Edgewood and Emerald Hills

Post Occupancy Performance Analysis

Objectives

- Our intent is to convey some of the information learned about two different system types in Passive Building projects
- We hope that our experience will help you to evaluate system options for future projects
- You will also gain understanding of some of the issues that can cause buildings to use more energy than modeling predicts

Outline

Emerald Hills

- Building and systems description
- Measured energy consumption versus modeled
- Discussion of discrepancies
- Discussion of construction related issues for Emerald systems

Edgewood

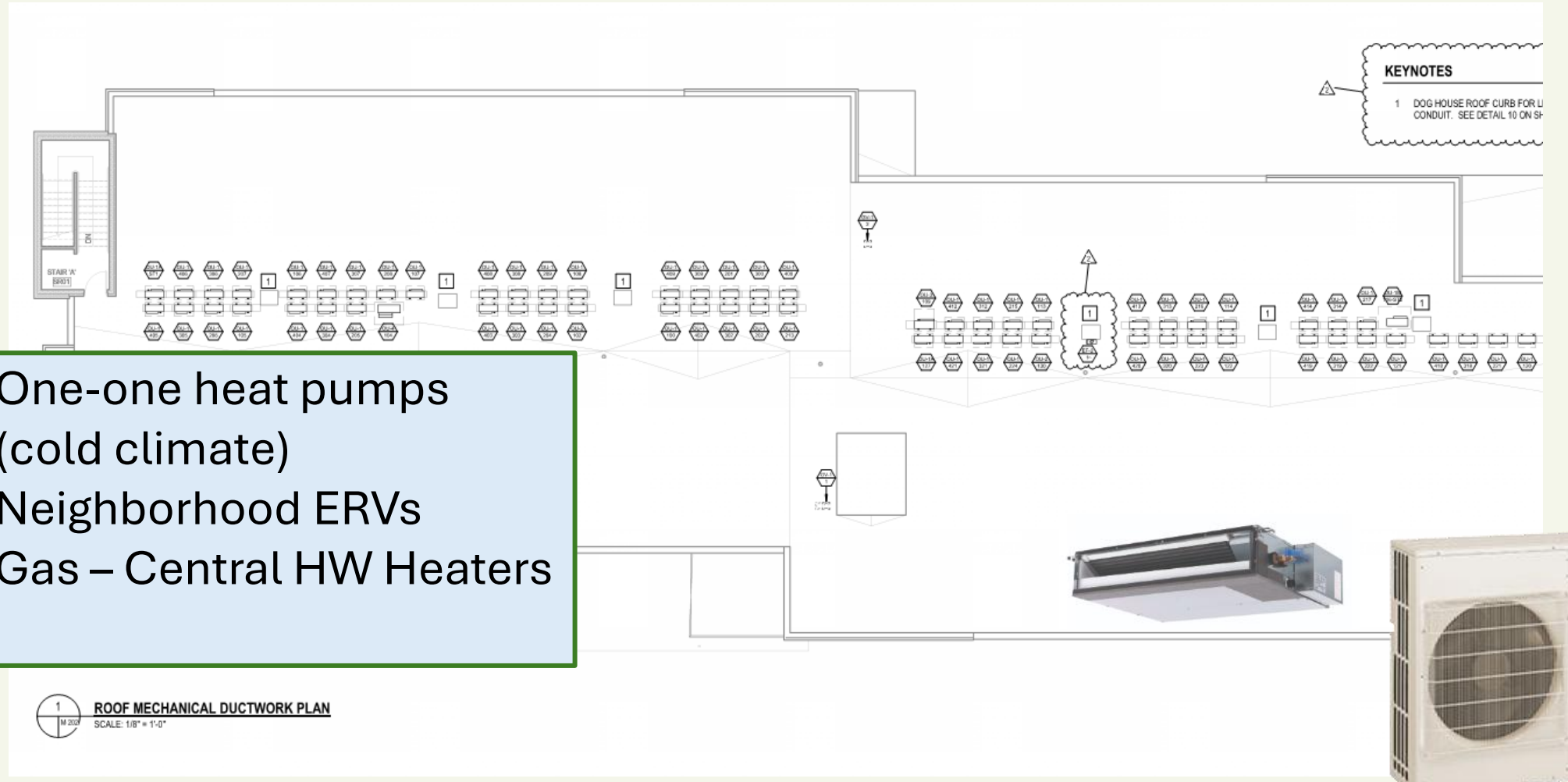
- Building and systems description
- Measured energy consumption versus modeled
- Discussion of discrepancies
- Discussion of construction related issues for Edgewood systems
- Investigation of larger than expected energy consumption for Edgewood
- Discussion of systems comparison

Emerald Hills

Location	Size	Population	Envelope	HVAC	Ventilation	HW System	Solar	Occupied
Pittsburgh	55 Apartments	Senior Housing	Walls: R37 Roof: R53 Windows: 3-pane	Ducted - Split Heat Pumps	Semi-Central ERVs	Condensing Gas	116 kW Solar Array feeds House Panel	Spring 2022

Emerald Hills

- One-one heat pumps (cold climate)
- Neighborhood ERVs
- Gas – Central HW Heaters



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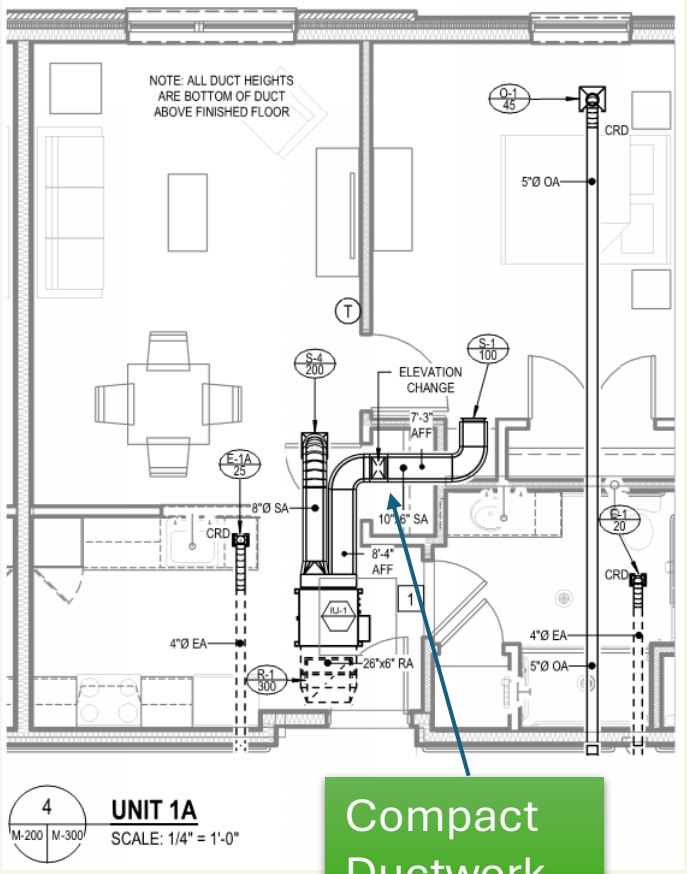
Emerald Hills



Compact Ductwork Design

Neighborhood ERVs

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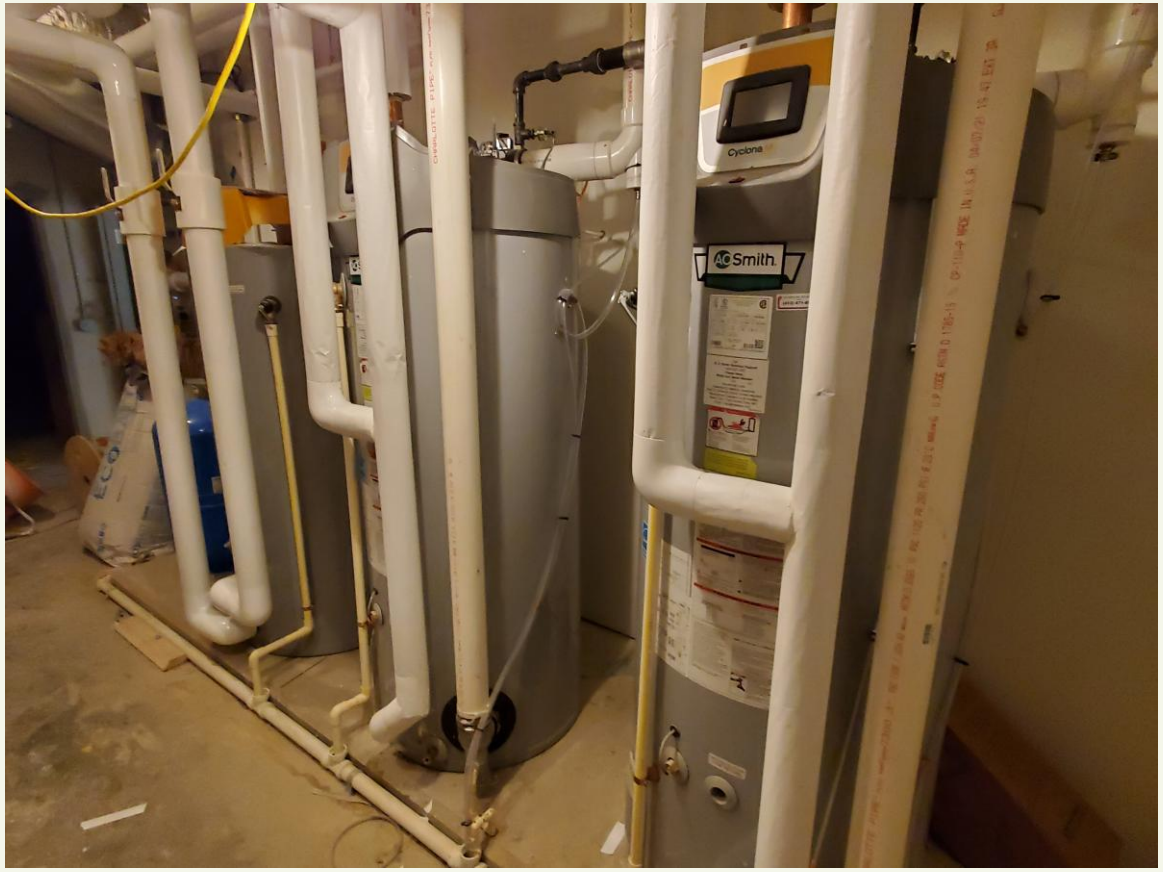
Emerald Hills - DHW

- Domestic HW generated by condensing gas HW heaters.
- Three 199,000 BTU/hr sealed combustion heaters.



