

Welcome to the 2021 Codes HVAC

Seattle City Light
Lighting Design Lab
May 2023

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
Construction & Inspections

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Seattle City Light



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ASHRAE BEMP & BEAP, Certified Commissioning Professional,
Certified Energy Plans Examiner

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



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?

Seattle amendments: 4 Guiding Principles

1. Envelopes meet our “2050” standard

- We have to decide what that 2050 standard is

2. No “internal combustion buildings”

- Electrical infrastructure for exceptions

3. Efficient use of electricity

- Typically heat pumps for space heating & water heating

4. Increased on-site renewables

- Options for off-site purchase
- Plus “solar readiness” for bigger future system

Today:
HVAC

Seattle: “Intent” section includes “reduction of carbon emissions”

New buildings must be *capable of* meeting Seattle’s 2050 targets.

What belongs on our HVAC Top 10 list?

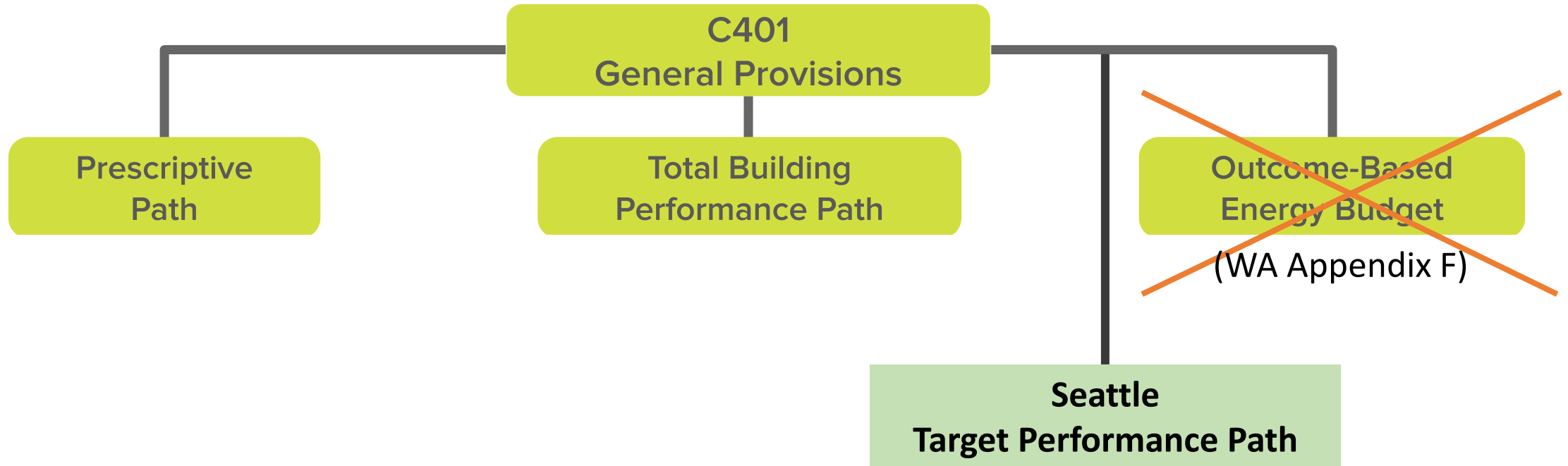
1. Commissioning
2. Metering
3. Heating type
4. TSPR
5. DOAS
6. Economizers
7. Energy Recovery
8. Controls
9. DDC
10. C406 options



+ Special Occupancies

- Commercial kitchen
- Data center cooling
- Refrigerated spaces
- Multifamily
- Garage/loading dock
- Outdoor café
- Lab exhaust
- Hotel guest room
- Grocery

Code Paths



Engineering Terms - Examples



Electric Resistance Heaters



Electric Resistance Heat

1kW Work In = 1kW Heat Out

Gas and Fuel Fired Heating Appliances



Burning Things for Heat (gas, wood, coal, oil, etc.)

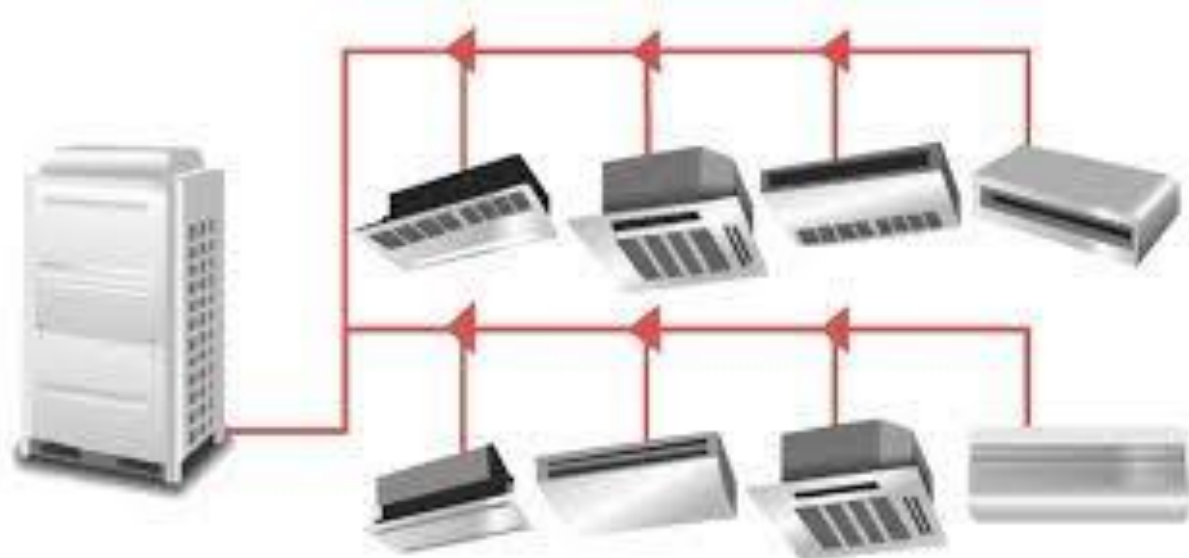
1kW "Work" In = less than 1 kW Heat Out



Heat Pump Layout



Heat Pump Layout, variable speed

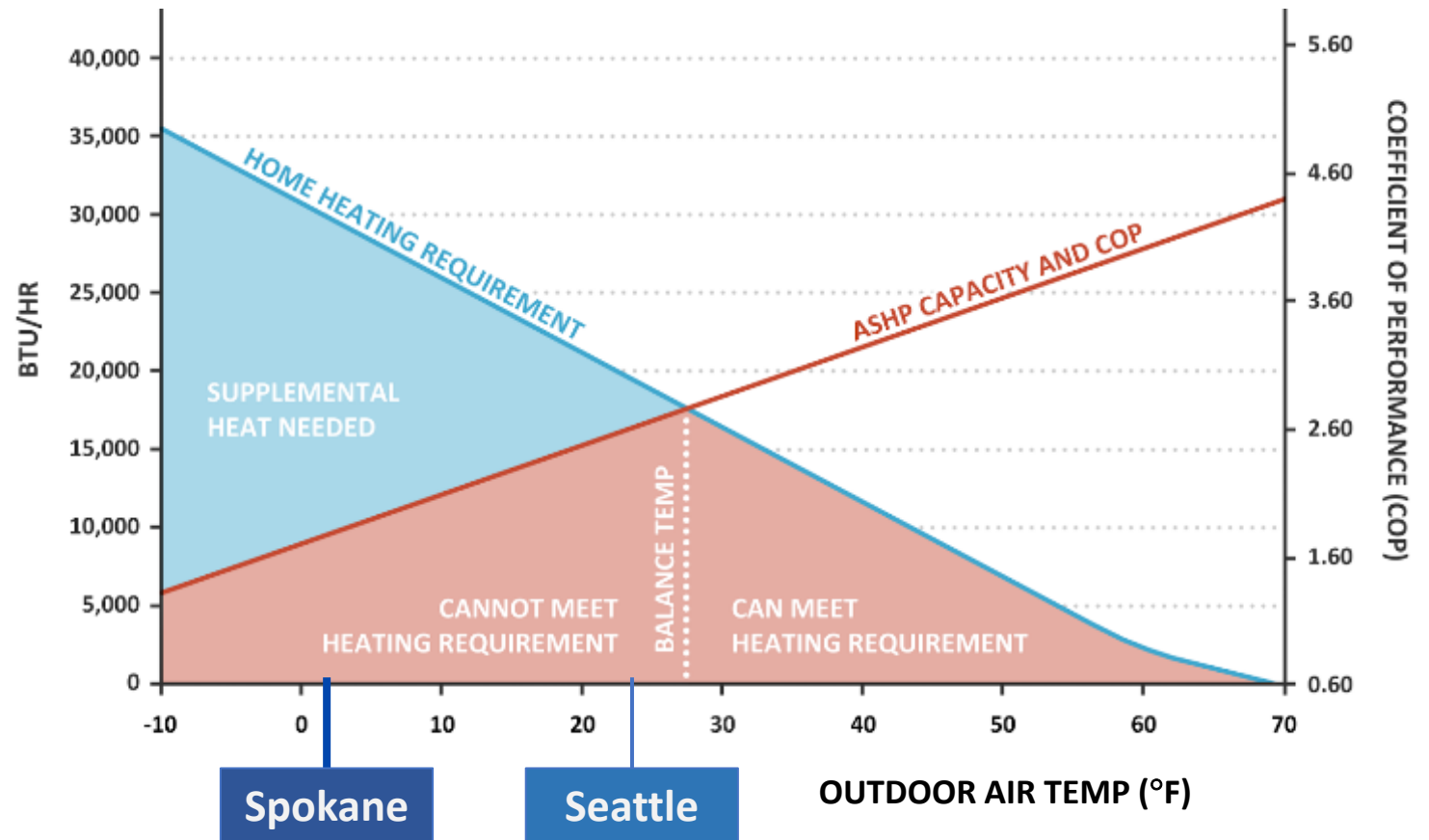


Engineering View, Limitations



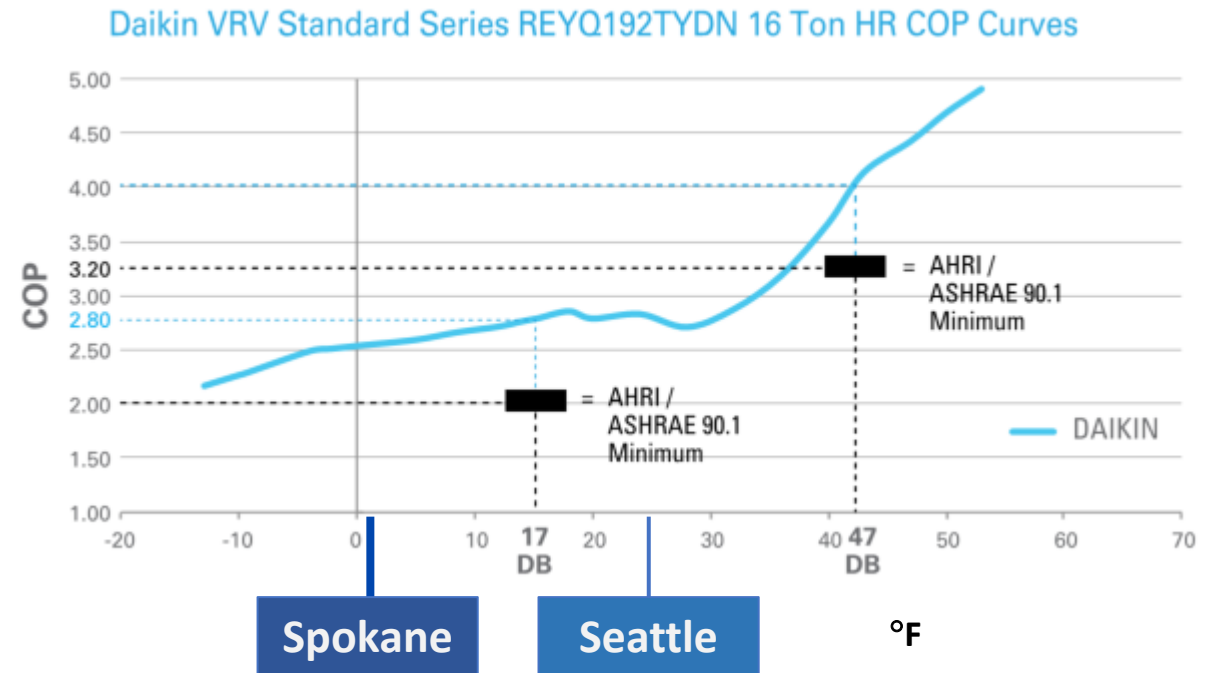
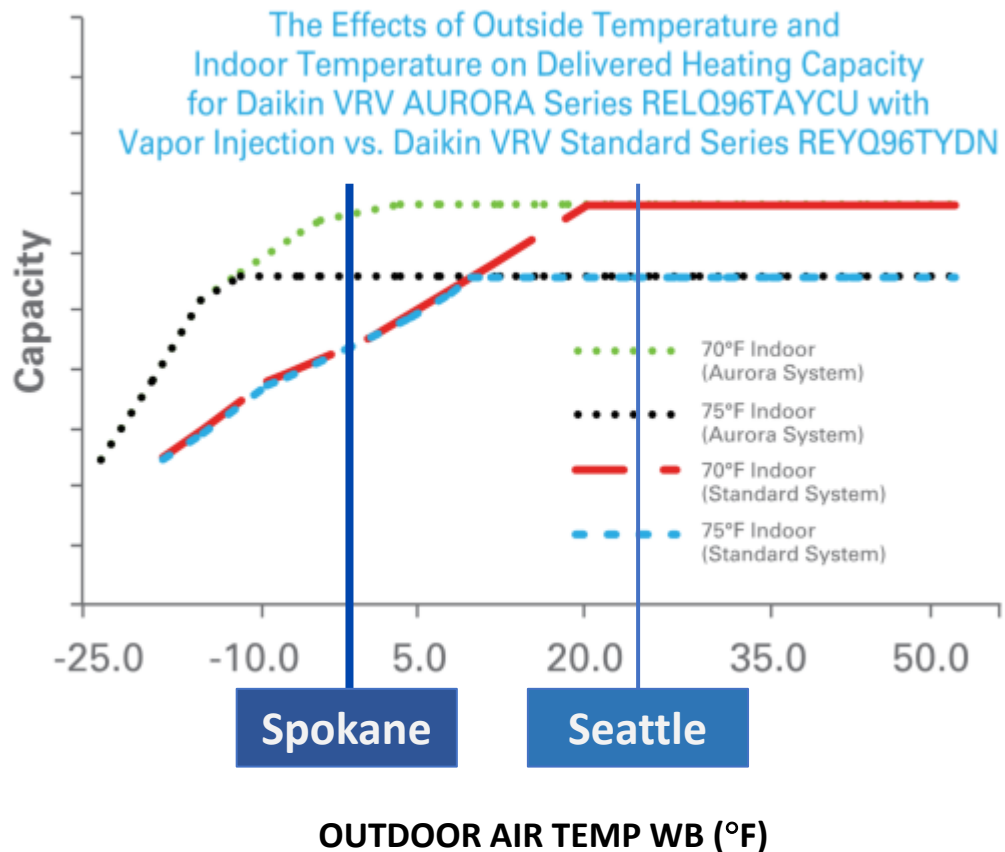
Heat Pump
Performance,
Cold Temp Impacts
(cheap version)

Performance of typical 2-ton air-source heat pump

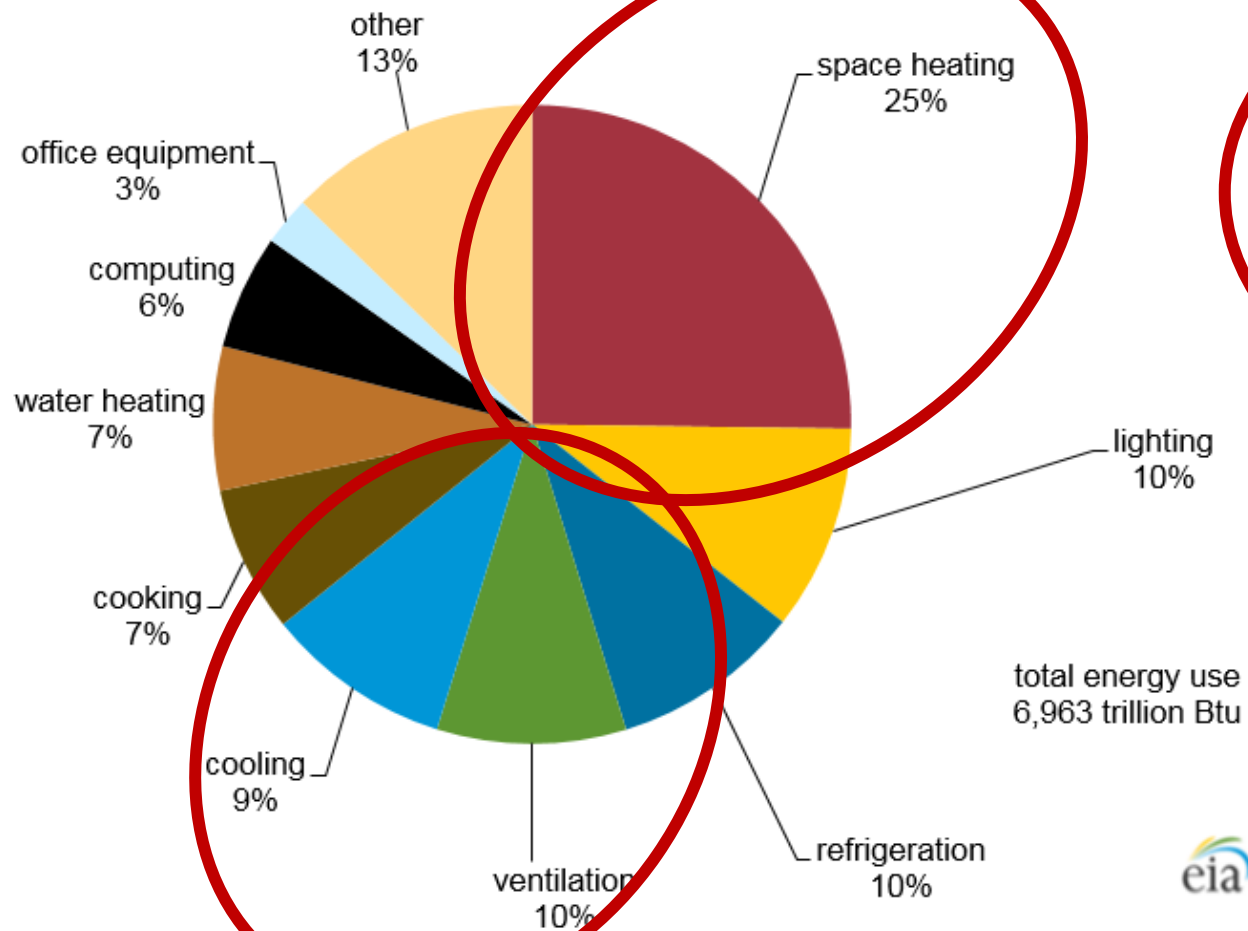


Engineering View, Less Limitations

Variable Speed Version



Start with the big slices



- **Space heating**
 - System efficiency
 - Heat recovery
 - Envelope UA & air tightness
- **Cooling**
 - System efficiency
 - Ventilation
 - Fenestration size & shading
- Lighting
 - Efficiency
 - Controls
- Water heating
 - System efficiency
- Plug loads

COST-EFFECTIVENESS

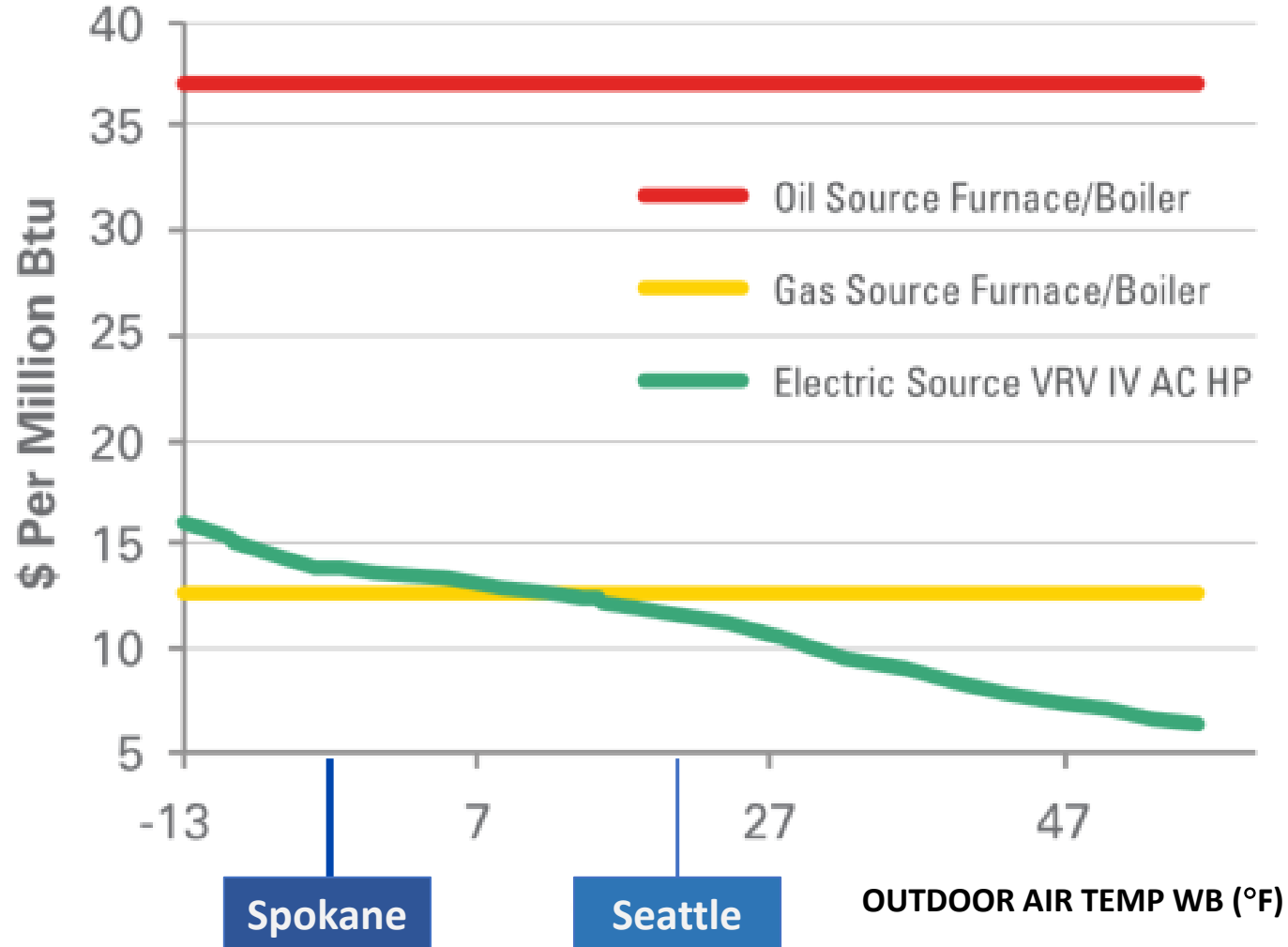
New energy code provisions should be:

- ...**necessary** for meeting the City's goals...
- ...and **as cost-effective as possible** for owners and tenants
 - Costs typically moderate after new code becomes "business as usual."

