

The Levers of Power

A sensitivity analysis of various mechanical system metrics on multi-family passive house projects, and how our projects measure up



Galen Staengl PE
CPHC, LEED BD +C

A Tale of Three Projects



PIONEER APARTMENTS



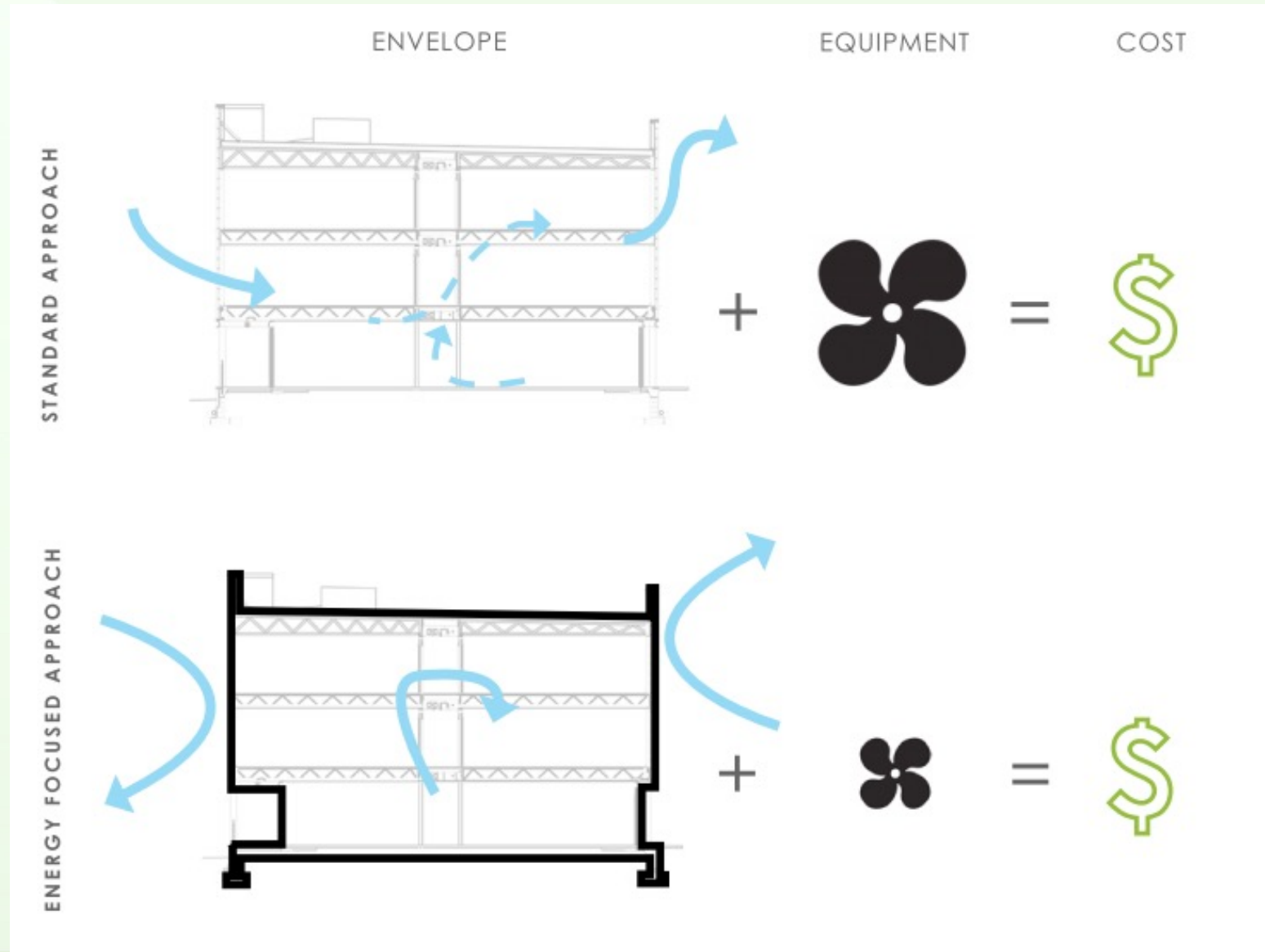
NEGLY AVENUE APARTMENTS



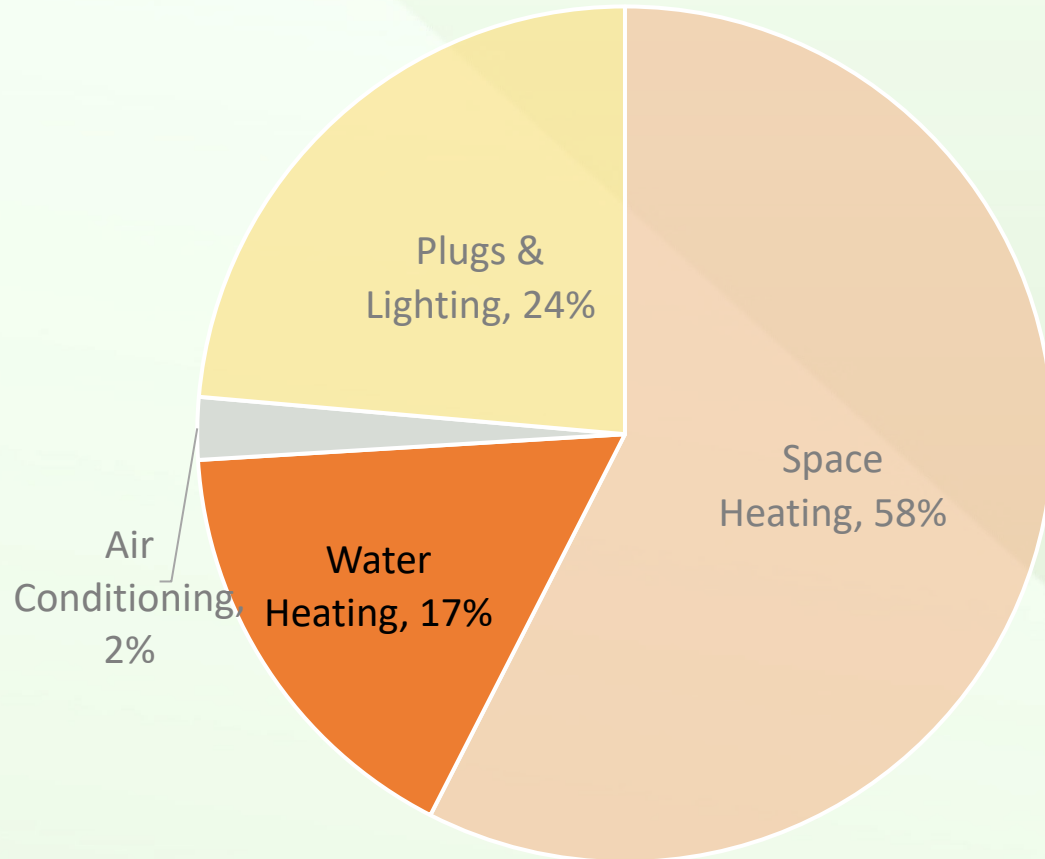
EMERALD HILLS APARTMENTS

Multi-Family Buildings
In Pittsburgh, PA

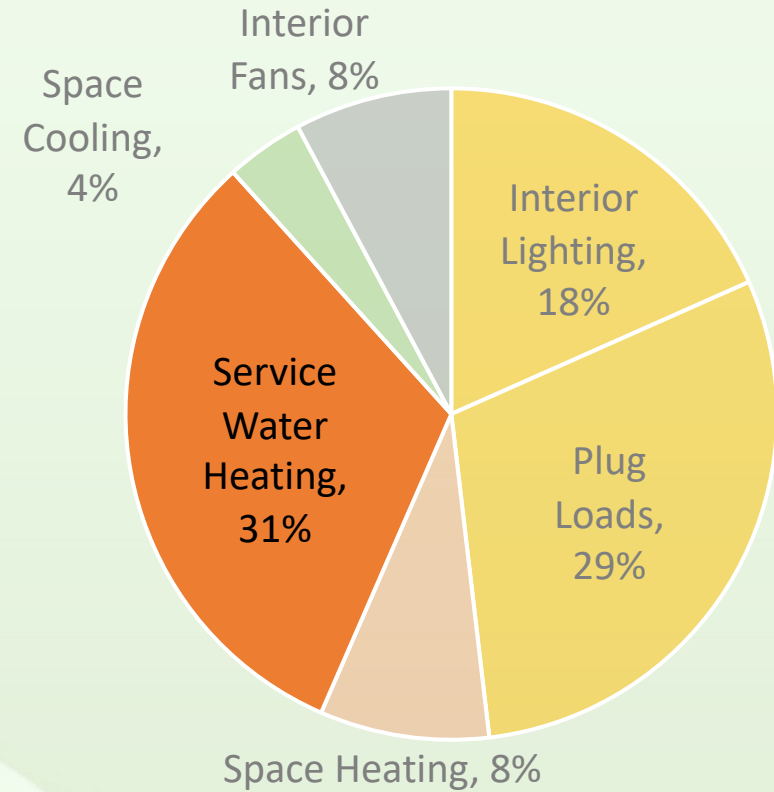
Passive House Project Optimization



Typical MF Building in the NE



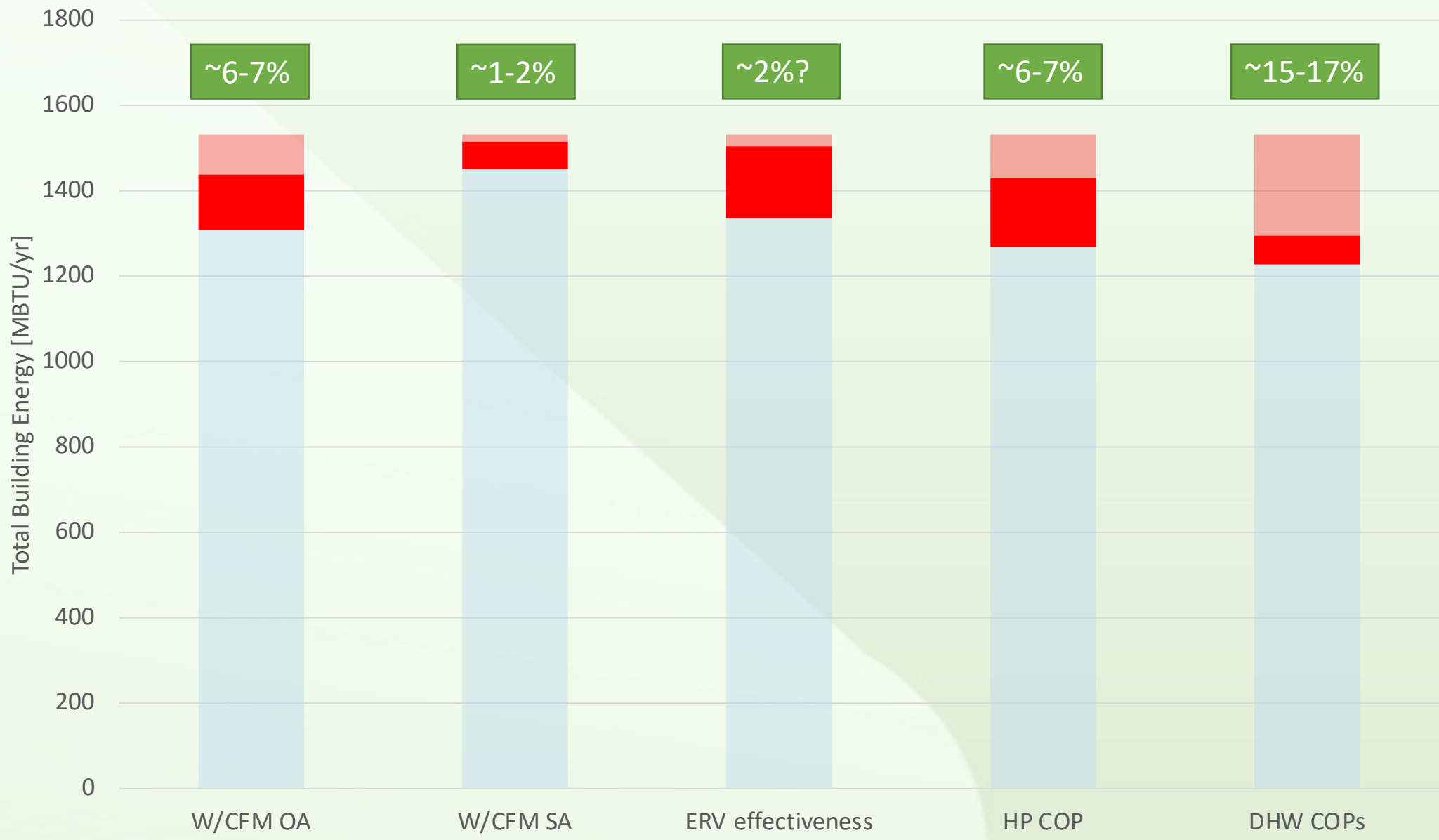
