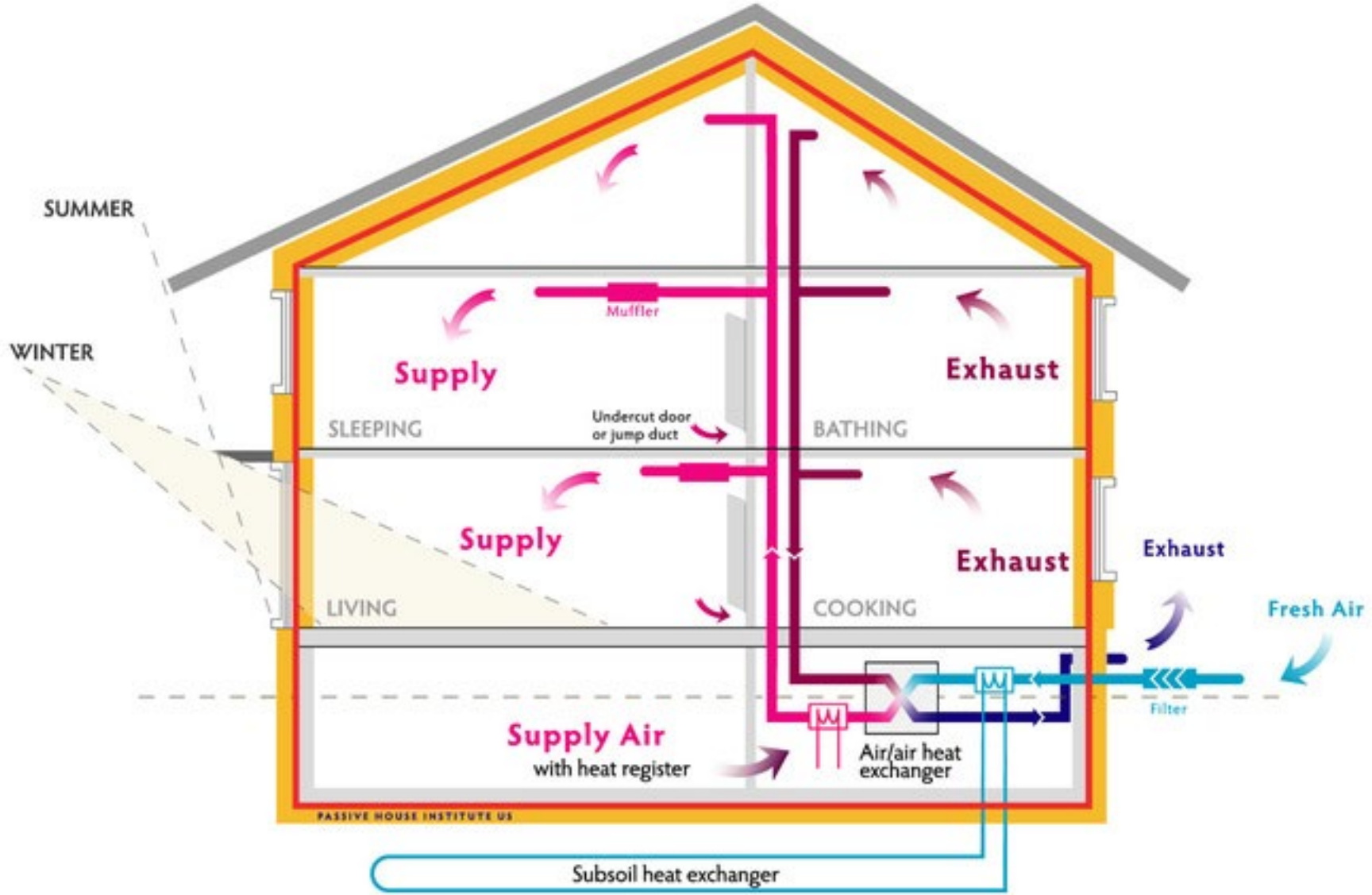
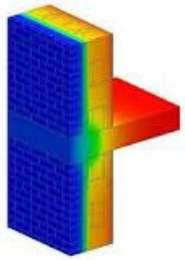
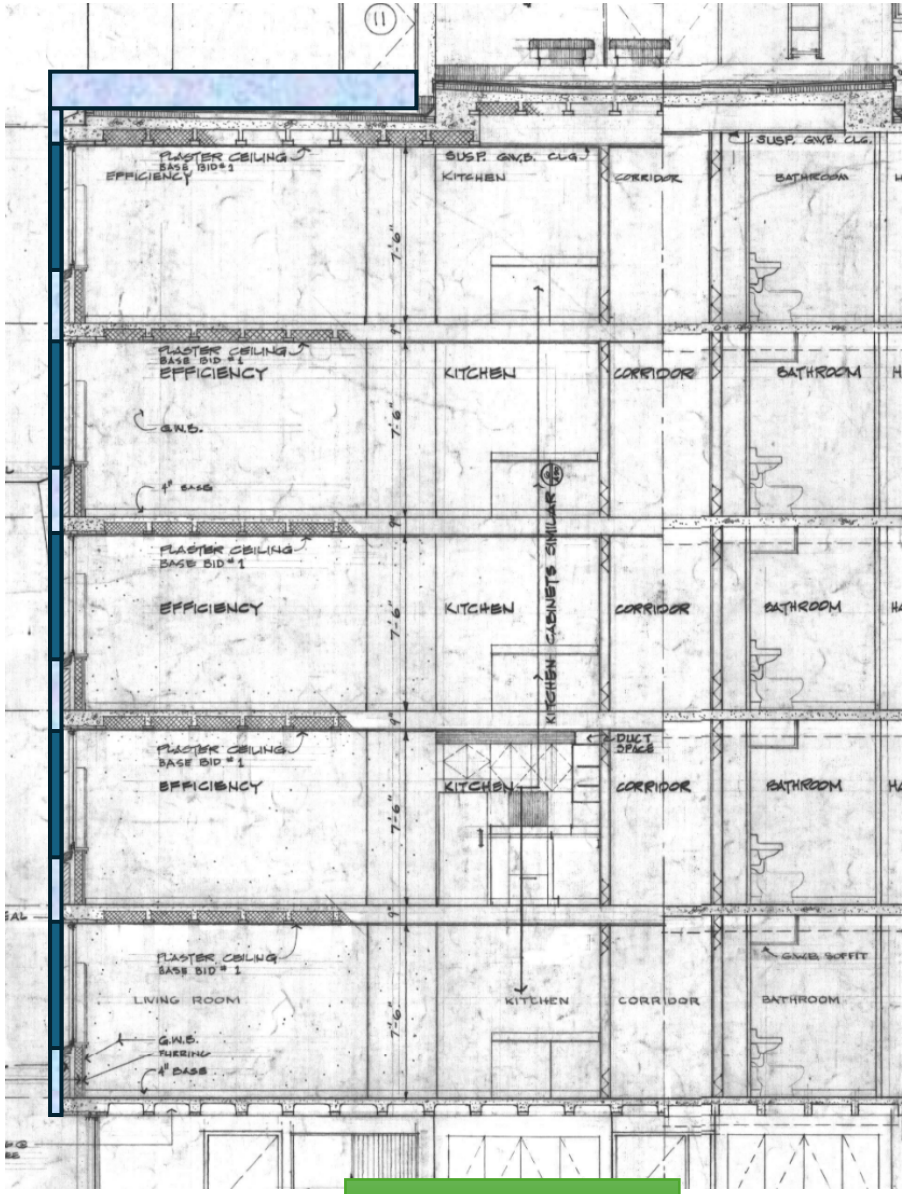
Passive House Concept

