

Heat Pumps in Seattle

Commercial

Seattle City Light
Lighting Design Lab
June 15, 2021

Cooling “food for thought”

- 90 degree day in May – the future is hot!
 - The value of cooling cannot be understated
 - South and west facing glazing
- Heat pumps for commercial spaces?
 - 30-35% of new construction sales are still unitary equipment
 - 80% gas/electric
 - 20% heat pump
 - Only a handful of heat pump and VRF projects applied for City Light incentives in the last year
 - These projects are happening – 50% of new office buildings in PNW installed VRF
 - Code, cost, process?



We are here to help to make efficient cooling the norm!

Before we Begin...

During the Webinar

- Attendees will be muted
- Please use the chat feature in the control panel to submit questions to LDL staff
- The presenter will pause to address questions periodically.
- Please participate in the online polls.

Following the Webinar

- Please take the short survey
- A recording and the slide deck will be posted on LDL's webpage
- Reach out to LightingDesignLab@seattle.gov with comments or questions.

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Seattle Department of
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Seattle City Light



Ben Roush, Principal, PE-ME, FPE, LEED AP BD+C, ASHRAE BEMP & BEAP, Certified Commissioning Professional

Mechanical & FP Engineer
Board Chair Emeritus, USGBC-MD
AIA MD COTE Chair
LEED E&A TAG member
Sustainable Mechanical Engineering
Energy Modeling and Auditing
130+ LEED Projects
2 Certified Living Buildings
9 current projects targeting Net Zero
Code Nerd



Duane Jonlin, FAIA

- 30 years as technical architect
- 9 years as Energy Code guy
- 4th generation Seattleite



We got this.

It's not *whether* we're going to do this, it's *how*



Washington state:
70% less building
energy use by 2030

- Zero-carbon buildings
- Gov says move faster

Washington state:
45% reduction in GHG
emissions by 2030

- 95% reduction by 2050

Seattle: Carbon-neutral
building & vehicle
operations by 2050

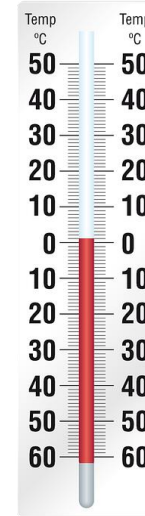
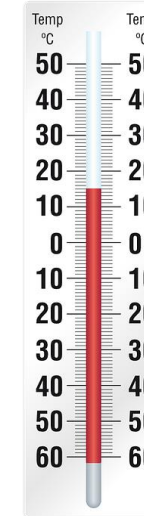
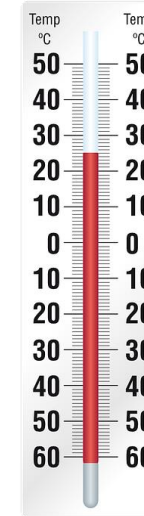
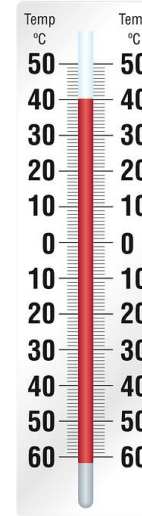
- ...or sooner with Green New Deal?

Commercial building HP system options

Heat Pump System	Building types	Cost	Pros	Cons
Split systems, Mini Split	Simple low rise	\$	Low cost, good efficiency, high flexibility	Only works with DOAS for most building types, no economizer
Packaged Rooftop HP, VAV or single zone	Simple low and midrise if DOAS not required	\$	Low Cost, moderate efficiency, medium flexibility, economizer	Can't easily use for office, education, assembly, retail.
VRF (w/ DOAS)	Low and Midrise, existing buildings, DOAS systems	\$\$	High flexibility	High refrigerant volume is problematic for sleeping or non-ambulatory occ's
2-Pipe hydronic w HP chiller	Facilities with uniform usage	\$\$	Good flexibility, lower cost, good energy performance	Changeover problematic in spring/fall for multi-zone buildings
4-Pipe Hydronic w/ HP chiller, or centrifugal chiller	Large and tall facilities	\$\$\$	Moderate flexibility, good performance, heat recovery from process loads possible	High Cost, system complexity, Centrifugal requires backup boiler, may be electric
Water Source w/ heat recovery chiller loop	Large & medium facilities, highrise residential	\$\$\$	High flexibility, tried and true systems, can be high performance.	Distributed compressors with distributed noise
Ground source Water to water 2 or 4-pipe	Large & medium facilities with enough land	\$\$\$\$	High efficiency, good in cold weather. Water side heat recovery OK.	Highly complex systems, specialty maintenance, High cost

Heat pump OSA operating range

- **40° - 45°** PTHP/VTHP
- **20° - 25°** Single speed compressors
 - Before steep drop in capacity & COP
- **5° - 15°** Modern variable speed compressors
 - Before steep drop in capacity & COP
- **-10° to -15°** *Some* variable speed compressors
 - Before needing backup electric heat
- **Q:** Why do so many engineers still think heat pumps don't work below 45°?



SPLIT SYSTEM, MINI-SPLIT

Building types: Simple low-rise
(not tall, complex, or DOAS buildings)

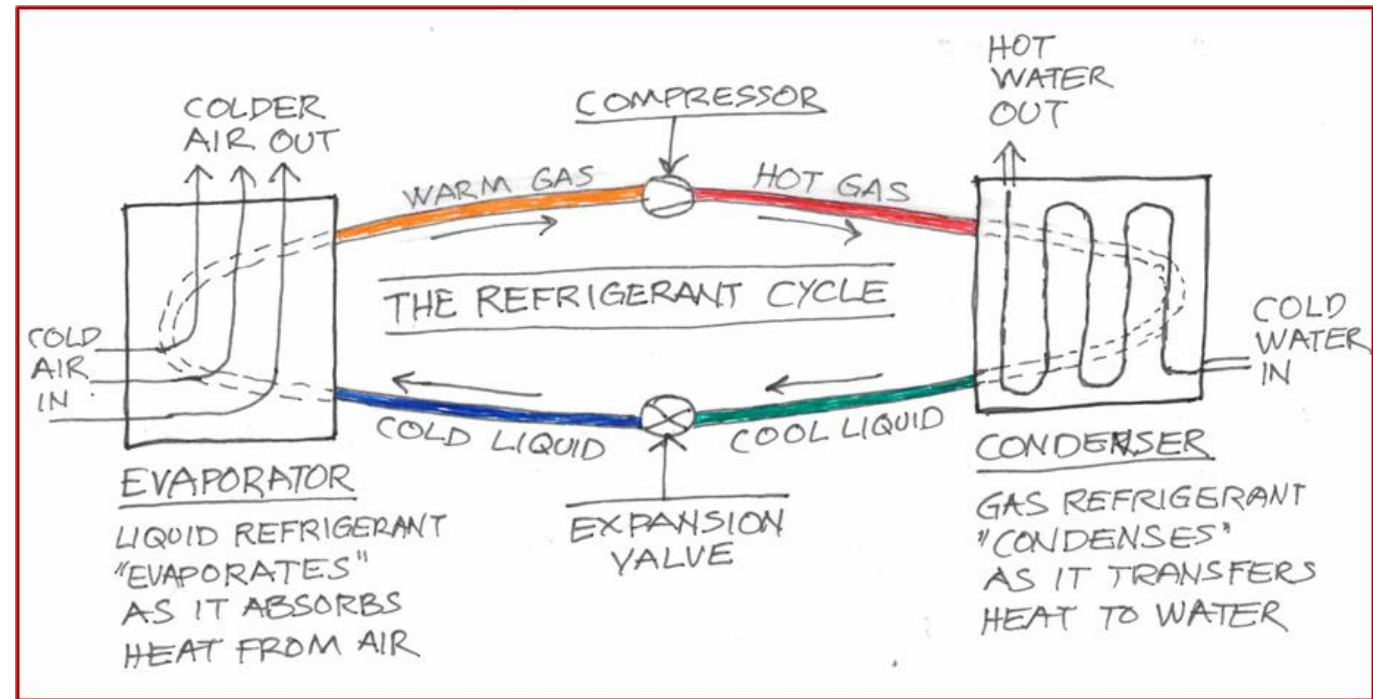
System cost: Low

Refrigerant: 2021: R410a, 2025: R??

Backup heat required? No

Pro: Low cost, good efficiency, high flexibility

Con: Only works with DOAS for most of energy code, no economizer



PACKAGED ROOFTOP HEAT PUMP

VAV OR SINGLE-ZONE

Building types: Simple low & mid-rise

(not tall or DOAS buildings)

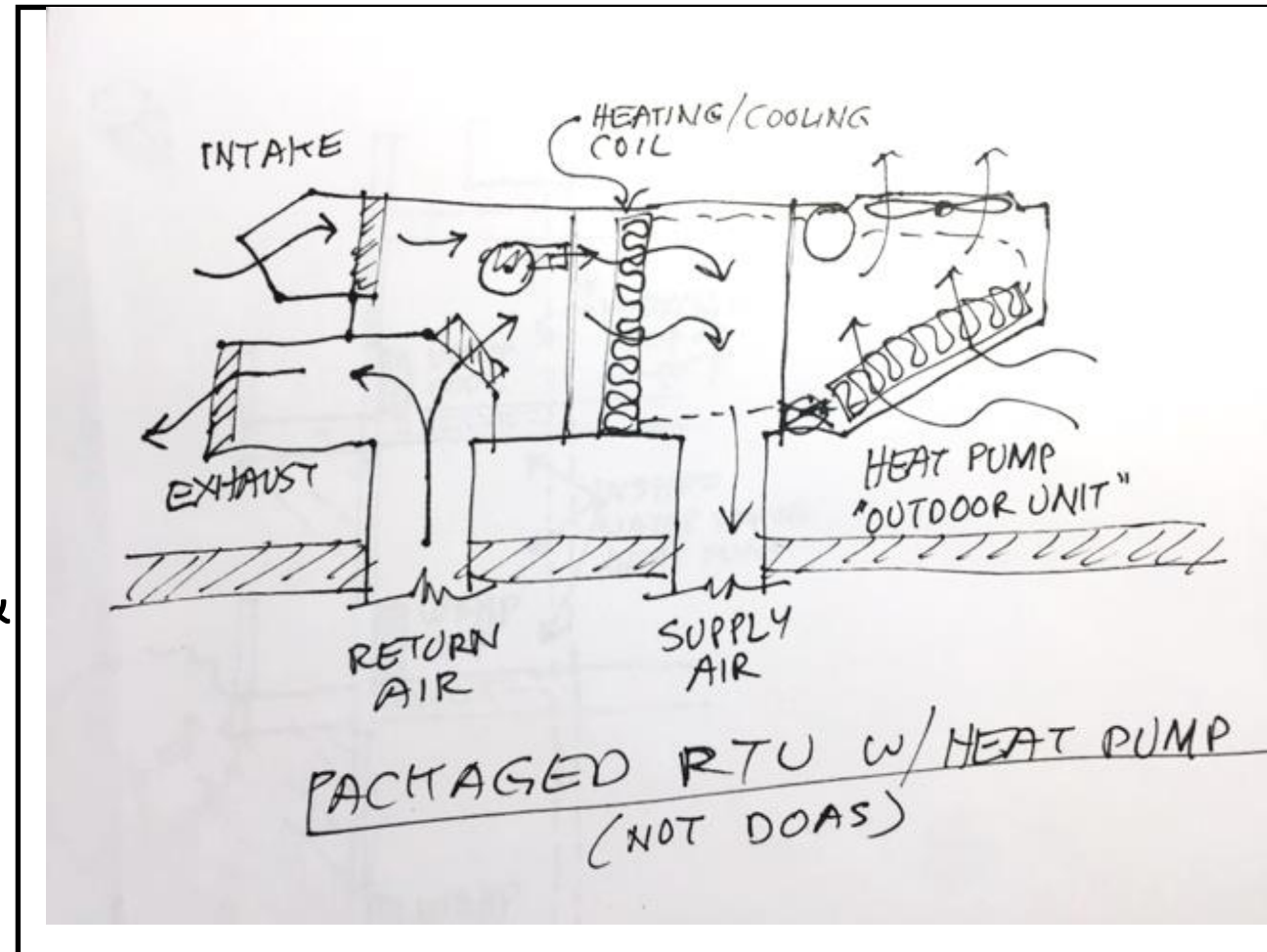
System cost: Low

Refrigerant: 2021: R410a, 2025: R??

