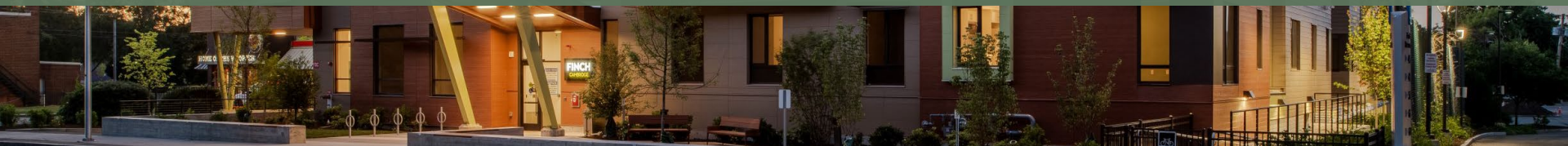




PHMass Symposium  
December 10, 2024

# Performance Data and Building Operations



# Objectives

## Presentation Objectives

- Project Summary
- Qualitative Performance
- Quantitative Performance
- Summary and Next Steps



# Project Overview

## Project

- Boston, MA
- 4-story, 55 unit senior housing
- 100% affordable
- ~50,000 gsf

## Sustainability

- LEED MF Lowrise Platinum
- Phius+ 2021 CORE Certified

## Awards

- Passive House Projects Design Competition Awards | Low-Rise Multifamily, Phius Convention 2022
- Excellence in Design Award | Residential, New Construction, Environmental Design & Construction Magazine
- Best Development | Affordable Housing, Multi-Housing News Magazine
- John M. Clancy Award for Socially Responsible Housing, Boston Society of Architects



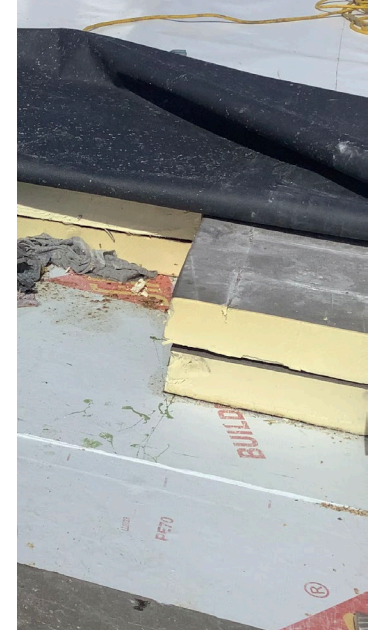
# Project Overview

	Target	Certified
Heating Demand	5.2 kBtu/ft <sup>2</sup> yr	3.76 kBtu/ft <sup>2</sup> yr
Cooling Demand	7.0 kBtu/ft <sup>2</sup> yr	4.19 kBtu/ft <sup>2</sup> yr
Heating Load	4.2 Btu/hr ft <sup>2</sup>	3.35 Btu/hr ft <sup>2</sup>
Cooling Load	3.1 Btu/hr ft <sup>2</sup>	2.63 Btu/hr ft <sup>2</sup>
Air Tightness	0.48 ACH / 0.065 cfm/ft <sup>2</sup>	



# Envelope Summary

	Descriptions	Derated Thermal Performance
Slab	4" EPS, CIP Concrete	R-16.4
Wall	2x6 wood, cellulose, mineral wool	R-27.1
Windows	Triple pane; PVC	U-0.18; SHGC-0.392
Roof	Polyiso continuous	R-41.8



# Mechanical Summary

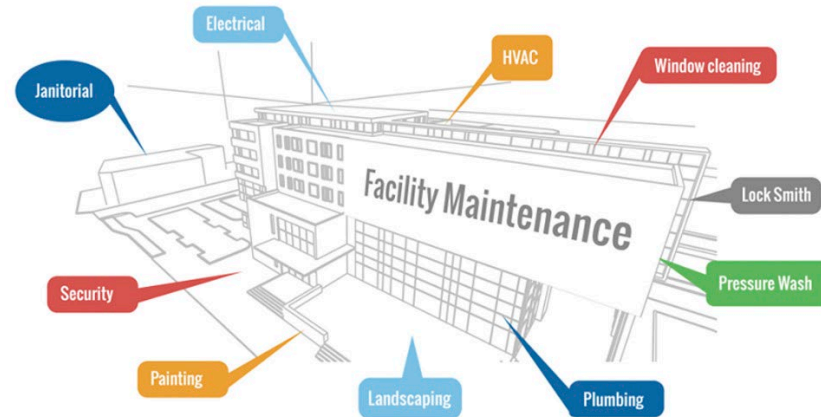
	Descriptions	Performance
Heating/Cooling	Mitsubishi VRF HP	COP: 3.68/2.49
DHW	Lochinvar Armor 3x119 gal storage	Efficiency: 99% (88%)
Ventilation	Annexaire ERP-E03	Sensible: 0.80 Latent: 0.4
PV	SolarEdge REC Alpha	35kW



# Qualitative Performance

Through interviews with maintenance and operations team members we have learned:

- No moisture issues/complaints reported
- No heating or cooling issues/complaints reported
- No smell issues – noted fewer smell complaints
- Windows and direct entry doors difficult to open



# Qualitative Performance

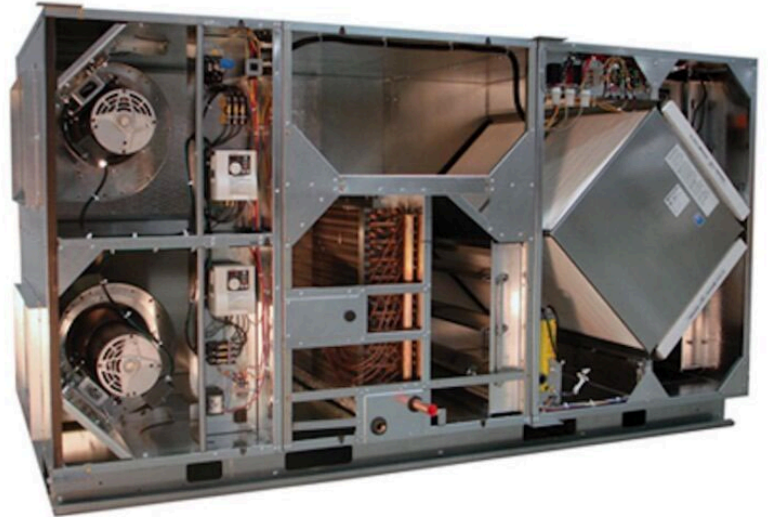
## VRF Comments

- Due to location and local ongoing construction the grid 'flickers' in the immediate area.
  - Causes VRF system to reset and requires site visit
- During 6 day heat wave with 50% of the system down most tenants stayed in apartments
- Portable A/C units were provided (ducted to bathroom exhaust)



# Qualitative Performance

- Commissioning was prolonged
  - System was undercharged
  - Too complex with everything needing a call
- Filters need frequent changes – both in units and at ERVs



# Qualitative Performance

- New systems work well, but
  - Current team has 20 people that can fix a boiler or replace a FCU motor
  - Team has 0 people with similar experience with HPs so everything is a call
- Team has requested additional training.



# Health and Comfort

12 out of 55 units have AIRTHINGS sensors monitoring:

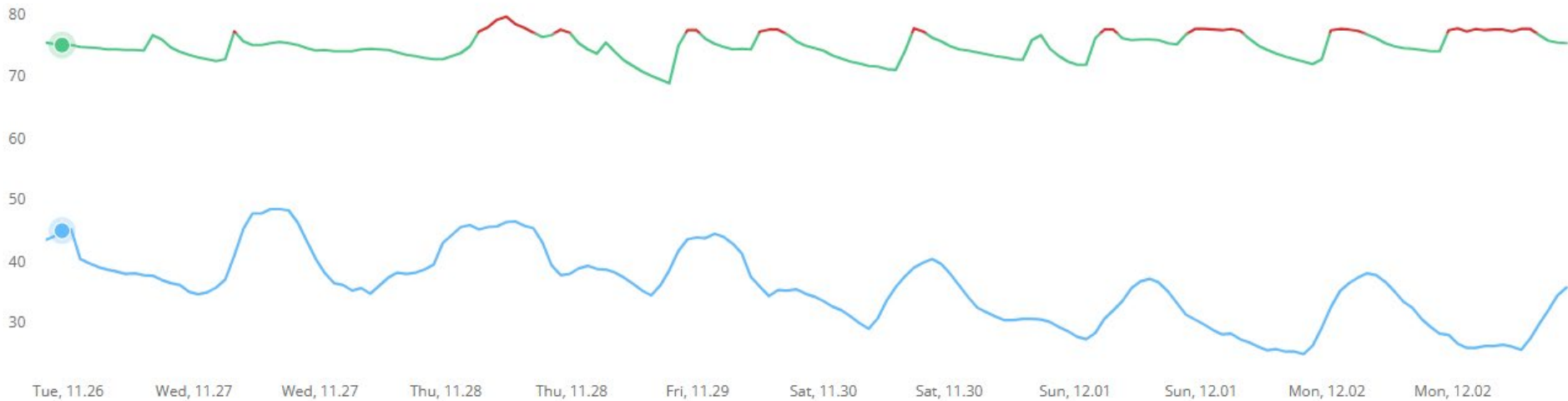
- Temperature
- CO<sub>2</sub>
- VOC
- PM1, PM2.5, PM10
- Humidity



