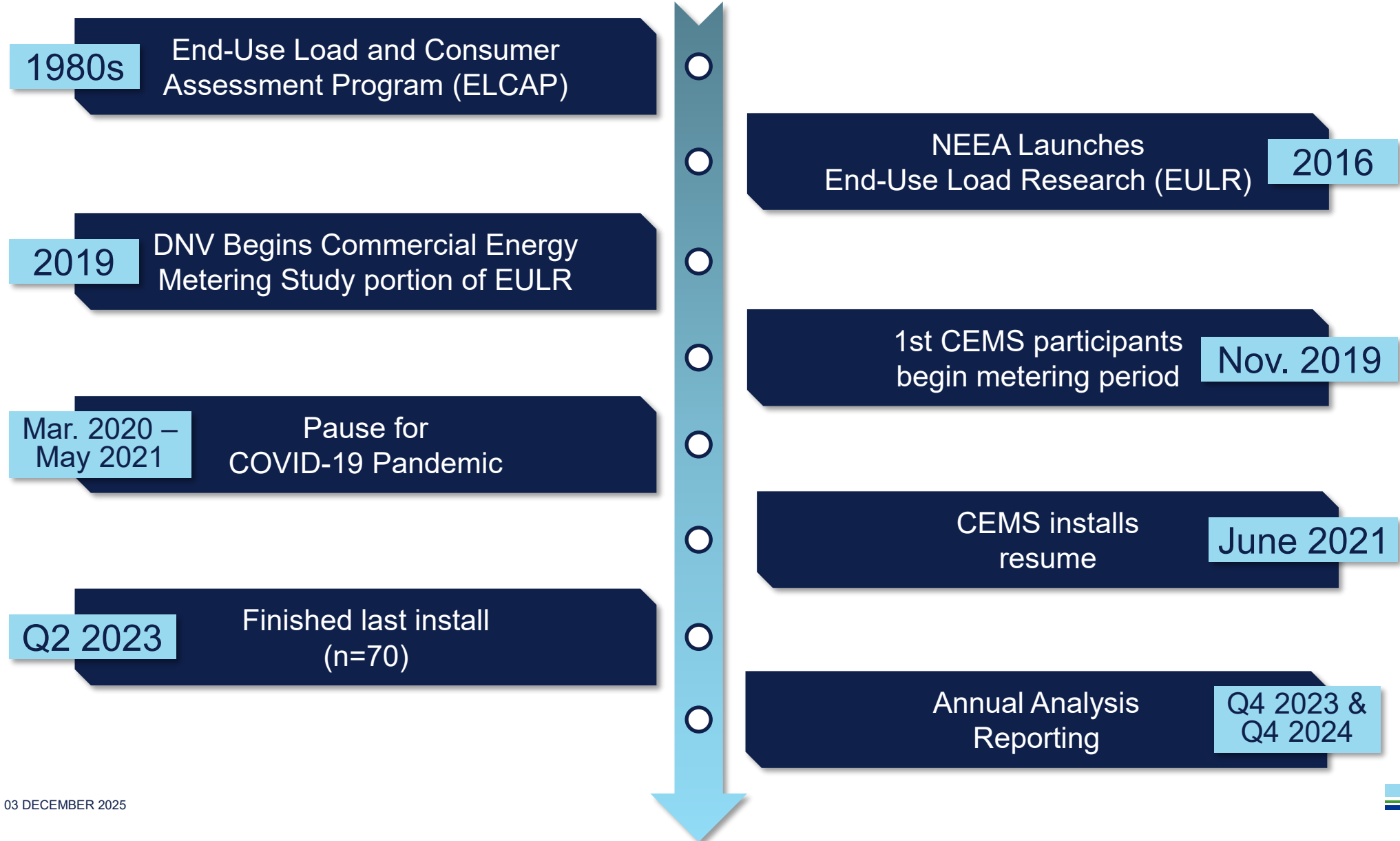
Energy efficiency planning – better define the impacts of energy efficiency measures

Load management – evaluate the demand reduction value of measures across 8760

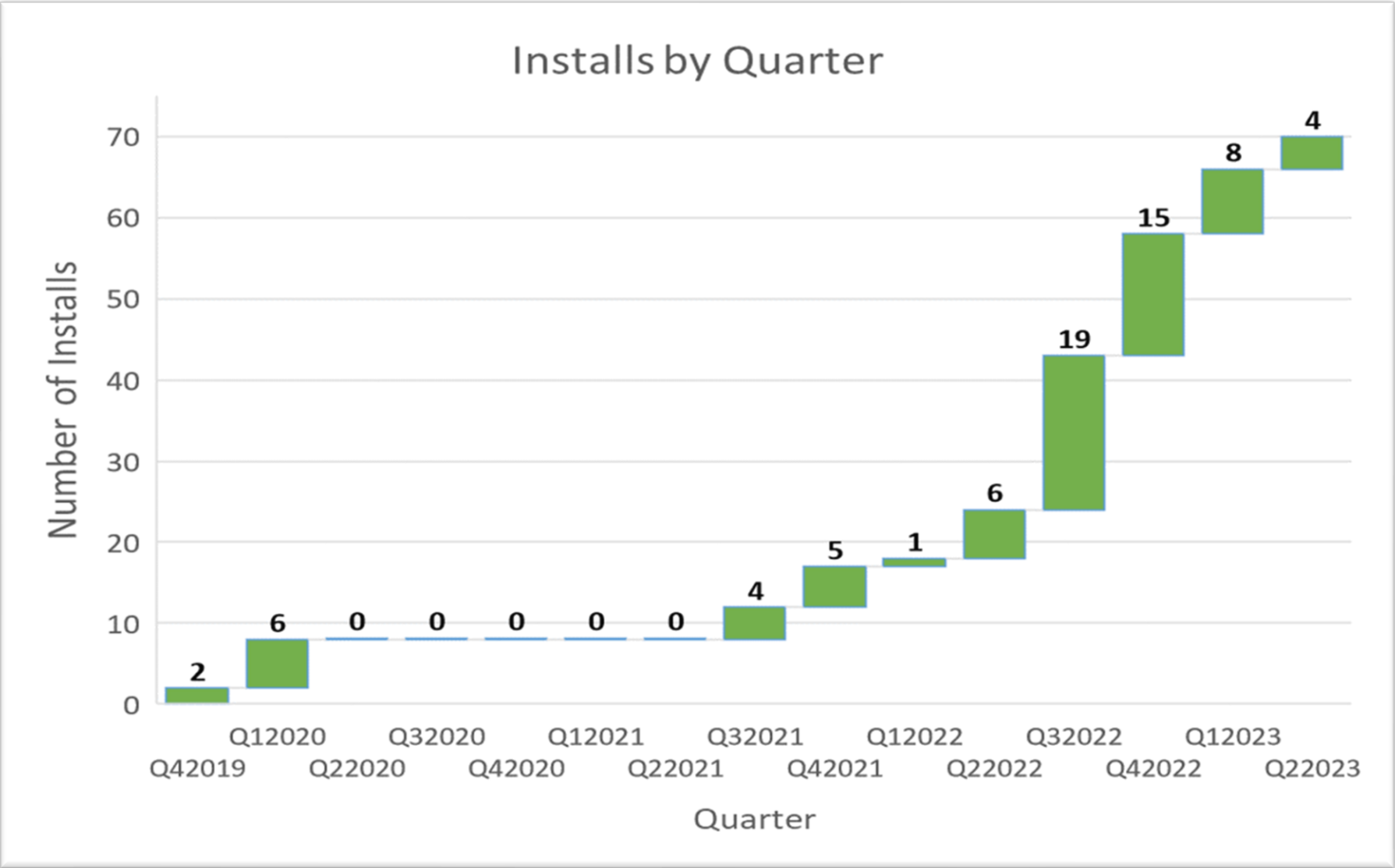
Cost-effectiveness testing – support time-of-use cost-effectiveness analysis

Integrated resource planning – update the energy utilization intensities across various HVAC system configurations

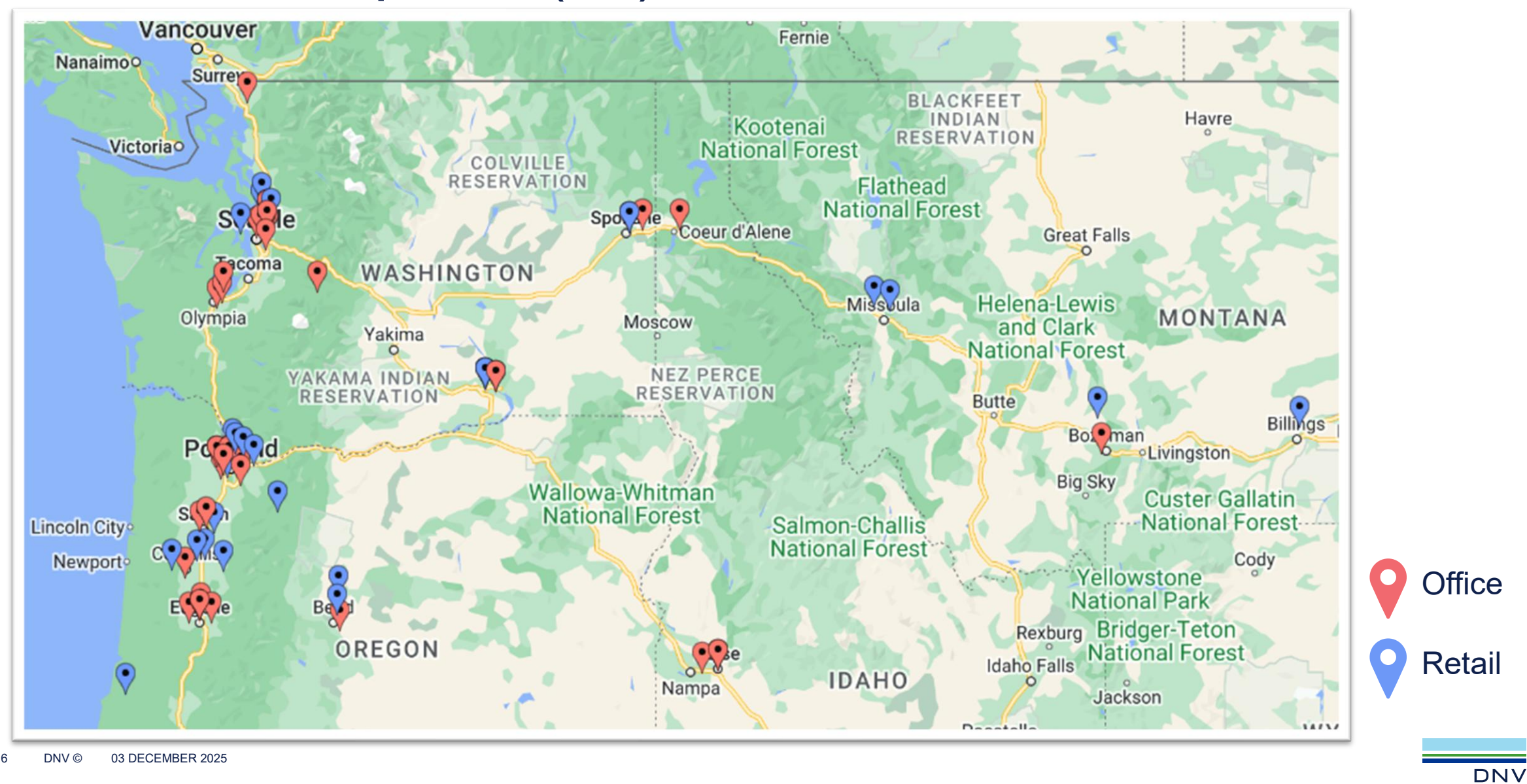
Timeline of End-Use Load Research



Meter install timeline



CEMS Participants (70)



Challenges

Recruiting

- Limited commercial building stock assessment (CBSA) soft recruits
- COVID-19
- Call center closed

Metering

- Primary electrician backed out
- Comprehensive monitoring on budget

Data reliability

- SIM cards
- Wireless sensor firmware

Participant project closeout

Solutions

Recruiting

- Expanded to include COSTAR Database
- Virtual inspections, troubleshooting, patience
- DNV hired lead call center recruiter

Metering

- Found and vetted 11 different electricians
- Pre-site inspections and dedicated staffing











Data reliability

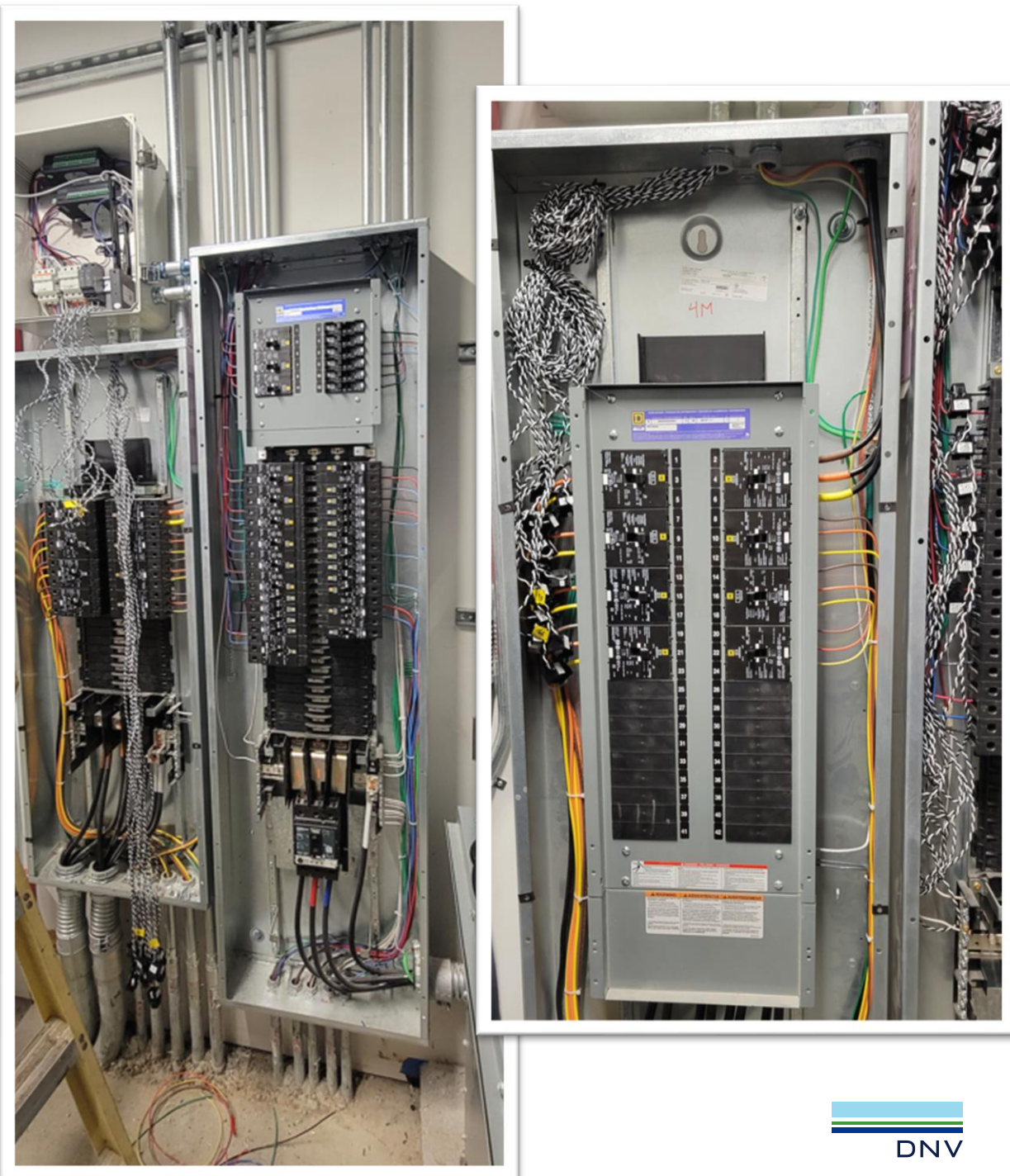
- Proactive replacements
- Lithium batteries