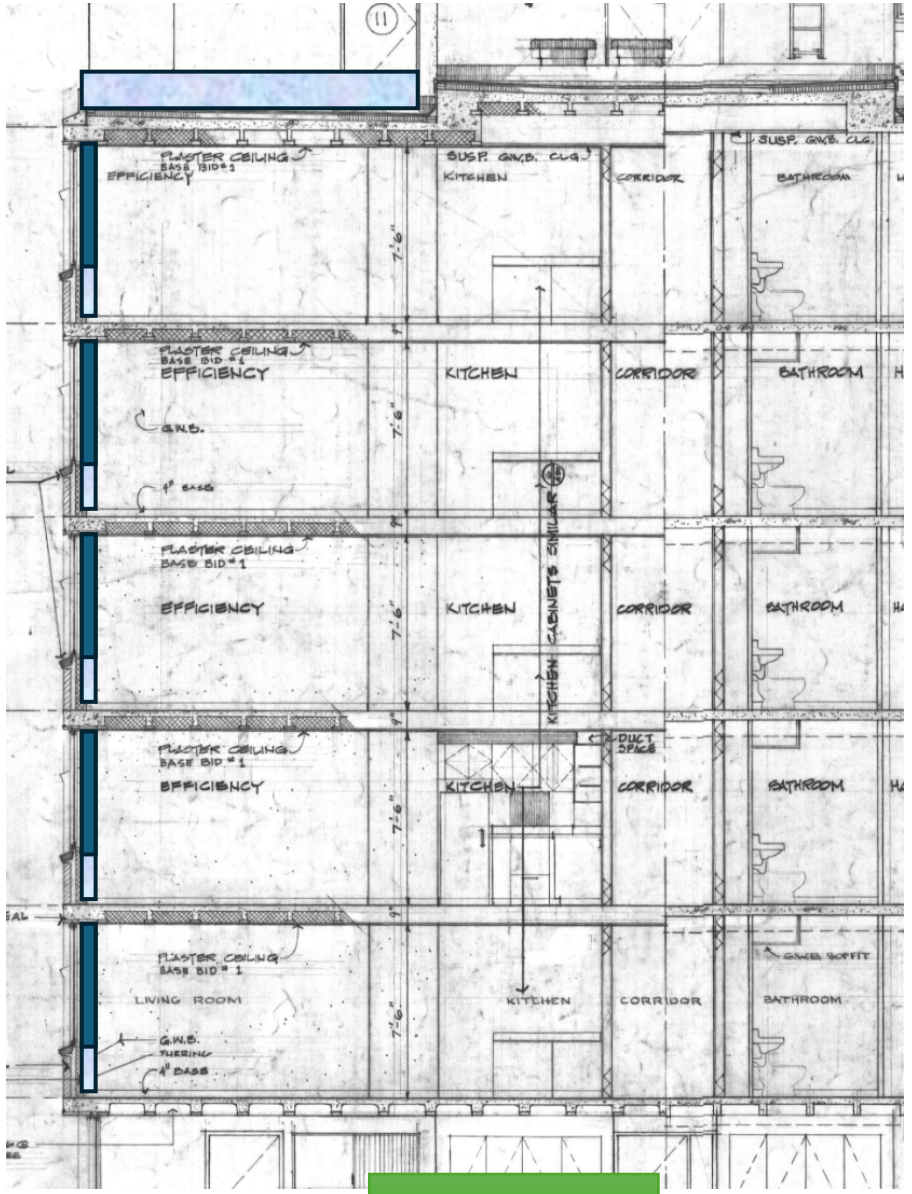


Insulate the Envelope





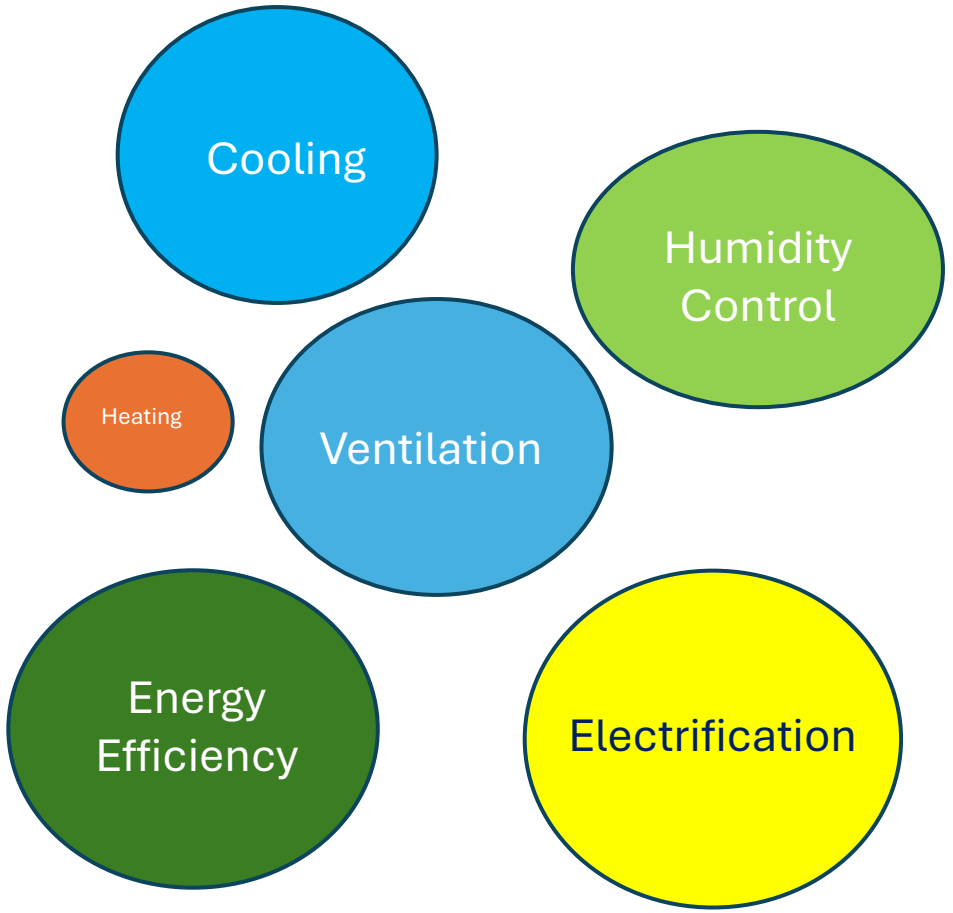
Exterior



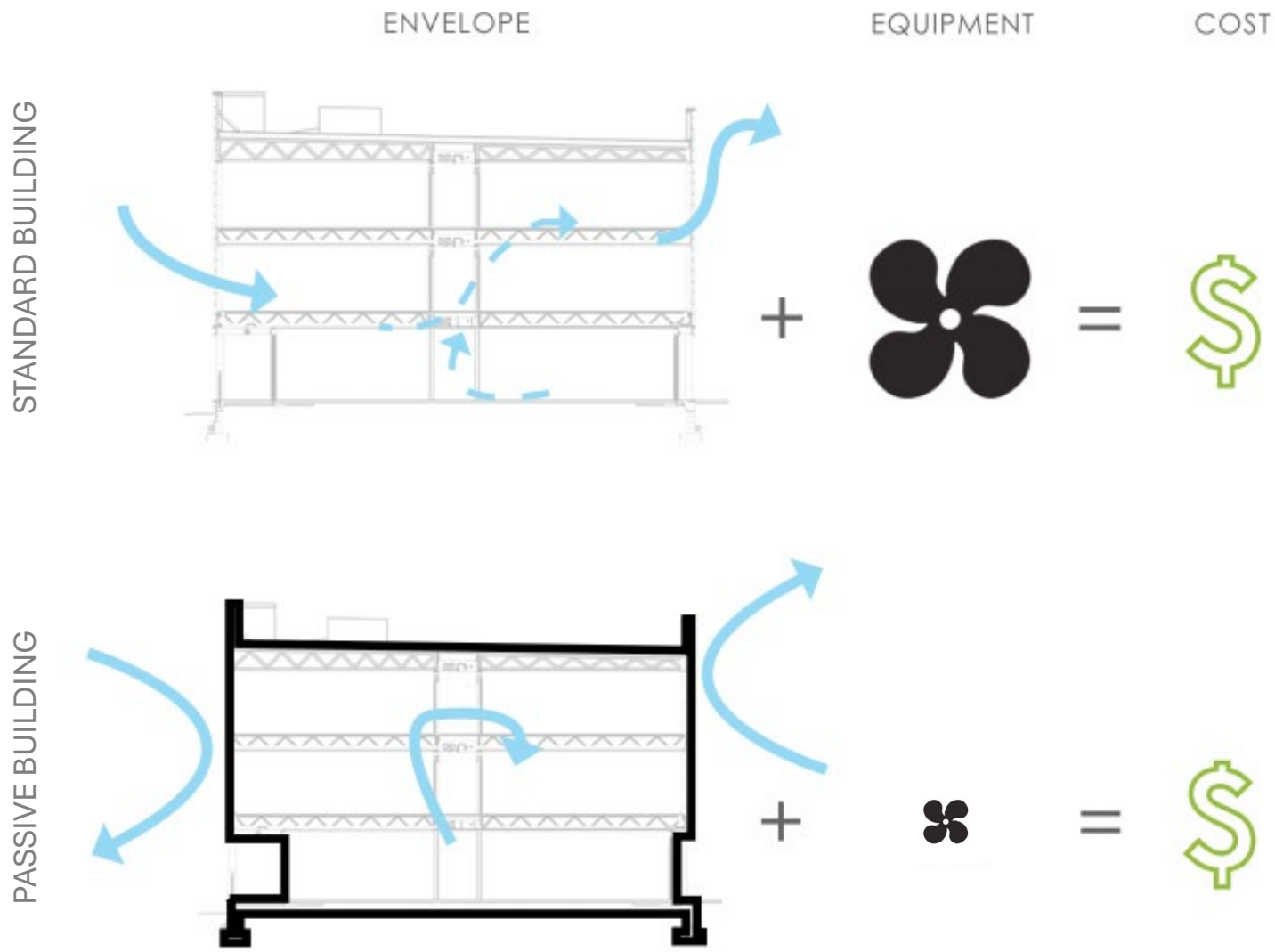
Interior

System Requirements

- Right sized
- Energy Efficient
- Controls Humidity?
- Cooling?
- Ventilation for IAQ
- ELECTRIFIED



Passive House Concept



Refrigerants: Why do we care?

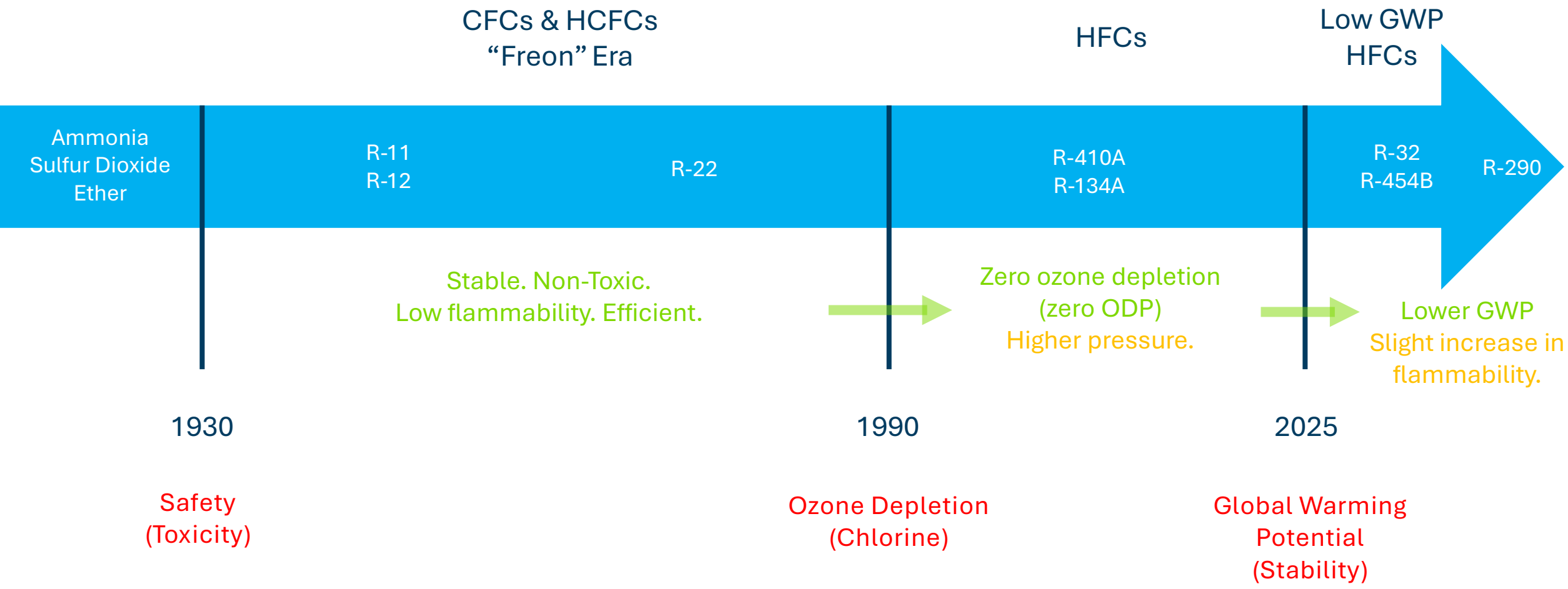
1. Refrigerants are used in basically every type of cooling & dehumidification equipment, and in all heat pumps. New tech*

2. Refrigerants impact the life cycle climate performance of a building (they can improve it if they are more efficient, they can worsen it if they have high GWPs and if there are leaks)

3. We are currently in the middle of a major refrigerant transition, with major impacts on the heat pump industry (all types).

   This is a very positive change for heat pumps, but the transition will cause hiccups, and there are new codes and standards to understand.

Quick History of HVAC refrigerants...