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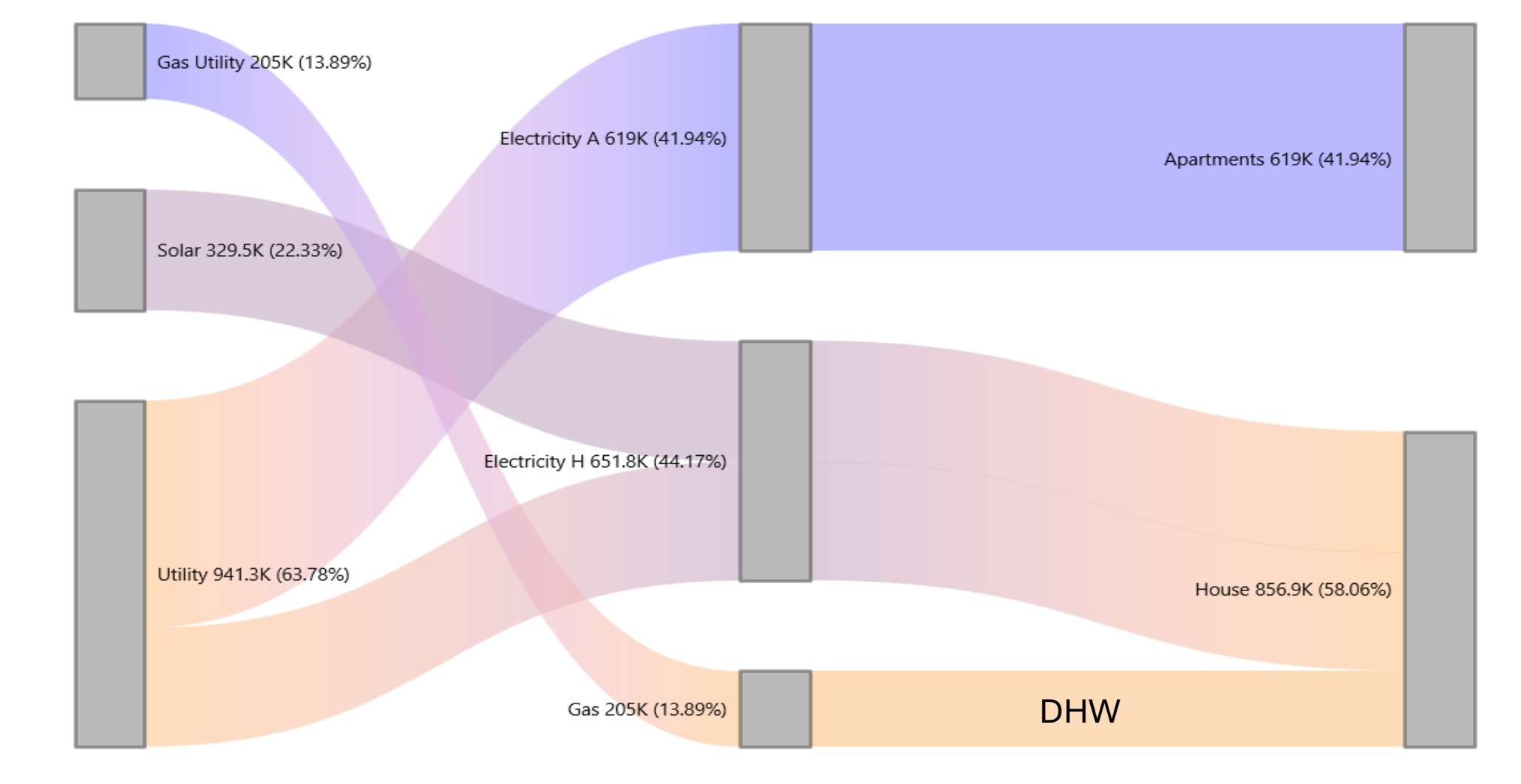
Results



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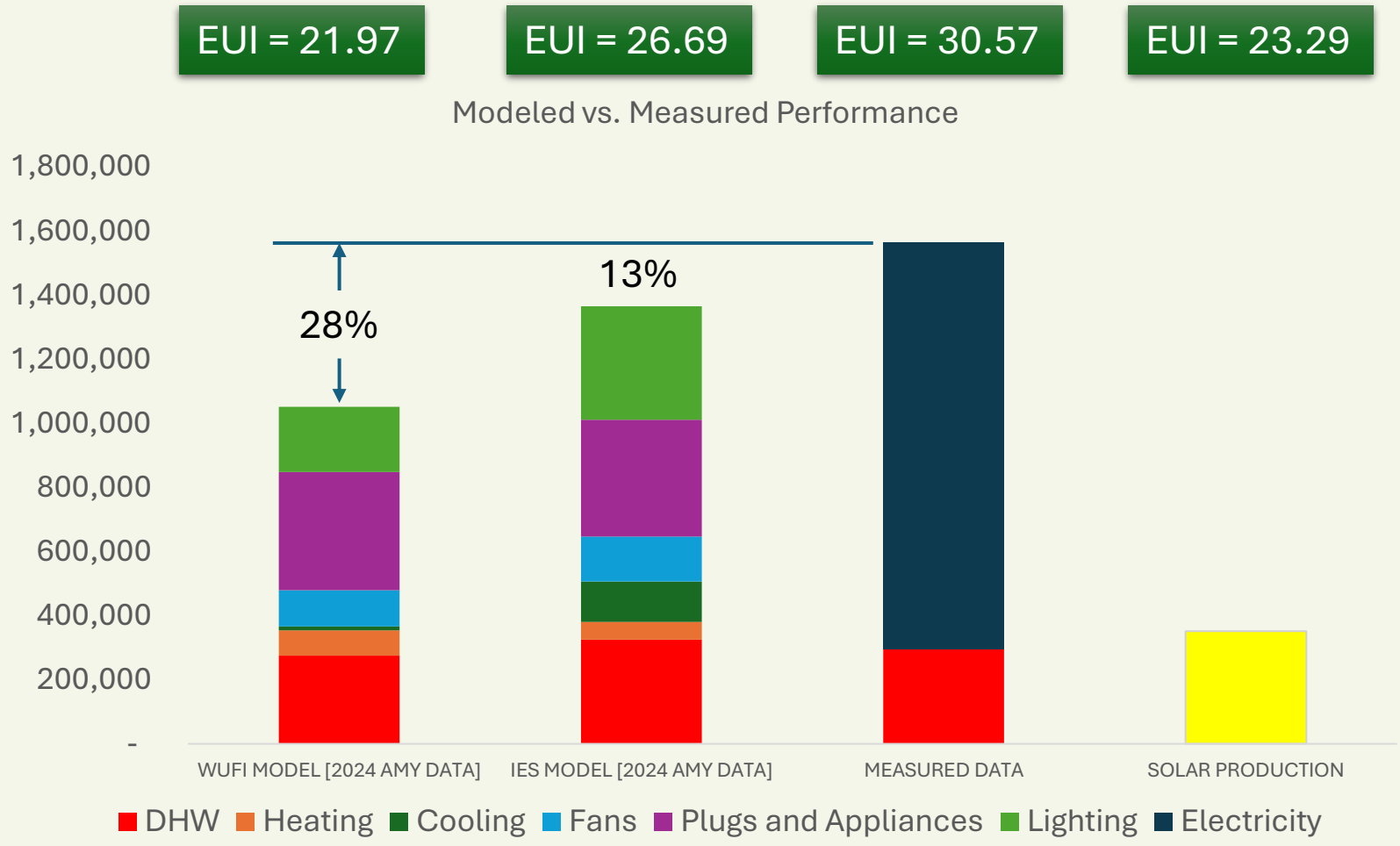
Energy Performance

Weather Corrected Models:

- WUFI model low on cooling and lighting compared to IES model.
- IES model likely low on HVAC due to less than optimal COP
- Domestic HW energy right in line with models
- Removed solar production from analysis



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Results

- Emerald Hills ERV fan energy modeled vs actual (estimate).

Emerald Hills Engineering Checks
By: G. Staengl J. Nilsen
Date: 8/19/2022

ERV	Measured Power [W]	Corrected Power Draw [W]	Design Supply Flow [CFM]	W/CFM
1-5	236	**200**	355	0.6
1-3	570	**534**	270	2.0
1-4	50	**14**	230	0.1
1-6	630	**594**	360	1.7
1-7	440	**404**	485	0.8
1-8	280	**244**	360	0.7
1-9	460	**424**	435	1.0
2-1	290	**254**	550	0.5
2-2	450	**414**	640	0.6
		3082	**3685**	**0.836**

Modeled ERV Fan Energy: 109,000 kBTU/yr
Calculated ERV Fan Energy: 92,145 kBTU/yr

Actual ERV energy likely larger because power draw goes up as the filters get dirty.

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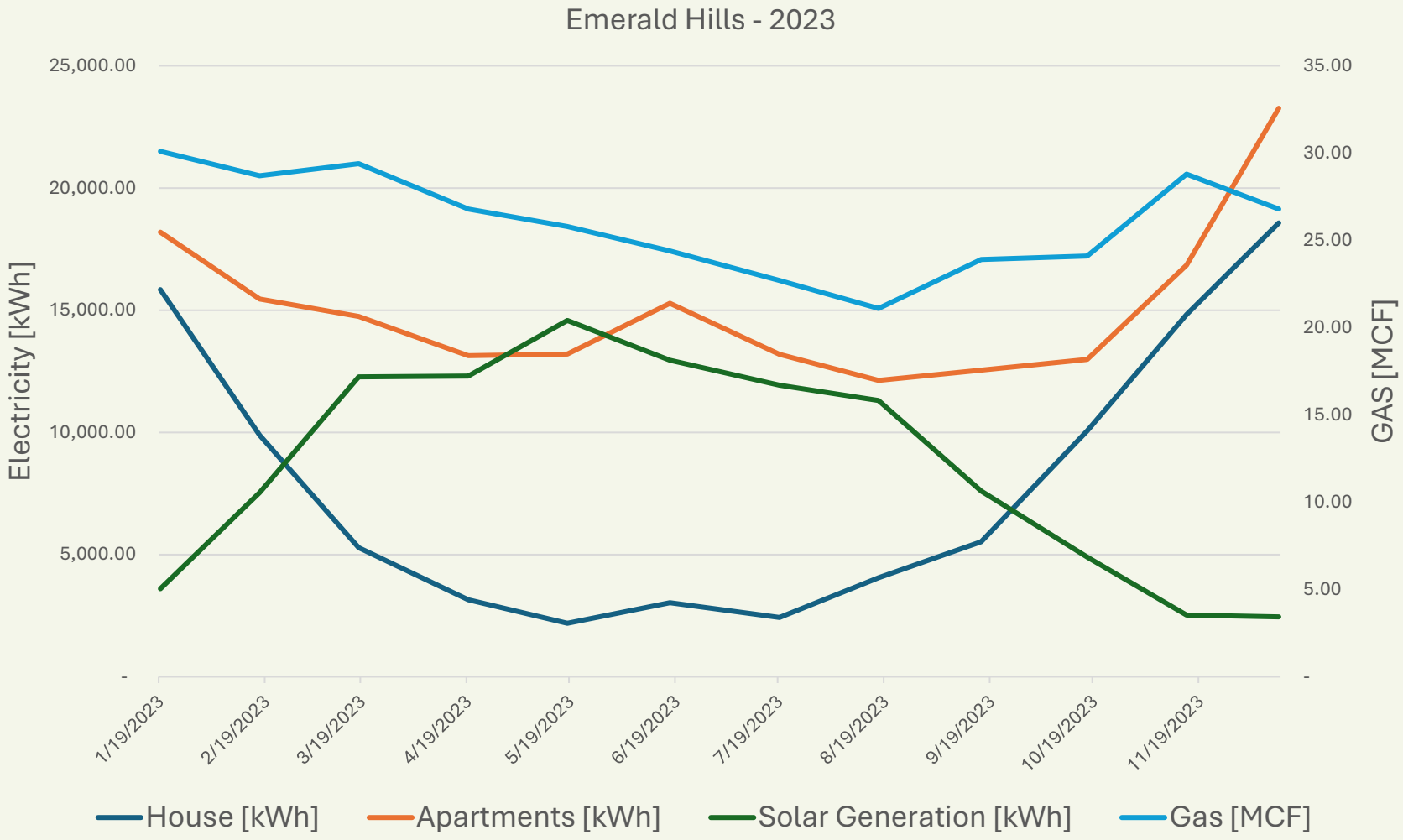
Results