# Health and Comfort

Average in unit temperatures

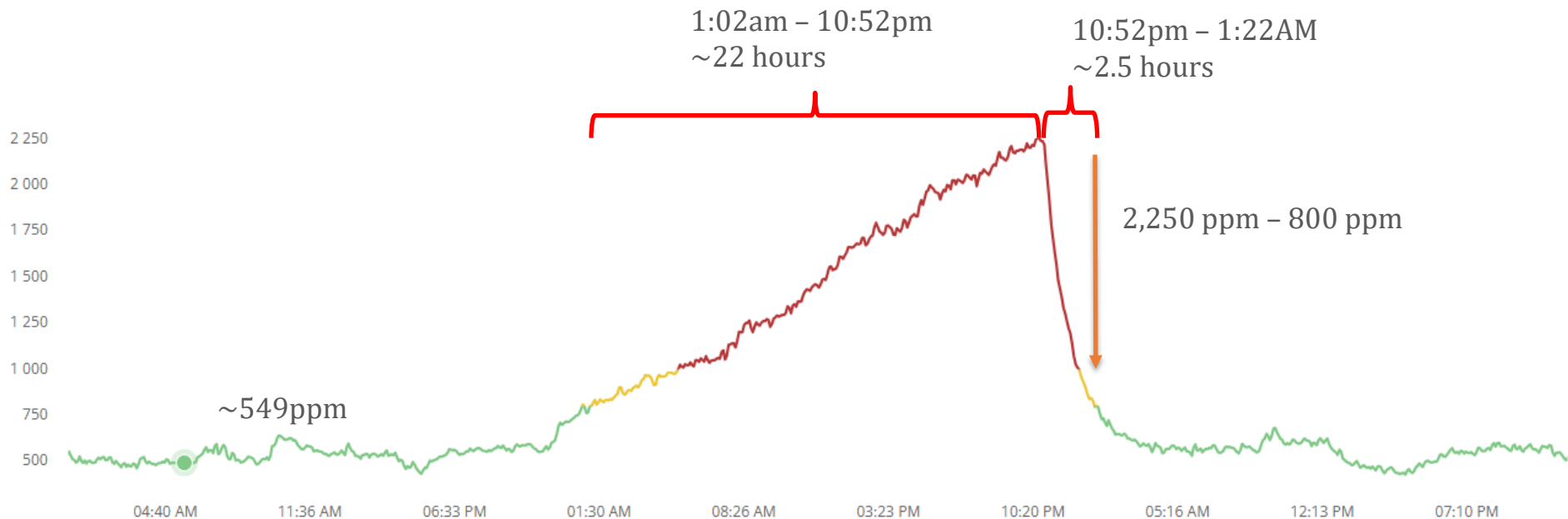
	Summer	Winter	>68F in Nov
Observed	74	74	99%
Modeled	77	68	



# Health and Comfort

CO2 Concentration: 11/16/24 - 11/18/24

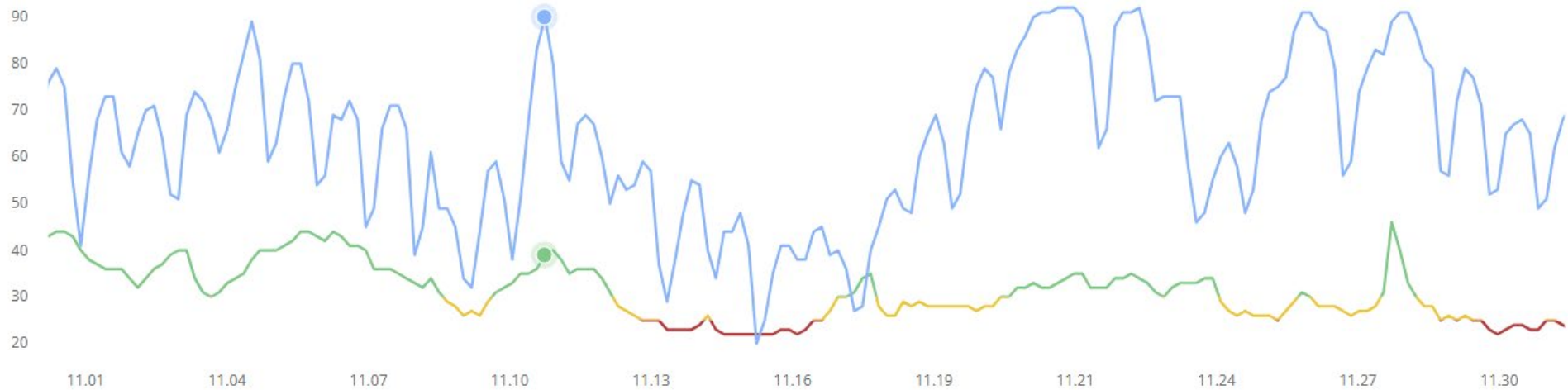
- System shut down for 24 hours?
- Average CO2: 549 (November)