Backup heat required? Maybe

Pro: Low cost, moderate efficiency & flexibility, has economizer

Con: Doesn't work for common (DOAS) occupancies



VRF

Building types: Low & mid-rise, existing buildings, DOAS

(not highrise, yet! 295 ft coming soon)

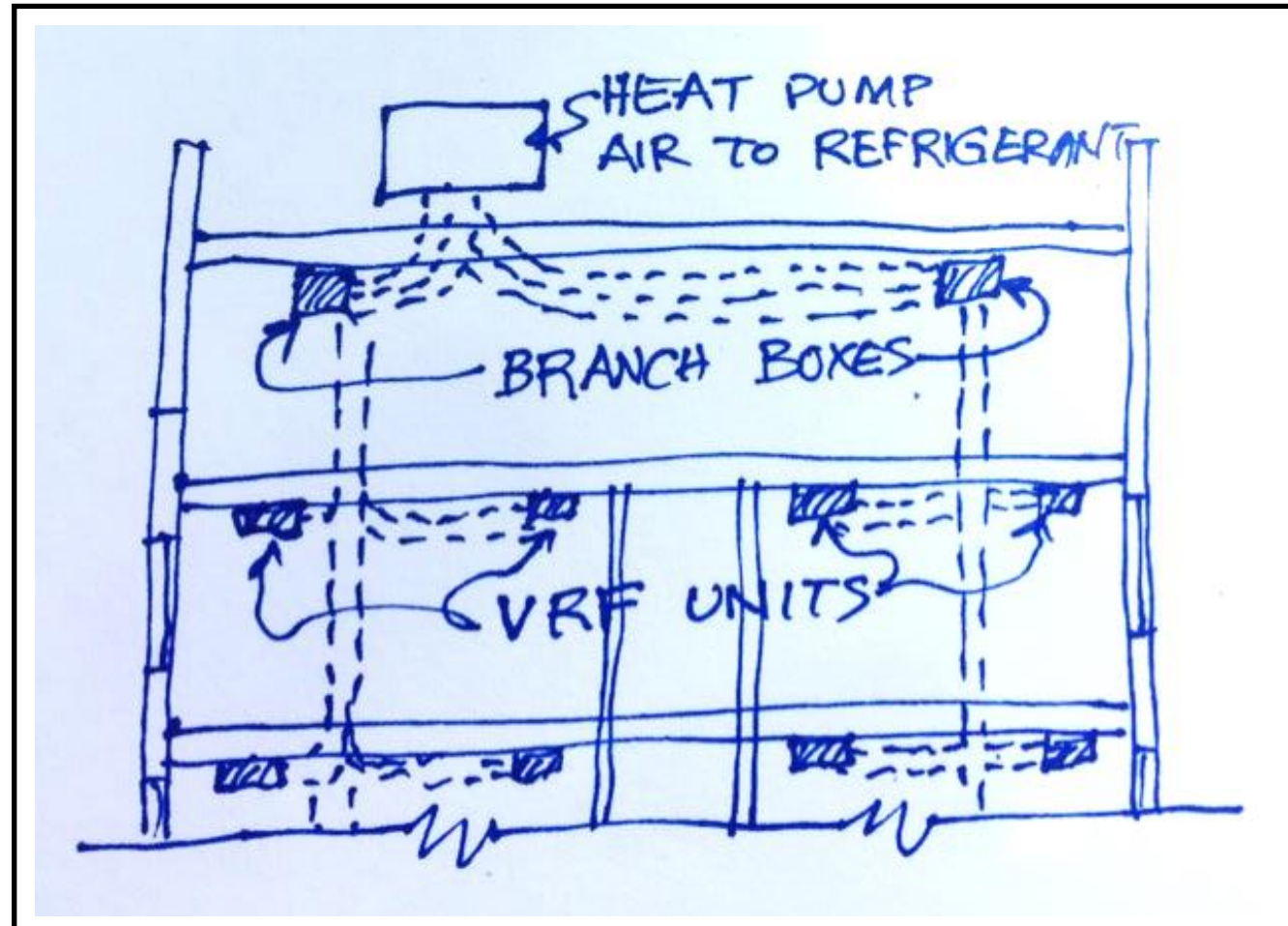
System cost: Medium

Refrigerant: 2021: R410a, **2025:** R??

Backup heat required in WA? No

Pro: Very flexible, works for retrofits

Con: High refrigerant volume is hazard for sleeping or non-ambulatory occupants (not to mention for the world)



2-PIPE HYDRONIC W/ HEAT PUMP CHILLER

(OR WITH CENTRIFUGAL CHILLER)

Building types: Facility w/ uniform usage throughout

(not variable usage or retrofit projects)

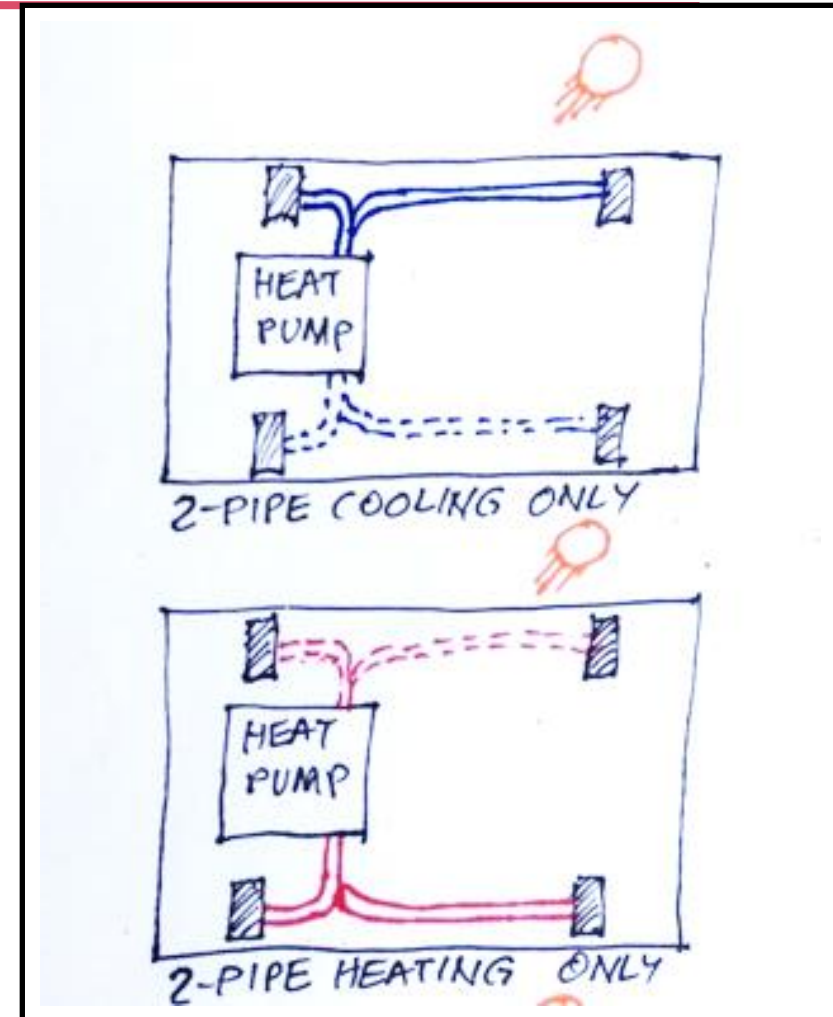
System cost: Medium

Refrigerant: 2021: R410a, R134a, **2025:** ??

Backup heat required in WA? Maybe

Pro: Very flexible, reasonable cost, good energy performance

Con: Changeover problematic in spring & fall if different parts of the building are in heating and cooling together. Complex maintenance.



4-PIPE HYDRONIC WITH HEAT PUMP CHILLER

(OR WITH CENTRIFUGAL CHILLER)

Building types: Large & tall buildings
(not retrofits)

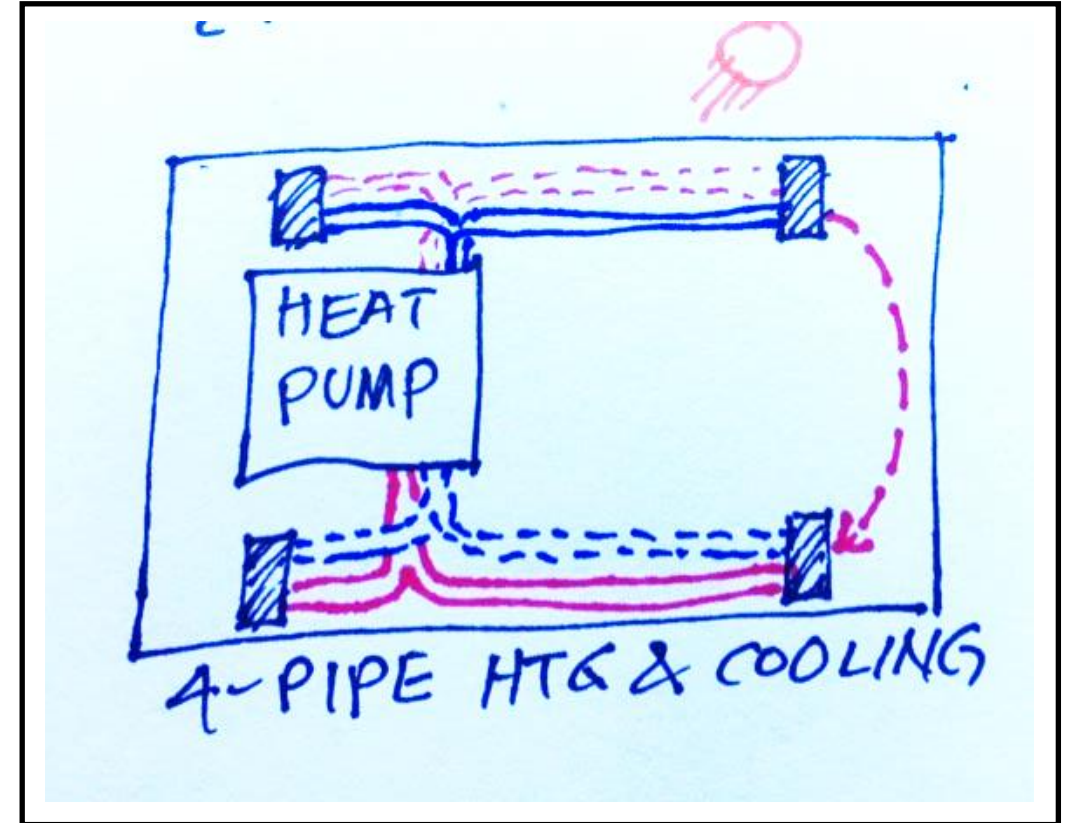
System cost: High

Refrigerant: 2021: R410a, R134a, 2025: ??