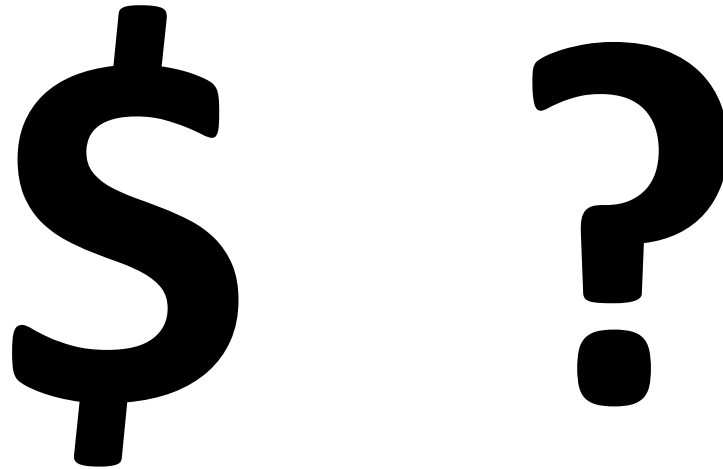


Engineering View, Cost

\$ Per Million Btu Comparison by Fuel Type and Equipment Type



Engineering View, Cost



Sea & WA: Envelope U-value of PTAC/PTHP units

- Conventional PTAC & PTHP units leak heat & leak air badly
- Through-wall mech units assigned default U-value of 0.50
 - Unless mfr has tested U-value
 - 10x typical wall heat loss

C402.1.3

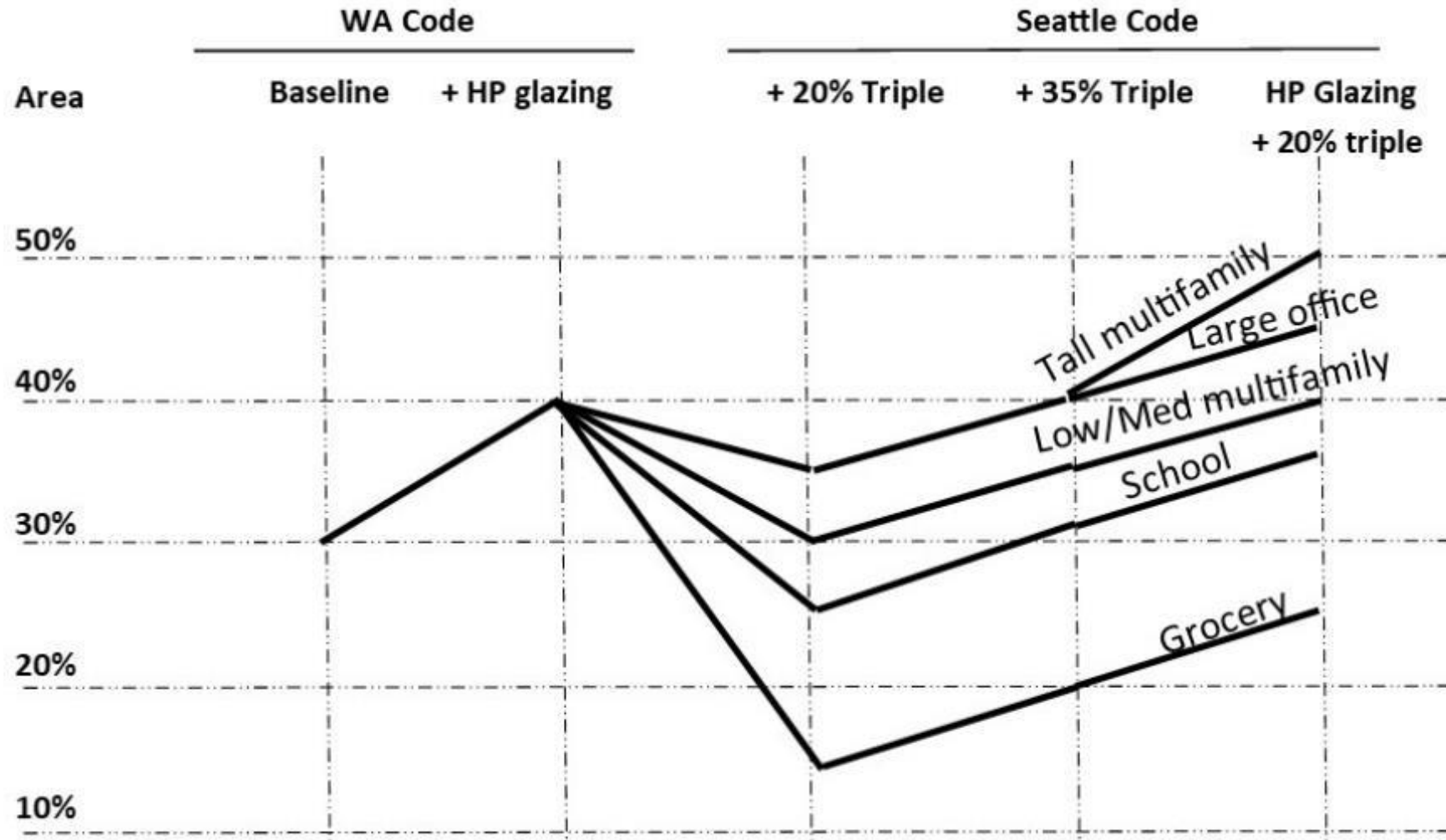


Your HVAC loads are shrinking

But will you believe your own engineering?

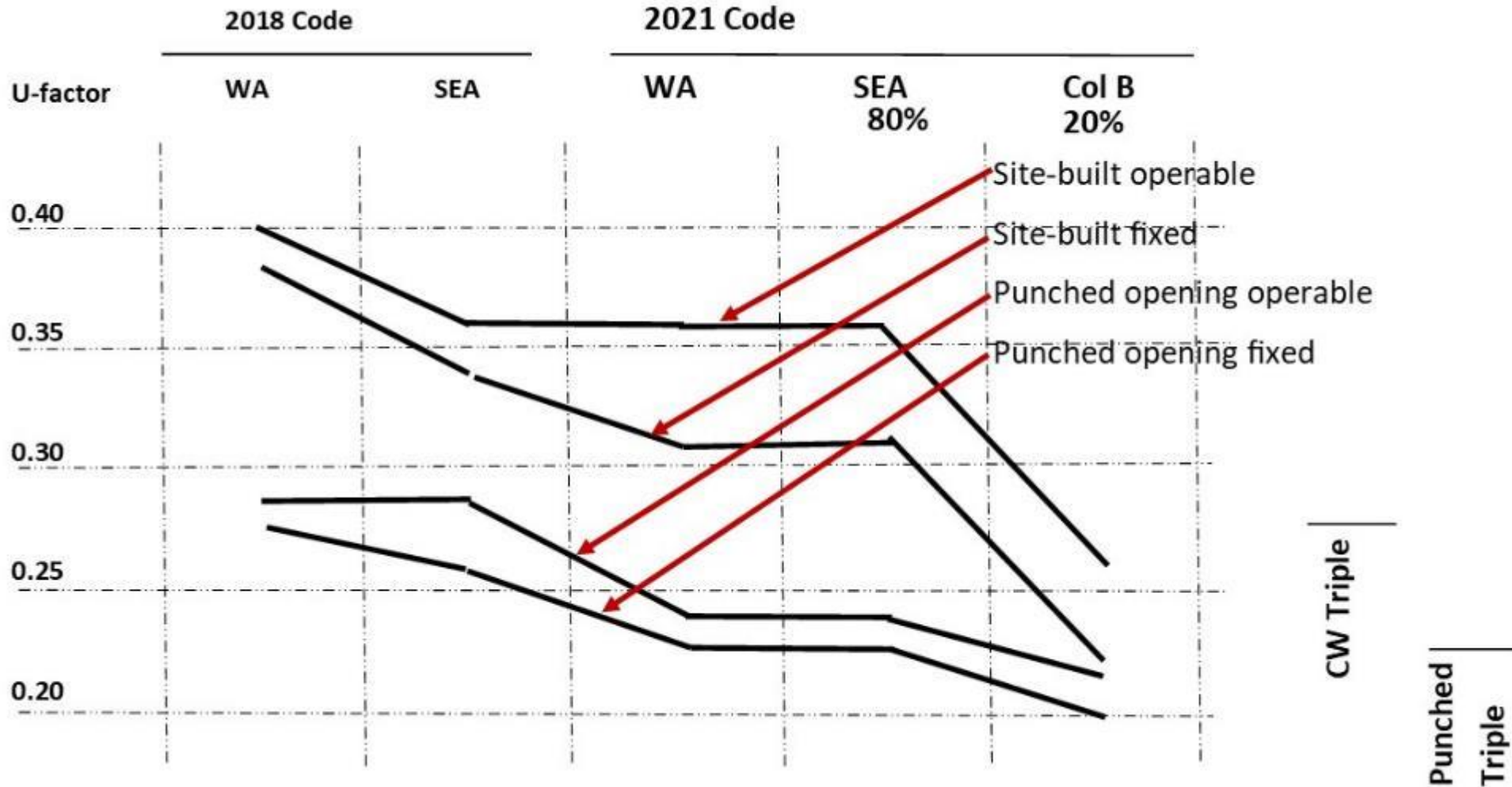
- Seattle: 20% (or 35%) of glazing is triple
 - And fenestration U-factors are lower, for the other 80%
- Seattle & WA: Max air leakage rate is 0.25 cfm/sf
 - And you have to pass

Allowable fenestration area

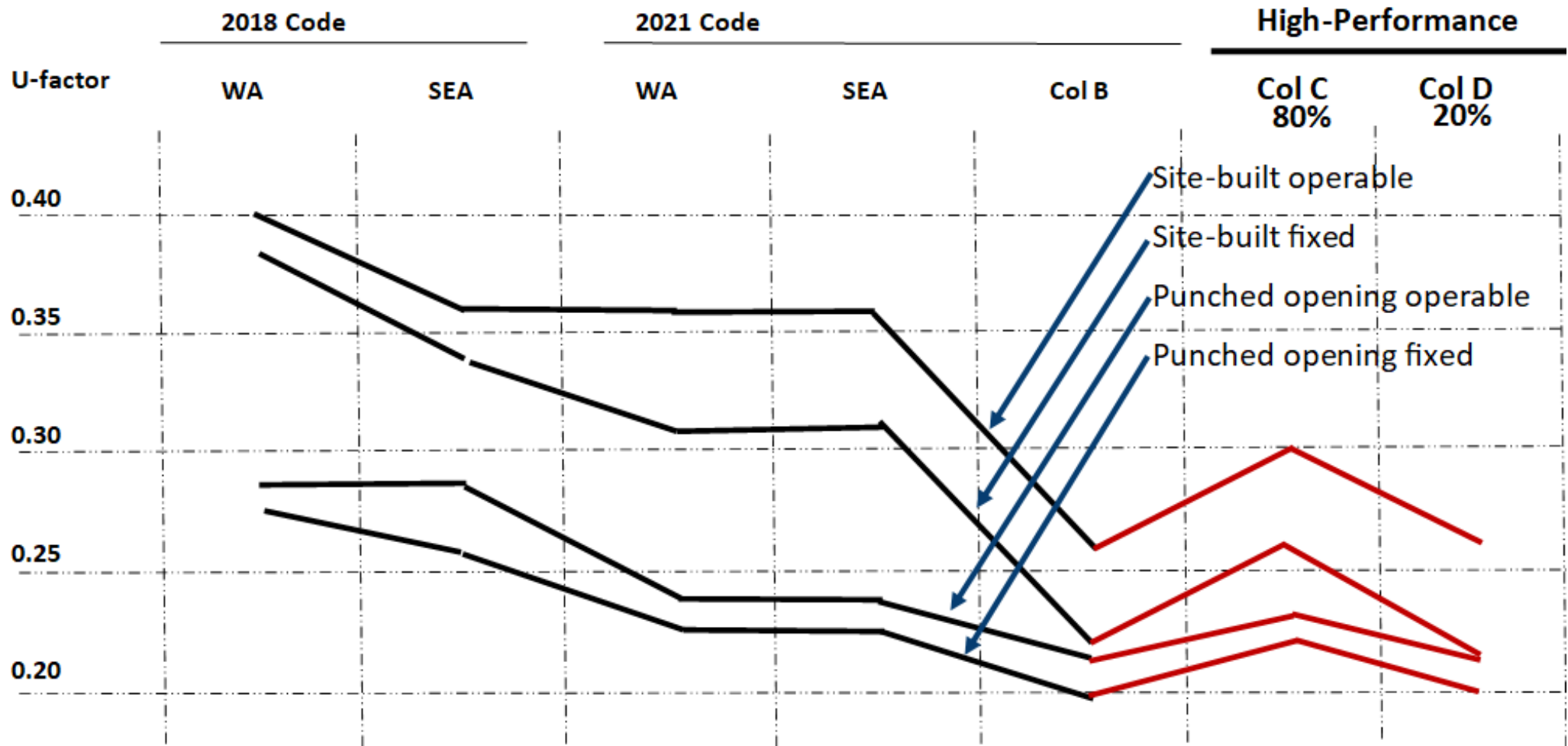


For UxA calculations, these are the baseline allowable areas

Fenestration U-factors



High-Performance U-Factors



WA & Seattle Air Barrier Testing

- Test standard 0.25 cfm/sf of envelope
 - Passing test now mandatory
 - ...at 0.25 cfm/sf
- Q: Do your HVAC design calcs account for reduced leakage?**



How is HVAC section organized? (It's not)

C403.1.1 TSPR

C403.1.2 Load calculations

C403.1.3 Data centers

C403.1.4 Fossil fuel and electric resistance

C403.2 System design. (zone isolation, ventilation & exhaust, variable speed drives)

C403.3 Equipment selection & Tables

(sizing, performance, chillers, humidification)

C403.3.5 DOAS (occupancy table, energy recovery, decoupled supply air)

C403.3.7 Hydronic flow rate

C403.4 HVAC system controls

(thermostats, heat pump supplementary heat, deadband, vestibules, door switch)

C403.4.3 Hydronic system controls

(hydronic heat pump controls, dead band, heat rejection, isolation valves, part load controls, pump isolation, variable flow controls)

C403.4.9 Multifamily units

C403.4.11 DDC

C403.5 Economizers

C403.6 Multi-zone systems

C403.6.10 High-efficiency VAV

systems (alternative to DOAS)

C403.7 Ventilation and exhaust (DCV, occ sensor, loading dock, garage)

C403.7.6 Energy recovery ventilation

C403.7.6.1 Balanced ventilation for R-2

C403.7.7 Exhaust systems (kitchen, laboratory)

C403.7.8 Shutoff dampers

C403.8 Fans and fan controls

C403.9 Heat rejection & heat recovery

C403.10 HVAC system construction

(ducts, pipes, insulation, sealing)

C403.11 Systems outside thermal envelope

(radiant heaters, snow melt, freeze protection)

C403.12 High-efficiency single-zone VAV

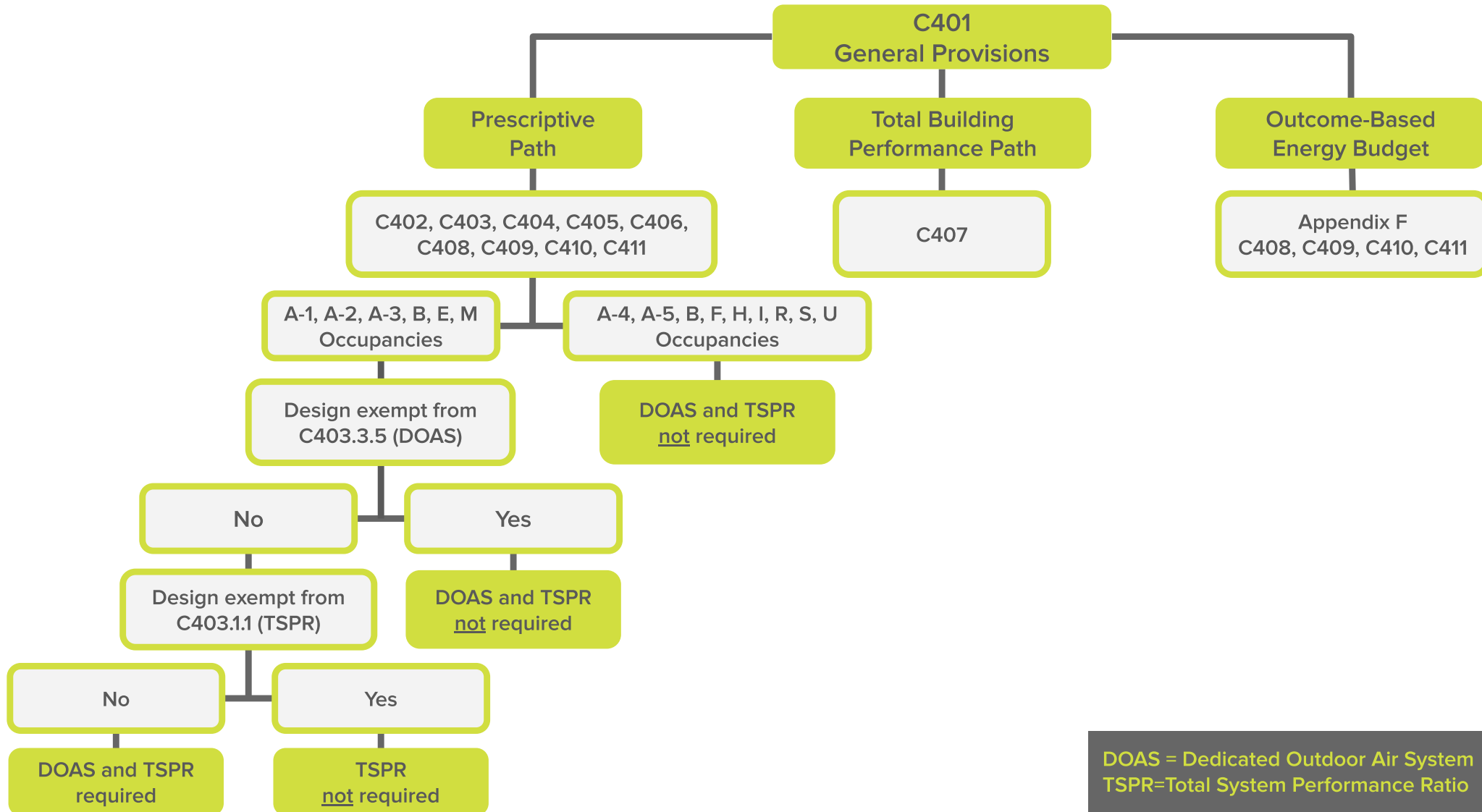
(alternative to DOAS)

C403.13 Dehumidification in grow op

C403.14 Commissioning

C403.15 Clean water pumps

Flow Chart Moment!



DOAS = Dedicated Outdoor Air System
TSPR=Total System Performance Ratio

C403 other notes



- FINALLY added a table for heat recovery chillers
- DOAS, effectiveness, limits on cooling
- VFD now 5 HP instead of 7.5
- Adopted SEER2 rating instead of SEER
- Really Big boilers require better combustion air controls
- coils selected for future changeover to heat pumps, sized @ 120 deg
- hydronic piping flow rate maximum
- coil design temp difference for 15 deg cooling, 20 degrees heating to limit pump power
- required demand response signals to slightly setback heating and cooling temps on large systems
- Seattle language on pressure independent control valves now in WSEC
- DCV mods for more spaces
- Change in fan power allowance
- Refrigerant piping insulation
- Dehumidification for plant growth efficiency

Data Center Cooling Efficiency C403.1.3

- WA & Seattle: ASHRAE 90.4
– **2022**, no modifications
- 90.4, Section 6 & 8



90.4 Basics



- Sections 6 and 8

DATA CENTER. A room or series of rooms that share *Data Center Systems* whose primary function is to house equipment for the processing and storage of electronic data, which has a design total *information technology equipment (ITE)* equipment power density **exceeding 20 watts** per square foot of conditioned area and a total design ITE equipment load greater than 10 kW.

COMPUTER ROOM. A room whose primary function is to house equipment for the processing and storage of electronic data and that has a design total *information technology equipment (ITE)* equipment **less than or equal to 20 watts** per square foot of conditioned area or a design *ITE* equipment load less than or equal to 10 kW.



$$\text{TSPR} = \frac{\text{Heating + Cooling Loads}}{\text{Carbon Emissions}}$$

(annual)

TSPR: Total System Performance Ratio
Office, Medical office, Retail,
Library, Education, Multifamily



TSPR evaluates HVAC efficiency by comparing:

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

Free online calculation tool from PNNL

TSPR clarifying table: What's in, what's out

Table C403.1.1
Occupancy Classifications Requiring TSPR

Occupancy Classification	Inclusions	Excluded
A	Library	All other Group A uses
B	Office, medical office	All other Group B uses
E	All occupancies included	
M	All occupancies included	
R	Dwelling units and common areas within Group R-2 areas of buildings	Groups R-1 and R-3 occupancies. Sleeping units and associated residential common areas in Group R-2
F, H, I, S, U		All occupancies

TSPR, ~~guesses on~~ outcomes



BUILDING ENERGY
Asset Score

Release 2020.2.2.1390 U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

BUILDINGS MANAGE HELP Help Desk

Test Building 1

Warnings Score Building

HVAC SYSTEMS

Disabled by the user selected option for Verified TSPR

VRF systems and Plant Loops that serve HVAC systems should be added before Air Handlers or Zone Equipment.

VRF CONDENSER UNITS

No VRF systems have been added.

PLANT LOOPS

Plant Loop 1

Heating Loop
Plant Loop 1 Plant - Boiler, Natural Gas 89.3% Et

AIR HANDLERS

Air Handler 1

No Cooling
NA COP
Heating Loop: Plant Loop 1
89.3% Et
3 blocks, 10,000 ft²

Navigation: N S E W Top Bottom

Mechanical: TSPR

$$\text{Annual TSPR} = \frac{\text{Heating} + \text{Cooling Loads}}{\text{Carbon Emissions from Building HVAC}}$$

**Table C407.1 (Reprinted from Chapter 4)
Carbon Emissions Factors**

<u>Type</u>	<u>CO2e (lb/unit)</u>	<u>Unit</u>
<u>Electricity</u>	<u>0.70</u>	<u>kWh</u>
<u>Natural gas</u>	<u>11.70</u>	<u>Therm</u>
<u>Oil</u>	<u>19.2</u>	<u>Gallon</u>
<u>Propane</u>	<u>10.5</u>	<u>Gallon</u>
<u>Other^a</u>	<u>195.00</u>	<u>mmBtu</u>
<u>On-site renewable energy</u>	<u>0.00</u>	

^a District energy systems may use alternative emissions factors supported by calculations approved by the code official.