# Health and Comfort

## Relative Humidity in November

Average	Max	Min	>60 <30
35.9%	72.4%	12.6%	20.6%

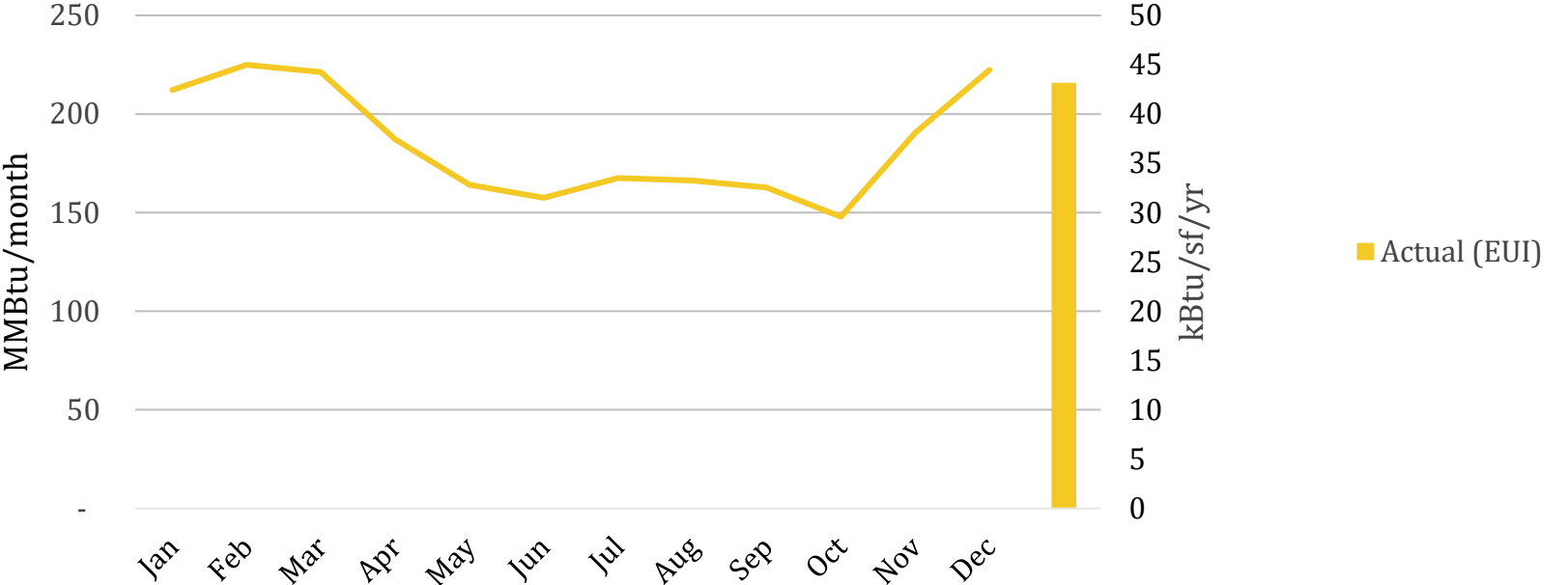


# Quantitative Data

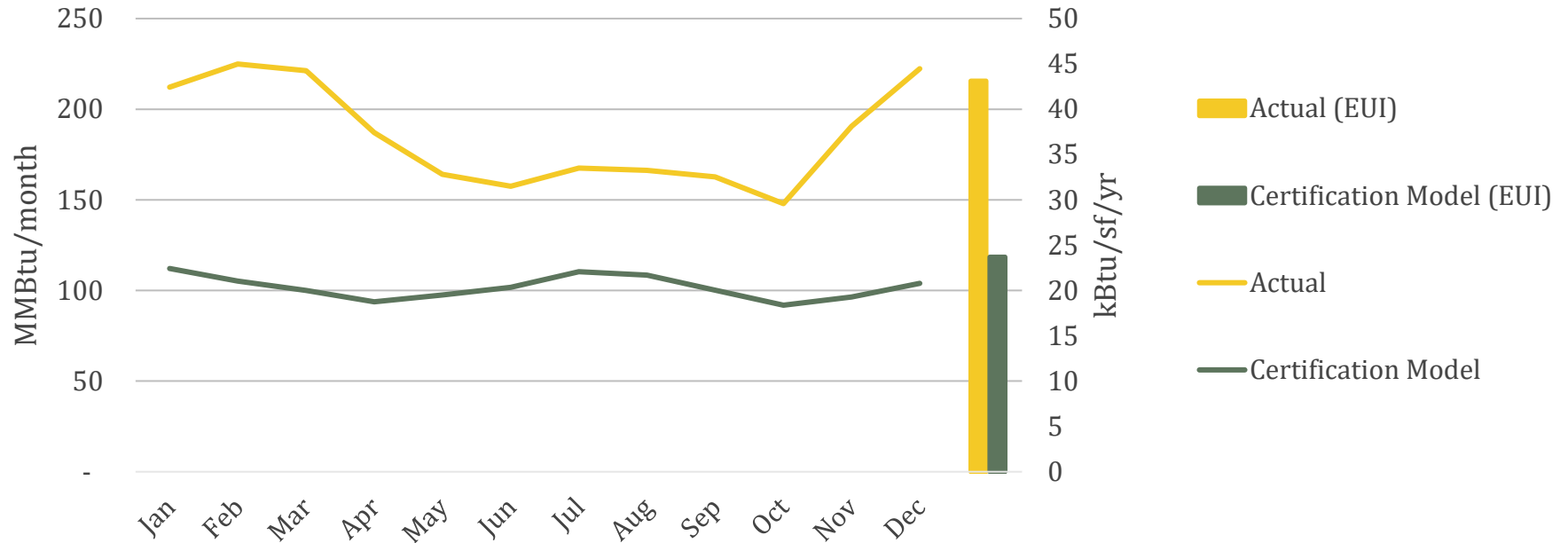
- Utility data
- Actual usage vs. certification model
- “Trued” model
- Actual usage vs. “trued” model
- Unknown variables



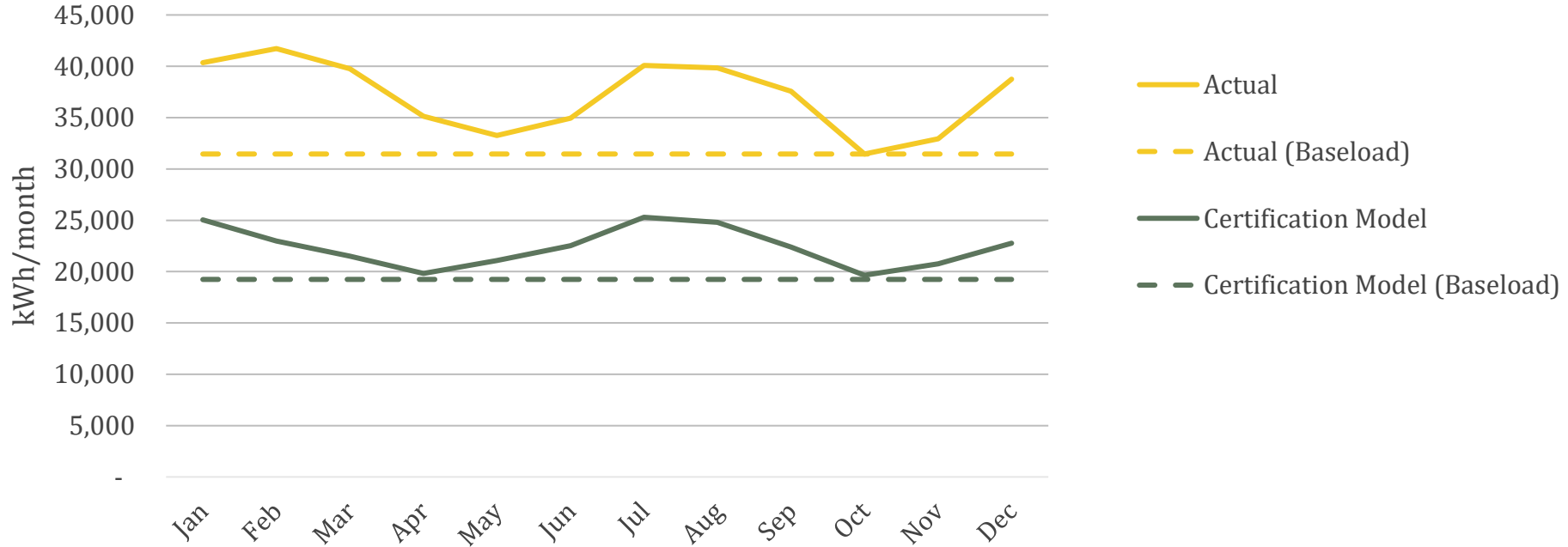
# Total Site Energy Usage



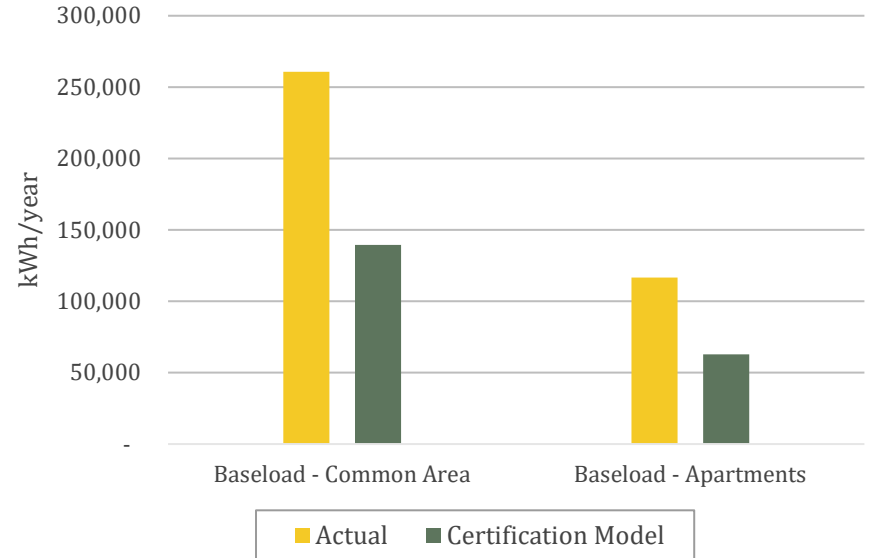
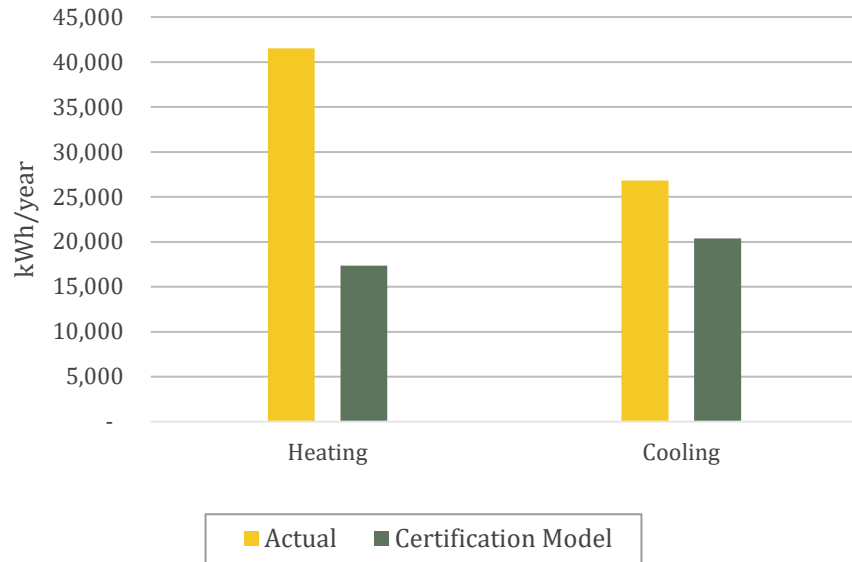
# Total Site Energy Usage Comparison