Custom site reports and meter benefits

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 HVAC 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



Data Quality and Assurance



Thorough meter install plans created and shared with electricians prior to install

On-site checks

- CT direction, sizing, and config
- Reference voltage
- Circuit config (voltage phase & CT alignment)
- Sample spot checks



Post-install remote meter config

Maximum kW flag



Daily timestamp accuracy check

50+ meter install photos per building



Data Continuity

- Daily meter check-ins
- Programmed fault detection warnings
- Monthly gap reports
- Dozens of outreach events to re-establish connection and backload data

	DNV Meters*	AMI	Total
Total possible readings	240 million	5.6 million	245 million
Total gap in readings	2.5 million	0.17 million	2.7 million
Additional gap from bad data	2.5 million	N/A**	2.5 million
% completeness	98%	97%	98%

*Counts are for 15-minute profiles

**Bad data from AMI was not counted in this table

Flexible Data Model

Adapted Load Research System to receive, store, and analyze CEMS data

Create interface with meters (eGauge and Monnit)

- Store 1-minute data that can be used for other applications

System has run continuously since 2019

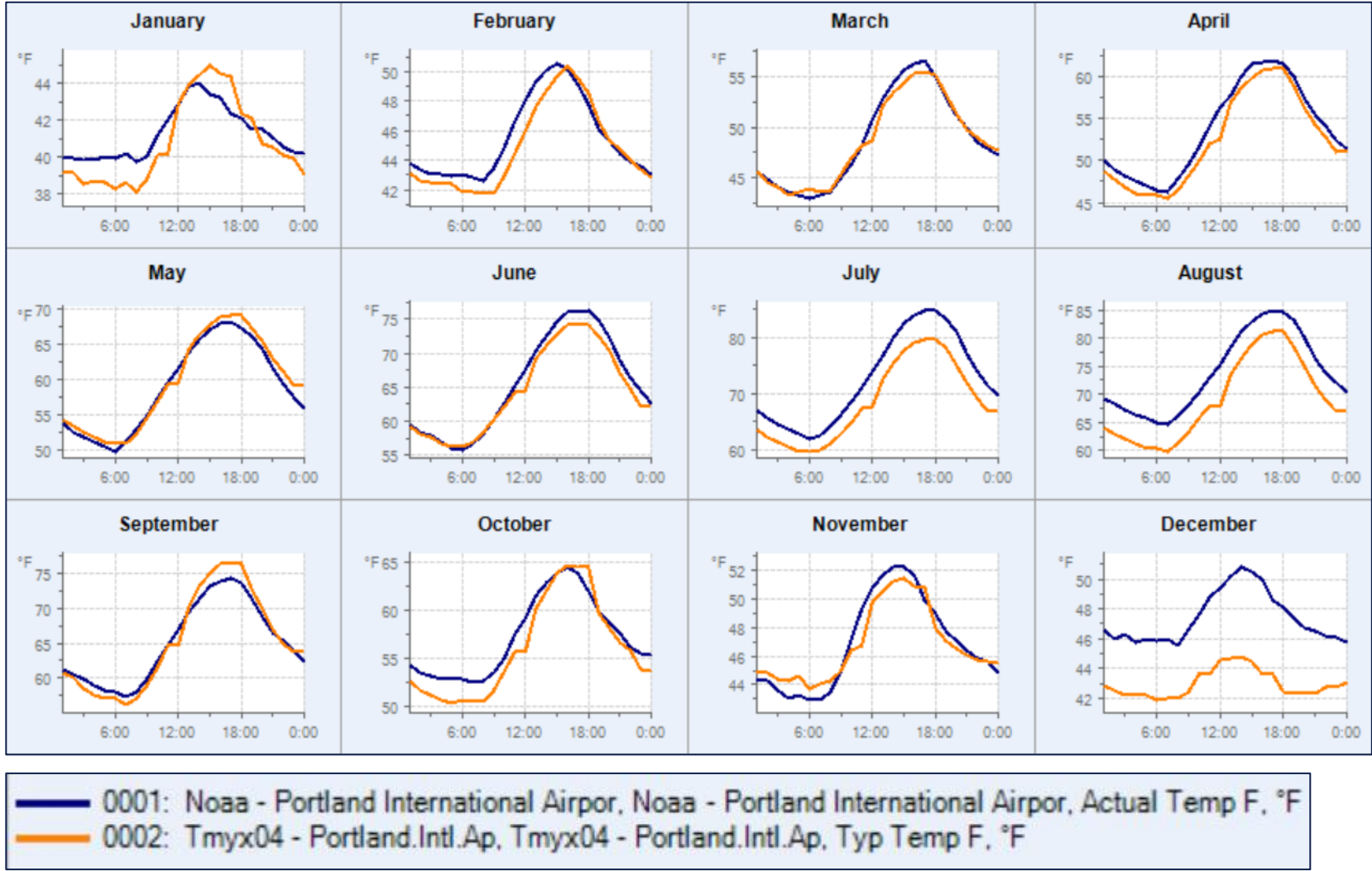
3,163,497,397 register readings stored, 150 GB of data

No gaps in the data stream

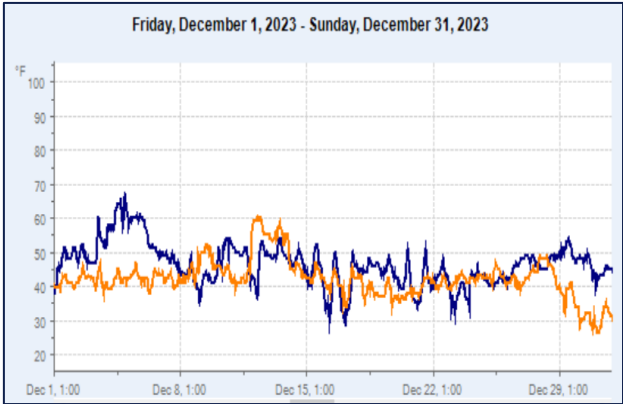
Monthly reporting data completeness & quarterly extracts of the data provided to NEAA

Flexible Data Model allows all site attributes and descriptive metadata to be stored and utilized during analysis, removing potential data issues moving between systems

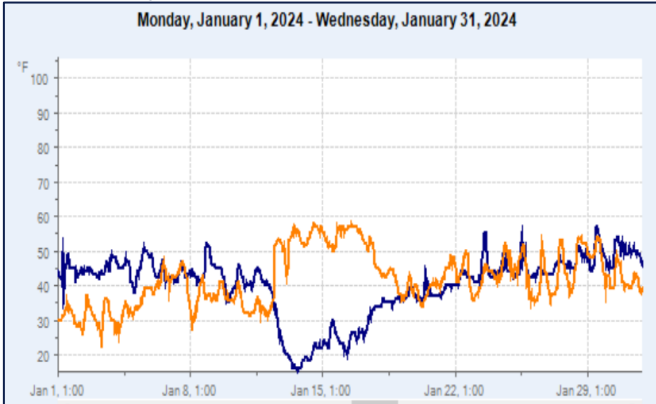
Average Daily Temperatures (Actual vs TMYx)