2025 U.S. EPA HFC Phase Ruling (AIM Act)

Refrigeration, Air Conditioning, and Heat Pump Systems*			
Subsector	**Systems**	**Global Warming Potential Limit or Prohibited Substances**	**Installation Compliance Date[5]**
Stationary air conditioning and heat pumps	Residential and light commercial air conditioning and heat pump systems	700	January 1, 2025[6]
	Variable refrigerant flow systems	700	January 1, 2026
Chillers	Industrial process refrigeration with exiting fluid below -50 °C (-58 °F)	Not covered	Not covered
	Industrial process refrigeration with exiting fluid from -50 °C (-58 °F) to -30 °C (-22 °F)	700	January 1, 2028
	Industrial process refrigeration with exiting fluid above -30 °C (-22 °F)	700	January 1, 2026
	Comfort cooling	700	January 1, 2025

https://www.epa.gov/system/files/documents/2023-10/technology-transitions-final-rule-fact-sheet-2023.pdf

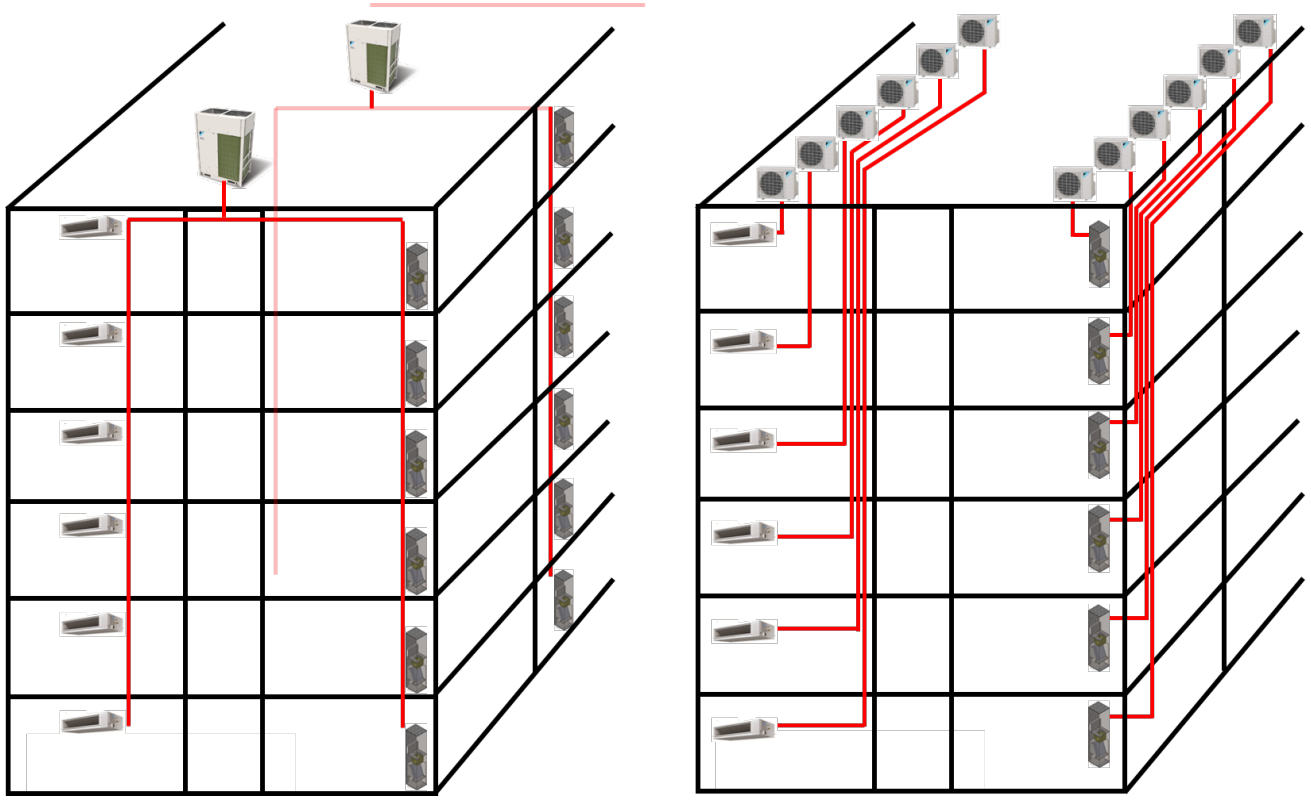
Code Adoption for A2L refrigerants – MA & 10th Edition Code

- 10th Edition code carries 2021 I-Codes (IMC 2021) which does not have the latest language surrounding A2Ls.
- Code change progress
  - MARCH 27 2024: BBRS voted to adopt the first 2 of 8 proposals, updating the ASHRAE 15/34 referenced standard to 2022 and UL 60335-2-40
  - JULY 9 2024: BBRS voted to adopt the remaining 6 of 8. These are still going through the process.
  - NOV 12 2024: BBRS issues advisory document allowing the use of ASHRAE 15 2022 to comply with 10th edition code

*** Solves pipe shaft requirement issues, R-32 & R-454B classifications, proper formulas for volume calculations, use of safety shut off valves etc.***

Passive House buildings can accommodate various System Approaches

- Heating & Cooling
  - Central vs. Decentralized
  - Refrigerant vs. Hydronic
- Ventilation
  - Central vs. Decentralized
- DHW
  - Central vs. Decentralized
  - Refrigerant Considerations
  - Waste Water Heat Recovery



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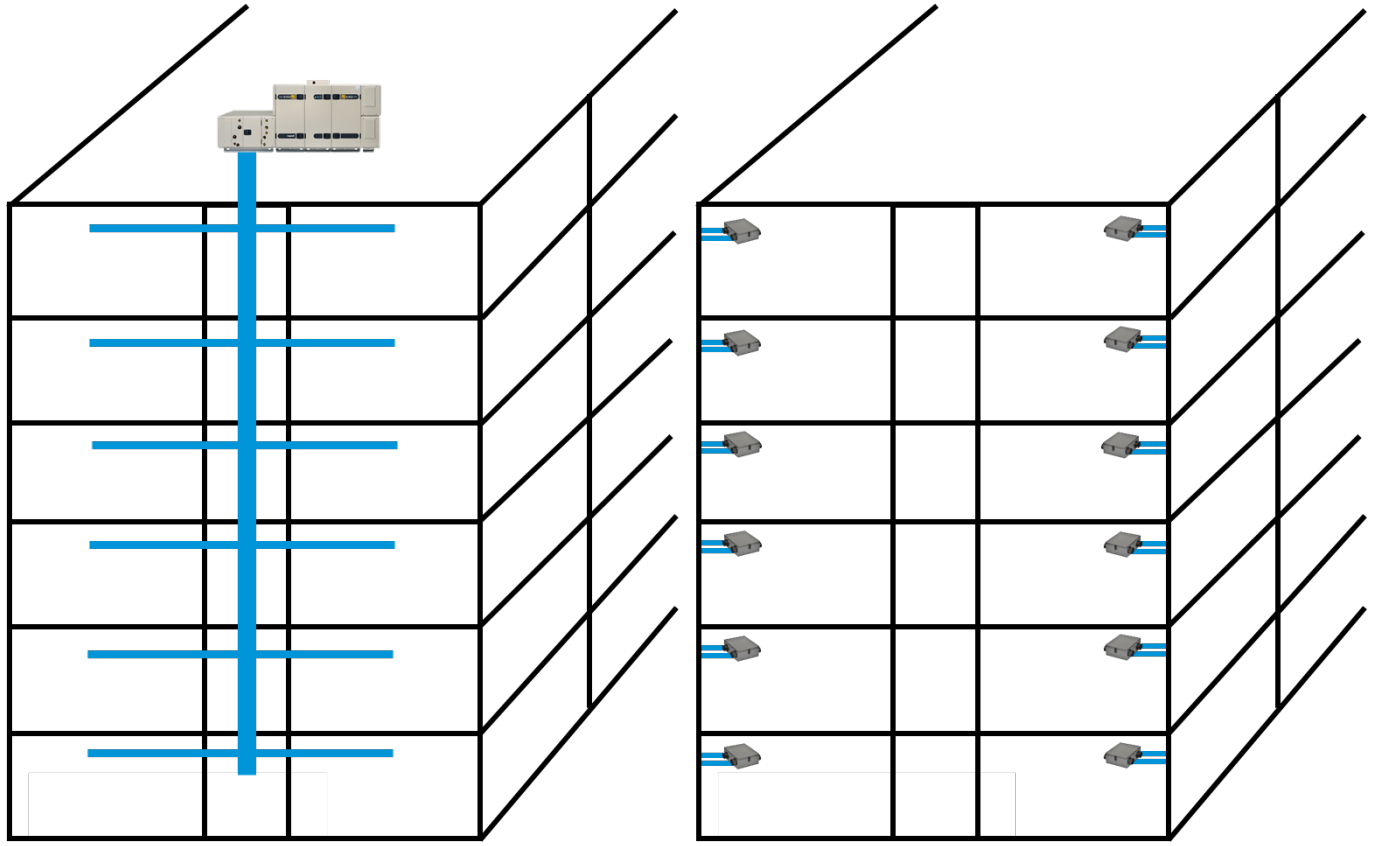


System Approach

VRF

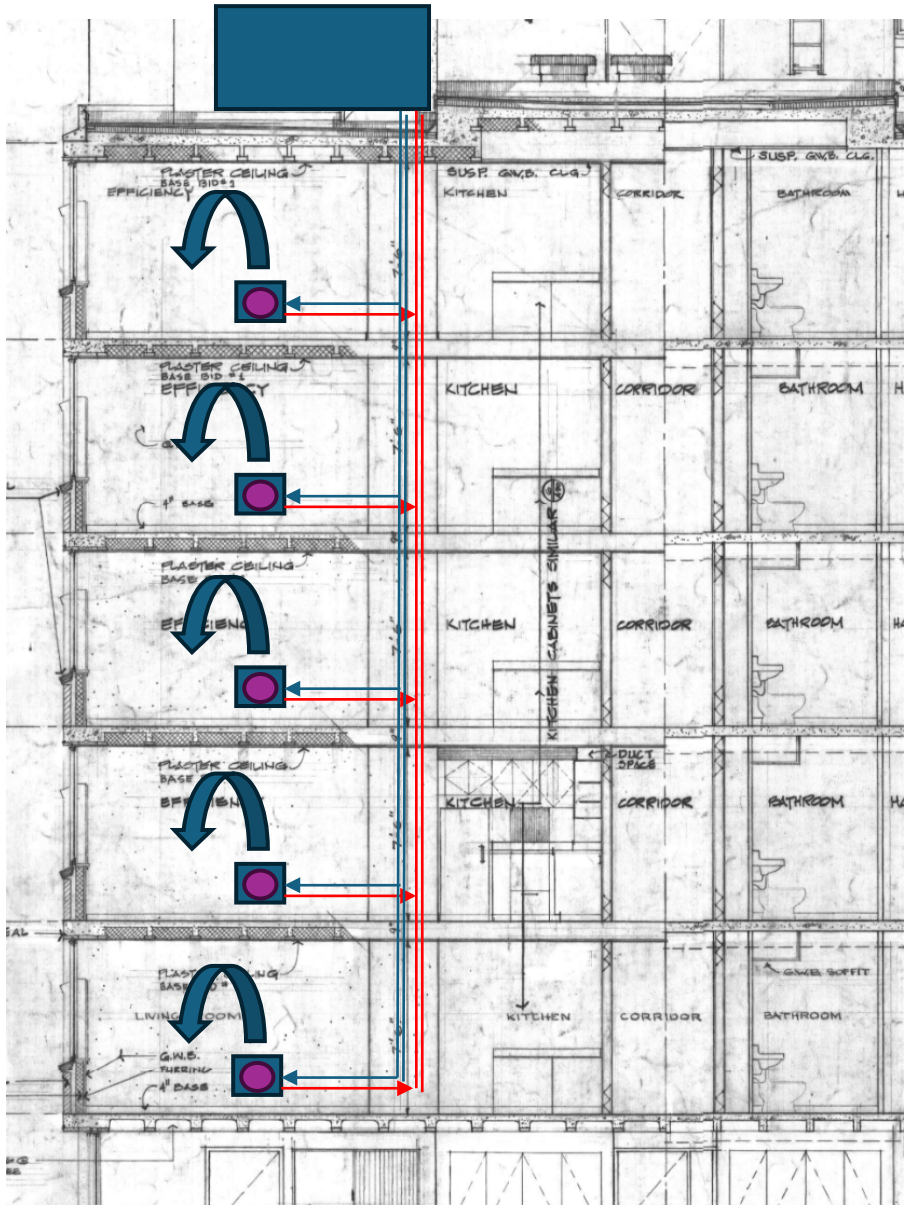
Advantages

- Less costly than hydronic
- Packaged control system
- Heat recovery during shoulder season

Disadvantages

- Requires refrigerant line-sets to be run throughout the building
- Potential refrigerant loss, with high global warming potential – refrigerant transition
- Maintenance costs

