lighting design lab

The 2021 Energy Code: HVAC

Presented by

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March 20, 2025

Seattle City Light

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What Is This “Lighting Design Lab”?

- Seattle City Light's go-to resource for lighting and lighting controls since 1989 – 30+ years
- Formed by BPA and NW utilities to fill education needs for the transforming market
- Now expanded to include resources that support whole buildings
- Being rebranded!

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Upcoming Events

Course	Day	Time
Don't Be Burned by Boiler Decarb Retrofits	Tue April 1	10:00-11:00 a.m.
2021 WA & Seattle Commercial Energy Codes: **Water Heating**	Thu April 17	10:00-11:30 a.m.
2021 WA & Seattle Commercial Energy Codes: **Alterations**	Thu May 15	10:00-11:30 a.m.

Open Soon!

Event	Day	Time
Seattle City Light Trade Ally Office Hours	Fri Mar 21	9:00 a.m.

Stay up-to-date at LightingDesignLab.com and by subscribing to our newsletter.

The 2021 Energy Code

HVAC

Seattle City Light

Lighting Design Lab

March 2025

Ben Roush, Principal, PE-ME, FPE, LEED AP BD+C,

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

Mechanical & FP Engineer

Board Chair Emeritus, USGBC-MD

USGBC E&A TAG Vice Chair (yay v5! Go vote)

AIA MD COTE Chair

Sustainable Mechanical Engineering

Energy Modeling and Auditing

150+ LEED Projects

2 Certified Living Buildings

11 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.

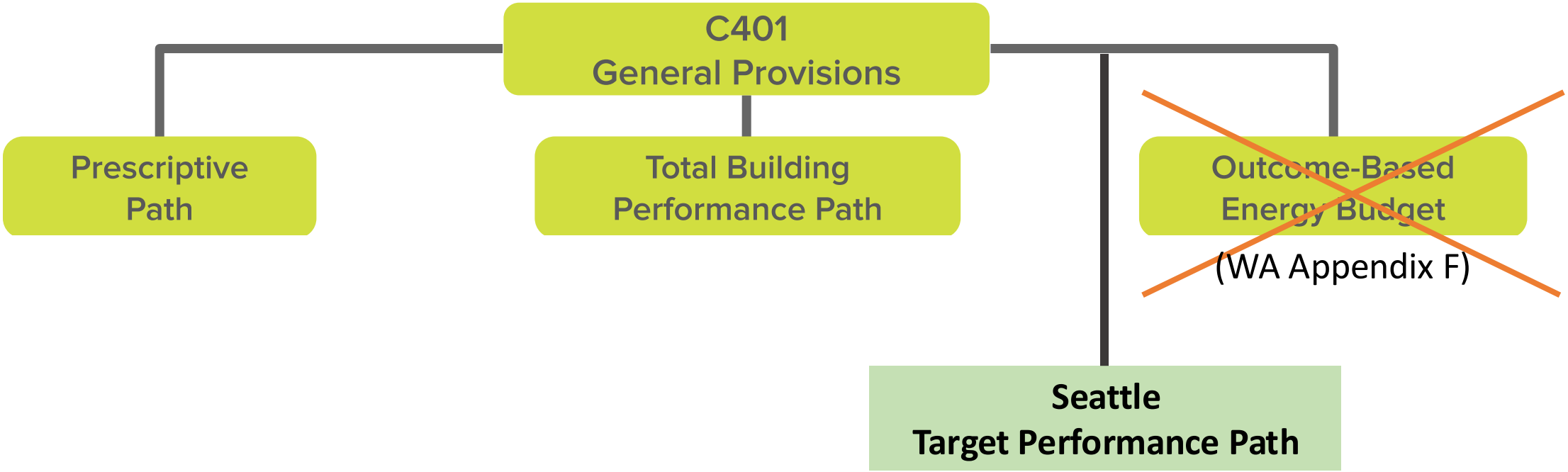
What belongs on our HVAC Top 10 list?

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

<u>+ Special Occupancies</u>

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

Code Paths


C401
General Provisions
Prescriptive Path
Total Building Performance Path
Outcome-Based Energy Budget
(WA Appendix F)
Seattle
Target Performance Path

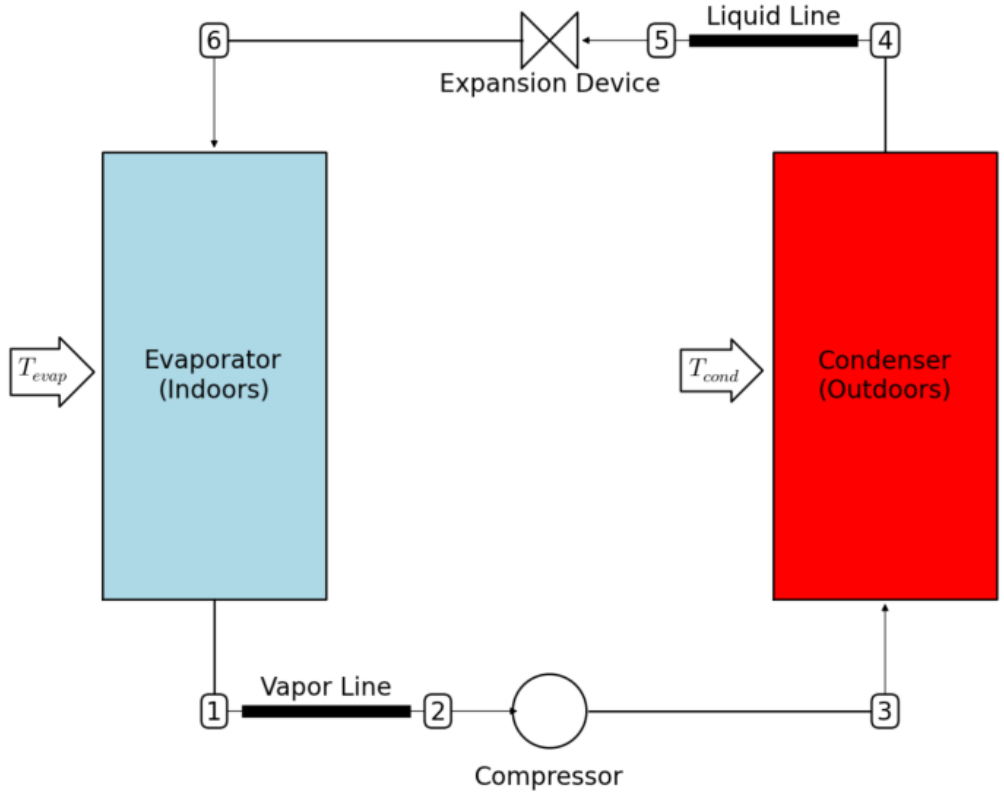
Engineering Terms

Heat Pump

Performance

COP

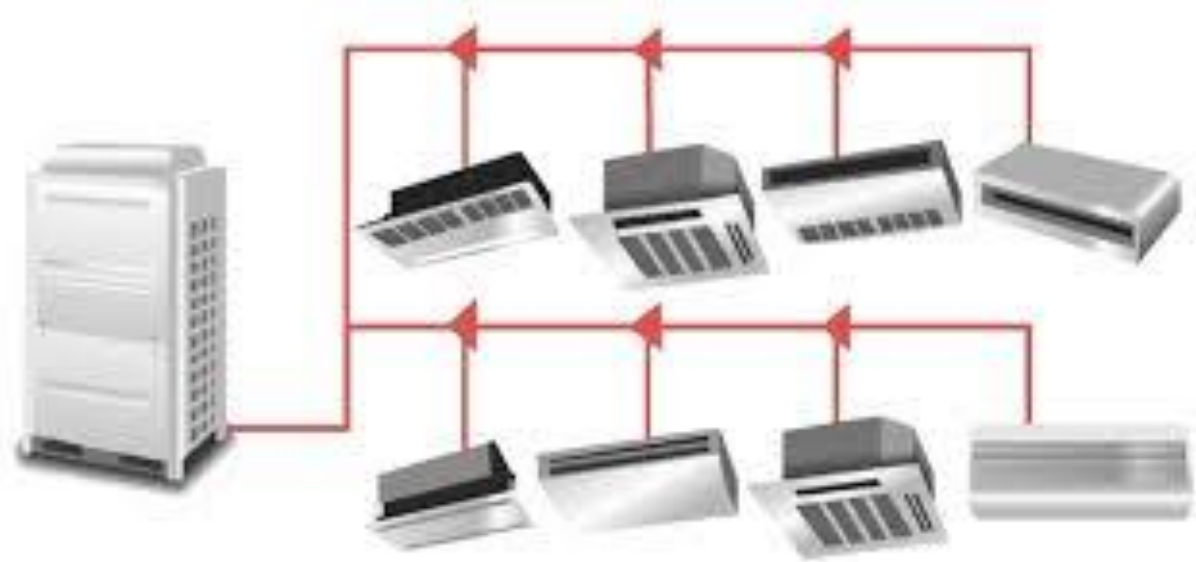
Resistance:
1kW in=1kW Work Out



Refrigeration cycle:
1kW in=3kW Work Out

Heat Pump Layout

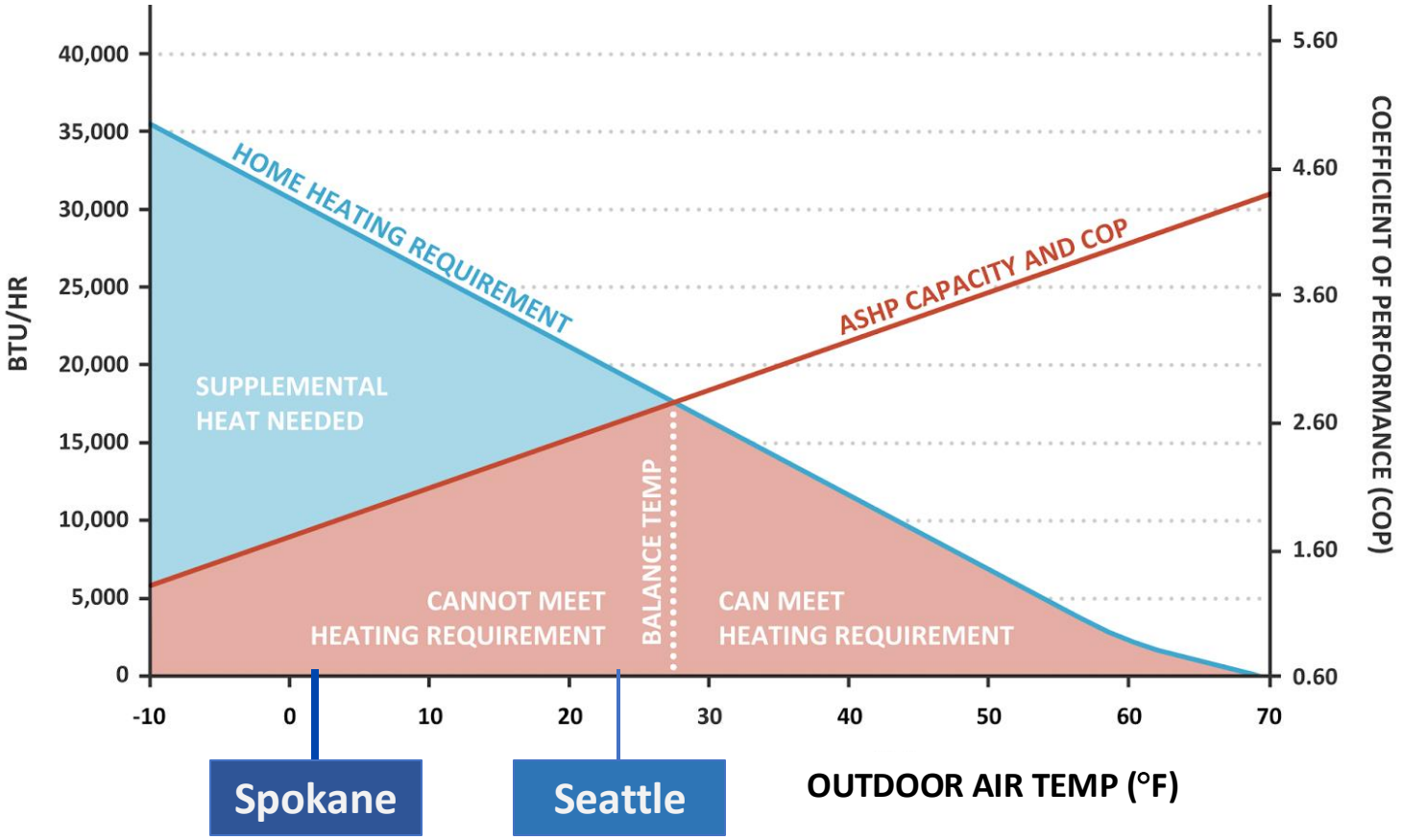
Heat Pump Layout, variable speed



Engineering View, Limitations

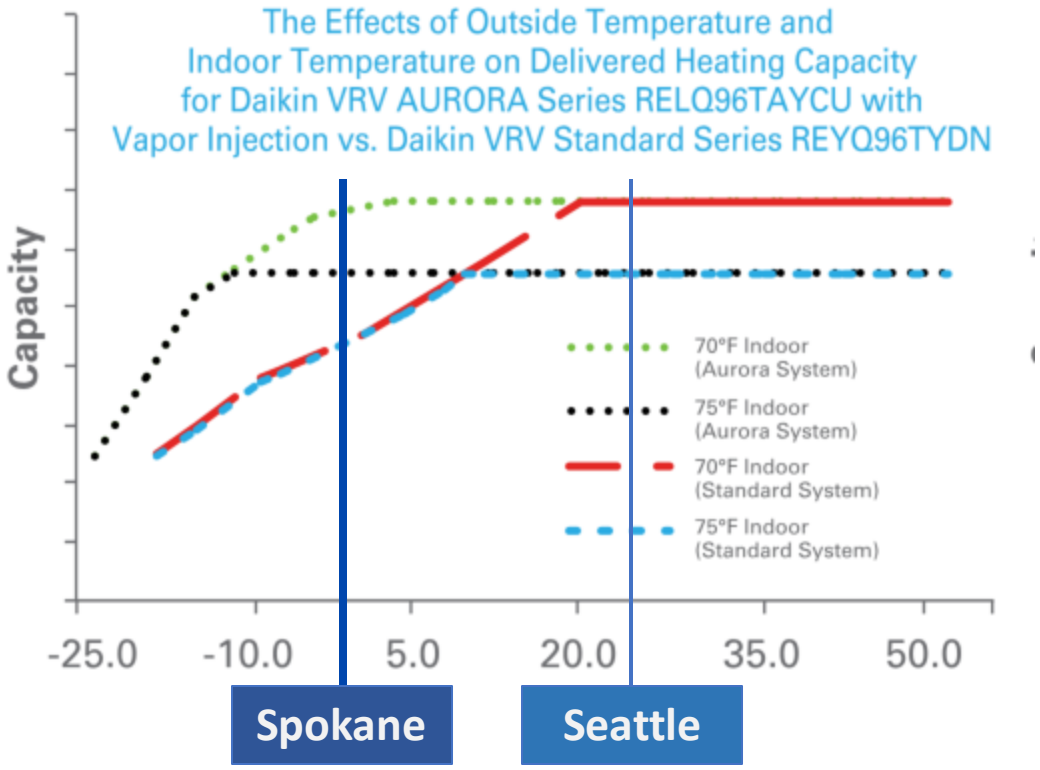
Heat Pump Performance, Cold Temp Impacts (cheap version)

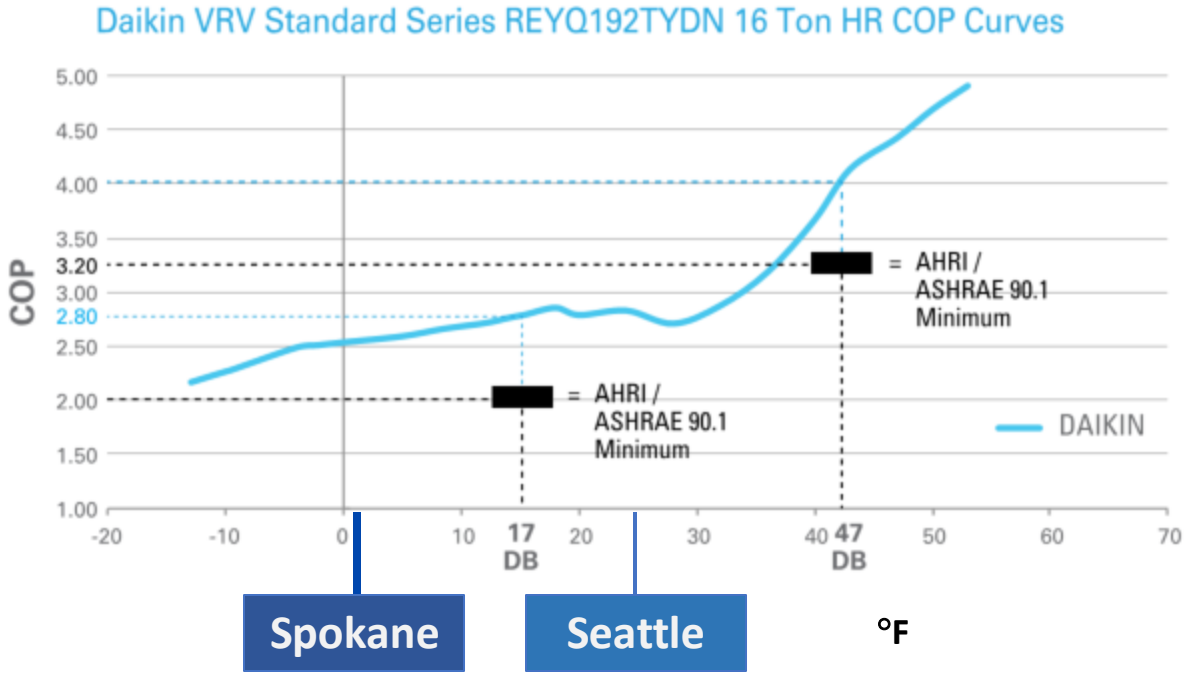
Performance of typical 2-ton air-source heat pump