Backup heat required in WA? Maybe

Pro: Somewhat flexible, good performance,
heat recovery possible from data center or
other heat source

Con: Expensive and complicated. Centrifugal
would require backup boiler



WATER SOURCE HEAT PUMPS

WITH HEAT RECOVERY CHILLER LOOP

Building types: Medium & large buildings, high rise residential

(not lowrise, low-budget, or retrofit projects)

System cost: High

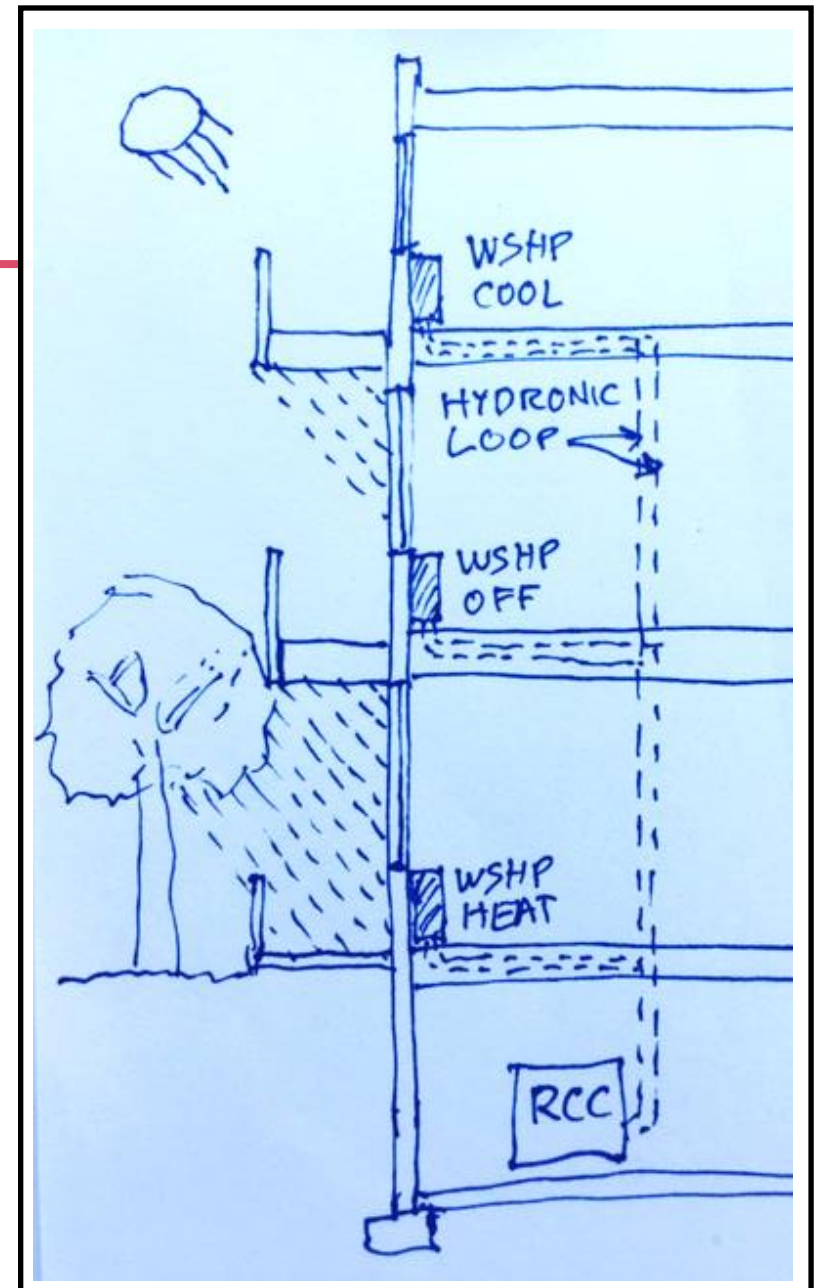
Refrigerant: 2021: R410a, **2025:** R??

Backup heat required in WA? Maybe

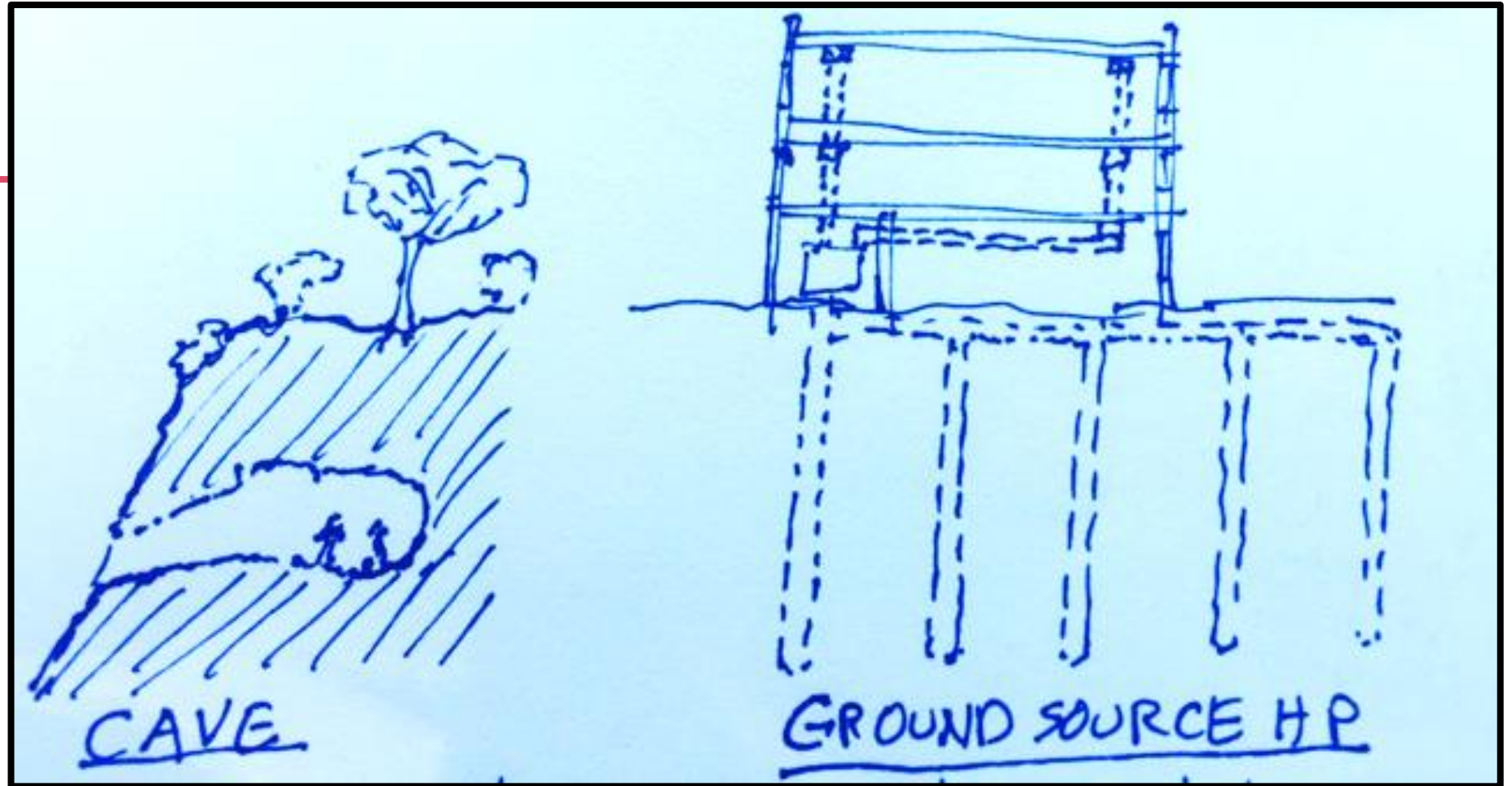
Pro: High flexibility, high performance possible, tried and true system

(Also, very low refrigerant volume, compared with VRF)

Con: Distributed compressors, distributed noise



Ground source heat pump



- Stable earth temperature
- Warms air in winter, cools in summer
- The ultimate thermal mass
- Deposit excess summer heat
- Withdraw heat in winter
- Much nicer lighting than in cave

GROUND SOURCE HEAT PUMPS

2-PIPE OR 4-PIPE WATER-TO-WATER SYSTEMS

Building types: Medium & large buildings with enough land

(not low-budget, or projects on tight sites)