December 2023 Extreme Temperatures

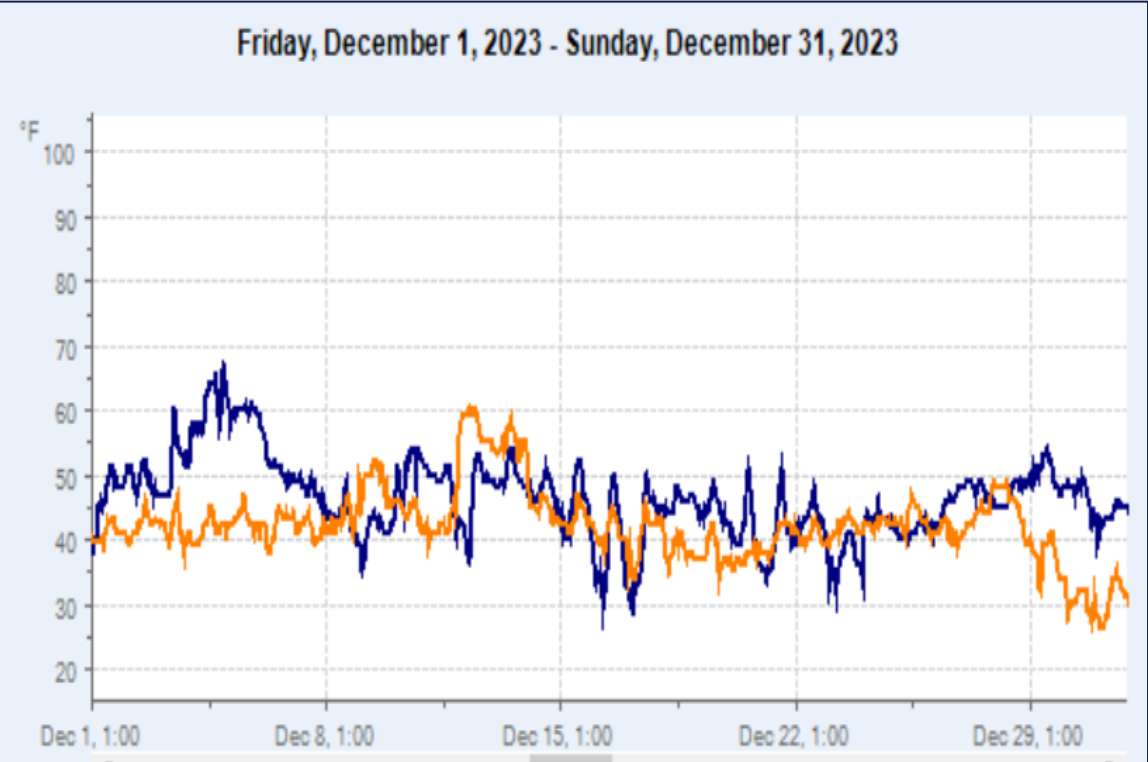


January 2024 Extreme Temperatures

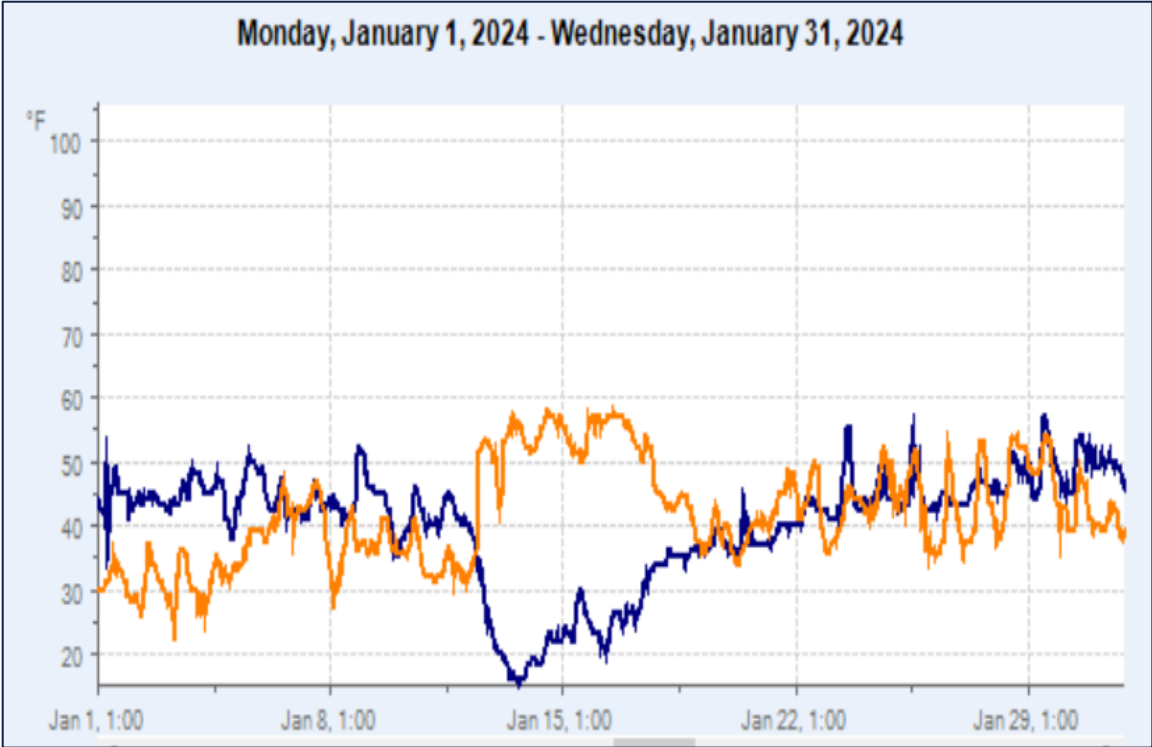


Extreme Temperatures

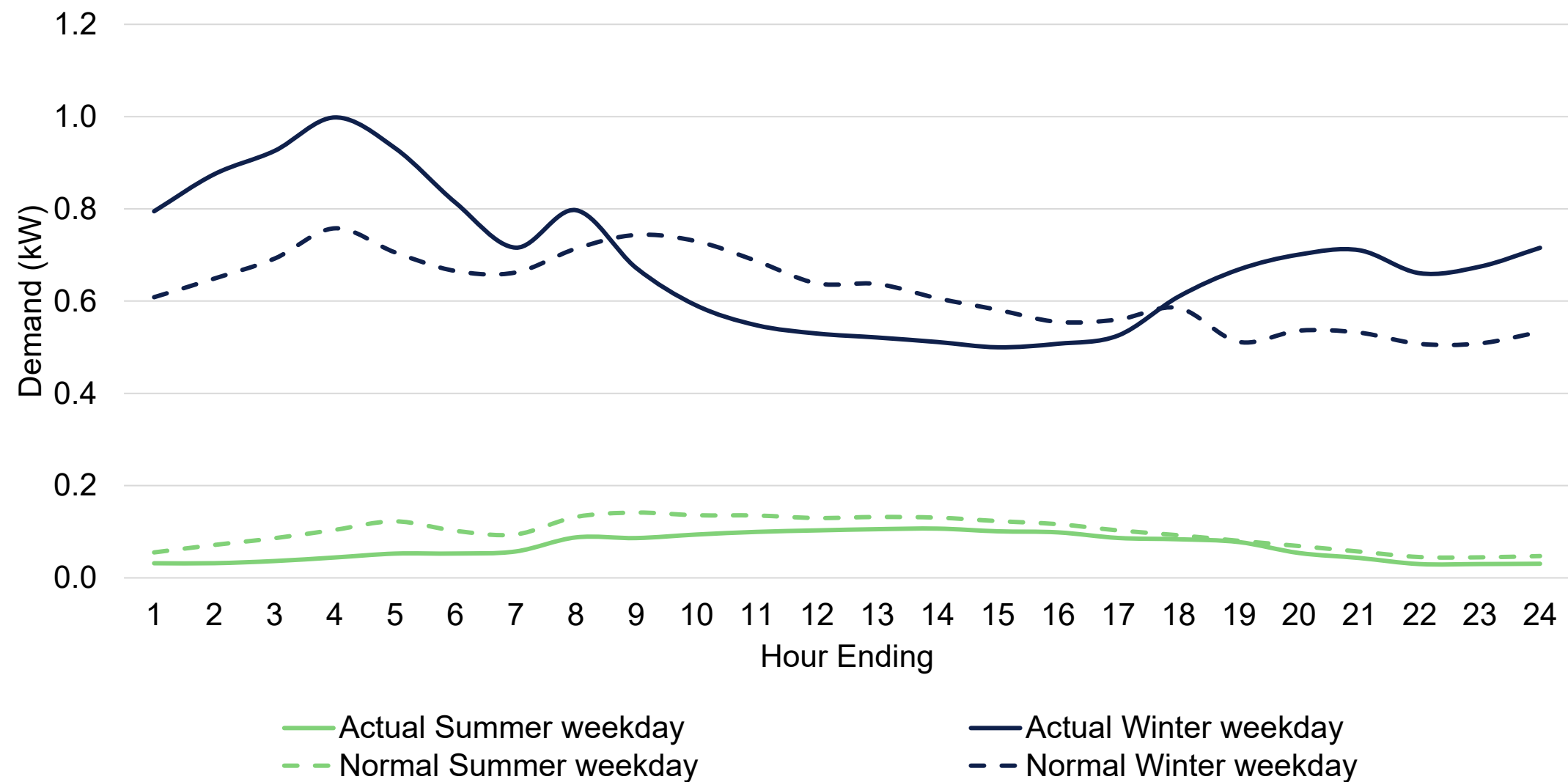
December 2023 Extreme Temperatures



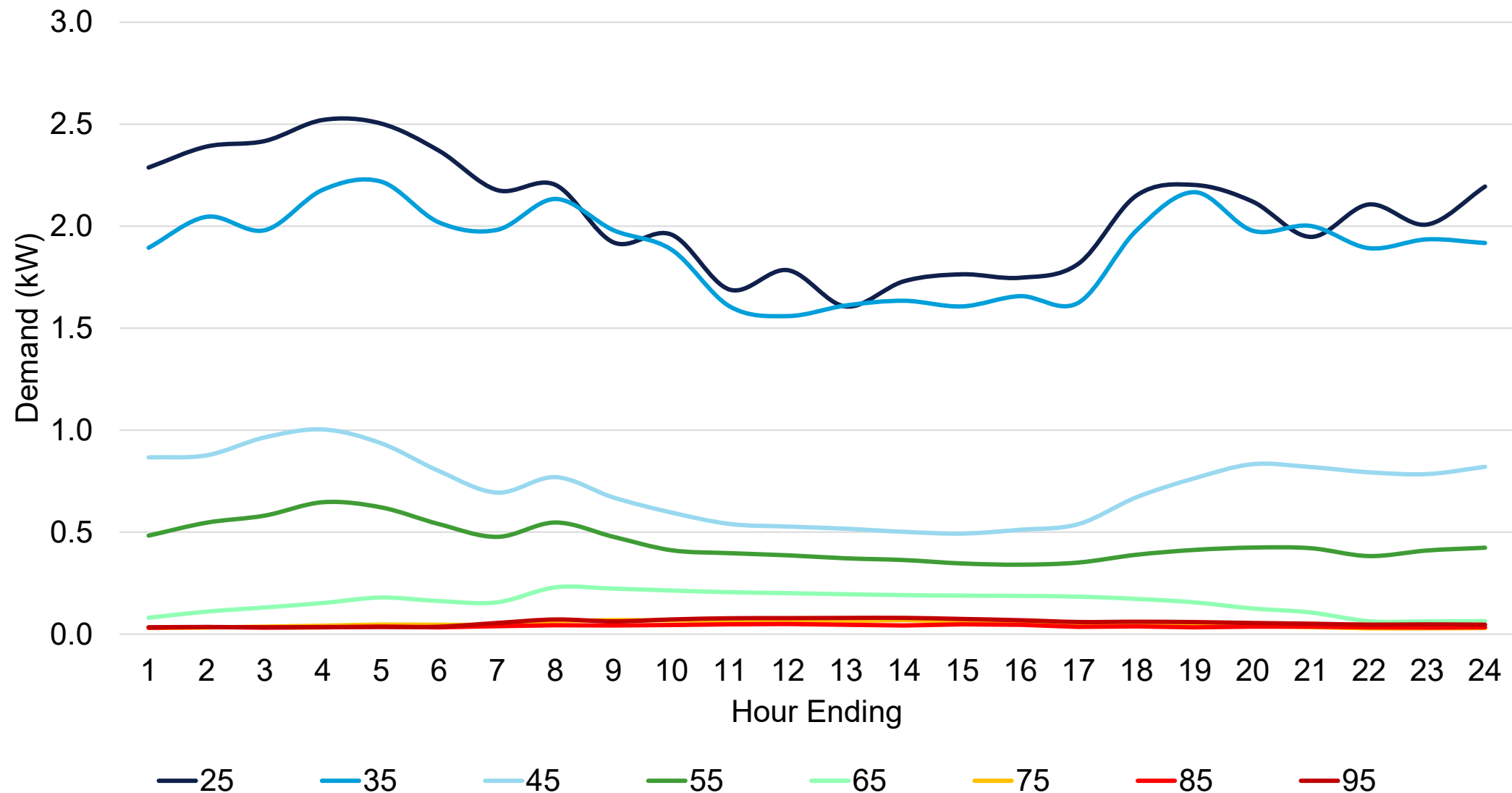
January 2024 Extreme Temperatures



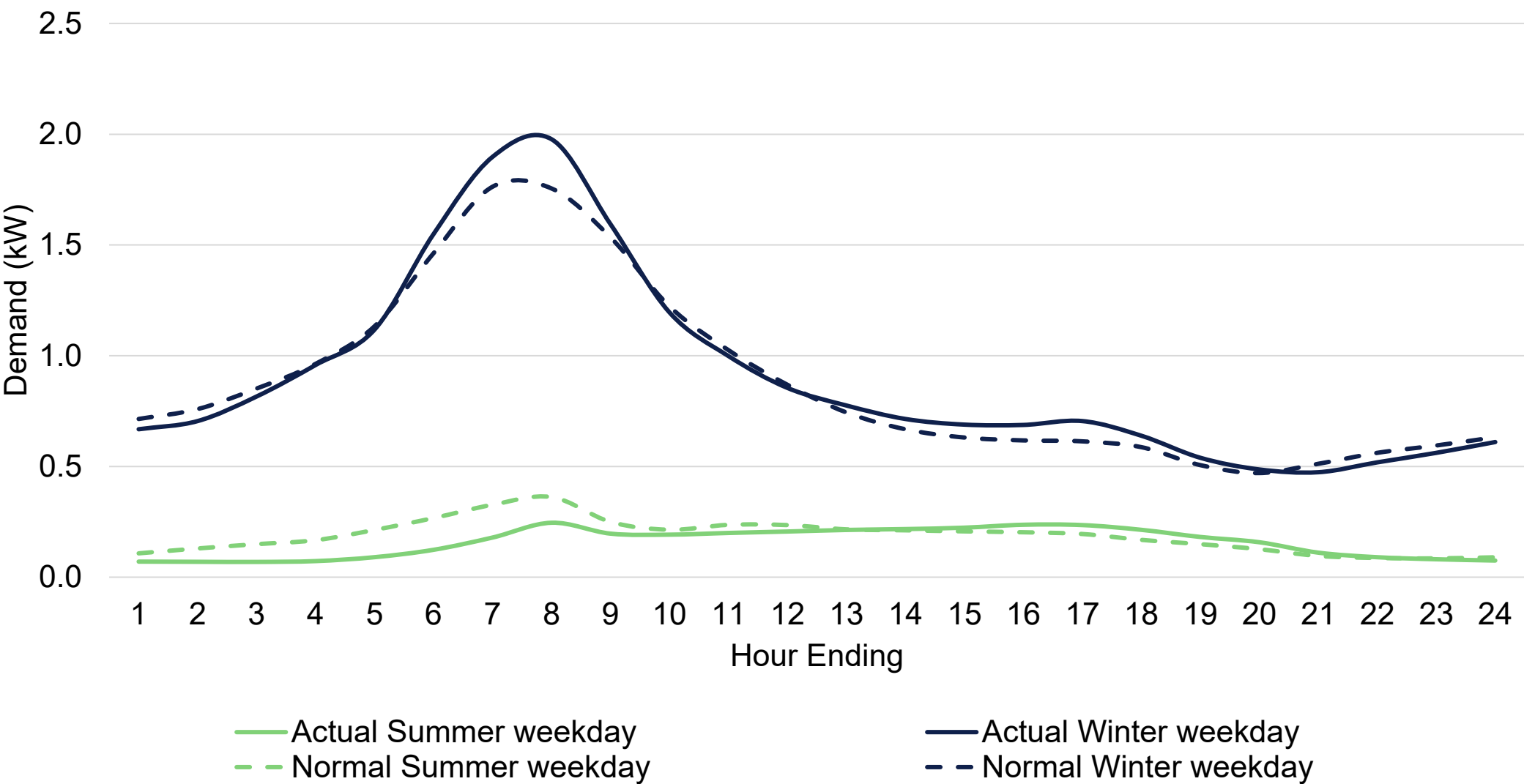
Average ERH summer and winter weekday



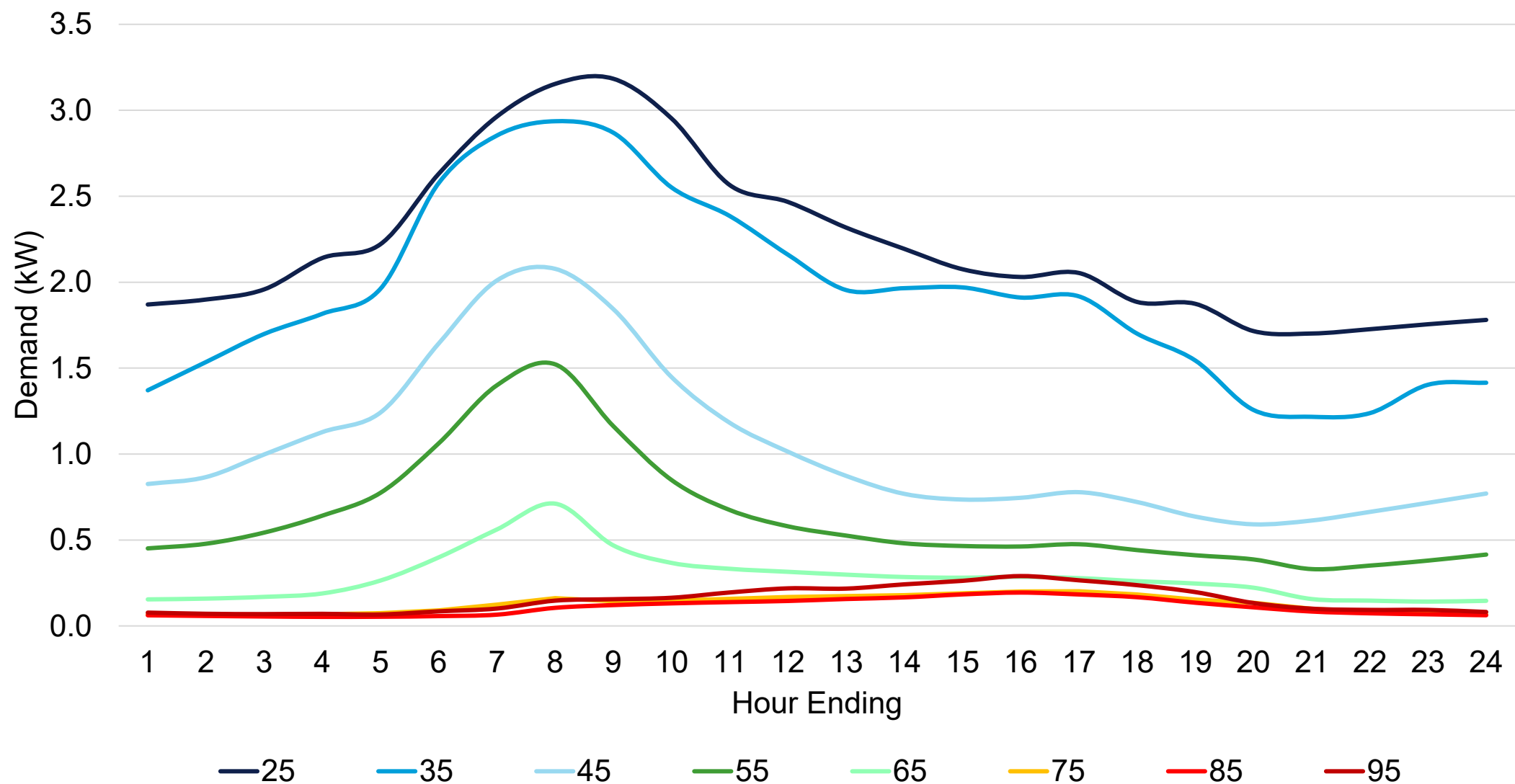
Average ERH demand by temperature gradient