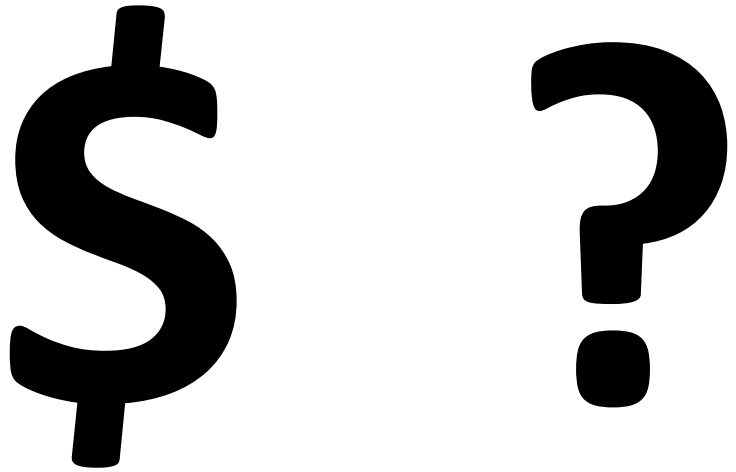
Engineering View, Less Limitations

Variable Speed Version



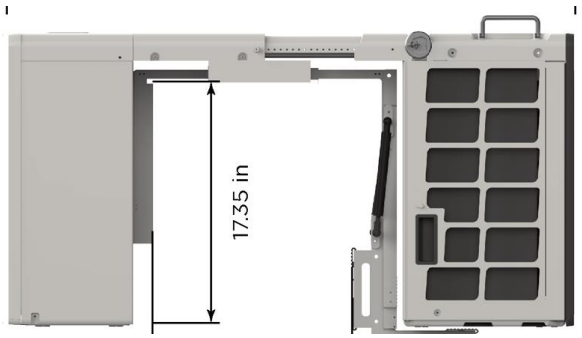


Engineering View, Cost

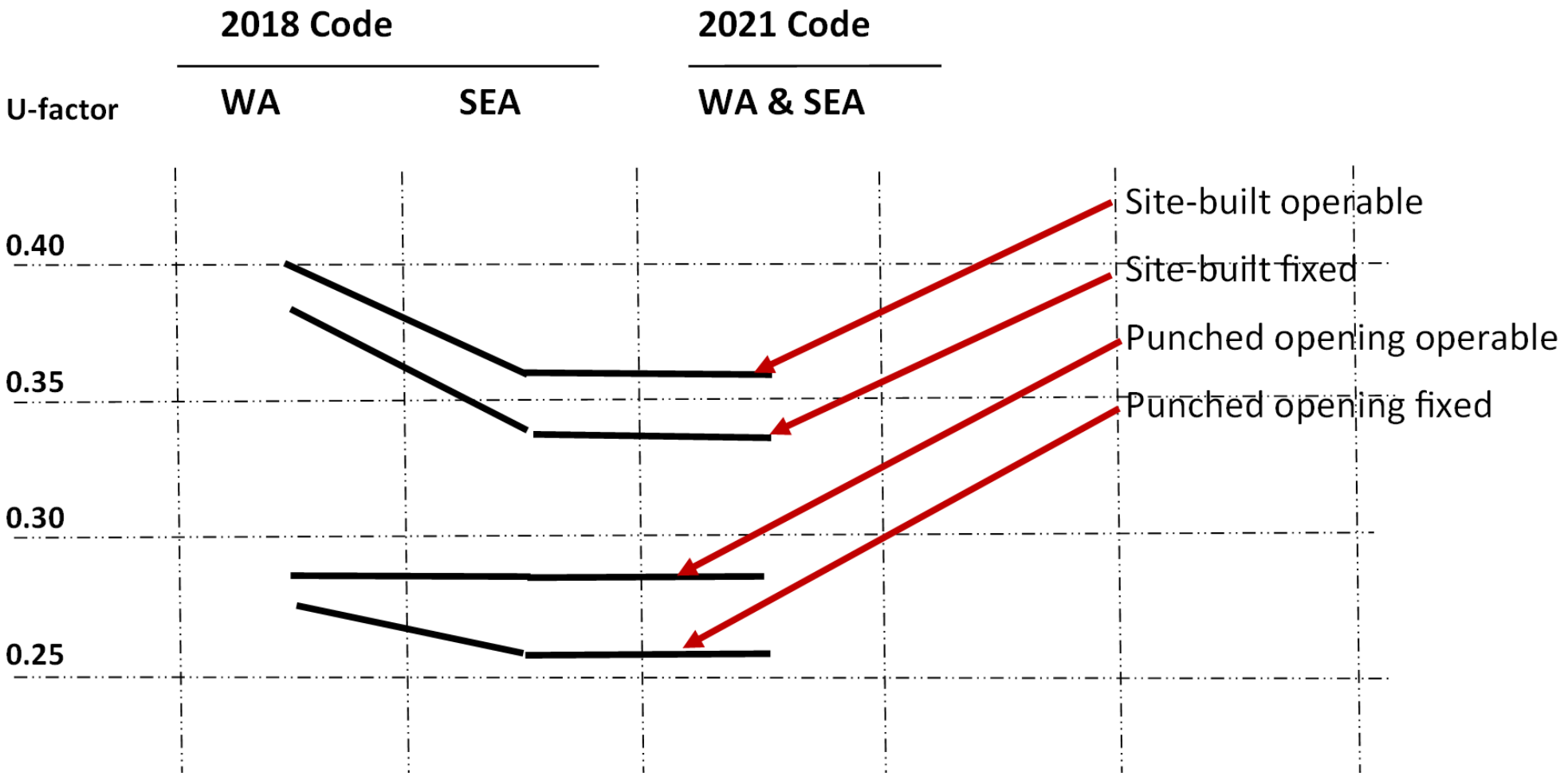


Sea & WA: Envelope U-value of PTAC/PTHP C402.1.3

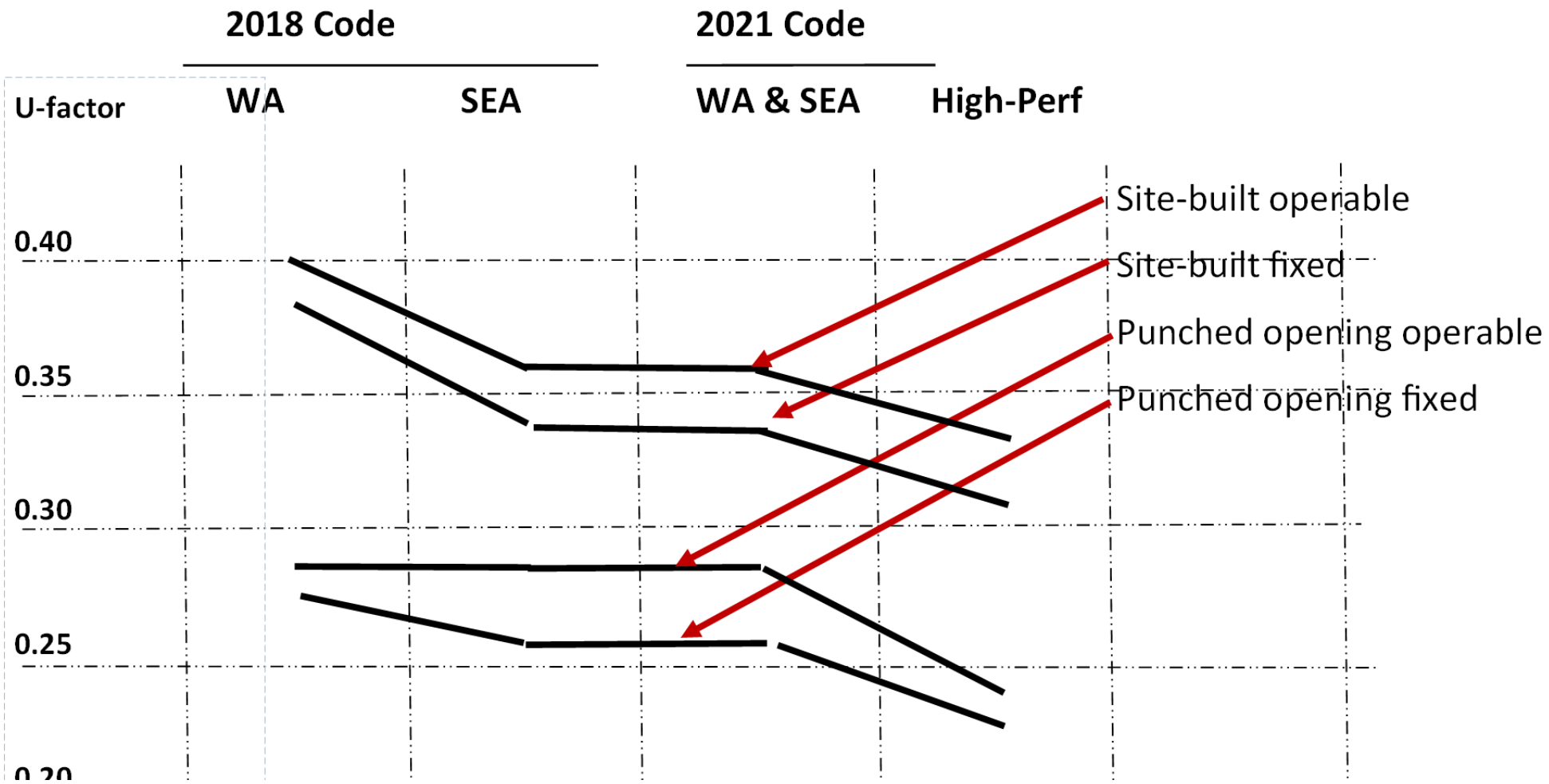
- Conventional PTAC & PTHP units leak heat & leak air badly
- Through-wall mech units assigned default value of **U-0.500**
  - Unless mfr has tested U-value
  - (wood framed wall is **U-0.051**)



Fenestration U-factors



High-Performance U-Factors



WA & Seattle Air Barrier Testing

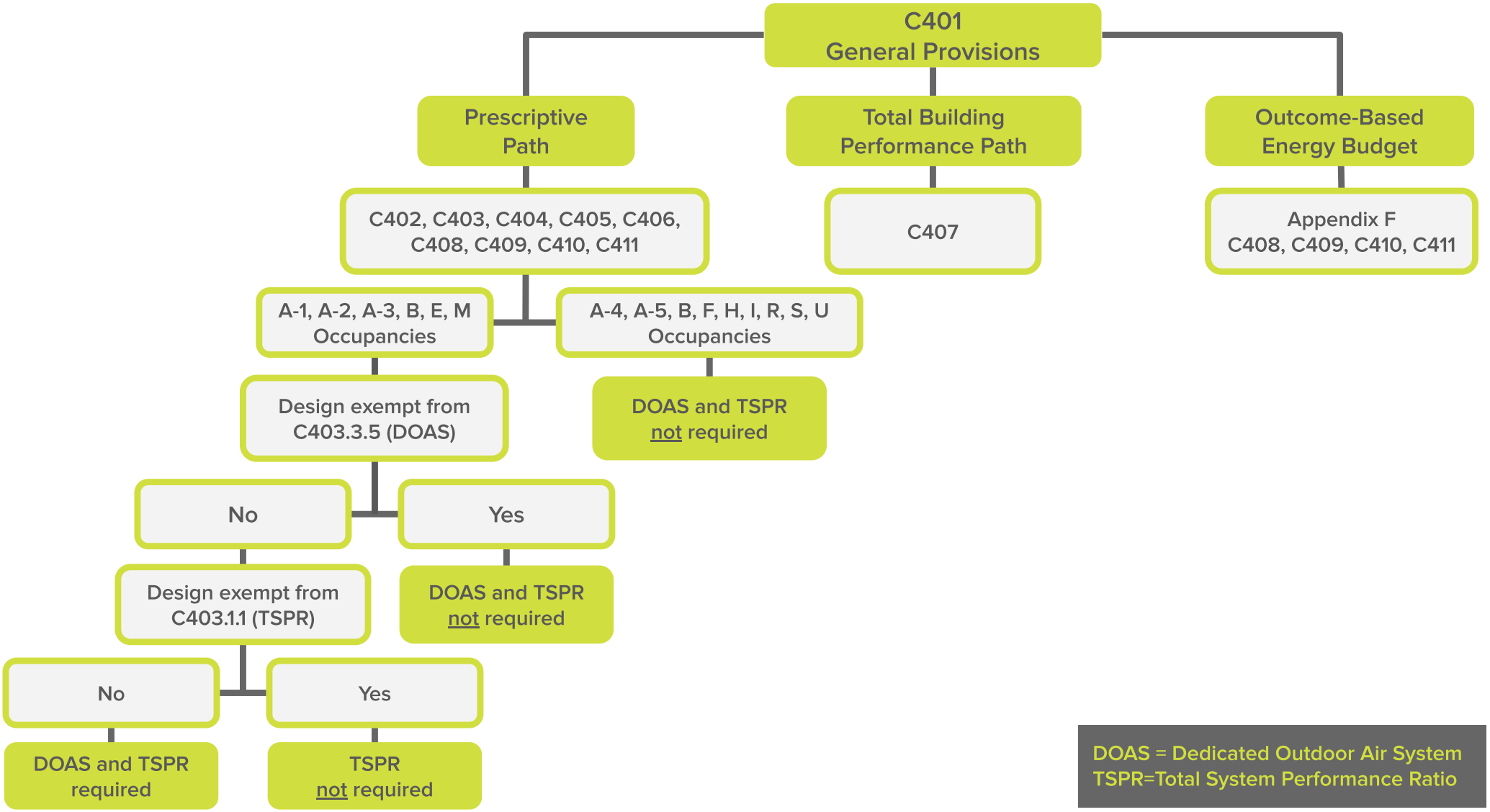
Q: Do your HVAC design calcs still assum 1.0 cfm leakage?

- Test standard 0.25 cfm/sf of envelope
- Passing test now mandatory
  - …at 0.25 cfm/sf
- …and Seattle U-factors are close to Minnesota's

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

Mechanical Changes

Largely unchanged mech efficiencies

Mechanical Controls

DOAS Clarifications

Total System Performance Ratio

C407 changes

Table C403.4.11.1

DDC Applications and Qualifications

Building Status	Application	Qualifications
New building		
	Air-handling system and all zones served by the system	Individual systems supplying more than three zones and with fan system bhp of 10 hp and larger
	Chilled-water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design cooling capacity of 300,000 Btu/h and larger
	Hot-water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design heating capacity of 300,000 Btu/h and larger
Alteration or addition	Zone terminal unit such as VAV box	Where existing zones served by the same air-handling, chilled-water, or hot-water system have DDC
	Air-handling system or fan coil	Where existing air-handling system(s) and fan coil(s) served by the same chilled- or hot-water plant have DDC
	New air-handling system and all new zones served by the system	Individual systems with fan system bhp of 10 hp and larger and supplying more than three zones and more than 75 percent of zones are new
	New or upgraded chilled-water plant	Where all chillers are new and plant design cooling capacity is 300,000 Btu/h and larger
	New or upgraded hot-water plant	Where all boilers are new and plant design heating capacity is 300,000 Btu/h and larger

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.