System cost: *Very High*

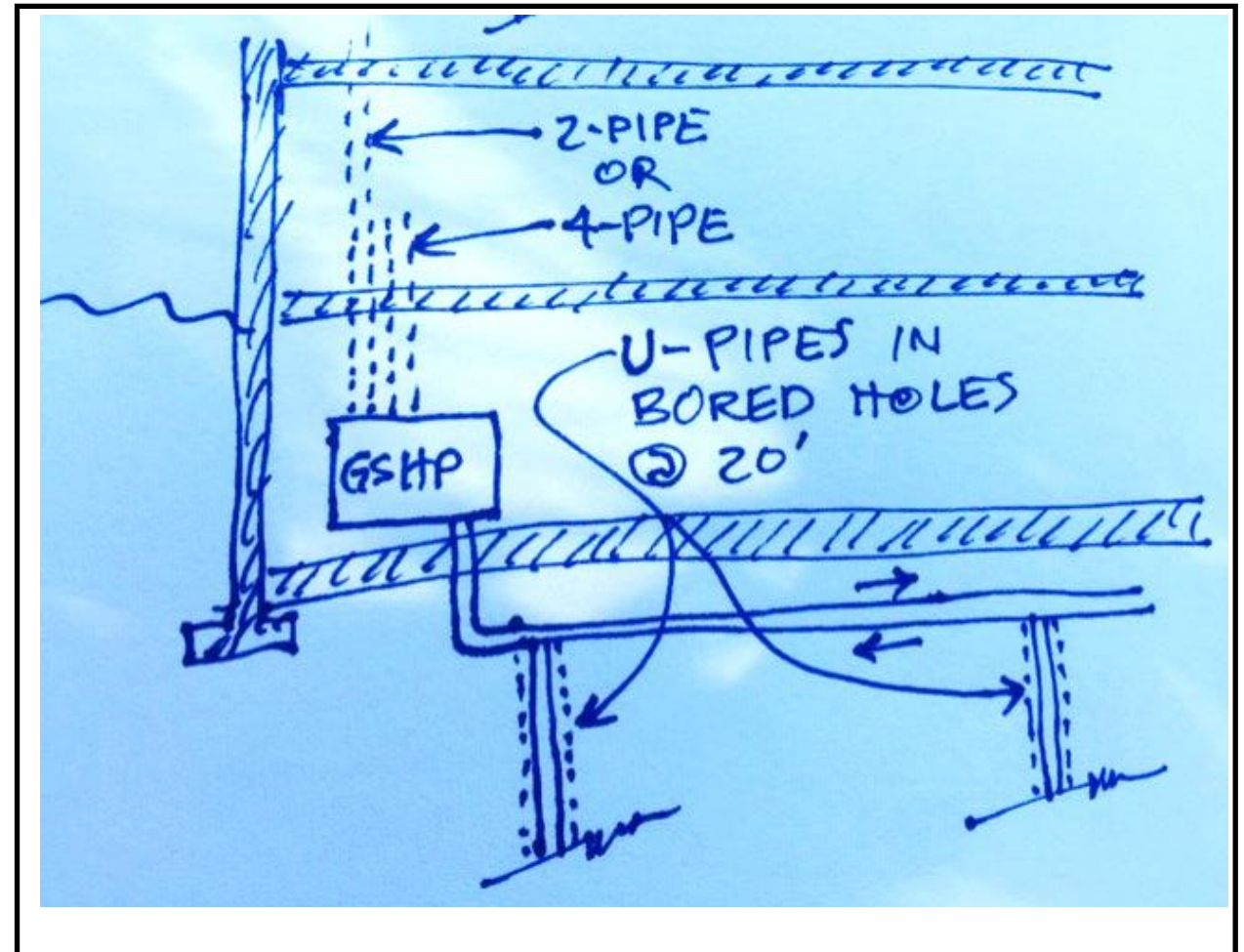
Refrigerant: **2021:** R410a, **2025:** R??

OSA temp range: irrelevant

Backup heat required in WA? No

Pro: High efficiency, no cold weather issues, water side heat recovery possible

Con: Highly complex, specialty maintenance required, high cost

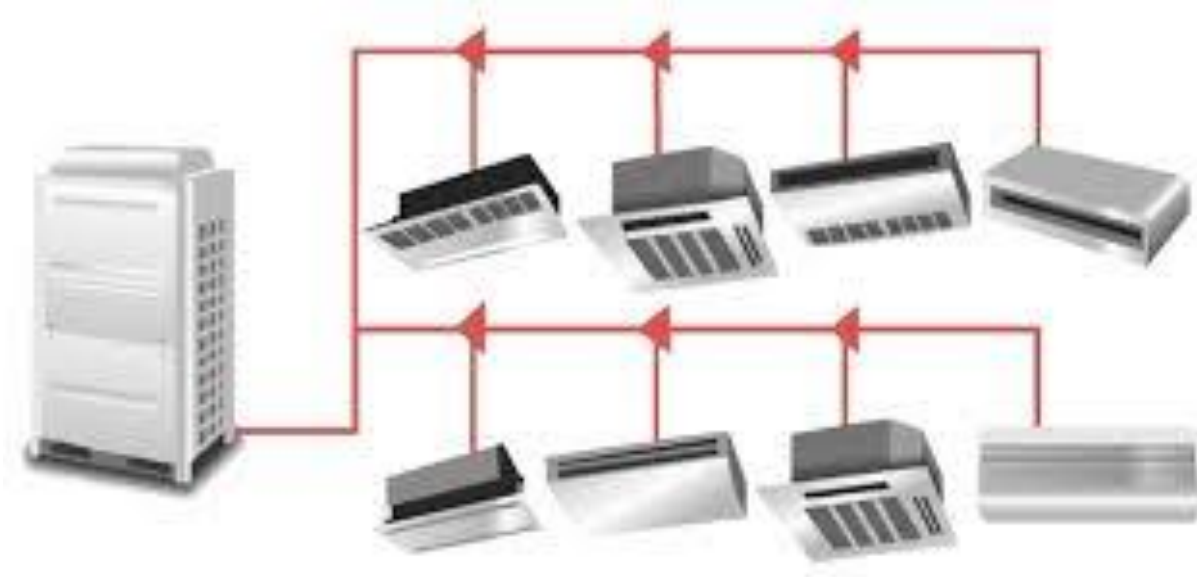


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Heat Pump Layout



Heat Pump Layout, variable speed

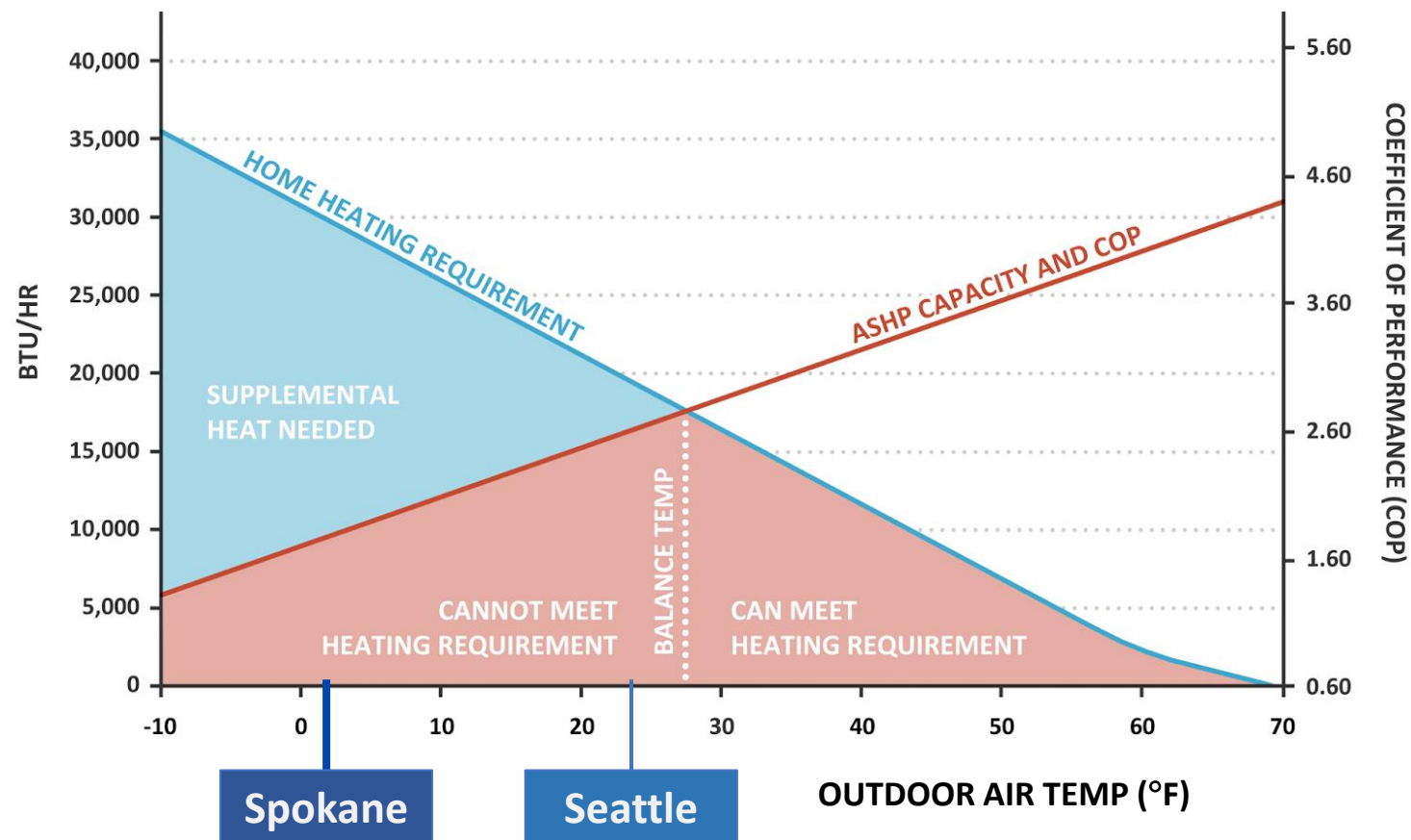


Engineering View, Limitations



Heat Pump
Performance,
Cold Temp Impacts
(cheap version)