Passive Building



Metrics

- W/CFM – Ventilation
- W/CFM – Heat & AC
- ERV Effectiveness
- HVAC SEER/COP
- DHW COP
- Sqft/ton
- Embodied Carbon

Some MEP Levers of Power



Ventilation W/cfm

Negley – Central DOAs



Negley – 0.91 W/CFM

Emerald Hills - Neighborhood ERVs



Emerald – 0.84 W/CFM

Pioneer – Individual Apartment ERVs



Emerald – 0.53 W/CFM

Ventilation W/cfm



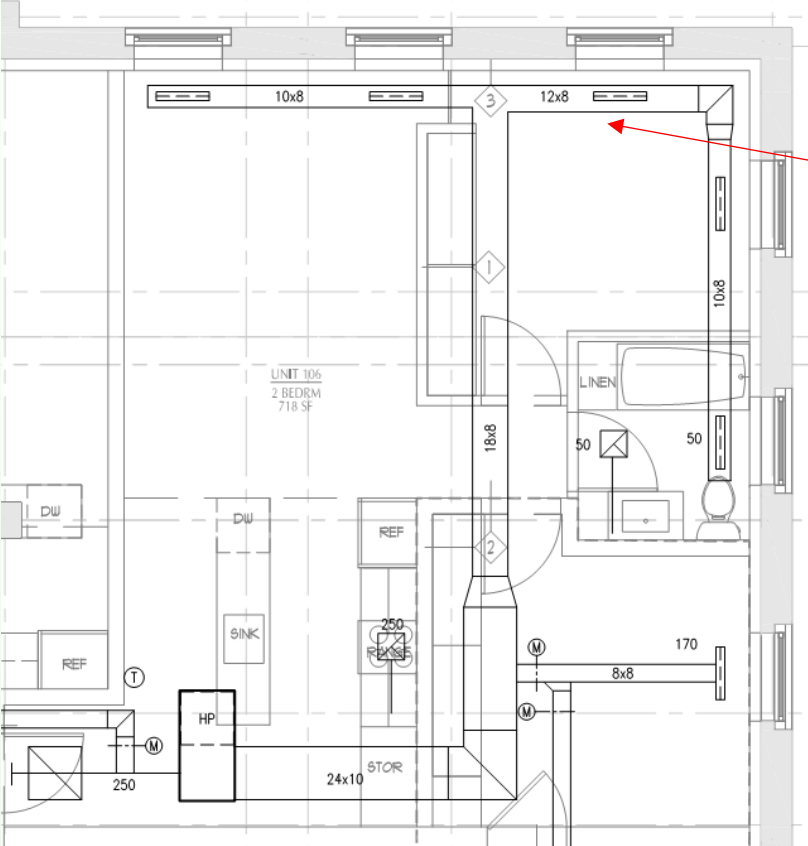
Large Impact!
~6-7% of overall
building energy!

Space Conditioning W/cfm

Less ductwork / low static pressure design.