Seattle Department of Construction & Inspections

Pacific Northwest NATIONAL LABORATORY

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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

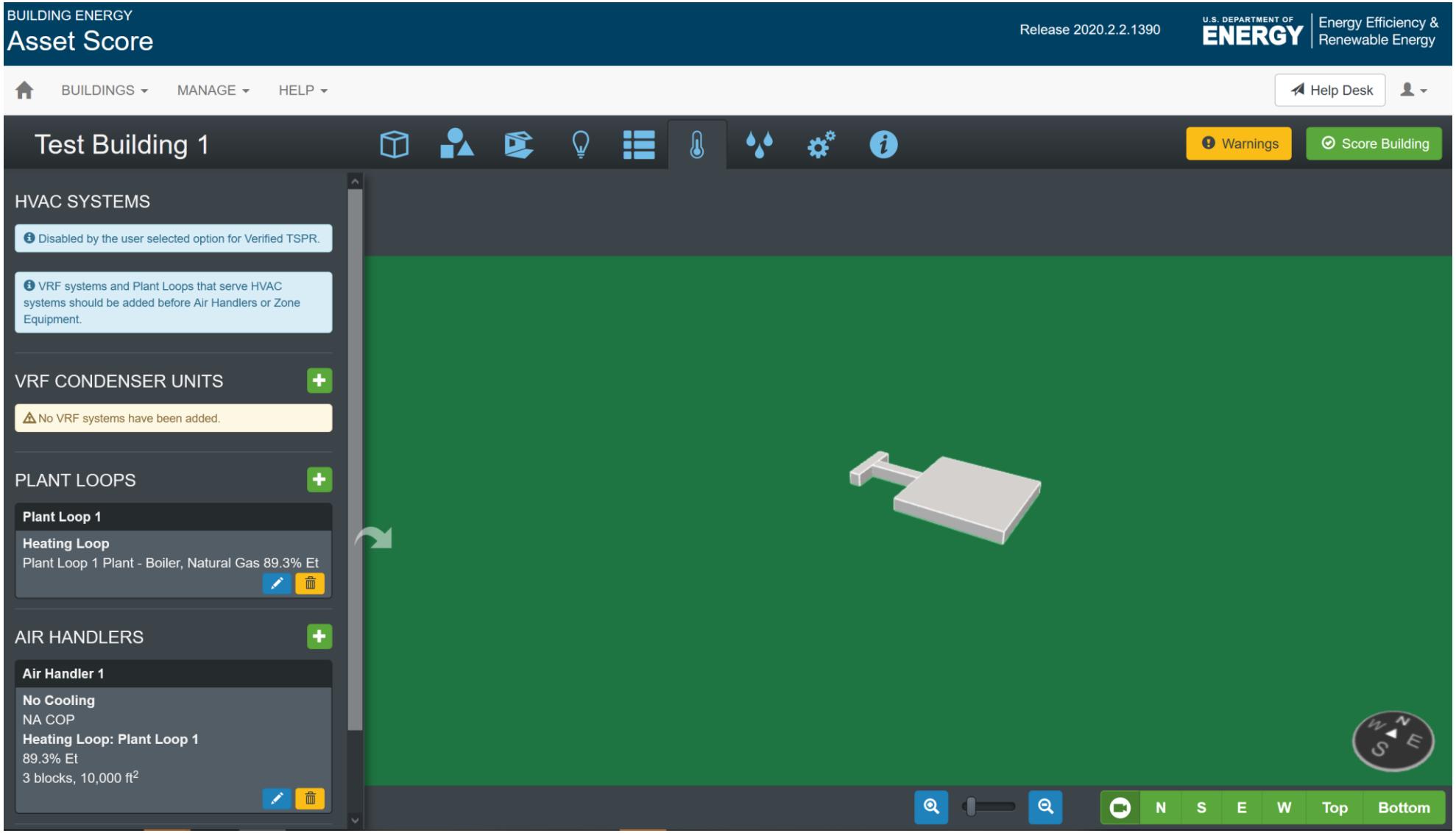
Free online calculation tool from PNNL

Clarifying TSPR table – what's in, what's out

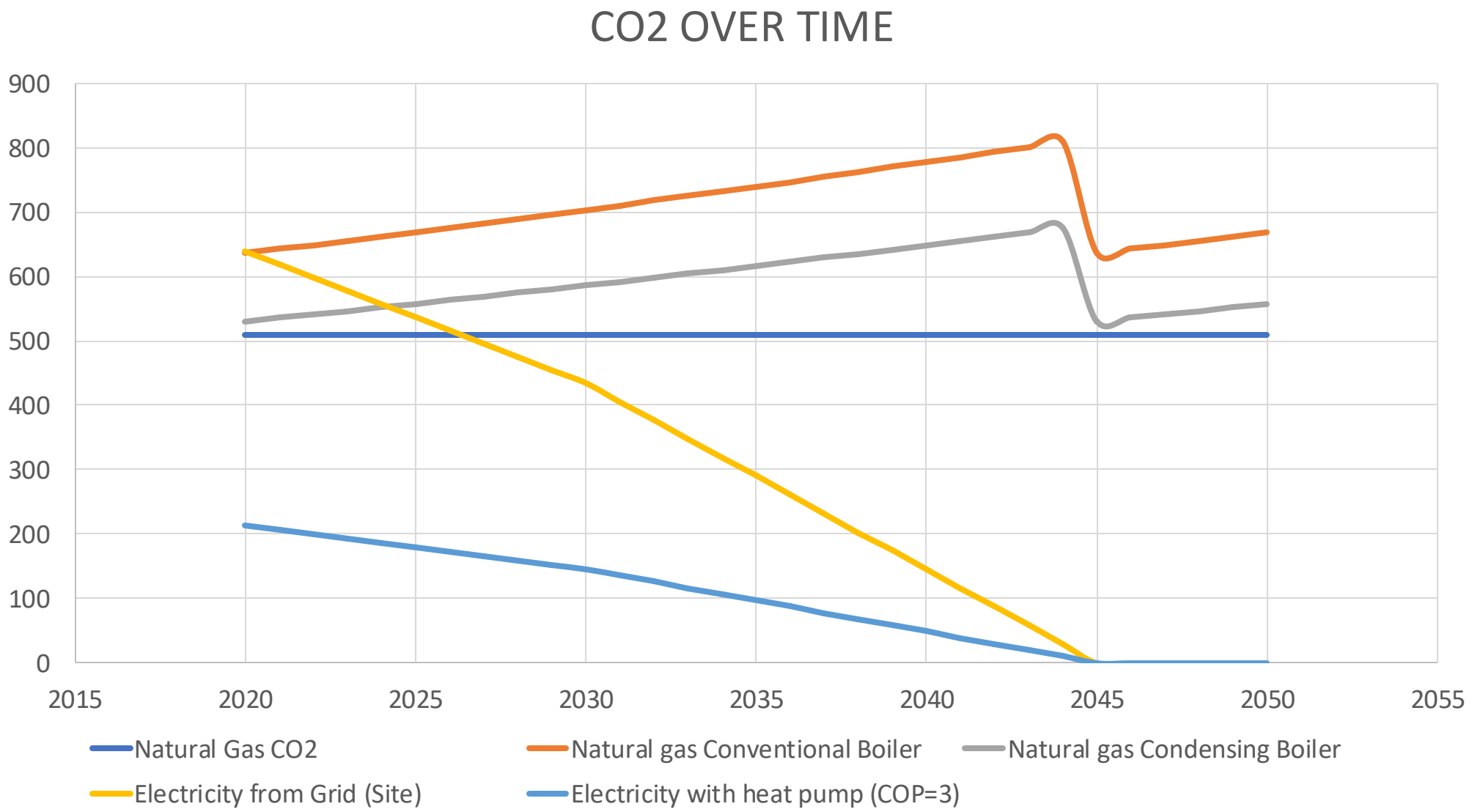
Table C403.1.1 – Occupancy Classifications Requiring TSPR

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, outcomes from the real world

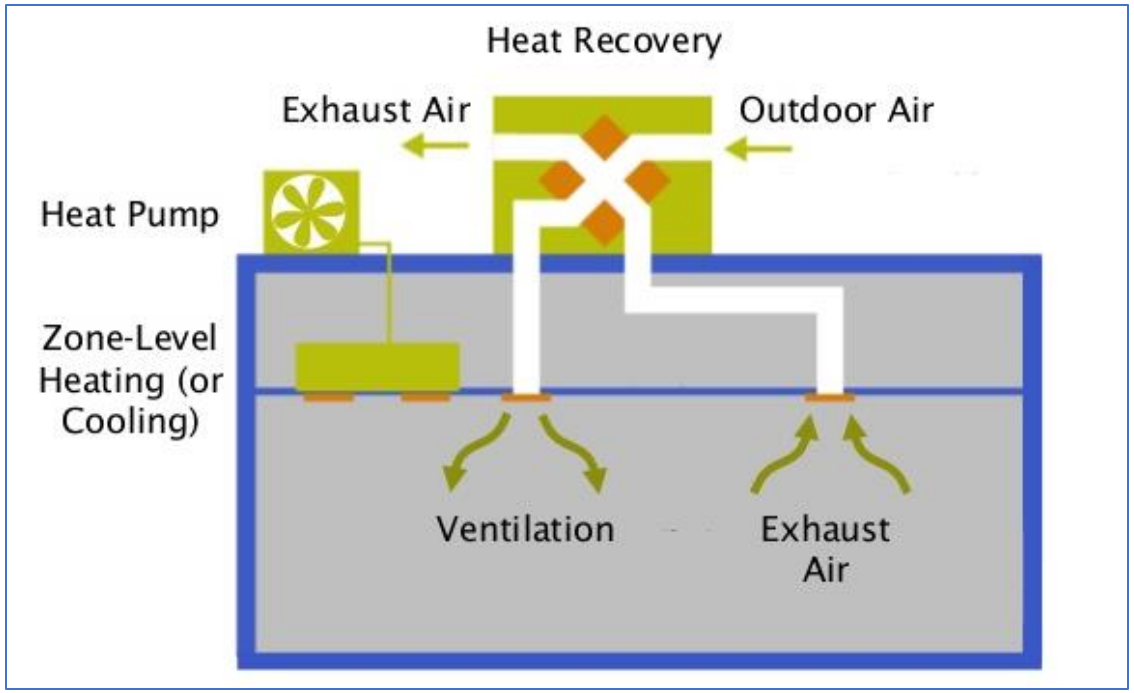


Engineering View, Future CO2



DOAS scope (C403.3.5)

- Office, education, retail, library, assembly
- “Accessory Occupancies” exempt
- Seattle: DOAS fan power 0.8 W/cfm
- DOAS can “temper” air up to 55, or cool for dehumidification (C403.7.3)



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

Clarifying DOAS table – what's in, what's out

Table C403.3.5 – Occupancy Classifications Requiring DOAS

Occupancy Classification	Inclusions	Exempted
A-1	All not exempted	TV & radio studios
A-2	Casino gaming areas	All other A-2 uses (dining/drinking)
A-3	Lecture halls	All other A-3 uses
A-4 & A-5		All occupancies
B	All not exempted	Commercial kitchens, restaurants, labs, data centers, animal hospitals, kennels, pounds, ambulatory care facilities
E, M	All occupancies included	
F, H, I, R, S, U		All occupancies

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
  - So, includes retail sales floors
  - Exempts several small occupancy types
- Exception for dining rooms that use most of their outdoor air for adjacent kitchen makeup air
- 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 C403.3.5

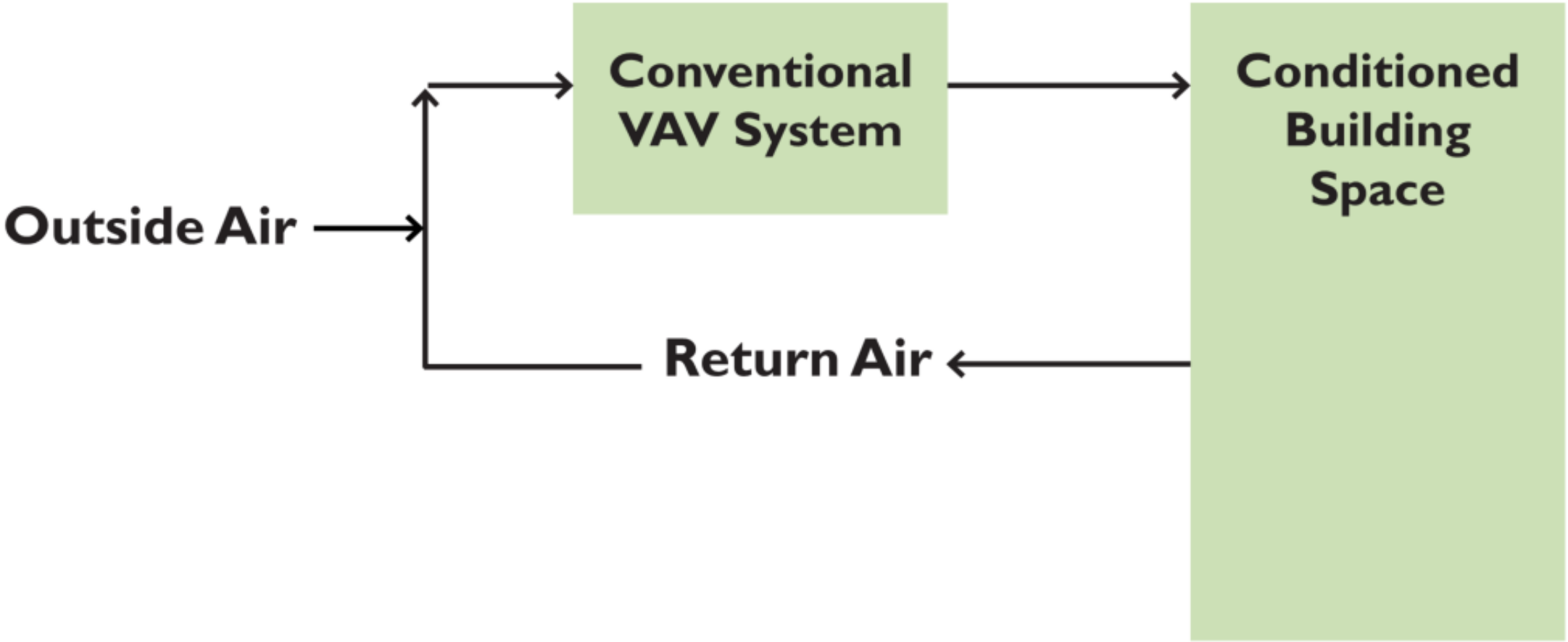
- Economizer *required* for DOAS if cooling equipment is outdoors or in a space adjacent to an exterior wall or roof.
  - Exception 1b only applies if chiller is buried in some interior space

C403.5 Economizers. *Air economizer*s 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.