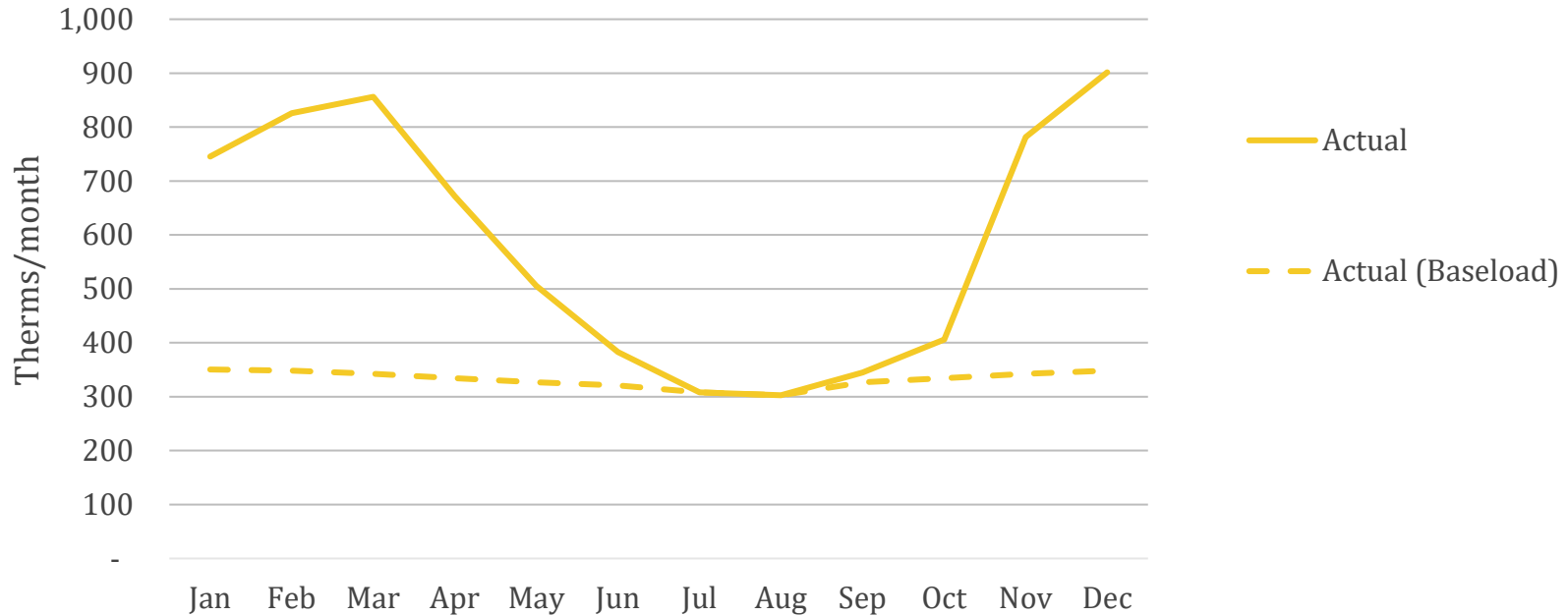
# Monthly Electricity Usage Comparison



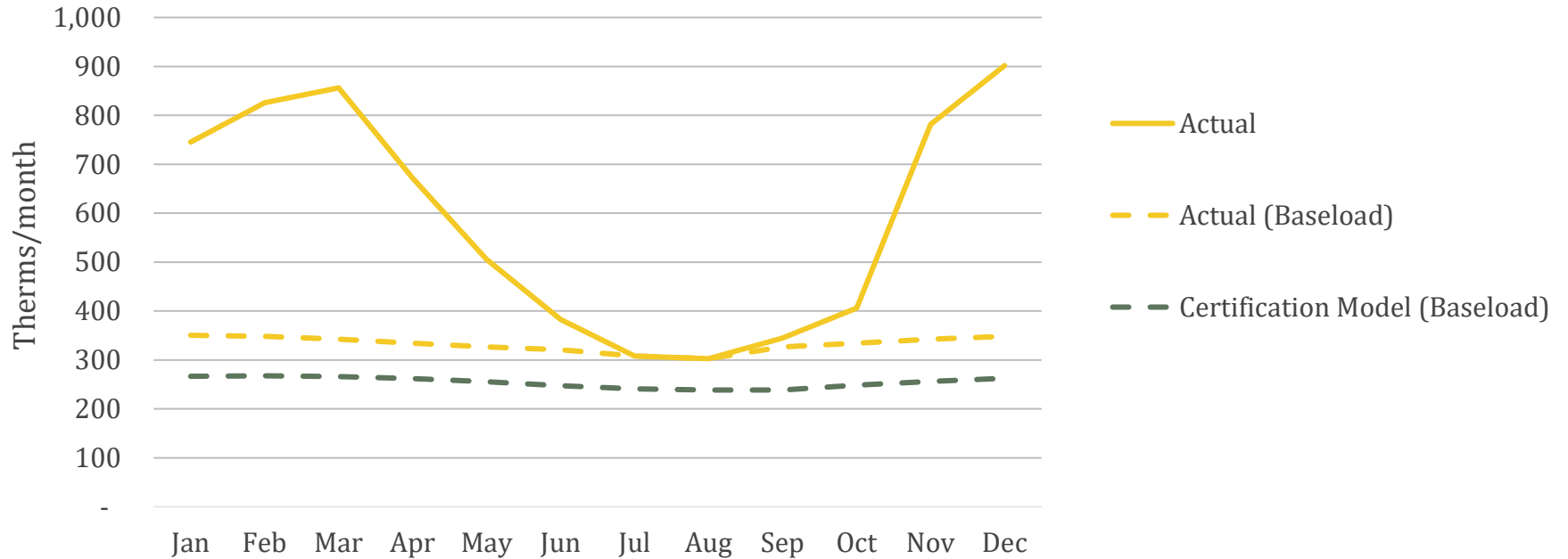
# Annual Electricity Usage Comparison



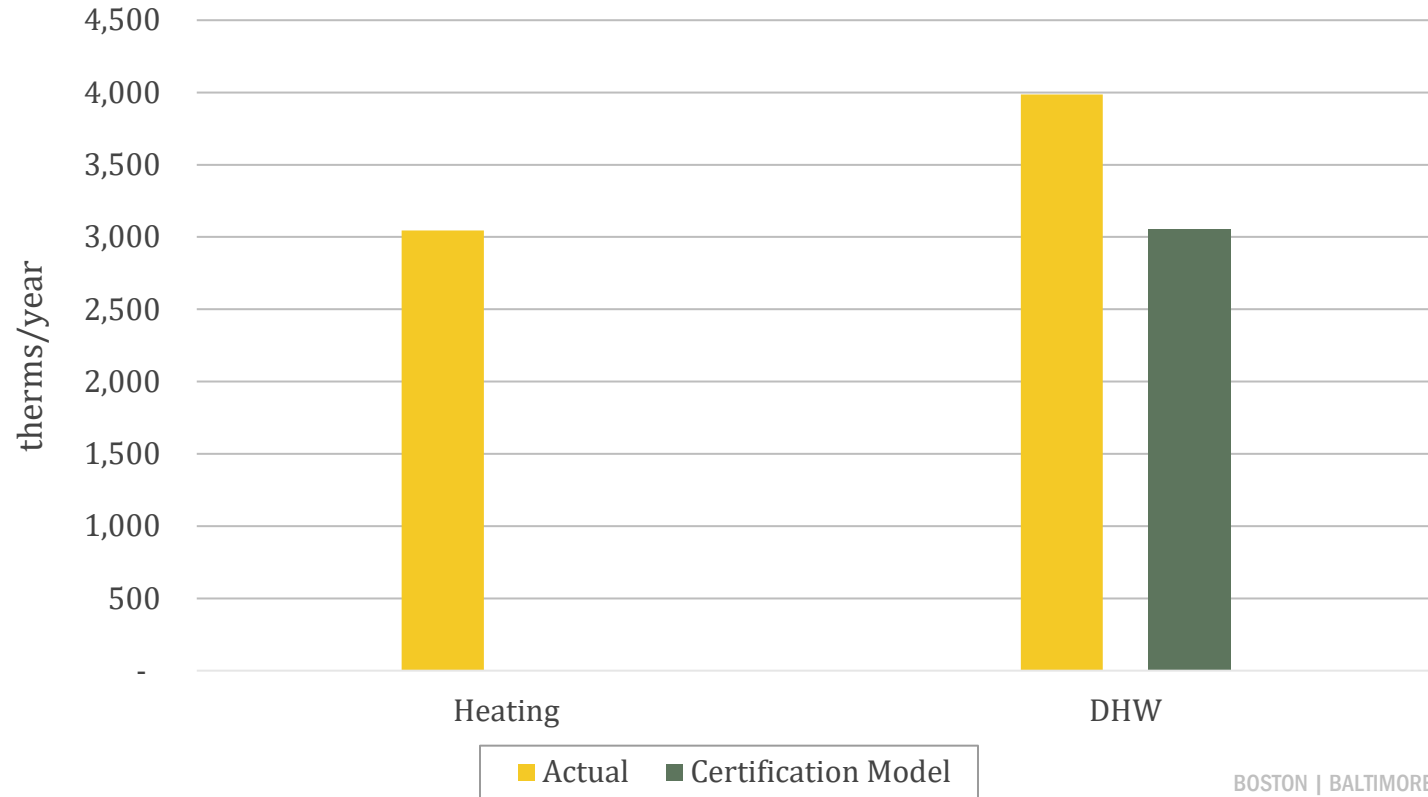
# Monthly Gas Usage



# Monthly Gas Usage Comparison



# Annual Gas Usage Comparison



# Data Discrepancy

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## Known Variables

- Weather
- Indoor Air Temperature
- Infiltration
- Occupancy
- Gas Furnace
- Hot Water Use