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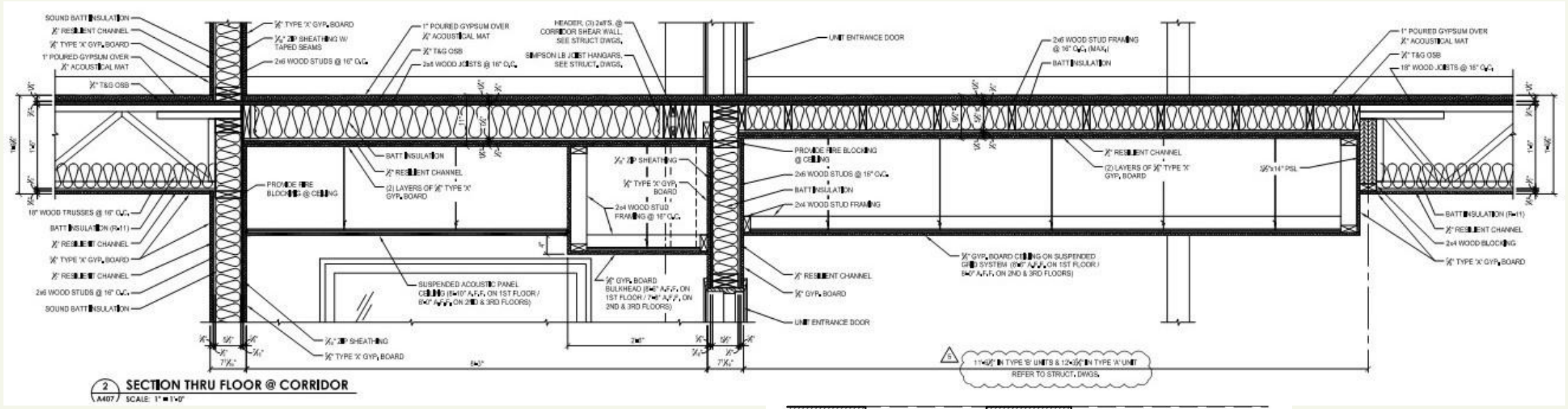
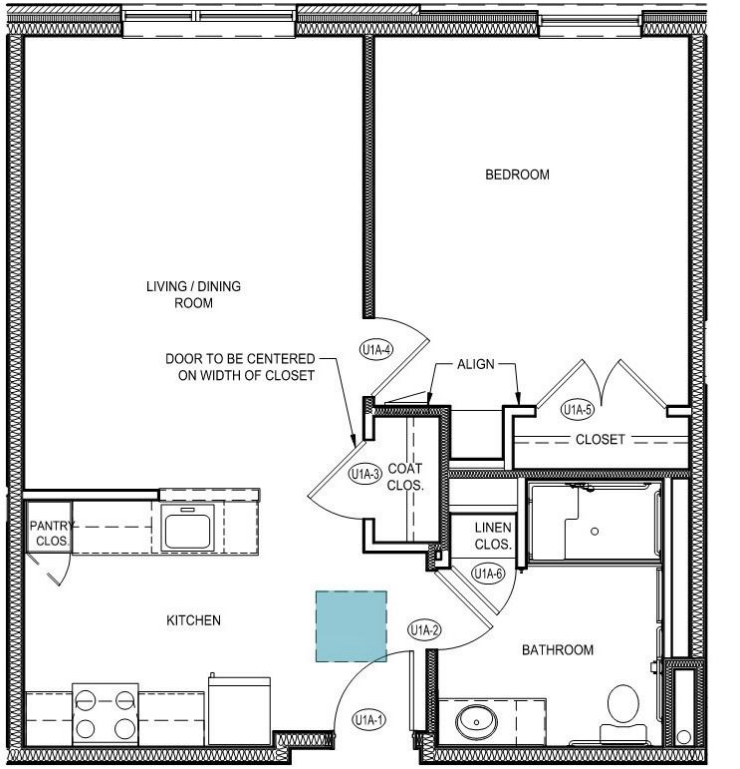


2 A407 **SECTION THRU FLOOR @ CORRIDOR**
SCALE: 1" = 1'-0"

Emerald
Year: 2020
Senior Affordable Housing Apartments 52 total
Occupancy: R-2
Construction Type: VB
Sprinkler: NFPA 13R
floor rating : 1 hour
Square footage

First Floor	14,733 sq. ft.
Second Floor	14,501 sq. ft.
Third Floor	14,345 sq. ft.
Fourth Floor	14,345 sq. ft.
Total	57,924 sq. ft.

Floor to Floor Heights:
1st to 2nd : 11”-5”
2nd to 3rd : 10’-6”
3rd to 4th : 10’-6”



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Edgewood

FRANJO CONSTRUCTION

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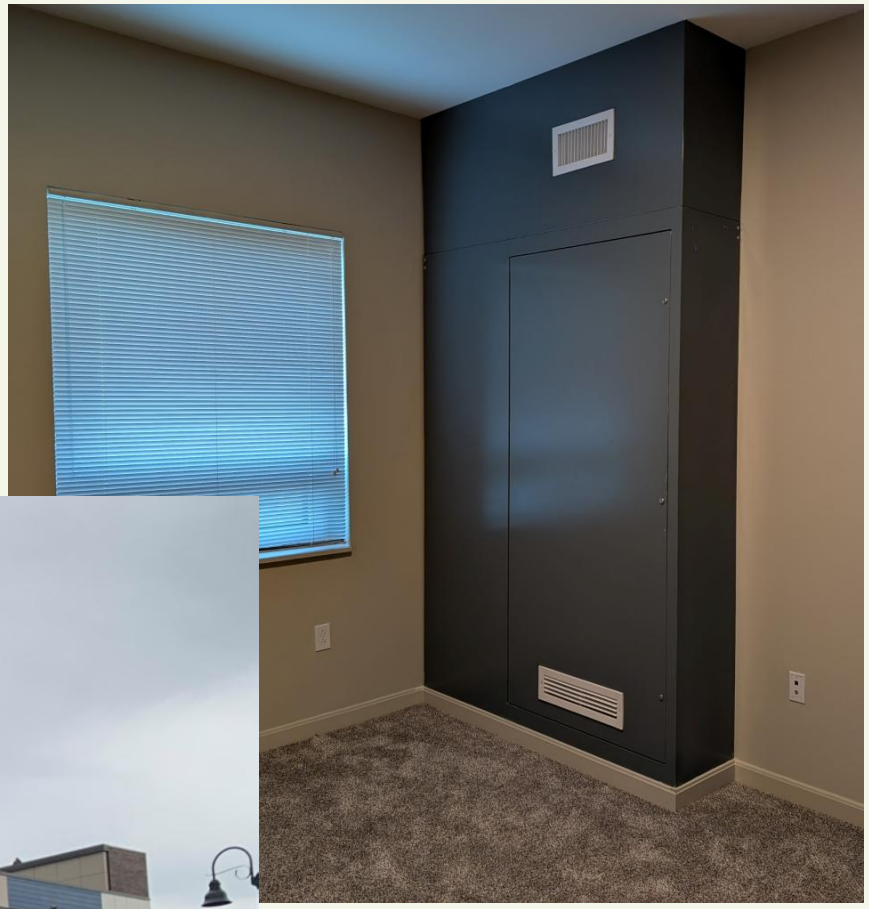
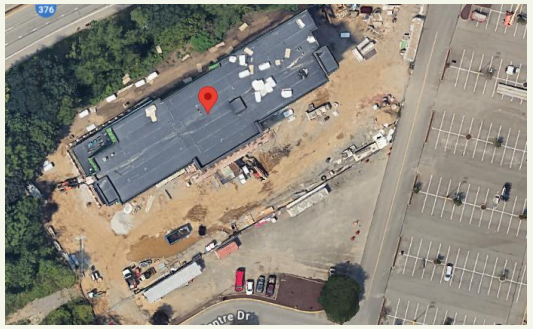
CMS housing

Location	Size	Population	Envelope	HVAC	Ventilation	HW System	Occupied
Pittsburgh	55 Apartments	Senior Housing	Walls: R37 Roof: R53 Windows: 2-pane	EPHOCA All-In-One units	EPHOCA All-In-One units	CO2 Heat Pumps	Spring 2024





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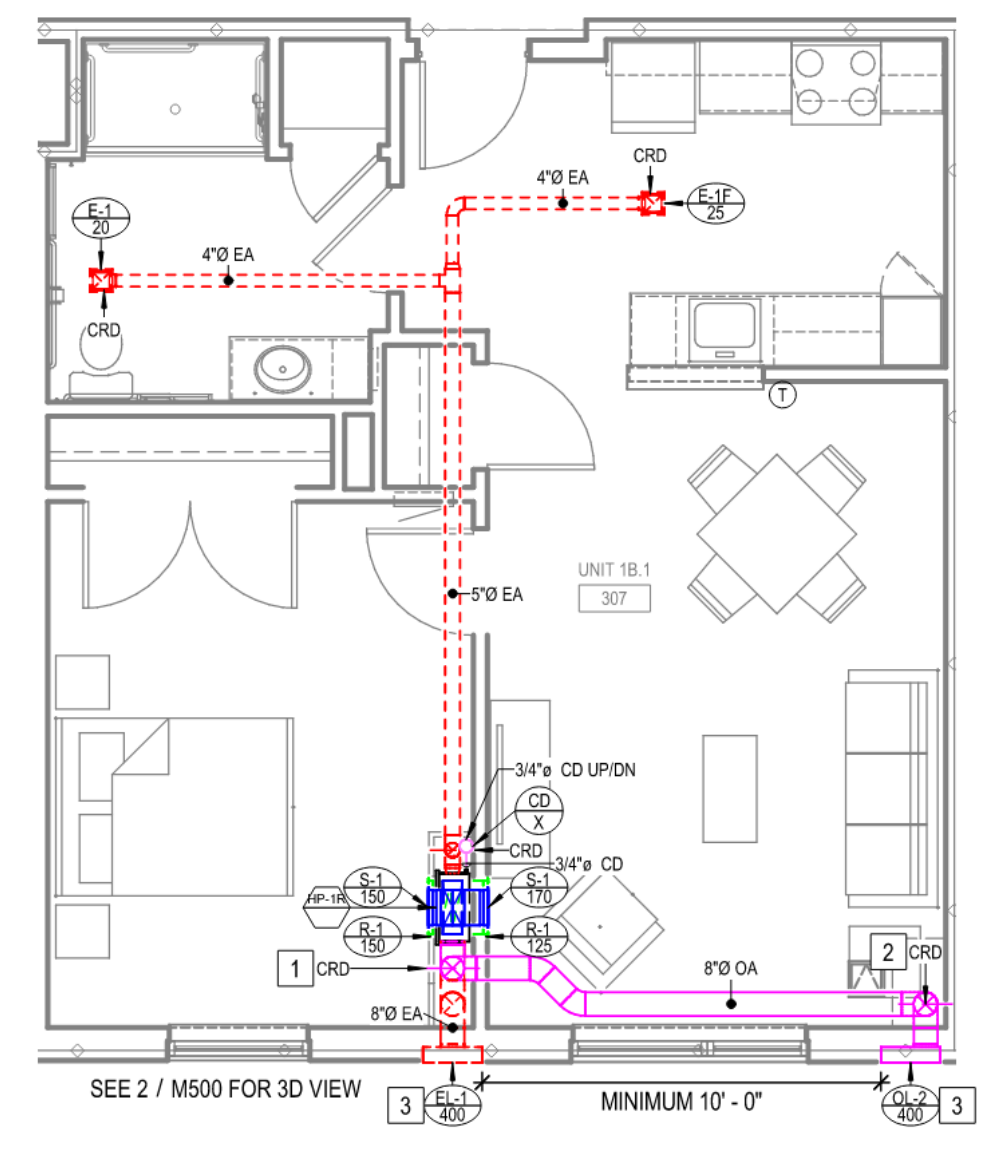
EHPOCA is a trademark of Innova SRL