VRF CENTRAL PLANT



System Approach

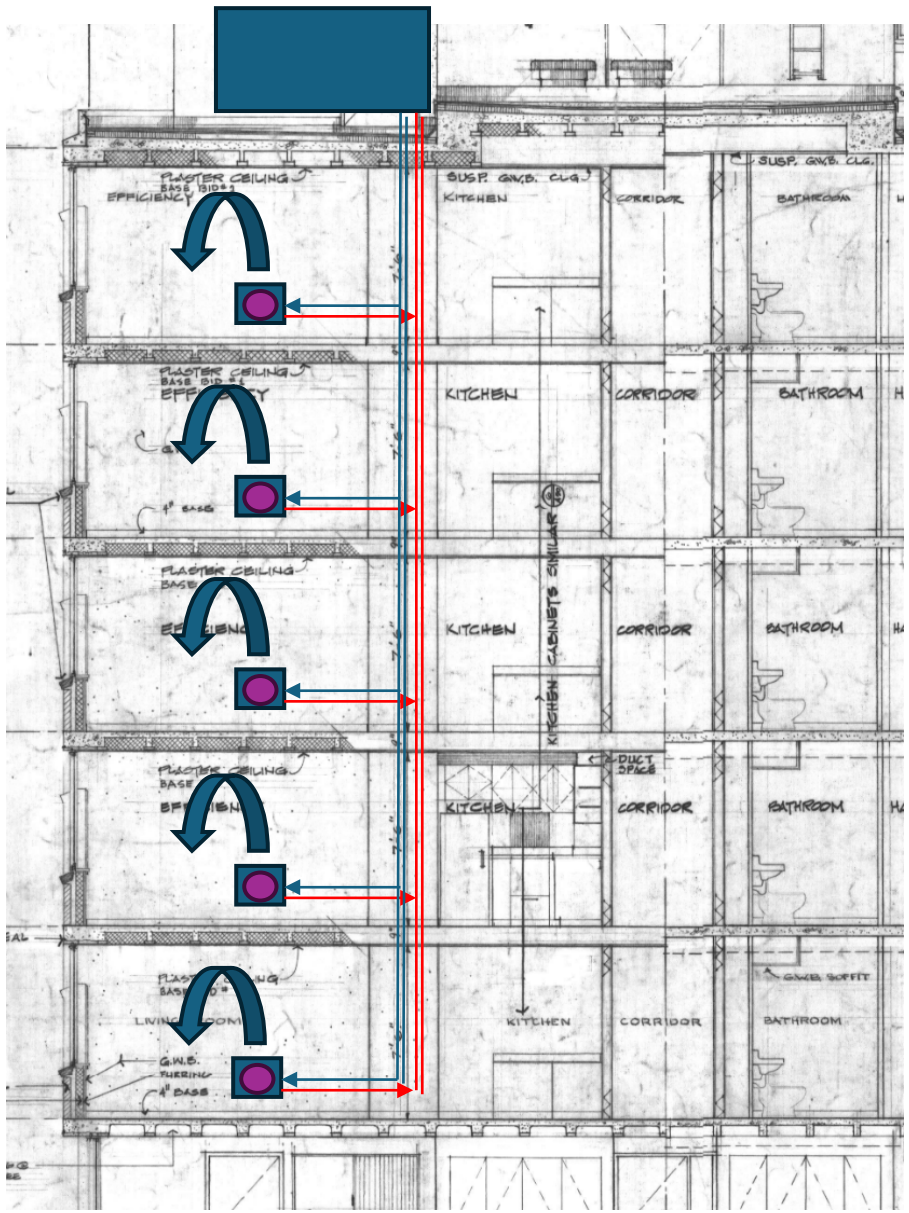
4-pipe or 2-pipe hydronic system

Advantages

- High Efficiency
- Opportunities for heat recovery to domestic hot water in central DHW system
- Improving cold climate performance
- Existing buildings with hydronic piping

Disadvantages

- Cost of equipment and piping is high if not already there
- Water / glycol management
- Higher maintenance costs



Air-to-Water Heat Pumps

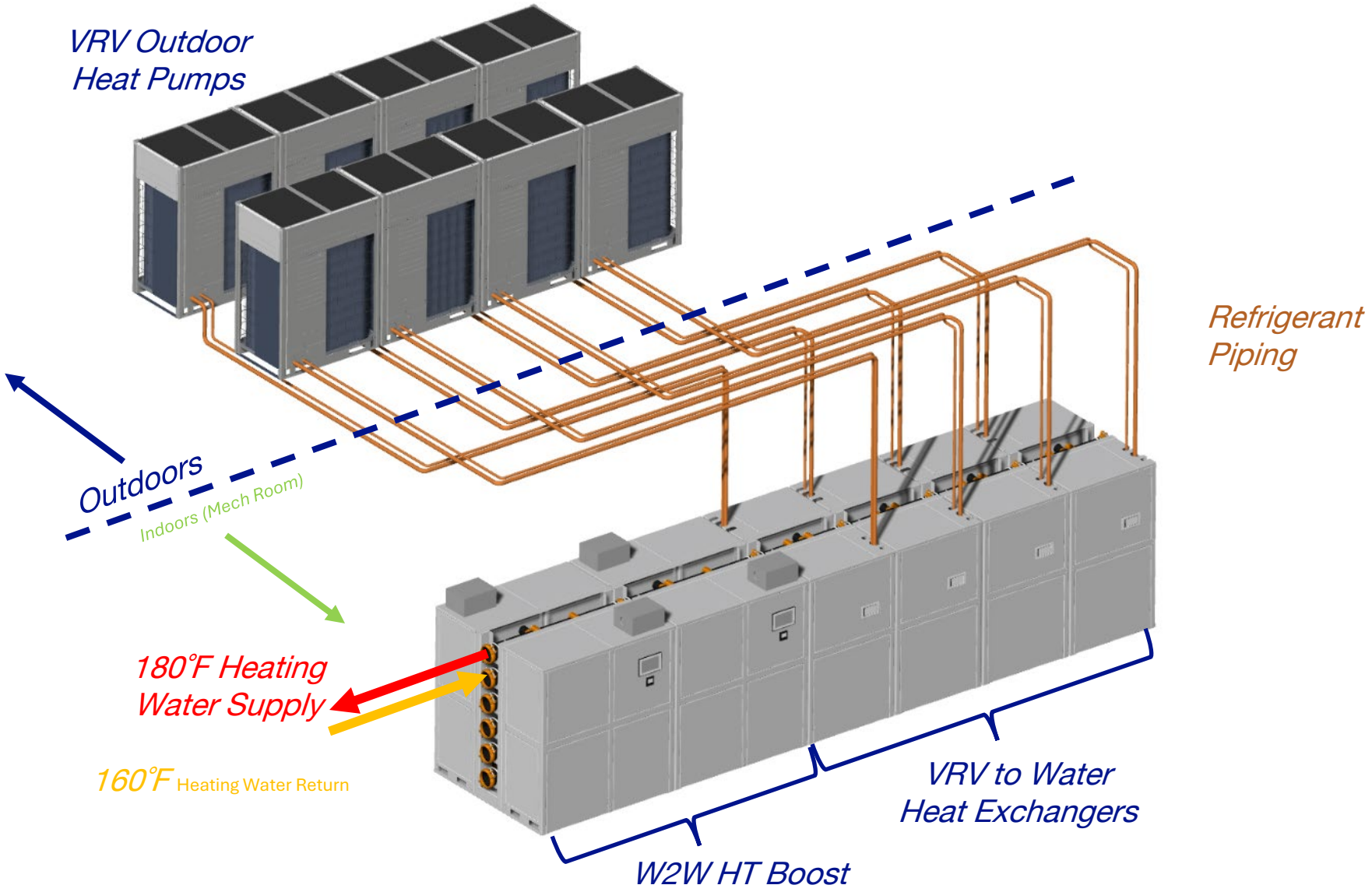
- Where were we?
    - Modular: 120F HW at -4F ambient
    - Unitary: 105F HW at 5F ambient
- Where are we in 2025?
    - Modular: 120F HW at -15F ambient
    - Unitary: 120F HW at -4F ambient
- Key considerations
    - Heat pump or Heat Recovery
    - Low temp terminal units (very small capacities)
    - Integration with back-up heating (Gas or electric)
    - High storage also creates thermal battery

Modular

Unitary

VRV driven, split, modular cold climate heat pump chiller

*** Up to 180˚F Water ***



System Approach

Water-source heat pumps

Advantages

- Neutral water piped through the building. Can re-use existing heating water piping
- Can capture waste heat for domestic hot water heating in a central DHW plant

Disadvantages

- Compressor in every apartment
- Lower COP if using air-to-water heat pumps in central plant

HEAT PUMP
CENTRAL PLANT

System Approach

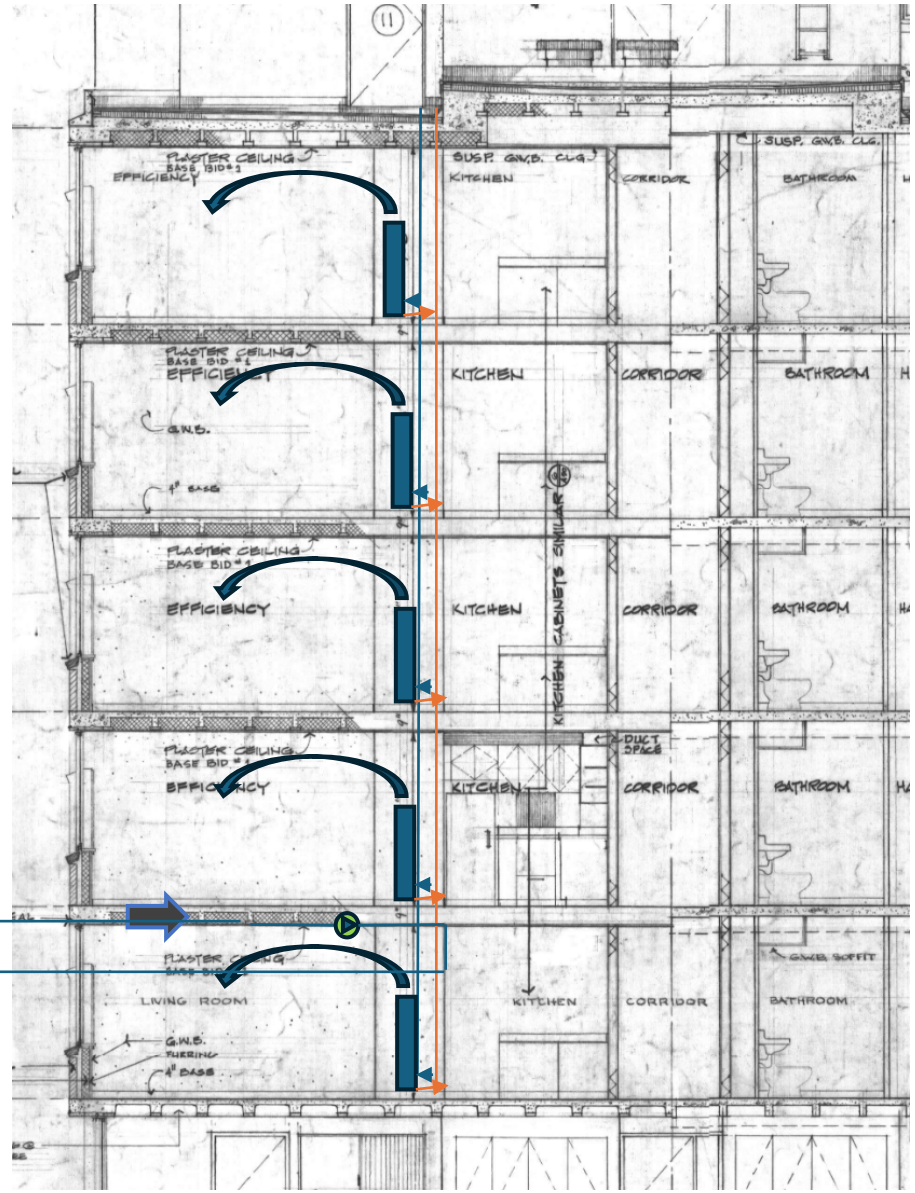
Ground-source heat pumps

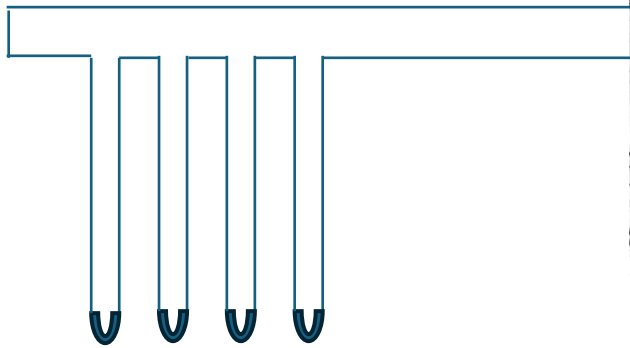
Advantages

- Very low energy use
- Can be integrated with solar
- Lower maintenance costs
- Heat recovery to DHW possible