TSPR

Carbon-based calculation

Prevents “buying out” of more sustainable solutions

Energy Modeling Professional

Equivalent Electric to Gas:

- Electric in Therms is 20.5 lb/Therm
- Gas in kWh is 0.40 lb/kWh
- Heat Pumps Win!

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:

Go

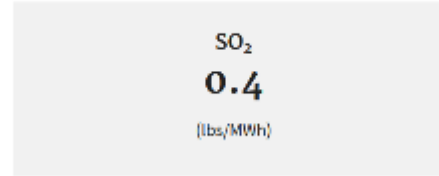
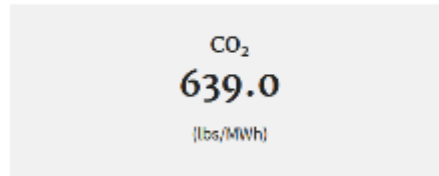


eGRID Subregions [More Info](#)

NWPP (WECC Northwest) ▾

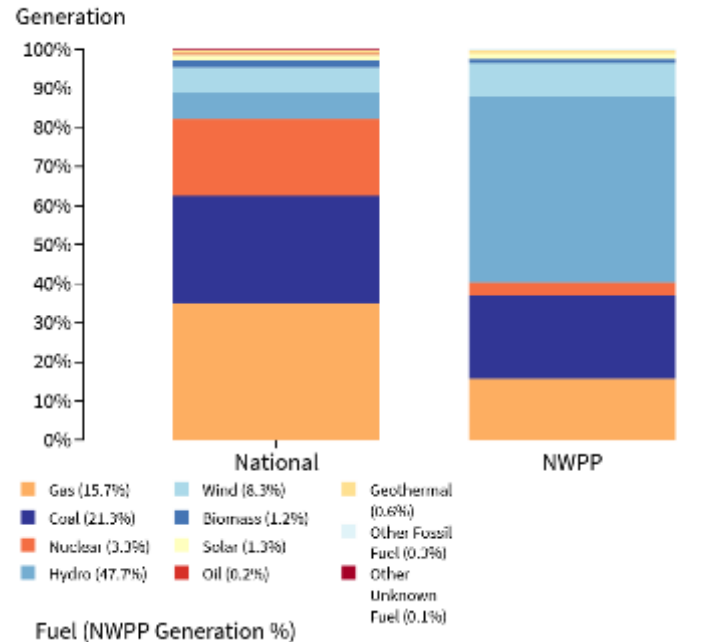


NWPP Emission Rates



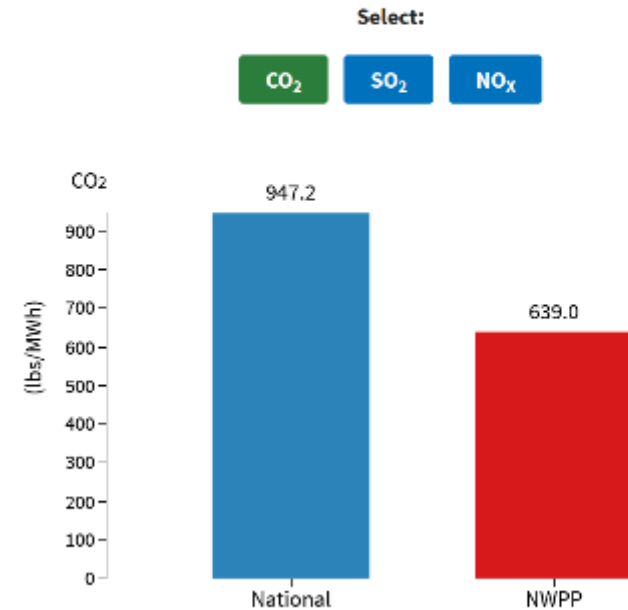
Fuel Mix

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

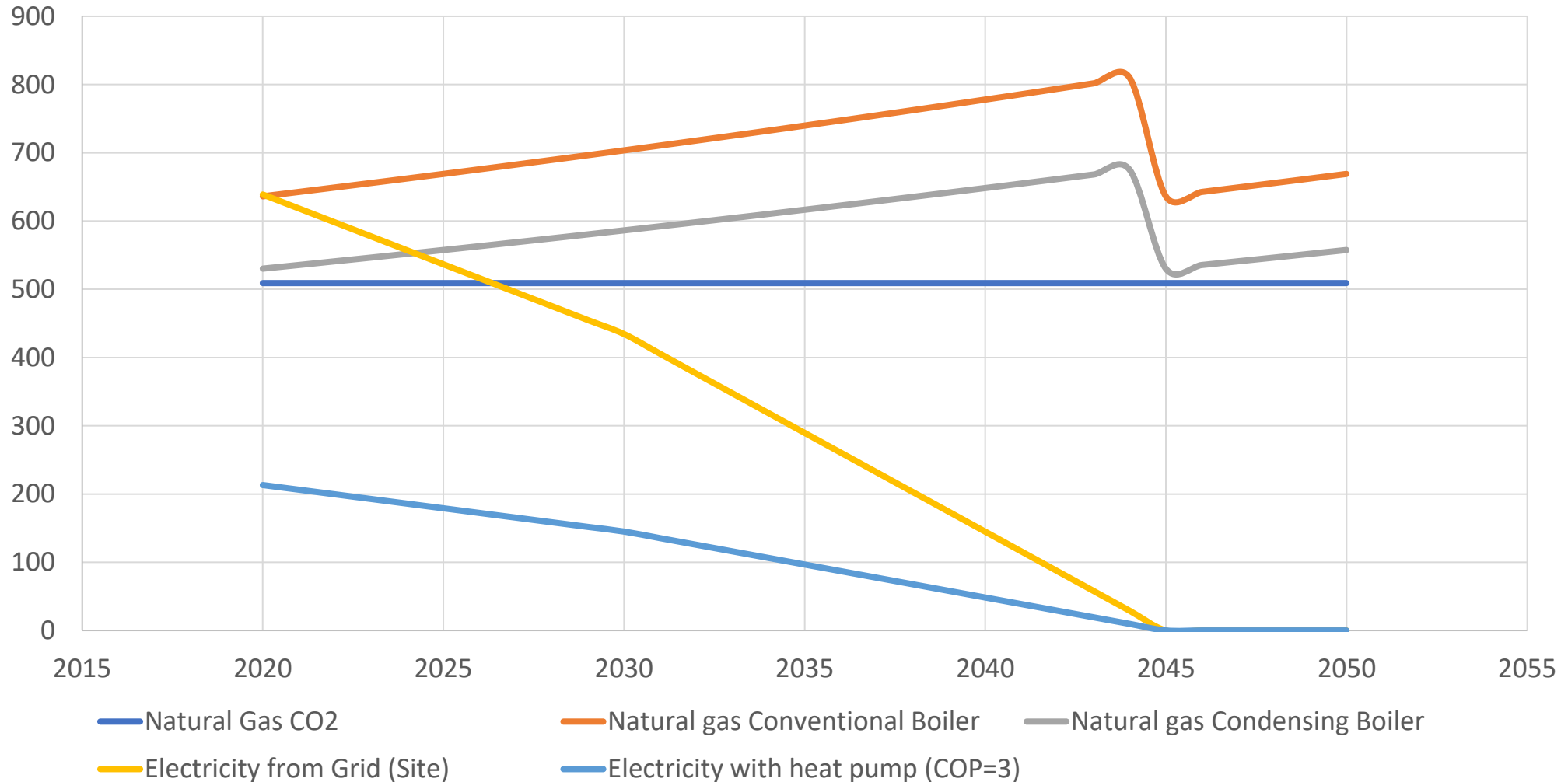


Washington Senate
Bill 5116 (2019-2020)
established goals of

Engineering View, Future CO2

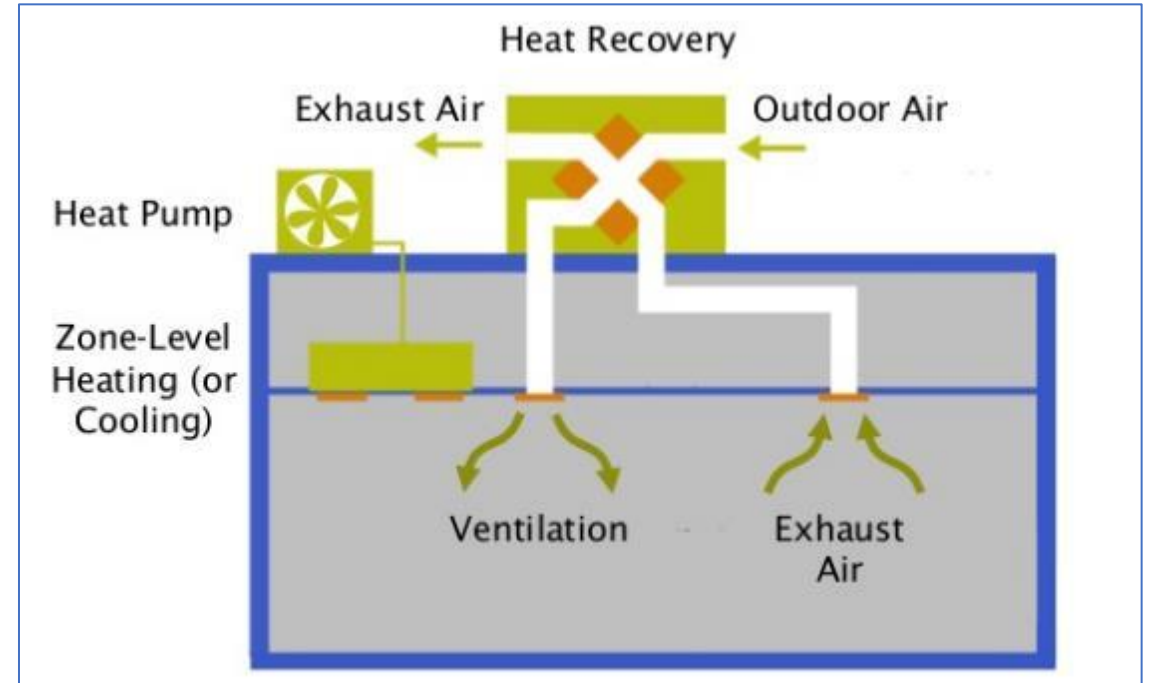


CO2 OVER TIME



DOAS scope

- Office, education, retail, library, assembly
- Seattle: add “Dwelling & Sleeping Units,” served by central system
- Seattle: add Group R corridors and other common areas
- “Accessory Occupancies” exempt
- Seattle: DOAS fan power 0.8 W/cfm
- Seattle: DOAS can “temper” air up to 55, or cool for dehumidification



Dedicated Outdoor Air System:
Ventilation is “decoupled” from heating & cooling, has energy recovery

Clarification:

Table C403.3.5

Occupancy Classification ^a	Inclusions	Exempted
A-1	All occupancies not specifically exempted	Television and radio studios
A-2	Casinos (gaming area)	All other A-2 occupancies
A-3	Lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, places of religious worship	All other A-3 occupancies
A-4, A-5		All occupancies excluded
B	All occupancies not specifically exempted	Food processing establishments including commercial kitchens, restaurants, cafeterias; laboratories for testing and research; data processing facilities and telephone exchanges; air traffic control towers; animal hospitals, kennels, pounds; ambulatory care facilities
F, H, I, R, S, U		All occupancies excluded
R	<p>Group R dwelling and sleeping units served by energy recovery ventilation systems that each serve two or more dwelling or sleeping units for which energy recovery ventilation is required in accordance with Section C403.7.6.</p> <p>Group R spaces other than dwelling and sleeping units, including corridors and other common use areas.</p>	<p>Groups R-1 and R-3 dwelling or sleeping units for which energy recovery ventilation is not required in accordance with Section C403.7.6.</p> <p>Group R dwelling and sleeping units served by energy recovery ventilation systems that each serves only one dwelling or sleeping unit.</p>
E, M	All occupancies included	

Special Assembly Occupancies



Large Concert Halls

Small Lecture Rooms

Gymnasiums

Places of Religious Worship



DCV Required c403.7.1.1

- Single-zone systems with economizer
- Spaces over 500 sf with 15 occ's per 1000 sf need DCV
 - Includes retail
 - Exempts several small occupancy types
- Exception for “total system design outdoor airflow” less than 750 cfm (or 1500 cfm with 60% effective ERV)
- Exception for multi-zone system with “design occupant component outdoor airflow” less than 100 cfm (or 200 cfm with 60% effective ERV)



DOAS & Economizers

- Economizer *required* for DOAS if cooling equipment is outdoors or in a space with an exterior wall or roof.
 - Exception only applies if chiller is buried in some interior room

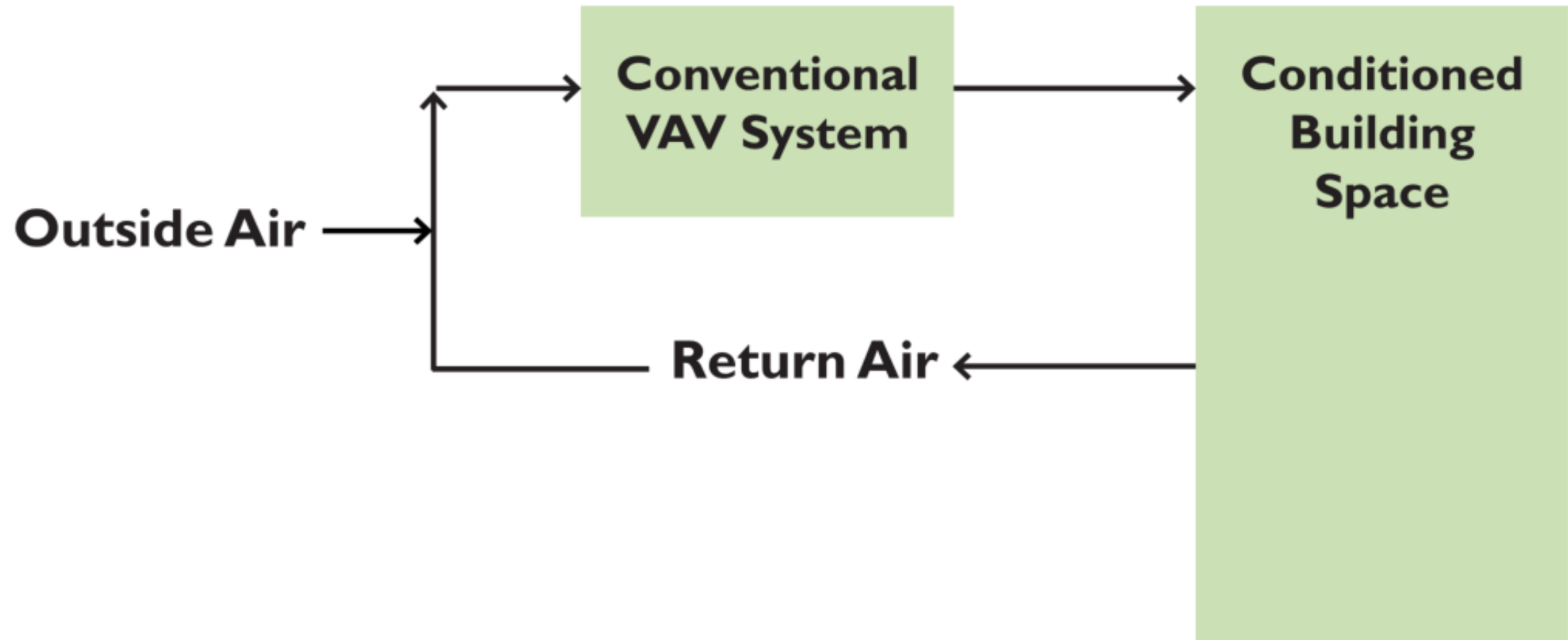
C403.5 Economizers. *Air economizers* shall be provided on all new cooling systems including those serving computer server rooms, electronic equipment, radio equipment, and telephone switchgear. Economizers shall comply with Sections C403.5.1 through C403.5.5.

Exceptions...

DOAS, demystified



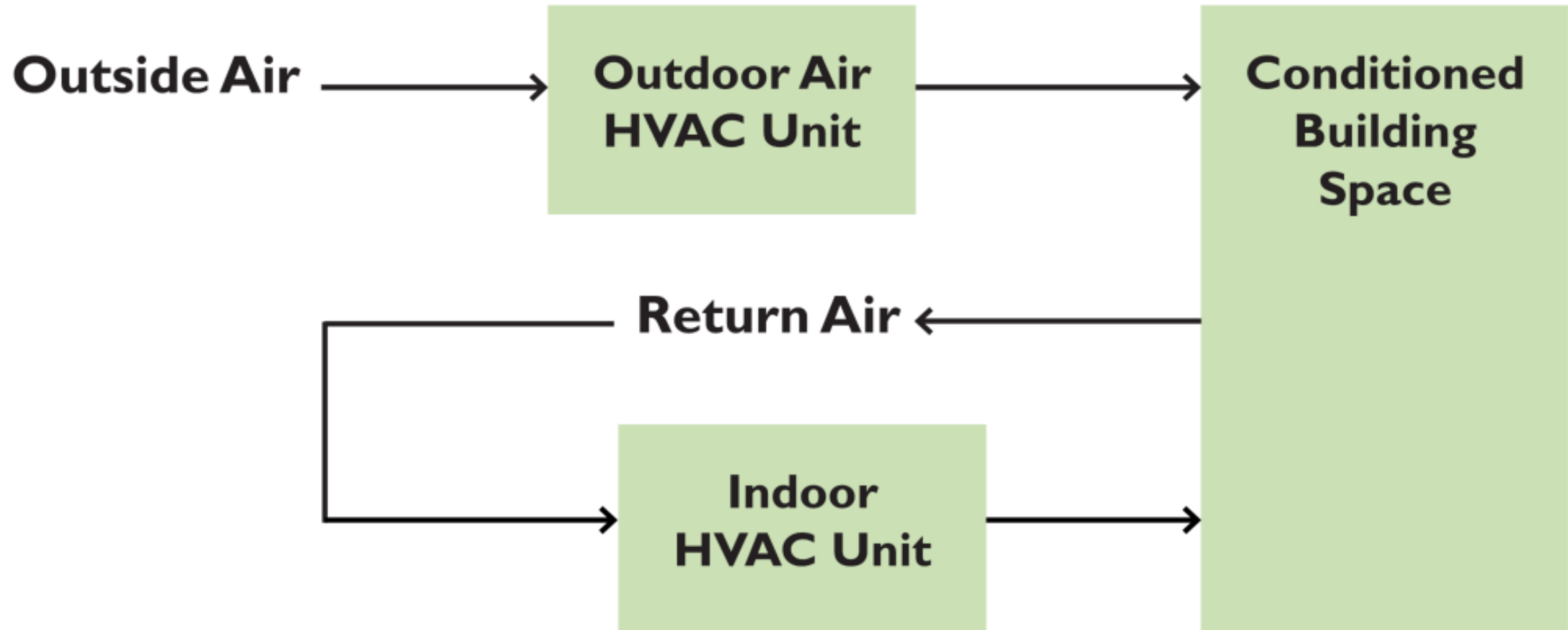
A. Basic arrangement of a conventional all-air VAV system



DOAS, demystified



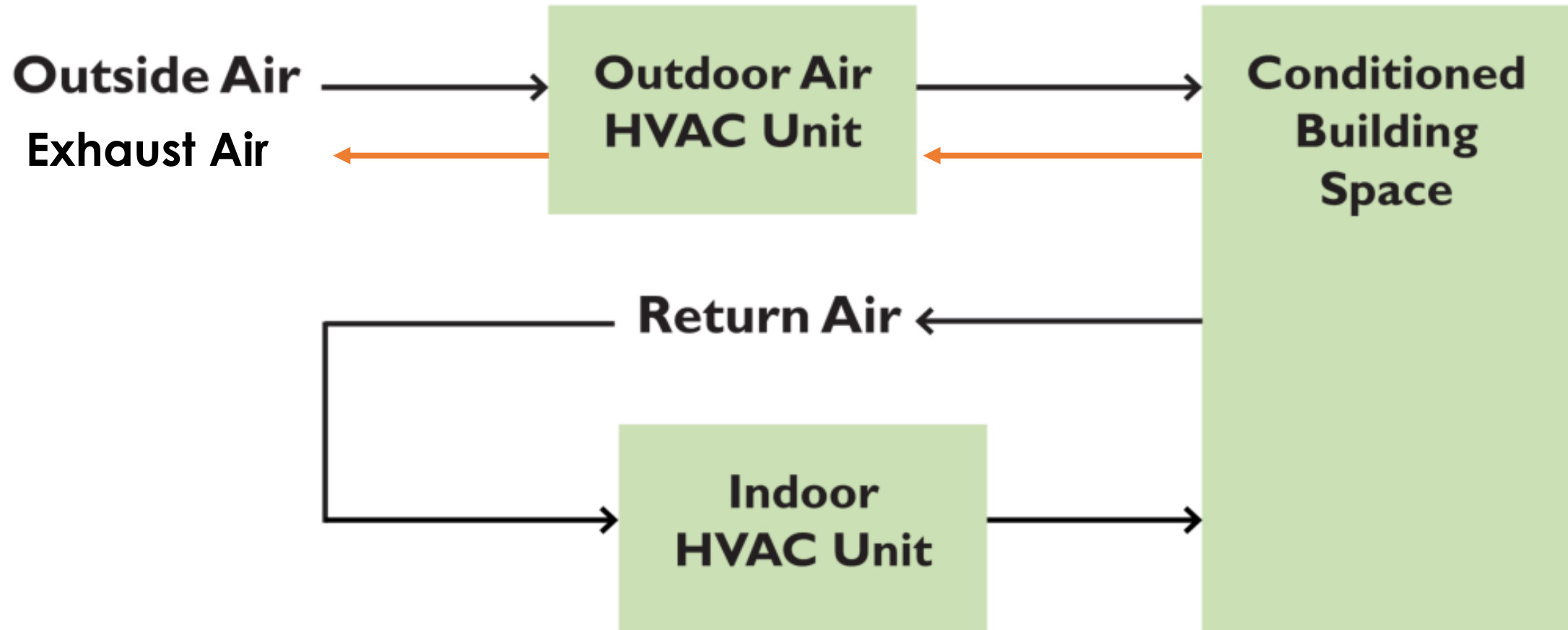
B. DOAS with separate conditioning of outdoor and return air