## Unknown Variables

- ERV Fan Power
- Overheating
- System Efficiency
- Operable Windows
- Apartment Plug Loads
- Common Area Lighting
- Elevator Usage

# Case 1 – Weather + IAT

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## Known Variables

- **Weather**
- **Indoor Air Temperature**
- Infiltration
- Occupancy
- Gas Furnace
- Hot Water Use

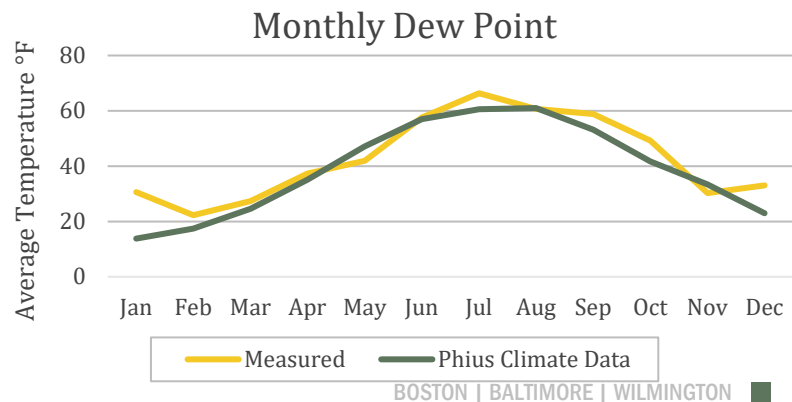
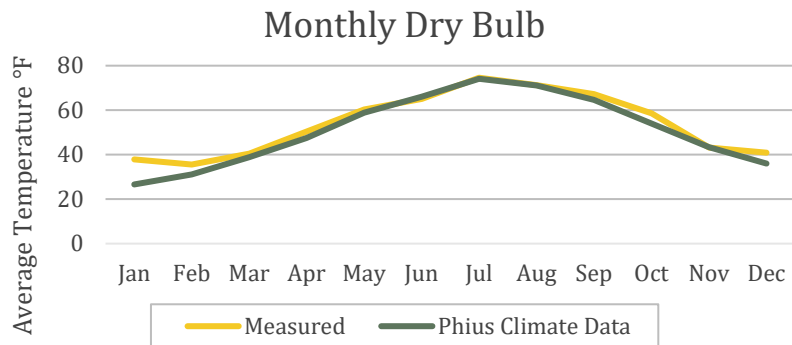
## Unknown Variables

- ERV Fan Power
- Overheating
- System Efficiency
- Operable Windows
- Apartment Plug Loads
- Common Area Lighting
- Elevator Usage

# Observed Weather vs. Phius Climate Data

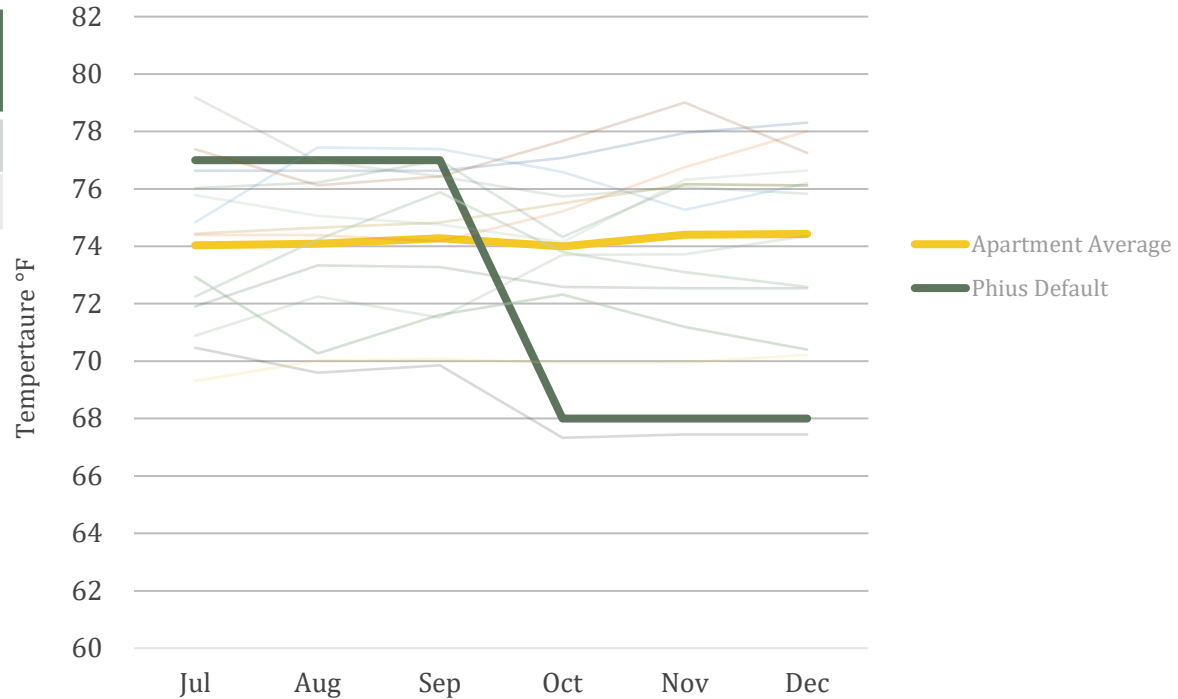
Dry Bulb Mean Temperature (°F)	Heating Season	Cooling Season
Phius Climate Data	42	69
Measured	46	69

Dew Point Mean Temperature (°F)	Heating Season	Cooling Season
Phius Climate Data	30	58
Measured	34	61



# Measured Indoor Air Temperature vs. Plius Set Points

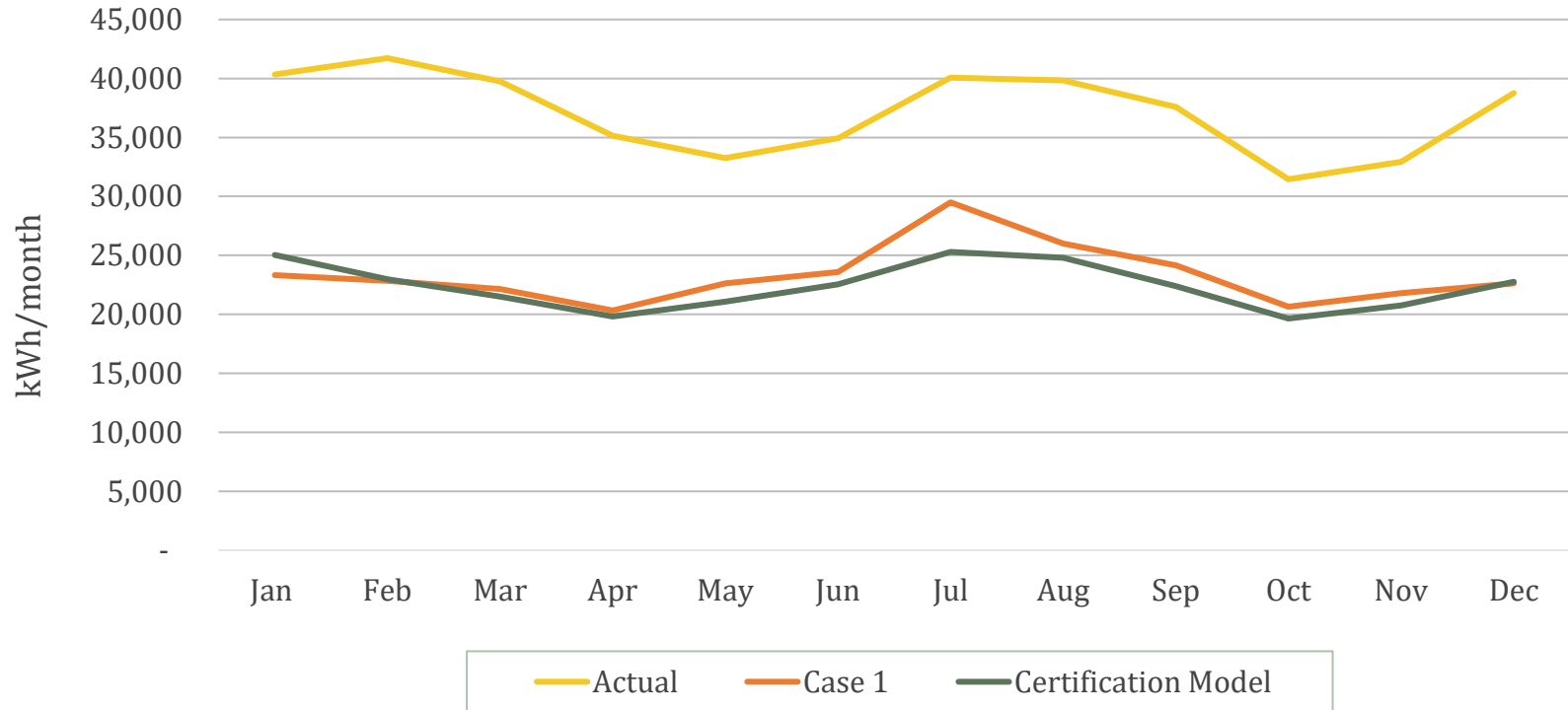
Set Point Temperatures (°F)	Heating Season	Cooling Season
Plius default	68	77
In-unit average	74	74