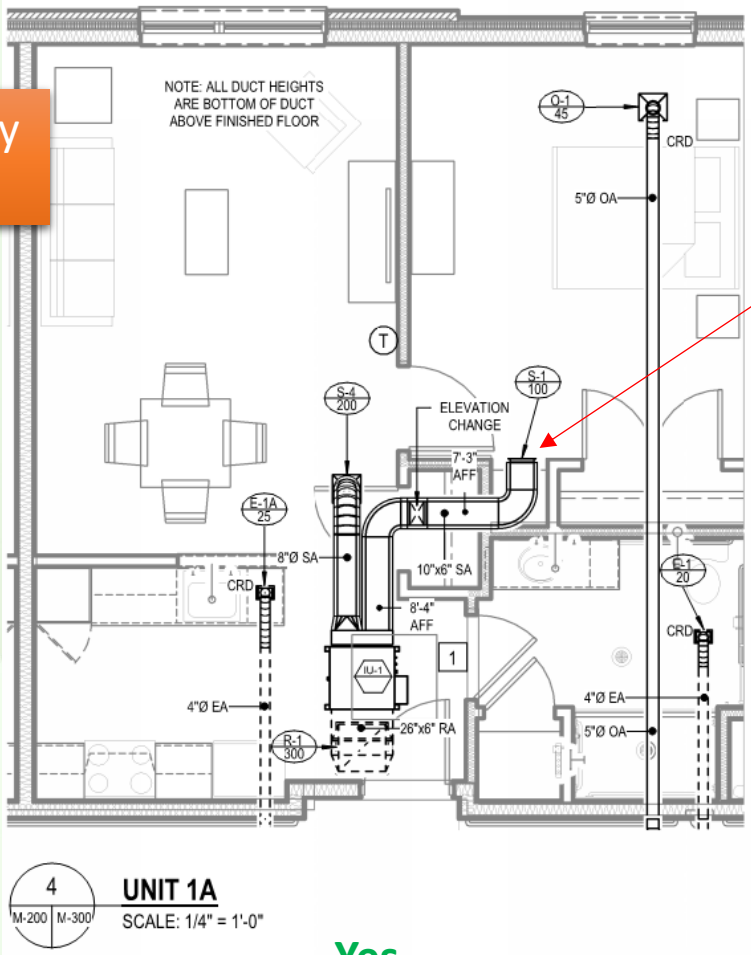


Lower First Cost - Lower Energy Cost



Unnecessary Ductwork

No

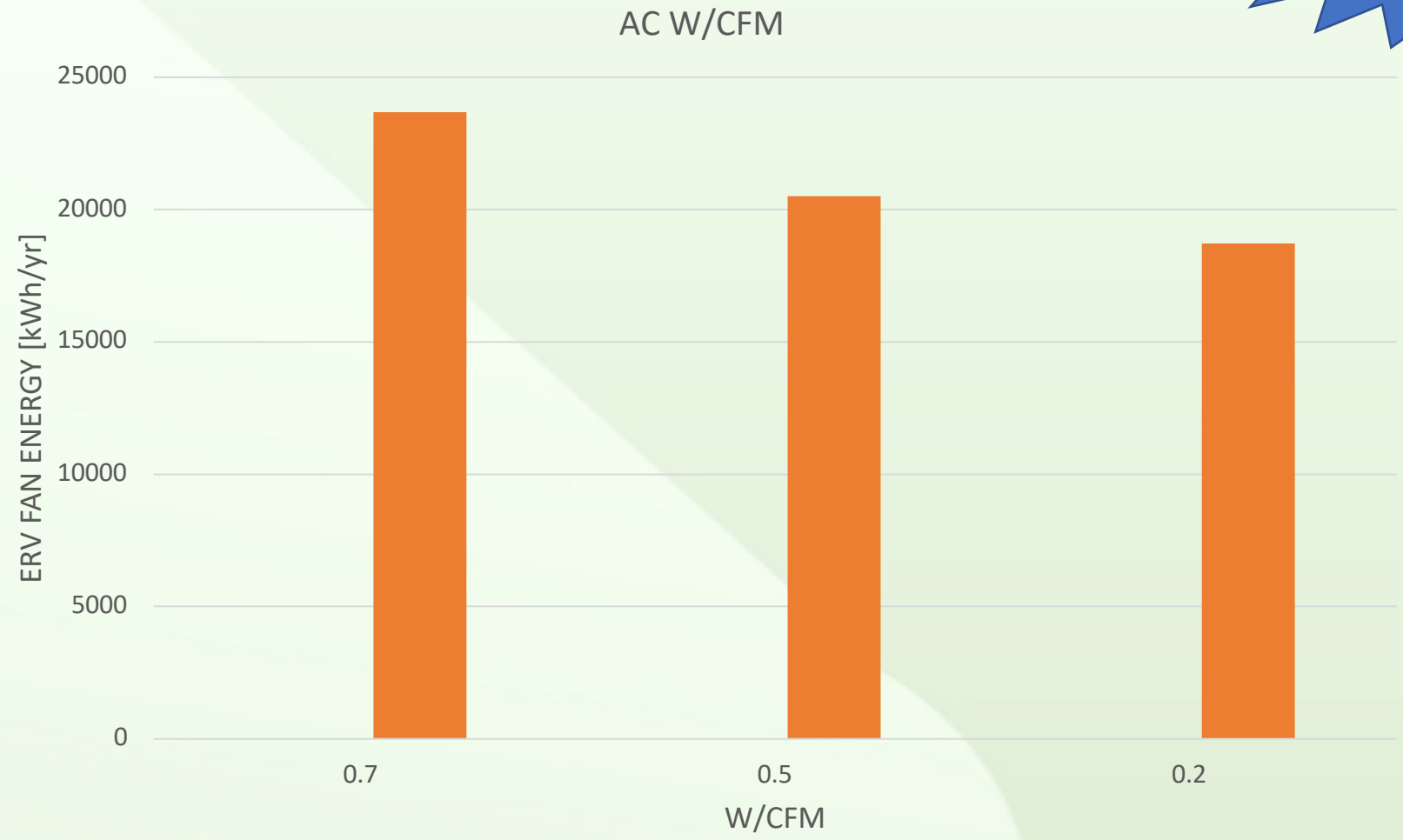


Passive Envelope eliminates need to heat at the perimeter

Yes

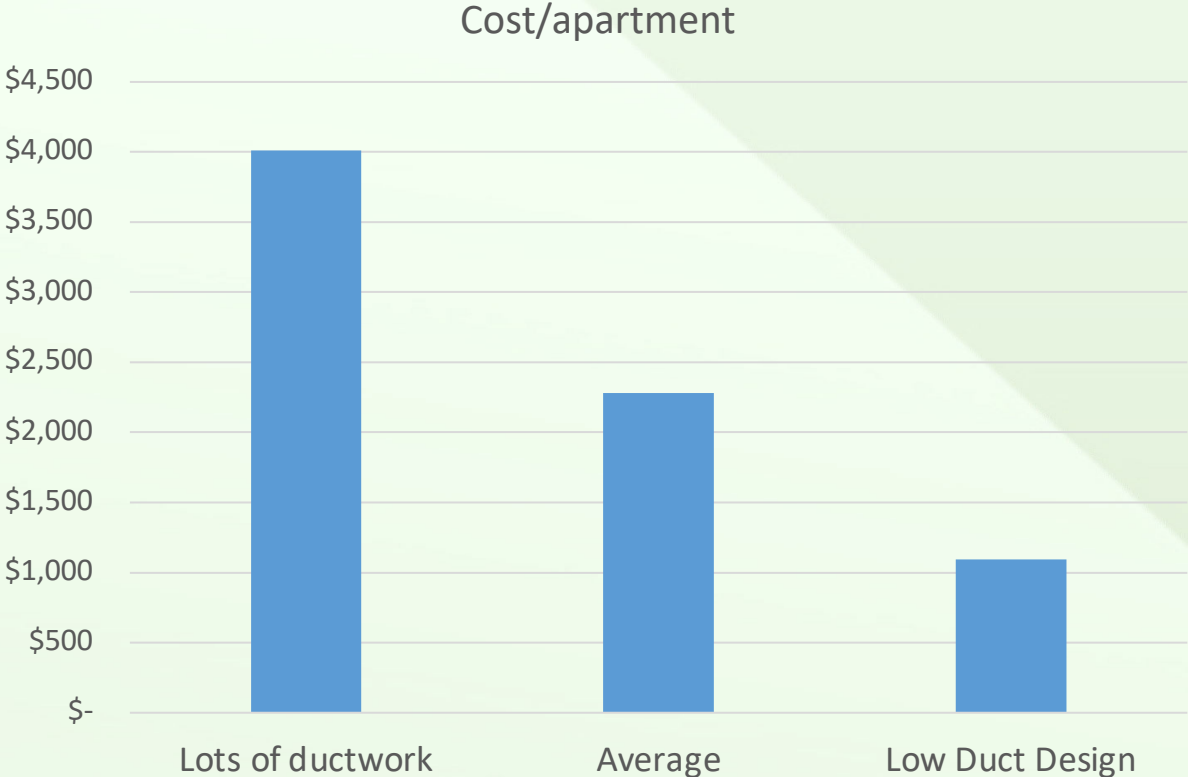
Space Conditioning W/cfm

Medium Impact.
~1-2% of overall
building energy.



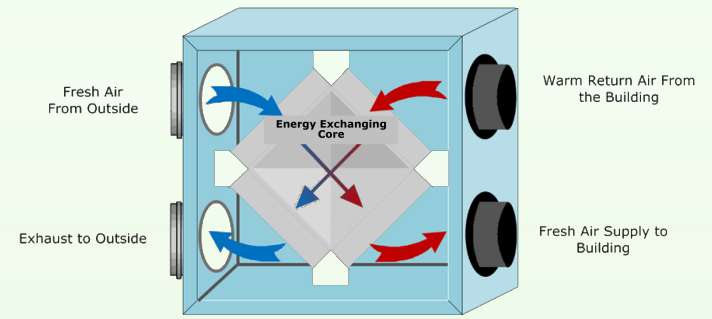
Space Conditioning W/cfm