Edgewood



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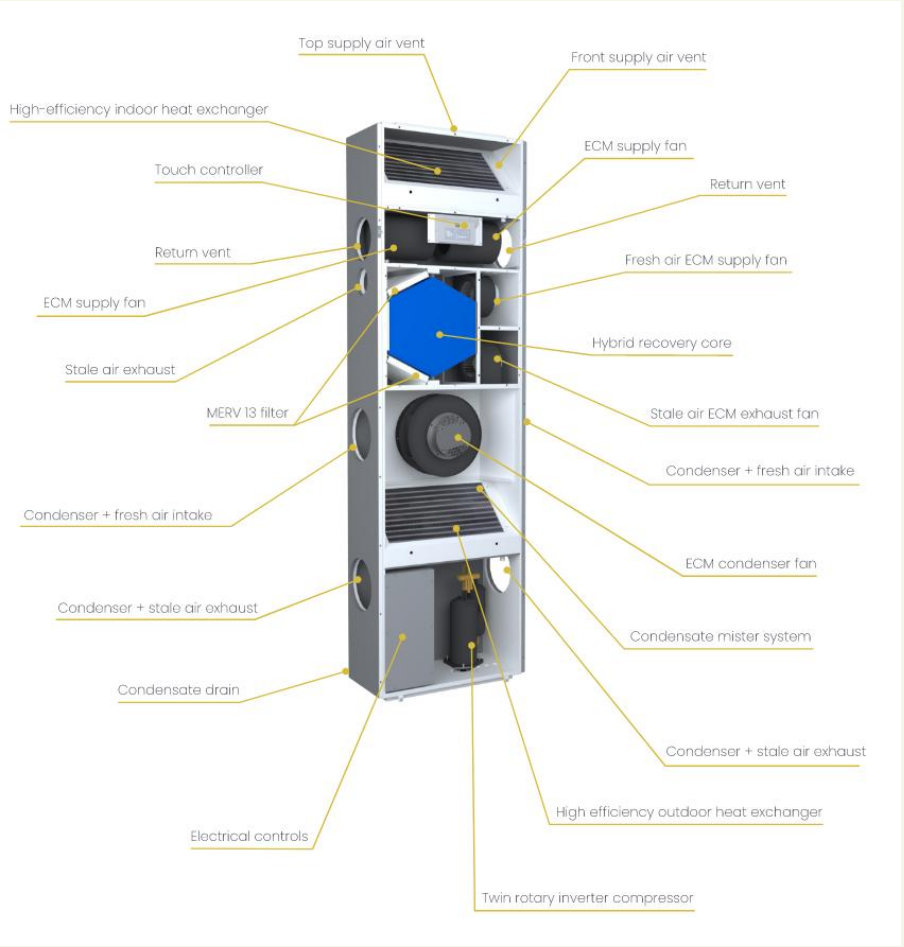
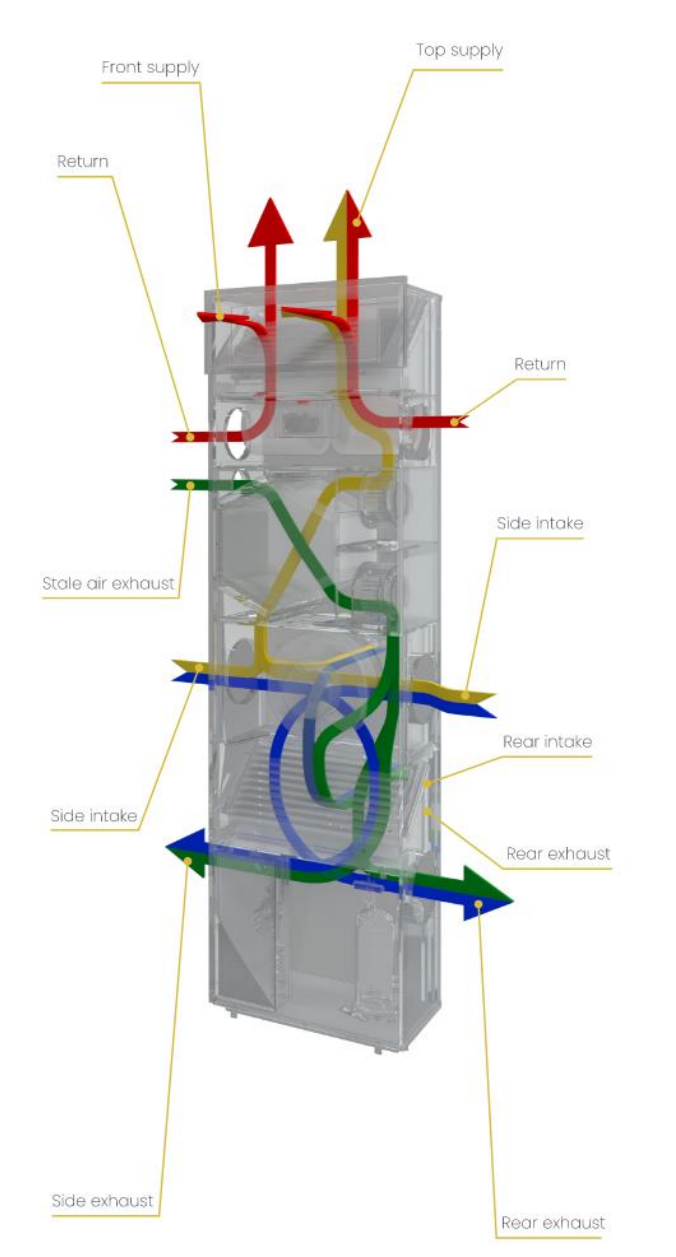
EPHOCA™ AIO (ALL IN ONE) Heat Pump + ERV

- Heat Pump and ERV combined
- Fresh air is drawn out of the condenser air stream
- Exhaust air is pushed into condenser air exhaust
- ECM fans all around
- Inverter driven compressor





Diagrams courtesy of EPHOCA

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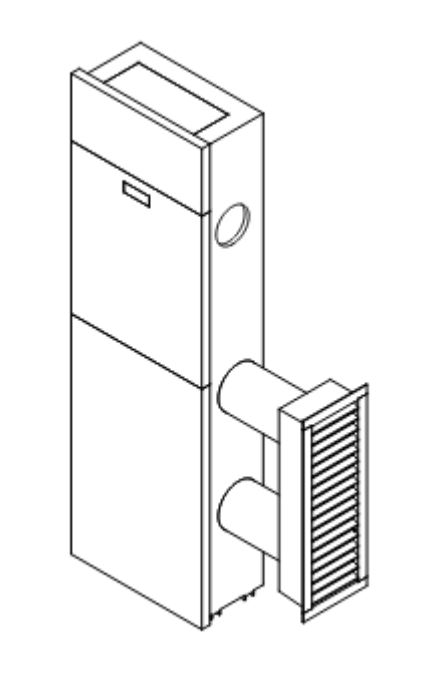
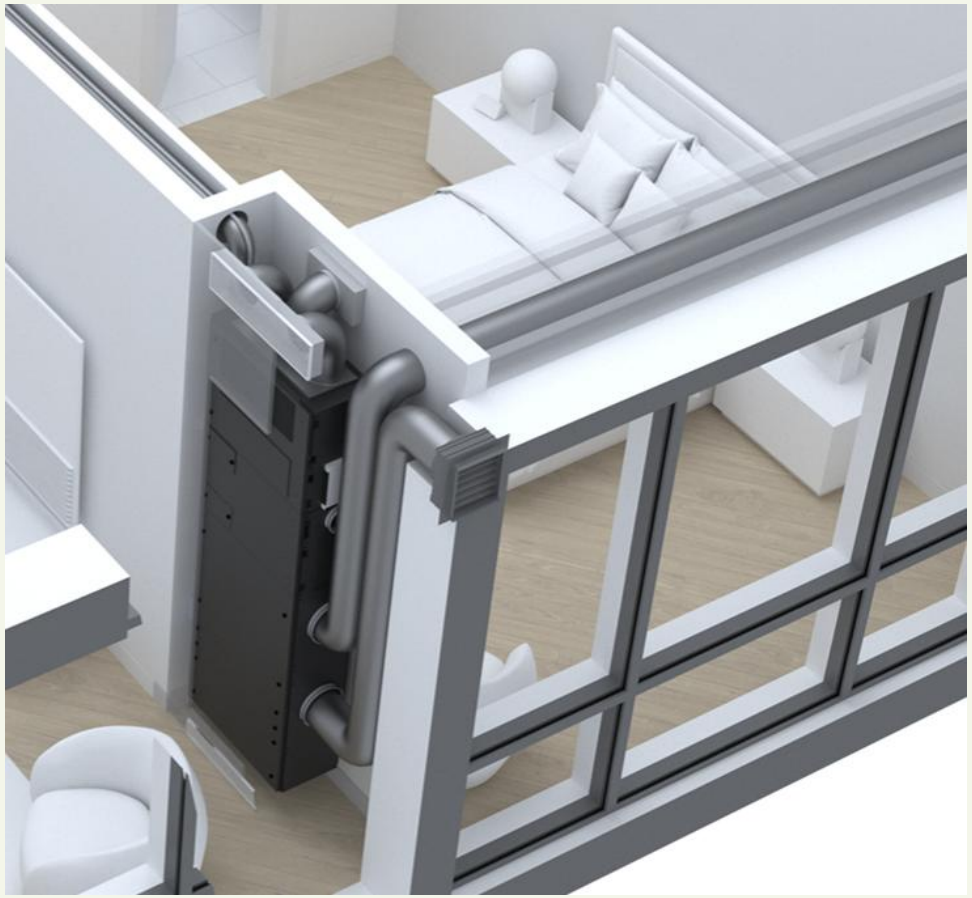
Condenser Air

Code issue forces louver because of built-in ERV.