More Exceptions…

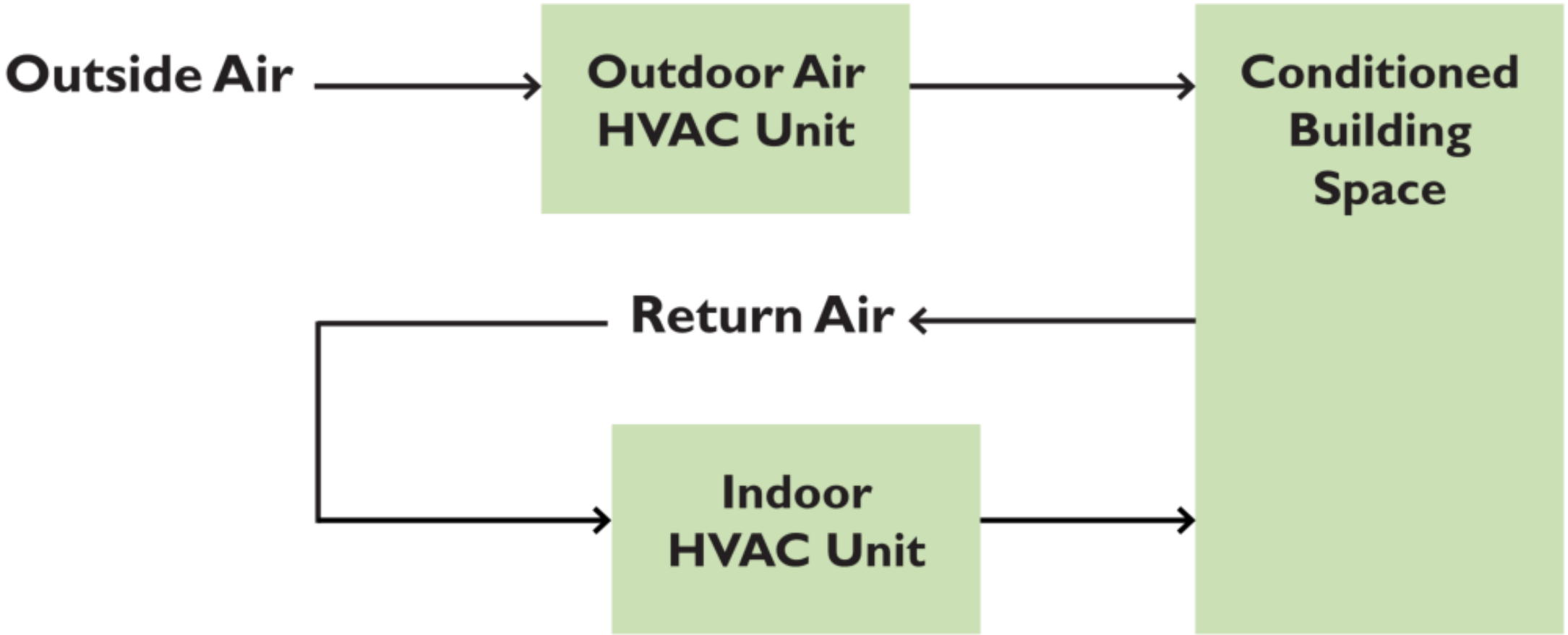
DOAS, demystified

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



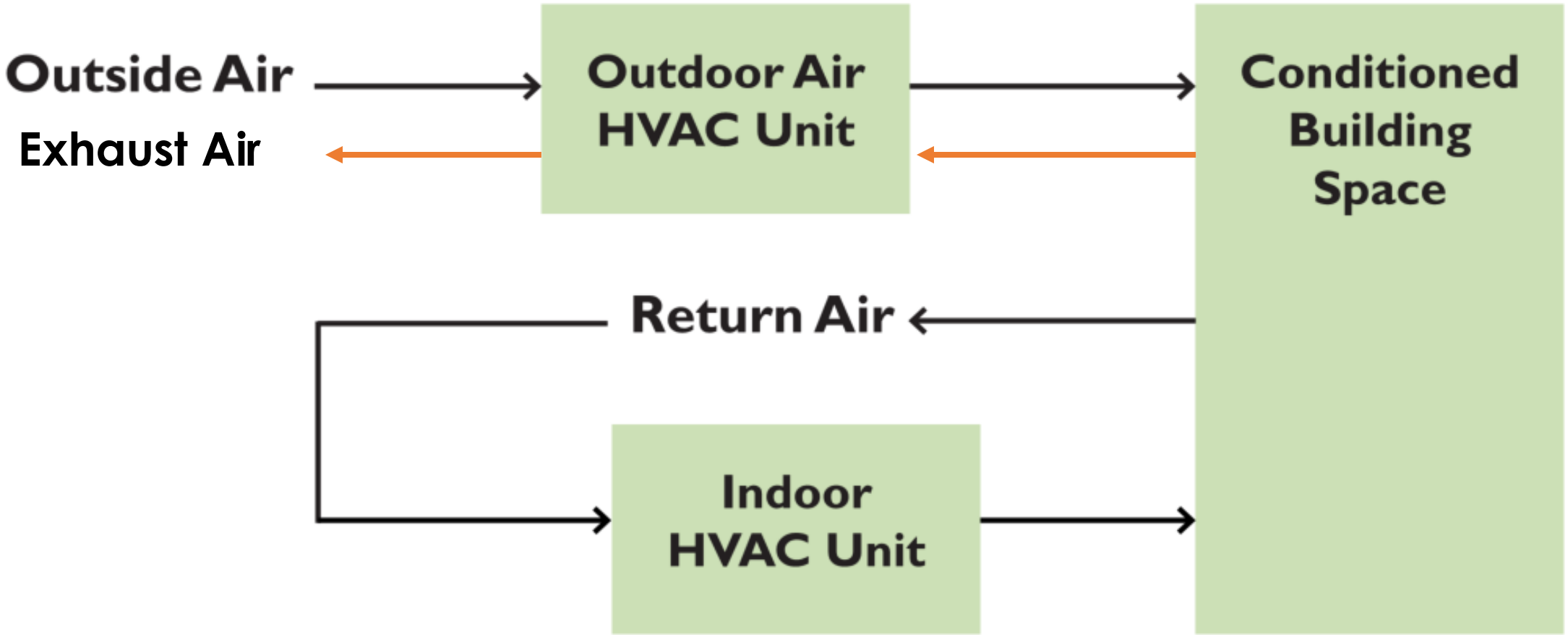
DOAS, demystified

B. DOAS with separate conditioning of outdoor and return air

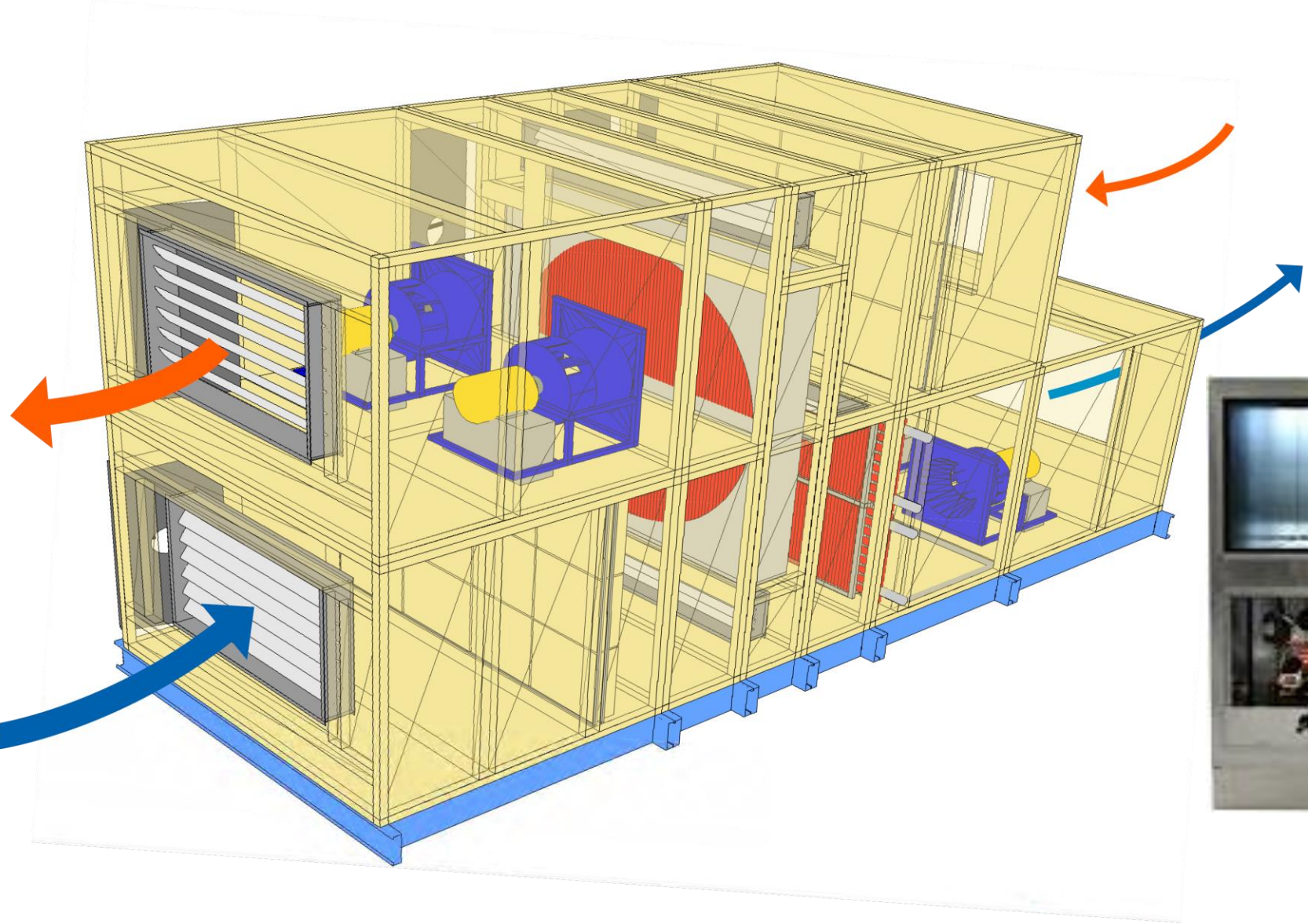


DOAS, demystified, ERV/HRV

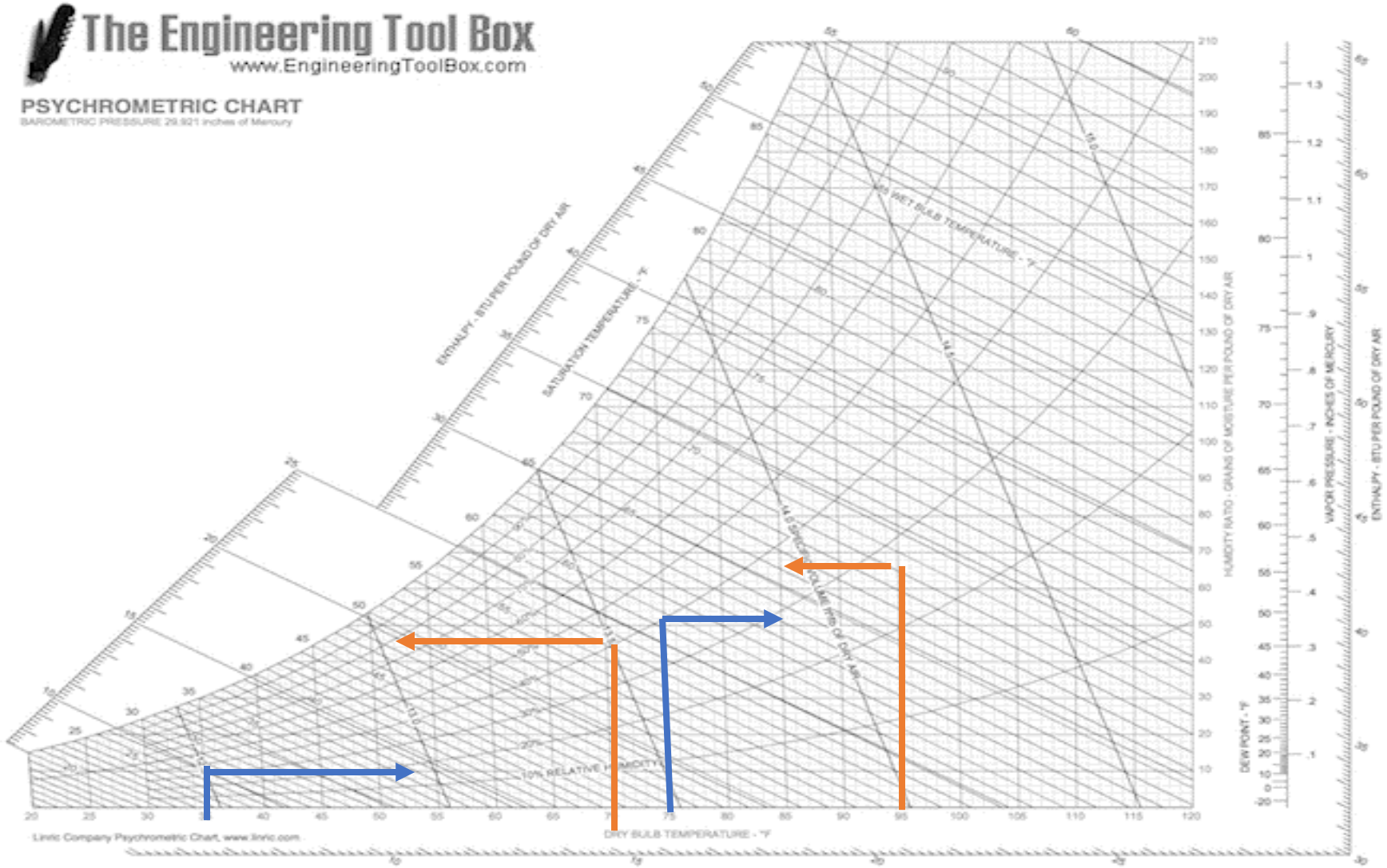
B. DOAS with separate conditioning of outdoor and return air



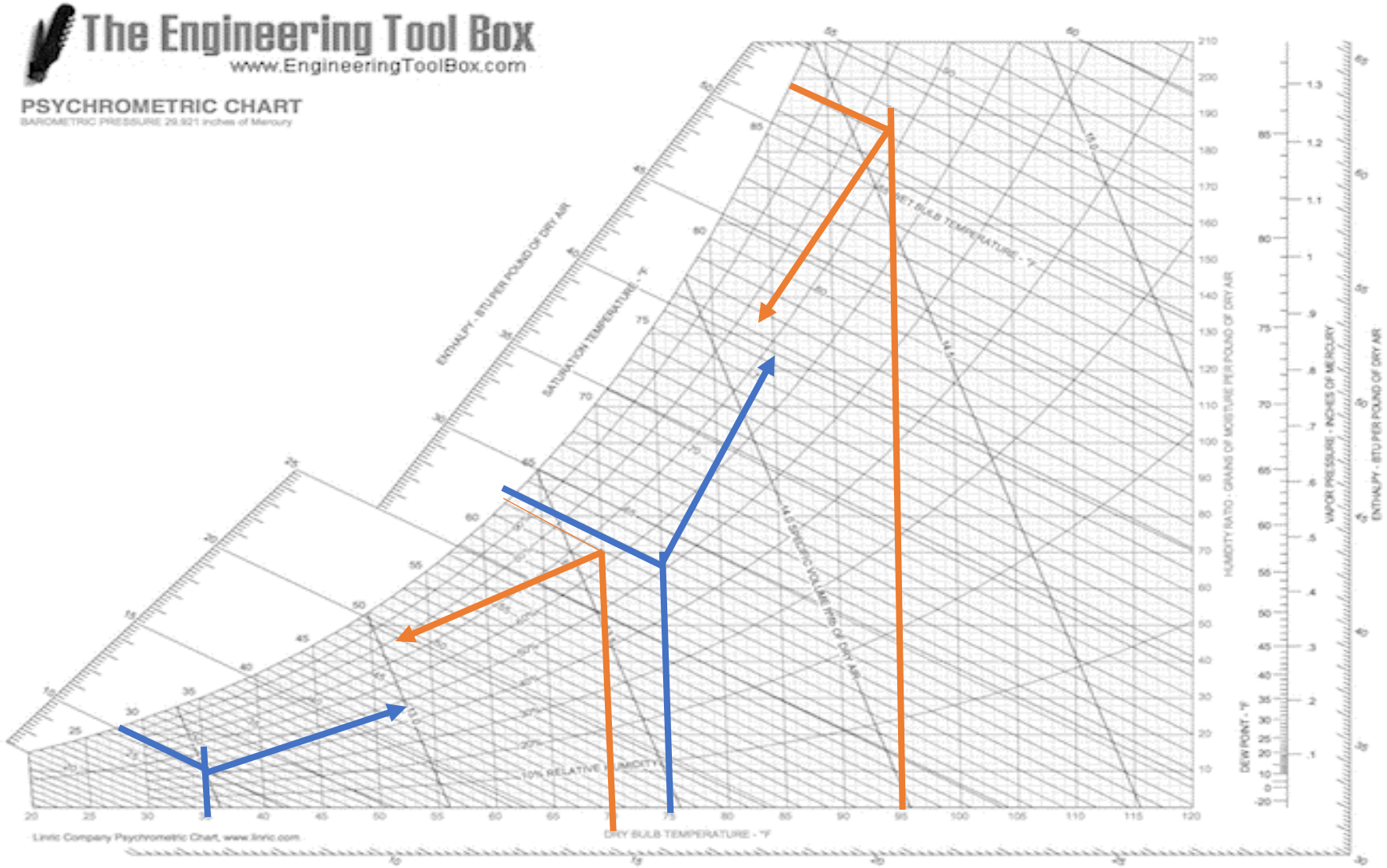
DOAS, ERV, and economizer



Effectiveness and Efficiency



Effectiveness (Energy)

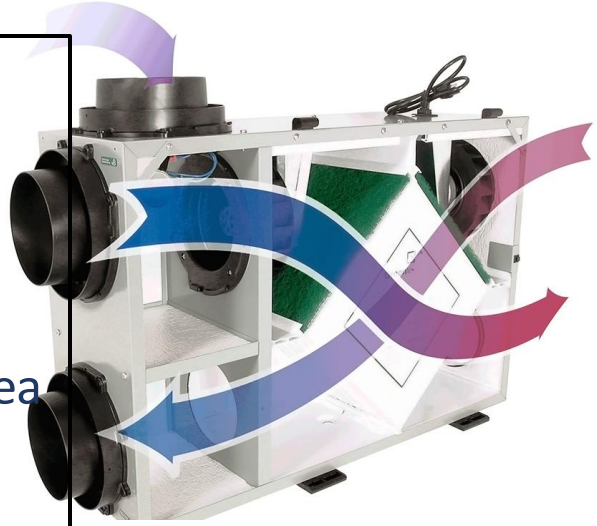


“Balanced ventilation” R-2 dwelling units C403.7.6.1

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 (60% in WA code)
  - “Informative note” about how to determine sensible heat recovery effectiveness from HVI publication

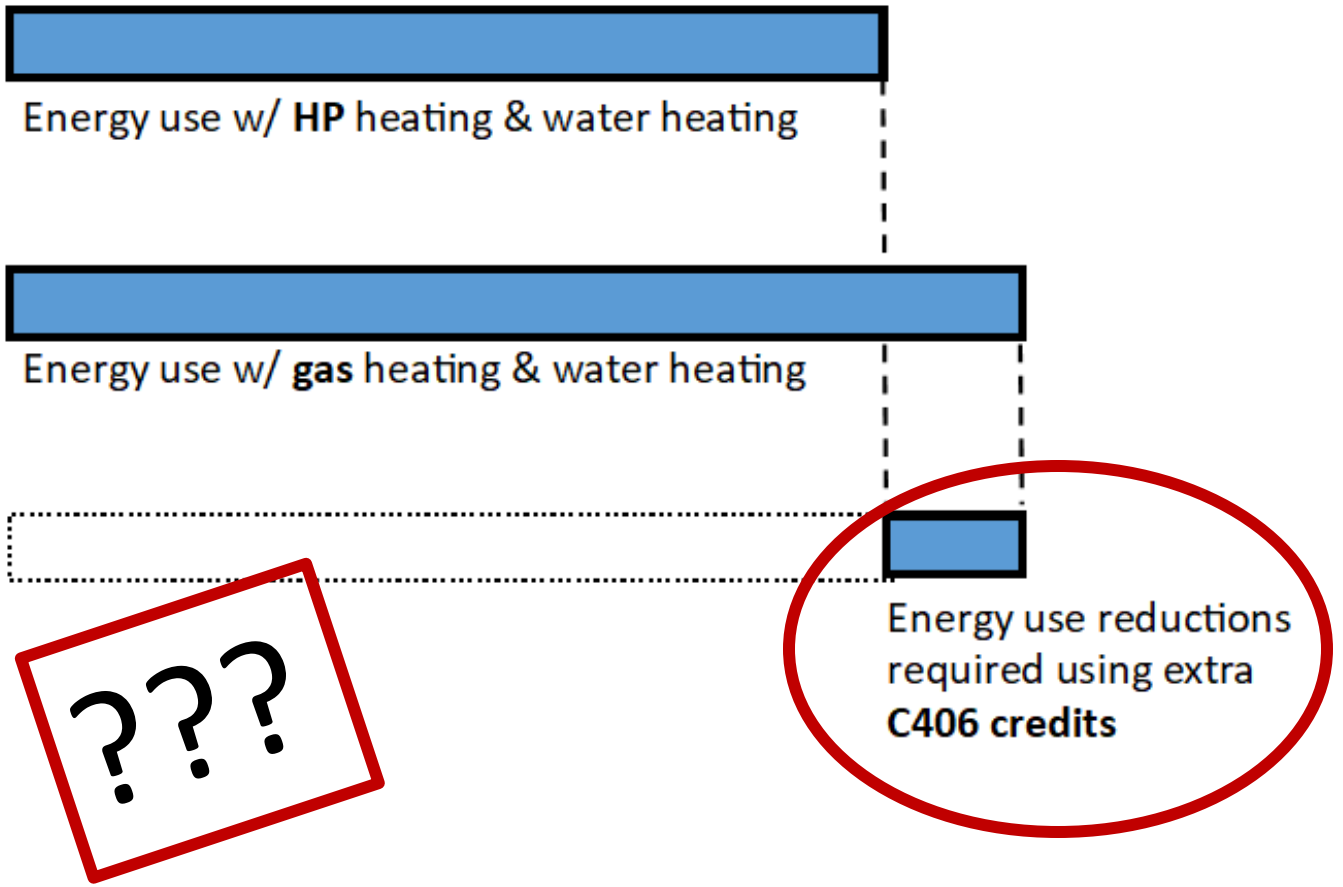
- Individual HRVs in apts?
  - Remember you still need to clean every filter twice a year
- Rooftop units?
  - Shafts eat up rentable floor area
- Floor-by-floor HRVs?
  - Each serving 6 – 8 units
  - Ducts running above bathrooms
    - Noise/privacy problem?