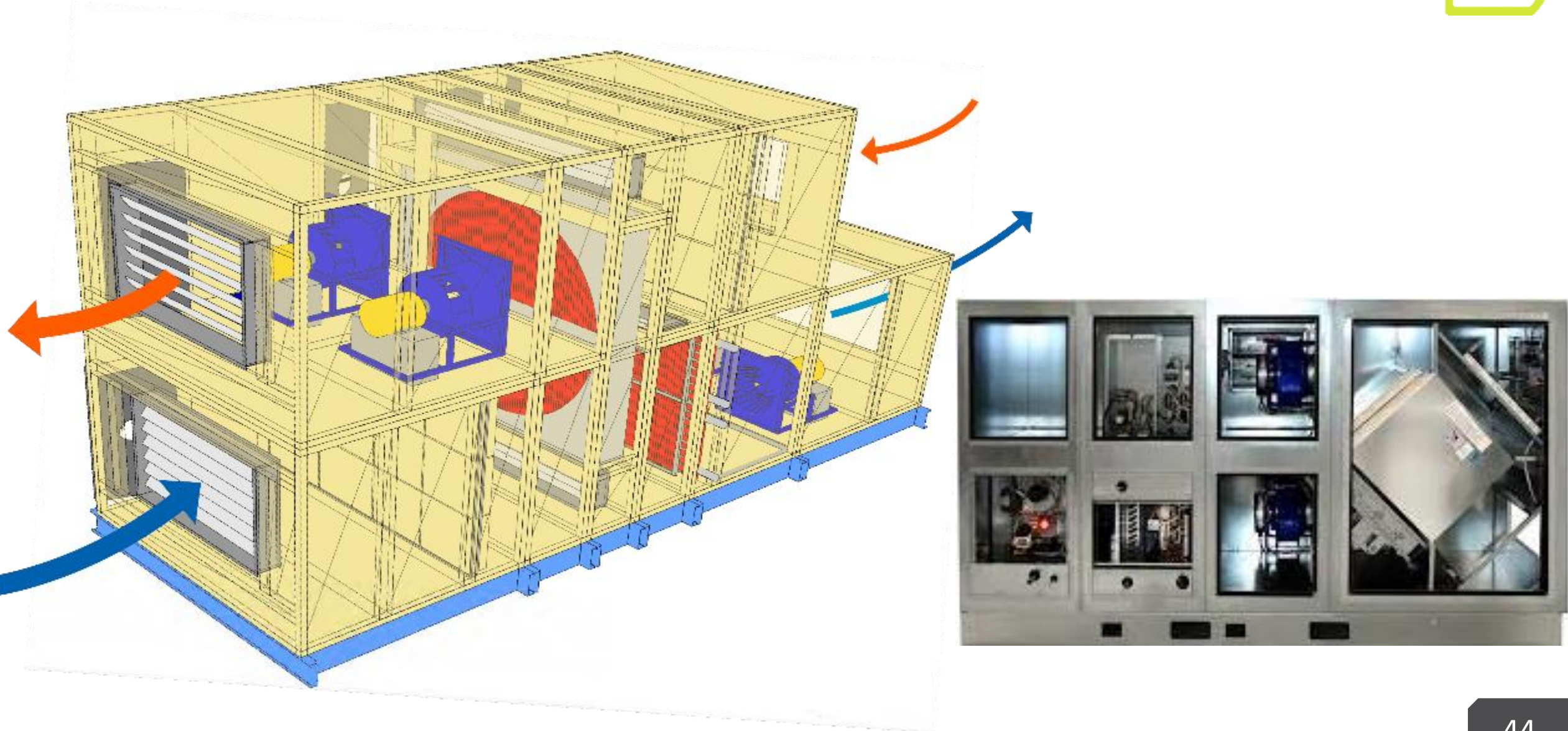
DOAS, demystified, ERV/HRV



B. DOAS with separate conditioning of outdoor and return air



DOAS, ERV, and economizer

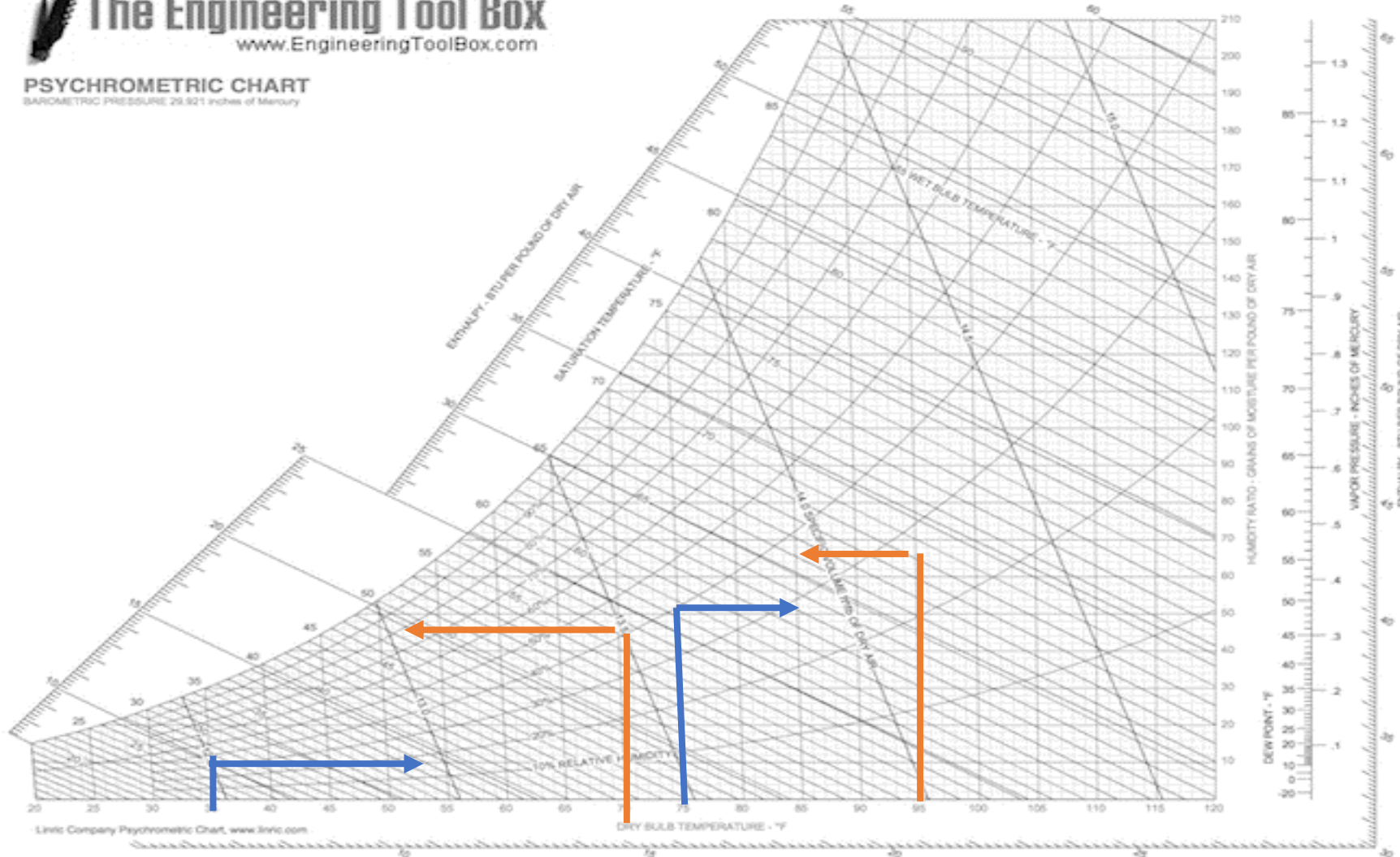


Effectiveness and Efficiency



 **The Engineering Tool Box**
www.EngineeringToolBox.com

PSYCHROMETRIC CHART
BAROMETRIC PRESSURE 29.921 inches of Mercury

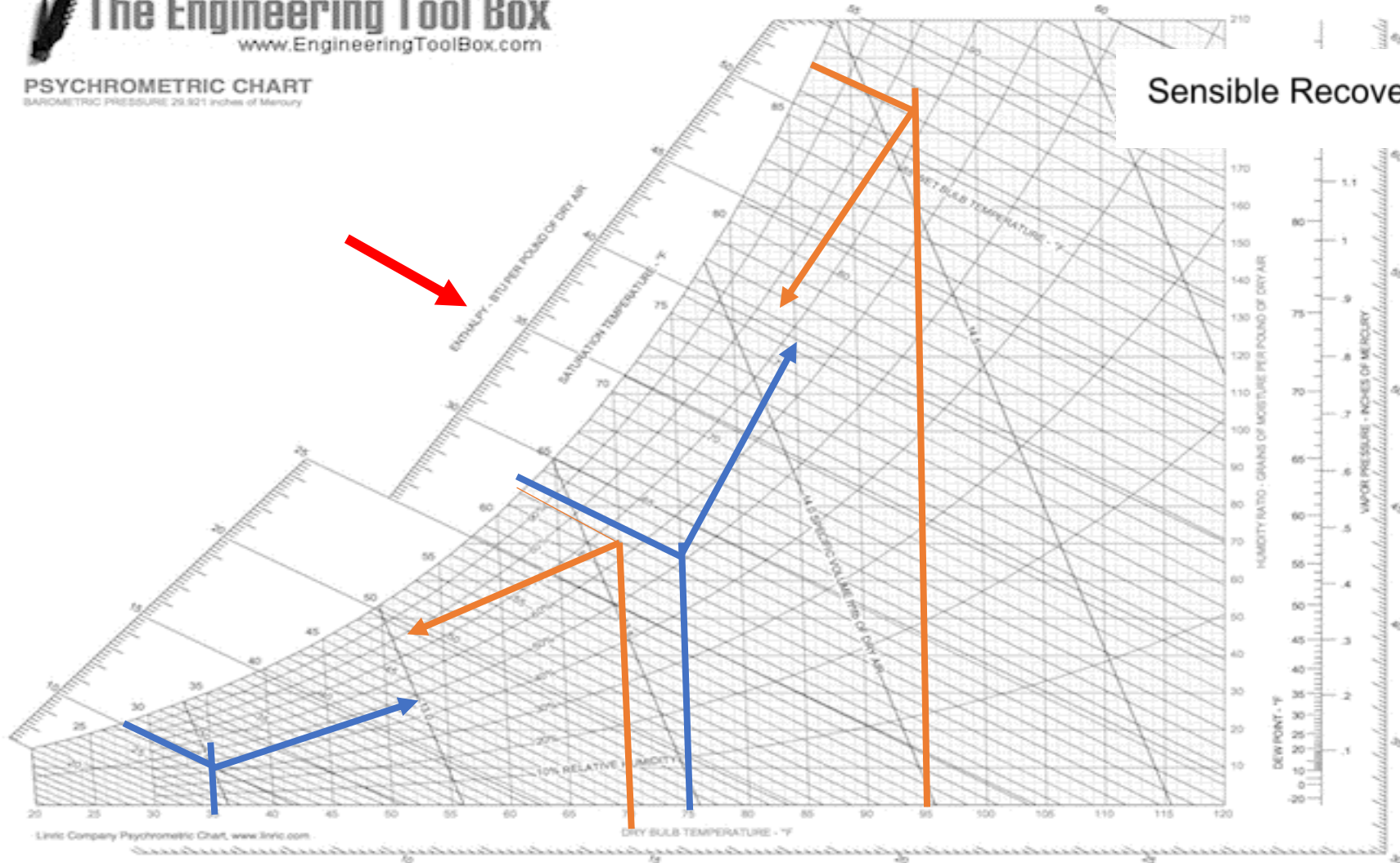


Effectiveness (Energy)



The Engineering Tool Box
www.EngineeringToolBox.com

PSYCHROMETRIC CHART
BAROMETRIC PRESSURE 29.921 inches of Mercury



$$\text{Sensible Recovery Effectiveness} = \frac{T_{OA} - T_{SA}}{T_{OA} - T_{RA}}$$

“Balanced ventilation” for R-2 dwelling units

R-2 dwelling & sleeping units

- Deliver ventilation air directly to each “habitable space”
 - Living room, bedrooms
 - Trickle vents & bathroom exhaust doesn’t work anymore
- Heat recovery required
 - w/ 67% sensible heat recovery effectiveness (68% in WA code)
 - “Informative note” about how to determine sensible heat recovery effectiveness from HVI publication



ERV and HRV

Cost impacts

Energy impacts

Fsi critiques Duane's ideas

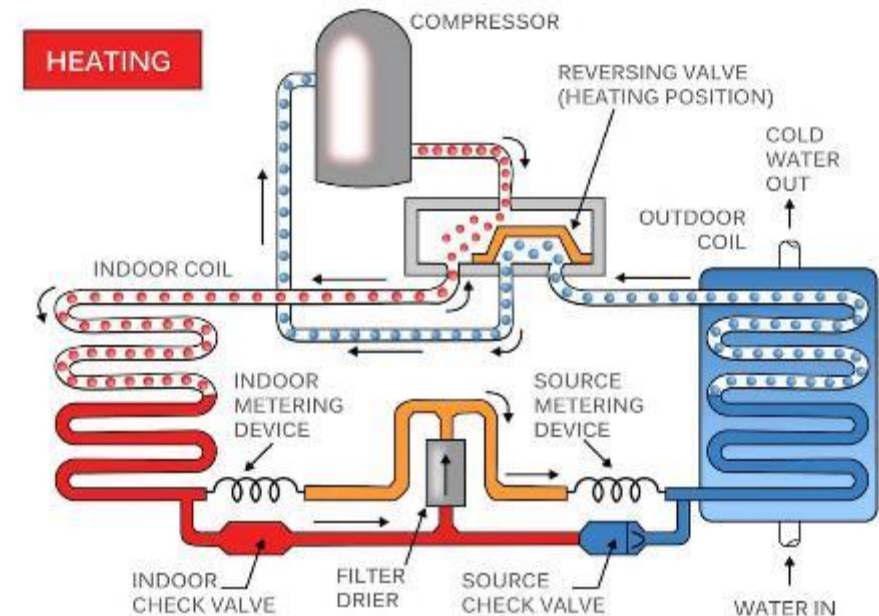
- Individual HRVs in apartments?
 - Remember you still need to clean each filter twice a year
- Rooftop units with vertical shafts?
 - Eats up some rentable floor area
- Floor-by-floor HRVs?
 - Each serving 6 – 8 units
 - Ducts running above bathrooms
 - So you don't need fire dampers
 - But is there a noise/privacy problem?

Seattle & WA: Heat pump space heating

No electric resistance or fossil fuel combustion for space heating

Exceptions allow electric resistance heat for:

1. “Passive House” rule: Max 2.5 W/sf total installed heating
2. Dwelling & sleeping units: Max **750 W** per habitable room
 - **1000 W** for corner room
 - 250 W for room at exterior wall, but no window
3. Buildings smaller than 2,500 sf
4. Heat pump defrost



Heat pumps squeeze warmth out of cold air

C403.1.4 (space heating) More Exceptions

5. Air-to-air heat pumps

1. Compressor is first stage of heat down to 17°F , capacity is 2X elec resistance

6. Air-to-water heat pump

1. All sizes
2. Auxiliary heat locked out down to 36°F
 1. Fossil fuel auxiliary OK in CZ 5 only
3. Compressor is first stage of heat down to lowest design temp
4. Capacity at 17°F is min 75% of cap at 29°F

7. Ground-source HP

8. Small systems

9. Specific conditions (if *approved*)

10. Kitchen make-up air

11. District energy

12. Heat tape

13. Temporary systems

14. Pasteurization cycle

15. Freeze protection

16. DOAS ERV auxiliary heat

17. Low-carbon district energy

18. Essential facilities

19. Standby heating equipment

20. Emergency generators

21. Wastewater heat recovery pumps

No electric resistance or gas heat



Airside systems we can use

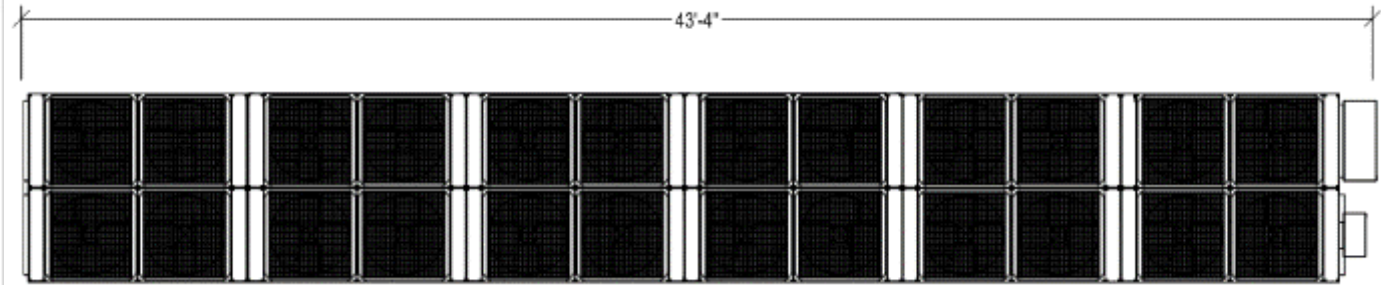
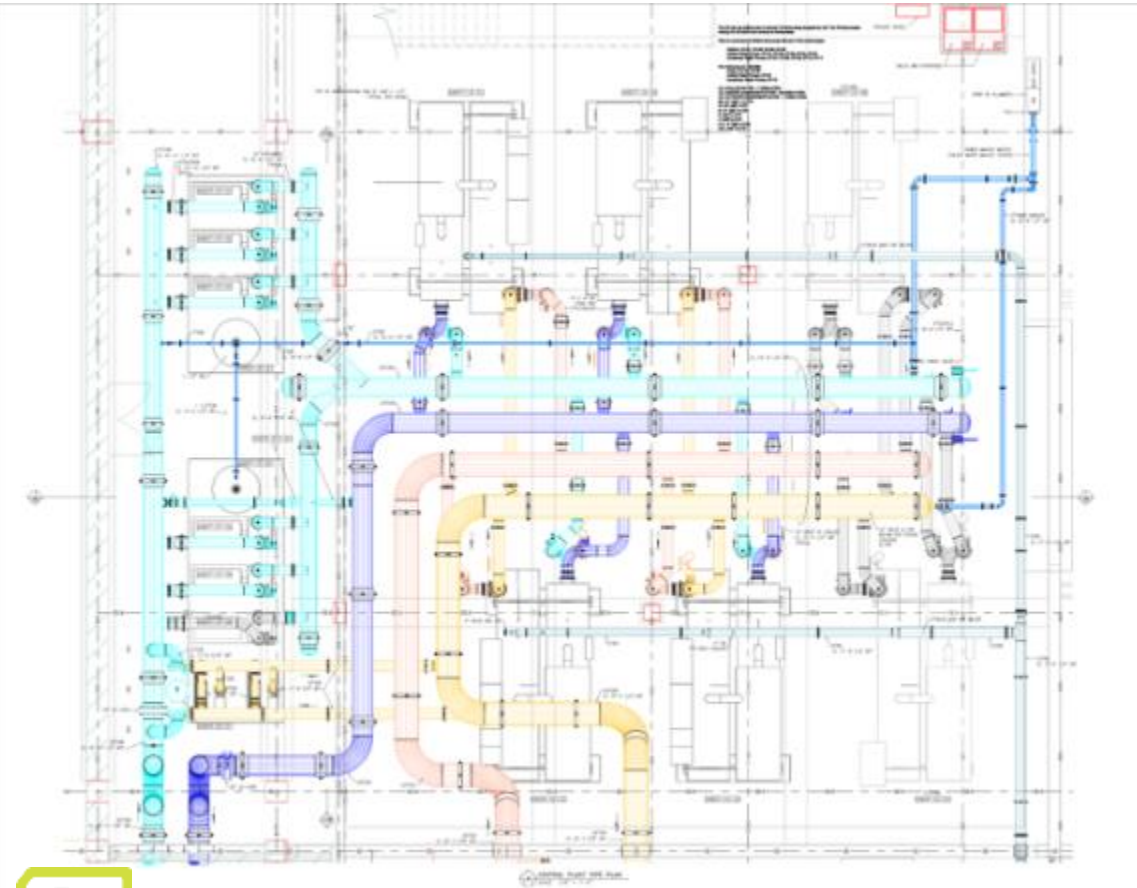
No electric resistance or gas heat (Seattle)



Waterside systems we can use

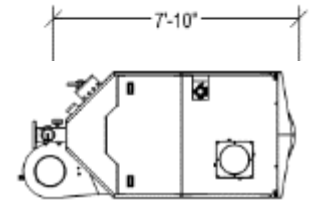
Engineering View, Impacts

Architectural – Yes, HVAC really does need all that space



17,500 lbs

3200 MBH Gas Boiler
-vs-
Same capacity AWHP



4,000 lbs

To gas or not to gas, that is the question

C403.1.4 Use of electric resistance and fossil fuel-fired HVAC heating equipment. HVAC heating energy shall not be provided by electric resistance or fossil fuel combustion appliances. For the purposes of this section, electric resistance HVAC heating appliances include, but are not limited to, electric baseboard, electric resistance fan coil and VAV electric resistance terminal reheat units and electric resistance boilers. For the purposes of this section, fossil fuel combustion HVAC heating appliances include, but are not limited to, appliances burning natural gas, heating oil, propane, or other fossil fuels.

To gas or not to gas, that is the question

Exceptions allowing electric resistance:

- Low heating capacity <8.5 BTH
- Dwelling and Sleeping units with wattage limits
- Buildings <2500 SF
- Defrost for heat pumps
- Air-to-air heat pumps, air-to-water heat pumps, & ground source heat pumps backup heating, with limitations
- Small systems less than 5% of total building capacity
- Kitchen makeup in climate zone 4 or 5
- Heat tape for freeze protection
- Temporary systems <40 degrees F
- Pasteurization
- Freeze protection <45 degrees F
- DOAS frost protection
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official

Exceptions allowing fossil fuel heating:

- Small systems > 5% of total building capacity
- Kitchen makeup in climate zone 5
- District energy predating 7/1/2023
- DOAS frost protection climate zone 5
- Low carbon district energy systems
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official

To gas or not to gas, that is the question (Seattle)

Exceptions allowing electric resistance:

- Low heating capacity <8.5 BTH
- Dwelling and sleeping units with wattage limits
- Buildings <2500 SF
- Defrost for heat pumps
- Air-to-air heat pumps, air-to-water heat pumps, & ground source heat pumps backup heating, with limitations
- Small systems less than 5% of total building capacity
- Kitchen makeup in climate zone 4 ~~or 5~~
- Heat tape for freeze protection
- Temporary systems <40 degrees F
- Pasteurization
- Freeze protection <45 degrees F
- DOAS frost protection
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official
- *Standby HVAC heating (manual switchover)*
- *Wastewater heat recovery auxiliary heating*

Exceptions allowing fossil fuel heating:

- Small systems less than 5% of total building capacity
- ~~Kitchen makeup in climate zone 5~~
- District energy predating 7/1/2023
- ~~DOAS frost protection climate zone 5~~
- Low carbon district energy systems
- I-2 and I-3 essential facilities *and research laboratories* with required redundant backup systems
- As approved by code official
- *Emergency generators*

Simultaneous heating/cooling

C403.4.1

- In “thermostatic control” section
- You can’t have heating in the perimeter zone with cooling in the interior zone of the same space at the same time.
 - Duh-oh!
 - You *can* have one zone in heating or cooling while the other is neutral
 - Permanent opening between areas bigger than 10% of either floor area constitute a single space for this requirement



Simultaneous Heating and Cooling



C403.7, Ventilation and Exhaust Systems



- DCV (already mentioned)
- Occupancy Sensors
- Ventilation heating control
- Garage Ventilation
- Energy Recovery Ventilation
- Kitchen Hoods
- Labs
- Building Isolation Dampers



Occupied standby controls c403.8.7

“Occupied standby” ventilation & temp control is huge.