Case	Duct Length [ft]	Size	Weight/lb	Total weight per apartment [lbs]	Cost/lb	Cost	Soffit Cost/ft	Soffit Cost	Total Cost	Cost/unit
Lots of ductwork		44 12x16	3.62	7167.6	8.45	\$ 121,132	\$ 30.00	\$ 59,400.00	\$ 180,532.44	\$ 4,011.83
Average		25 12x16	3.62	4072.5	8.45	\$ 68,825	\$ 30.00	\$ 33,750.00	\$ 102,575.25	\$ 2,279.45
Low Duct Design		12 12x16	3.62	1954.8	8.45	\$ 33,036	\$ 30.00	\$ 16,200.00	\$ 49,236.12	\$ 1,094.14

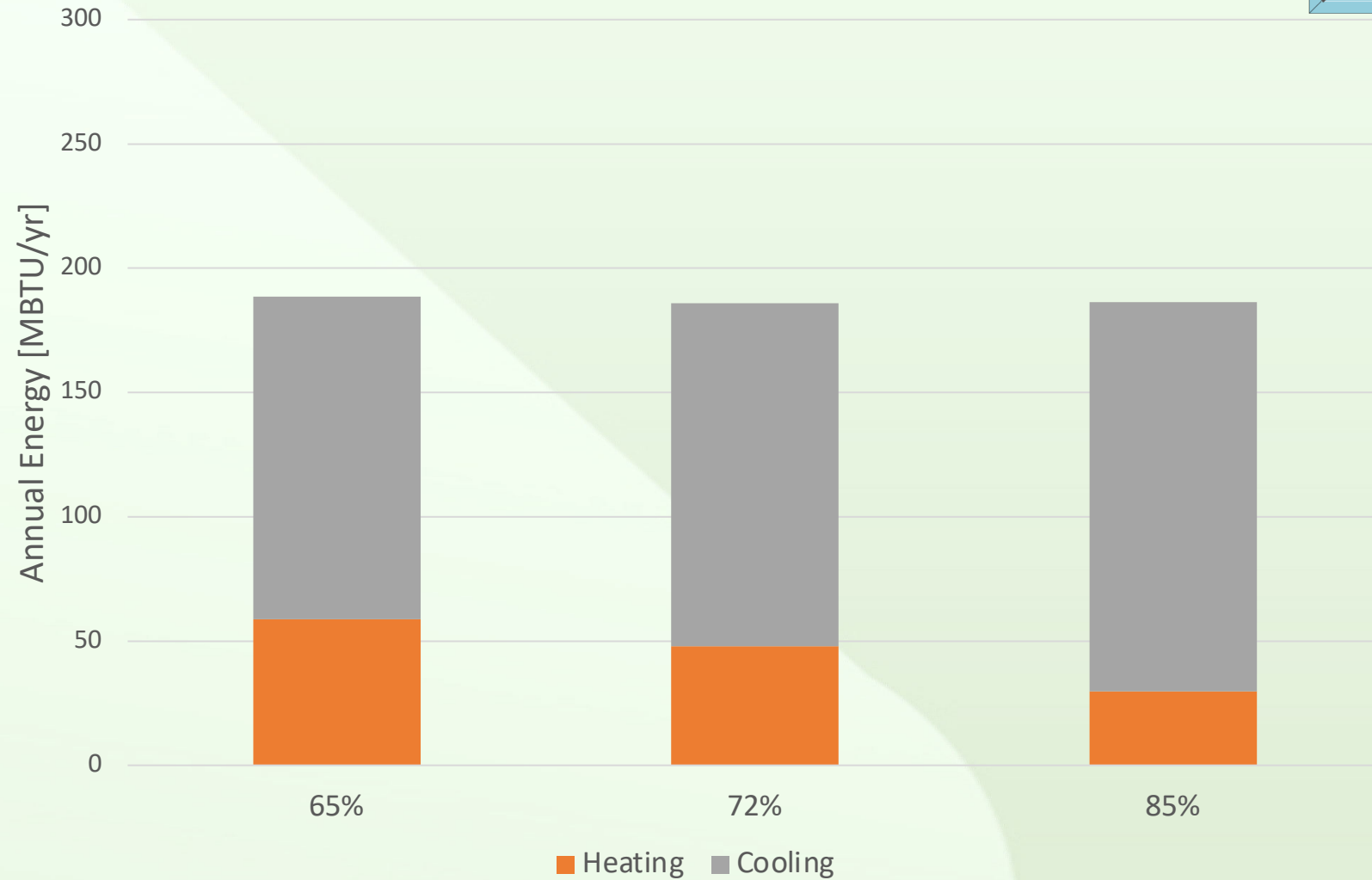


Simplifying ductwork can have a big impact on cost.