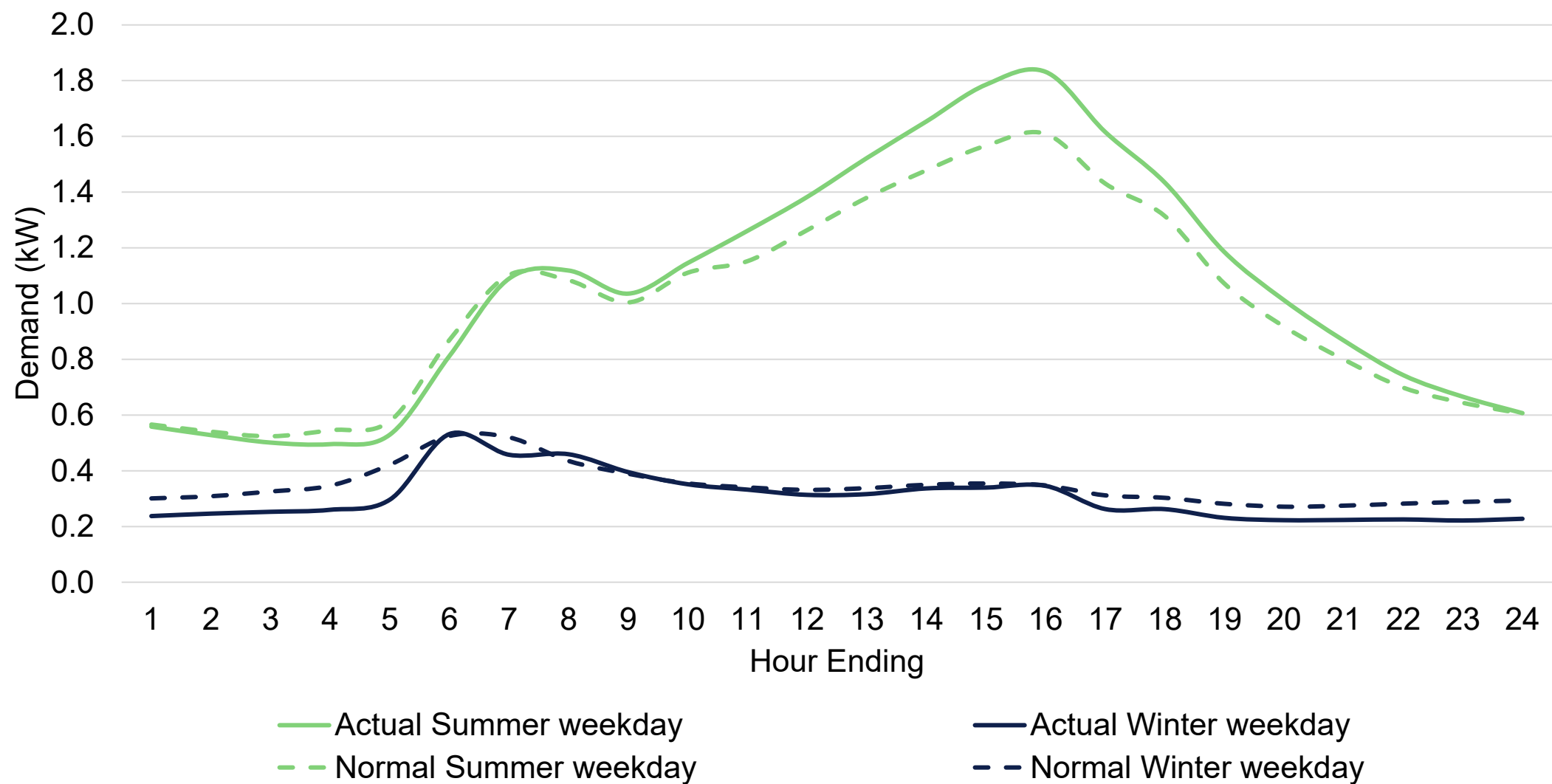
Average HP heating summer and winter weekday



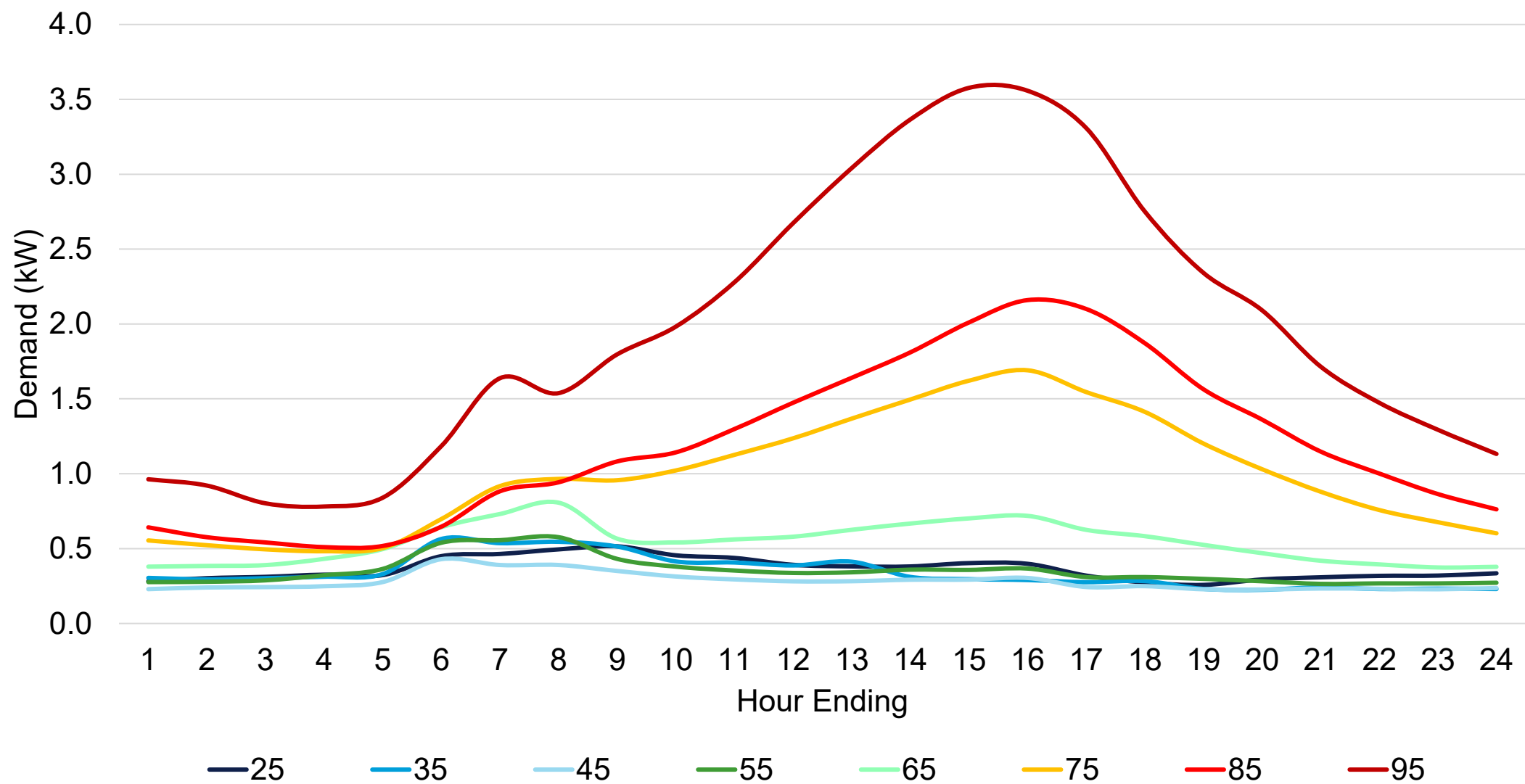
Average HP heating by temperature gradient



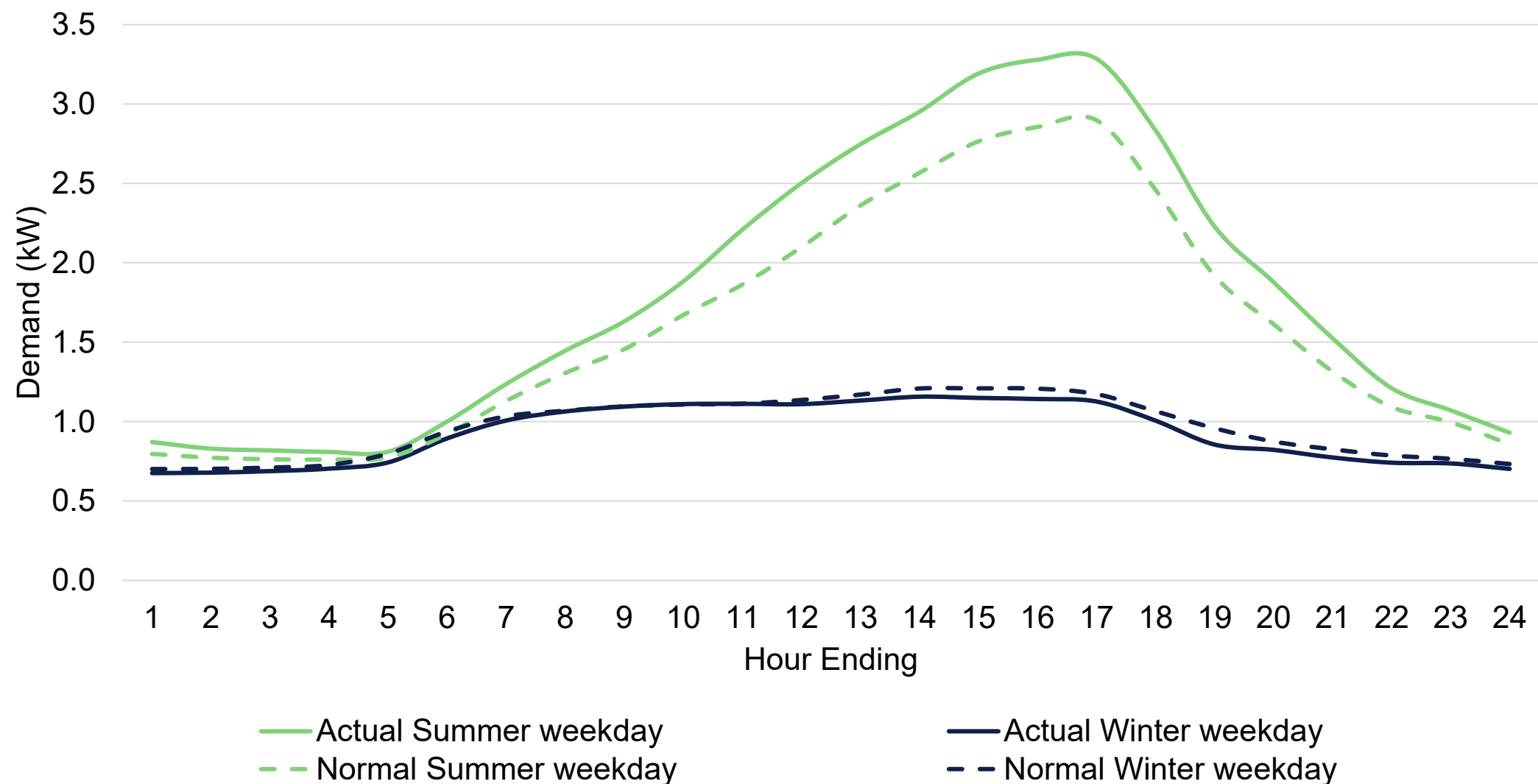
Average HP cooling summer and winter weekday



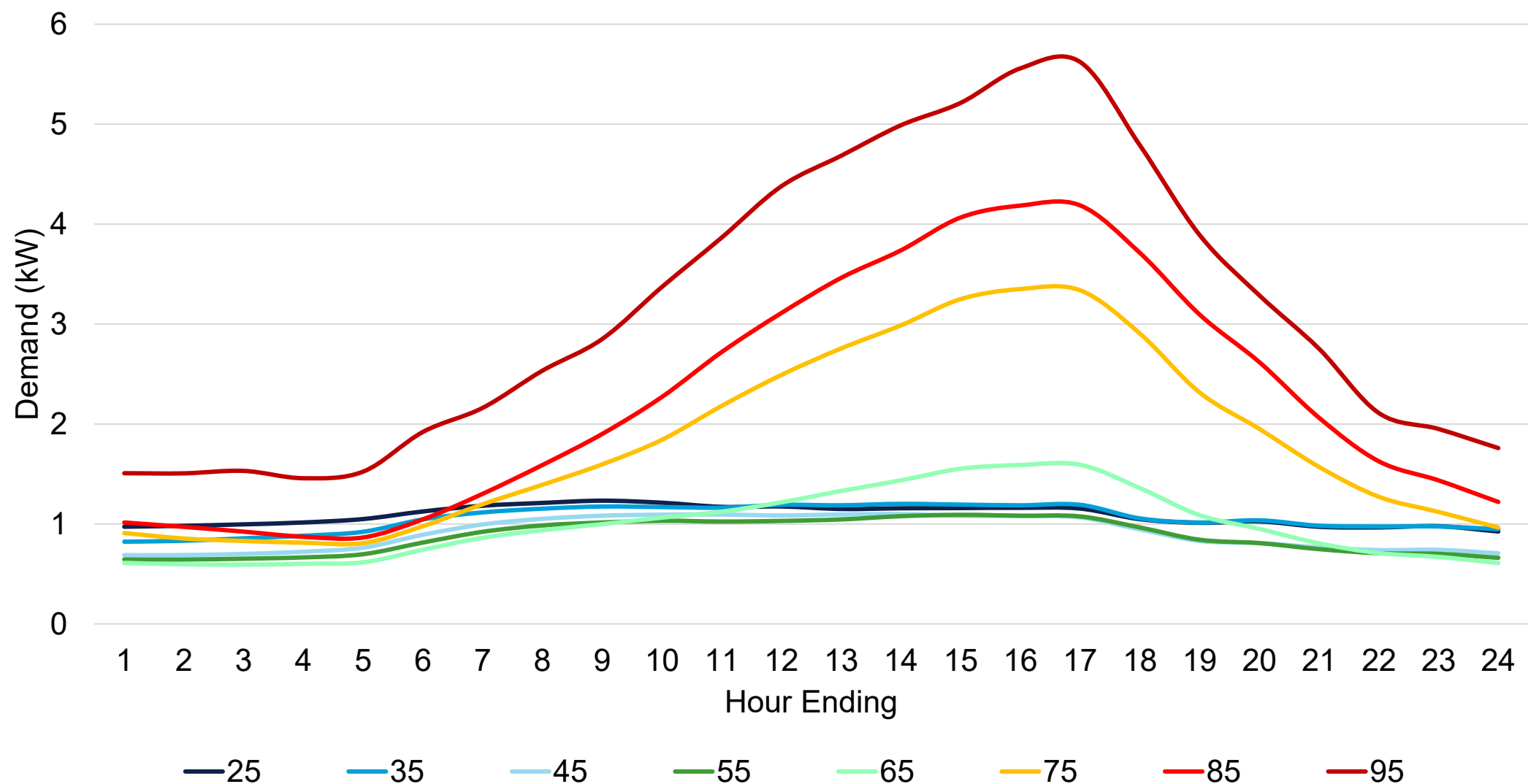
Average HP cooling by temperature gradient