Disadvantages

- Requires real estate for geothermal wells
- High cost, but lower now with tax credits available, that apply to full HVAC system
- Compressor in every apartment

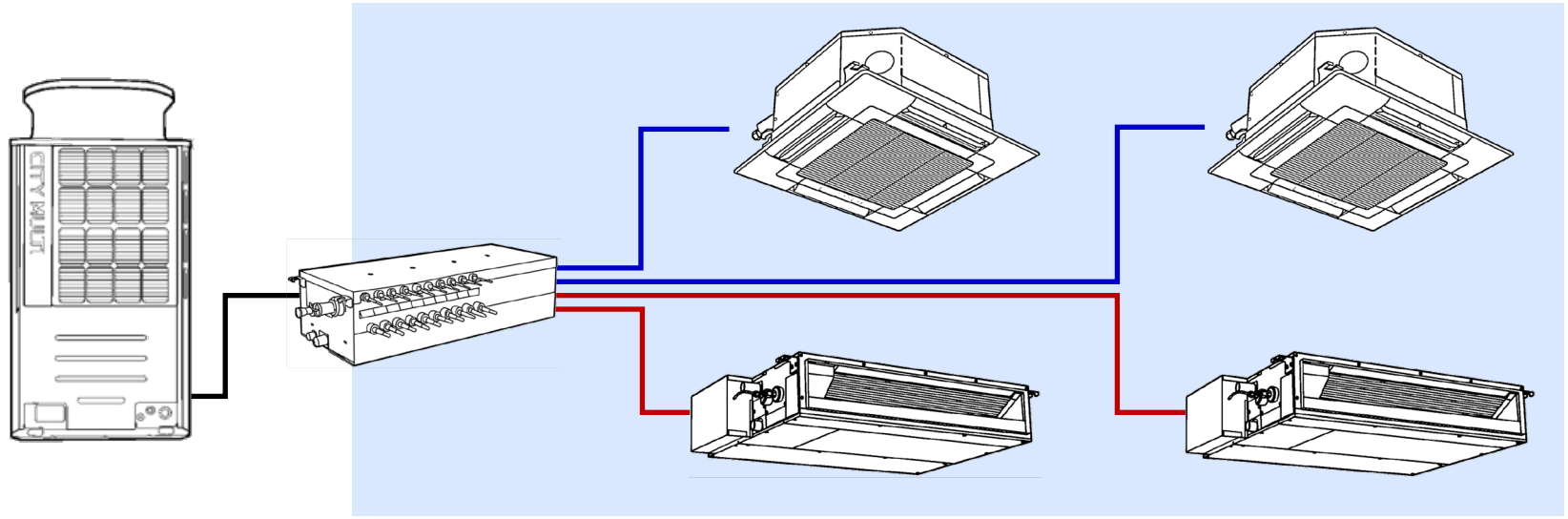




Ground Loop
Vertical Wells

Hybrid Systems

HYBRID VRF™ is a simultaneous system utilizing air or water-source outdoor units. Hybrid BC Controllers with refrigerant-water heat exchangers supply variable chilled or hot water to hydronic indoor units



HYBRID VRF BC CONTROLLER
HYDRONIC PIPING
HYBRID VRF INDOOR UNITS

System Approach

Decentralized – Splits

Apartment Level Solutions

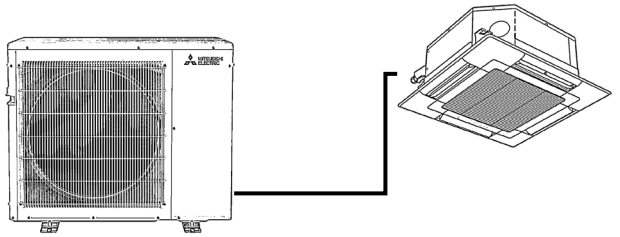
- Ducted and ductless split heat pumps

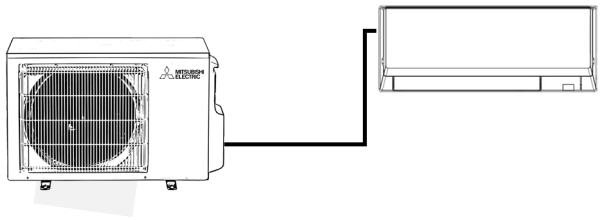
PROs

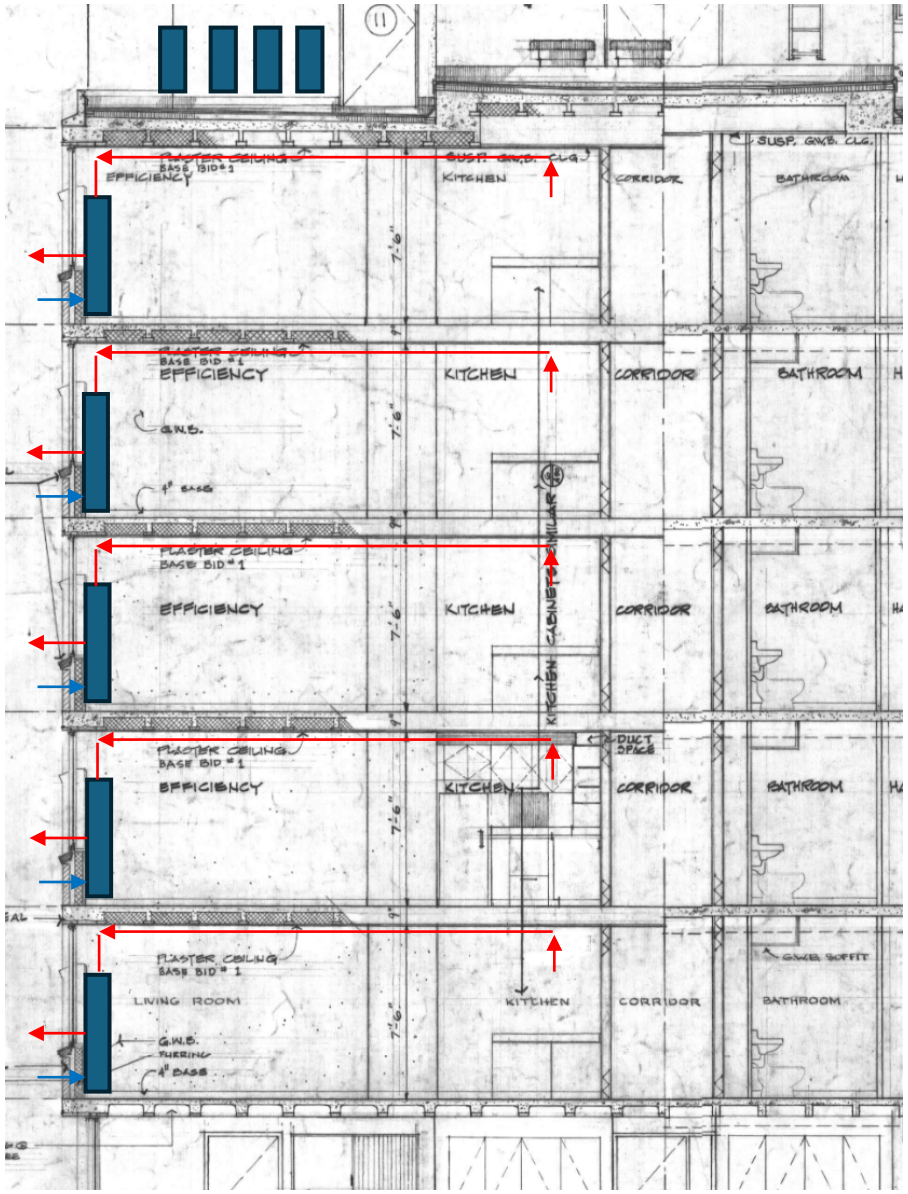
- Inexpensive
- Less ductwork / site labor
- Redundancy

CONs

- More equipment to service
- Space requirements for outdoor units
- Poor filtration for ductless splits







System Approach

Decentralized - Packaged

Apartment Level Solutions

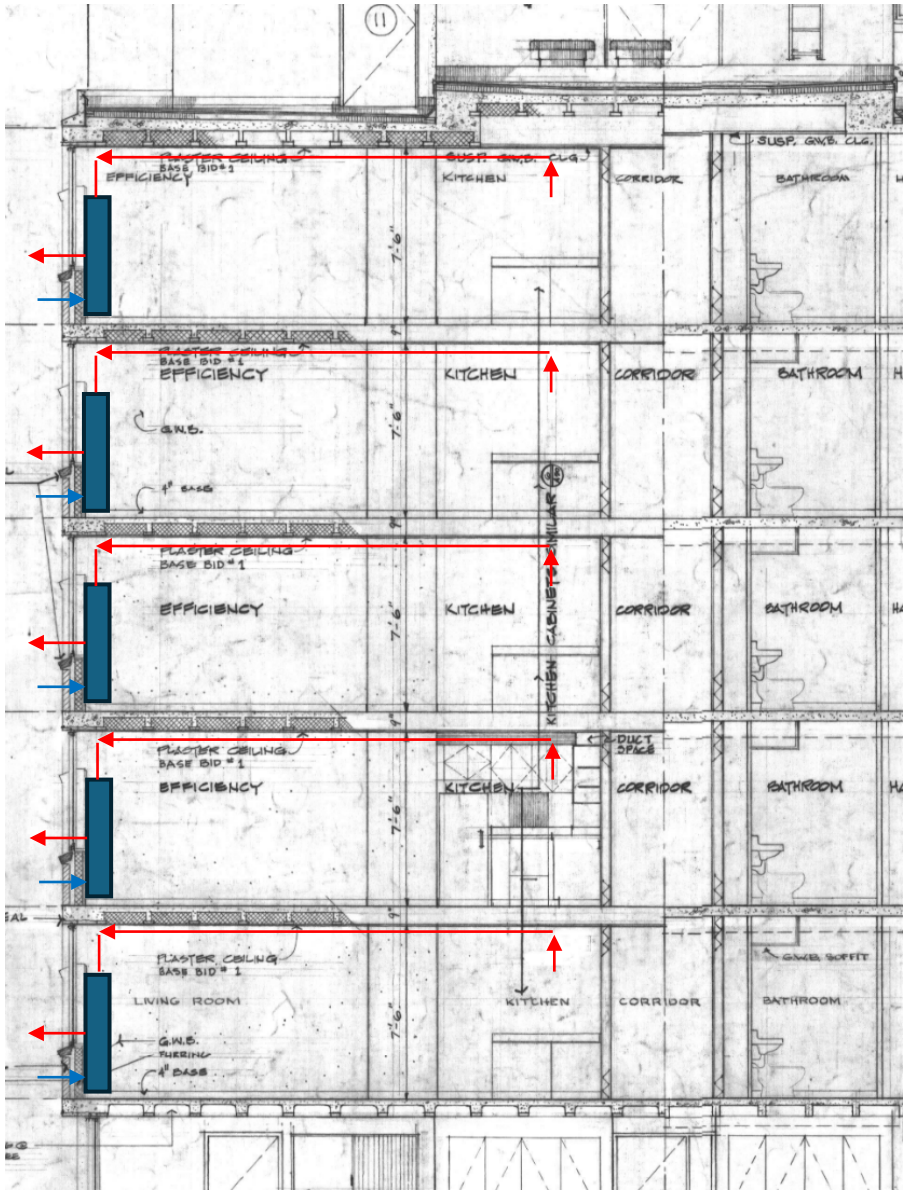
- Ventilation and Condenser Air From Facade
- Mechanical Pod
- PTAC
- WSHP