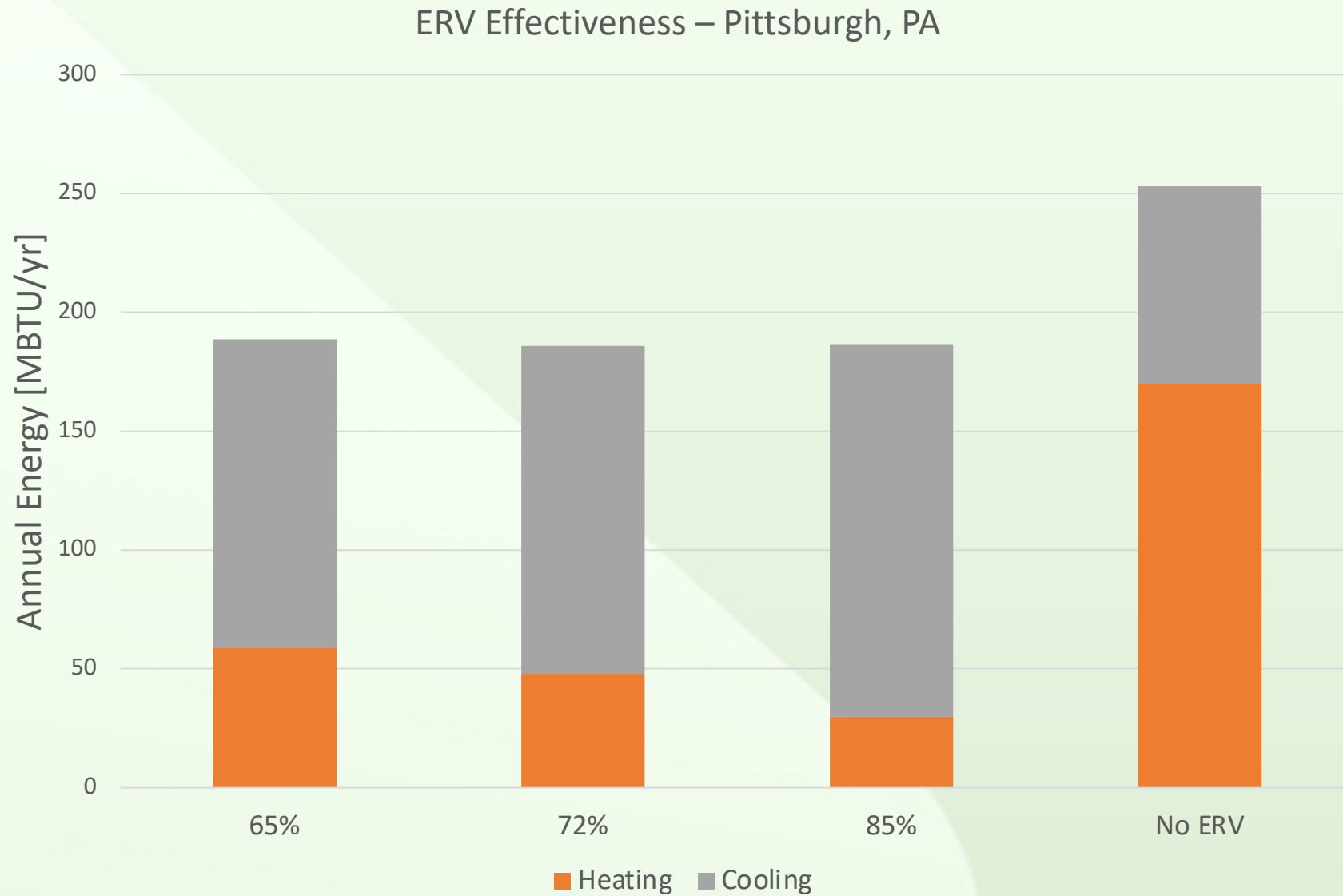
ERV Effectiveness



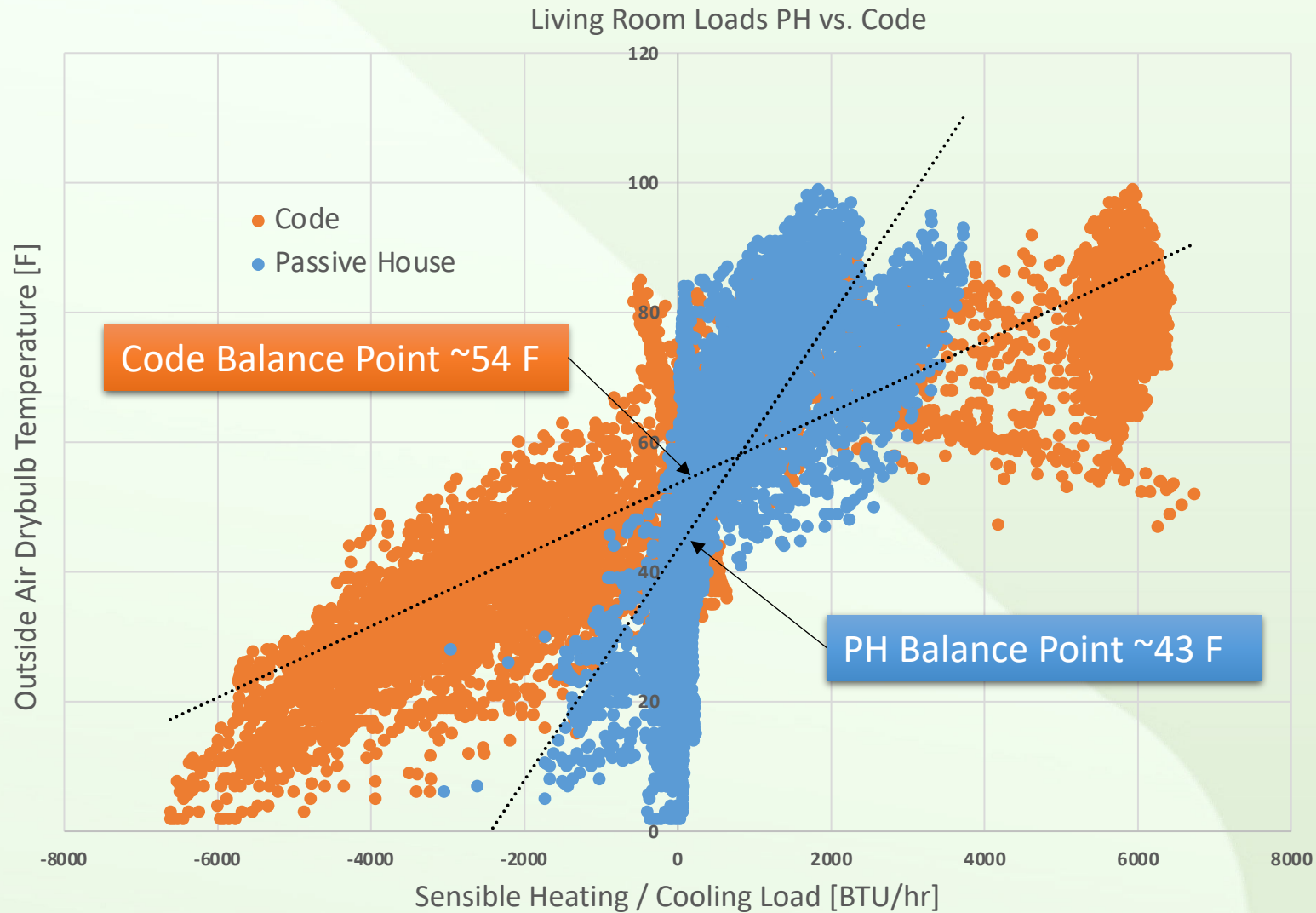
ERV Effectiveness – Pittsburgh, PA



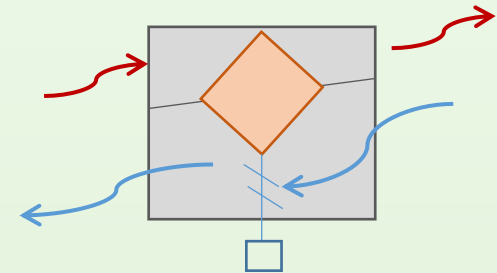
ERV Effectiveness



ERV Effectiveness



Ideal for
Ventilation System
to Economize!