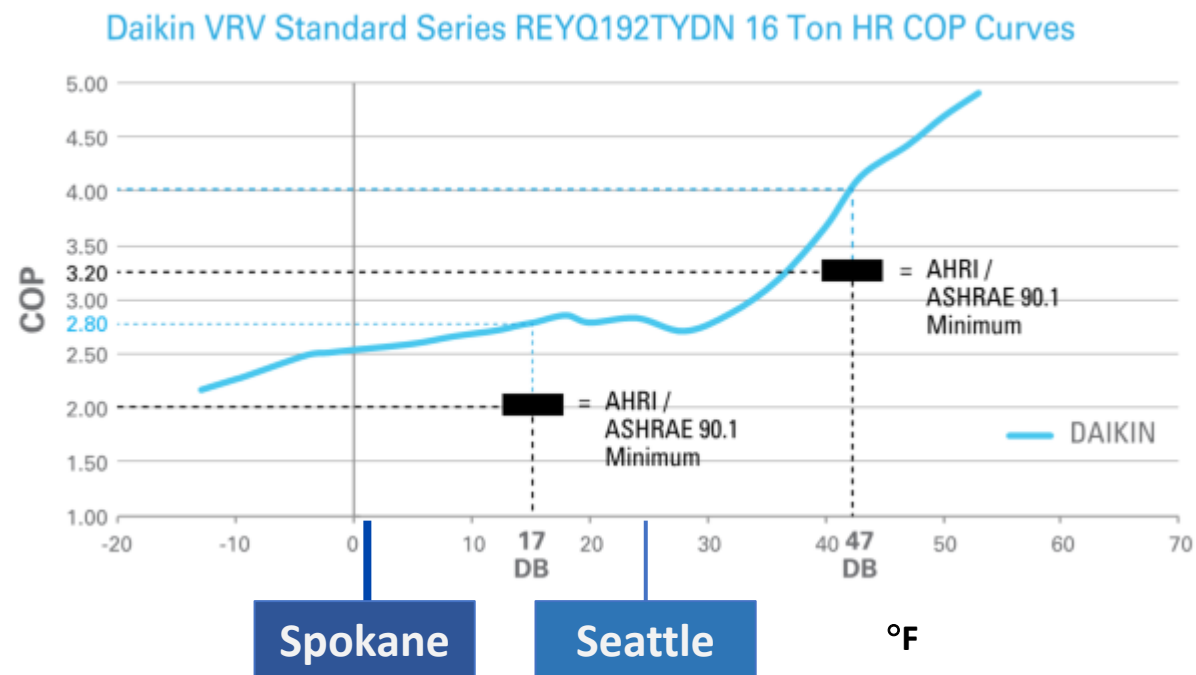
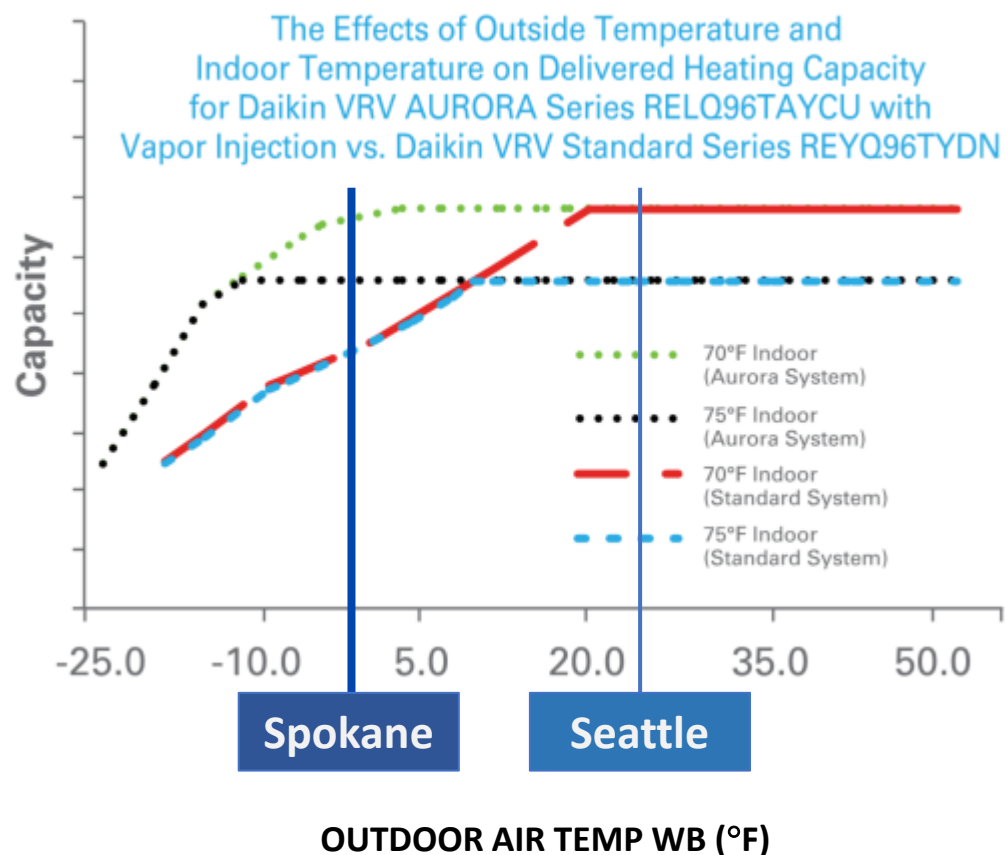
Performance of typical 2-ton air-source heat pump



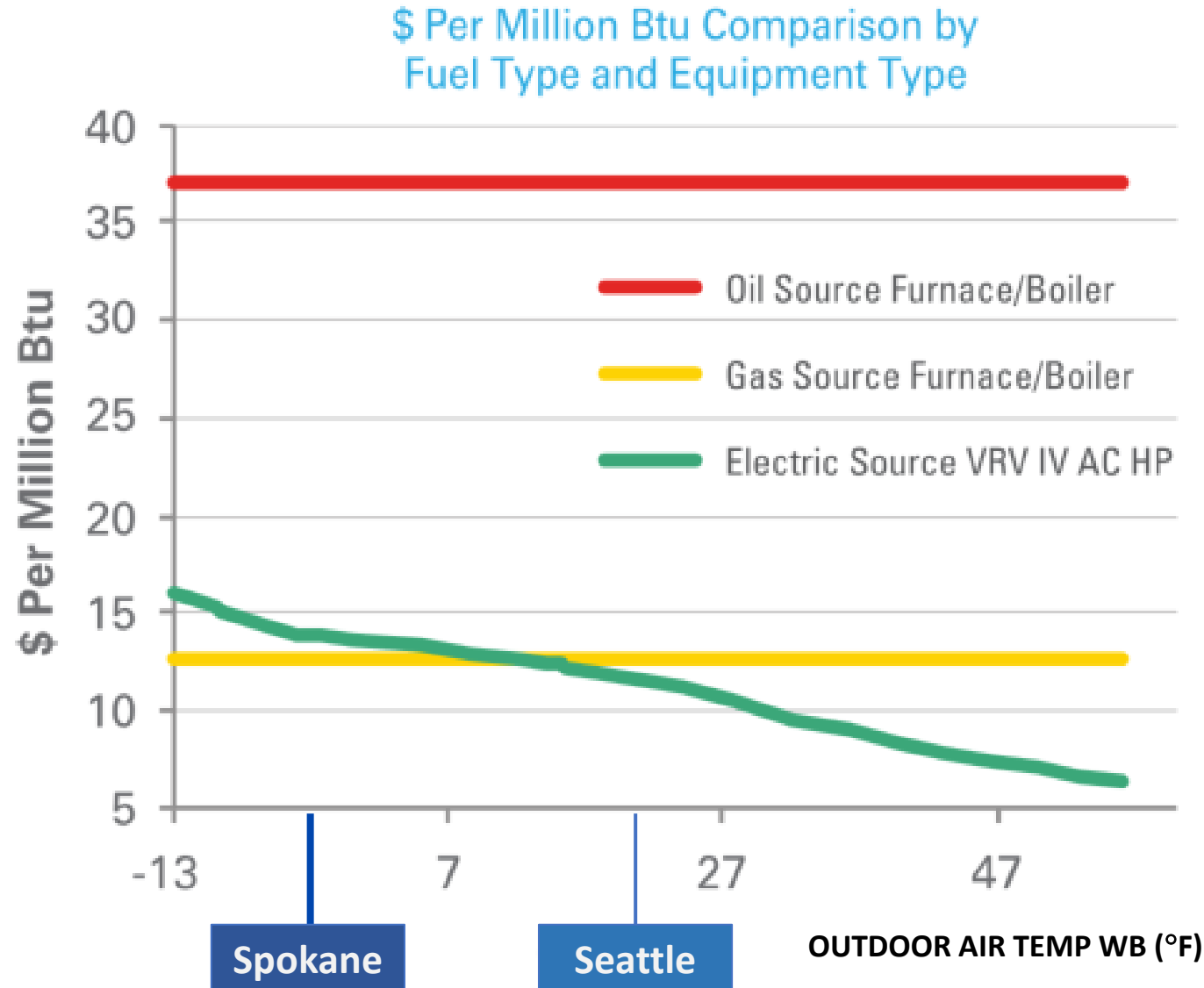
Engineering View, Less Limitations



Variable Speed Version



Engineering View, Cost





TSPR = Heating + Cooling Loads
(annual) Carbon Emissions

**TSPR: Total System
Performance Ratio**
Office, Retail, Library, Education



Seattle adds multifamily
and medical office

TSPR evaluates HVAC
efficiency by comparing:

- required annual heating
& cooling, to
- carbon emissions due to
heating & cooling

Free online calculation tool
from PNNL

Engineering View, CO2



How clean is the electricity you use?

Electricity is produced by many different sources of energy, including, but not limited to, wind, solar, nuclear, and fossil fuels. The type and amount of emissions produced depend on how electricity is generated in your region. Type in your zip code (or select a region) to view your power profile. [More Info](#)

Power Profiler

Enter zip code:

Zip code

Go

eGRID Subregions [More Info](#)

NWPP (WECC Northwest) ▼

NWPP Emission Rates

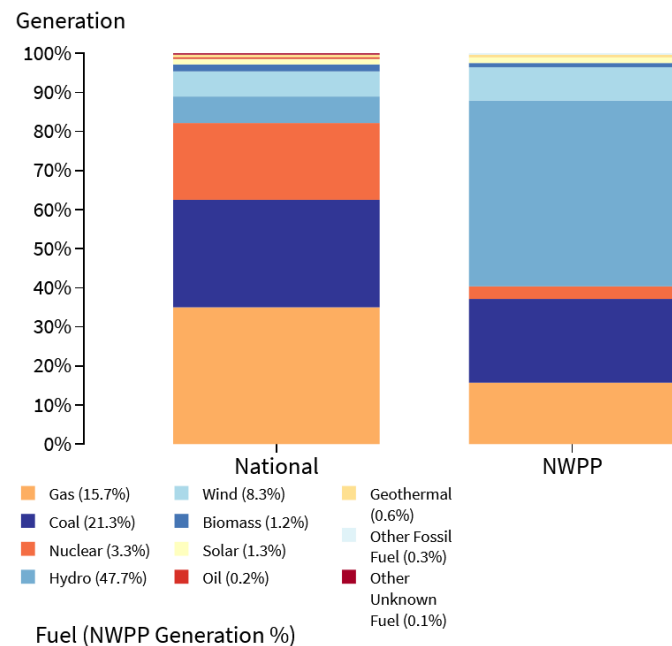
CO₂
639.0
(lbs/MWh)

SO₂
0.4
(lbs/MWh)

NO_x
0.6
(lbs/MWh)

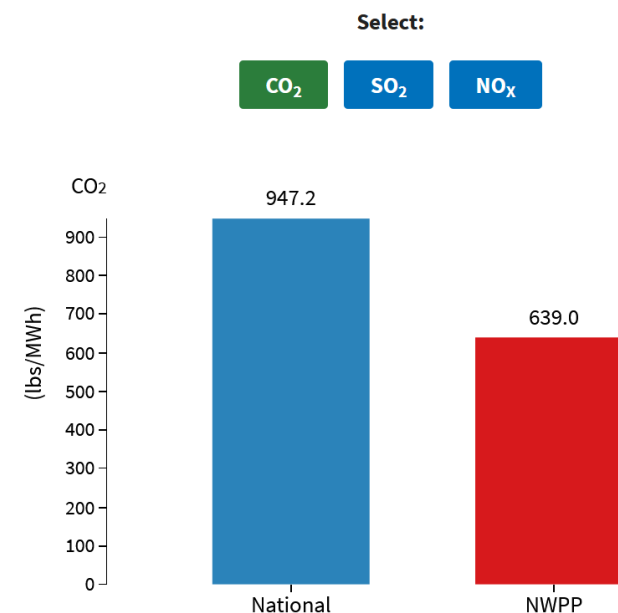
Fuel Mix

This chart compares fuel mix (%) of sources used to generate electricity in the selected [eGRID subregion](#) to the national fuel mix (%).