PROs

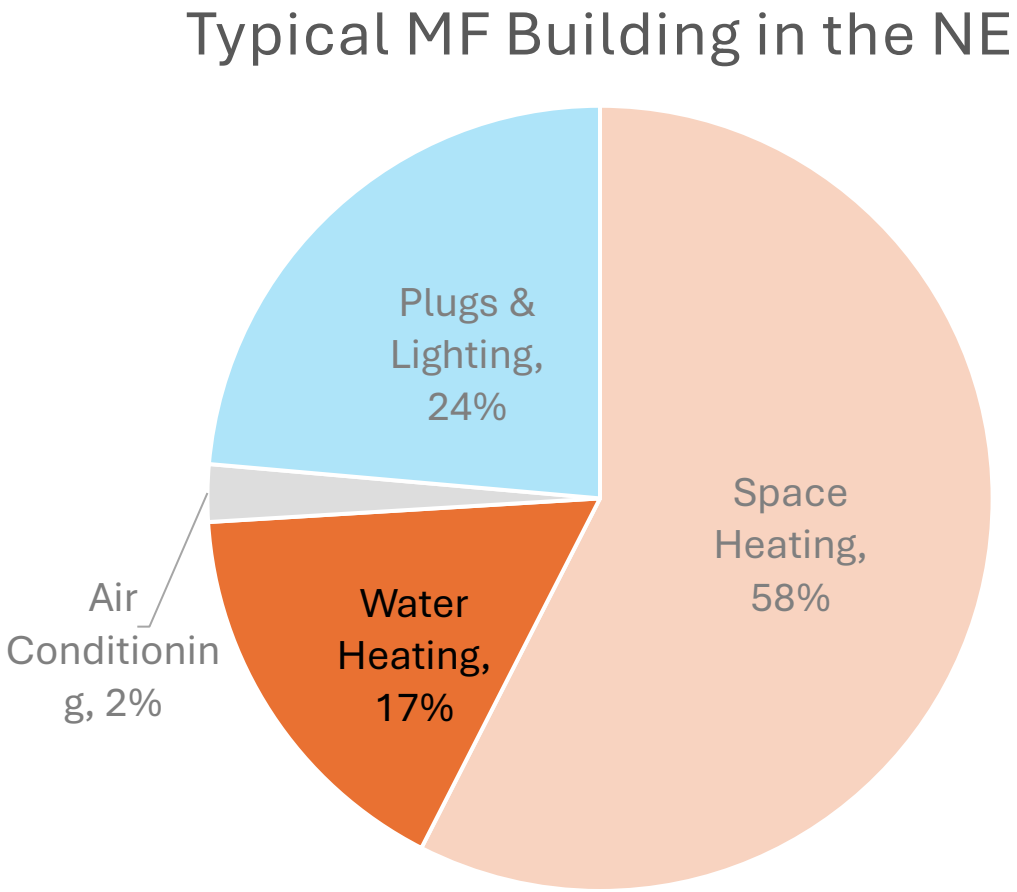
- Less ductwork / site labor
- Redundancy

CONs

- More equipment to service
- Market not yet mature for All-in-ones
- Often less efficient
- Poor cold temperature performance



Hot Water in Multi-Family in the North East



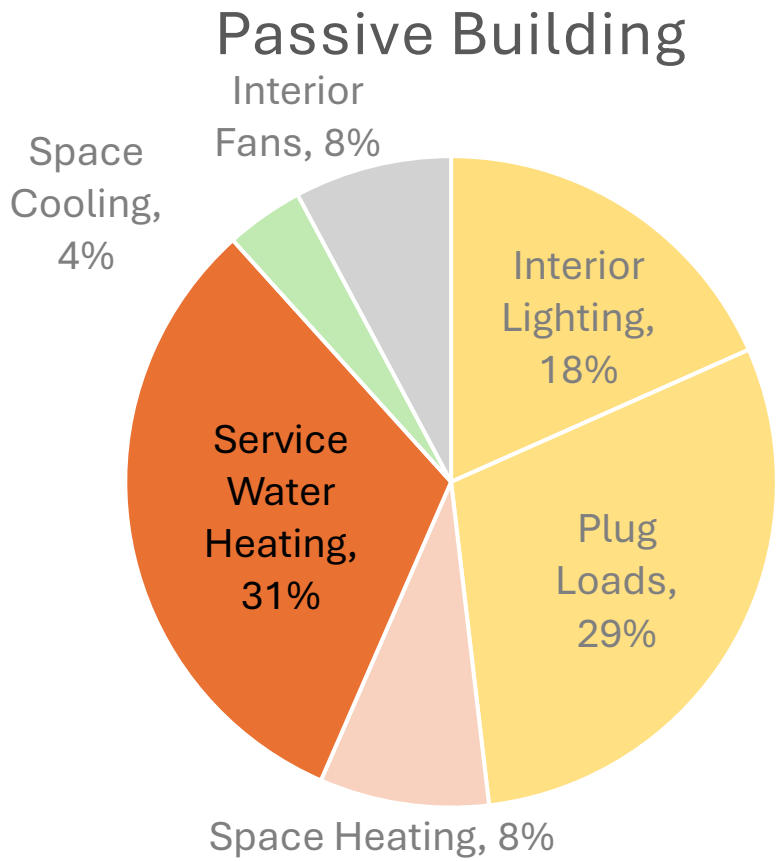
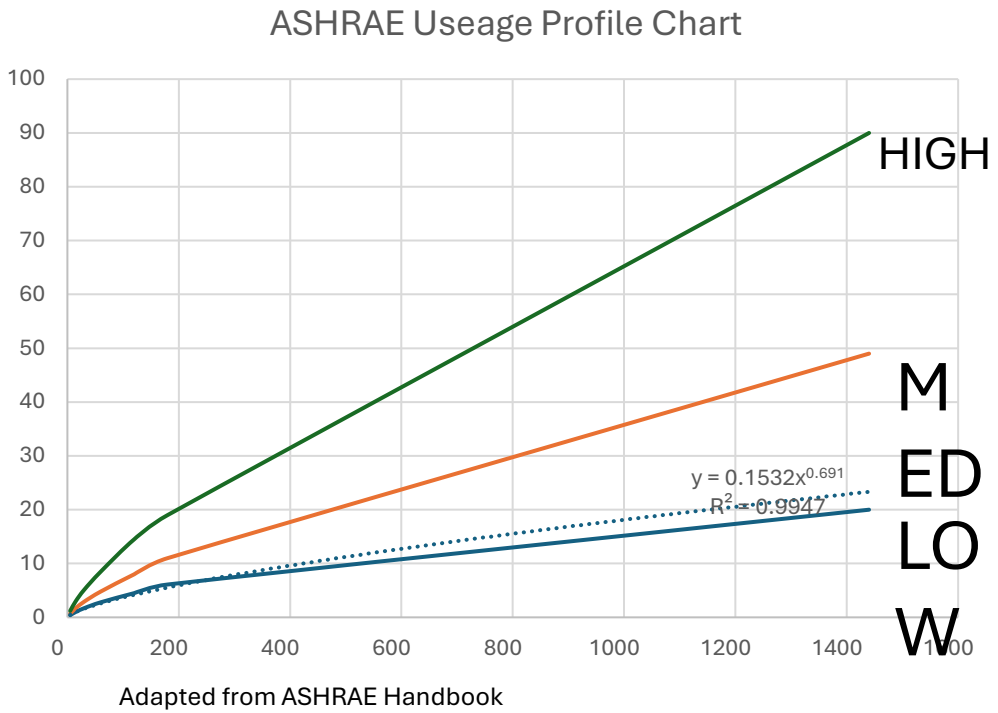


Table 1. Demographic Characteristics Correlation to DHW Consumption

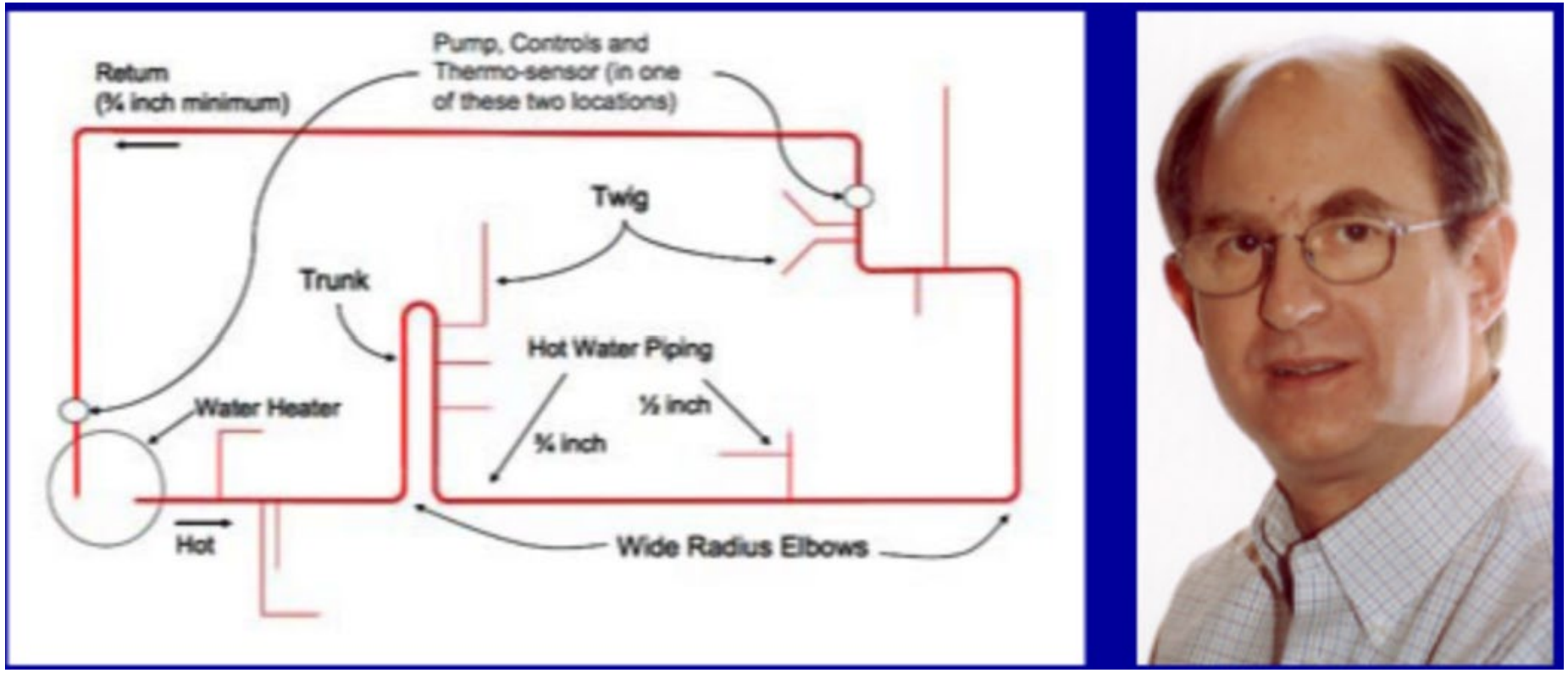
Demographic Characteristics	LMH Factor
No occupants work Public assistance & low income (mix) Family & 1 parent households (mix) High % of Children Low income	HIGH
Families Public assistance Singles 1 parent households	MEDIUM
Couples Higher population density Middle income Seniors One person works, 1 stays home All occupants work	**LOW**