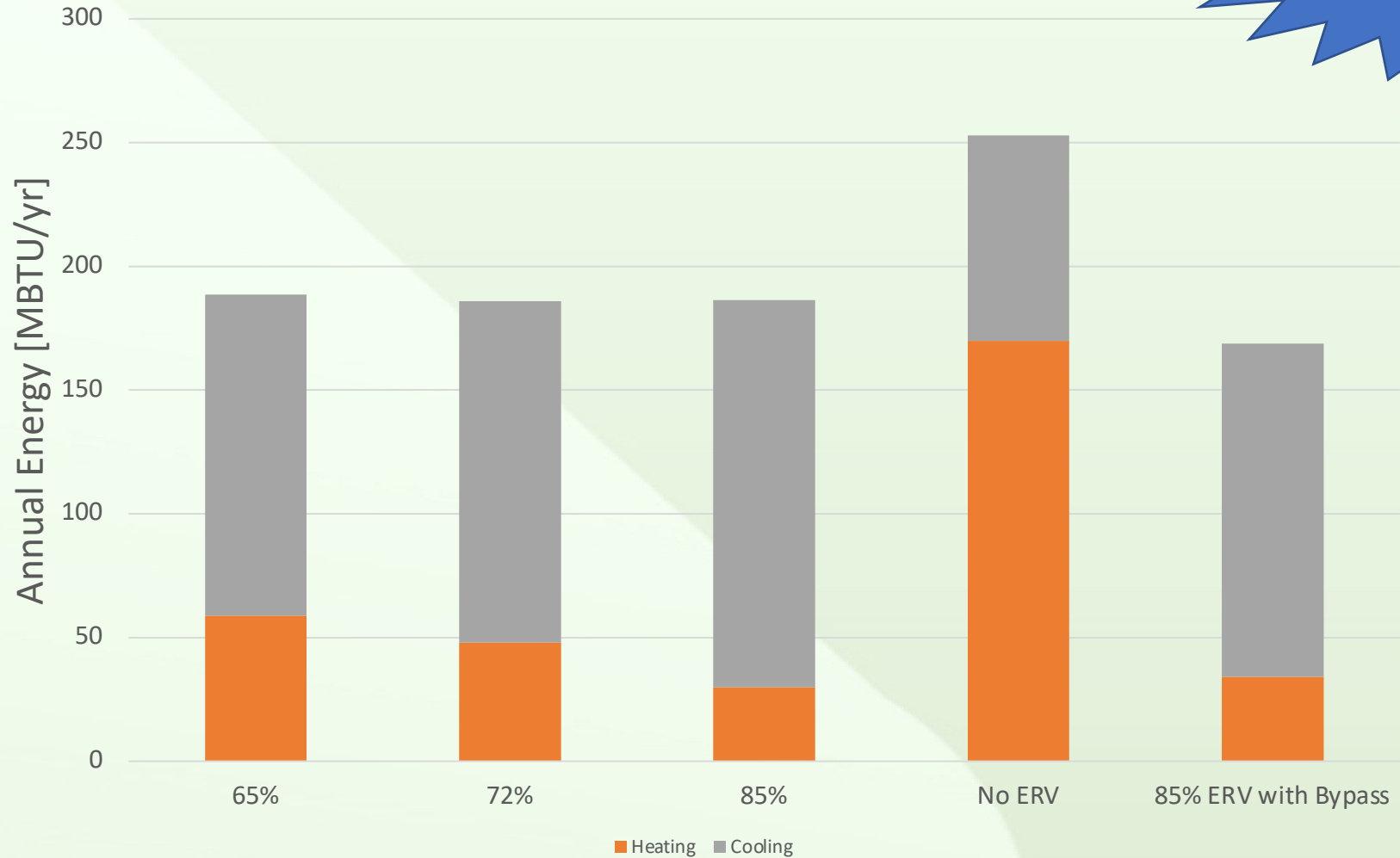


ERV BYPASSES
CORE TO ALLOW
COOL FRESH AIR
COOLS ROOMS
DIRECTLY

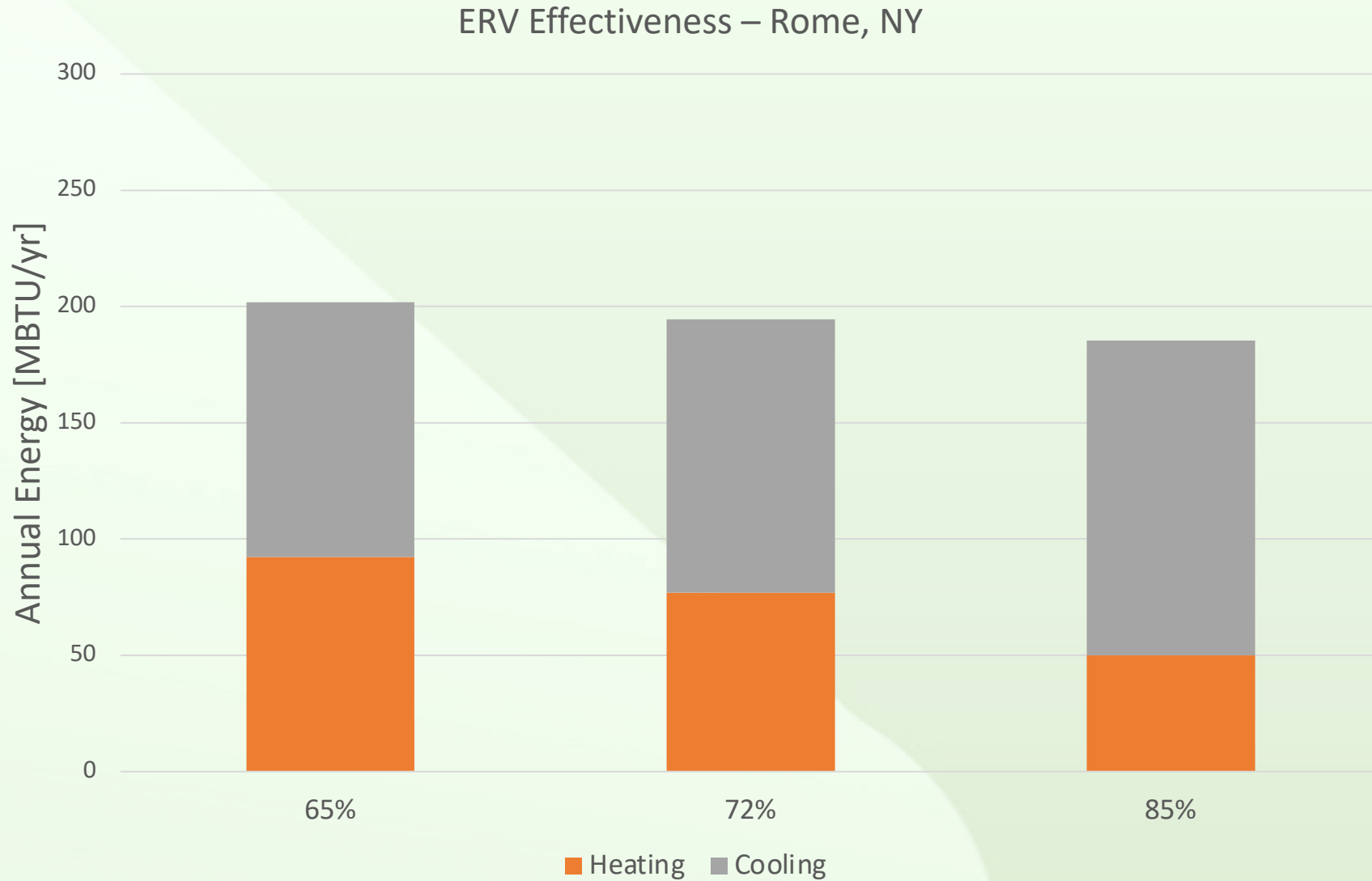
ERV Effectiveness

Medium Impact.
~1-2% of overall
building energy.