1300 FPM at Max Flow

We typically size louvers at below 700 fpm (less for intake).



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Domestic HW

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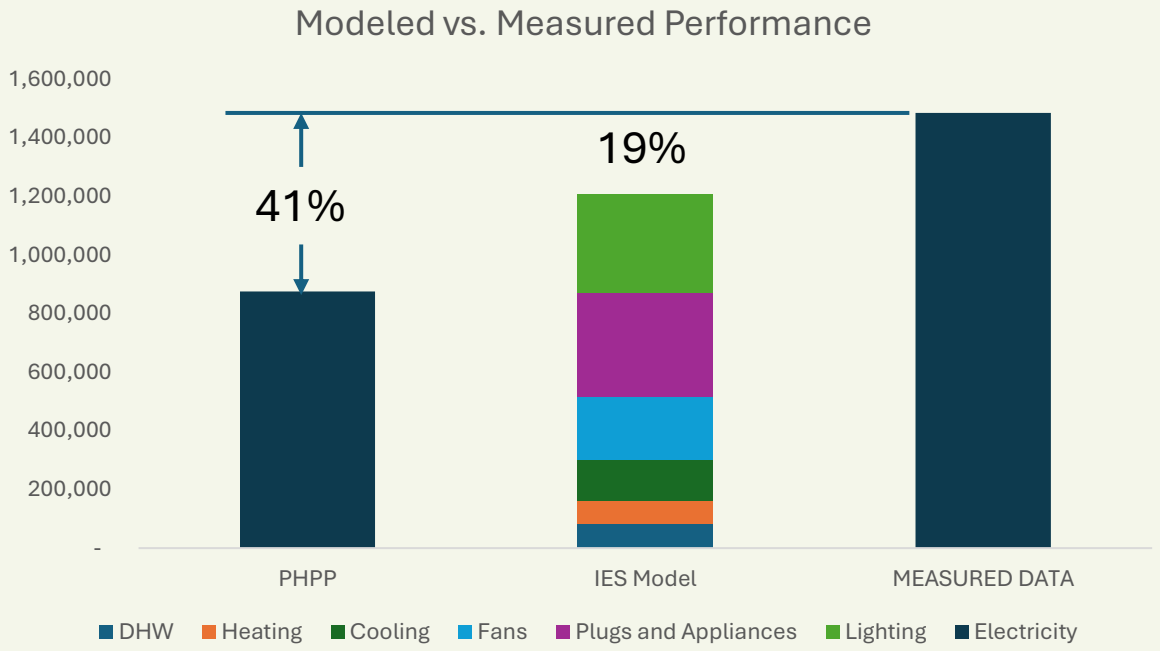
Results

- WUFI model low on cooling and lighting compared to IES model.
- IES model likely low on HVAC due to less than optimal COP?

EUI = 15.19

EUI = 20.96

EUI = 25.78



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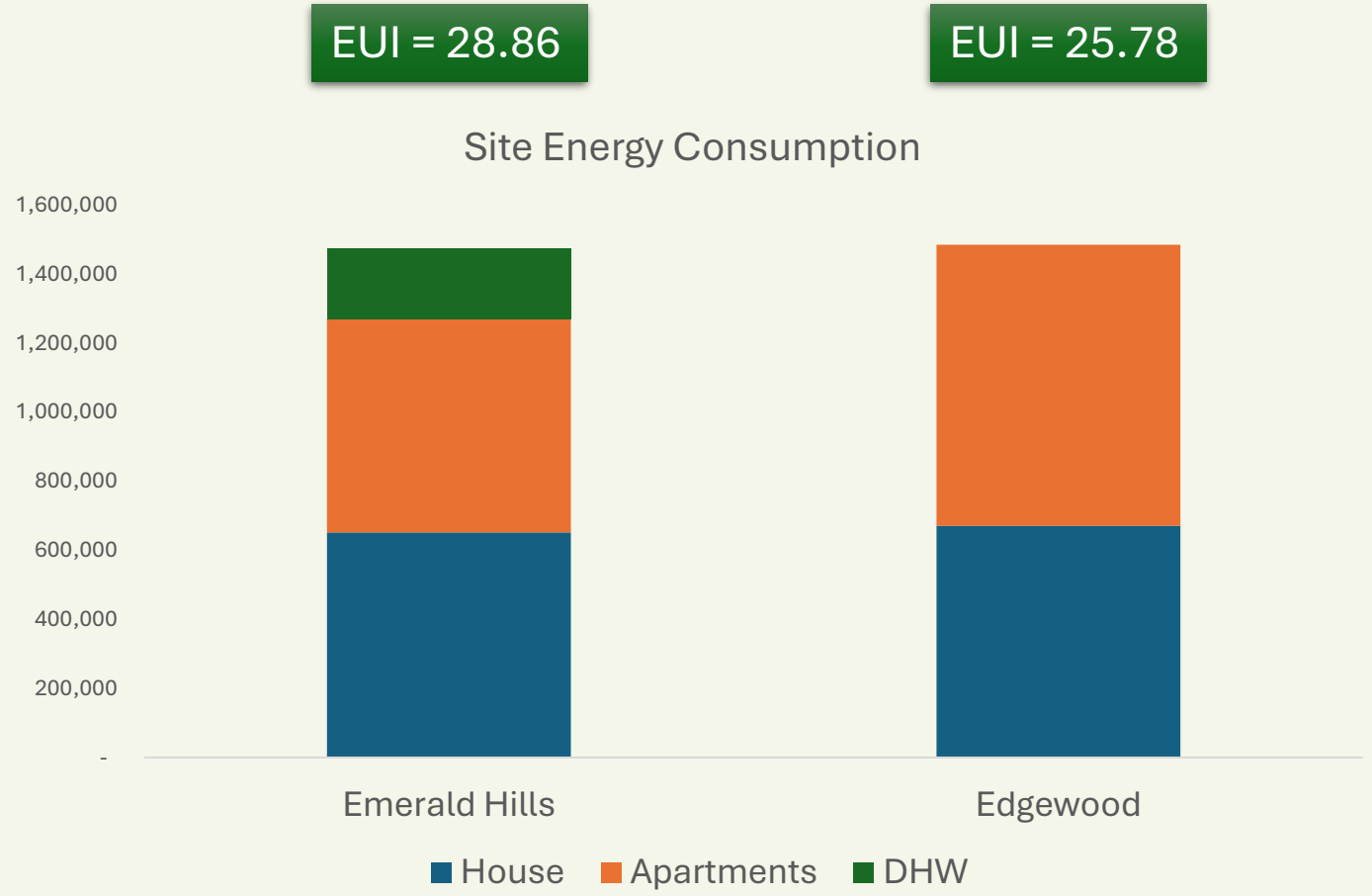
Comparisons



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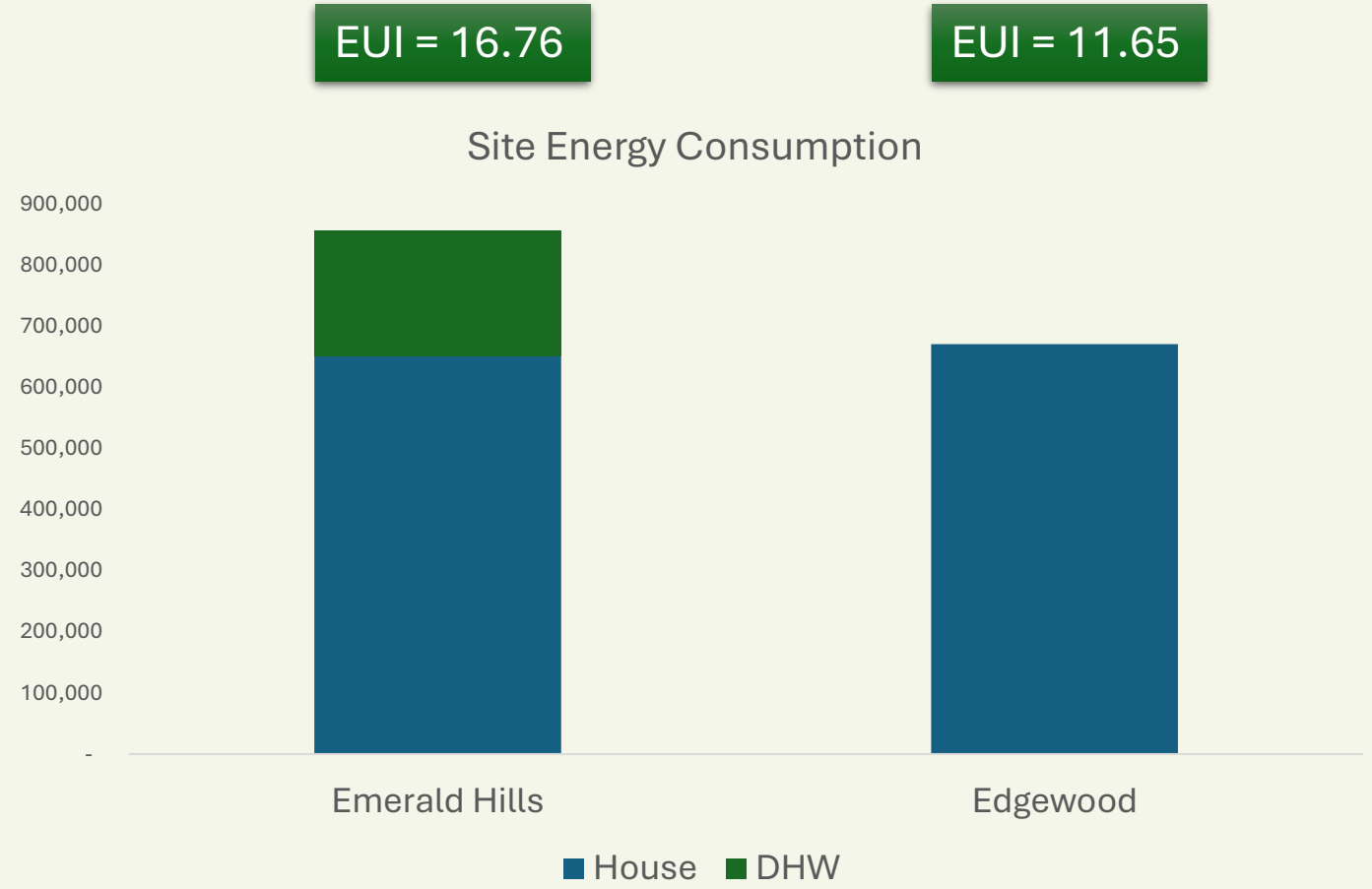
Comparisons - House

- Gas hot water amplifies Emerald Hills site energy (no COP)
- Neighborhood ERVs on house meter