# Case 1 Comparison – Annual Heating and Cooling



# Case 1 Comparison – Monthly Electricity Usage



# Case 2 – Infiltration + Occupancy

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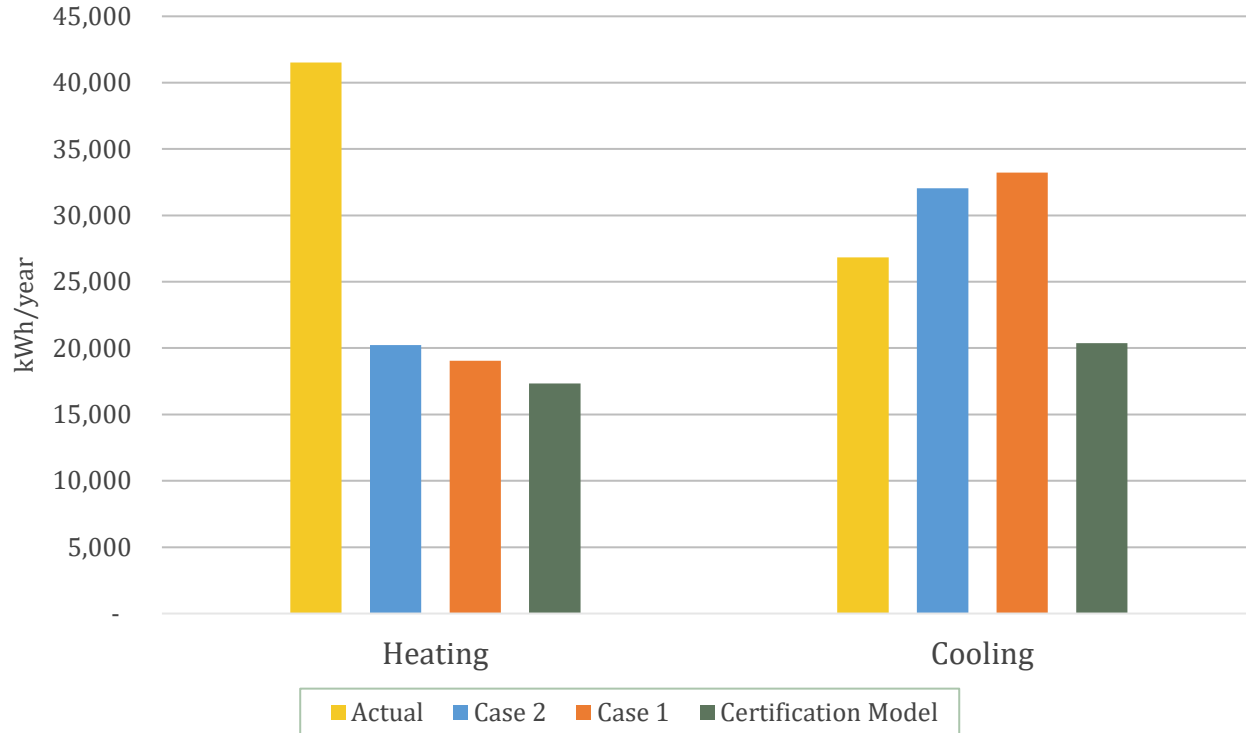
## Known Variables

- Weather
- Indoor Air Temperature
- **Infiltration**
- **Occupancy**
- Gas Furnace
- Hot Water Use

## Unknown Variables

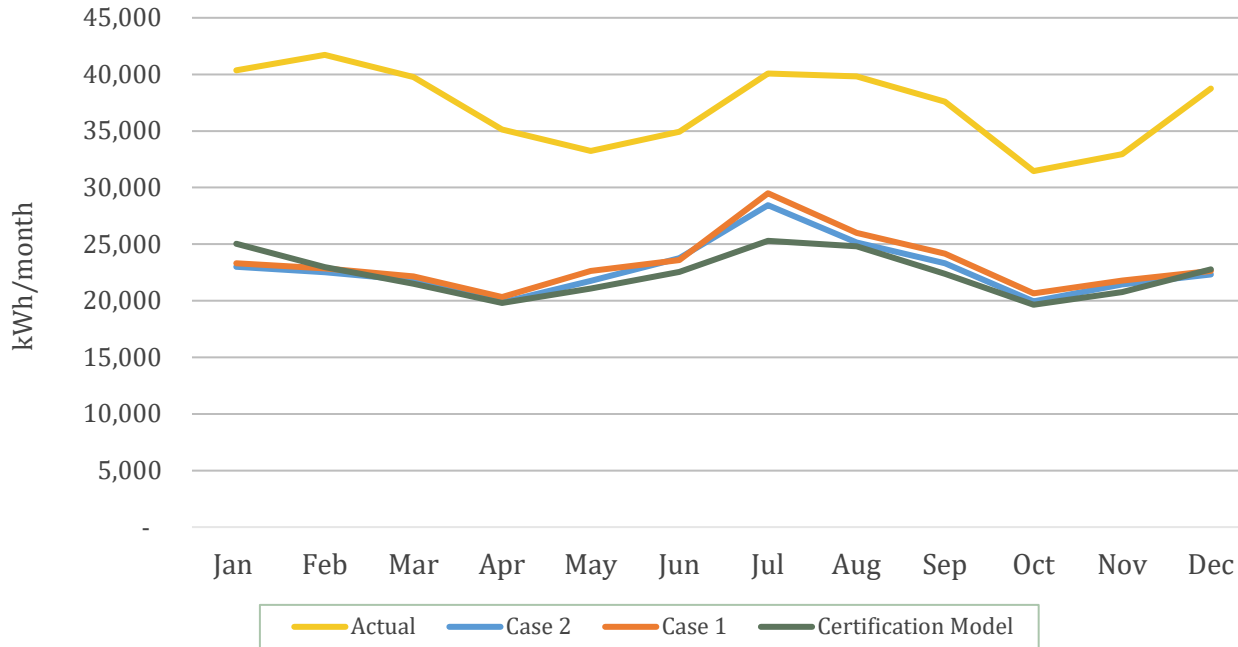
- ERV Fan Power
- Overheating
- System Efficiency
- Operable Windows
- Apartment Plug Loads
- Common Area Lighting
- Elevator Usage

# Case 2 Comparison – Annual Electricity Usage



	Infiltration Rate (cfm/sf)	Occupancy
Certification Model	0.041	110
Case 2 Model	0.065	55

# Case 2 Comparison – Monthly Electricity Usage



	Infiltration Rate (cfm/sf)	Occupancy
Certification Model	0.041	110
Case 2 Model	<b>0.065</b>	<b>55</b>

# Case 3 – Gas Furnace + Hot Water Use

## Known Variables

- Weather
- Indoor Air Temperature
- Infiltration
- Occupancy
- **Gas Furnace**
- **Hot Water Use**

## Unknown Variables

- ERV Fan Power
- Overheating
- System Efficiency
- Operable Windows
- Apartment Plug Loads
- Common Area Lighting
- Elevator Usage