ERV Effectiveness – Pittsburgh, PA



ERV Effectiveness



HP COP



EMERALD HILLS APARTMENTS



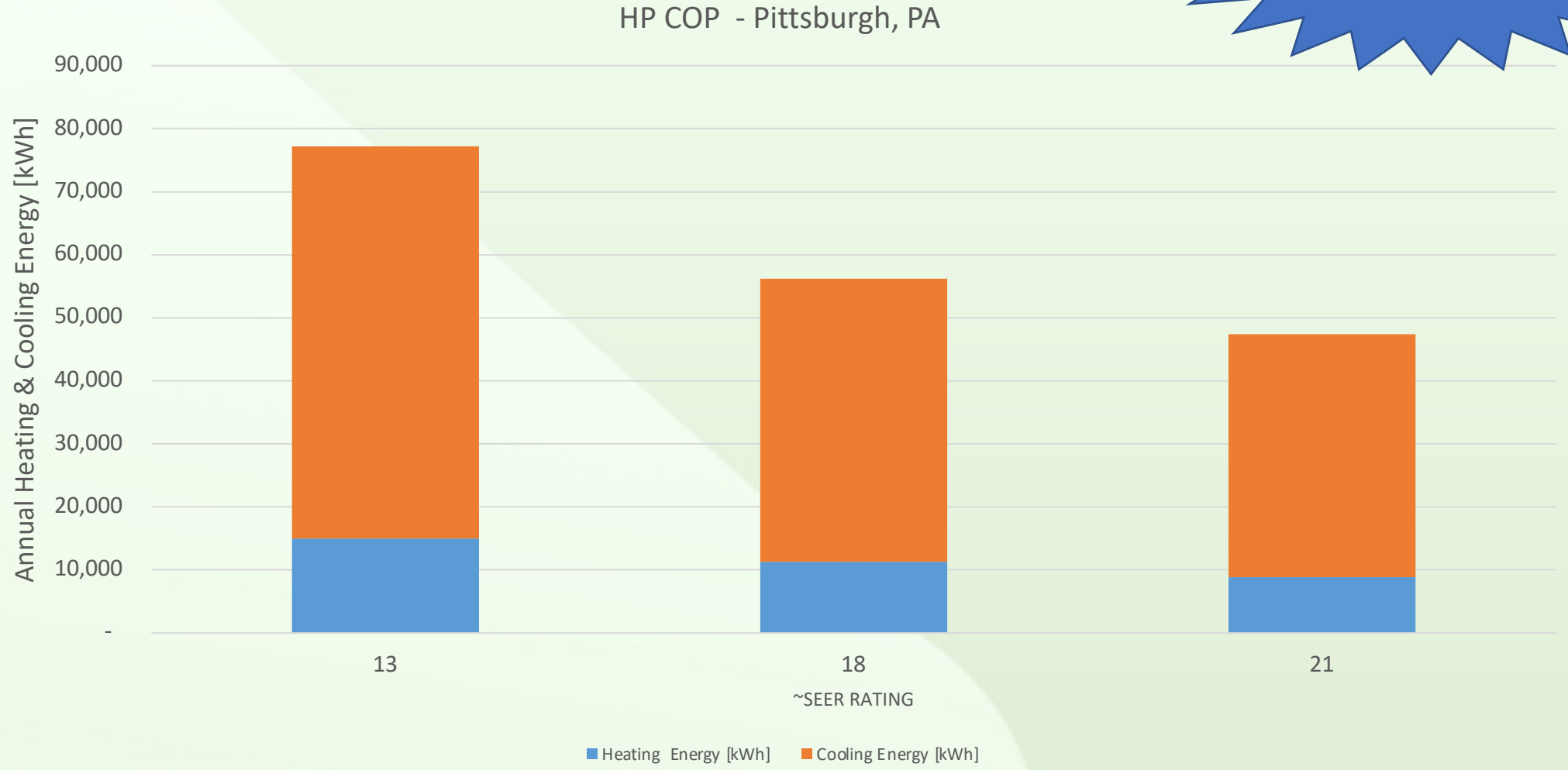
PIONEER APARTMENTS



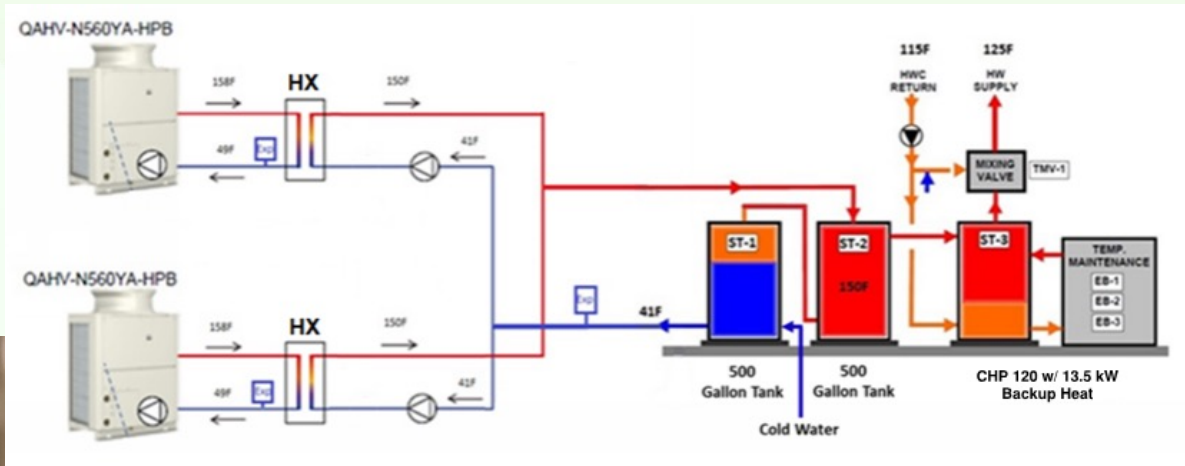
NEGLY AVENUE APARTMENTS

HP COP

Large Impact!
~6-7% of overall
building energy!

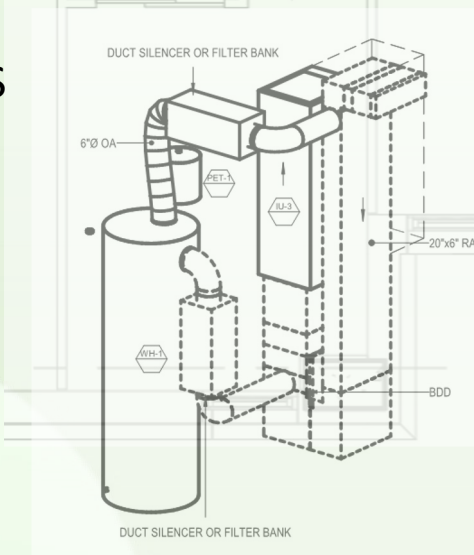


DHW COP



EMERALD HILLS APARTMENTS
- CENTRAL CONDENSING GAS HEATERS

PIONEER APARTMENTS
- VRF HP HOT WATER HEATERS



NEGLY AVENUE APARTMENTS
- DISTRIBUTED HP HOT WATER HEATERS

DHW COP

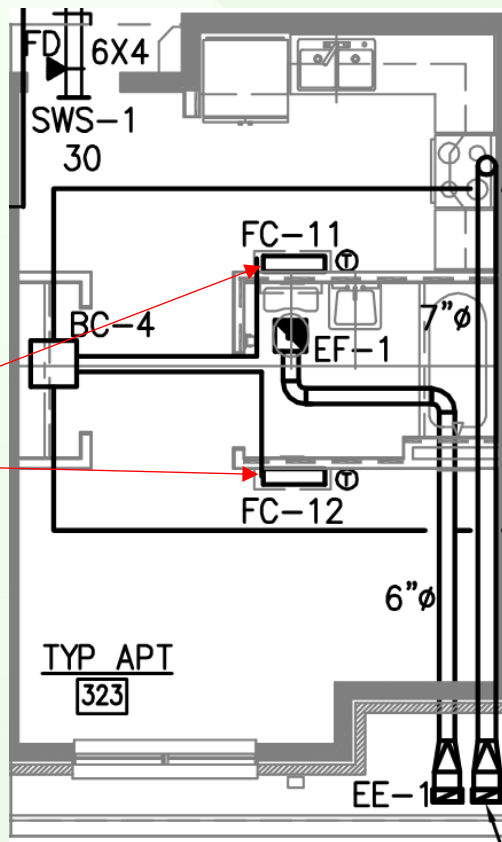


Large Impact!
~14-16% of
overall building
energy!