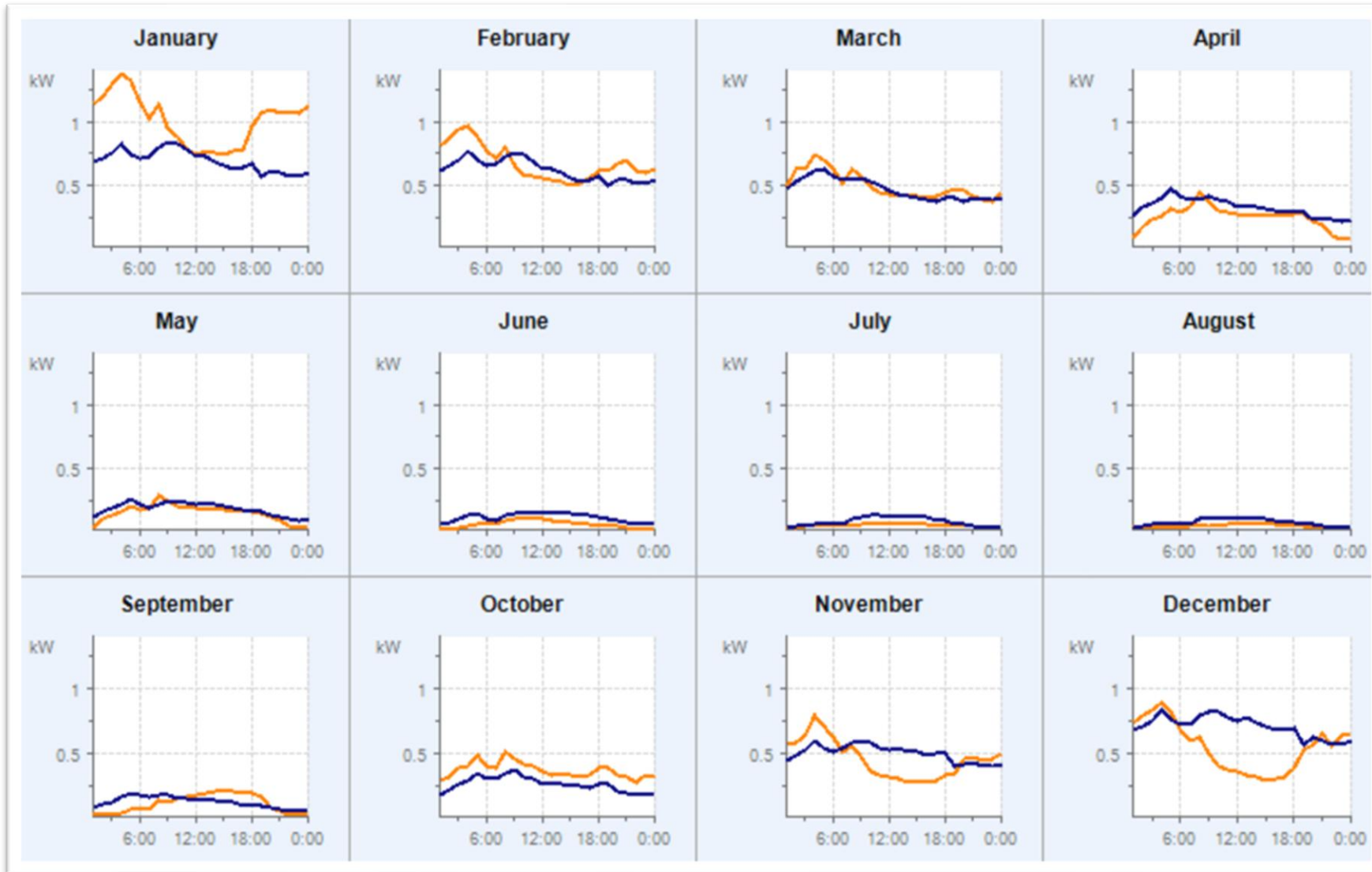
Average RTU summer and winter weekday



Average RTU by temperature gradient

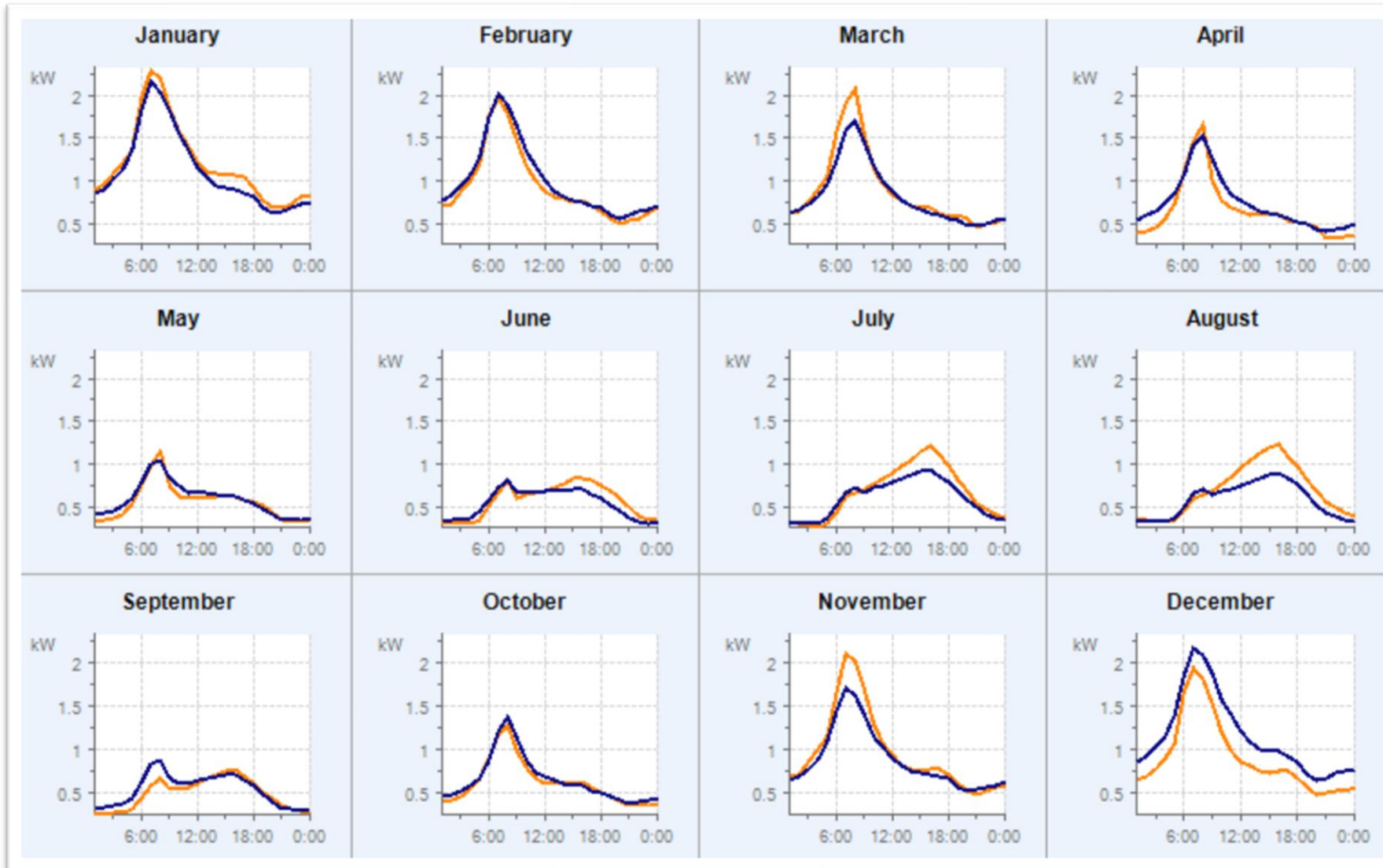


Aggregate ERH average weekday (Appendix K)



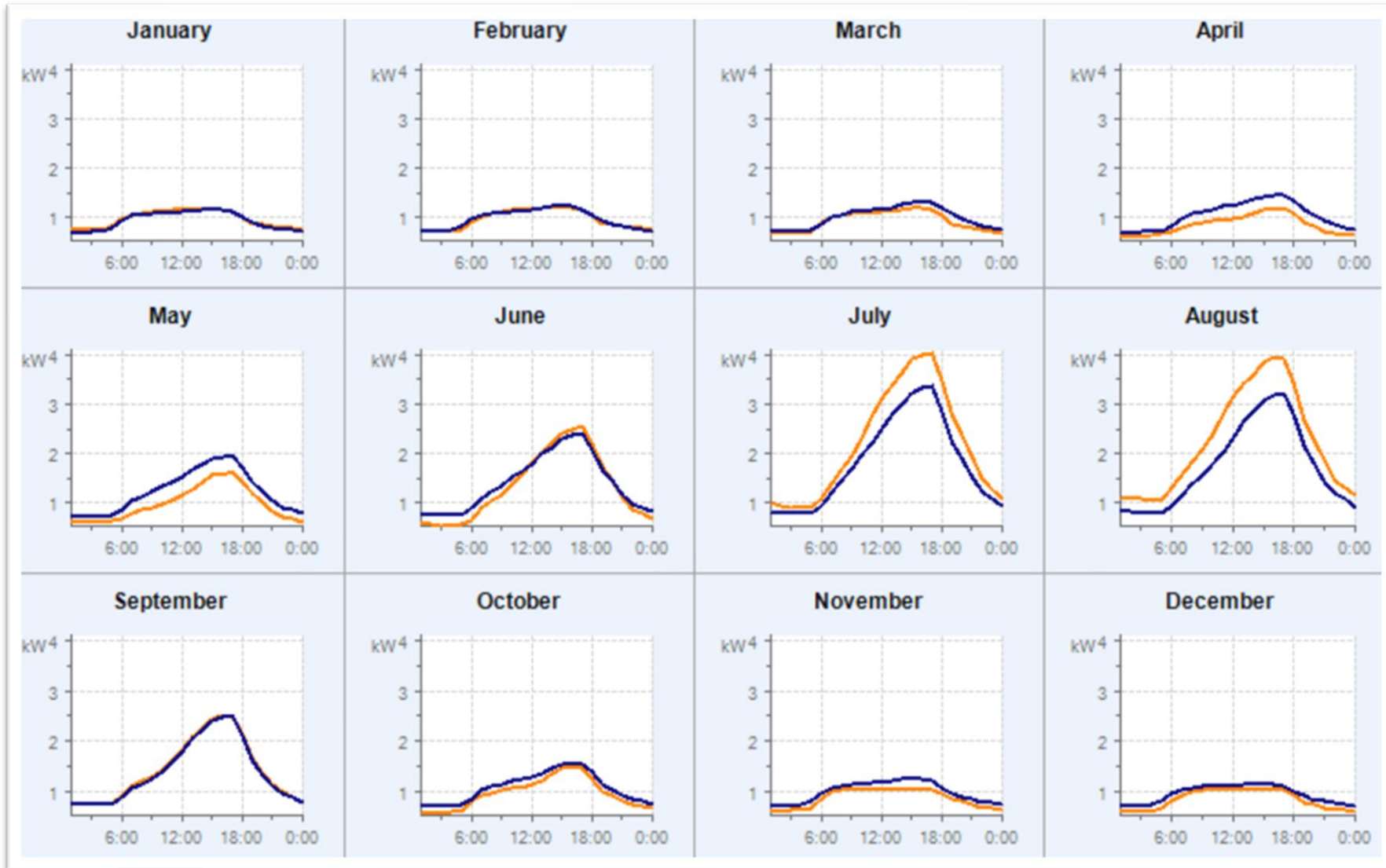
— Metered actual
— Normalized

Aggregate heat pump average weekday (Appendix K)



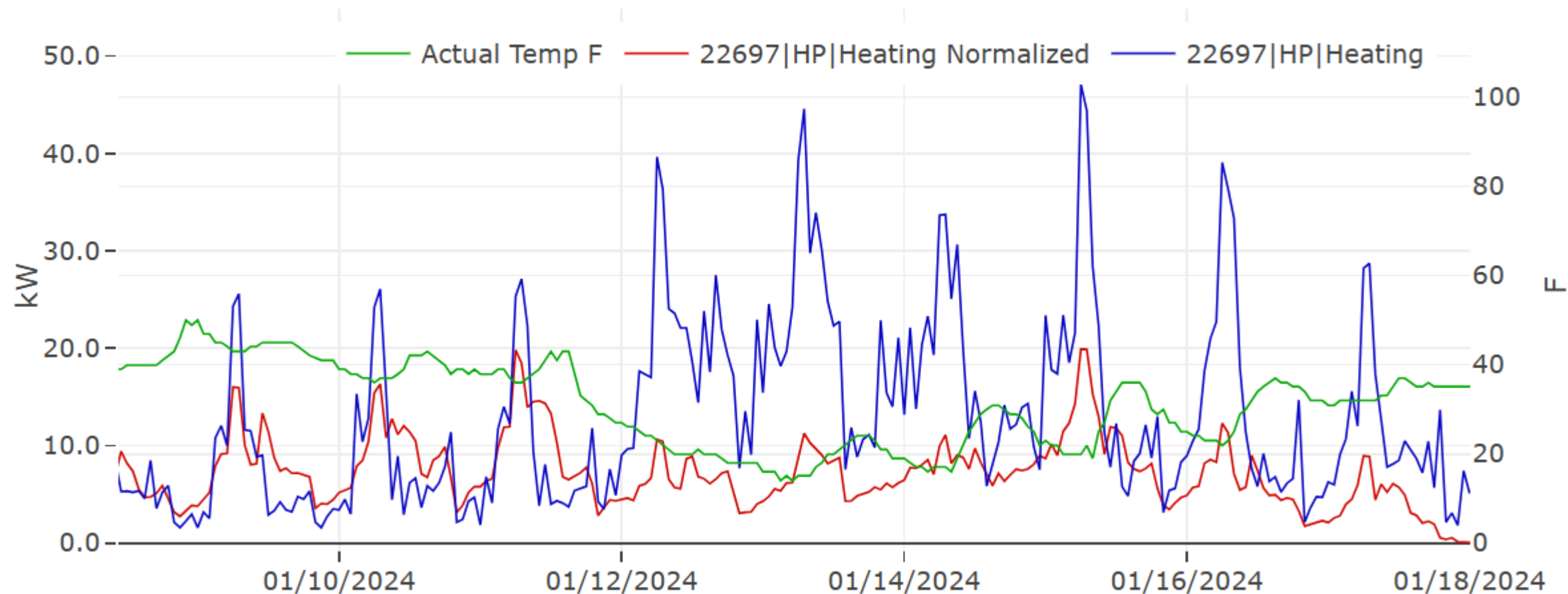
— Metered actual
— Normalized

Aggregate RTU average weekday (Appendix K)