Reprinted from: Goldner, F.S., and Price, D.C. - Domestic Hot Water Loads, System Sizing and Selection for Multifamily Buildings



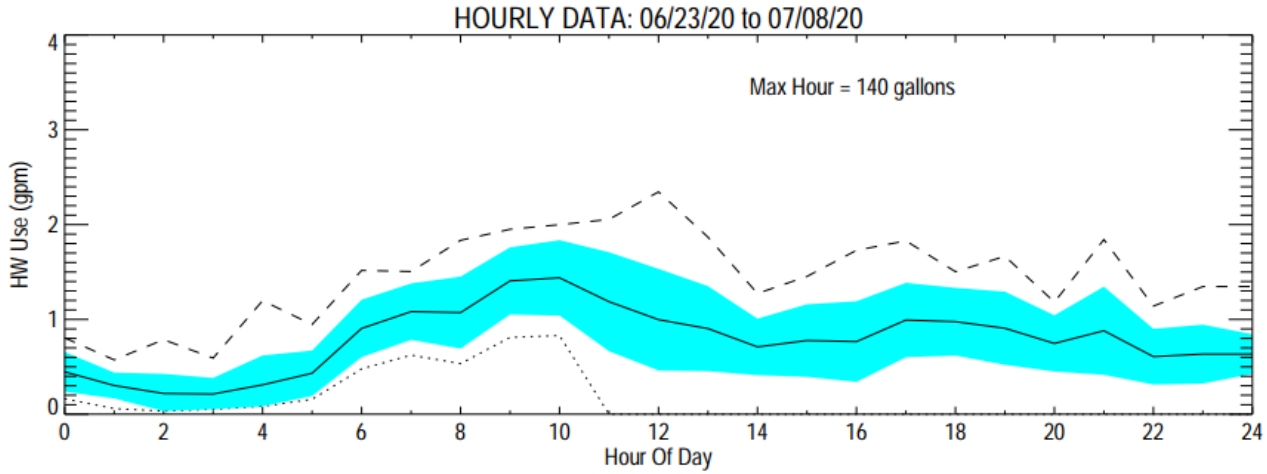
Adapted from ASHRAE Handbook

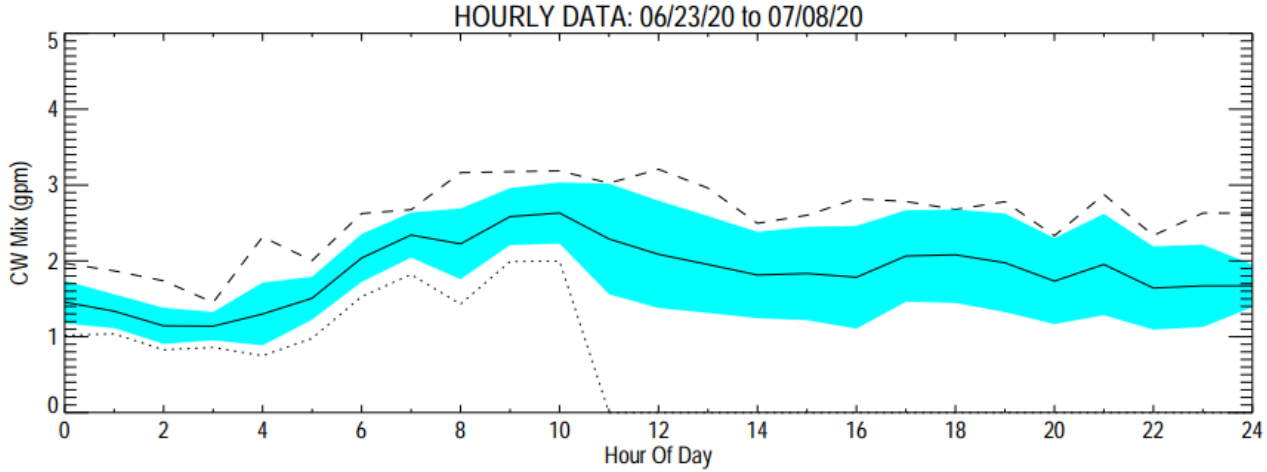
DHW Design and Layout



HW Consumption
Measured Data

HW Consumption Study for 99 unit Senior Housing apartment building in NY.





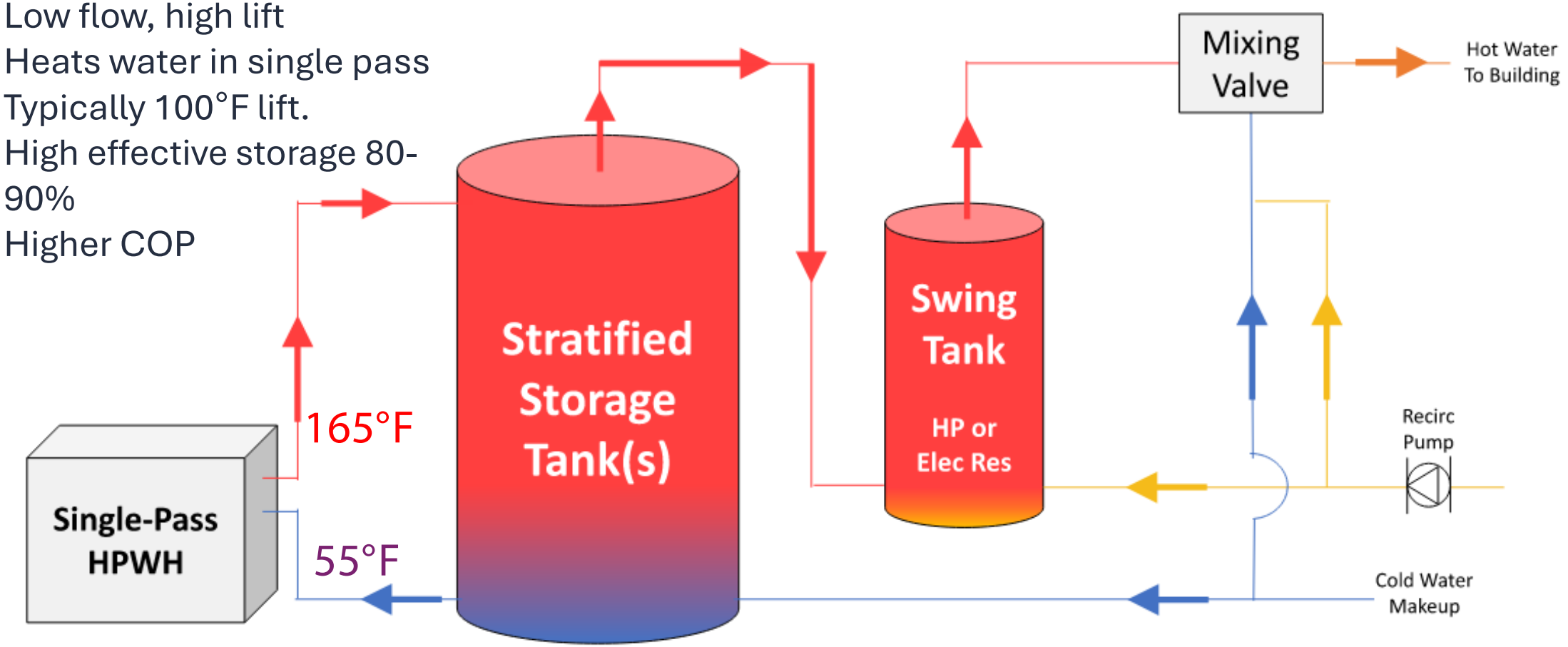
Colonial I monitoring study. Courtesy of P. Skinner & G. Klein.

Types of Commercial Heat Pump Water Heaters

- Integrated/Packaged
- Multi-pass
- Small single pass
- Large single pass
- Variable Refrigerant Flow
- Water source/ground source

Single-Pass HPDWH Typical Layout

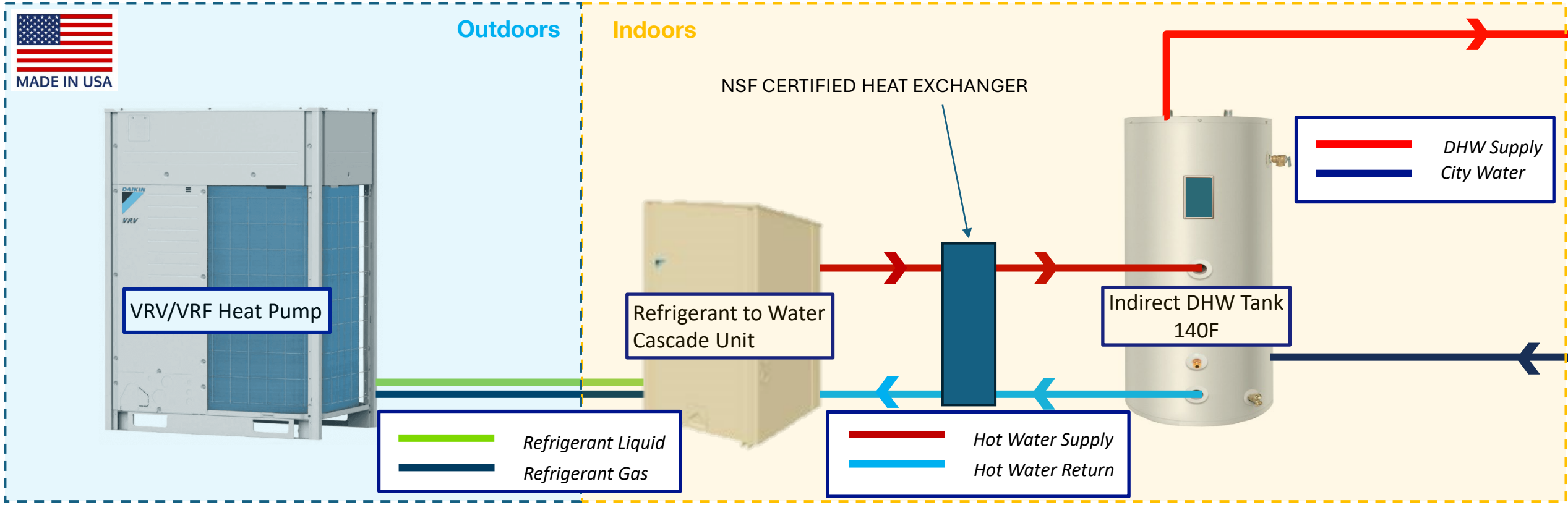
- Low flow, high lift
- Heats water in single pass
- Typically 100°F lift.
- High effective storage 80-90%
- Higher COP