Sqft/ton

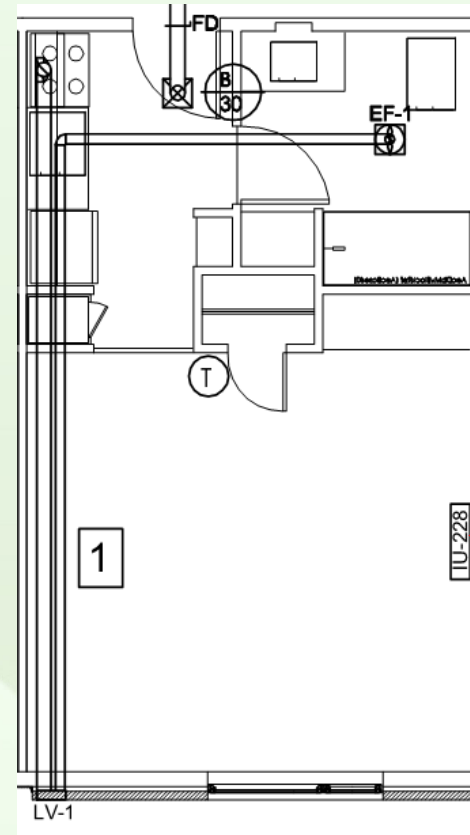
Lower First Cost - Lower Energy Cost - Better Humidity Control

2 Units,
17,100
BTU/hr unit
serves 350
sqft ~ 245
sqft/ton



No

104 Tons of
Outdoor
Unit
Capacity:
367 sqft/ton
HVAC Cost:
~\$20 / sqft



Yes

50 Tons of
Outdoor Unit
Capacity:
1,000 sqft/ton
HVAC Cost:
~\$12.50 / sqft

1 - 6,000
BTU/hr unit
serves 350
sqft ~ 700
sqft/ton

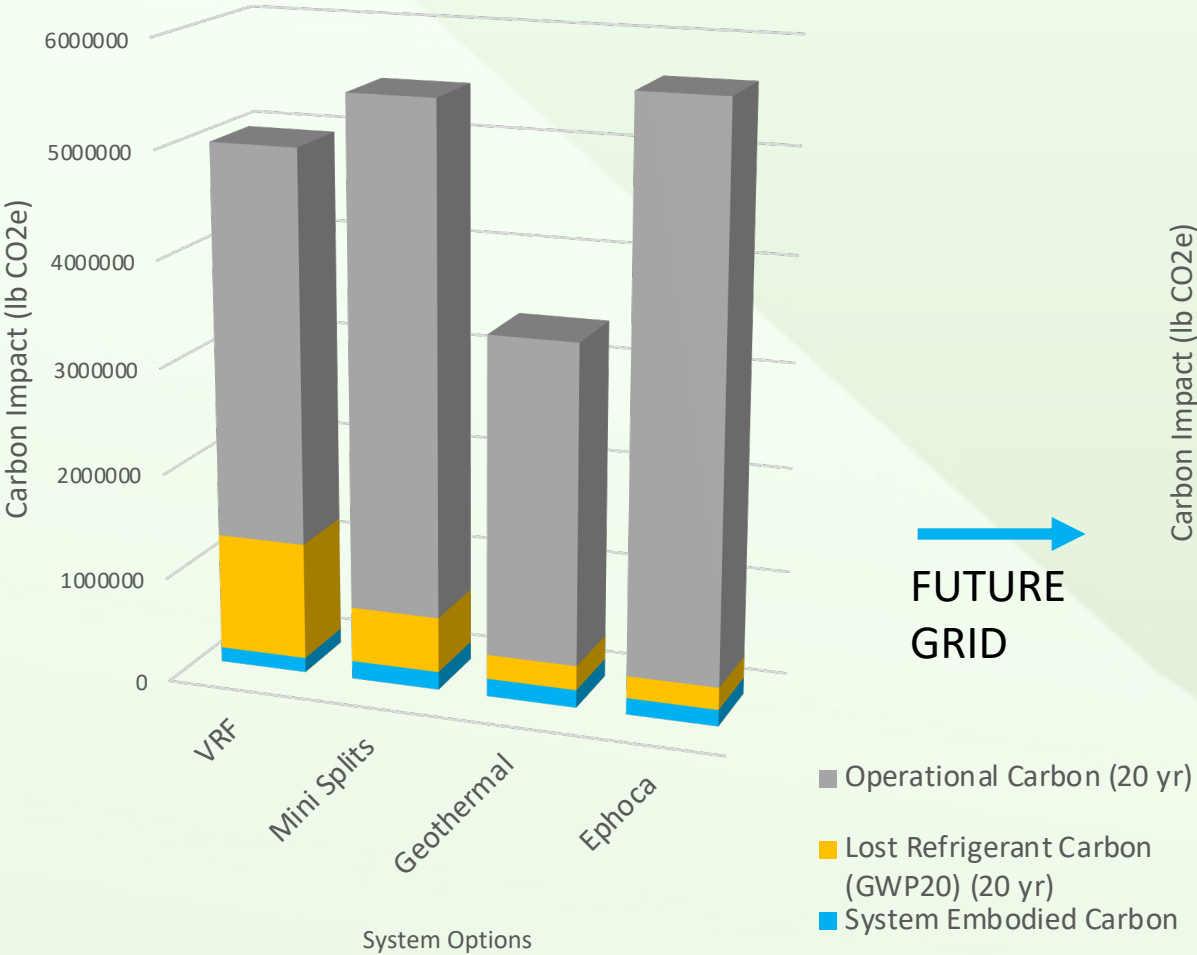
Sqft/ton



*Relative Cost Normalized to Sq.Ft.

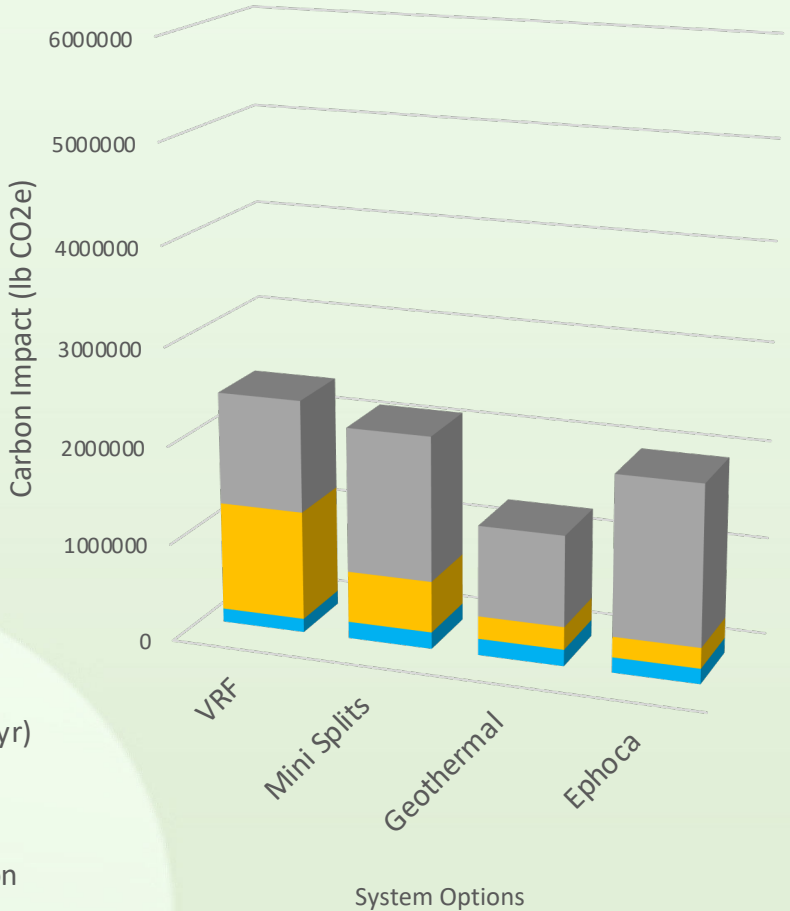
System Embodied Carbon

Carbon Impact of Heating and Cooling Options (PA "Dirty" Grid) 1757 lb CO₂e/MWh



FUTURE GRID

Carbon Impact of Heating and Cooling Options (NYS "Clean" Grid) 540 lb CO₂e/MWh



Takeaways

- These metrics help evaluate system design and impact.
- Use them to evaluate new and completed designs for constant improvement.
- Plus required metrics provide bounds for overall design. System metrics can help optimize system performance, cost, and carbon footprint.