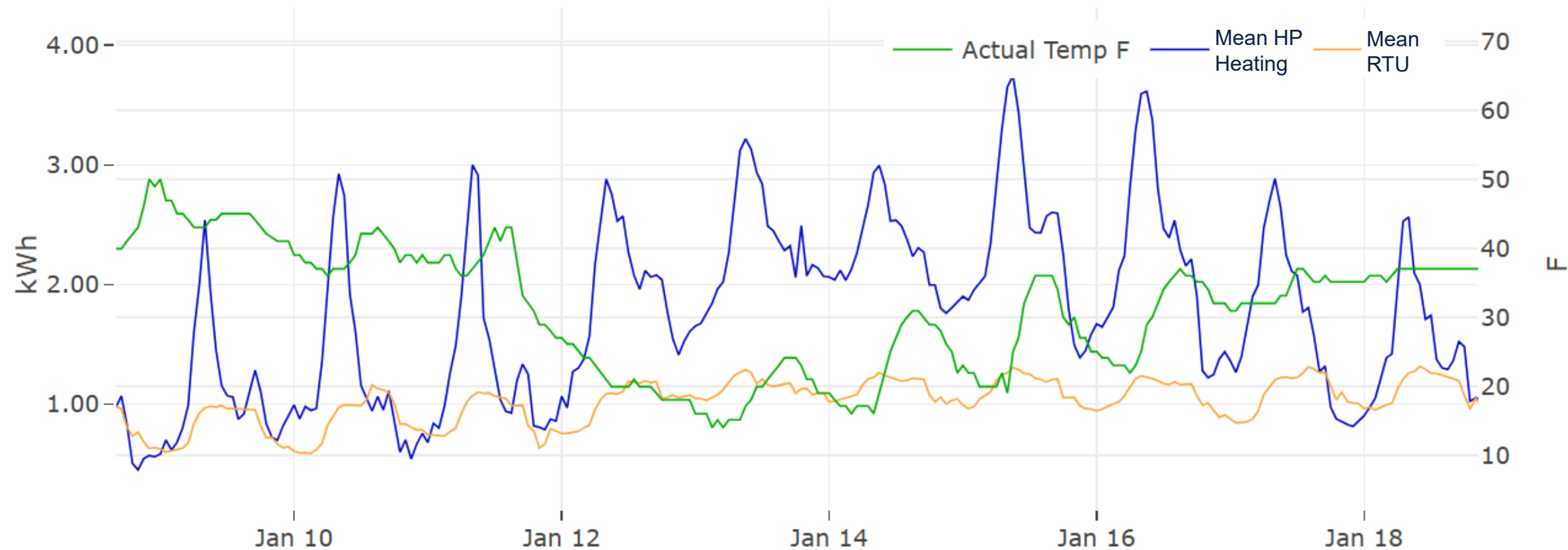


— Metered actual
— Normalized

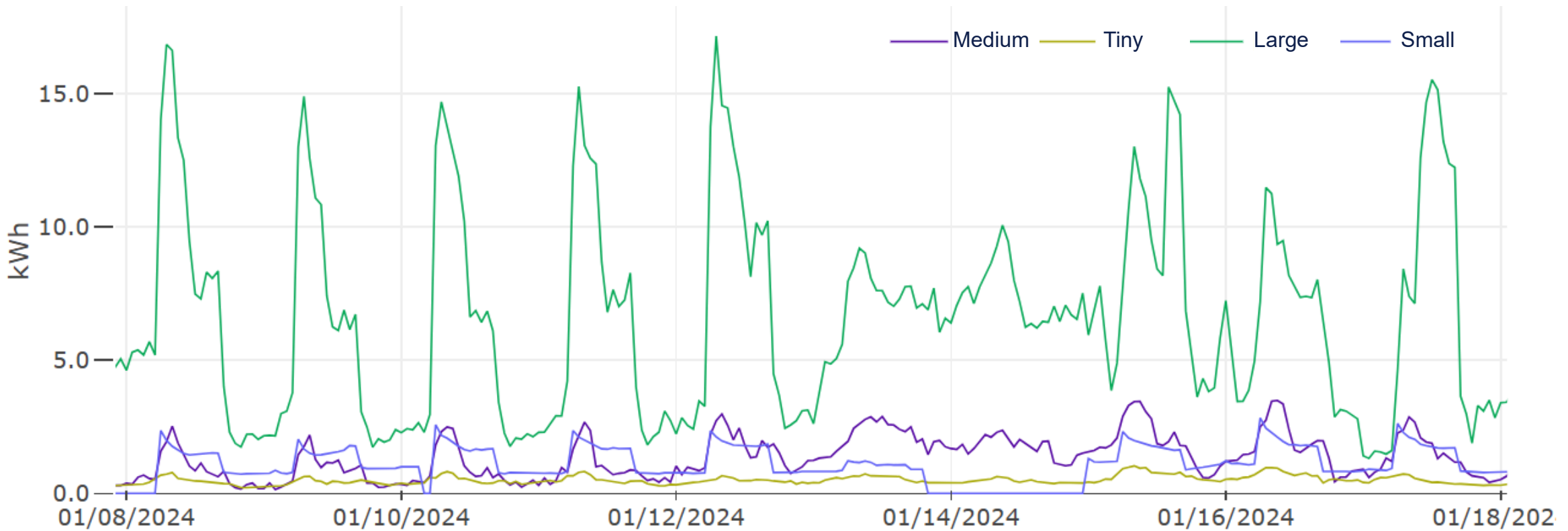
Heat Pump Heating – Single site cold snap



Overall HP Heating vs. RTU during cold snap



HP Heating Overall office usage by building size



Future CEMS applications

Increasing EE

- Confident updates to prior load shapes
- Retro-commissioning opportunities
- ERH to HP conversion opportunities

Demand Forecasting

- 8760 electrification impacts across weather zones
 - Extreme weather impacts
 - Compatibility with future weather data models

Demand Response

- Guide program design
- End-use weather dependency
- AMI assisted DR outreach opportunity

In Memoriam – Curt Puckett

- ☀ 40+ years in utility industry
- ☀ Co-founded RLW Analytics in 1990 (now DNV)
- ☀ Key developer of Load Research System (now Flexible Data Model)
- ☀ Key end use load data and load research advisor across US
- ☀ Served as Load Research Lead for CEMS through July of 2025
- ☀ Brought joy wherever he went



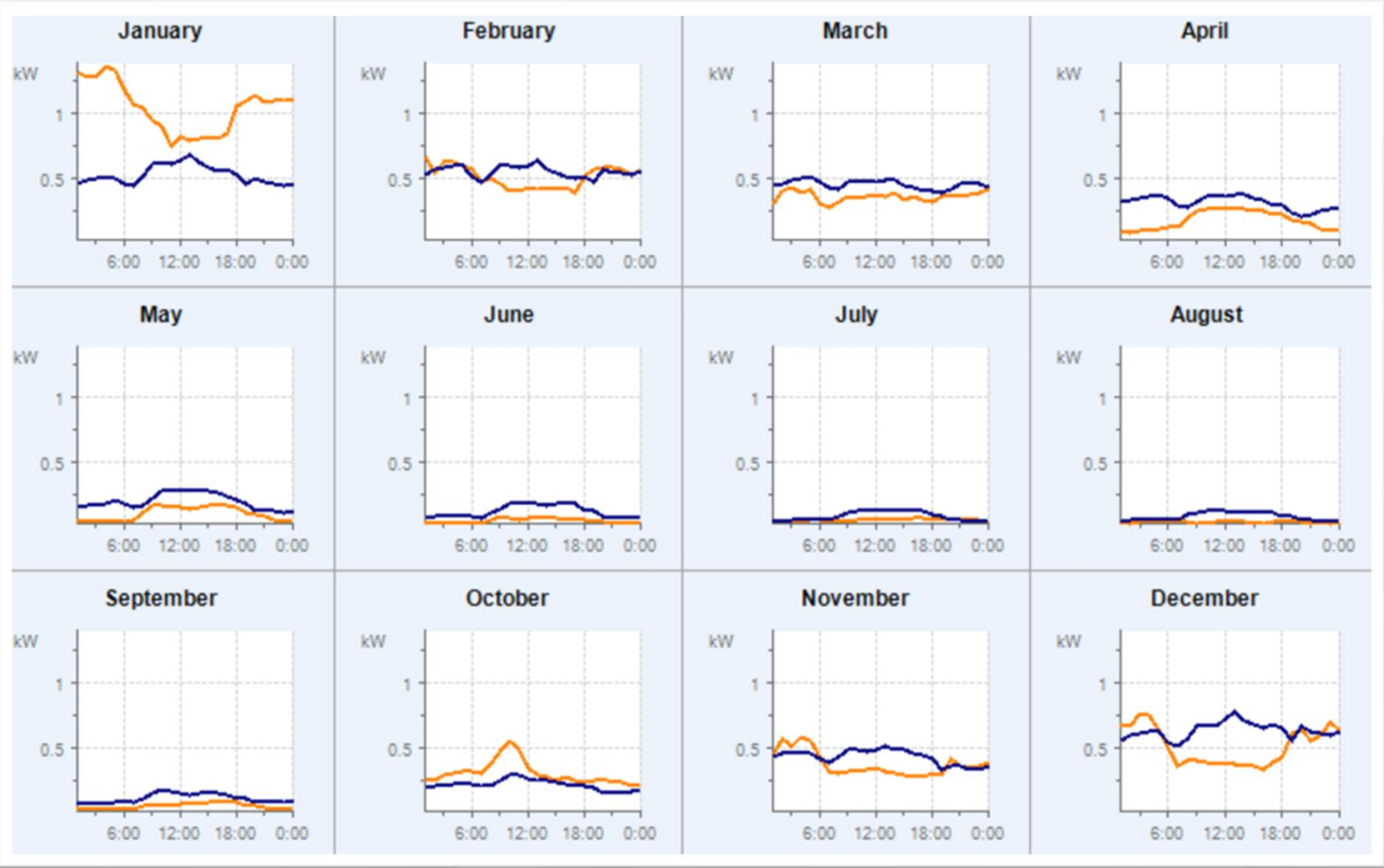
Questions?

Thanks

Contact info:

kevin.cracknell@dnv.com

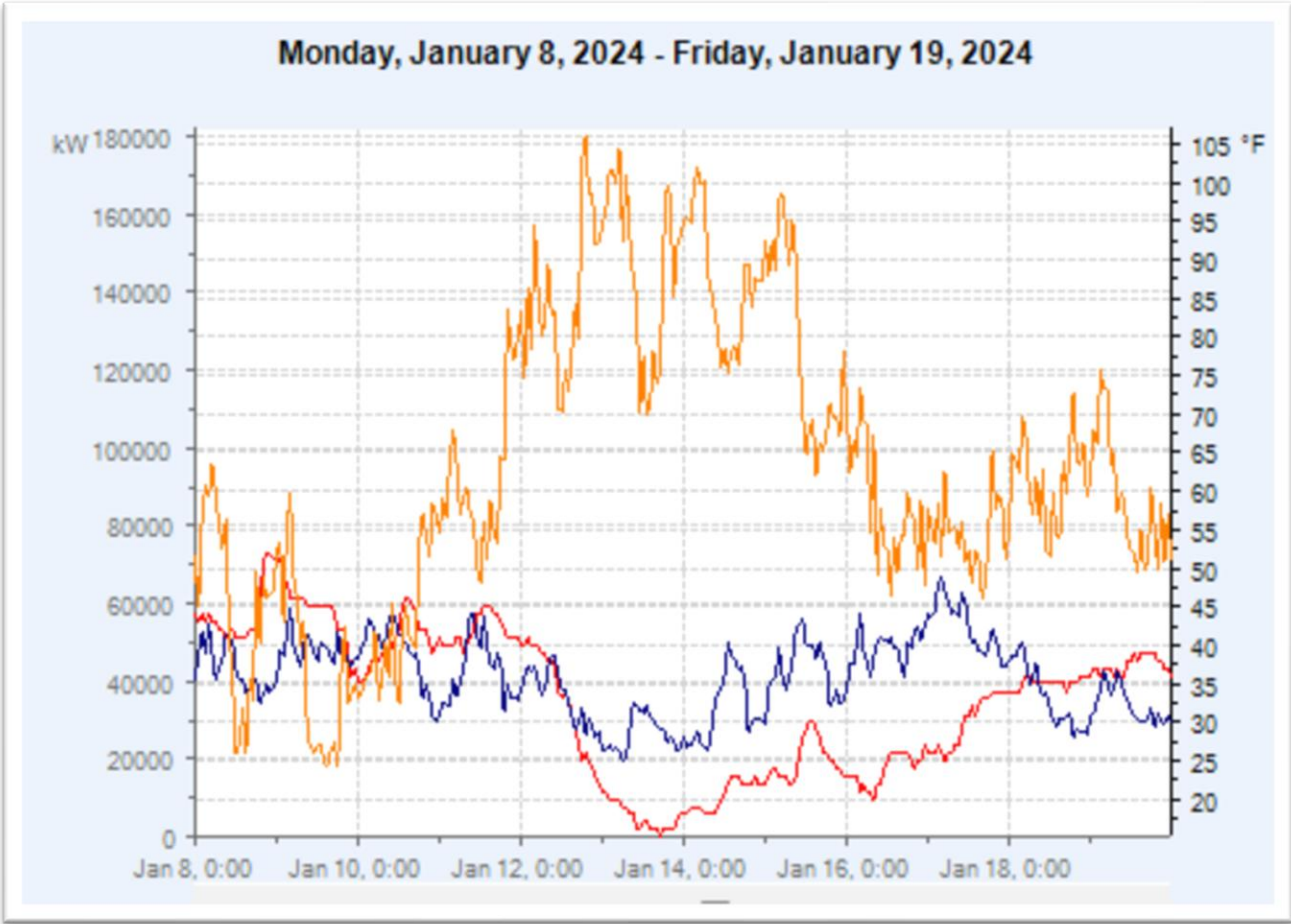
Aggregate ERH average weekend (Appendix K)