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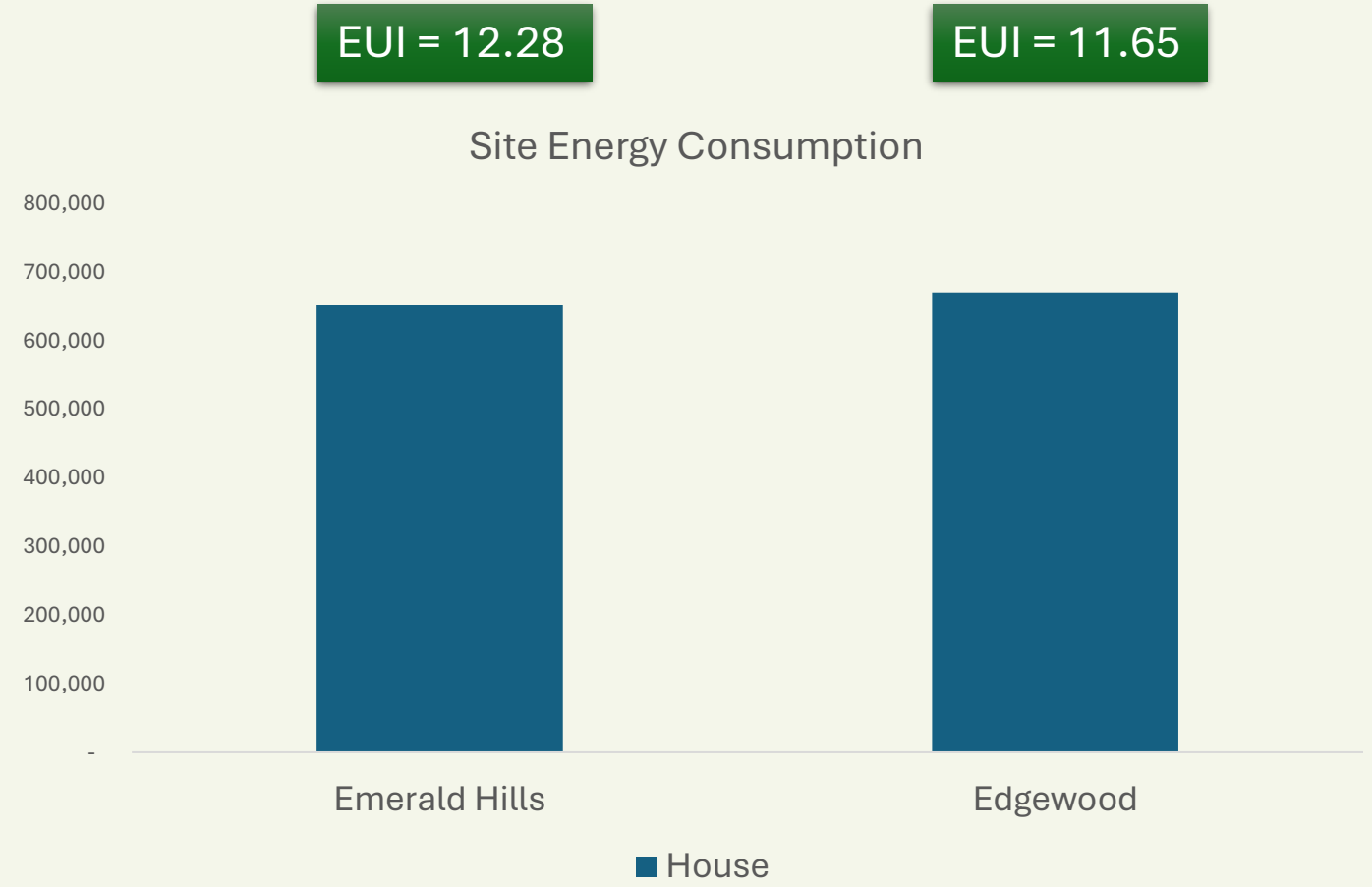
Comparisons - House

- Corrected with ERV energy and assumed COP of 3 for DHW



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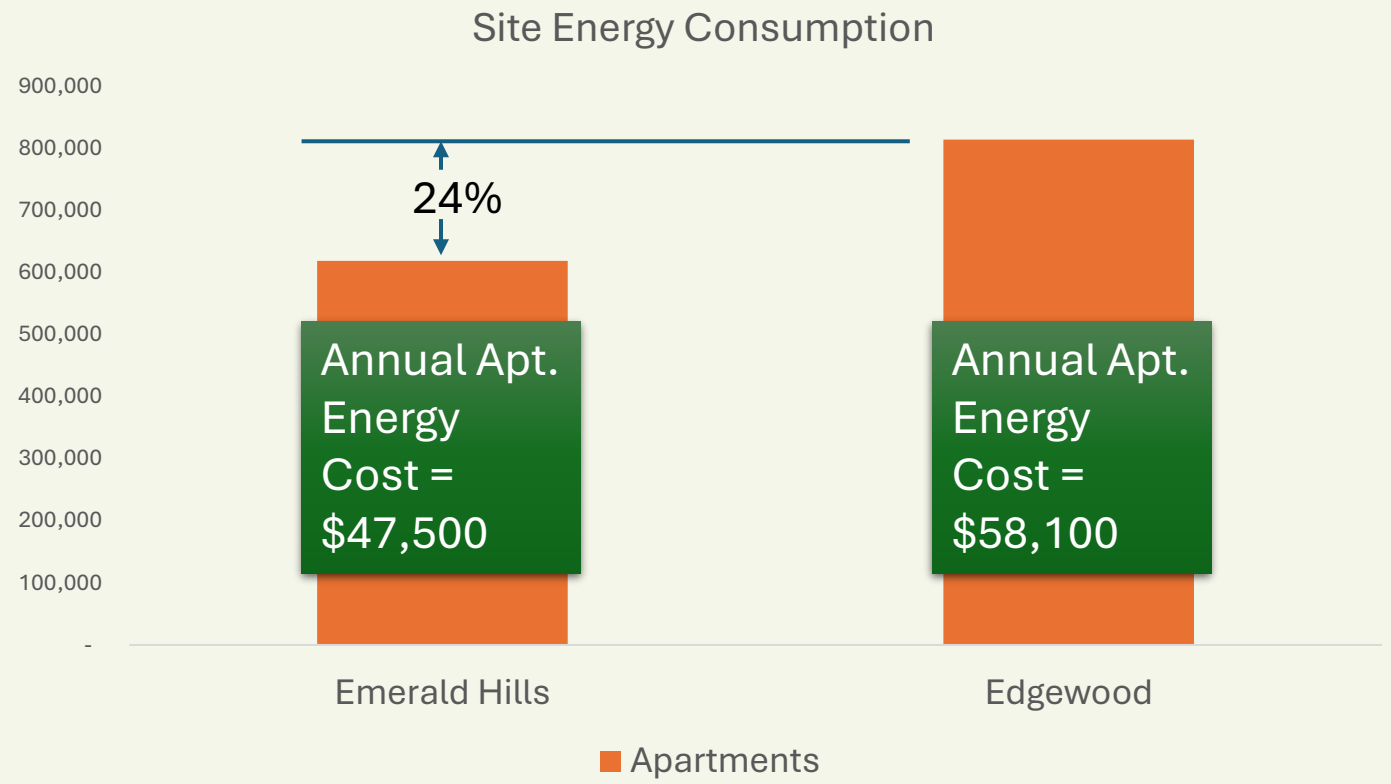
Comparisons - Apartments

- Why is apartment energy higher at Edgewood?



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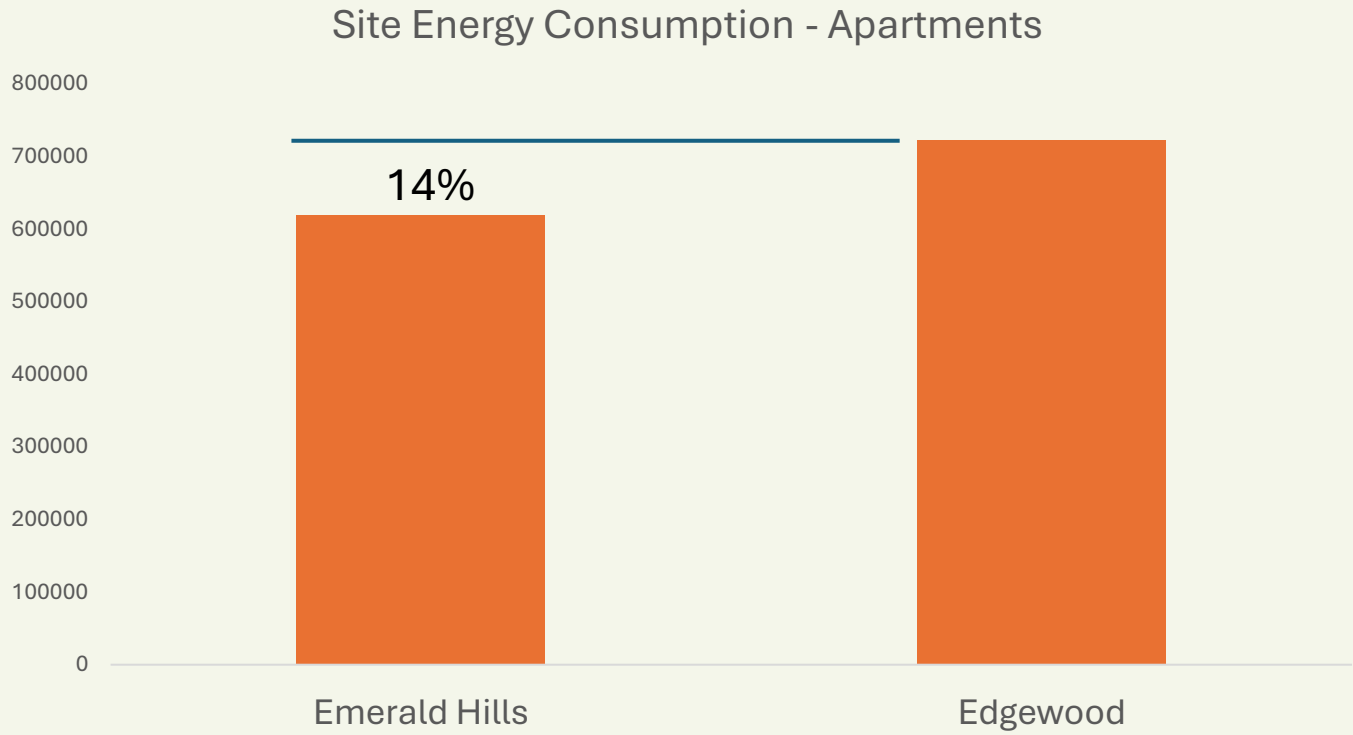
Comparisons - Apartments

- Corrected for ERVs
- Emerald Hills:
  - One Bedroom: 672 sqft
  - Two Bedroom
  - 934 sqft
- Edgewood
  - One Bedroom:
  - 694 sqft (3% larger)
  - Two Bedroom
  - 976 sqft (5% larger)