Emission Rates

This chart compares the average emission rates (lbs/MWh) in the selected [eGRID subregion](#) to the national average emission rates (lbs/MWh) for [carbon dioxide \(CO₂\)](#), [sulfur dioxide \(SO₂\)](#), and [nitrogen oxide \(NO_x\)](#).



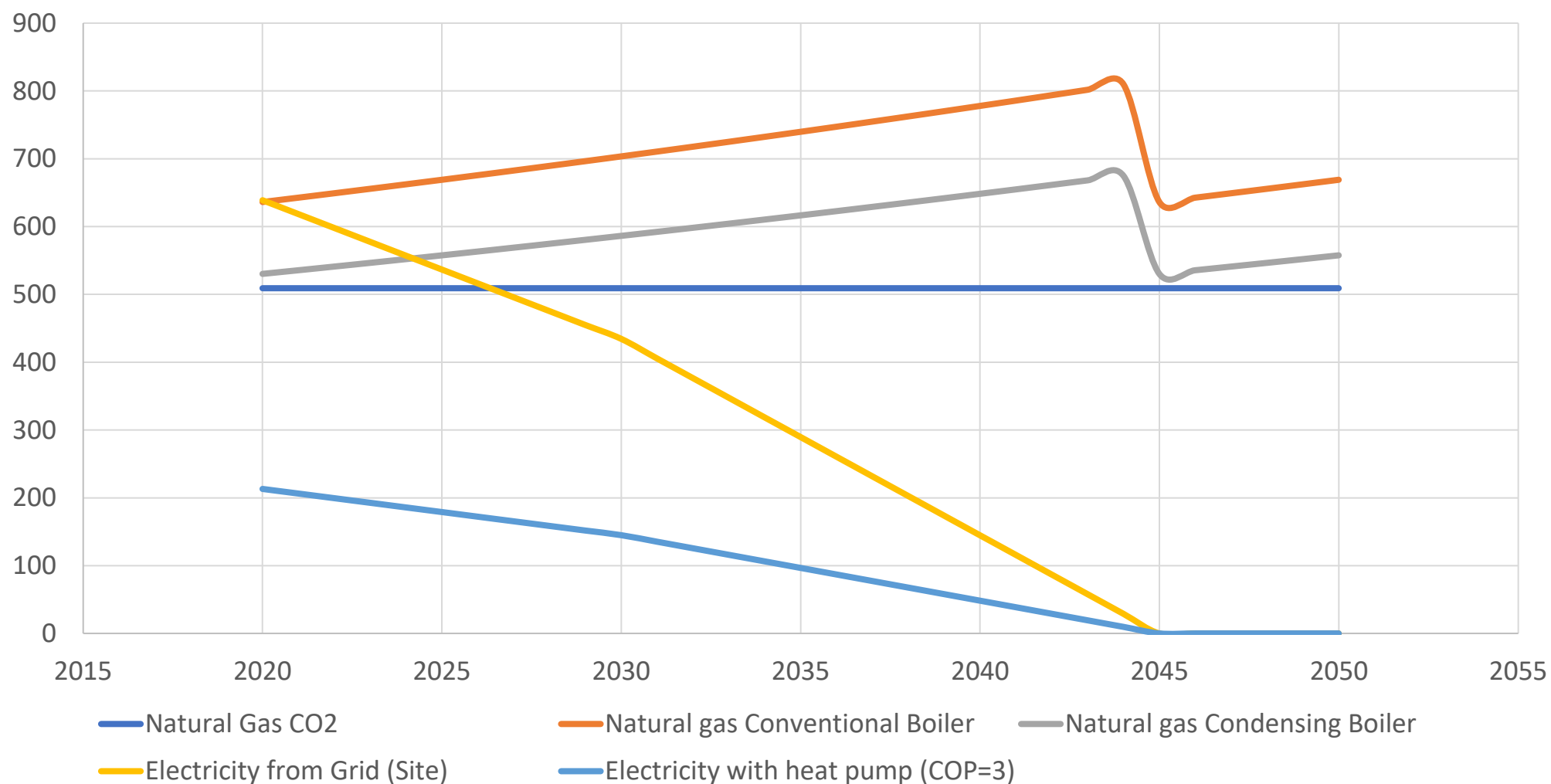
Engineering View, Future CO2



Washington Senate
Bill 5116 (2019-2020)
established goals of
carbon neutrality in 2030
and carbon-free by 2045

Engineering View, Future CO2

CO2 OVER TIME



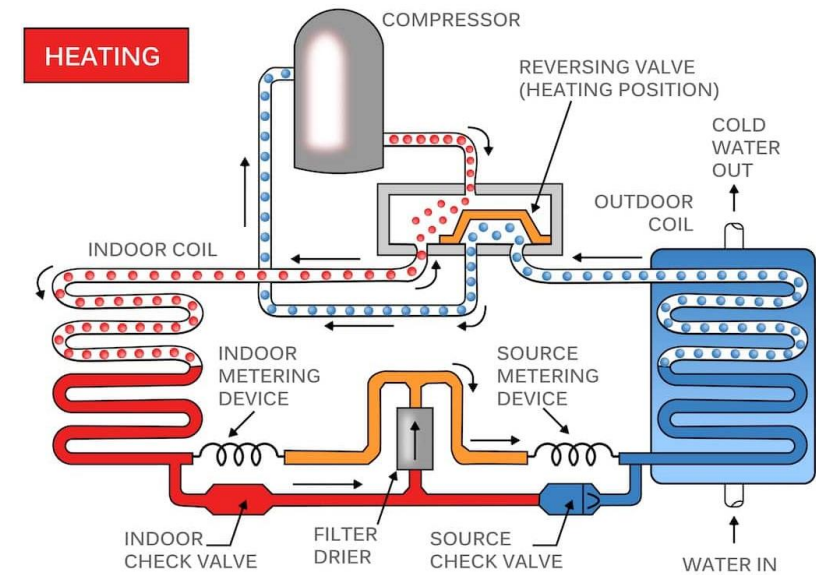
Seattle: Space heating

No electric resistance or fossil fuel combustion for space heating

- Usually means “use heat pumps”

Exceptions allow electric resistance heat for:

1. Permits applied for prior to 1/1/2022
2. **Dwelling units: Max 750 W per room**
 - **1000 W** for corner room
3. Other space types: Max 2.5 W/sf total installed heating (The “Passive House” rule)
4. Heat pump auxiliary heat in cold weather
5. etc....



Heat pumps squeeze warmth out of cold air

No electric resistance or gas heat (Seattle)



Airside systems we can use

No electric resistance or gas heat (Seattle)



Waterside systems we can use

Simultaneous Heating and Cooling



Additional Efficiency Package Options

(aka choose your own adventure)

Previously

Select Two, aka “Choose Your Own Adventure”

Now

6 credits for Washington

8 credits for Seattle, based on occupancy

If DOAS is required, no additional points

Key

Most cost effective

2nd most cost effective

Code Section	Commercial Building Occupancy					
	Group R-1	Group R-2	Group B	Group E	Group M	All Other
	Additional Efficiency Credits					
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
2. Reduced lighting power: Option 1 in accordance with Section C406.3.1	1.0	1.0	2.0	2.0	3.0	2.0
3. Reduced lighting power: Option 2 in accordance with Section C406.3.2 ^a	2.0	3.0	4.0	4.0	6.0	4.0
4. Enhanced lighting controls in accordance with Section C406.4	NA	NA	1.0	1.0	1.0	1.0
5. On-site supply of renewable energy in accordance with C406.5	3.0	3.0	3.0	3.0	3.0	3.0
6. Dedicated outdoor air system in accordance with Section C406.6 ^b	4.0	4.0	4.0	NA	NA	4.0
7. High performance dedicated outdoor air system in accordance with Section C406.7	4.0	4.0	4.0	4.0	4.0	4.0
8. High-efficiency service water heating in accordance with Sections C406.8.1 and C406.8.2	4.0	5.0	NA	NA	NA	8.0
9. High performance service water heating in multi-family buildings in accordance with Section C406.9	7.0	8.0	NA	NA	NA	NA
10. Enhanced envelope performance in accordance with Section C406.10 ^c	3.0	6.0	3.0	3.0	3.0	4.0
11. Reduced air infiltration in accordance with Section C406.11 ^c	1.0	2.0	1.0	1.0	1.0	1.0
12. Enhanced commercial kitchen equipment in accordance with Section C406.12	5.0	NA	NA	NA	5.0	5.0 (A-2 Only)

Table C406.1 Efficiency Package Credits

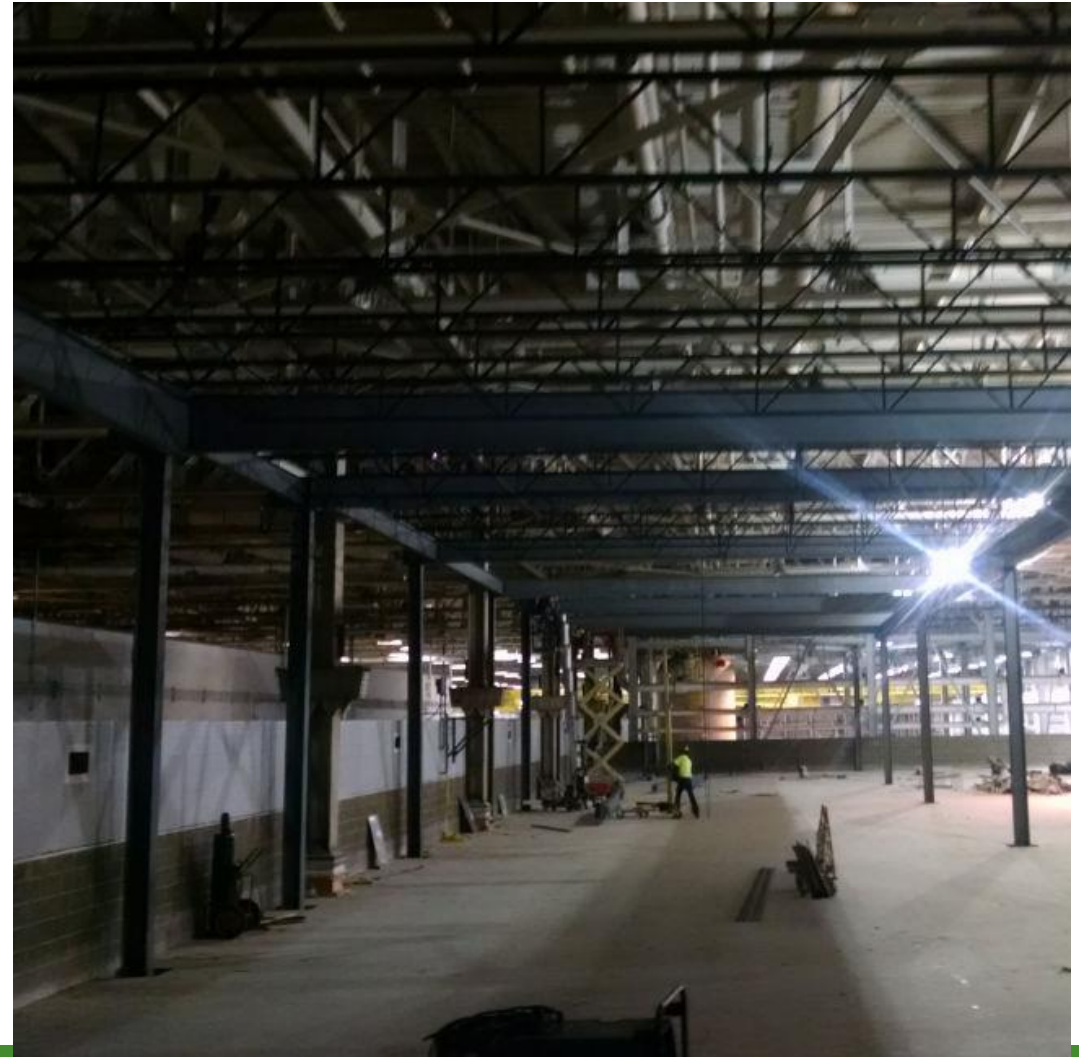
C406.2 Engineering Notes



Alterations C503

General principles:

- Existing (untouched) can remain as-is
- Service and repairs OK
- New equipment and new systems must meet code
- Seattle “Substantial Alterations”
Whole *building* meets code
 - With a small break for UA or BPF
- ... same with change of occupancy, change of space conditioning

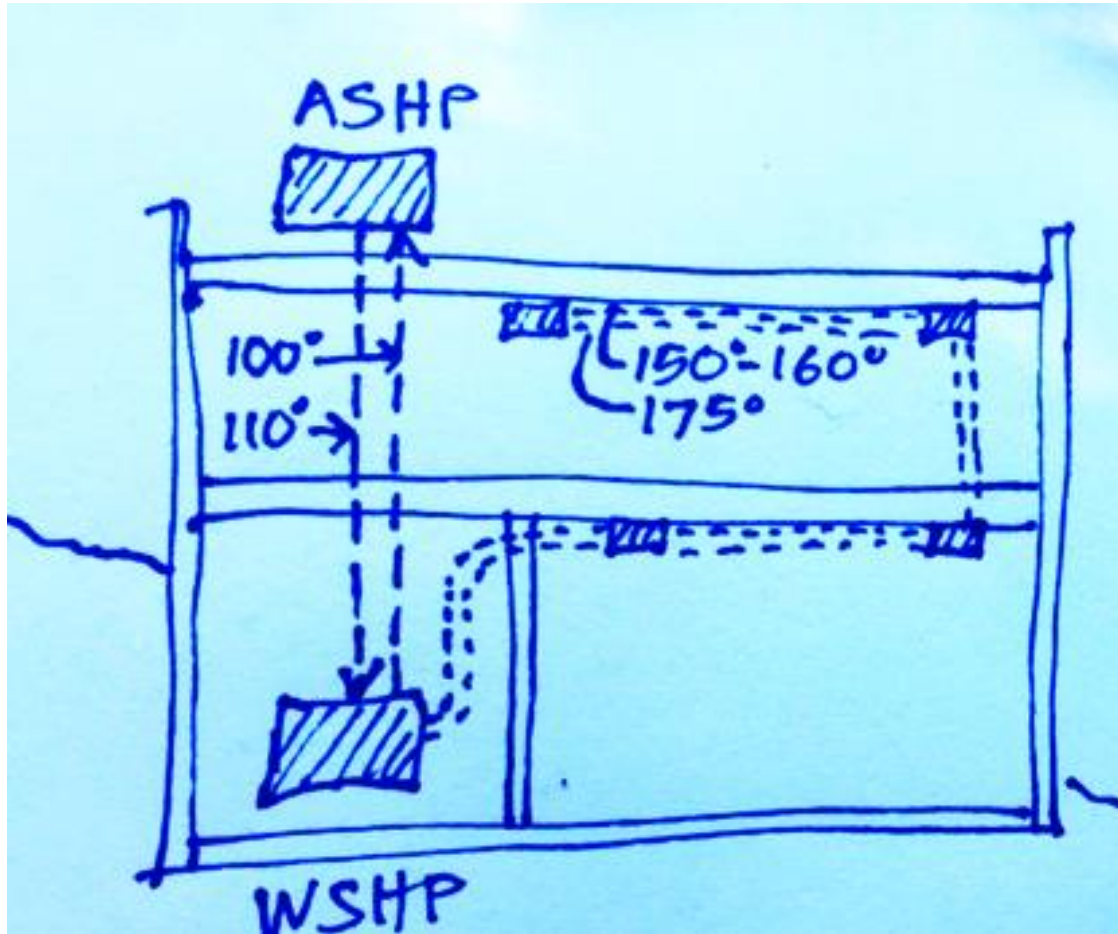


Replacement heating equipment

- New HVAC work must comply with all of C403
- New central heating must be heat pump
- Distributed fan coils not affected
- **Exception:** One (only) failing boiler or furnace can be replaced like for like. **Not** for planned replacements or part of a larger project



Alterations to Existing 180° Hydronic ASHP with WSHP booster



Potentially cheaper alternative?

Replace terminal units with larger coil units, run 120° water directly from ASHP

- Easy: existing condensing boiler
- Moderately difficult: existing conventional hot water boiler
- Impossible: existing steam system

Substantial Alterations: (Also) a sticky situation



HFC refrigerant phaseout – HB 1112 & HB 1050

- Cutoff dates for equipment using HFCs
 - Supermarket & warehouse refrigeration 2020
 - Chillers 2024, Heat pumps 2025, VRF 2026
 - Equipment manufacture date, not permit date
- R-410, R134...going, going, gone!
- R-32 approved, but no equipment yet
- CO2 systems already viable for HPWH



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Seattle City Light Midstream HVAC+ Program

Summer Heat Pump Series

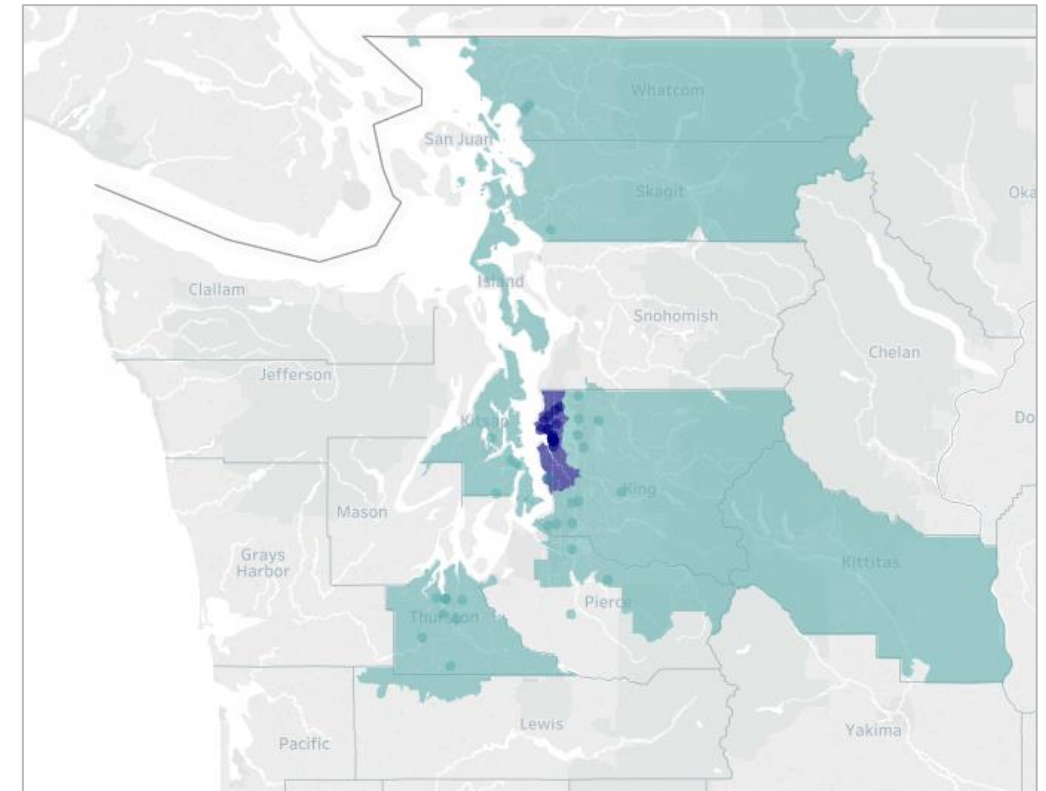
Program Overview

Midstream HVAC and HPWH Program Overview

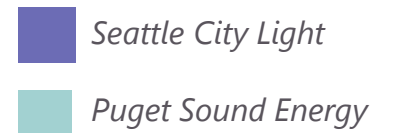
- Administered by City Light and Puget Sound Energy
 - Energy Solutions, the program implementer, provides support and guidance for program participants
- Contractor incentives available through enrolled distributors
 - Contractors are encouraged to pass incentives through to customers
- Includes heat pumps < 5.4 tons, hybrid heat pump water heaters, and ECM circulator pumps
- Includes residential and commercial installations

Program Goals

- Promote the stocking and upselling of high efficiency equipment
- Reduce energy use and carbon emissions through optimal HVAC design



Qualifying program territory (approx.)



Participating in the Program

Steps to Participate

1. Check if your distributor is enrolled, or identify an enrolled distributor
2. Purchase equipment for a qualifying installation through your distributor
3. Share requested customer information with your distributor*
4. Receive rebate

* You do not need to apply for rebates directly!
Distributors will complete application information.