— Metered actual

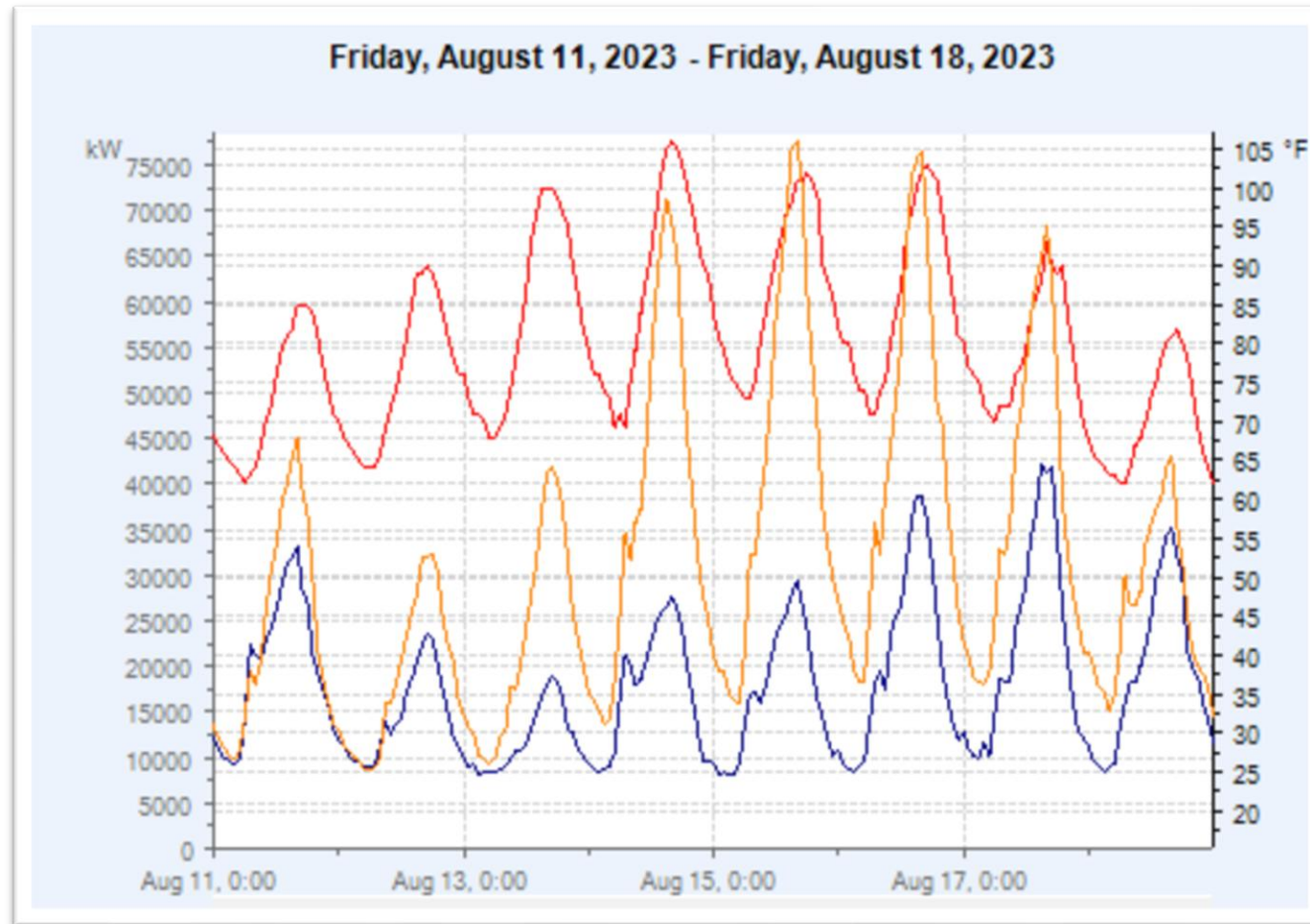
— Normalized

Extreme Temperature Response



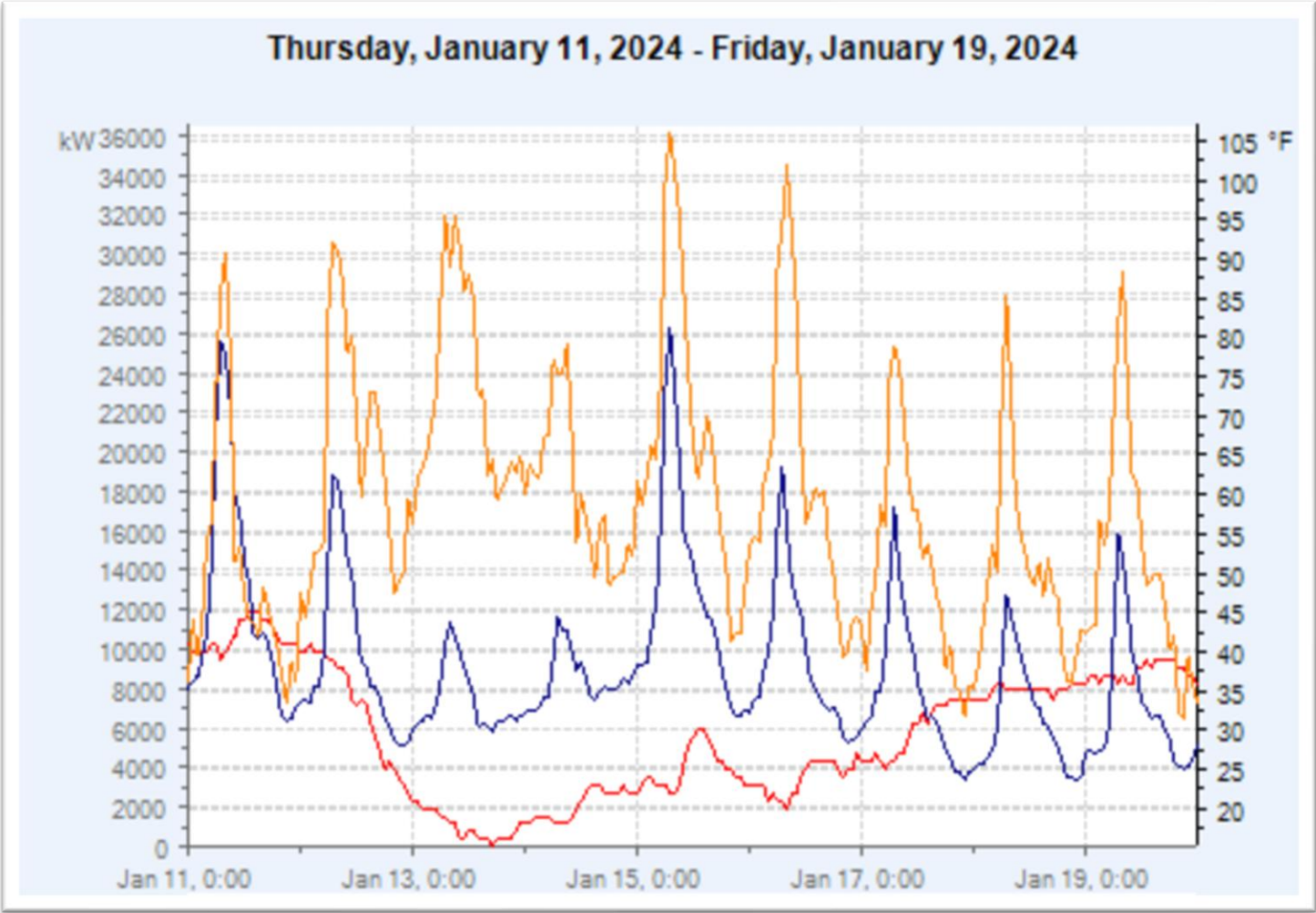
_____ Actual _____ Normal _____ Actual Temp

Heat Pump Cooling



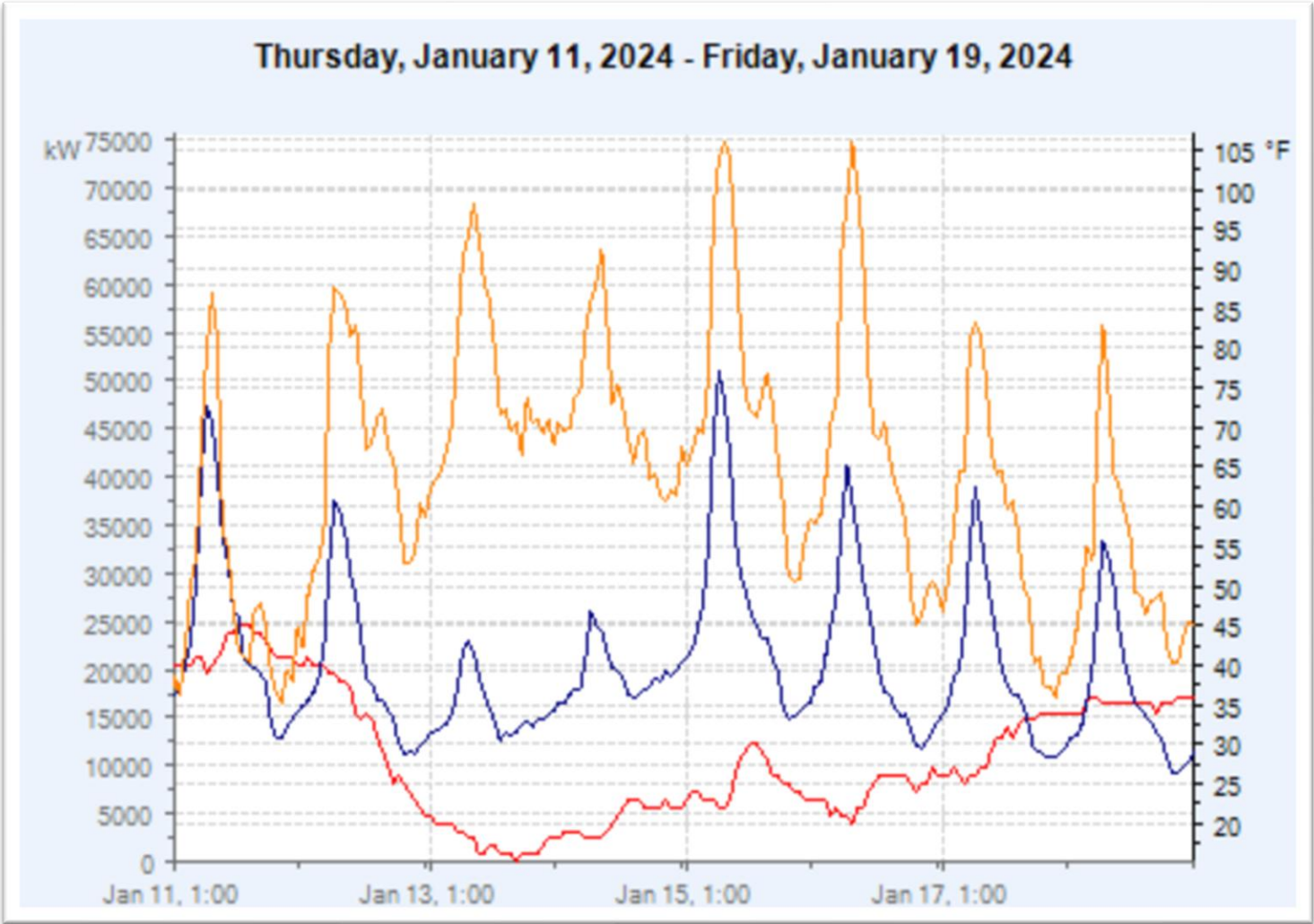
_____ Actual _____ Normal _____ Actual Temp

Heat Pump Heating



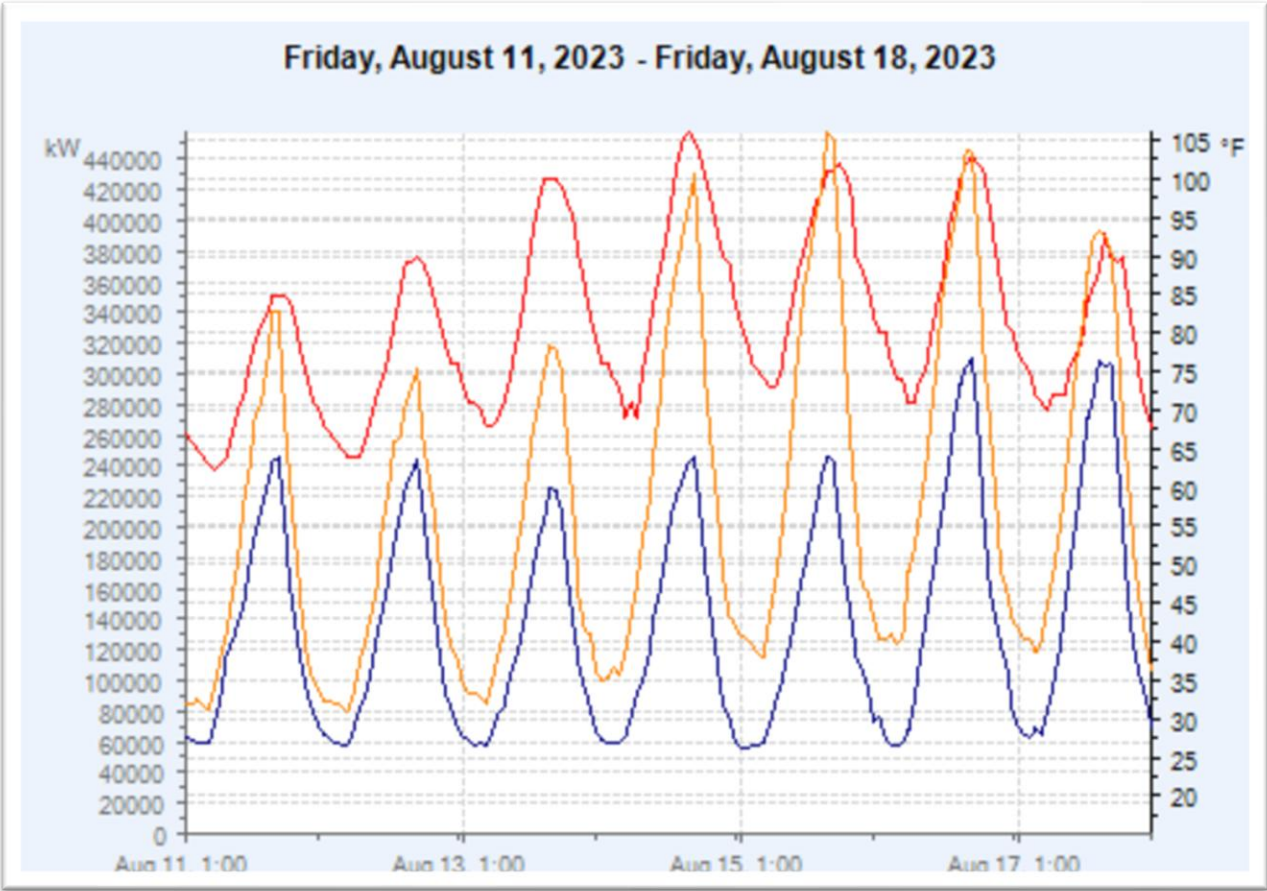
_____ Actual _____ Normal _____ Actual Temp