- Shuts down ventilation & tweaks temp while space is unoccupied
- Ventilation fan does not run while space temp is in the expanded deadband

Heat Recovery C403.9.2

- **Heat recovery required** to provide heat in buildings (like hospitals) with minimum:
 - 24/7 operations
 - 1.5 MBTUH total heat capacity of water-cooled systems
 - 250 kBTUH service water heating load
- **Steam: condensate** water recovery required
 - Or condensate *heat recovery* for off-site steam with no return
- **Refrigeration condenser** heat recovery (like groceries)
 - 500 kBTUH remote refrigeration condensers
 - Use heat for service water, space heating, or dehumidification
- and...



Heat recovery for space heating C403.9.2.1

- Water-source condenser heat recovery system required if:
 - Operating hours over 70 hours per week
 - Heat rejection equip capacity over 1.5 MBTUH
 - Min 0.45 cfm/sf airflow in zones with reheat
 - EXCEPTION: DOAS – dedicated outdoor air systems
- 90% of heating from heat recovery chiller or water-to-water heat pump, rejecting heat from cooling loop to heating loop as first stage of heating
- Heat recovery from 90% of exhaust airflow
 - Leaving exhaust air temp max 55F in full heat recovery mode
- Process heat recovery (like data center or computer room) over 5 W/sf
 - Cooling loops must be served by water-cooled equip & heat recovery
 - Economizer override required

Heat Recovery Engineering Notes





Heating the great outdoors C403.11

- Outdoor heat must be “radiant” (but no one regulates portable devices)
- Seattle adds “...or in unheated spaces” (repair garage, desk at warehouse...)
- Auto-off by timer or occ sensor
- Seattle adds “...in the area heated by each individual device for a period not to exceed 20 minutes.”
- Freeze protection (mainly heat tracing) shut off above 40°F

Fireplaces & fire pits C403.4.7.1

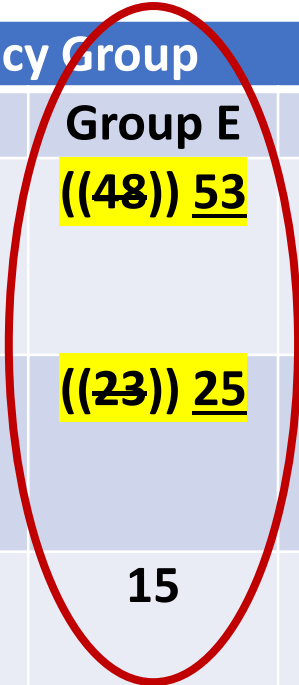
- Manual on
- Auto-off with 1-hour timer, or
- Auto-off with 15-minute occ sensor



C406 credit system Pick several “above-code” options

Table C406.1 Energy Measure Credit Requirements

Required Credits for Projects	Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
New building energy efficiency credit requirement	C406.2	((54)) <u>59</u>	((41)) <u>45</u>	((42)) <u>46</u>	((48)) <u>53</u>	((74)) <u>61</u>	((49)) <u>54</u>
Building additions energy efficiency credit requirement	C406.2	((27)) <u>30</u>	((20)) <u>22</u>	((21)) <u>23</u>	((23)) <u>25</u>	((36)) <u>30</u>	((21)) <u>23</u>
New building load management credit requirement	C406.3	12	15	27	15	13	26



Additional Efficiency Package Options

Efficiency Measure Credits

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Dwelling unit HVAC control	C406.2.1	NA	7	NA	NA	NA	NA
2. Improved HVAC TSPR ^a	C406.2.2.1	NA	8	11	17	22	NA
3. Improve cooling and fan efficiency	C406.2.2.2	((2)) 8	((2)) 5	((3)) 10	((4)) 10	((3)) 8	((2)) 8
4. Improve heating efficiency	C406.2.2.3	((2)) 1	((3)) 1	((3)) 1	((40)) 1	(16) 2	((2)) 1
5. Improved low-carbon district energy system (10% better)	C406.2.2.4	3	3	4	11	17	8
6. Improved low-carbon district energy system (20% better) ^b	C406.2.2.5	9	10	12	33	52	24
7. High performance DOAS	C406.2.2.6	31	31	21	39	40	21/ (Group A: 40) ^c
8. Fault detection & diagnostics (FDD)	C406.2.2.7	2	2	2	6	9	4
9. 10% reduced lighting power	C406.2.3.1	7	4	18	16	((20)) 36	((15)) 16
10. 20% reduced lighting power ^d	C406.2.3.2	13	8	36	32	((52)) 72	((29)) 32
11. Lamp efficacy improvement	C406.2.3.3	5	6	NA	NA	NA	NA
12. Residential lighting control	C406.2.4.1	NA	8	NA	NA	NA	NA
13. Enhanced lighting control	C406.2.4.2	1	1	6	6	11	((6)) 5
14. Renewable energy	C406.2.5	7	12	13	13	10	11
15. Shower drain heat recovery	C406.2.6.1	9	30	NA	3	NA	NA
16. Service water heat recovery	C406.2.6.2	35	111	13	14	(Grocery) 41 ^a	NA
17. ((Heat pump water heating))	((C406.2.6.3))	((81))	((261))	((17))	((33))	(Grocery) ((95)) ^a	(A-2) ((95))

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
18. Heat trace system	C406.2.7.1	6	13	4	1	NA	6
19. Point of use water heater	C406.2.7.2	NA	NA	19	5	NA	NA
20. Service hot water distribution right sizing	C406.2.8	13	((42)) 10	NA	NA	NA	NA
21. High performance service hot water temperature maintenance system	C406.2.9	6	13	4	1	NA	6
22. ((High efficiency service hot water circulation system))	((C406.2.10))	((3))	((6))	((2))	((4))	((NA))	((4))
23. Low flow residential showerheads	C406.2.11	3	3	NA	NA	NA	NA
24. Enhanced envelope performance ^e	C406.2.12	24	20	13	5	19	((14)) 16
25. Base reduced air leakage ^e	C406.2.13.2	29	24	6	3	9	((11)) 14
26. Enhanced reduced air leakage ^e	C406.2.13.3	53	44	11	5	16	((20)) 26
27. Enhanced commercial kitchen equipment	C406.2.14	30 ^a	18 ^a	18 ^a	30 ^a	30 ^a	31 ^a
28. Enhanced residential kitchen equipment	C406.2.15	12	19	NA	NA	NA	NA
29. Enhanced residential laundry equipment	C406.2.16	NA	6	NA	NA	NA	NA
30. Heat pump clothes dryers	C406.2.17	6	6	NA	NA	NA	NA
31. Efficient elevator equipment	C406.2.18	3	5	5	5	4	4



Additional Efficiency Package Options

Table C406.3

Load Management Measure Credits

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Lighting load management	C406.3.1	12	15	27	15	NA	NA
2. HVAC load management	C406.3.2	29	24	42	23	13	26
3. Automated shading	C406.3.3	NA	7	12	16	NA	NA
4. Electric energy storage	C406.3.4	41	50	126	72	37	65
5. Cooling energy storage	C406.3.5	13	10	14	19	NA	14
6. Service hot water energy storage	C406.3.6	31	248	59	8	5	70
7. Building thermal mass	C406.3.7	NA	NA	50	95	96	80

Table C406.2

List all your HVAC-related efficiency credits & load mgmt. credits on HVAC set cover page

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Dwelling unit HVAC control	C406.2.1	NA	7	NA	NA	NA	NA
2. Improved HVAC TSPR ^a	C406.2.2.1	NA	8	11	17	22	NA
3. Improve cooling and fan efficiency	C406.2.2.2	((2)) 8	((2)) 5	((3)) 10	((4)) 10	((3)) 8	((2)) 8
4. Improve heating efficiency	C406.2.2.3	((2)) 1	((3)) 1	((3)) 1	((10)) 1	((16)) 2	((7)) 1
5. Improved low-carbon district energy system (10% better)	C406.2.2.4	3	3	4	11	17	8
6. Improved low-carbon district energy system (20% better) ^b	C406.2.2.5	9	10	12	33	52	24
7. High performance DOAS	C406.2.2.6	31	31	21	39	40	21/ (Group A: 40) ^c
8. Fault detection & diagnostics (FDD)	C406.2.2.7	2	2	2	6	9	4

C406 credit: Improved TSPR C406.2.2.1

- 5% higher TSPR
- Or, prorated up to 20% higher TSPR



HVAC C406 credit for tenant spaces C406.1.1.2

- **Where shell & core permit includes C406.2 (HVAC) credit, tenant spaces also qualify if they connect to building HVAC system.**
- Tenant space can also qualify for HVAC credit independently

C406.1.1.2 Applicable HVAC and service water heating credits. Where HVAC and service water heating systems and services are installed ... **Tenant spaces qualify for the credits assigned to the occupancy type of the tenant space in accordance with Table C406.2 if the tenant space includes the distribution system and equipment that the central HVAC systems or service water heating systems were designed to support.**

- Seattle: Initial TI permit can use S&C permit code edition within 18 months of C/O

C406 Engineering Notes



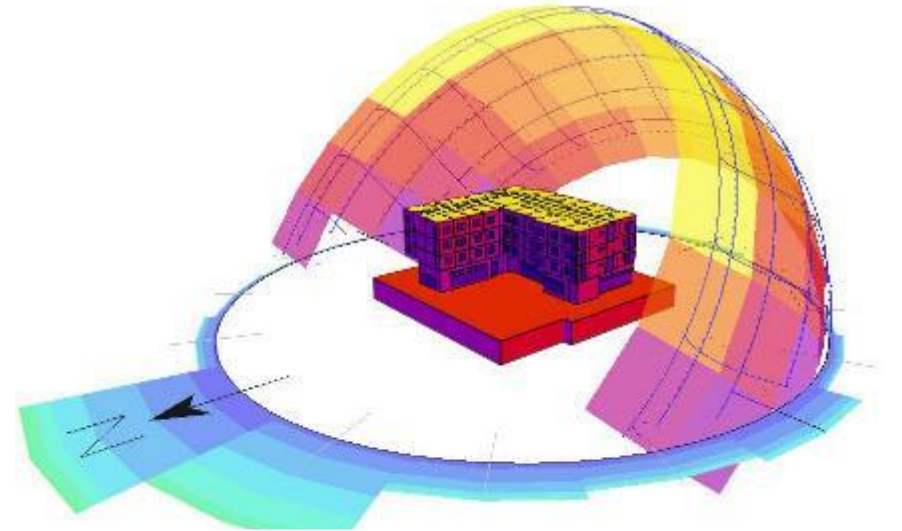
Seattle: No C406 credits for fossil fuel equipment

- **C406.2.2.6 High-performance dedicated outdoor air system (DOAS).** No less than 90 percent of the total conditioned floor area of the whole project, excluding floor area of unoccupied spaces that do not require ventilation as specified by the International Mechanical Code, shall be served by DOAS installed in accordance with Section C403.3.5 with the following adjustments:
 - ...
 - ... **No HVAC systems incorporating fossil fuel-fired equipment, or heat from district energy systems that are primarily heated by fossil fuel combustion, are permitted to utilize this credit.**
 - **Same** for C406.2.6 Service water heating

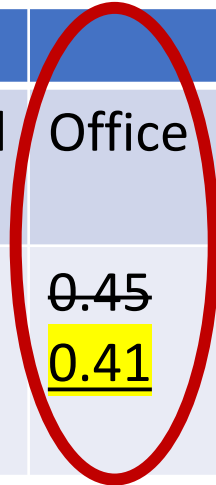
Energy Modeling – emissions based

...plus EUI cap

- **Carbon emissions** compared with 2004 ASHRAE 90.1 standard
- Seattle BPF **10% below** WA code
 - To align models with more stringent Seattle Energy Code requirements



SEATTLE 10% lower									
Building Area Type	Multi family	53	Hotel	Office	Rest.	Retail	School	Ware house	Others
Building Performance Factor	0.55 <u>0.50</u>	0.71 <u>0.64</u>	0.53 <u>0.48</u>	0.45 <u>0.41</u>	0.35 <u>0.32</u>	0.41 <u>0.37</u>	0.36 <u>0.32</u>	0.19 <u>0.17</u>	0.44 <u>0.40</u>



C407, Welcome to ASHRAE 90.1



C407, Welcome to ASHRAE 90.1



C407.3 Performance-based compliance. Compliance with this section requires compliance with ASHRAE Standard 90.1 Appendix G, Performance Rating Method, in accordance with Standard 90.1 Section 4.2.1 with the following modifications.

1. The mandatory requirements of Section G1.2.1a of Standard 90.1 are not required to be met.
2. The reduction in annual carbon emissions of the proposed building design associated with on-site renewable energy shall not be more than 3 percent of the total carbon emissions of the baseline building design. This limitation only applies to onsite renewable energy provided in excess of the renewable energy required by Section C412.
 - a. The equation $PCI + [(PBP_{nre} - PBP)/BBP] - 0.05 < PCIt$ in Section 4.2.1.1 shall be modified to read $PCI + [(PBP_{nre} - PBP)/BBP] - 0.03 < PCIt$.
 - b. The term PBP_{nre} shall be defined as the proposed building performance without credit for reduced annual energy emissions from on-site renewable energy generation system capacity in excess of that installed to satisfy the requirements of Section C412.
3. References to energy cost in Section 4.2.1.1 and Appendix G shall be replaced by carbon emissions calculated by multiplying site energy consumption by the carbon emission factor from Table C407.3(1).
4. ...

Total Building Performance Path

$$PCI = \frac{\text{Proposed Building (Carbon)}}{\text{Baseline Building (Carbon)}}$$

$$PCI_t = [BBUEC + (BPF \times BBREC)] / BBP$$

where

- PCI = Performance Cost Index calculated in accordance with Section [G1.2](#).
- BBUEC = Baseline *Building Unregulated Energy Cost*, the portion of the annual *energy cost* of a *baseline building design* that is due to *unregulated energy use*.
- BBREC = Baseline *Building Regulated Energy Cost*, the portion of the annual *energy cost* of a *baseline building design* that is due to *regulated energy use*.
- BPF = *Building Performance Factor* from Table [4.2.1.1](#). For *building area types* not listed in Table [4.2.1.1](#) use “All others.” Where a *building* has multiple *building area types*, the required BPF shall be equal to the area-weighted average of the *building area types*.
- BBP = *Baseline Building Performance*.

Building Area Type	BPF (WSEC)	BPF (SEC)
Multifamily	0.55	0.50
Healthcare / Hospital	0.71	0.64
Hotel / Motel	0.53	0.48
Office	0.45	0.41
Restaurant	0.35	0.32
Retail	0.74	0.37
School	0.36	0.32
Warehouse	0.19	0.17
All Others	0.44	0.40

C407, Welcome to ASHRAE 90.1



**Table C407.3(1)
Carbon Emissions Factors**

Type	CO ₂ e (lb/unit)	Unit
Electricity	0.70	kWh
Natural Gas	11.7	Therm
Oil	19.2	Gallon
Propane	10.5	Gallon
Other ^a	195.00	mmBtu
On-site renewable energy	0.00	

^a District energy systems may use alternative emissions factors supported by calculations approved by the *code official*.

Table G3.1.1-1 Baseline Building Vertical Fenestration Percentage of Gross Above-Grade-We

Building Area Types ^a	Baseline Building Gross Above-G
Grocery store	7%
Healthcare (outpatient)	21%
Hospital	27%
Hotel/motel (≤75 rooms)	24%
Hotel/motel (>75 rooms)	34%
Office (≤5000 ft ²)	19%
Office (5000 to 50,000 ft ²)	31%
Office (>50,000 ft ²)	40%
Restaurant (quick service)	34%
Restaurant (full service)	24%
Retail (stand alone)	11%
Retail (strip mall)	20%
School (primary)	22%
School (secondary and university)	22%
Warehouse (nonrefrigerated)	6%

C407, Welcome to ASHRAE 90.1



How hard is this?

C407, Welcome to ASHRAE 90.1



Why do it?

Commissioning of HVAC required, plus...

- Cx qualifications, checklist
- Conflict of interest statement
- CX plan and Cx report
 - Lighting, controlled receptacles
 - HVAC, water heating
 - Refrigeration, Metering
- HVAC Cx thresholds:
 - 240 kBtu/h cooling
 - 300 Kbtu/h heating
- Write Cx requirement in mech permit docs, including MEP sets



Also see C408.1.4.1.1 for Pos-Occupancy Cx reqs!

C408, Brief note on Cx

Required (except very small systems)

Certified Commissioning Professional

CERTIFIED COMMISSIONING PROFESSIONAL. An individual who is certified by an ANSI/ISO/IEC 17024:2012 accredited organization to lead, plan, coordinate, and manage commissioning teams and implement the commissioning process.

Seattle: Approved unregulated loads C407.3.4.1

- You might get C407 “credit” for unregulated but high-performing systems
- If building official approves
- And it’s a pretty high bar
- Will be publicly listed so everyone else can use an approved credit
- A few residential appliances pre-approved

Like maybe?

- FDD
- Heat trace
- Point of use water heater

Metering Actionable energy display

- Graphic energy use display for bldgs. 20,000+ SF
 - Source meters (usually gas & elec pulse meters)
 - HVAC & water heating sub-meters
 - Lighting, plug load & process load sub-meters
- Also required for replacement HVAC systems
- Planning can reduce number of meters



C409, The Cx Perspective



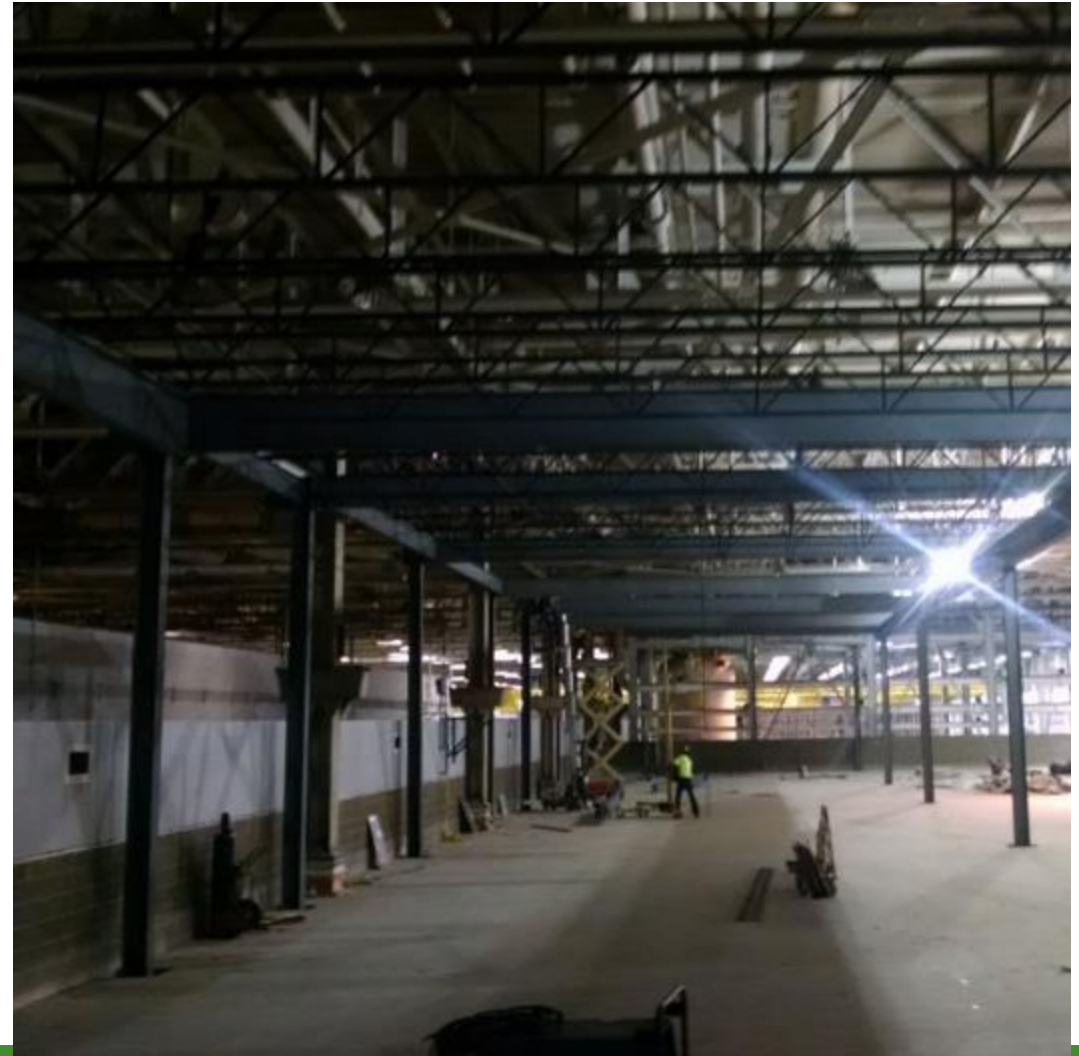
Meters, what are they good for anyway?



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”



Upgrading existing buildings

Getting real about good intentions

- Can existing buildings stay funky forever?
 - Nightclubs, high-rise stairs
- BPS is a radical departure
- Are we serious enough about climate commitments to mandate major upgrades?
- It's not popular.