“Fossil Fuel Compliance Path”
to resolve recent federal court ruling – C401.3

Gas heating & water heating OK, *if* total building efficiency is same as heat pump building:

Just add enough efficiency credits to make up the difference



Turns out it takes a *lot* of credits

Table C401.3.3
Additional Credits Required

Occupancy group	R-1	R-2	B	E	M	All other
HVAC heating	7	**24**	**101**	38	111	56
Service water heating	198	**212**	**27**	17	79	107
Total credits	205	**236**	**177**	55	190	163

Because: Heating/water heating are huge share of total energy use, and gas boilers consume triple the energy of heat pumps

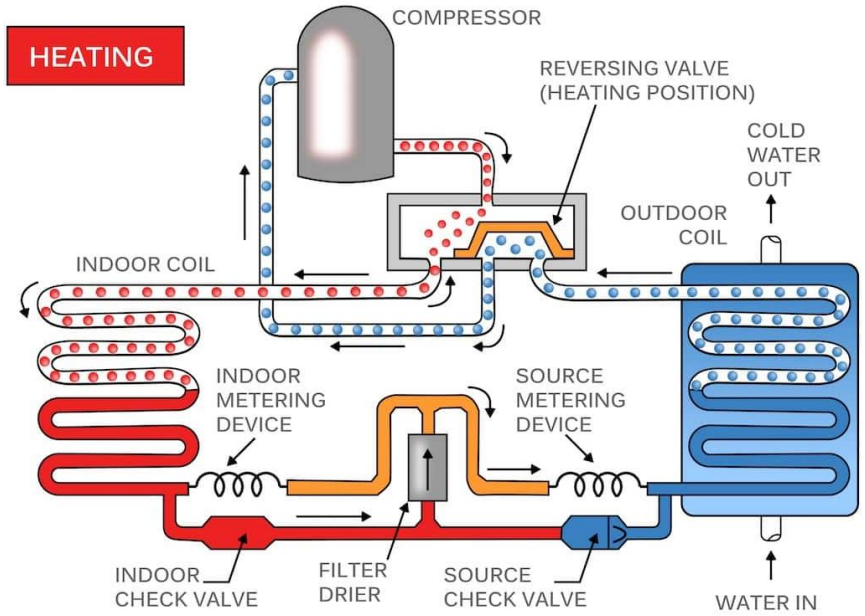
Seattle & WA: Heat pump space heating

…or use "fossil fuel compliance path"

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
22. Heating outside envelope.

No electric resistance or gas heat (?)

Airside systems we can use

No electric resistance or gas heat (?)

Waterside systems we can use

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

Kitchen ventilation & exhaust

TABLE C403.7.7.1.2
MAXIMUM NET EXHAUST FLOW RATE,
CFM PER LINEAR FOOT OF HOOD LENGTH

TYPE OF HOOD	LIGHT-DUTY EQUIPMENT	MEDIUM-DUTY EQUIPMENT	HEAVY-DUTY EQUIPMENT	EXTRA-HEAVY-DUTY EQUIPMENT
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/Pass-over	210	210	280	NA

For SI: 1 cfm = 0.4719 L/s; 1 foot = 305 mm.
NA = Not Allowed

Heat Recovery C403.9.2

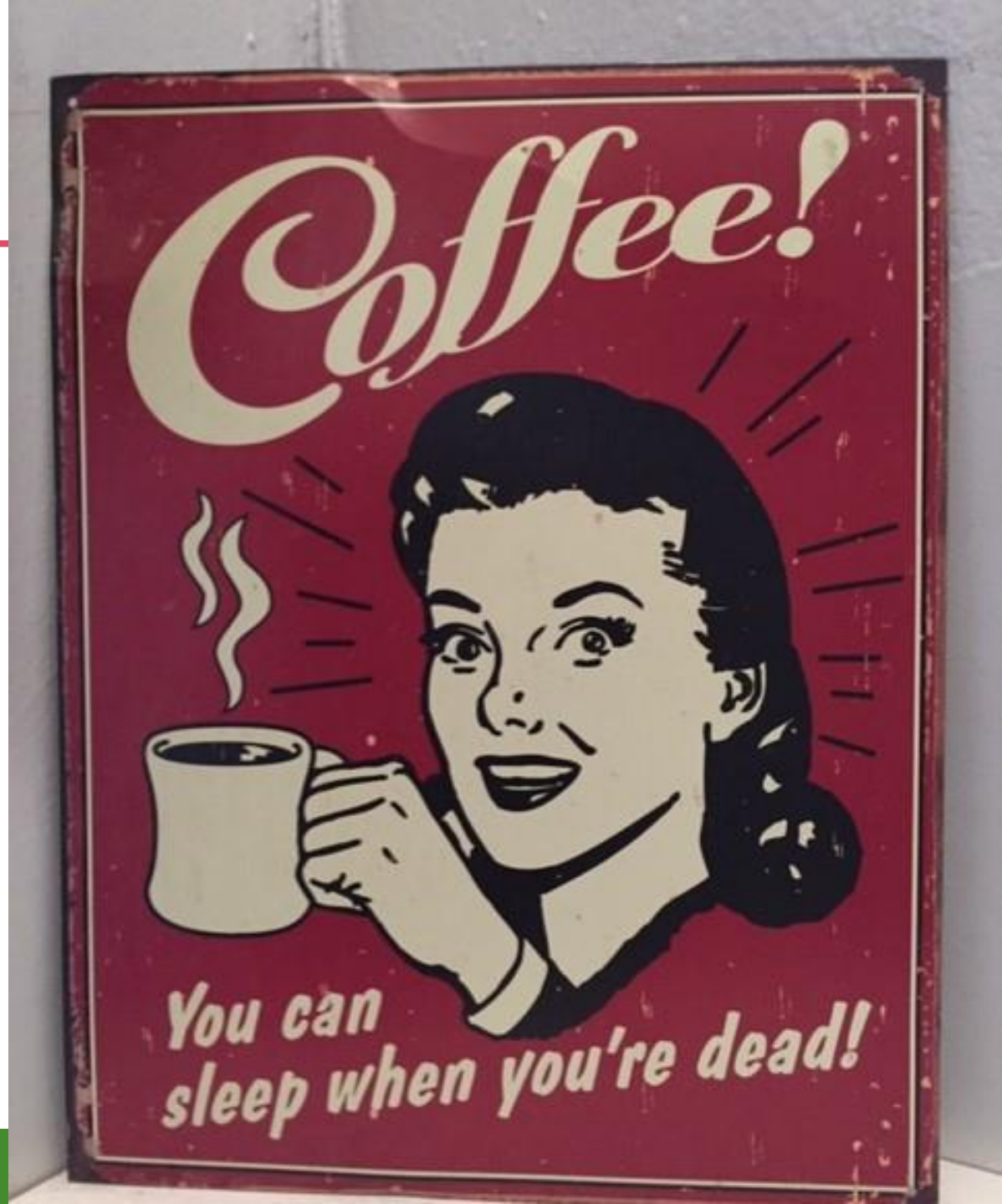
- **Condenser heat recovery required** to heat service hot water in buildings (like hospitals) with:
  - 24/7 operations
  - Min 1.5 MBTUH total heat rejection of water-cooled systems
  - Min 250 kBTUH service water heating load
- **Steam condensate water recovery** required
  - Or condensate *heat recovery* 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

- 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/ft^2
  - Cooling loops must be served by water-cooled equip & heat recovery
  - Economizer override required
- 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
- 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

Heat Recovery Engineering Notes

Break Time!



C406 Efficiency credits system

Pick a few “above-code” measures from 31 options

Table C406.1 Energy Measure Credit Requirements

Required Credits for Projects		Occupancy Group					
	Section	Group R-1	Group R-2	**Group B**	Group E	Group M	All Other
New building energy efficiency credit requirement	C406.2	54	41	**42**	48	74	49
Building additions energy efficiency credit requirement	C406.2	27	20	21	23	36	21
New building load management credit requirement	C406.3	12	15	**27**	15	13	26

Plus “load management credits”

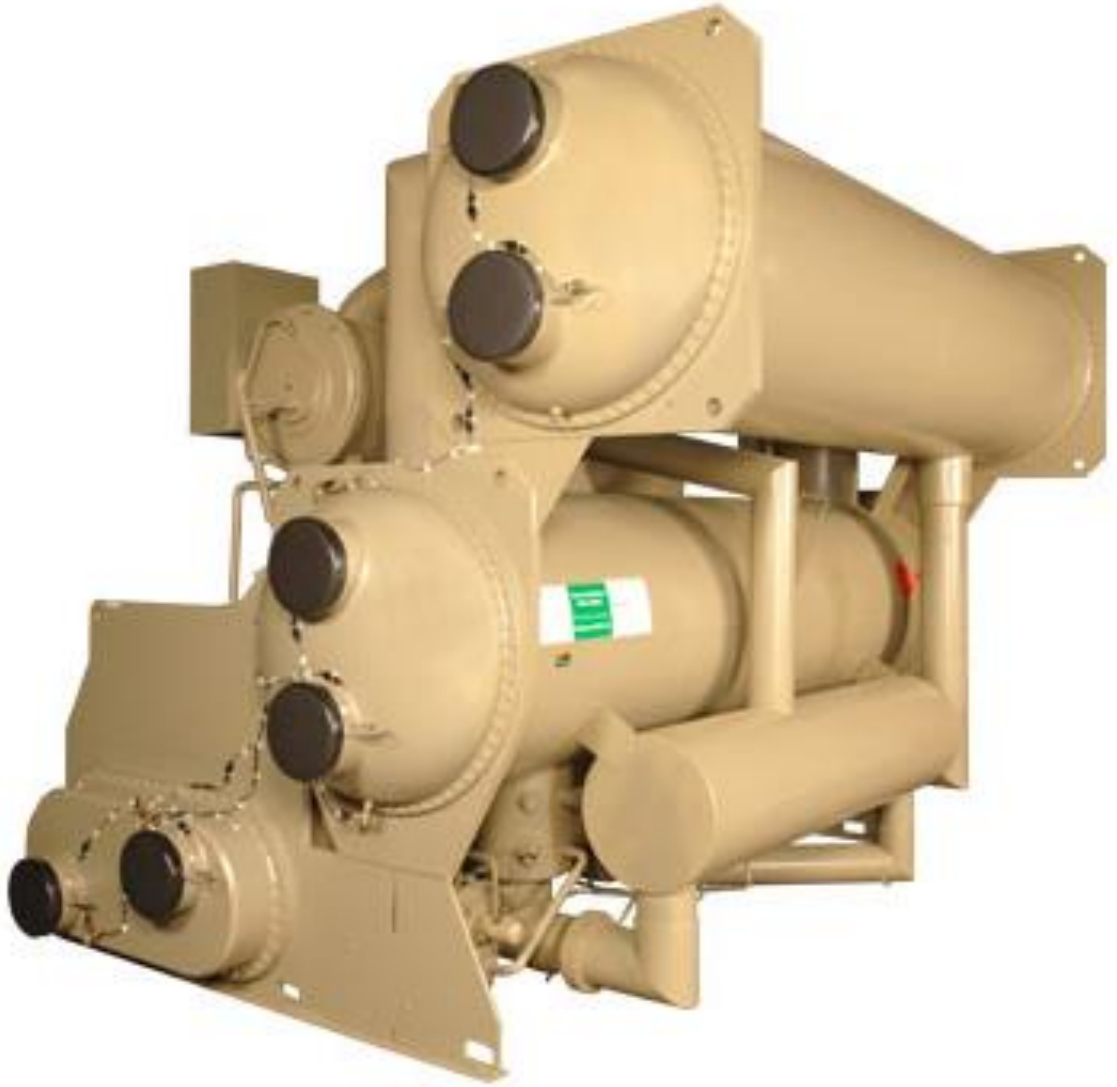
Table C406.2

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 example: Improved TSPR C406.2.2.1

- TSPR 5% above code
- Or prorated up to 20% higher TSPR



Load management credits

Table C406.3

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

C406 TSPR Credit: Engineering Notes

TABLE C406.2
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	2	3	4	3	2
4. Improve heating efficiency	C406.2.2.3	2	3	3	10	16	7
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/ (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	15
10. 20% reduced lighting power[d]	C406.2.3.2	13	8	36	32	40	29
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
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[e]	NA
17. Heat pump water heating	C406.2.6.3	81	261	17	33	(Grocery) 95[e]	(A-2) 95[f]
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

TABLE C406.2 - Continued
EFFICIENCY MEASURE CREDITS

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
20. Service hot water distribution right sizing	C406.2.8	13	42	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	1	NA	4
23. Low flow residential showerheads	C406.2.11	3	3	NA	NA	NA	NA
24. Enhanced envelope performance[g]	C406.2.12	24	20	13	5	19	14
25. Base reduced air leakage[g]	C406.2.13.2	29	24	6	3	9	11
26. Enhanced reduced air leakage[g]	C406.2.13.3	53	44	11	5	16	20
27. Enhanced commercial kitchen equipment	C406.2.14	30[h]	18[h]	18[h]	30[h]	30[h]	31[h]
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

a. Projects using Item 2 shall not use Items 3 through 5.
b. Projects using C406.2.2.5 shall not use C406.2.2.4.
c. For C406.2.2.6, occupancy Group A achieves 40 credits while other occupancy groups within the "all other" category achieve 21 credits.
d. Projects using C406.2.3.2 shall not use C406.2.3.1.
e. Service water heat recovery and heat pump water heating are available in Group M only for grocery stores larger than 10,000 ft^2. Large mixed retail with full grocery and butcher sections shall achieve half the credits. This credit is not available where refrigeration recovery to heat service hot water is used to meet the requirements of Section C403.9.2.3.
f. Heat pump water heating efficiency credits are available in the "all other" category only for Group A-2.
g. Buildings or building areas that are exempt from the thermal envelope requirements in accordance with Sections C402.1.1 and C402.1.2, do not qualify for this package.
h. Additional energy efficiency credits, up to the maximum shown in Table C406.2, shall be calculated according to Section C406.2.11.

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

Total Building Performance C407

- Use ASHRAE 90.1 Appendix G “Performance Rating Method”
- But using “site energy use,” not energy cost
- And use Seattle “mandatory measures” list
  - Can’t be “traded” away through modeling
- 10% more stringent than WA code for:
  - Multifamily
  - Hotel
- Use DOE compliance forms
- Energy modeler certification/experience

Two flavors of site energy

Regulated site energy target

- Doesn't count renewables
- Or unregulated loads

Site energy perf target

- Subtract renewables
- Add unregulated loads:
  - Assumed plug loads
  - And process loads
- Credit for optimizing window area & orientation, equipment efficiency & right-sizing, thermal mass

Table C407.3(2)
Building Performance Factors (excluding solar & unregulated)

Building Area Type	Building Perf Factor (BPF)
Multifamily	((~~0.51~~)) 0.45
Health care/hospital	0.71
Hotel/motel	((~~0.51~~)) 0.46
Office	0.44
Restaurant	0.35
Retail	0.41
School	0.35
Warehouse	0.18
All others	0.43

Table C407.3(3)
Site Energy Performance Targets (subtract solar, add unregulated)

Building Area Type	Site Energy Perf Target
Multifamily	((~~0.59~~)) 0.53
Health care/hospital	0.72
Hotel/motel	((~~0.62~~)) 0.56
Office	0.58
Restaurant	0.59
Retail	0.46
School	0.52
Warehouse	0.29
All others	0.55

C407, Welcome to ASHRAE 90.1

C407, Welcome to ASHRAE 90.1

2. Compliance with Section C407 requires meeting both a regulated site energy target and a total site energy reduction target in accordance with the following:

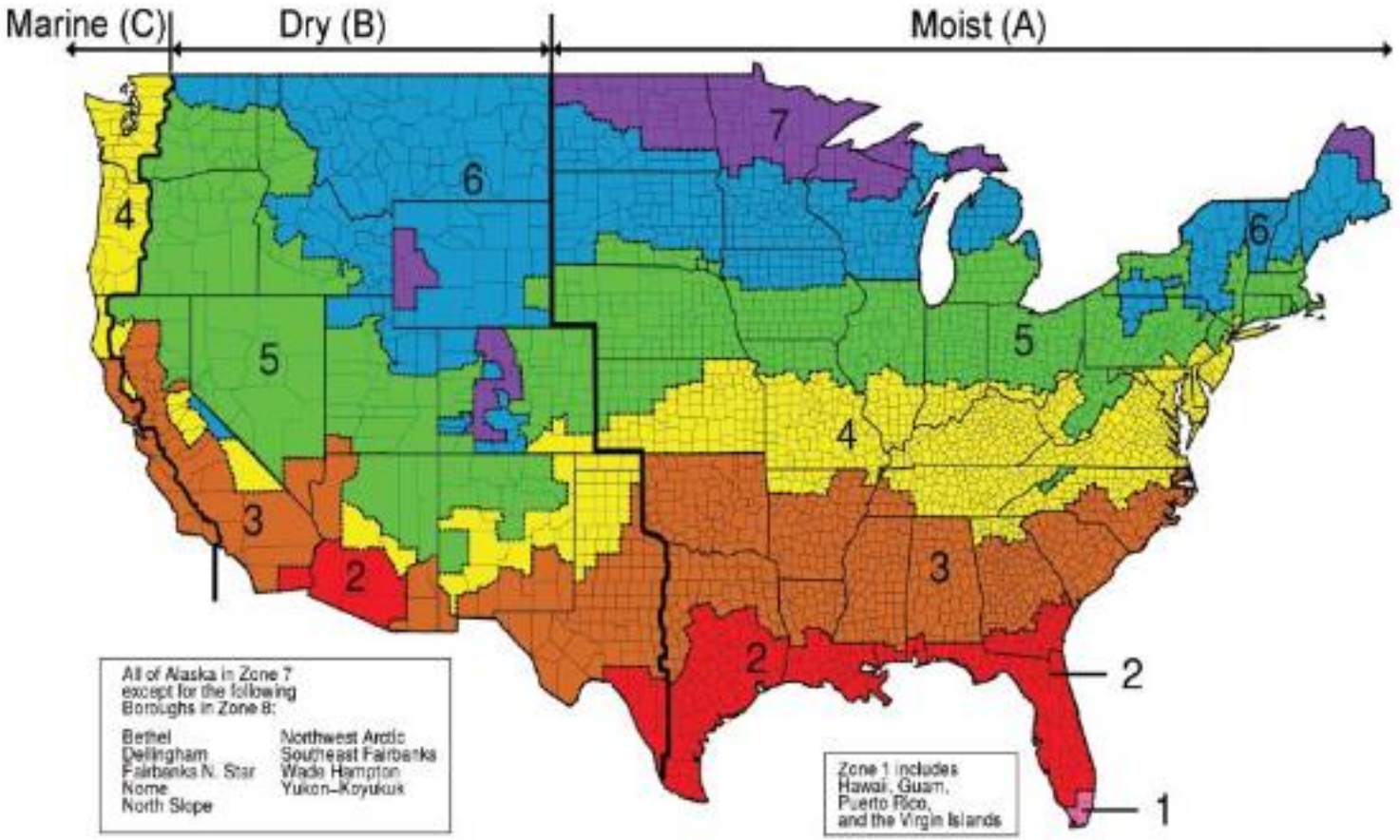
   2.1. Regulated site energy target. The regulated site energy target is focused on regulated load energy efficiency, thus shall be met only via regulated load savings without consideration of the contribution of on-site or off-site renewable energy or unregulated load savings. Adjustments to the PCI, to account for the contribution of renewable energy found in ANSI/ASHRAE/IESNA 90.1 Section 4.2.1.1 shall not be used. References to energy cost in Section 4.2.1.1 and Appendix G shall be replaced by site energy use. Heating or cooling energy provided by a district energy system may utilize coefficient of performance (COP) ratios acceptable to the *code official* for the respective district energy sources. The building performance factors in Table 4.2.1.1 of ANSI/ASHRAE/IESNA 90.1 shall be replaced with those in Table C407.3(2).