# Gas Furnace Coverage

Method 1

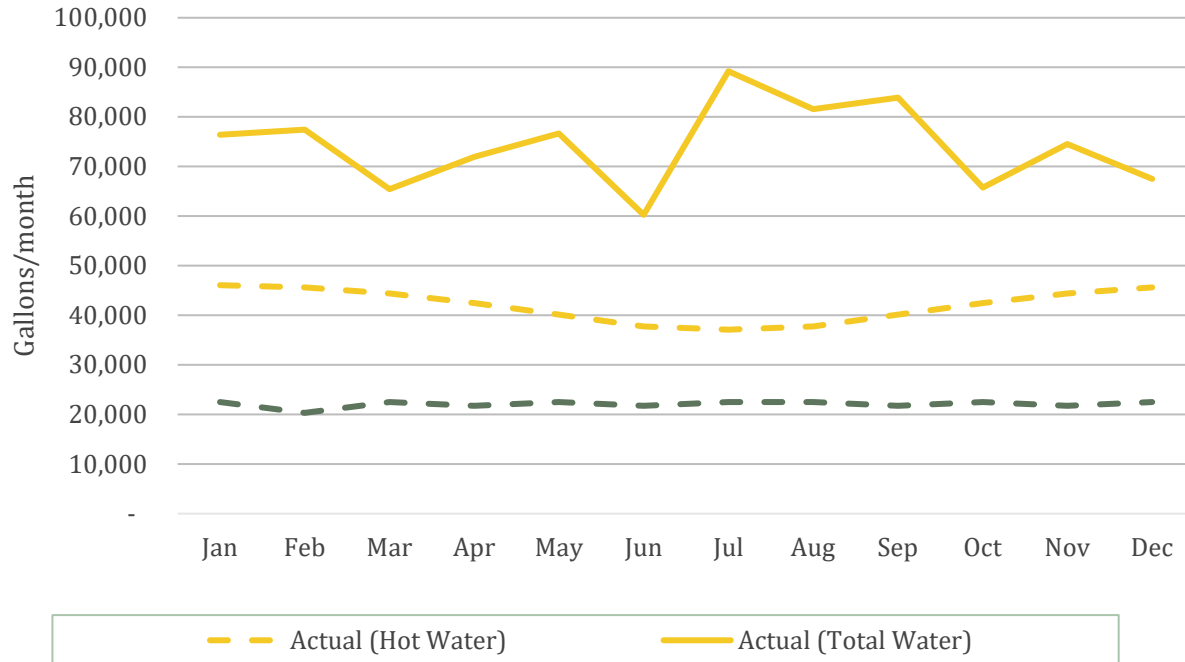
Fuel	Capacity (Btu/hr)	Coverage
Electric	876,000	78%
Gas	250,000	22%

Method 2

Fuel	Annual Usage (kBtu/yr)	Average Efficiency	Annual Load (kBtu/yr)	Coverage
Electric	141,657	364%	515,026	68%
Gas	304,627	80%	243,701	32%

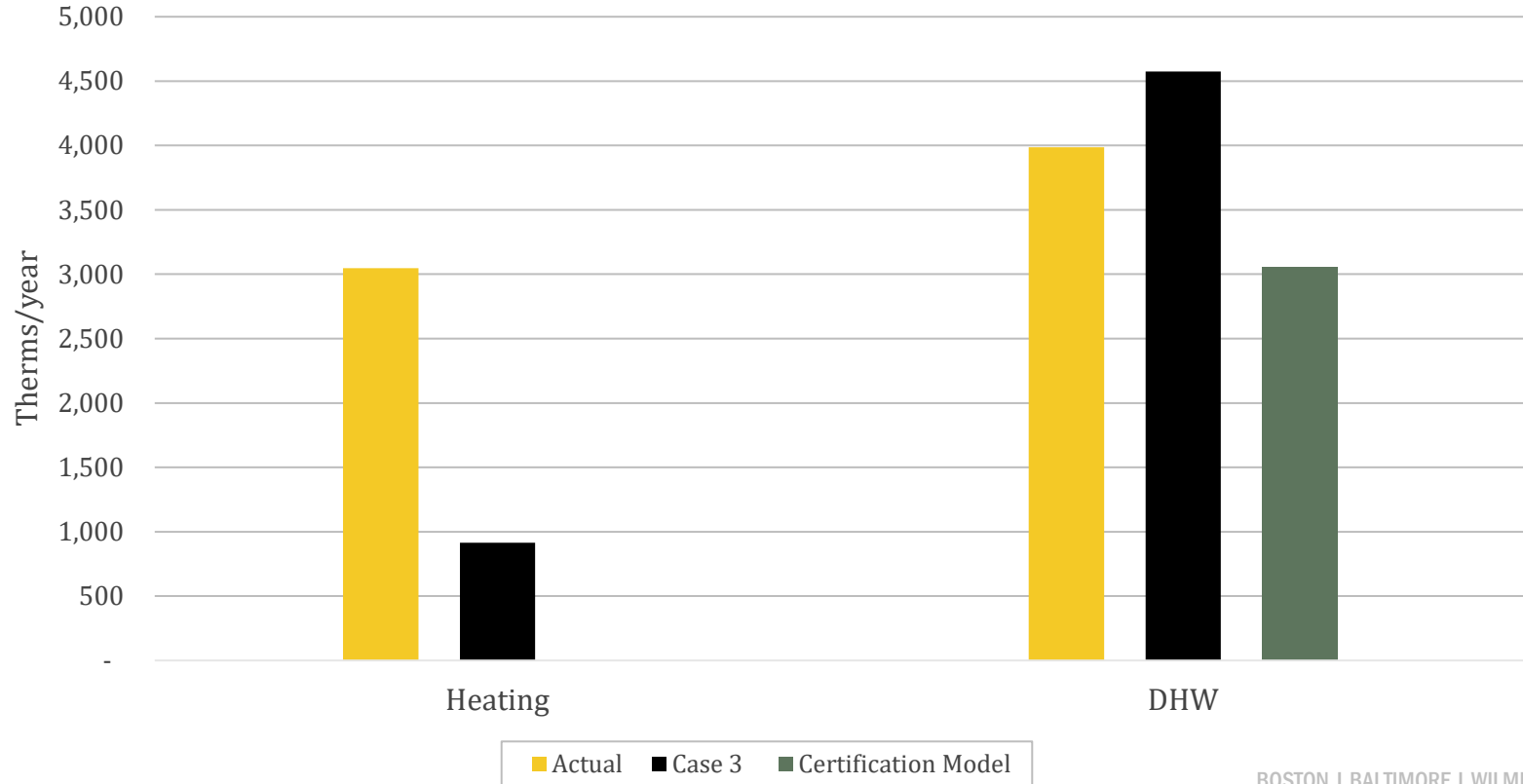
# Hot Water (Gallons/Person/Day)

Monthly Total vs. Hot Water Usage

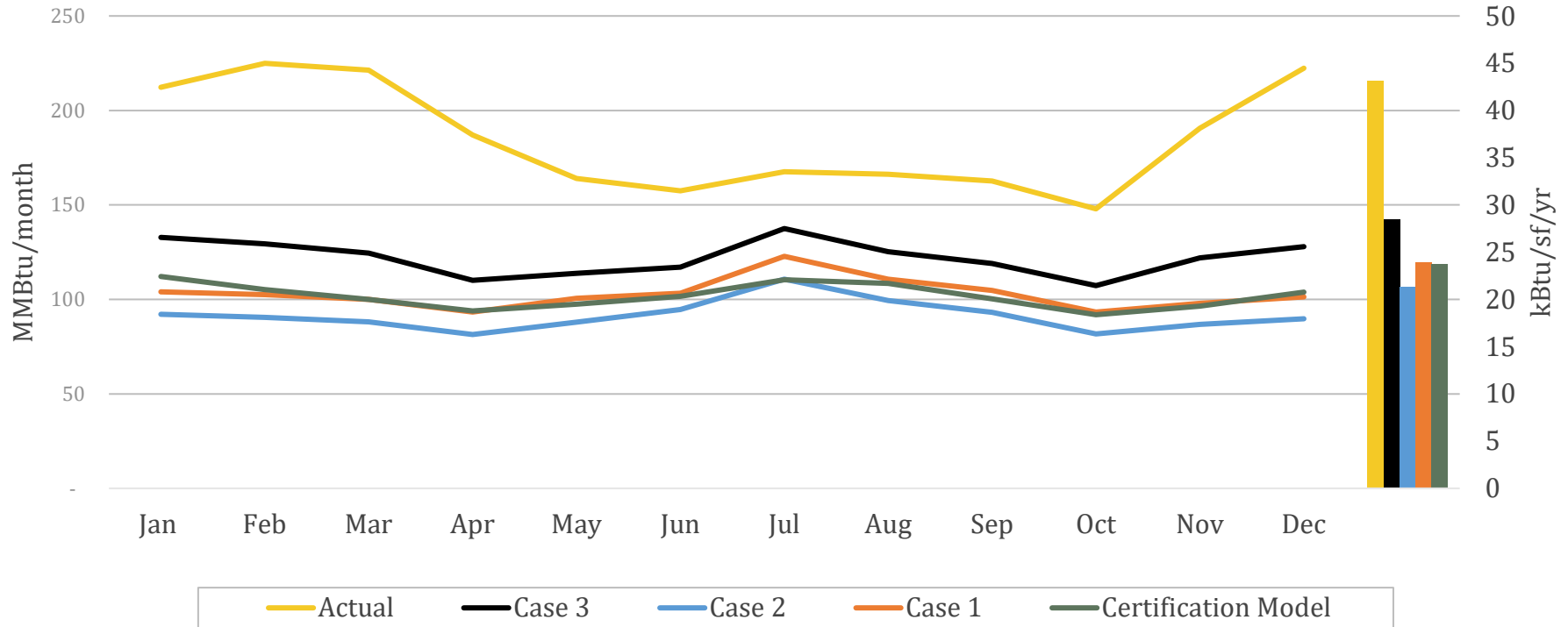


Daily Hot Water Usage (gallons)	Gal/person/day
Certification Model	6.6
Actual Building	25