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Investigation

Edgewood Ephoca Testing								
UNIT 105								
Outdoor Temp	44	F						
Cooling - High			Cooling - Medium			Cooling - Low		
Setpoint	66	F	Setpoint	65	F	Setpoint	65	F
Return Air Temp	74	F	Return Air Temp	72	F	Return Air Temp	72	F
Supply Air Temp	48.5	F	Supply Air Temp	45	F	Supply Air Temp	42	F
Bedroom Airflow	95	CFM	Bedroom Airflow	75	CFM	Bedroom Airflow	59	CFM
Living Room Airflow	140	CFM	Living Room Airflo	115	CFM	Living Room Airflo	98	CFM
Return Airflow		CFM	Return Airflow		CFM	Return Airflow		CFM
Current Draw	2.9	A	Current Draw	2.33	A	Current Draw	1.8	A
Voltage*	208	V	Voltage*	208	V	Voltage	208	V
Watts	603.2	W	Watts	484.6	W	Watts	374.4	W
Output	6472	BTU/hr	Output	5540	BTU/hr	Output	5086.8	BTU/hr
COP	4.558		COP	5.458		COP	7.96164	
Heating - High			Heating - Medium			Heating - Low		
Setpoint	75	F	Setpoint	83	F	Setpoint	83	F
Return Air Temp	73	F	Return Air Temp	72	F	Return Air Temp	72	F
Supply Air Temp	94.5	F	Supply Air Temp	93	F	Supply Air Temp	93.9	F
Bedroom Airflow	90	CFM	Bedroom Airflow	76	CFM	Bedroom Airflow	55	CFM
Living Room Airflow	135	CFM	Living Room Airflo	106	CFM	Living Room Airflo	84	CFM
Return Airflow		CFM	Return Airflow		CFM	Return Airflow		CFM
Current Draw	3.5	A	Current Draw	3.1	A	Current Draw	2.1	A
Voltage	208	V	Voltage	208	V	Voltage	208	V
Watts	728	W	Watts	644.8	W	Watts	436.8	W
Output	-5225	BTU/hr	Output	-4128	BTU/hr	Output	-3287.6	BTU/hr
COP	-2.83		COP	-2.64		COP	-3.8592	
Ventilation Only								
Current Draw	0.9	A						
Voltage	208	V						
Watts	187.2	W						
Bathroom Airflow	25	CFM						
Kitchen Airflow	25	CFM						
Bedroom Airflow	23	CFM						
Living Room Airflow	25	CFM						

3.75 W/cfm!

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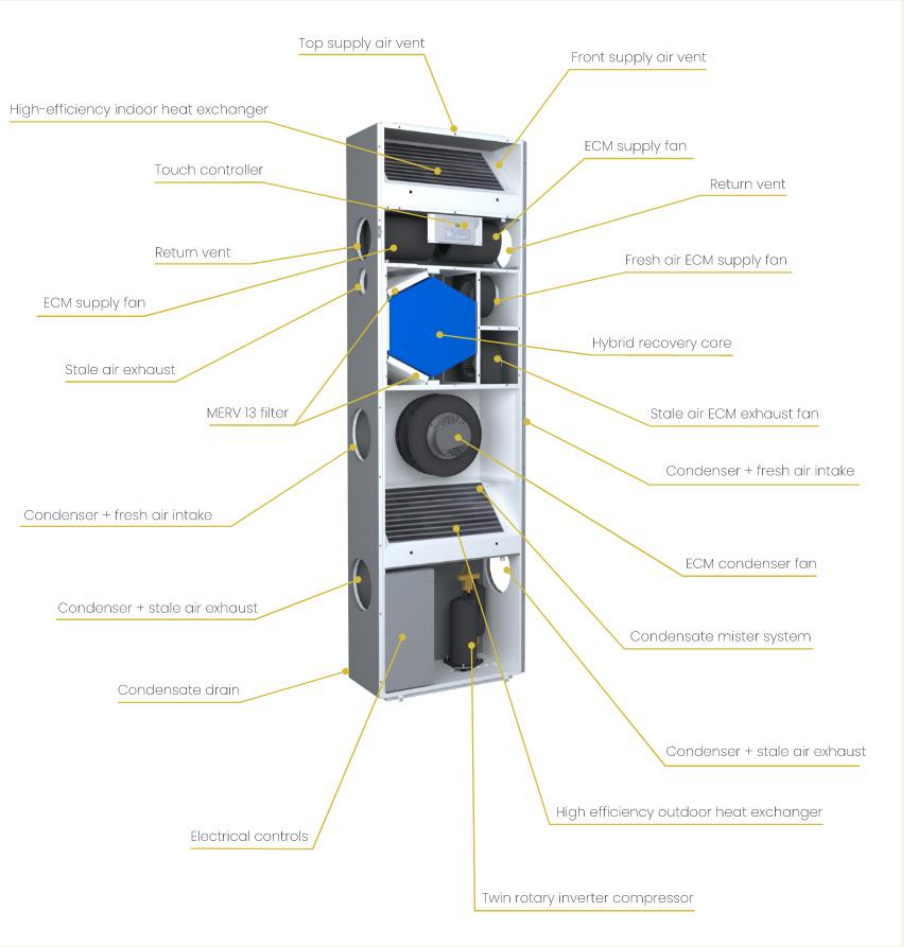
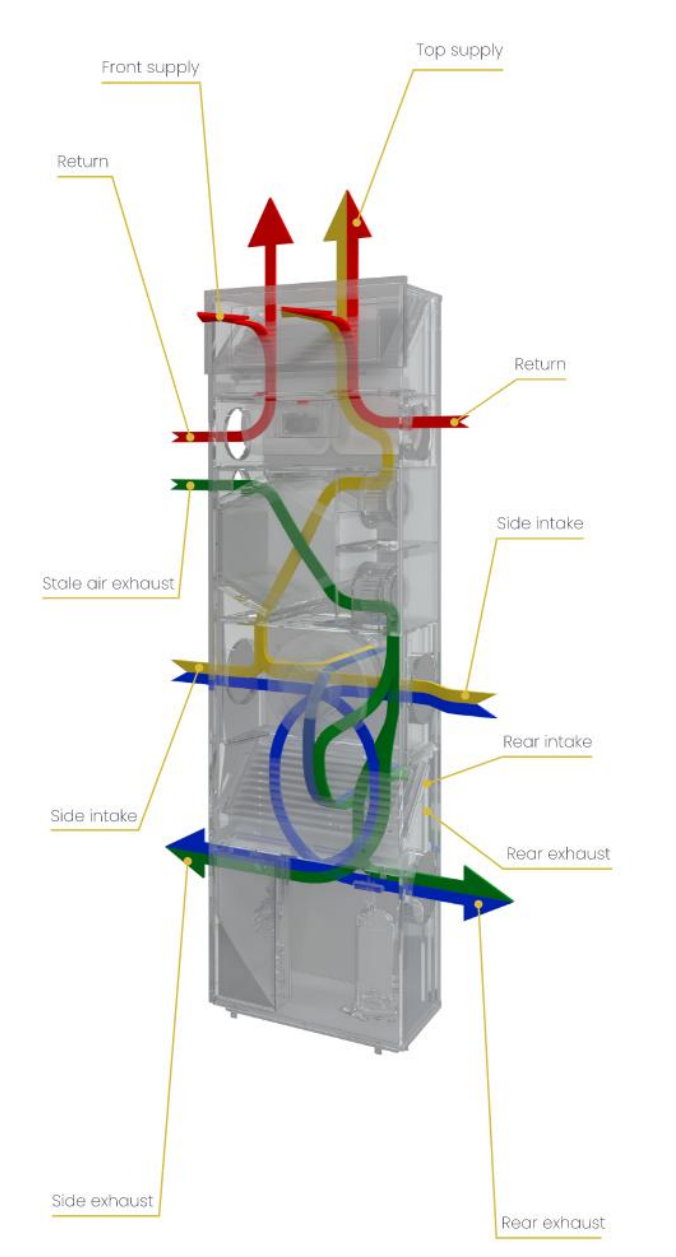
EPHOCA™ AIO (ALL IN ONE) Heat Pump + ERV

- Heat Pump and ERV combined
- Fresh air is drawn out of the condenser air stream
- Exhaust air is pushed into condenser air exhaust
- ECM fans all around
- Inverter driven compressor





Diagrams courtesy of EPHOCA

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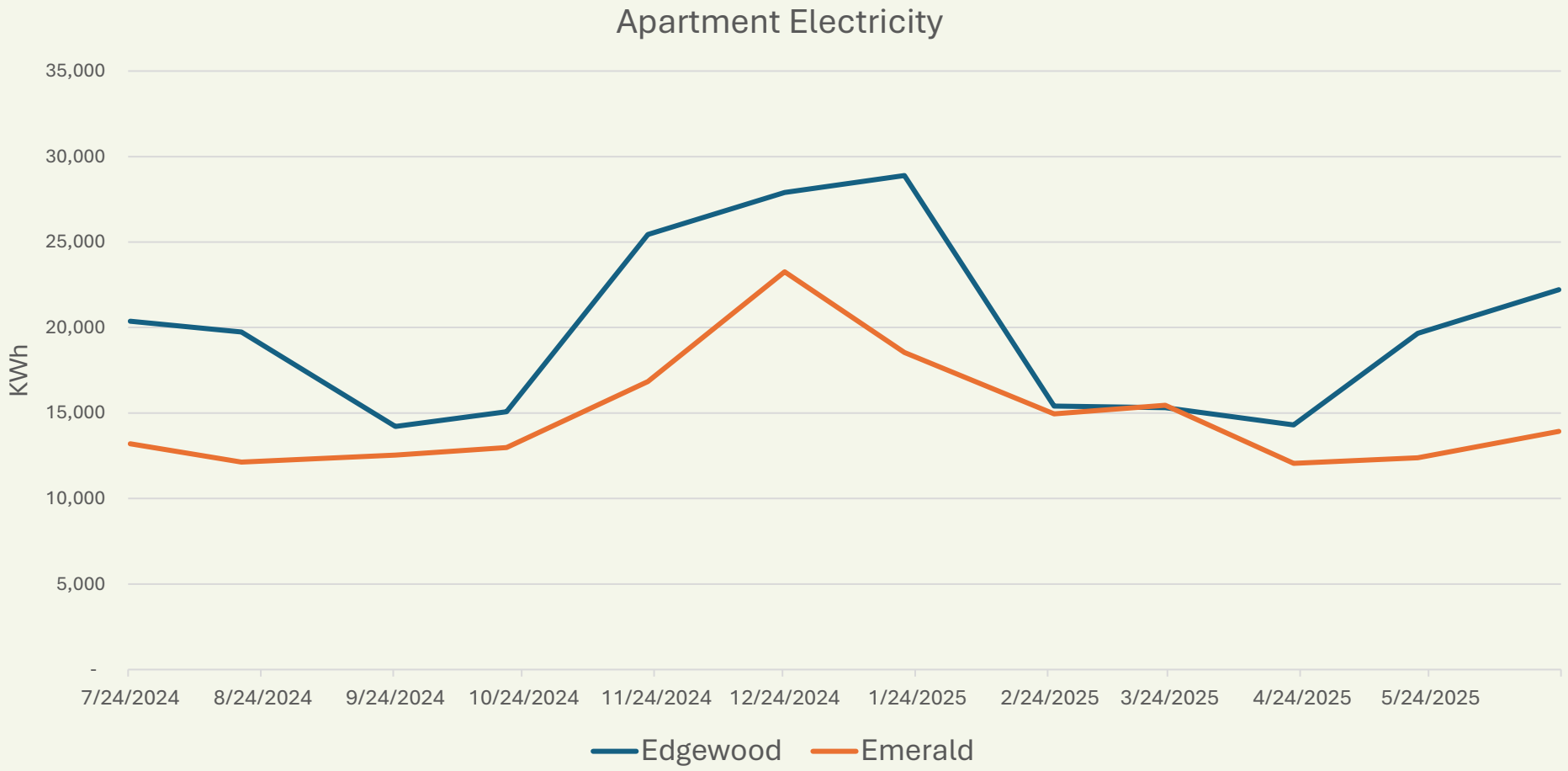
Investigation