   2.2. Total site energy target. The total site energy performance target shall be met including the contributions of on-site or off-site renewable energy as described in Section C411.2 as well as the contributions of improvements in unregulated loads as allowed by Section C407.3.4. The annual on-site and off-site renewable energy production (as adjusted by the factors in Table C411.2.1) shall be subtracted from the proposed building annual site energy use. Compliance with the site energy performance target requires that the proposed building site energy use/baseline building site energy use is less than or equal to the site energy performance target from Table C407.3(3).

C407, Welcome to ASHRAE 90.1

How hard is this?

C407, Welcome to ASHRAE 90.1



- 1A: Miami, Florida (very hot, humid)
- 1B: Riyadh, Saudi Arabia (very hot, dry)
- 2A: Houston, Texas (hot, humid)
- 2B: Phoenix, Arizona (hot, dry)
- 3A: Memphis, Tennessee (warm, humid)
- 3B: El Paso, Texas (warm, dry)
- 3C: San Francisco, California (warm, marine)
- 4A: Baltimore, Maryland (mixed, humid)
- 4B: Albuquerque, New Mexico (mixed, dry)
- 4C: Salem, Oregon (mixed, marine)
- 5A: Chicago, Illinois (cool, humid)
- 5B: Boise, Idaho (cool, dry)
- 5C: Vancouver, B.C. Canada (cool, marine)
- 6A: Burlington, Vermont (cold, humid)
- 6B: Helena, Montana (cold, dry)
- 7: Duluth, Minnesota (very cold)
- 8: Fairbanks, Alaska (subarctic)

C407, Welcome to ASHRAE 90.1

Table 2.4 Building Performance Factors (BPF) for Compliance with Standard 90.1-2016

Building Type	Climate Zone																	Building Type Average
	0A & 1A	0A & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8	
Office	0.58	0.62	0.57	0.62	0.60	0.64	0.54	0.58	0.60	0.58	0.60	0.61	0.58	0.61	0.61	0.57	0.61	0.60
Retail	0.52	0.58	0.53	0.58	0.54	0.62	0.60	0.55	0.60	0.60	0.55	0.59	0.61	0.55	0.58	0.53	0.53	0.57
School	0.46	0.53	0.47	0.53	0.49	0.52	0.50	0.49	0.50	0.49	0.50	0.50	0.50	0.49	0.50	0.47	0.51	0.50
Healthcare	0.64	0.56	0.60	0.56	0.60	0.56	0.54	0.57	0.53	0.55	0.59	0.52	0.55	0.57	0.52	0.56	0.56	0.56
Restaurant	0.62	0.62	0.58	0.61	0.60	0.60	0.61	0.58	0.55	0.60	0.62	0.58	0.60	0.63	0.60	0.65	0.68	0.61
Hotel	0.64	0.65	0.62	0.60	0.63	0.65	0.64	0.62	0.64	0.62	0.60	0.61	0.60	0.59	0.61	0.57	0.58	0.62
Warehouse	0.51	0.52	0.56	0.58	0.57	0.59	0.63	0.58	0.60	0.63	0.60	0.61	0.65	0.66	0.66	0.67	0.67	0.61
Apartment	0.73	0.73	0.71	0.69	0.74	0.73	0.68	0.78	0.81	0.81	0.76	0.80	0.81	0.76	0.79	0.74	0.80	0.76
All Others	0.62	0.61	0.55	0.57	0.56	0.61	0.59	0.58	0.57	0.61	0.57	0.57	0.61	0.56	0.56	0.53	0.52	0.58

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-25202Rev1.pdf

C407, Welcome to ASHRAE 90.1

Table 4.2.1.1 *Building* Performance Factor (BPF)

Building Area Type	Climate Zone																
	0A and 1A	0B and 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.68	0.70	0.66	0.66	0.69	0.68	0.59	0.74	0.76	0.74	0.70	0.73	0.75	0.68	0.71	0.68	0.72
Healthcare/ hospital	0.60	0.60	0.58	0.54	0.56	0.55	0.55	0.55	0.54	0.54	0.57	0.52	0.54	0.57	0.52	0.57	0.57
Hotel/motel	0.55	0.53	0.53	0.52	0.53	0.54	0.54	0.53	0.53	0.52	0.50	0.51	0.51	0.50	0.51	0.50	0.50
Office	0.52	0.57	0.50	0.56	0.53	0.56	0.48	0.51	0.52	0.49	0.51	0.51	0.49	0.52	0.51	0.49	0.51
Restaurant	0.63	0.64	0.60	0.60	0.60	0.61	0.58	0.62	0.57	0.61	0.63	0.60	0.64	0.65	0.62	0.67	0.70
Retail	0.51	0.54	0.49	0.55	0.51	0.55	0.53	0.51	0.55	0.54	0.50	0.54	0.55	0.50	0.51	0.48	0.50
School	0.39	0.47	0.38	0.43	0.38	0.42	0.40	0.37	0.40	0.38	0.36	0.40	0.36	0.36	0.37	0.36	0.37
Warehouse	0.38	0.42	0.40	0.42	0.43	0.44	0.43	0.44	0.43	0.46	0.49	0.47	0.48	0.54	0.51	0.57	0.57
All others	0.56	0.57	0.50	0.52	0.50	0.54	0.53	0.53	0.52	0.54	0.51	0.51	0.50	0.50	0.50	0.50	0.46

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

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*.

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-25202Rev1.pdf

C407, Welcome to ASHRAE 90.1

Building Area Type	4C	5A	5B
Multifamily	0.74	0.70	0.73
Healthcare/ hospital	0.54	0.57	0.52
Hotel/motel	0.52	0.50	0.51
Office	0.49	0.51	0.51
Restaurant	0.61	0.63	0.60
Retail	0.54	0.50	0.54
School	0.38	0.36	0.40
Warehouse	0.46	0.49	0.47
All others	0.54	0.51	0.51

90.1-2019

TABLE C407.3(2)
BUILDING PERFORMANCE FACTORS (BPF) TO BE USED FOR COMPLIANCE WITH SECTION C407.3

Building Area Type	Building Performance Factor
Multifamily	0.55
Healthcare/hospital	0.71
Hotel/motel	0.53
Office	0.45
Restaurant	0.35
Retail	0.41
School	0.36
Warehouse	0.19
All Others	0.44

TABLE C407.3(3)
SITE ENERGY PERFORMANCE TARGETS TO BE USED FOR COMPLIANCE WITH SECTION C407.3

Building Area Type	Building Performance Factor
Multifamily	0.59
Healthcare/hospital	0.72
Hotel/motel	0.62
Office	0.58
Restaurant	0.59
Retail	0.46
School	0.52
Warehouse	0.29
All Others	0.55

WSEC

Table C407.3(2)
Building Performance Factors (BPF) to be used for Compliance with Section C407.3

Building Area Type	Building Performance Factor
Multifamily	((~~0.51~~)) 0.45
Health care/hospital	0.70
Hotel/motel	((~~0.51~~)) 0.46
Office	0.44
Restaurant	0.33
Retail	0.41
School	0.35
Warehouse	0.18
All others	0.43

Table C407.3(3)
Site Energy Performance Targets to be used for Compliance with Section C407.3

Building Area Type	Site Energy Performance Targets
Multifamily	((~~0.59~~)) 0.53
Health care/hospital	0.72
Hotel/motel	((~~0.62~~)) 0.56
Office	0.58
Restaurant	0.59
Retail	0.46
School	0.52
Warehouse	0.29
All others	0.55

SEC

C407, Welcome to ASHRAE 90.1

How hard is this (reprise)?

Commissioning of HVAC required, plus…

C408

- 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, <u>including MEP sets</u>

Take your project all the way across the finish line!

See C408.1.4.1.1 for Post-Occupancy Cx

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 as approved credit
- A few residential appliances pre-approved
- Like maybe a “smart lab” fume hood ventilation control system?

~~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

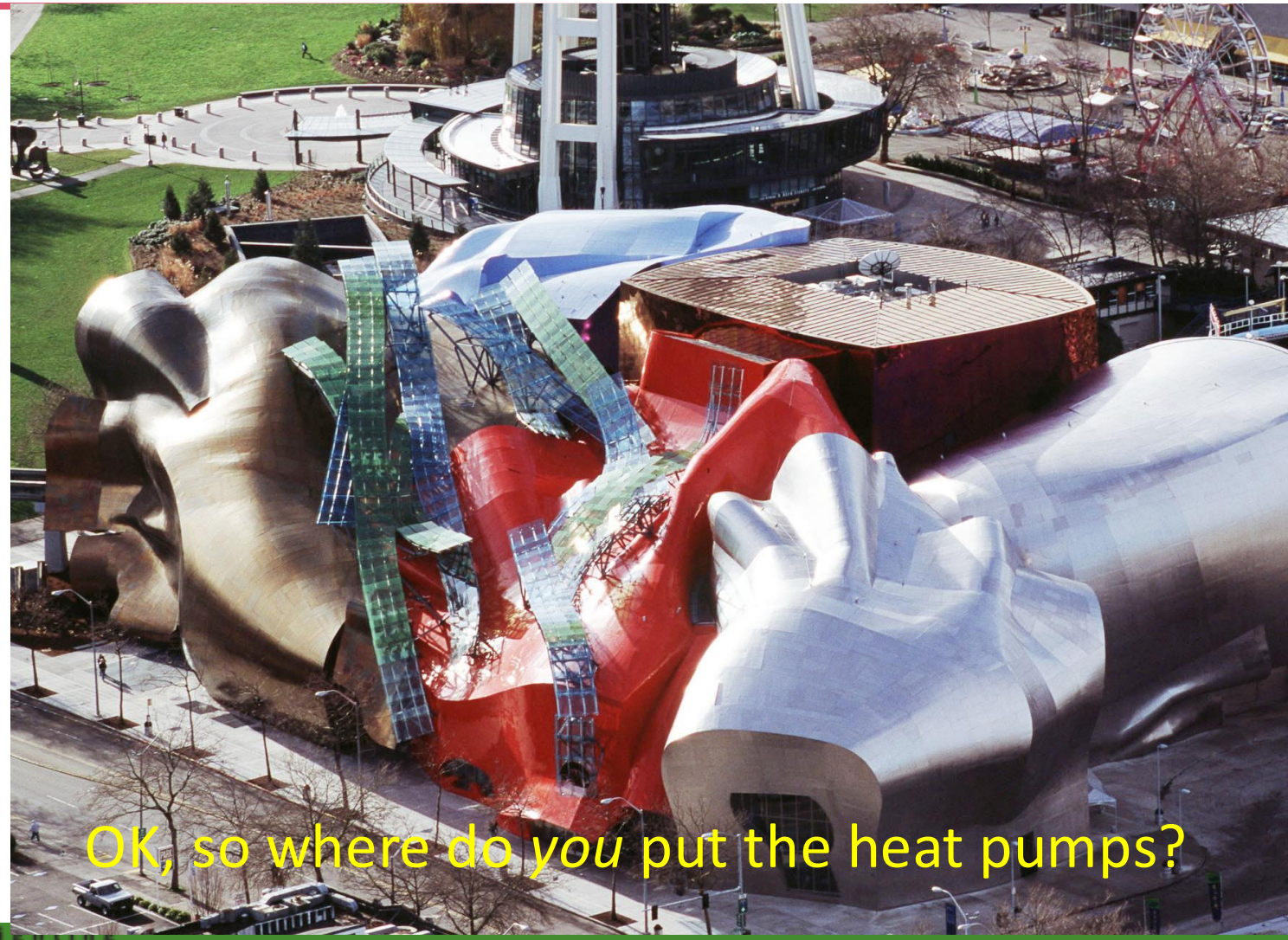
C409, The Cx Perspective

Meters, what are they good for anyway?

Alterations C503

General principles:

- Existing (untouched) can remain
- Service and repairs OK
- New equipment and new systems must meet code
- Seattle “Substantial Alterations” Whole *building* meets code
- Same with “change of occupancy,” & “change of space conditioning”
- **CBPS & BPS are a new departure**



Seattle:
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 more option to “change nothing & keep burning gas forever”