# Case 3 Comparison – Annual Gas Usage



# Case 3 Comparison – Total Monthly Energy Usage



# Case 4 – ERV Fan Power

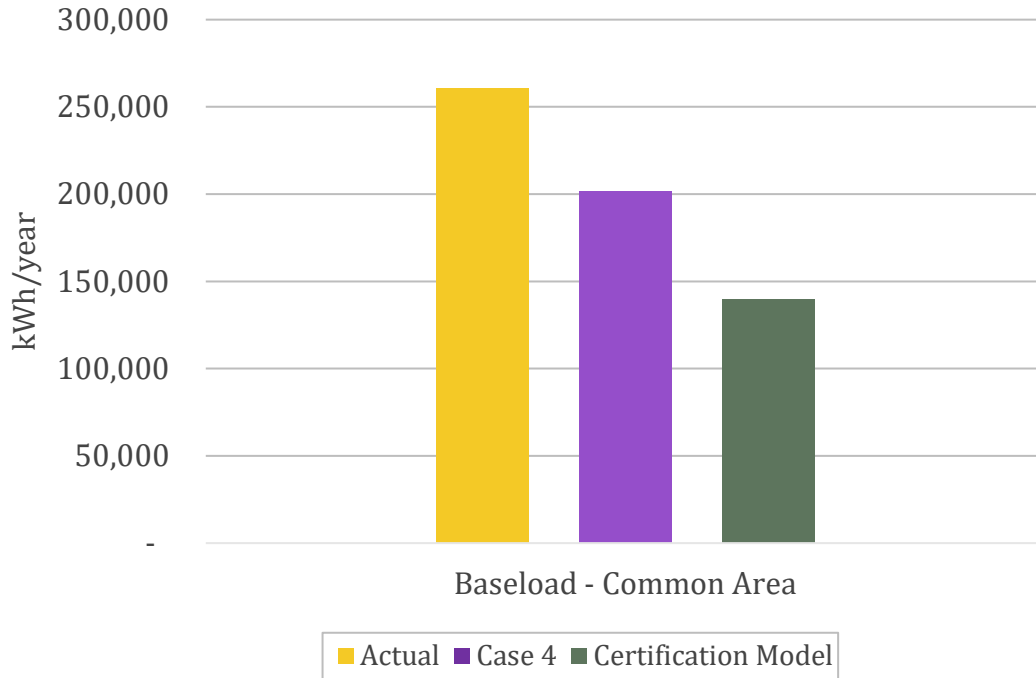
## Known Variables

- Weather
- Indoor Air Temperature
- Infiltration
- Occupancy
- Gas Furnace
- Hot Water Use

## Unknown Variables

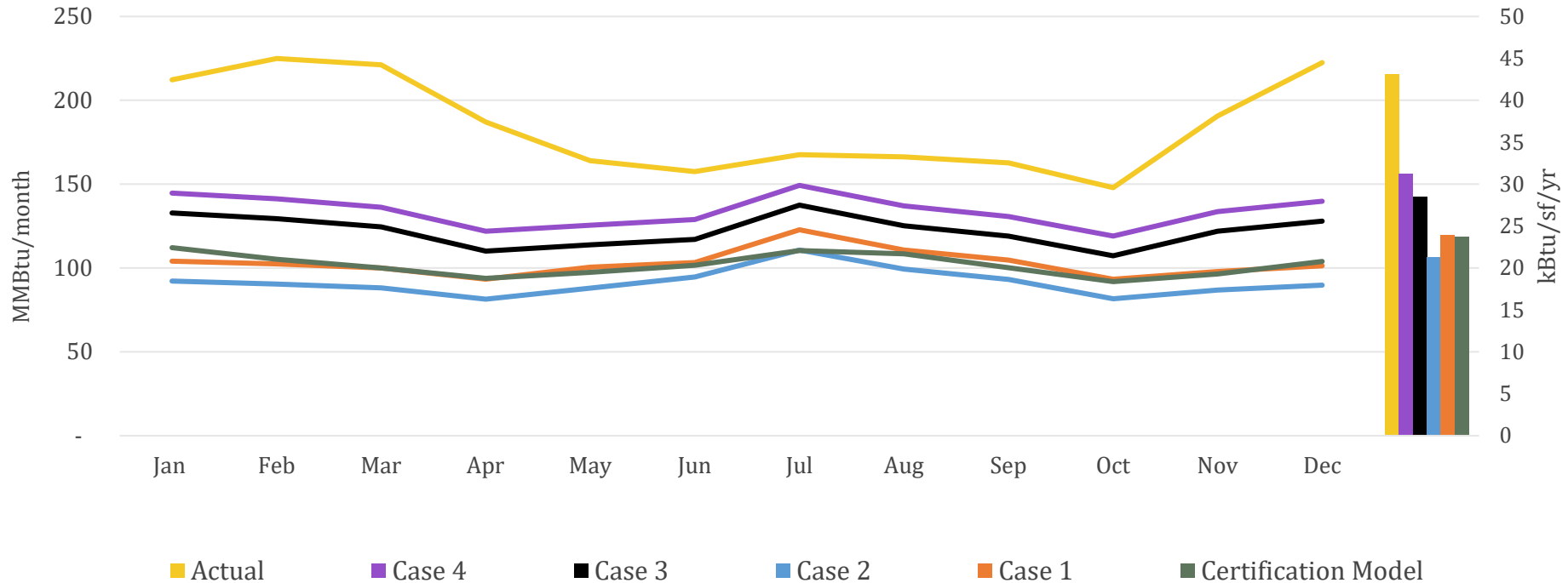
- **ERV Fan Power**
- Overheating
- System Efficiency
- Operable Windows
- Apartment Plug Loads
- Common Area Lighting
- Elevator Usage

# Case 4 Comparison – Annual Electric Baseload



	Fan Power (W/cfm)
Certification Model	1.06
Case 4 Model	<b>2.00</b>

# Case 4 Comparison – Total Monthly Energy Usage



# Overheating?

Cooling Mode (outdoor air temperature greater than 60°F): Initiate cooling mode as required to maintain the supply air set point temperature of 55°F. The DX cooling circuit shall be enabled and modulated as required.

Dehumidification mode (outdoor air temperature greater than 50°F): Initiate dehumidification mode as required to maintain the return air relative humidity set point of 55% RH. The DX cooling circuit shall be enabled and modulated as required.

Hot gas reheat shall be used to temper supply air according to the following reset schedule:

OAT = 60°F, SAT = 65°F (Adjustable)

OAT = 72°F, SAT = 58°F (Adjustable)

OAT > 72°F, hot gas reheat shall be disabled (Adjustable)

Heating Mode (outdoor air temperature less than 60°F): The gas-fired heating circuit shall be activated as required to maintain the supply air set point temperature of 75°F (adjustable).

# Overheating?

Heating Fuel	Total Input Energy (kBtu/yr)	Average Efficiency	Annual Load (kBtu/yr)
Electric	141,657	3.64	515,026
Gas	304,627	0.8	243,701
Total			758,728

## Heating demand

specific: **4.64** kBtu/ft<sup>2</sup>yr  
target: **5.2** kBtu/ft<sup>2</sup>yr  
total: **228,799.99** kBtu/yr

# Summary and Next Steps

- Tenants and owners like the building
- Ventilation performs well
- Relative humidity is lower
- EUI is higher than expected
- Certification model does not predict performance
  - There are many known and unknown factors
- NEXT STEPS:
  - ERV deep dive
  - VRF deep dive – cooling vs heating
  - Baseload questions – potential \$ savings



  
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