Seattle Energy Code: Replacement of existing gas equipment

- **Most economical time to upgrade.**
- **Current (2018) Code.** Replacement heating and water heating equipment must be heat pump system
 - Exception like-for-like replacement of “failing” equipment
- **New (2021) Code.** More options to postpone full conversion
 - But, no option to “do nothing and keep burning gas forever” anymore



BPS: WA State *plus*

BEPS: Seattle

Energy

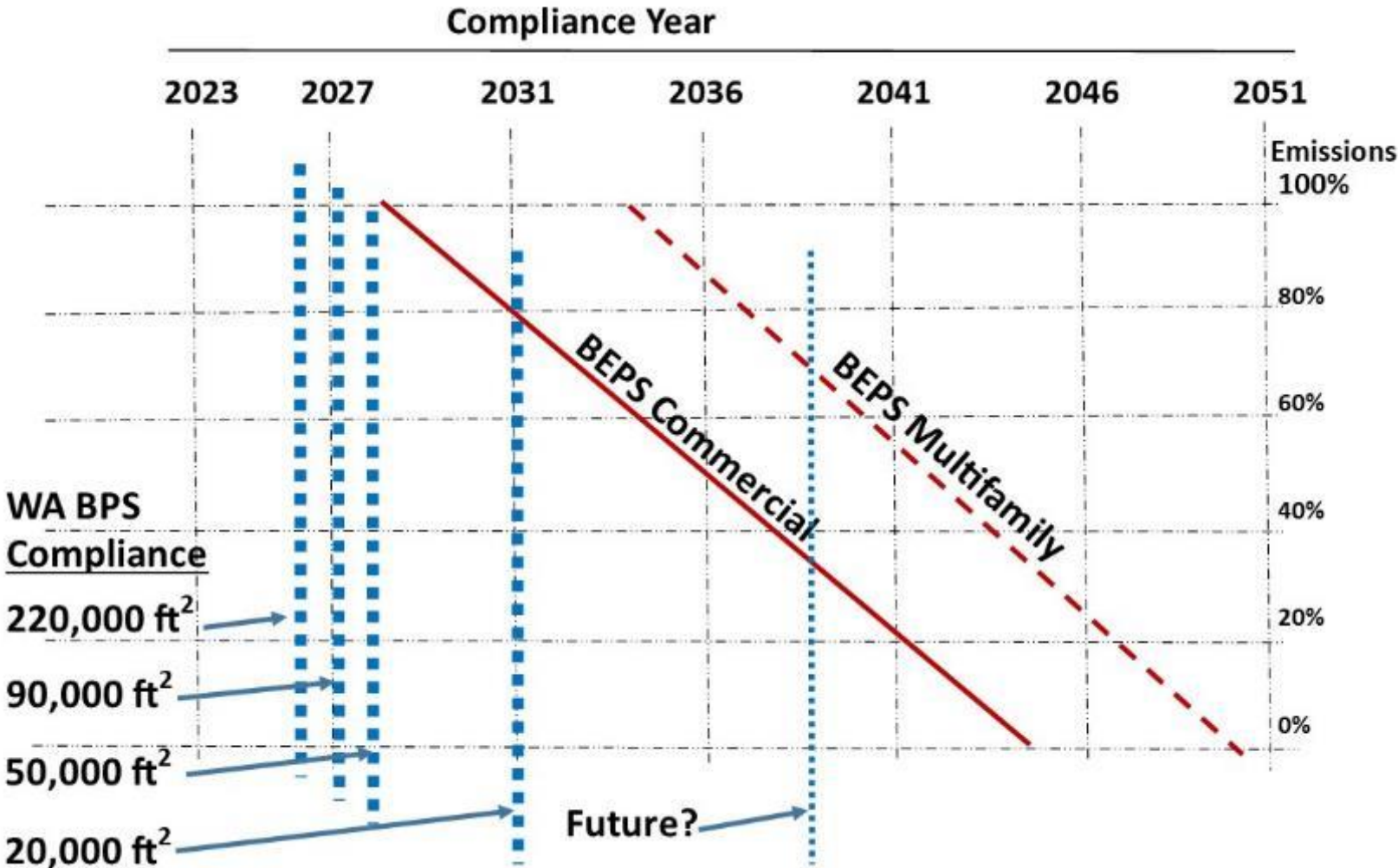
- Most building types
- **EUI targets** set at state “average” for each building type
- Lower EUIs in future?
- 50,000 ft²: Starts 2026
- 20,000 ft²: Starts 2031

GHG Emissions

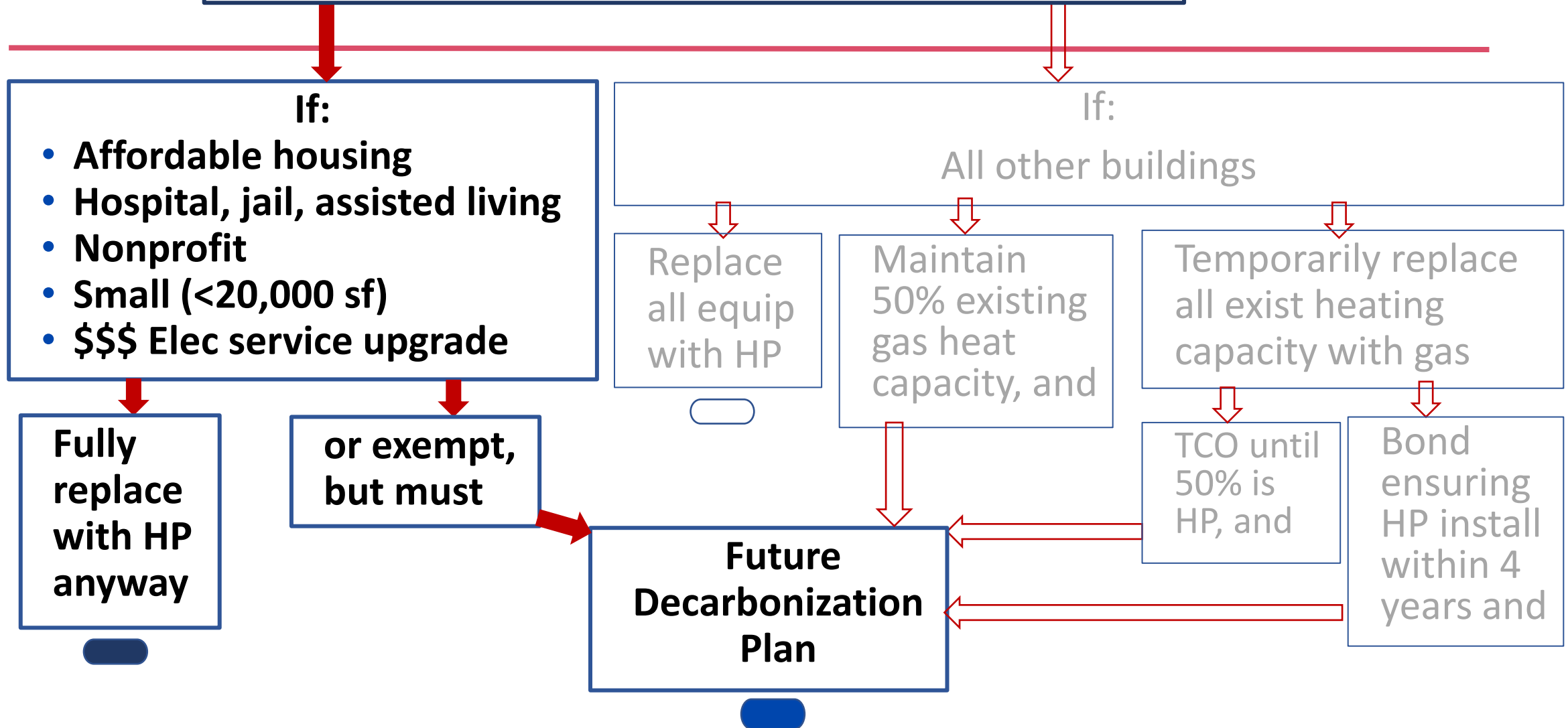
- *In addition to* State BPS
- **Emissions targets** shrink every 5 years...
- ...to zero carbon in the 2040s
- 50,000 ft²: Starts 2028

BPS + BEPS

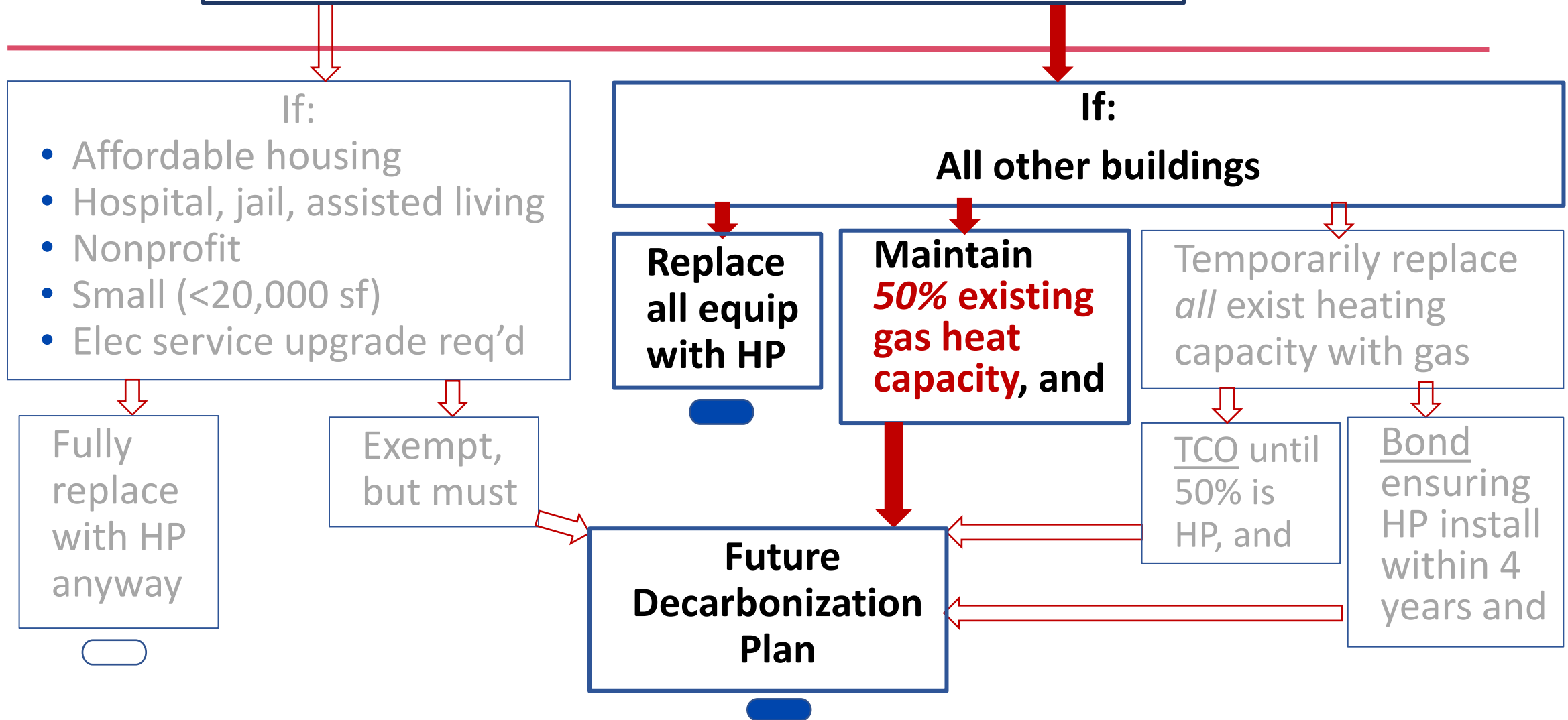
- **2-fer Bonus Prize:** Heat pumps tackle both energy *and* emissions



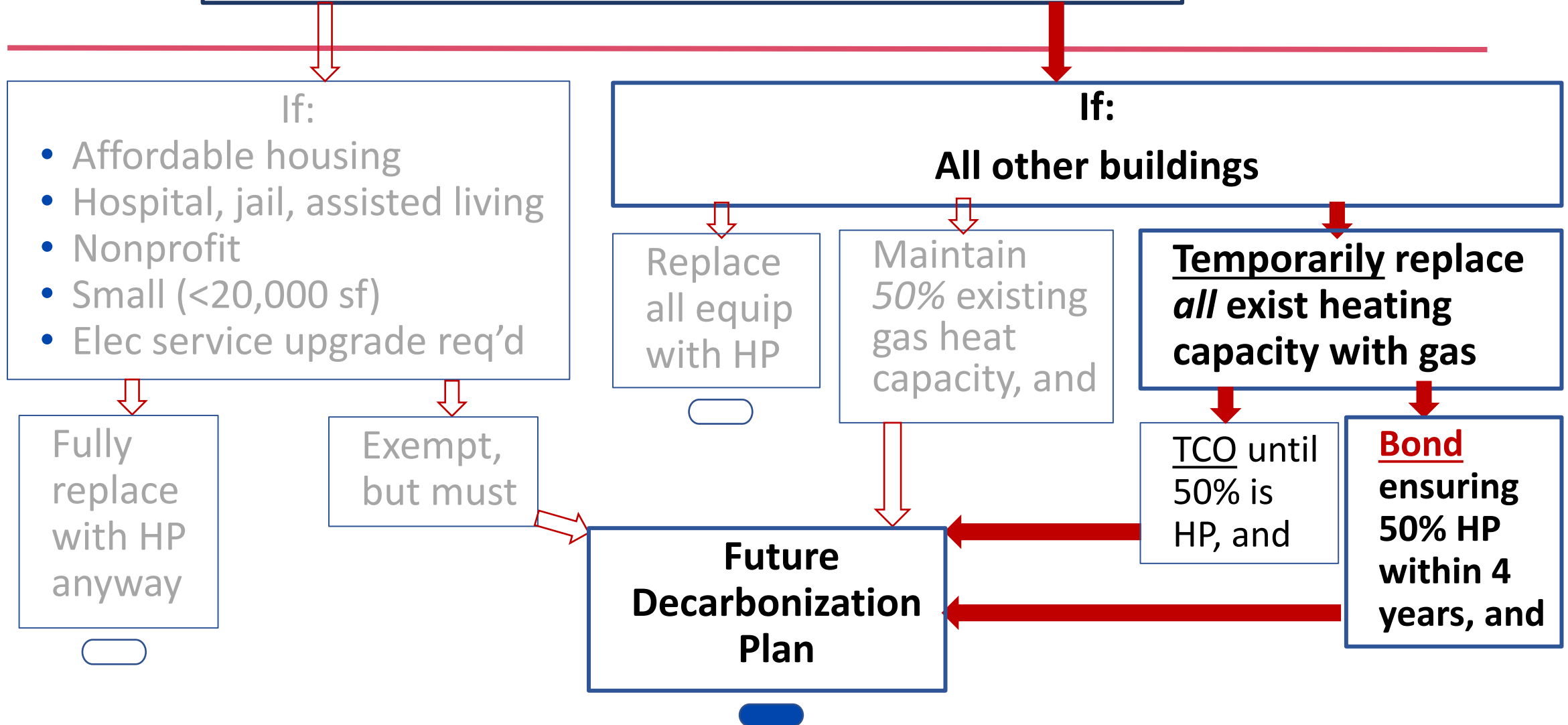
General rule: Replacement central space heating equipment must be heat pump



General rule: Replacement central space heating equipment must be heat pump



General rule: Replacement central space heating equipment must be heat pump



Existing Buildings (WA)

Fossil Fuel and electric resistance limits:

Exceptions allowing electric resistance:

- Low heating capacity <8.5 BTH
- Dwelling and Sleeping units with wattage limits
- Buildings <2500 SF
- Defrost for heat pumps
- Air to air heat pumps, air to water heat pumps, and ground source heat pumps backup heating, with limitations
- Small systems less than 5% of total building capacity
- Kitchen makeup in climate zone 4 or 5
- Heat tape for freeze protection
- Temporary systems <40 degrees F
- Pasteurization
- Freeze protection <45 degrees F
- DOAS frost protection
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official
- Terminal Equipment and AHU with hydronic
- Like for like replacement of single piece of equipment

Exceptions allowing fossil fuel heating:

- Small systems less than 5% of total building capacity
- Kitchen makeup in climate zone 5
- District energy predating 7/1/2023
- DOAS frost protection climate zone 5
- Low carbon district energy systems
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official
- Terminal Equipment and AHU with hydronic heating
- Oil and steam boilers
- Where triggering an unplanned electrical upgrade
- Like for like replacement of single piece of equipment

Existing Buildings

Fossil Fuel and electric resistance limits:

**Table C503.4.6
Compliance Options for Mechanical Heating Equipment Alterations**

	Proposed Heating Equipment Type^a	Heating Efficiency Table Reference	Alternate Compliance Options to Section C403.1.4
1	Air-Cooled Unitary Heat Pumps	Table C403.3.2(2)	1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5 ^c 2. Compliance with C403.1.4, except electric resistance mixed air preheat is permissible ^c
2	Packaged terminal, single-package vertical, and room air-conditioner heat pumps	Table C403.3.2(4)	1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 Exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5
3	Furnaces, duct furnaces, and unit heaters	Table C403.3.2(5)	1. Efficiency: +10% ^b
4	Gas-fired hot water boilers with fewer than 80% of served coils replaced	Table C403.3.2(6)	1. Efficiency: +10% ^b
5	Variable refrigerant flow air-to-air and applied heat pumps	Table C403.3.2(9)	No alternate compliance option
6	DX-DOAS equipment	Table C403.3.2(12) and Table C403.3.2(13)	1. DX-DOAS is provided with heat recovery if not required by C403.3.5.1.
7	Water-source heat pumps	Table C403.3.2(14)	No alternate compliance option

^a Includes replacement of equipment with a unit that is the same type or higher efficiency and the same or lower capacity, or a replacement of one equipment type with a different equipment type.
^b Equipment shall have a capacity-weighted average heating system efficiency that is 10 percent better than that shown in the reference table (1.10 x values in reference table).
^c Option 1 and Option 2 can be combined.



Existing Buildings (Seattle)

Fossil Fuel and electric resistance limits:

Exceptions allowing electric resistance:

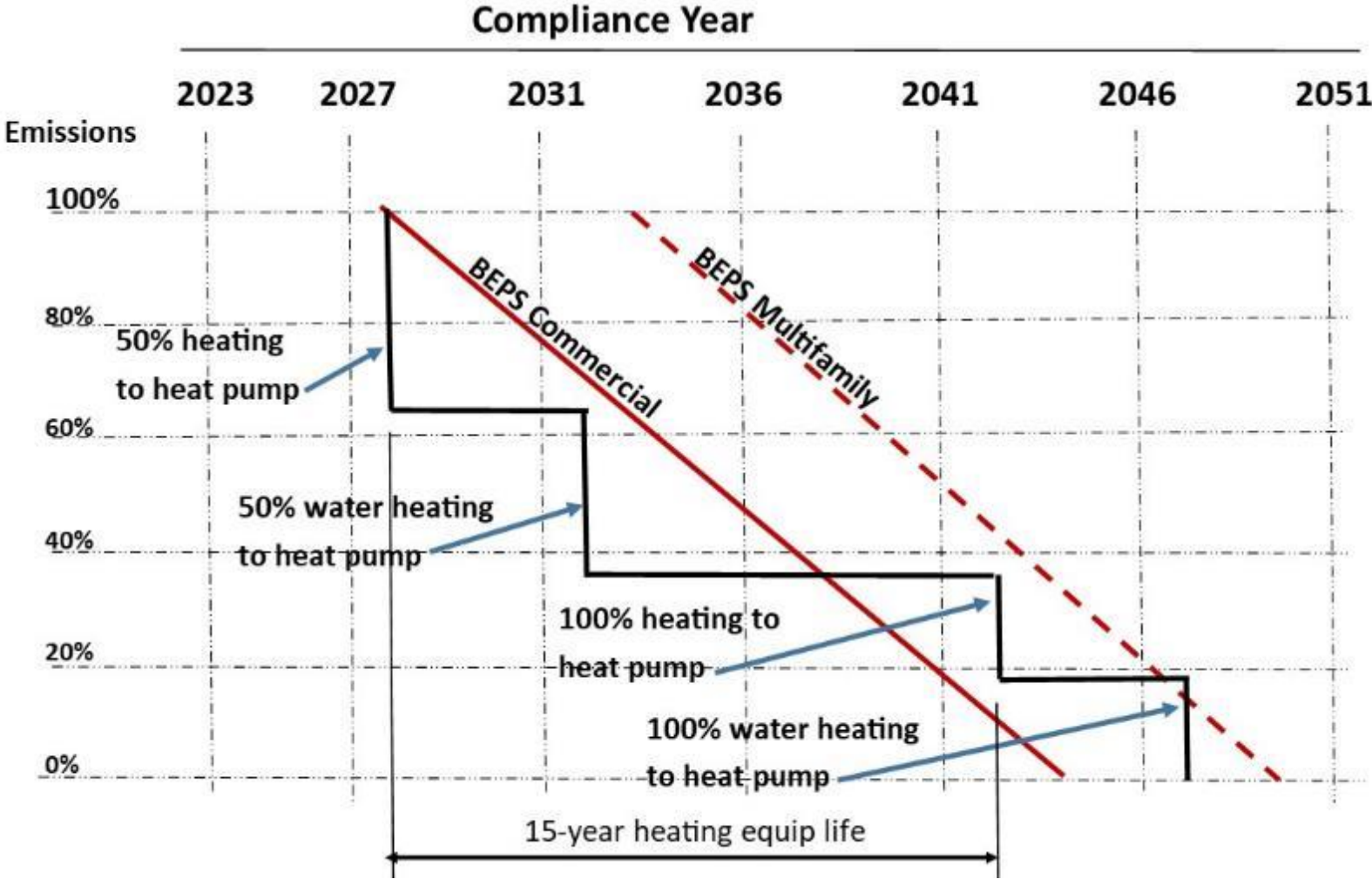
- Low heating capacity <8.5 BTH
- Dwelling and Sleeping units with wattage limits
- Buildings <2500 SF
- Defrost for heat pumps
- Air to air heat pumps, air to water heat pumps, and ground source heat pumps backup heating, with limitations
- Small systems less than 5% of total building capacity
- Kitchen makeup in climate zone 4 or 5
- Heat tape for freeze protection
- Temporary systems <40 degrees F
- Pasteurization
- Freeze protection <45 degrees F
- DOAS frost protection
- I-2 and I-3 essential facilities with required redundant backup systems
- As approved by code official
- Terminal Equipment and AHU with hydronic
- Like for like replacement of single piece of equipment
- *Affordable Housing*
- *Group I-1, I-2, I-3 occupancies*
- <20,000 SF
- >50% occupied by non-profit organizations

Exceptions allowing fossil fuel heating:

- Small systems less than 5% of total building capacity
 - Kitchen makeup in climate zone 5
 - District energy predating 7/1/2023
 - DOAS frost protection climate zone 5
 - Low carbon district energy systems
 - I-2 and I-3 essential facilities with required redundant backup systems
 - As approved by code official
 - Terminal Equipment and AHU with hydronic heating
 - Oil and steam boilers *only with exception*
 - Where triggering an unplanned electrical upgrade
 - Like for like replacement of single piece of equipment
 - *Affordable Housing*
 - *Group I-1, I-2, I-3 occupancies*
 - <20,000 SF
 - >50% occupied by non-profit organizations
- **FUTURE DECABONIZATION PLAN**