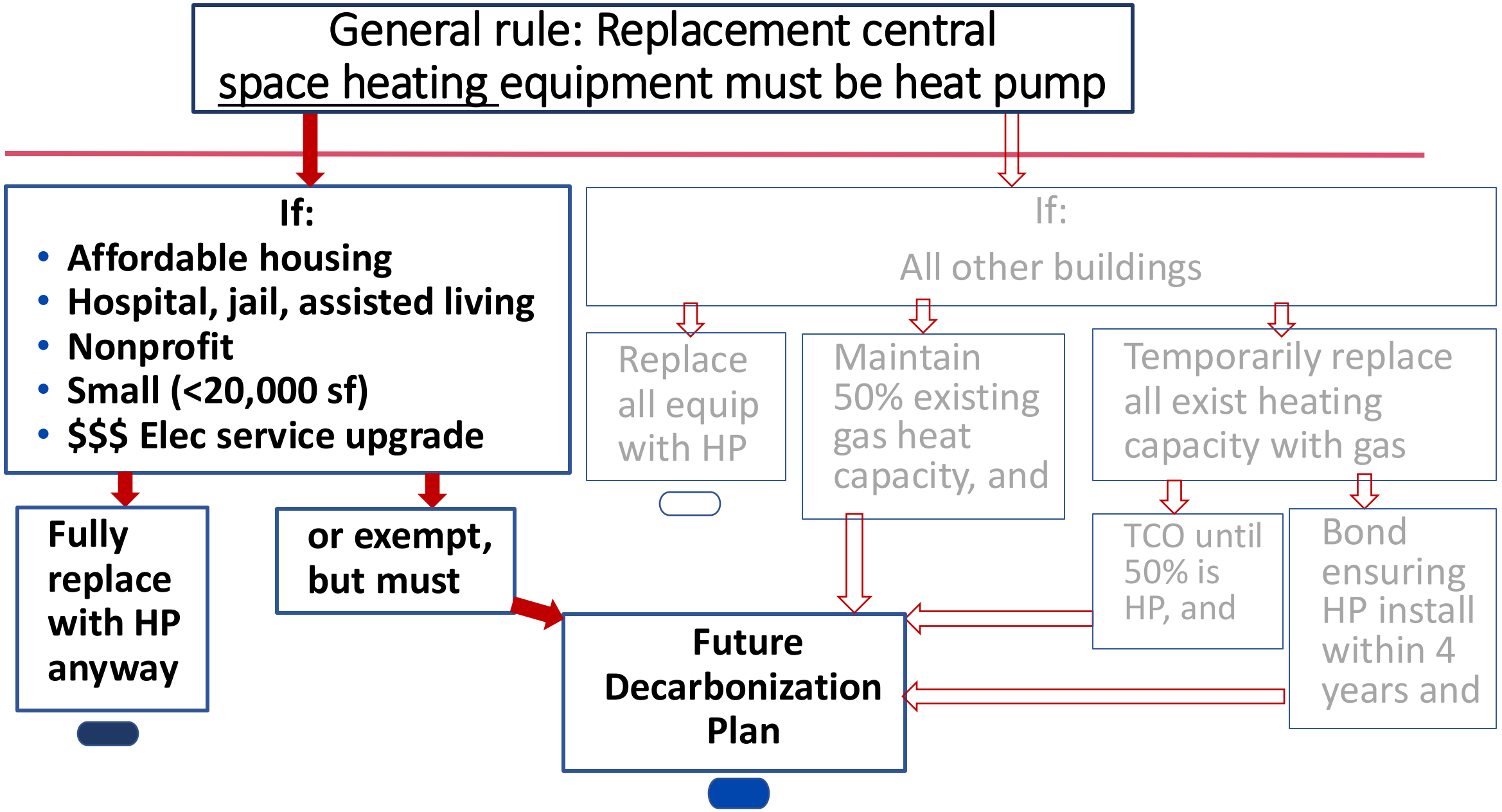
CBPS: WA *plus* BEPS: Seattle

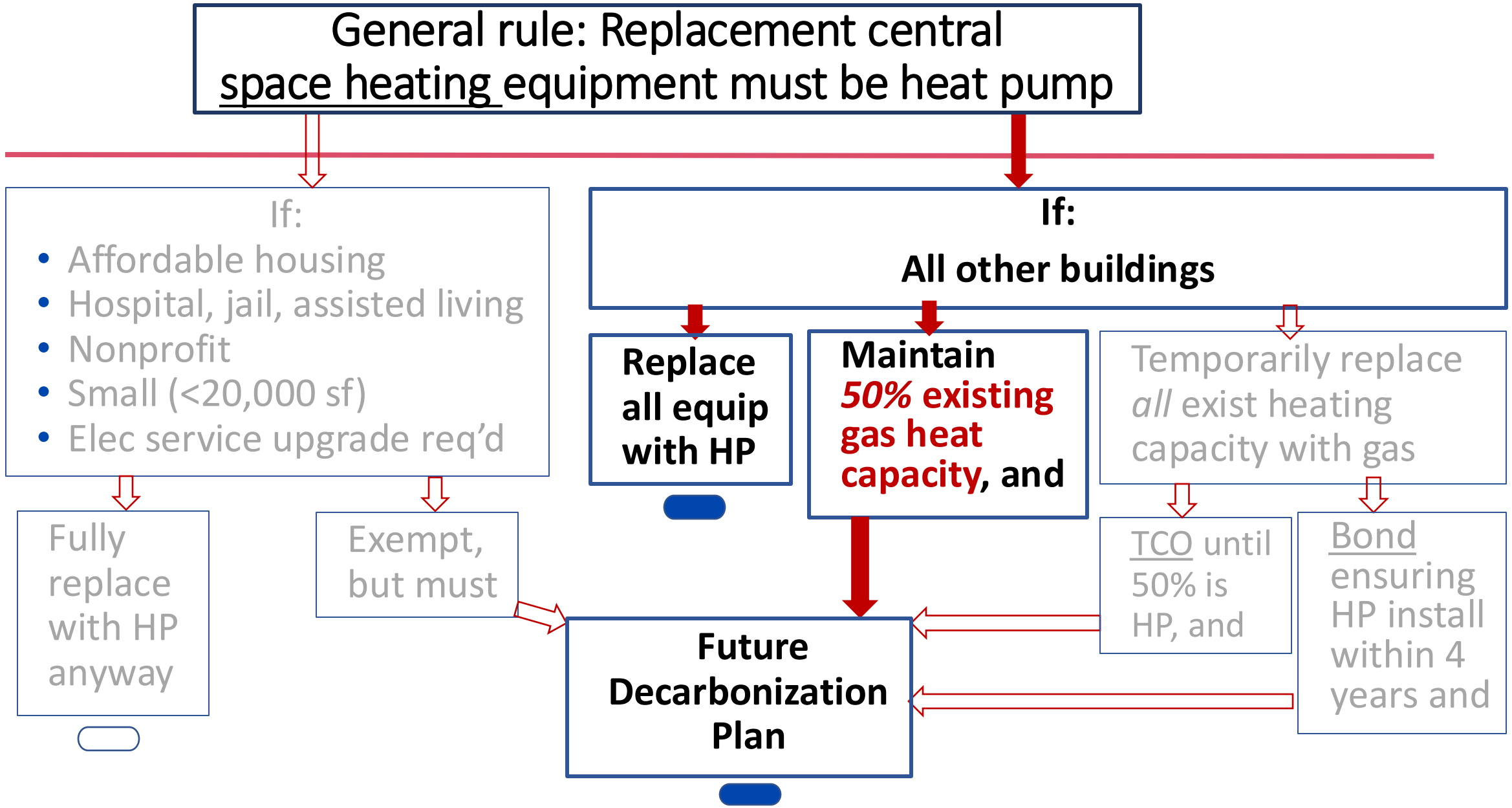
Energy

- Most building types
- **EUI targets** set at state "average" for each building type
- Lower EUIs in future?
- 50,000 ft^2: Starts 2026
- 20,000 ft^2: Starts 2031

GHG Emissions

- *In addition to* State BPS
- **Emissions targets** shrink every 5 years…
- …to zero carbon in the 2040s
- 50,000 ft^2: Starts 2028


General rule: Replacement central space heating equipment must be heat pump
If:
Affordable housing
Hospital, jail, assisted living
Nonprofit
Small (<20,000 sf)
$$$ Elec service upgrade
Fully replace with HP anyway
or exempt, but must
If:
All other buildings
Replace all equip with HP
Maintain 50% existing gas heat capacity, and
Temporarily replace all exist heating capacity with gas
TCO until 50% is HP, and
Bond ensuring HP install within 4 years and
Future Decarbonization Plan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If:
• Affordable housing
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• Elec service upgrade req'd
Fully replace with HP anyway
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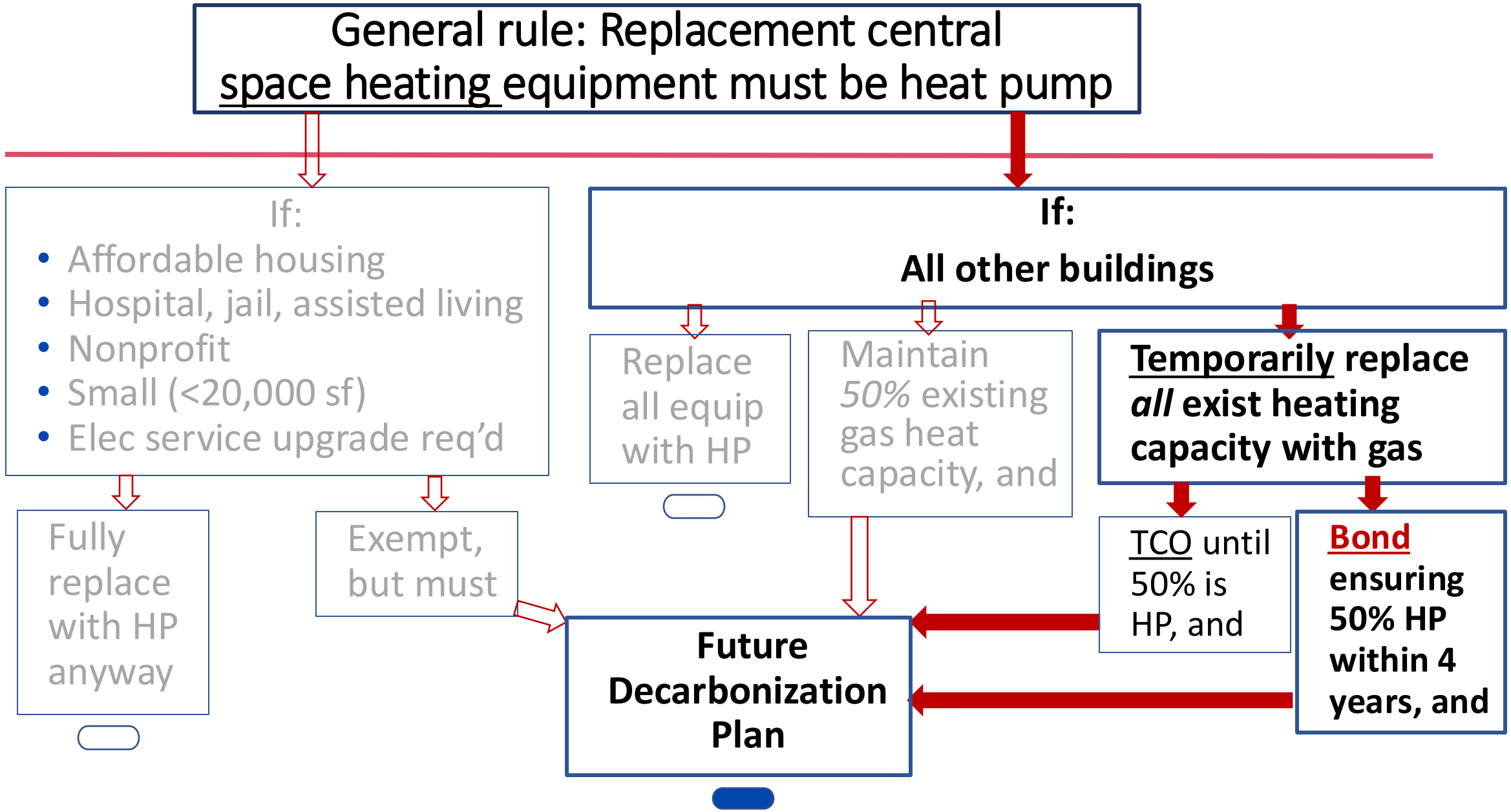
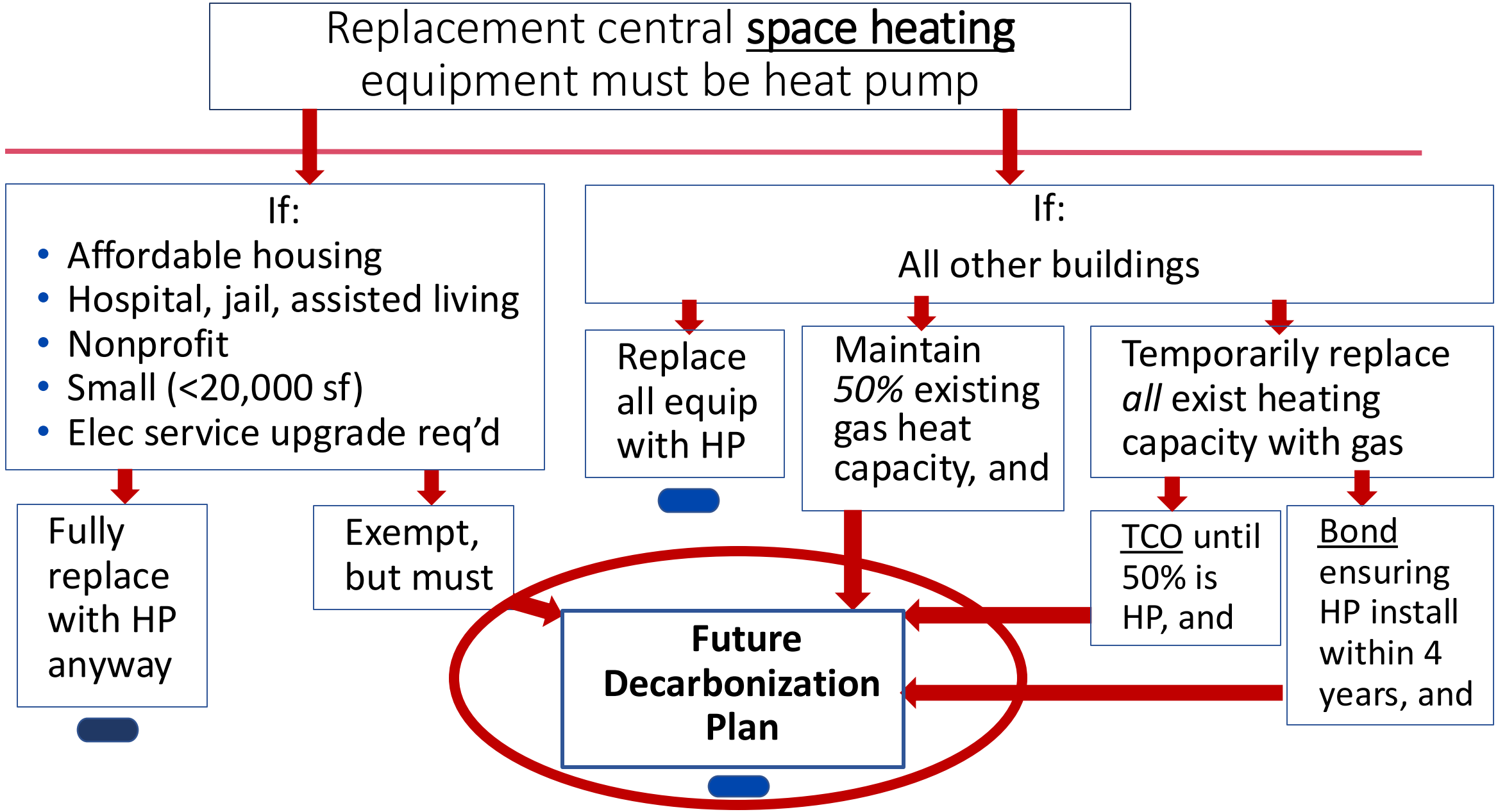
If:
All other buildings
Replace all equip with HP
Maintain 50% existing gas heat capacity, and
Temporarily replace all exist heating capacity with gas
TCO until 50% is HP, and
Bond ensuring HP install within 4 years and
Future Decarbonization Plan


General rule: Replacement central space heating equipment must be heat pump
If:
• Affordable housing
• Hospital, jail, assisted living
• Nonprofit
• Small (<20,000 sf)
• Elec service upgrade req'd
Fully replace with HP anyway
Exempt, but must
If:
All other buildings
Replace all equip with HP
Maintain 50% existing gas heat capacity, and
Temporarily replace all exist heating capacity with gas
TCO until 50% is HP, and
Bond ensuring 50% HP within 4 years, and
Future Decarbonization Plan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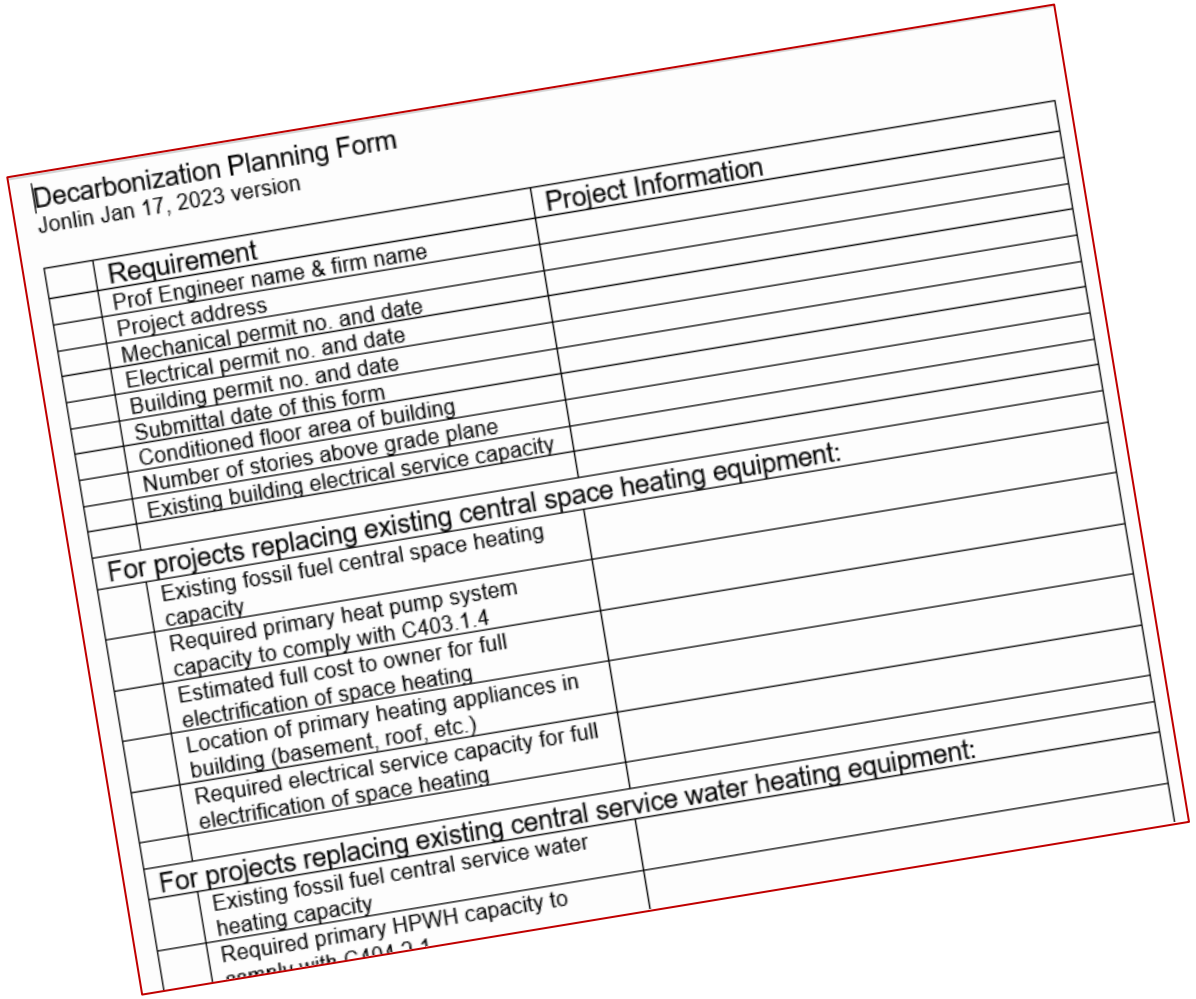
Future Decarbonization Plan