Your Distributor Will Need:

- Installation address
 - Suite/unit number(s) if applicable
- Building type
 - Examples: single family, office, laboratory
- Project type
 - New construction or retrofit
- Estimated installation date



Participating Distributors

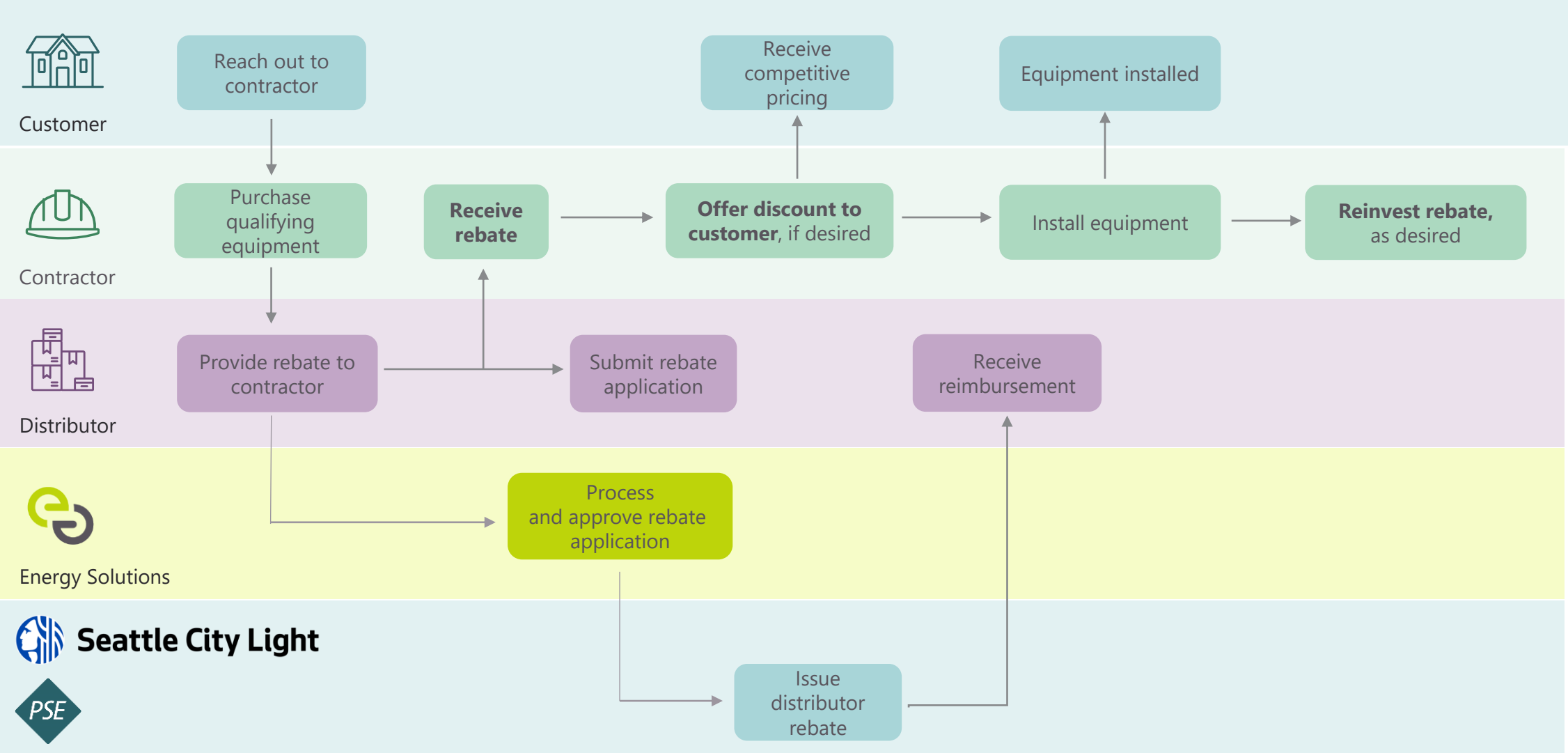
"These kinds of programs are great because they help us stock more efficient equipment and give us incentive to get the units into customers' hands."
-Ken Porter, AirReps



"This is one of the most successful rebate programs PSE or SCL has ever had."
- Mark Stearns, Gensco



Program Process



Eligible Installations

Heat Pumps

- Mini- or multi-split heat pumps < 5.4 tons
- Traditional heat pumps < 5.4 tons
- \$300-\$600 available for heat pumps
- Limit 1 heat pump per residence

Hybrid Heat Pump Water Heaters

- \$500 rebate per hybrid HPWH
- Limit 1 hybrid HPWH per residence

ECM Circulator Pumps

- \$100 - \$400 rebate per pump
- No installation limit



Incentives

Commercial and Residential Air-Cooled Heat Pumps (under 5.4 tons)

Unit Type	Size Category	Tier	SEER		HSPF	Contractor Rebate (\$/unit)
Mini- or multi- split heat pump	< 65 kBtuh (<5.4 tons)	1	16.0	and	9.5	\$400
		2	16.0	and	11.0	\$600
Traditional heat pump	< 65 kBtuh (<5.4 tons)	1	15.0	and	9.0	\$300
		2	15.0	and	10.0	\$500

Commercial and Residential Hybrid Heat Pump Water Heaters

Unit Type	Size Category	UEF/COP	Contractor Rebate (\$/unit)
Hybrid Heat Pump Water Heater	≤ 200 gallon storage	3.0	\$500

Commercial ECM Circulator Pumps

Unit Type	Subcategory	Size Category	Contractor Rebate (\$/unit)
ECM Circulator Pump	Hydronic Heating	≤ 1/6 hp	\$100
		> 1/6 and ≤ 3/4 hp	\$200
		> 3/4 and ≤ 3.5 hp	\$400
ECM Circulator Pump	Service Hot Water	≤ 1/6 hp	\$100
		> 1/6 and ≤ 3/4 hp	\$200
		> 3/4 and ≤ 3.5 hp	\$400

Residential ECM Circulator Pumps

Unit Type	Subcategory	Size Category	Contractor Rebate (\$/unit)
ECM Circulator Pump	Hydronic Heating	Any Pump Size	\$100
ECM Circulator Pump	Service Hot Water	Any Pump Size	\$100

Multifamily and Large Commercial Solutions

Access to High-Efficiency Solutions

- City Light and Puget Sound Energy are working with the supply chain to improve access to high-performance, high-efficiency equipment for commercial and industrial customers
- Contact your distributor to determine the availability of high-efficiency equipment and understand installation options



Multifamily, Commercial, and Industrial Options

- City Light encourages you to work with your distributor to identify high-efficiency options for large commercial and multifamily installations, including:
 - Variable refrigerant flow (VRF)
 - Water source heat pumps
 - Heat pumps (split and packaged)
 - Air conditioners (split and packaged)
- City Light is also supporting efforts to increase sales and stocking of efficient FEI-rated fans and PEI-rated pumps



Contact Us

- Email: pnw-rebates@energy-solution.com
- Hotline: (503) 914-0008

Energy Solutions is happy to assist you!

Resources

Additional resources are available through:

- Your participating distributor
- Energy Solutions
- Seattle City Light, at <http://www.seattle.gov/city-light/residential-services/home-energy-solutions>

Seattle City Light Midstream HVAC+ Program: Participating Distributor List

Residential and Commercial HVAC – Heat Pumps Under 5.4 Tons

Distributors must pass through incentive to contractors for all sales of heat pumps under 5.4 tons.

Distributor	City Light	Participating
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ACI Mechanical &
HVAC Sales

Airelec

Geary Pacific

Gensco

Johnson Barrow

Johnstone
(POPMA Group)

Johnstone
(Sadler Group)

Lennox

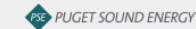
Refrigeration
Supplies Distributor

Thermal Supply

Thrifty Supply

Trane

York



Midstream HVAC+ Program

Rebates and Minimum Efficiencies

Small Heat Pumps

The table below outlines the minimum efficiency requirements for heat pumps under 5.4 tons in the Puget Sound Energy Midstream HVAC+ Program. All customers purchasing qualifying heat pumps or Seattle City Light. Heat pump sales requirements do not apply to sales made by contractors who purchase qualifying equipment from a participating distributor. The rebates are applied at the point of sale or as a credit to the contractor account, and must be shown on the invoice.

Commercial and Residential Air-Cool

Unit type	Size
Mini or multi split heat pump*	< 5 tons
Traditional heat pump	< 5 tons

*These products are listed in the AHRI Database as Variable Refrigerant Flow (VRF) systems.

Water Heaters

The table below outlines the minimum efficiency requirements for water heaters in the Puget Sound Energy Midstream HVAC+ Program. All customers purchasing qualifying heat pump water heaters or Seattle City Light. Heat pump water heater sales requirements do not apply to sales made by contractors who purchase qualifying equipment from a participating distributor. The rebates are applied at the point of sale or as a credit to the contractor account, and must be shown on the invoice.

Commercial and Residential Hybrid

Unit type
Hybrid heat pump water heater

Questions? Contact the Program Implementer, Energy Solutions, at 503-914-0008 or pnw-rebates@energy-solution.com.



Midstream HVAC+ Program

Rebates and Minimum Efficiencies

ECM Circulator Pumps

The tables below outline the minimum efficiency requirements for qualifying commercial and residential pumps in the Seattle City Light Midstream HVAC+ Program. Eligibility is listed by equipment type and size category. Incentives are listed as \$/unit. Qualifying ECM circulator pumps may be installed at sites with either a valid commercial electric service account or a valid residential electric service account with Seattle City Light. Sales made on or after October 7, 2020 are eligible for incentives. Please reach out to the Program Implementer with any questions about qualifying installations. To access these rebates, contractors must purchase qualifying equipment from a participating distributor. The rebates are applied at the point of sale or as a credit to the contractor account, and must be shown on the invoice.

Commercial ECM Circulator Pumps			
Unit type	Subcategory	Size category (rated)	Contractor rebate (\$/unit)
ECM circulator pump	Hydronic heating	≤ 1/6 hp	\$100
		>1/6 and ≤ 3/4 hp	\$200
		>3/4 and ≤ 3.5 hp	\$400
ECM circulator pump	Service hot water	≤ 1/6 hp	\$100
		>1/6 and ≤ 3/4 hp	\$200
		>3/4 and ≤ 3.5 hp	\$400

Residential ECM Circulator Pumps			
Unit type	Subcategory	Size category	Contractor rebate (\$/unit)
ECM circulator pump	Hydronic heating	Any pump size	\$100
ECM circulator pump	Service hot water	Any pump size	\$100

Questions? Contact the Program Implementer, Energy Solutions, at 503-914-0008 or pnw-rebates@energy-solution.com.

v2021-0108

Multifamily New Construction

Measure, Technology	Incentive
Clothes Dryers	\$ 75 – 175 (per dryer)
Clothes Washers	\$ 50 (per washer)
CO2 Central Heat Pump Water Heating	\$ 500 / unit
Centralized Heat Pump Water Heating, High COP	\$ 250 / unit
Envelope	\$ 0.58

Whole Building, System	Incentive
BPA Energy Efficient, third party certificate based	\$ 350 / living unit
BPA Zero Energy Ready, third party certificate based	\$ 900 / living unit
Whole building SEC-407 based	\$ 0.23 / kWh

Commercial and Industrial New Construction

Measure, Technology	Incentive (\$/kWh)		Whole Building, System	Incentive (\$/kWh)
Central heat pump water heaters	\$ 0.24		Multi-measure HVAC equipment	\$ 0.27
Chillers (industrial only)	\$ 0.27 - 0.34		Interactive building systems	\$ 0.27
Envelope	\$ 0.12 - 0.58		Whole building SEC-407 based	\$ 0.23
Process Loads	\$ 0.23 - 0.27			
Refrigeration				

Upcoming LDL Online Events

LDL Course	Delivery Date	Time
Code Compliance: Heating Multifamily Units in Seattle	June 10 th	10am – Noon
Code Compliance: Heat Pump Space Heating For Commercial and Institutional Buildings	June 15 th	10am – Noon
Code Compliance: Heat Pump Water Heating in Seattle	June 22 nd	10am - Noon

Today's slide deck and previous online courses
can be found on our [website](#)

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