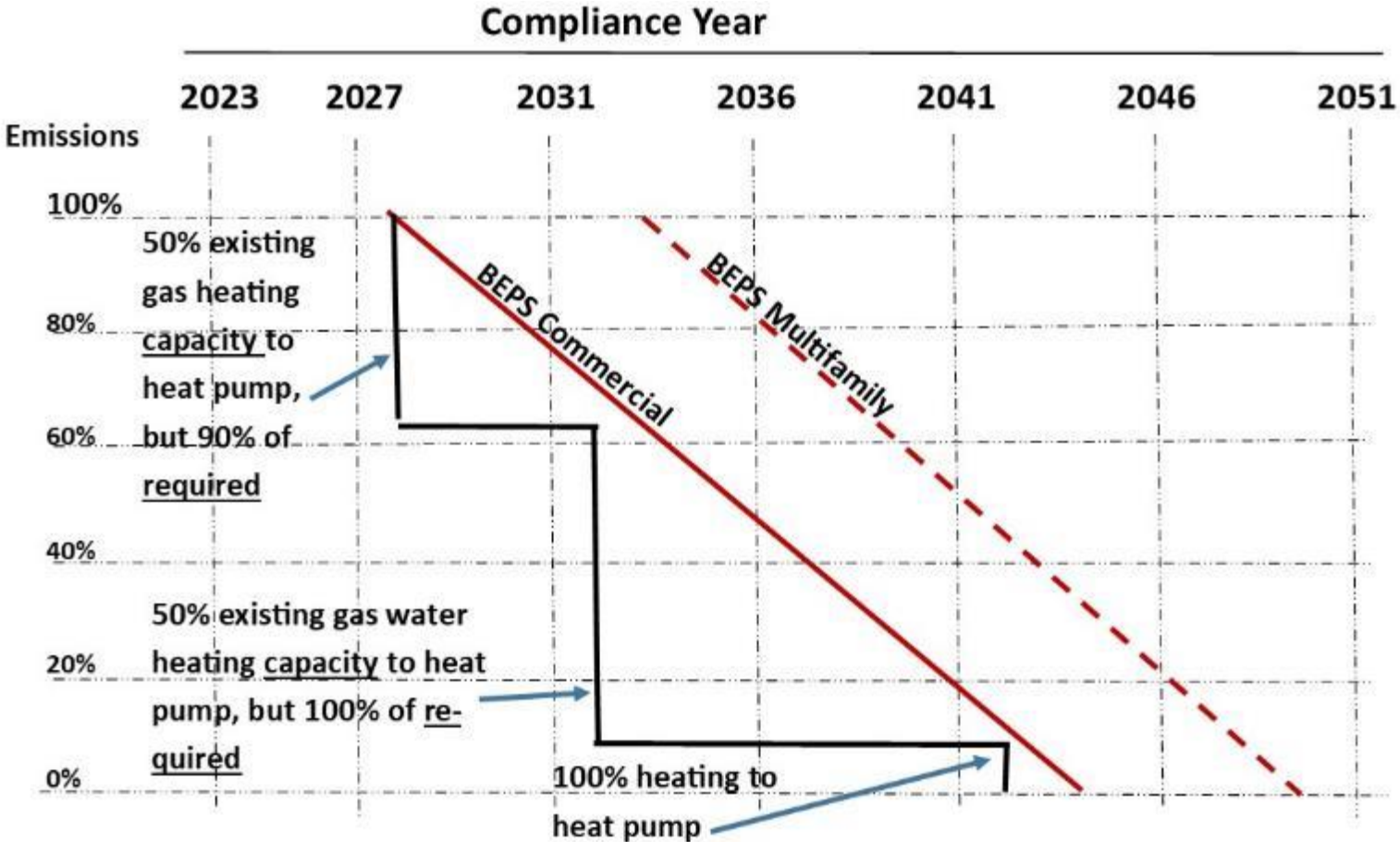
BEPS + SEC

- Seattle **BEPS**: emissions
- Seattle **Energy Code**: heat pump upgrade



BEPS + SEC – Take Two

- Seattle **BEPS**: emissions
- Seattle **Energy Code**: heat pump upgrade
- **Quiz**: By what factor are mech systems oversized?
- 10%, 20%, 50%, 100%?



Alternate possibility, accounting for gross oversizing of existing systems

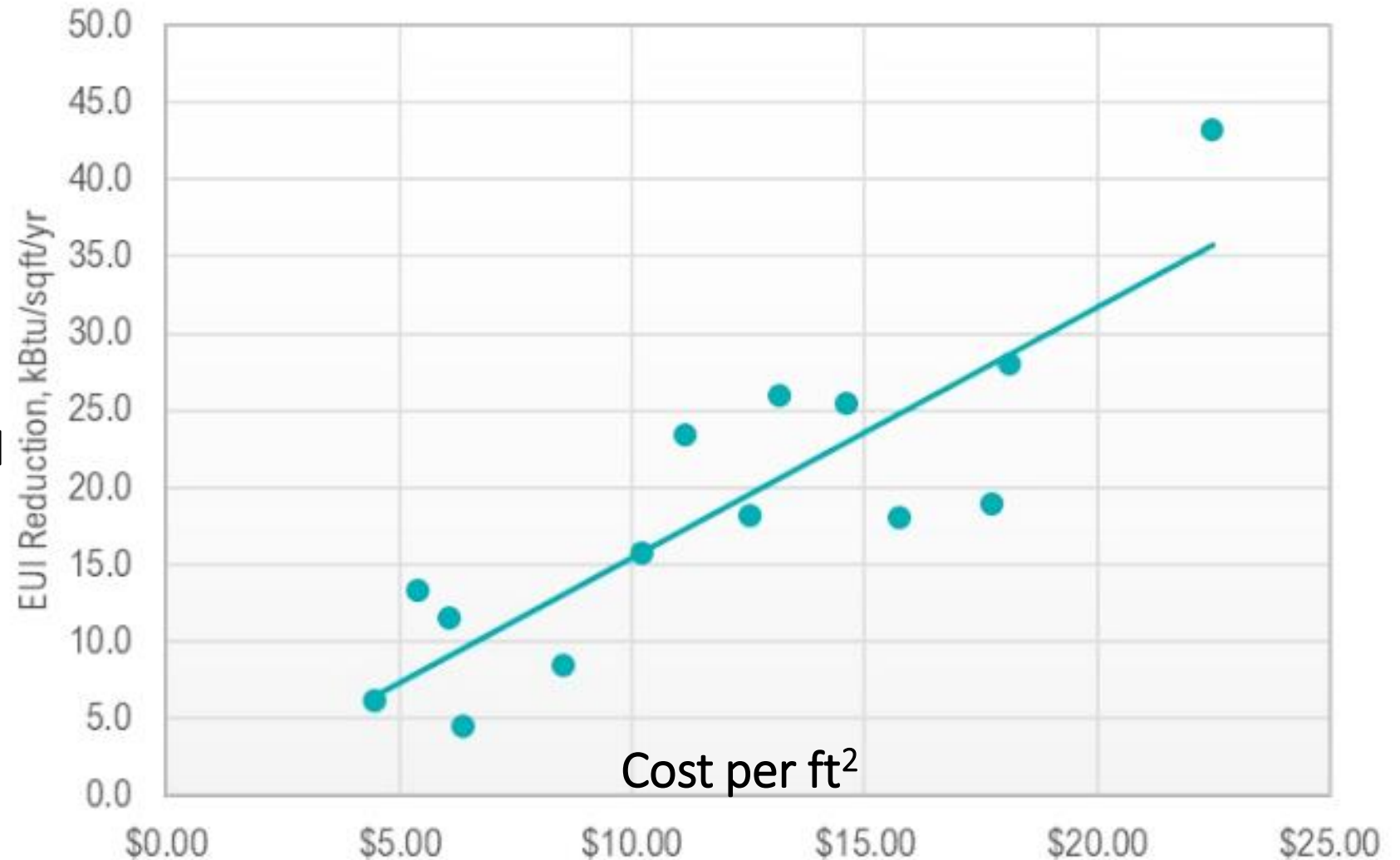
Costs

- These are *not* trivial.
- Real-world study of 16 local buildings

Required EUI reduction

Study courtesy of MacDonald Miller, Seattle, 2023

Project Cost per Square Foot Comparison



Potential Cost Reductions

Problems

1. Replacement heat pump system is big & expensive
2. Needs new electric service

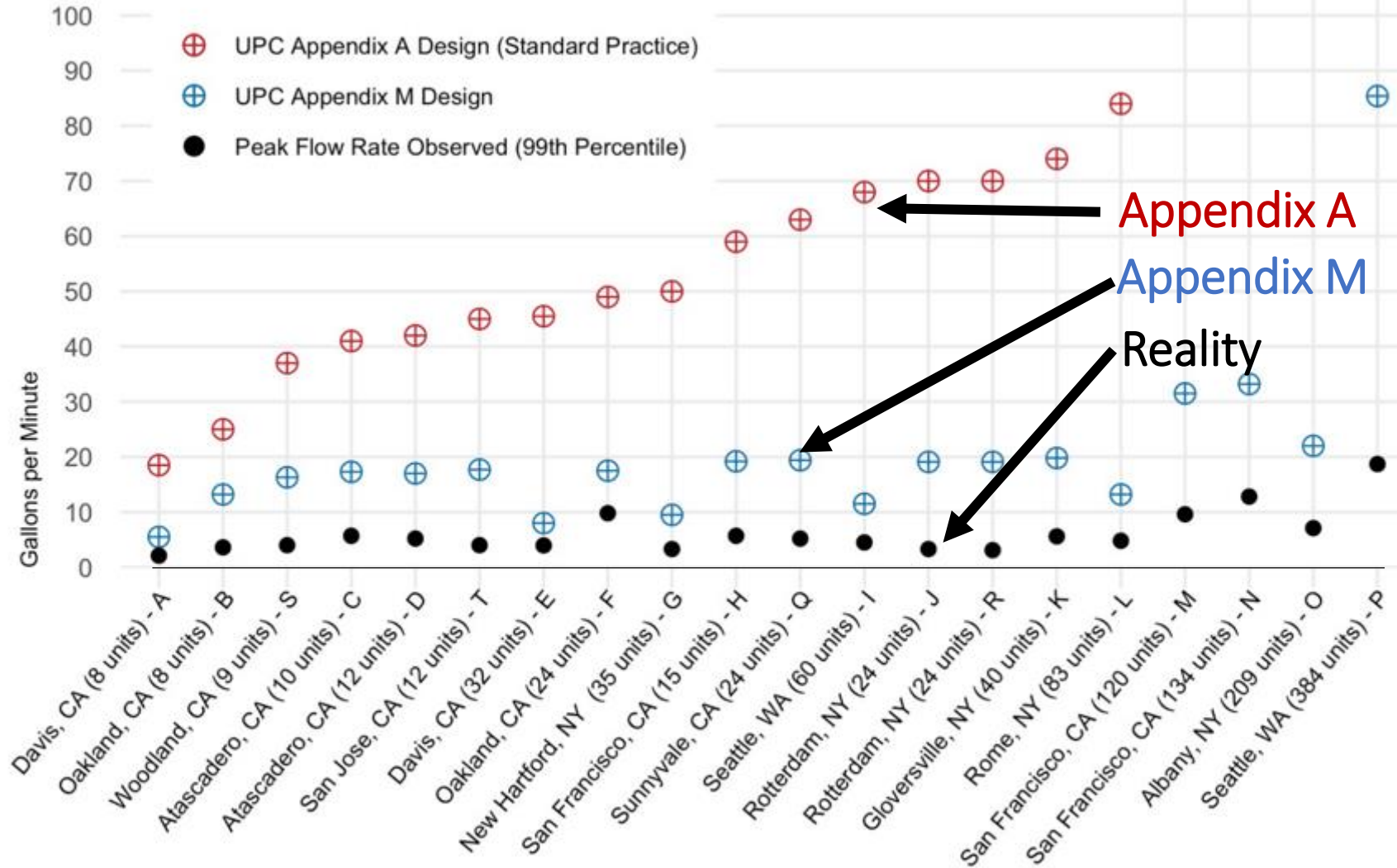
Solutions

1. Do you really need that much heating capacity? Are existing systems oversized?
2. Is metered building electric use as high as the default code assumption?
 - Electrical code allows metered peak + 25%

Image: Ecotope, Seattle 2023

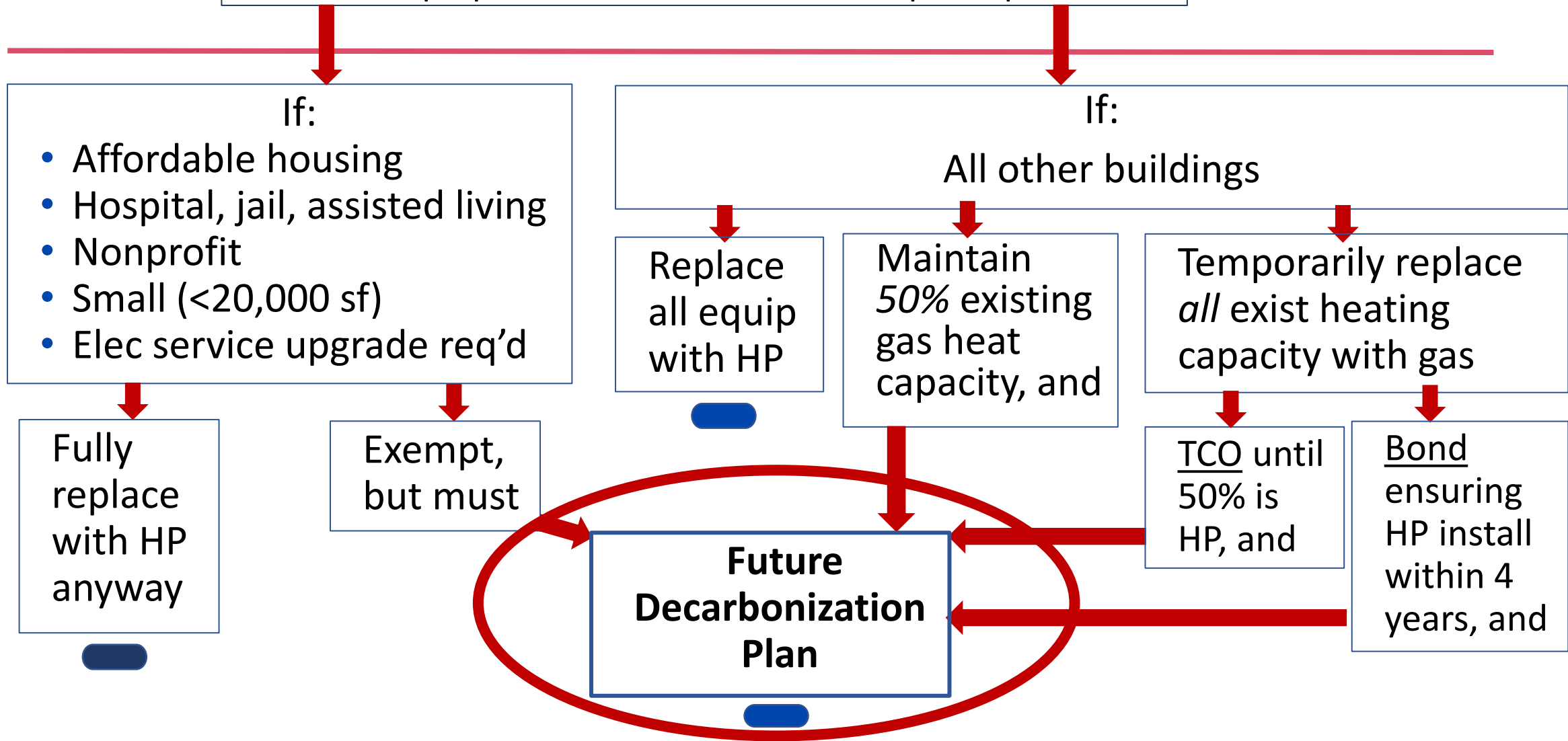
Comparing Design Predictions to Actual Peak Flow Rates

Peak Hot Water Flow Rates in Multifamily Buildings



Many thanks to the Association for Energy Affordability, Ecotope, Frontier Energy, Peter Skinner, and the UC Davis Western Cooling Efficiency Center for providing data.

Replacement central space heating equipment must be heat pump



Future Decarbonization Plan

Full engineered schematic design & cost estimate

- a. One-line system diagrams
- b. Equipment laid out to scale.
- c. Louvers, ducts, & air handling equipment
- d. Structural modifications
- e. Partitions & doors
- f. Electrical infrastructure
- g. Allowable roof coverage area & height
- h. Decarbonization planning form
- i. Schematic cost estimate
- j. Compliance dates for WA & Seattle Building Performance Standards

Decarbonization Planning Form
Jonlin Jan 17, 2023 version

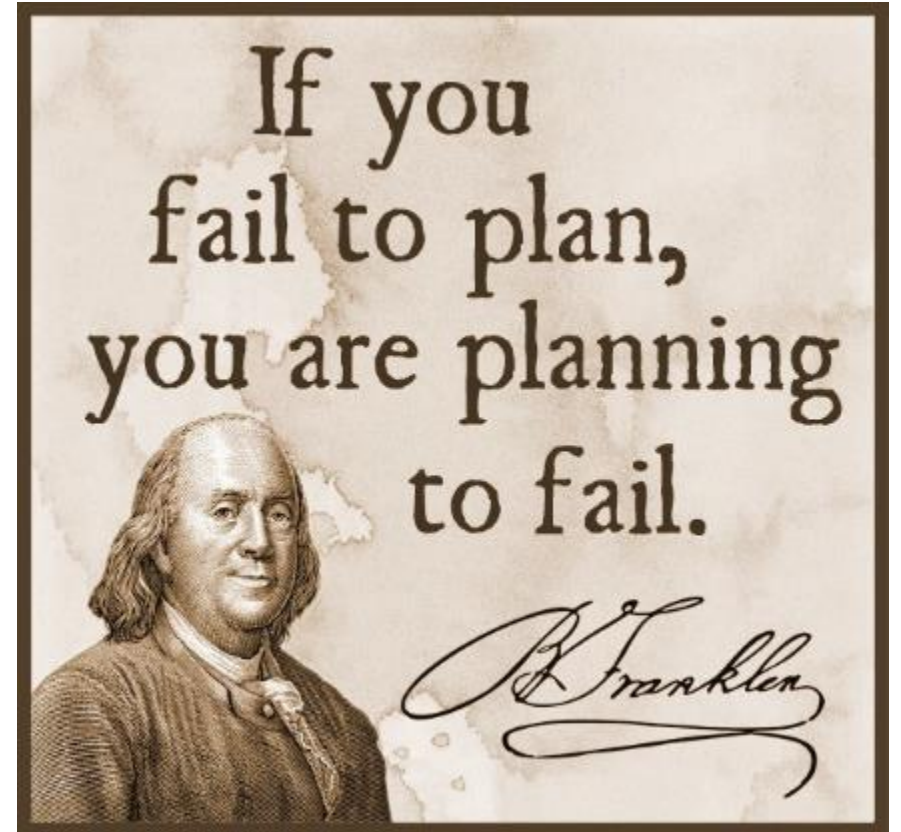
Requirement	Project Information
Prof Engineer name & firm name	
Project address	
Mechanical permit no. and date	
Electrical permit no. and date	
Building permit no. and date	
Submittal date of this form	
Conditioned floor area of building	
Number of stories above grade plane	
Existing building electrical service capacity	
For projects replacing existing central space heating equipment:	
Existing fossil fuel central space heating capacity	
Required primary heat pump system capacity to comply with C403.1.4	
Estimated full cost to owner for full electrification of space heating	
Location of primary heating appliances in building (basement, roof, etc.)	
Required electrical service capacity for full electrification of space heating	
For projects replacing existing central service water heating equipment:	
Existing fossil fuel central service water heating capacity	
Required primary HPWH capacity to comply with C404.2.1	

BPS collision with code? Not really.

Building Type	2018 SEC EUI (guess)	12% lower (2021 SEC target)	Best local examples	2030 Target EUI	WA BPS target
High-rise office	38	33	37	28	63-69
Mid-rise office	34	30	16, 21	22	63-69
Mid-rise multifamily	32	28	17, 19	20	--
Elementary school	28	25	16, 18 - 20	19	49
Warehouse, conditioned	18	16		12	36

BEPS & Code: Two paths, same destination

- BEPS sets date certain for decarbonization
- Energy code requires heat pump as systems are replaced
 - with options to postpone
- Postpone, or not, based upon:
 - Construction cost: Pay me now
 - Years until BPS or BEPS would mandate upgrade anyway: Pay me later



Cooling system alterations C503.4.1

- When adding cooling to an “uncool” space, must provide either DOAS or economizer, both at the individual equipment level and the total system level
- Alteration or replacement of cooling system: Table C503.4 - Economizers

Table C503.4.3

Economizer Compliance Options for Mechanical Alterations

	Option A	Option B (alternate to A)	Option C (alternate to A)	Option D (alternate to A)
Unit Type	Any alteration with new or replacement equipment	Replacement unit of the same type with the same or smaller output capacity	Replacement unit of the same type with a larger output capacity	New equipment added to existing system or replacement unit of a different type
1. Packaged Units	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b
2. Split Systems	Efficiency: min. ^a Economizer: C403.5 ^b	For units ≤ 60,000 Btuh, comply with two of two measures: 1. Efficiency: + 10% ^d 2. Economizer: shall not decrease existing economizer capability	For units ≤ 60,000 Btuh replacing unit installed prior to 1991 comply with at least one of two measures: 1. Efficiency: + 10% ^d 2. Economizer: 50% ^f	Efficiency: min. ^a Economizer: C403.5 ^b
		For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	

Important Exception:

If you upgrade from gas to heat pump, even though it’s adding cooling, it will not constitute a “change in space conditioning”

Seattle: Air cooled chiller replacement

Must replace air-cooled chiller with heat pump system serving as first stage of heating.

- Exempt buildings
- Exempt system types

C503.4.3.1 Addition of new or replacement of existing air-cooled chiller systems. Where one or more air-cooled chillers are added or replaced, and the existing HVAC heating equipment is included in one of the categories listed below and is fossil fuel-fired or electric resistance, the replacement cooling appliance shall be an electric heat pump system in compliance with Section C403.1.4, integrated with the existing HVAC heating system and configured to serve as the first stage of heating when conditions permit use of the fluid temperatures produced by the heat pump system, with the existing fossil fuel-fired or electric resistance HVAC heating equipment serving as supplemental heat. Additions, alterations, or replacements shall not be made to an existing HVAC heating system that will cause the system to become out of compliance.

Exceptions .

1. Exempt buildings and occupancies. The new heat pump is not required to serve as the first stage of heating if it serves any of the following building categories and the requirements of Section C503.4.6.2 are met.