Heat Pump Total



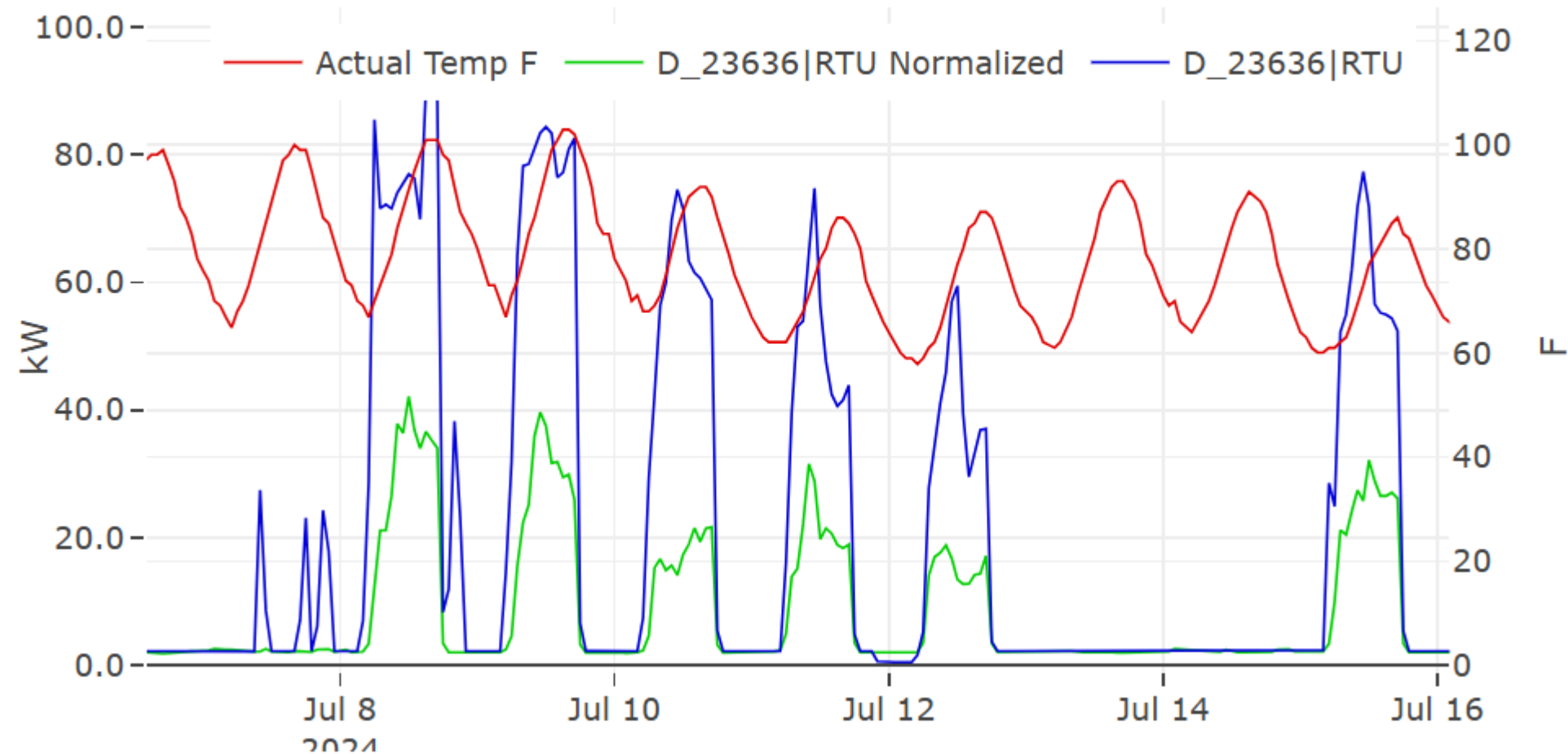
— Actual — Normal — Actual Temp

RTU – Summer Extreme Temperatures

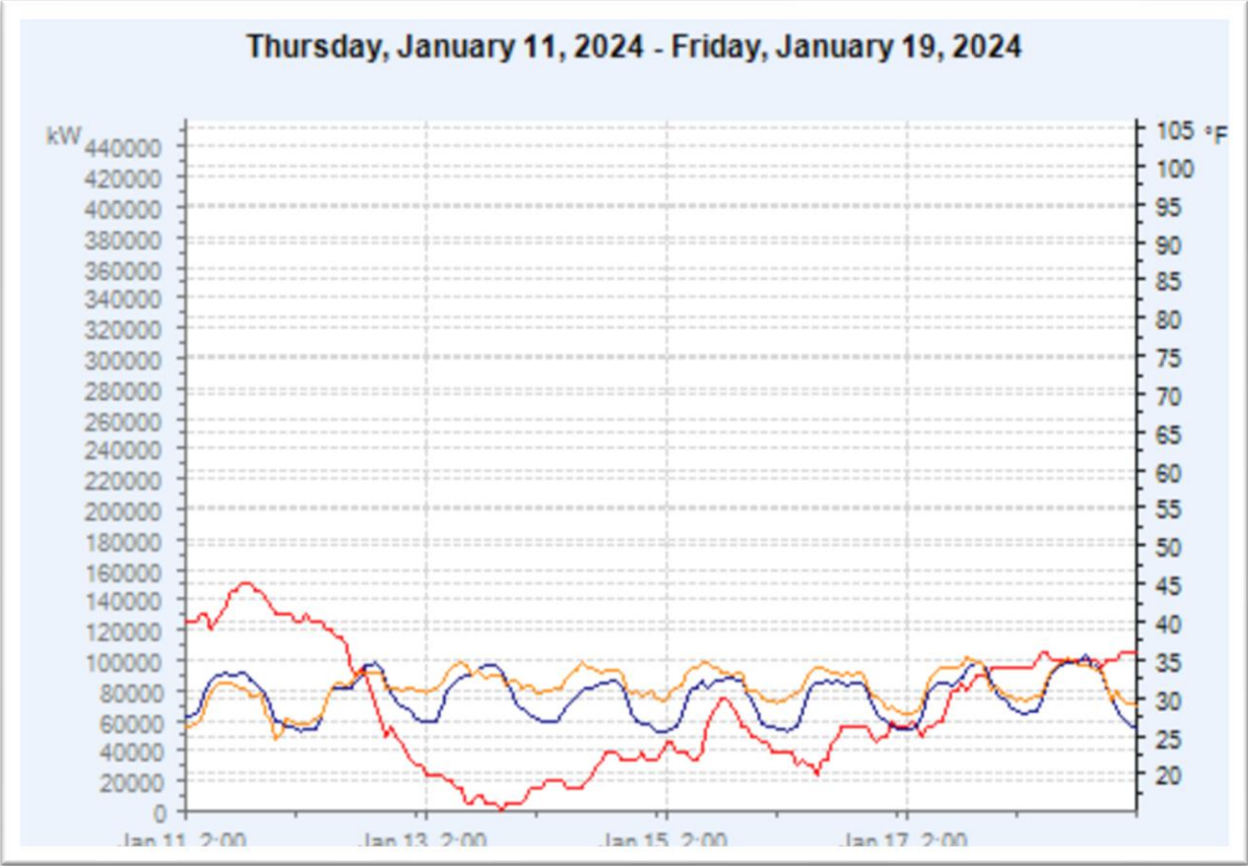


— Actual — Normal — Actual Temp

RTU – Summer Extreme Temperatures

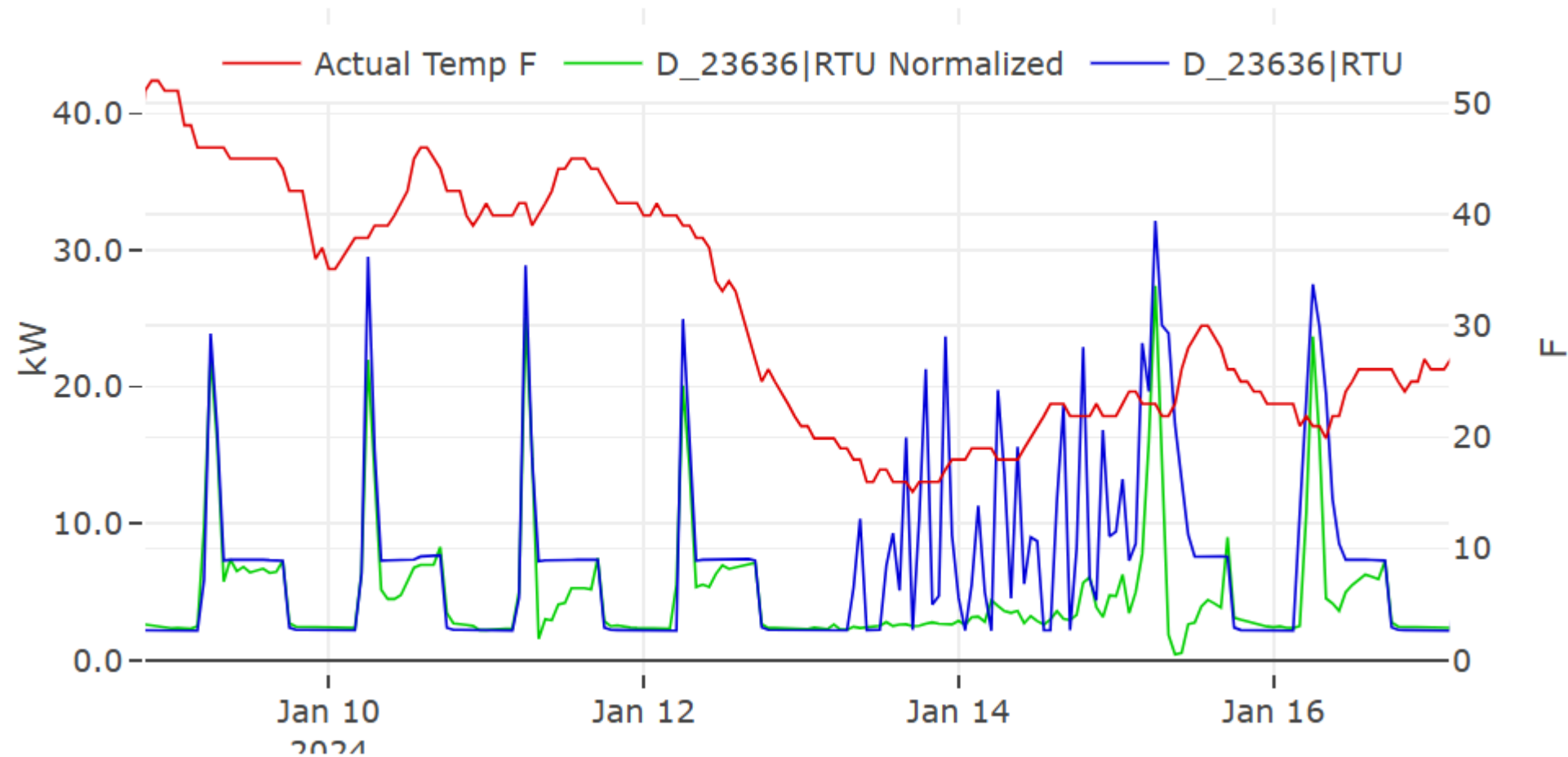


RTU – Winter Extreme Temperatures

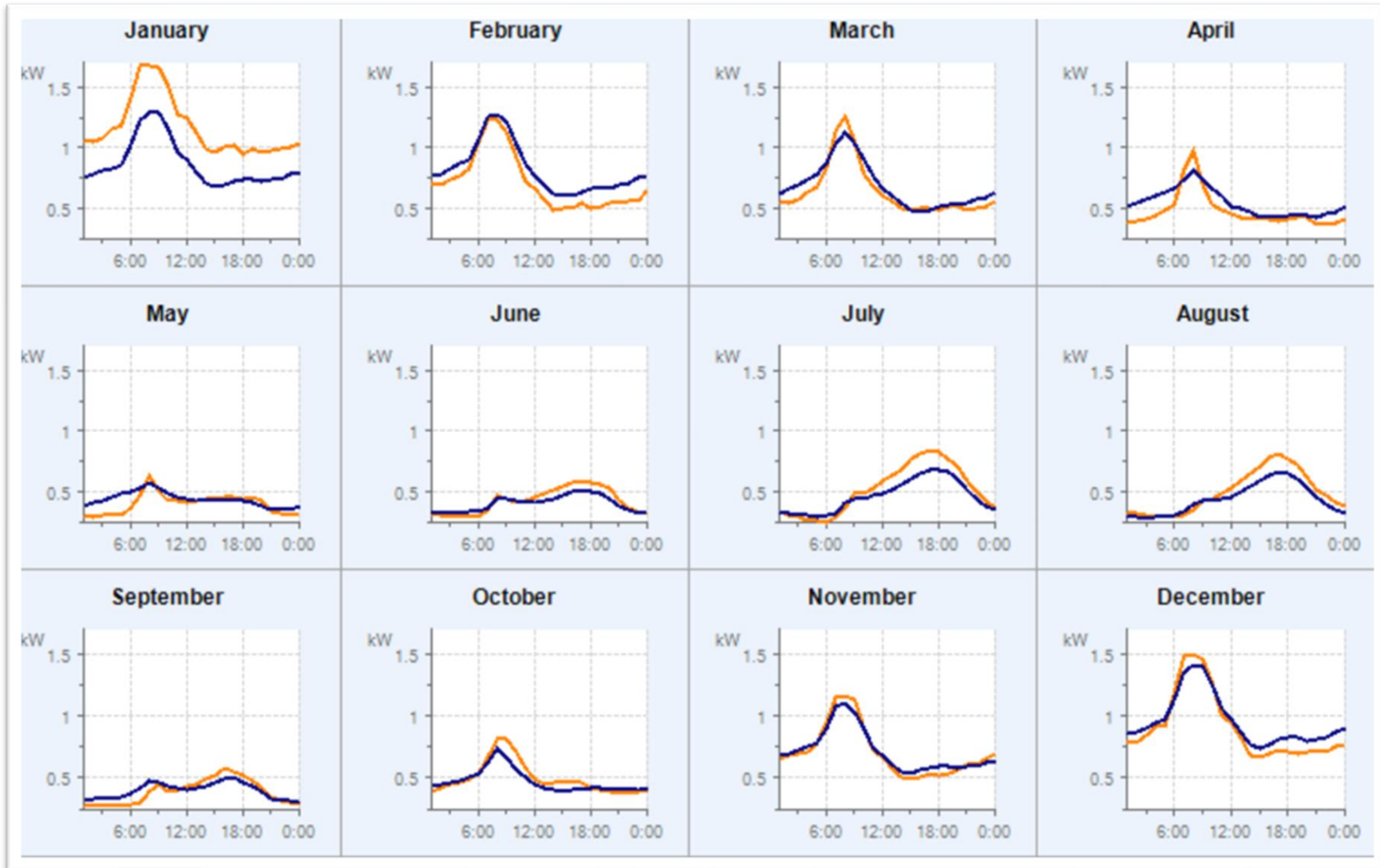


____ Actual ____ Normal ____ Actual Temp

RTU – Winter Extreme Temperatures

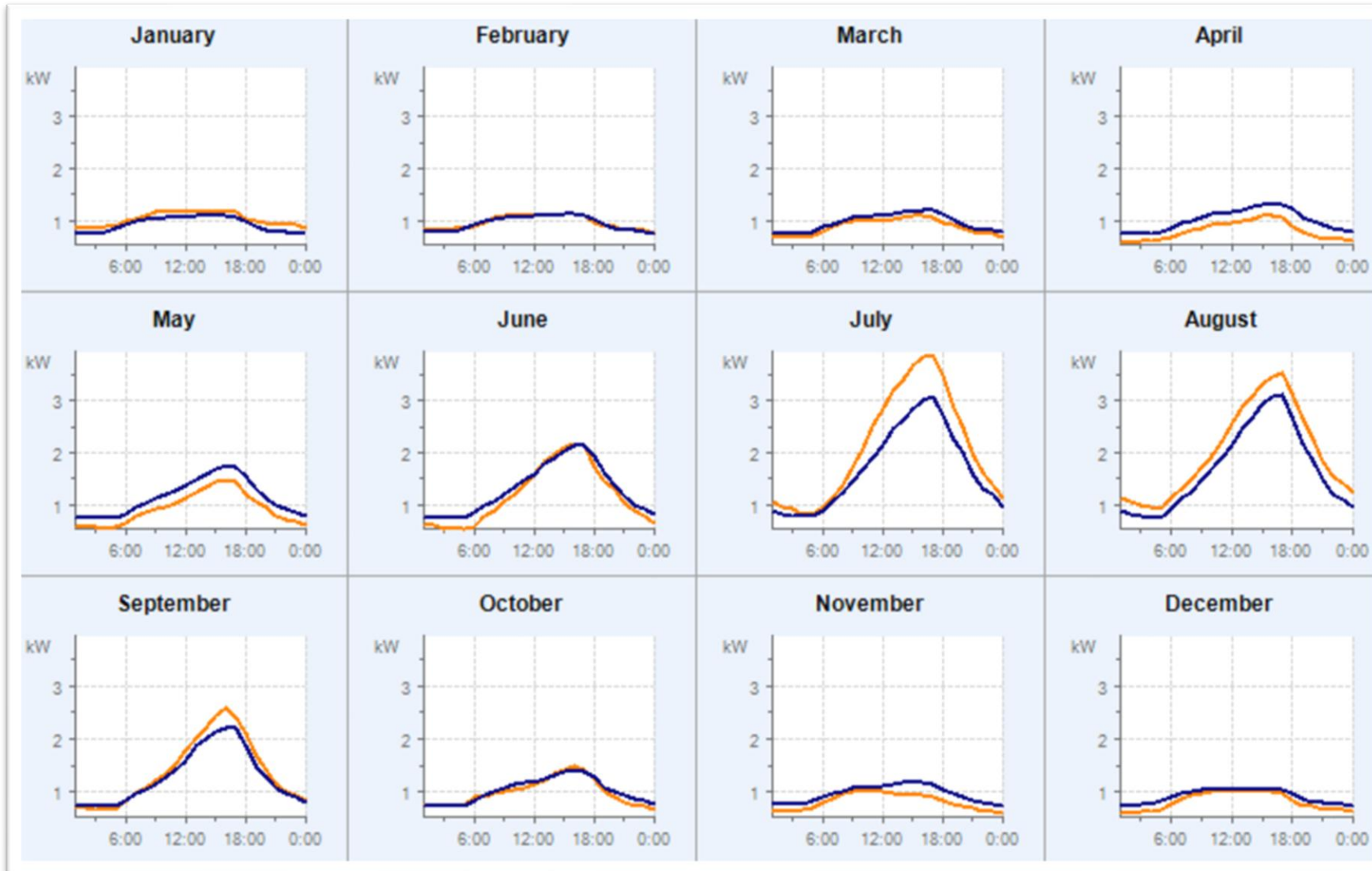


Aggregate heat pump average weekend (Appendix K)



— Metered actual
— Normalized

Aggregate RTU average weekend (Appendix K)



— Metered actual

— Normalized