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Investigation Results

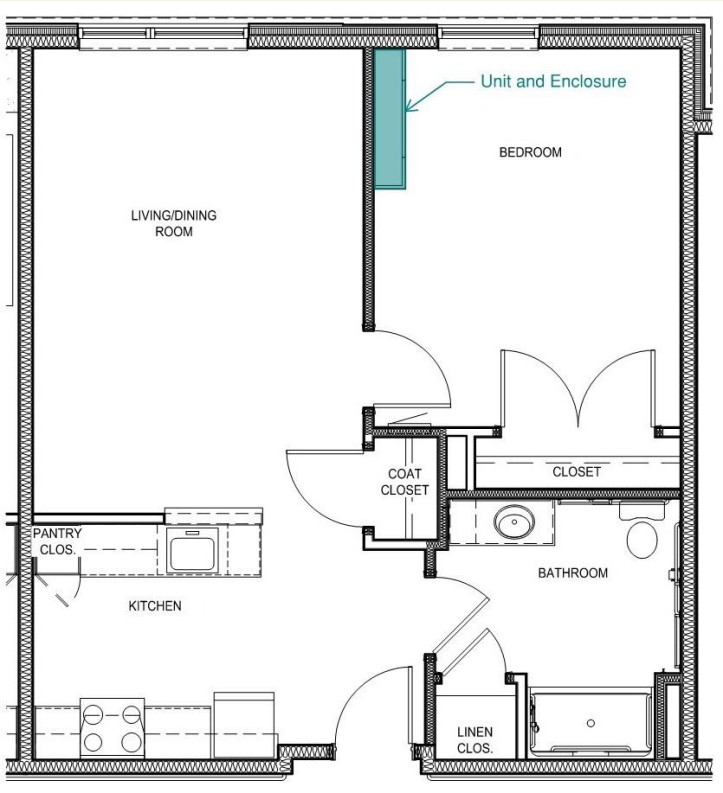
- EPHOCA has made a programming change to reduce fan energy when there is not heating or cooling required. This is being rolled out at Edgewood.
- Some units have been found to have restrictions in the return air pathway, which may be leading to increased indoor fan energy and decreased efficiency.
- Construction debris was left in coils which likely reduced efficiency during the first winter season. Coils have been cleaned and are on a regular maintenance schedule.

EPHOCA Updated Programming Results

	Old Firmware 2.0 version	
Fan speed Setting	Input / Heating mode comp off / ERV 50CFM	Input / Cooling mode comp off / ERV 50CFM
V1	95,5 watt	93,3 watt
V2	172 watt	168,7 watt
V3	240 watt	240 watt
Auto	96,3 watt	94,5 watt

	New Firmware 3.0 version	
Fan speed Setting	Input / Heating mode comp off / ERV 50CFM	Input / Cooling mode comp off / ERV 50CFM
V1	31,3 watt	35,9 watt
V2	31,5 watt	38,5 watt
V3	31,7 watt	38,7 watt
Auto	32,1 watt	37,5 watt

Data provided by EPHOCA



Edgewood

Senior Affordable Housing Apartments 52 total
Occupancy:R-2
Construction Type: VB
Sprinkler: NFPA 13R
Square footage

First Floor	16,347 sq. ft.
Second Floor	15,547 sq. ft.
Third Floor	15,547 sq. ft.
Fourth Floor	15,547 sq. ft.
Total	72,988 sq. ft

Floor to Floor Heights:
1st to 2nd : 11”-5”
2nd to 3rd : 11’-8”
3rd to 4th : 10’-6”

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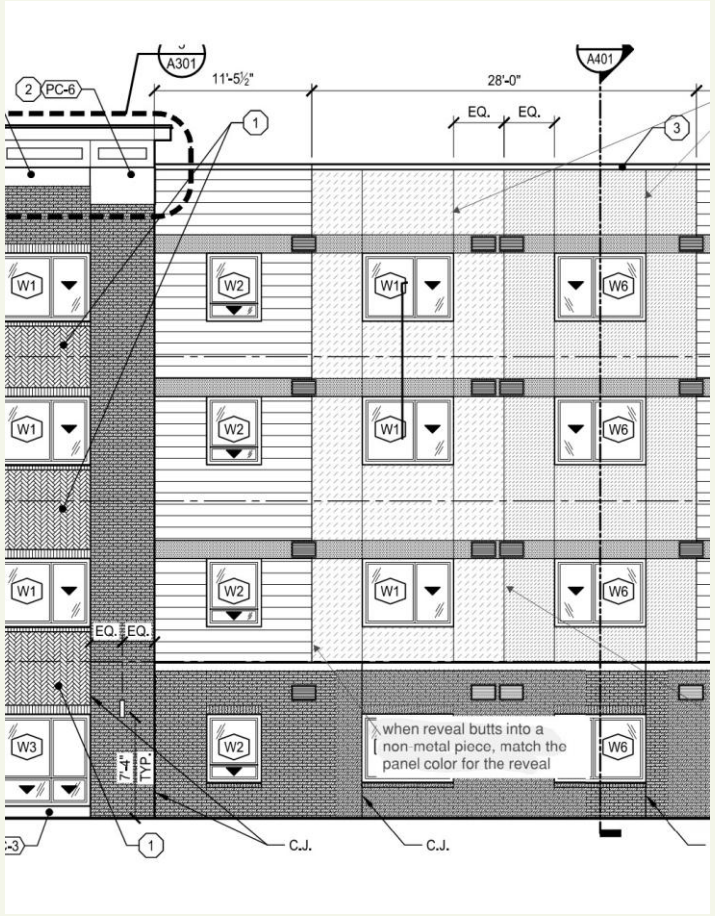

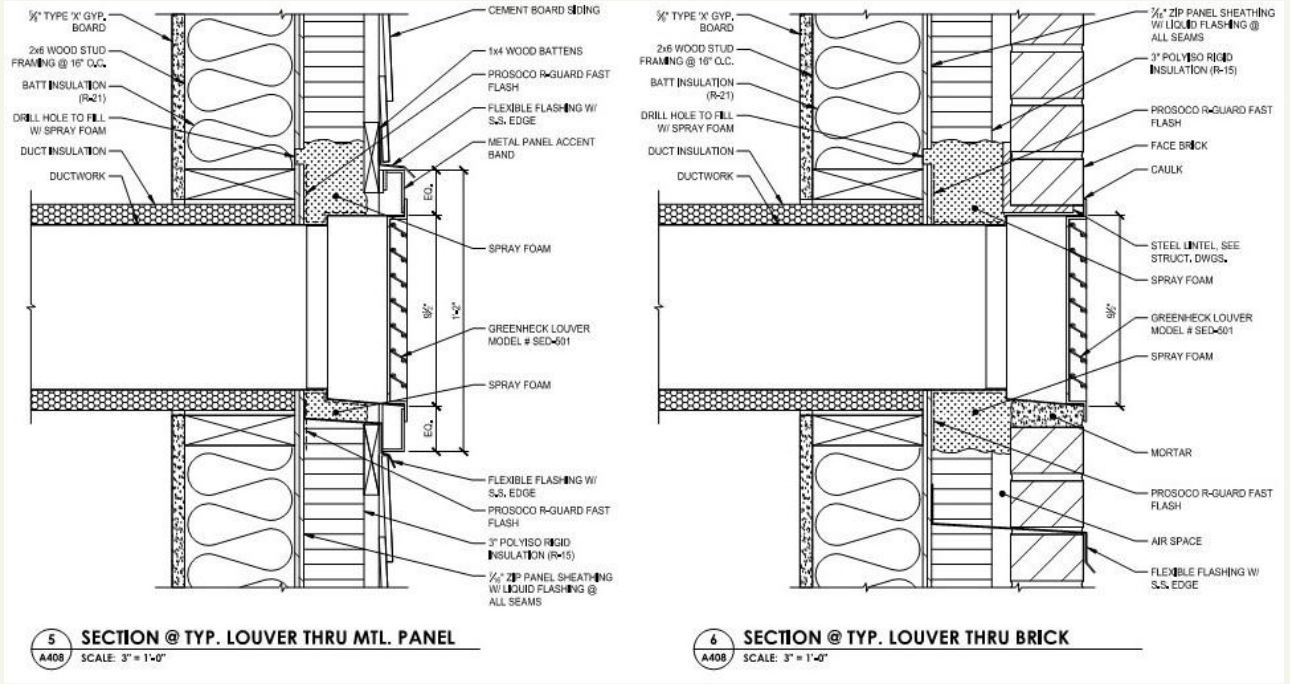

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Owner’s Perspective

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System type comparison

Strategy	Ductwork	Penetrations	Install difficulty
Emerald Hills (ducted splits with neighborhood ERVs)	More ductwork	Less penetrations . Façade coordination	More challenging due to coordination with ceilings / structure • Need slim vertical form factor • Site installed refrigeration line-sets • Location of ERVs and outdoor condensers
Edgewood (All-in-one)	Much less ductwork, could be even less.	Much more penetrations	More elegant, but need larger intake louver by manufacturer

System type comparison

Strategy	Cost	Equipment Support	Manufacturer Responsiveness	System Complexity
Emerald Hills (ducted splits with neighborhood ERVs)	Lower equipment cost Higher labor cost	Good	Slow – but product is mature and well supported	Separate systems are easier to design and commission because of industry experience
Edgewood (All-in-one)	Higher equipment cost Lower labor cost	Good	Fast	All-in-one is a simpler install, but understand of operation and efficiency is immature - Efficiency standard does not exist yet - Ventilation is integrated, and thus more complex to diagnose and verify

System type comparison

Strategy	Maintenance Required
Emerald Hills (ducted splits with neighborhood ERVs)	Moderate
Edgewood (All-in-one)	Higher - Condenser coil cleaning requires removal of cabinet panels

Cleaning Video

	EMERALD	EDGEWOOD	DIFFERENCE
Filters	$ 1,259.35	$ 1,950.00	$ 690.65
Coil Cleaning	$ 1,081.88	$ 4,000.00	$ 2,918.12
Maintenance Contract	$ 5,272.96	$ 6,231.86	$ 958.90
TOTAL	**$ 7,614.19**	**$ 12,181.86**	**$ 4,567.67**

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Thank You!

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Photo Credit: Ezra Staengl