Large Single Pass

- Split approach – remote HP outdoors
- Commercial use - larger load capacity
- Generally serves 40-60 residences, hotel rooms
- Single pass
- Larger footprint
- Capable of heating at lower ambient temperatures

Cold climate VRV split modular domestic hot water heater



- Split setup so all water can remain indoors (avoids the need for glycol)
- High temp: up to 194F hot water heating loops (via a cascade boost unit)

*Simplified schematics – for conceptual discussion only – components and accessories missing

Cold climate VRV split modular domestic hot water heater

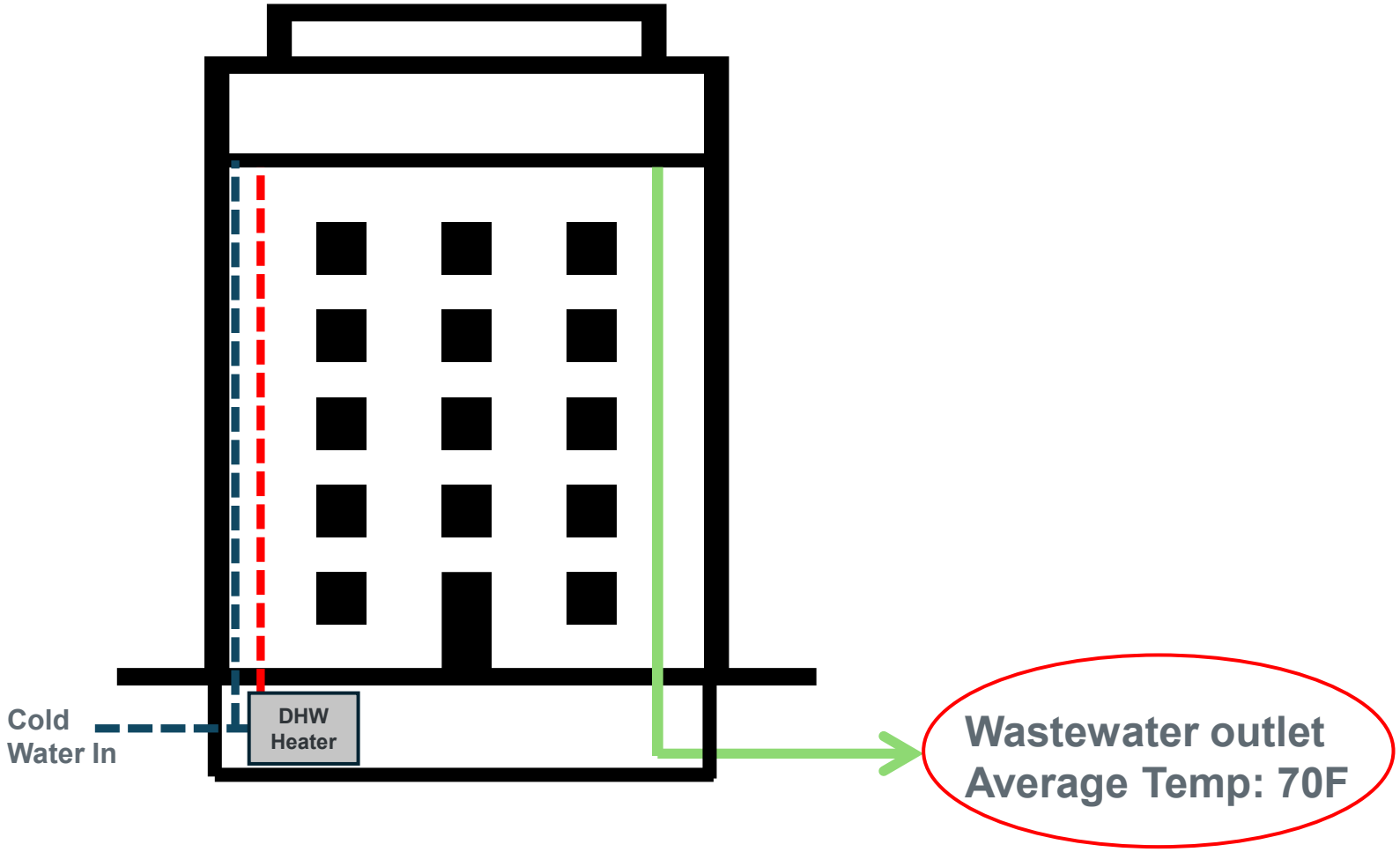
Water source / Geothermal domestic hot water heater

- Modular with single point electrical connection
- Low GWP refrigerant
- Double wall NSF rated heat exchanger

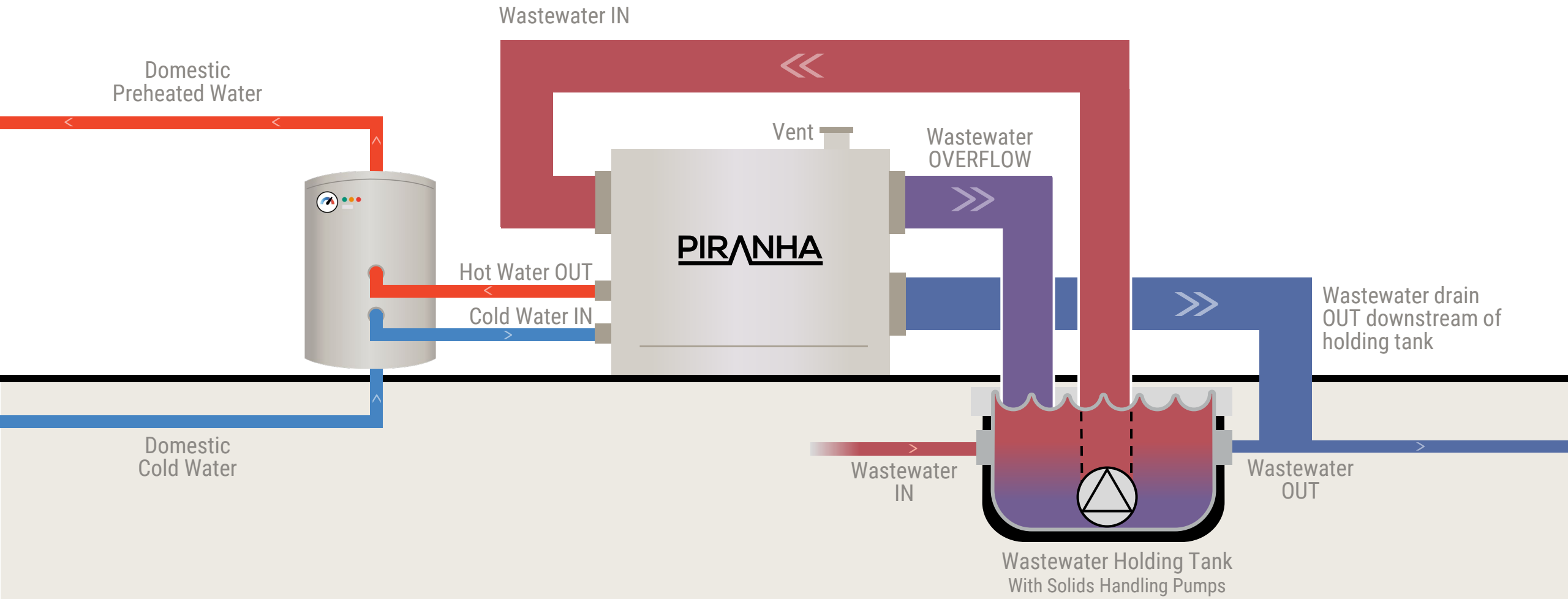
MADE IN USA

*Simplified schematics – for conceptual discussion only – components and accessories missing

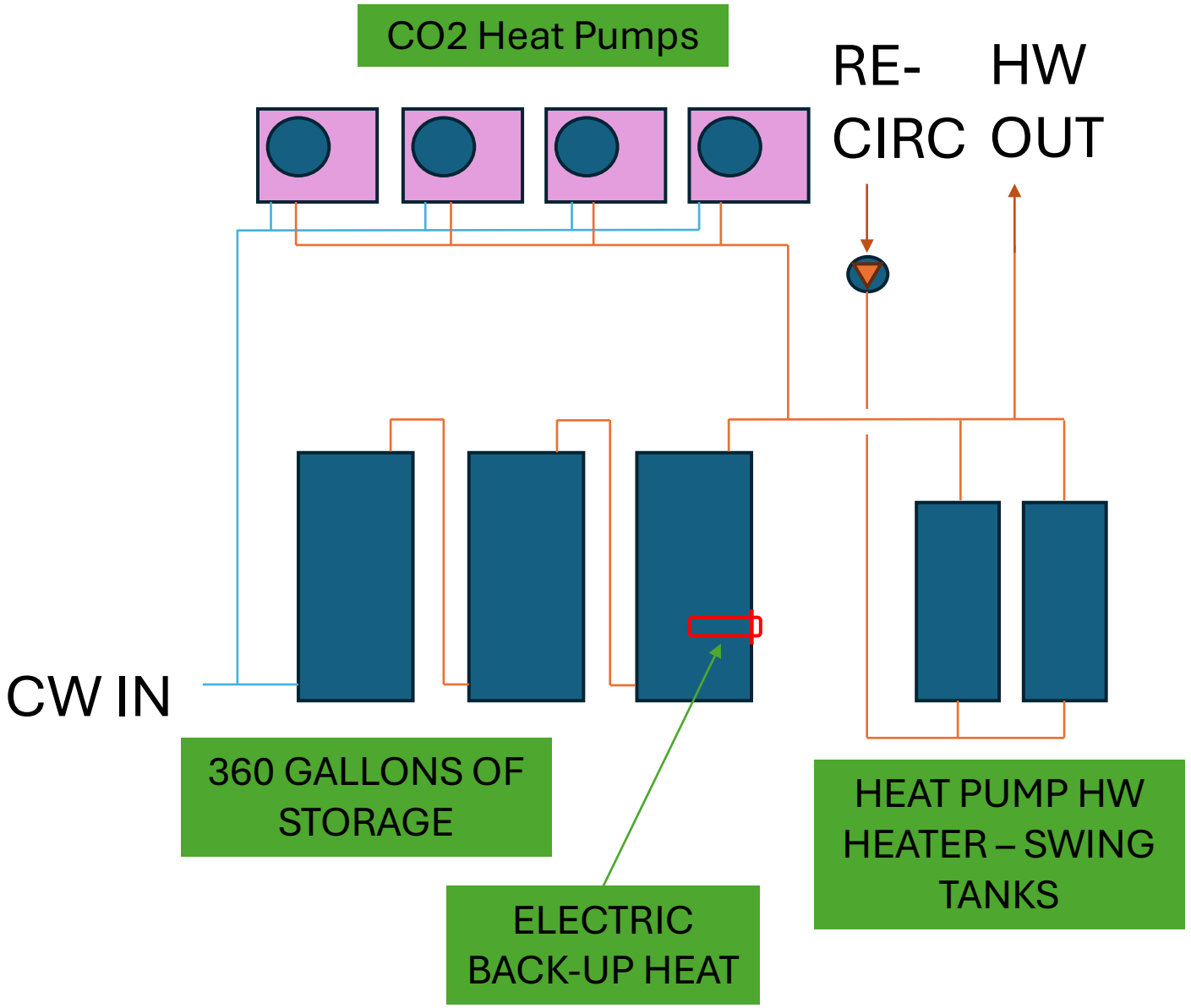
Where else can we recover heat?



Wastewater Heat Recovery



CO2 HP HW Heater Central Plant



HEAT PUMP CAPACITY ~12% OF ORIGINAL GAS CAPACITY!

55 unit Apartment Building in Pittsburgh

Thank you!

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