- Affordable housing*
- Group I-1, I-2, and I-3 occupancies
- Buildings with more than 50 percent of conditioned floor area occupied by organizations recognized as nonprofit by the State of Washington or by federal tax law
- Buildings with no more than 20,000 square feet of conditioned floor area

2. Exempt systems. The new heat pump is not required to serve as the first stage of heating if it serves any of the following system types, and the requirements of Section C503.4.6.2 are met.

- Steam heating systems, including replacement of existing steam boilers with steam distribution piping to terminal units and replacement of the existing associated boiler feed equipment.
- Terminal unit equipment including but not limited to electric resistance VAV boxes, electric duct heaters, electric resistance fan coils, or electric resistance heaters.
- Dedicated chillers serving only spaces that have no heating loads and are not served by heating equipment, including but not limited to data centers.**



Adding cooling: a sticky situation



New & replacement heating systems Seattle

C503.4.6 Addition or replacement of HVAC heating appliances. New HVAC heating systems shall comply with Section C403.1.4. Where one or more HVAC mechanical heating appliances are added or replaced, the added or replaced appliances shall comply with Section C403.1.4 or with an alternate compliance option in Table C503.4.6. When complying with the alternate compliance option in Table C503.4.6, added or replaced HVAC heating appliances must select HVAC heating appliances from one of the Proposed Heating Type Options and the applicable Heating Efficiency Tables. Additions, alterations, or replacements shall not be made to an existing HVAC heating system that will cause the existing system to become out of compliance.

1. Exempt buildings and occupancies. Replacement heating equipment serving any of the following building categories is permitted to use the same fuel type as the existing equipment, provided the replacement equipment complies with the minimum efficiency in Table C503.4.6 and the same or lower capacity than the existing, and that the requirements of Section C503.4.6.2 are met.

1. *Affordable housing*
2. Group I-1, I-2, and I-3 occupancies
3. Buildings with more than 50 percent of conditioned floor area occupied by organizations recognized as nonprofit by the State of Washington or by federal tax law
4. Buildings with no more than 20,000 square feet of conditioned floor area

New heating system, cont.

2. Retention of portion of existing system capacity. For buildings not exempted by Exception 1 above, a maximum of 50 percent of the existing fossil fuel or electric resistance heating capacity is permitted to be retained or replaced to serve as supplemental heat for the new heat pump heating system, provided that the supplemental heat is controlled to be used only when the heat pump system capacity is insufficient to meet the load, in compliance with the applicable Exception 5, 6, or 7 to Section C403.1.4, and that the requirements of Section C503.4.6.2 are met. **Where an alteration replaces less than 50 percent of the existing fossil fuel or electric resistance heating capacity, the remaining heating appliances are permitted to be retained.** Where the alteration project decreases the peak heating load, the fossil fuel or electric resistance heating capacity shall be limited to 50 percent of the calculated peak heating load. The replacement equipment shall comply with the minimum efficiency in Table C503.4.6.

3. Temporary replacement of failing equipment. Temporary like-for-like replacement of one or more heating appliances, in excess of the 50 percent capacity permitted by Exception 2 above, is permitted where those appliances require immediate replacement, and where no other work on the HVAC system is planned. When using this exception, it is acceptable to replace a single appliance with two or more smaller appliances, provided the total capacity is not greater than that of the original appliance. In addition, the requirements of Section C503.4.6.2 shall be met, and the applicant shall ensure completion of the required heat pump system in compliance with one of the following options.

- a. SDCI will issue a temporary certificate of occupancy (TCO), which will remain in force until the heat pump heating system is installed and the final inspection of the system has been completed.
- b. Applicant shall post a performance bond in the amount of the full estimated cost of installation of the required heat pump system, to ensure completion of the heat pump system within 48 months.

New heating system, cont.

4. Utility service upgrade. Compliance with Section C403.1.4 is not required where the requirements of Section C503.4.6.2 are met, and where such compliance would trigger an unplanned utility electrical service upgrade, based on the Seattle Electrical Code Section 220.87 method for determining existing loads, where one or more of the following is required:

- a. A new utility transformer vault located in the existing building or on the site, or an enlargement of the floor area of such a vault.
- b. Trenching across the vehicle lanes of a public way.
- c. The estimated construction cost for the required electrical service enlargement exceeds 50 percent of the project valuation for the remainder of the work, as determined in accordance with the *fee subtitle*. Construction cost shall be documented by an AACE **Class 3** or equivalent cost estimate, including required demolition, construction, site work, and utility fees.

The replacement equipment shall comply with the minimum efficiency in Table C503.4.6.

5. Exempt equipment. Alterations to the following equipment types are not required to comply with this section.

- a. Terminal unit equipment including but not limited to hydronic VAV terminal units, electric resistance VAV boxes, electric duct heaters, water source heat pumps, fan coils, or VRF indoor units, except such modifications to terminal equipment with hydronic heating coils as are required to accommodate lower-temperature fluids circulated from new central heat pump systems in accordance with Section C403.3.8.2.
- b. Air handling equipment with hydronic heating coils, except such modifications to the air handling equipment as are required to accommodate lower-temperature fluids circulated from central heat pump systems in accordance with Section C403.3.8.2.
- c. Replacement of existing steam boilers with steam distribution piping to terminal units and replacement of the existing associated boiler feed equipment.

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 not much equipment yet



HB1112, Refrigerants

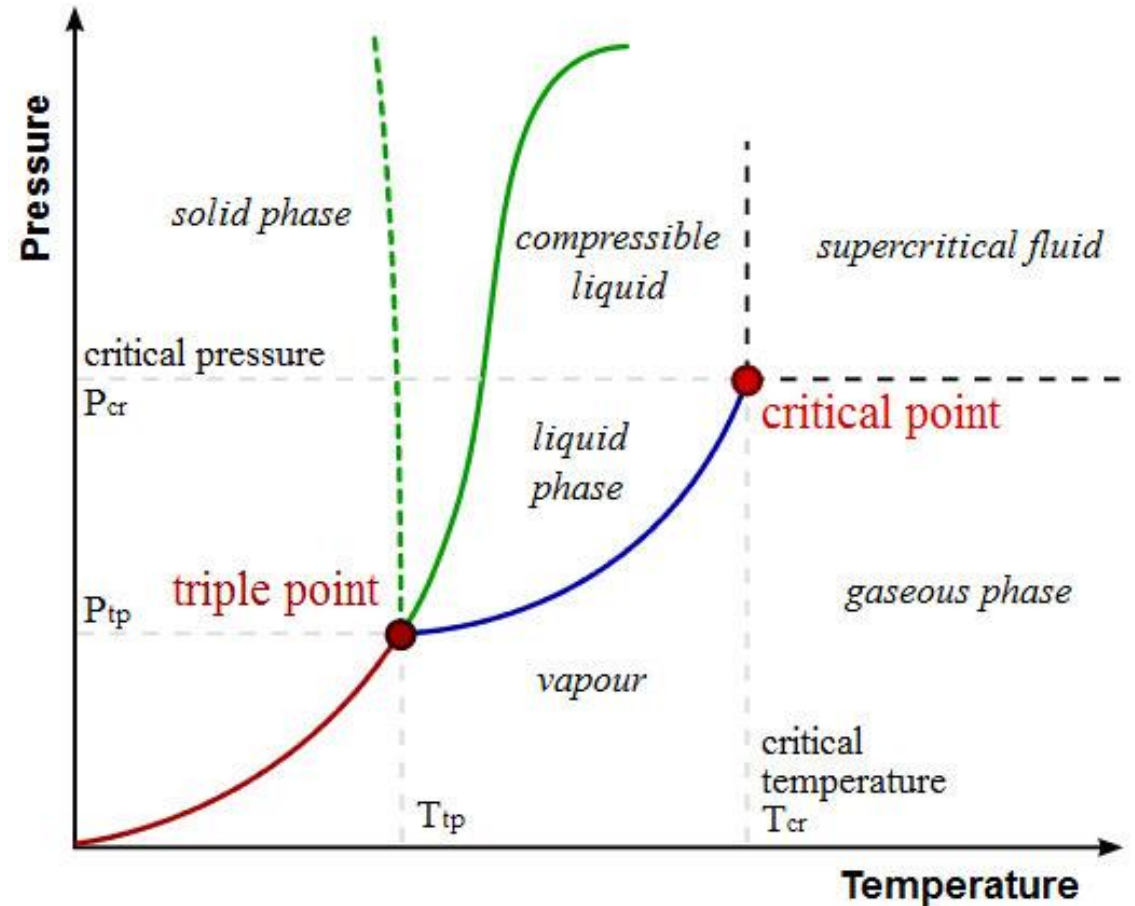
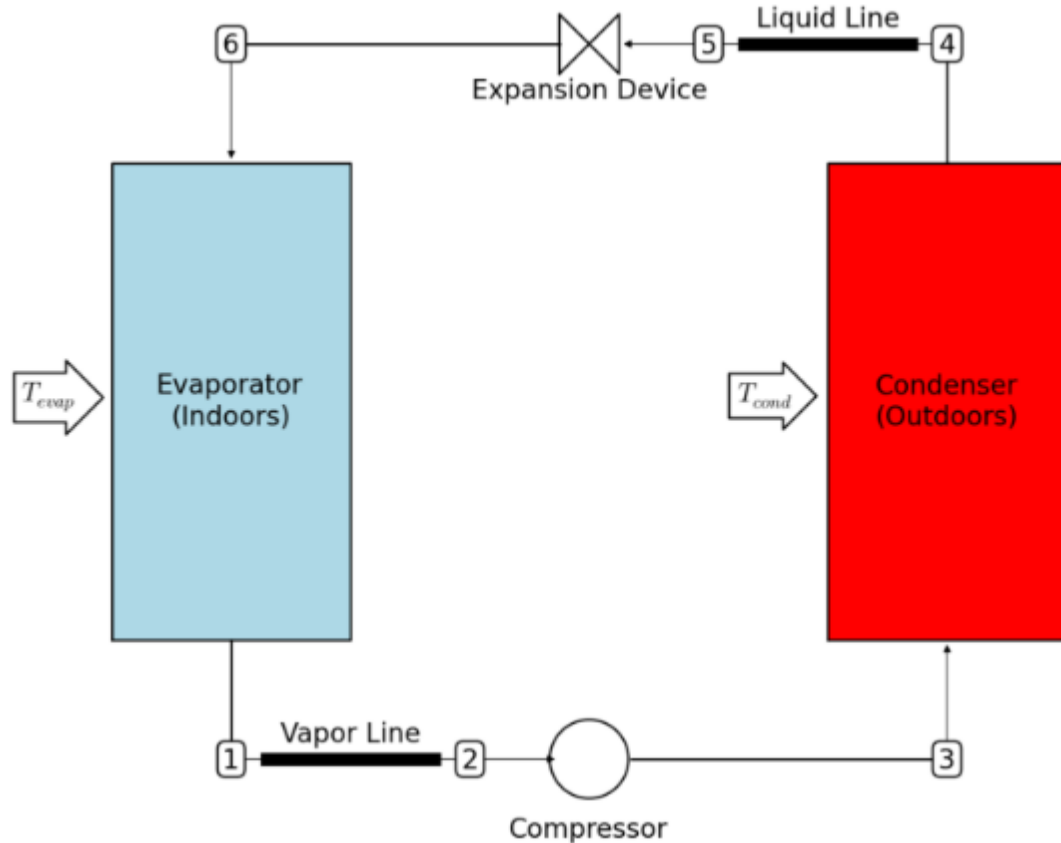


Refrigerant	ODP	GWP	Common Building Applications
Chlorofluorocarbons			
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air-conditioning, chillers
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	- 0	12,240	Ultra-low-temperature refrigeration
HFC-134a	- 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	- 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	- 0	3,900	Low-temperature refrigeration
HFC-407C	- 0	1,700	HCFC-22 replacement
HFC-410A	- 0	1,890	Air-conditioning
HFC-507A	- 0	3,900	Low-temperature refrigeration
Natural refrigerants			
Carbon dioxide (CO ₂)	0	1.0	
Ammonia (NH ₃)	0	0	
Propane	0	3	

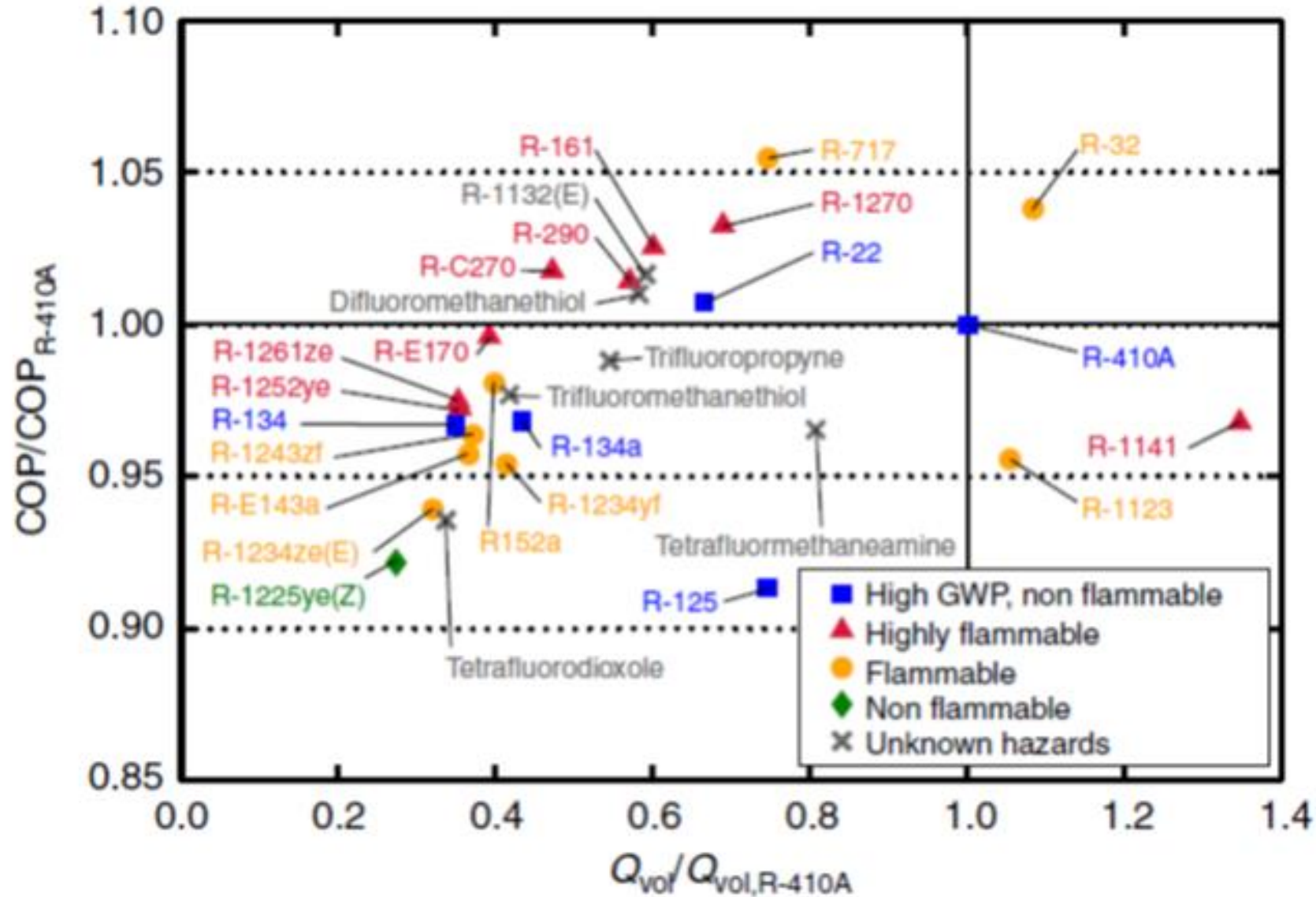
HB1112, Refrigerants



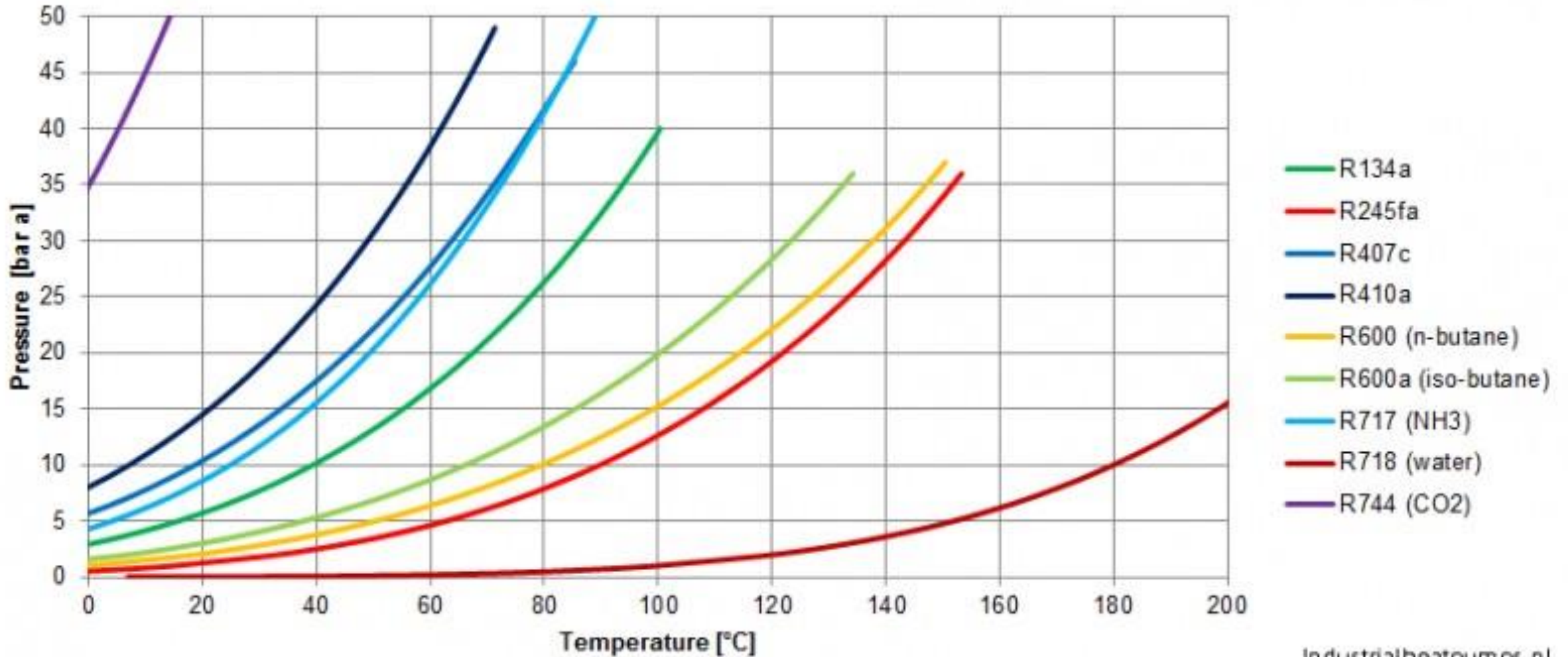
Refrigeration Cycle



HB1112, Refrigerants



HB1112, Refrigerants



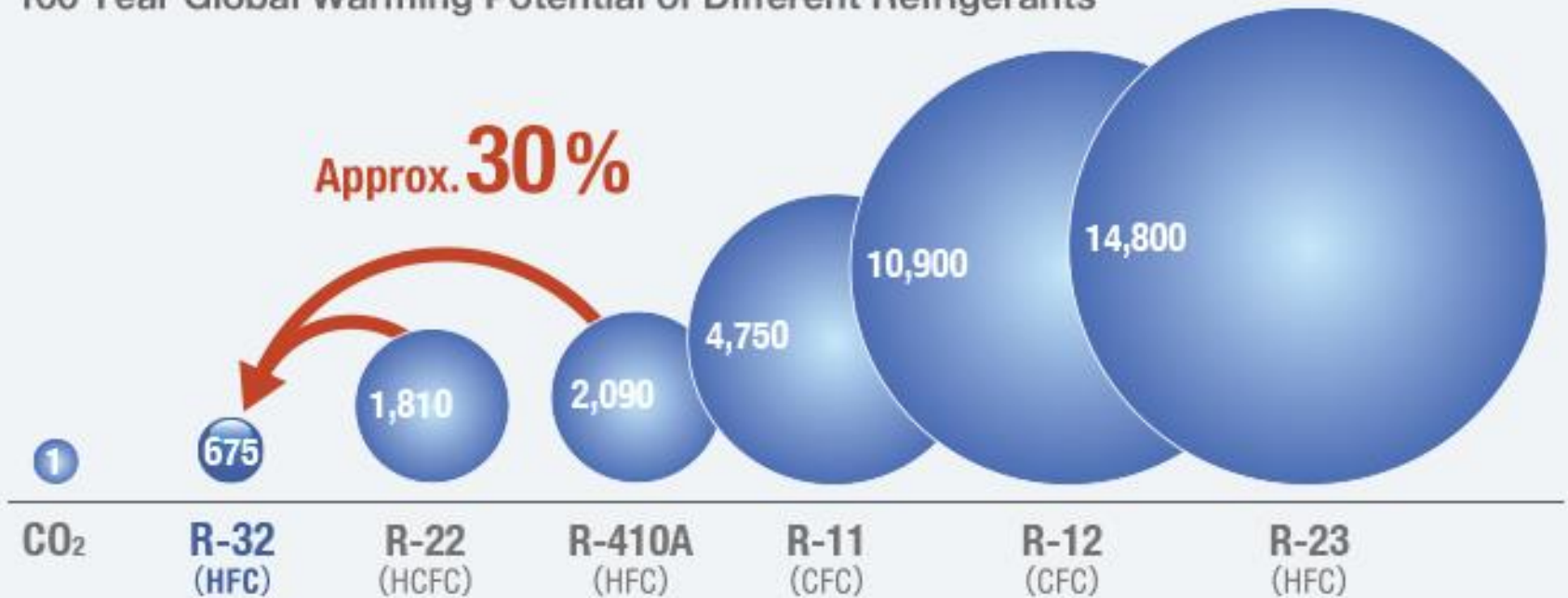
Industrialheatpumps.nl

HB1112, Refrigerants



Approximately
10%
Reduction
in Electricity
Consumption

100 Year Global Warming Potential of Different Refrigerants*



*Source: Values for 100 year global warming potential (GWP) from IPCC Fourth Assessment Report. Comparative 100 year GWP: HFC410A, 2,090; HFC32, 675.

HB1112, Refrigerants



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(But wait, there's more!)



Upcoming 2021 Code Update Deliveries

Webinar Topic	Delivery Date	Time
<u>Water heating</u>	May 30	10:00 – 11:00
<u>Alterations, Heat Pump Upgrades</u>	June 6	10:00 – Noon
<u>Lighting, Electric & Solar</u>	June 13	10:00 - Noon

Today's slide deck and video recording can be found on
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