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



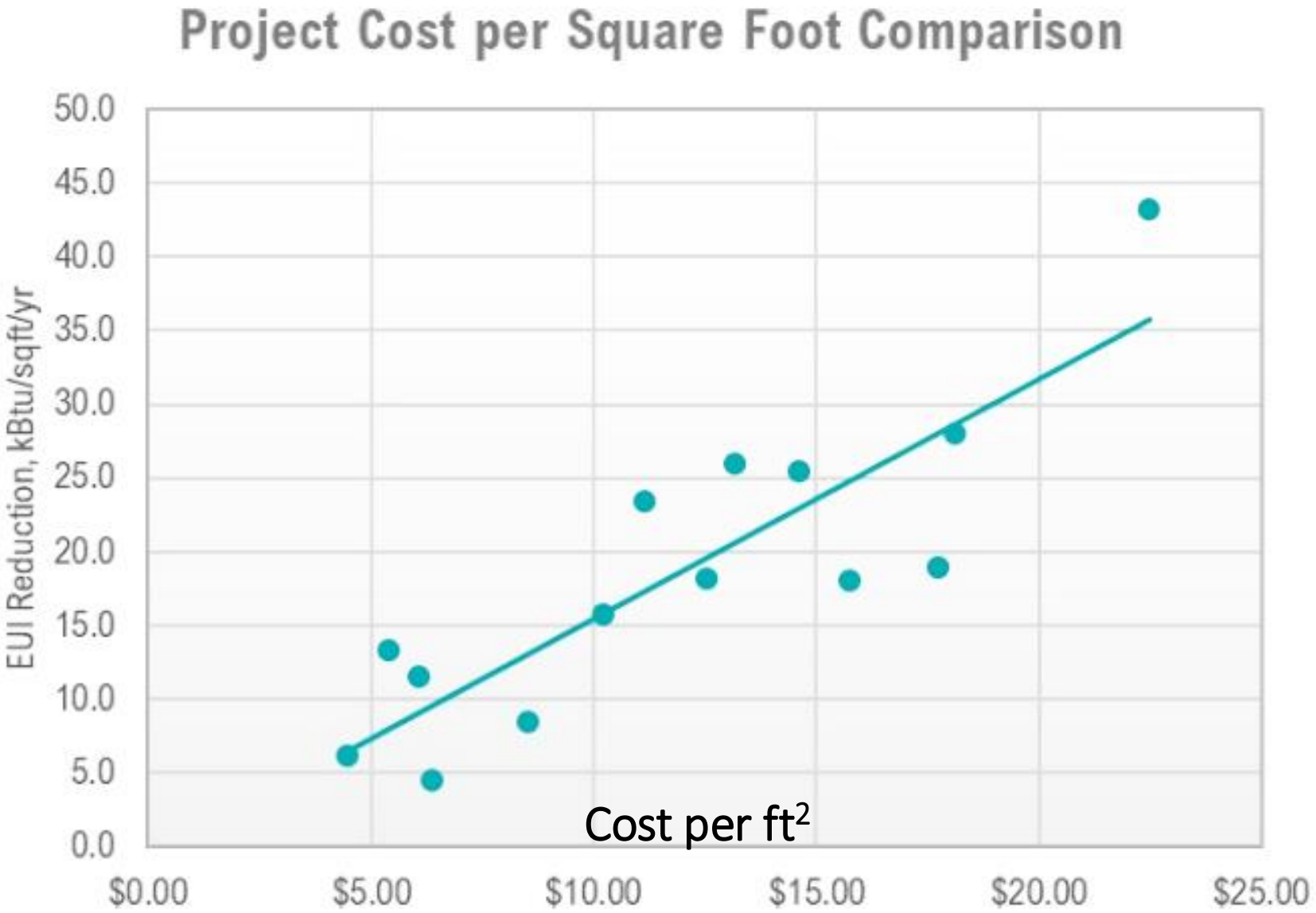
Decarbonization Planning Form
Jonlin Jan 17, 2023 version

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	

Costs

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

Required EUI reduction



Study courtesy of MacDonald Miller, Seattle, 2023

Potential Cost Reductions

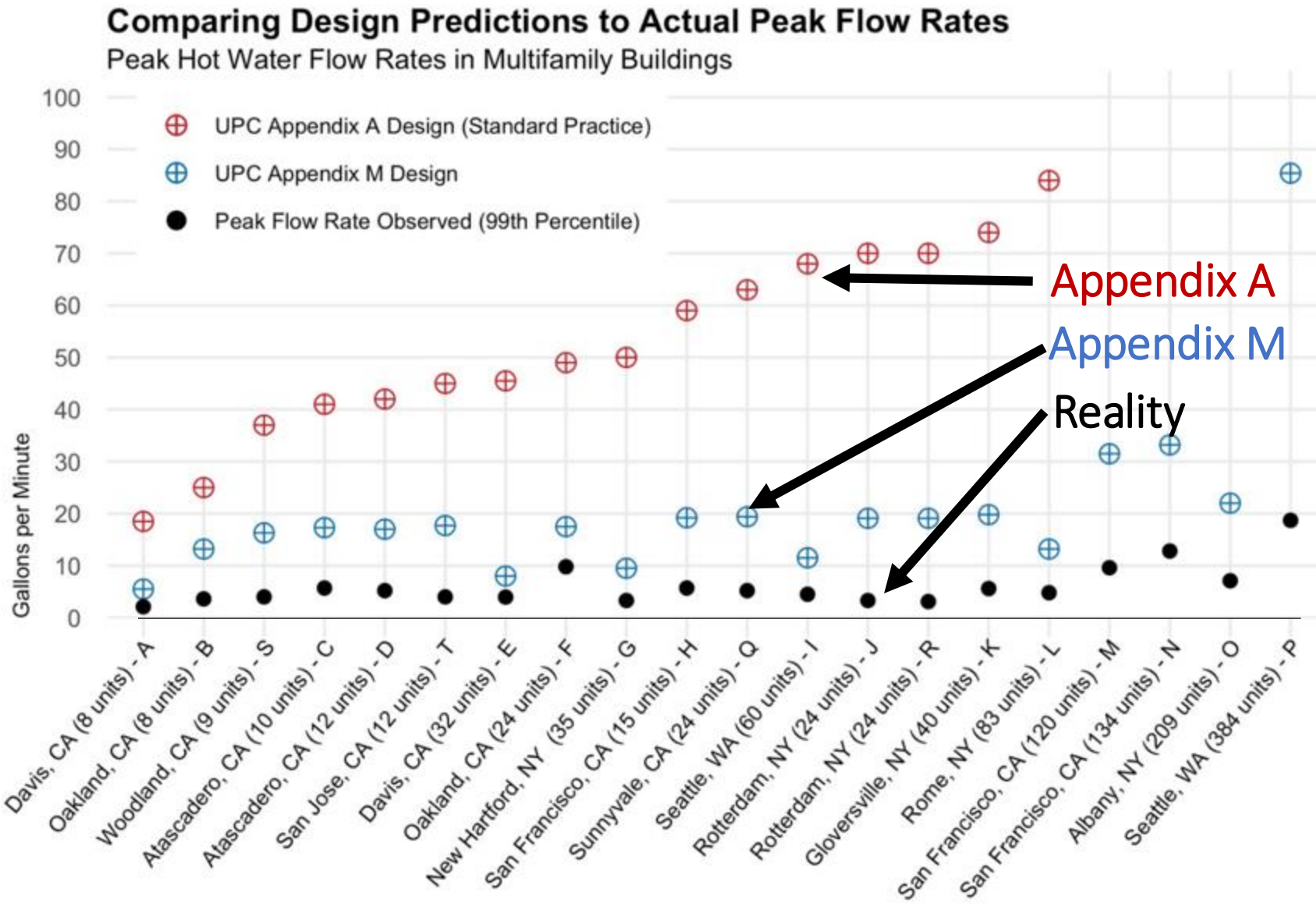
Problems

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



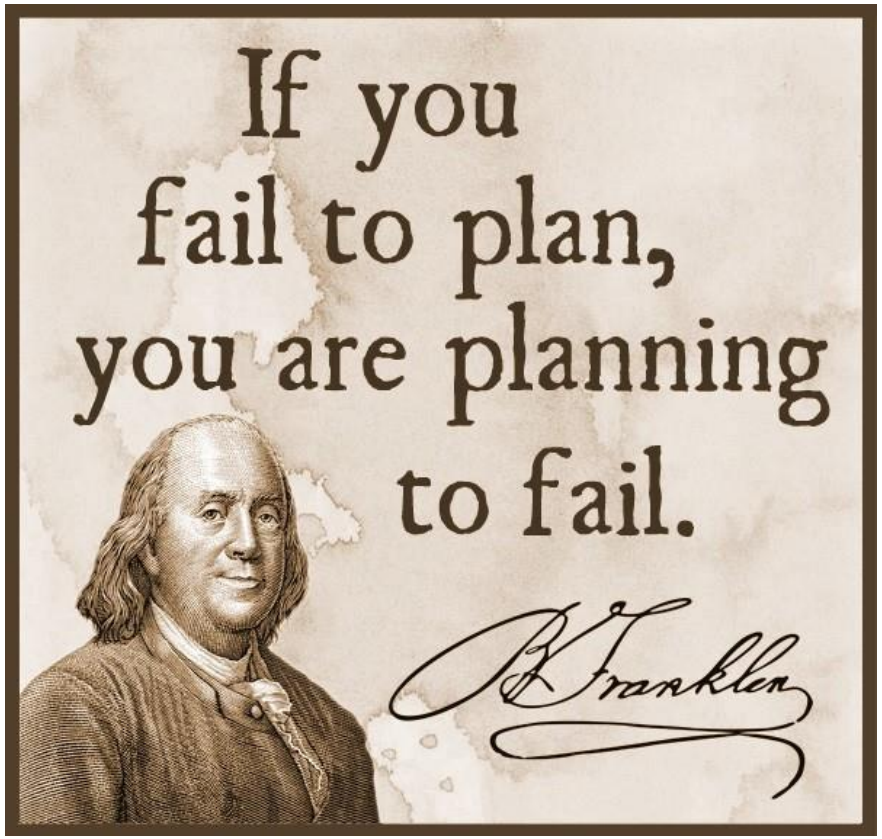
Many thanks to the Association for Energy Affordability, Ecotope, Frontier Energy, Peter Skinner, and the UC Davis Western Cooling Efficiency Center for providing data.

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 C503.4.3 – Economizer options

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%[e] 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%[e] 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]	

Seattle – Heat Pump Exception:
Change in space conditioning – C505.2

Where triggered by SEC 505.2, full energy upgrade of building not required under this exception:

1. A change in space conditioning does not require full compliance with this code if the existing heated but not cooled space is altered to become both heated and cooled solely **by replacement of the existing heating-only HVAC system with an electric heat pump HVAC system**, provided that there is no change in the use or occupancy classification of the area served by the HVAC system that would increase the cooling load, and the new system includes a DOAS with energy recovery in compliance with Section C403.3.5.

Seattle: Air cooled chiller replacement C503.4.3.1

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.

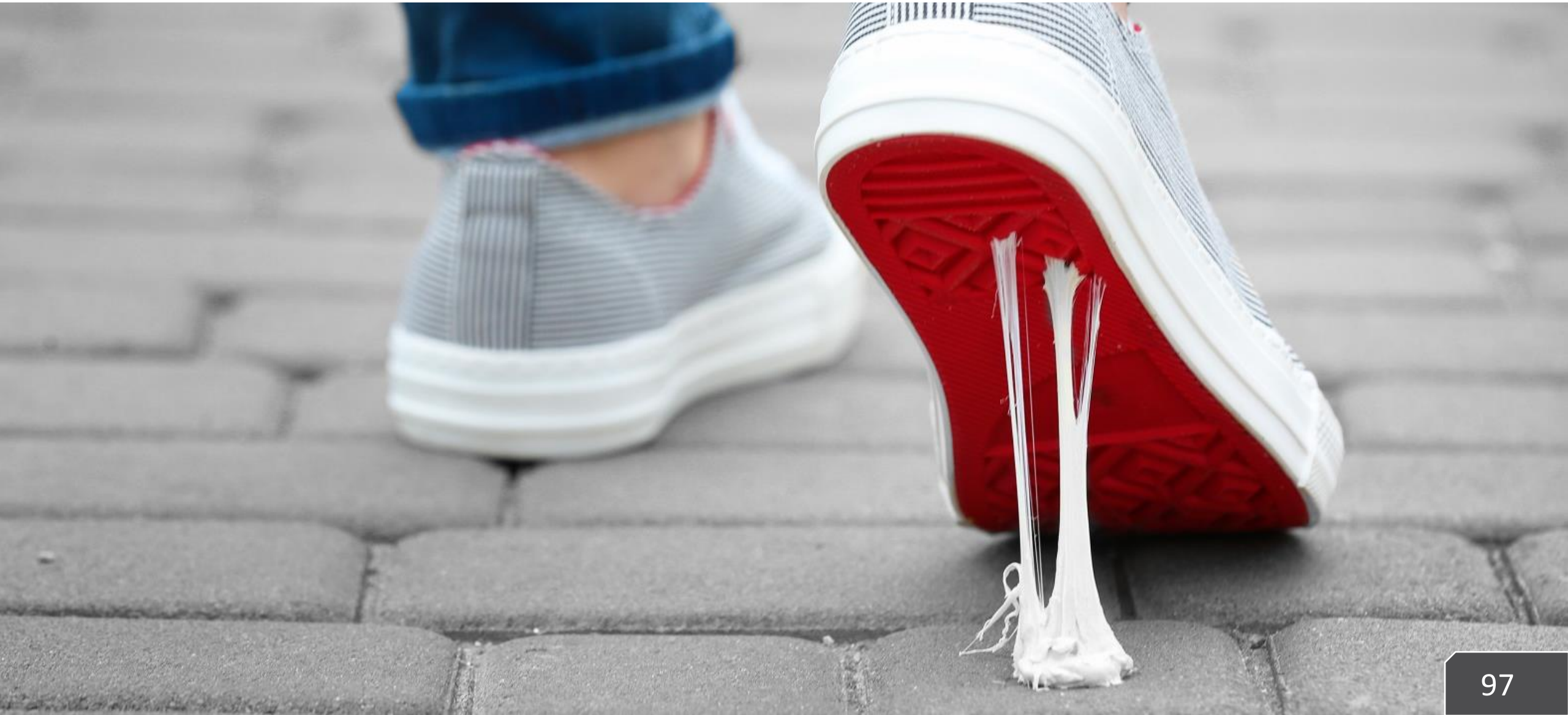
Exceptions:

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.
   a. Affordable housing.
   b. Group I-1, I-2, and I-3 occupancies.
   c. 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.
   d. Buildings with no more than 20,000 square feet of conditioned floor area.
2. Exempt systems. Air-cooled chillers that serve dedicated server rooms, electronic equipment rooms, telecom switch rooms, or similar spaces that only require cooling and do not have any associated space heating equipment are not required to be replaced with heat pump systems. New heat pump systems are not required to serve as the first stage of heating if they serve any of the following system types, and if the requirements of Section C503.4.6.2 are met.
   a. 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.
   b. Terminal unit equipment including but not limited to electric resistance VAV boxes, electric duct heaters, electric resistance fan coils, or electric resistance heaters.

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

- Exempt buildings
- Exempt system types

Adding cooling: a sticky situation



WA: Replacement heating systems

Replacement heating systems must comply with C403.1.4 (heat pump)

- Or an alternate compliance path from Table C503.4.6
- Or follow the FFCP, with all its extra credits

Exceptions:

- Terminal units (VAV boxes, VRF units, fan coils, etc.)
- Air handlers with hydronic coils
- Air handlers with 100% outside air & not required to be DOAS
- Replacement of oil-fired & steam boilers
- Unplanned electrical service upgrade
- **Replacement with same equipment type & capacity**

Seattle: Replacement heating systems

Replacement heating systems must comply with C403.1.4 (heat pump)

- Or an **alternate compliance path** from Table C503.4.6
  - Next slide
- And must also comply with C501.6 (Cx) & C506.1 (metering)
- Or follow "Fossil Fuel Compliance Path"
  - Including efficiency credits

Exceptions:

- Occupancies: Affordable housing, institutional, non-profits, buildings <20,000 ft^2
- Equipment:
- Terminal units (VAV boxes, VRF units, fan coils)
- Air handlers with hydronic coils
- Air handlers with 100% outside air & not required to be DOAS
- Replacement of oil-fired & steam boilers
- OK to maintain 50% of existing gas or resistance equipment capacity
- Temp replacement of 100% of existing
- Expensive utility upgrades

Table C503.4.6
Compliance Options for ((~~Mechanical~~)) HVAC 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. Permitted only when qualifying for and complying with Section C503.4.6 Exceptions 1, 2, 3 or 4 2. Efficiency: ((~~+10%~~)) +5%[b]
4	Gas-fired hot water boilers	Table C403.3.2(6)	1. Permitted only when qualifying for and complying with Section C503.4.6 Exceptions 1, 2, 3 or 4 2. Efficiency: +5%[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

Exceptions to C503.4.6

1. Exempt building types:
    1. Affordable housing
    2. Group I-1, I-2, I-3
    3. Nonprofits
    4. Smaller than 20,000 ft2
2. Retention of 50% of existing fuel type
3. Temporary replacement of failing equipment
    1. Temp Cof O
    2. Performance bond 2%
4. Utility service upgrade
    1. New or enlarged vault
    2. Trenching across vehicle lanes
    3. Exceeds 50% of project valuation

Minimum Energy Performance for "Substantial Alterations" C503.9

- Once in a generation "deep green" retrofit
- For major alterations (like complete gut-and-remodel) nearly full compliance required
- ***"…substantially extends the useful physical or economic life of the building"***
  - Or, vacant for more than 24 months
  - Or, major flood/fire damage repair
- "Impracticality" clause
- Also seismic & life safety

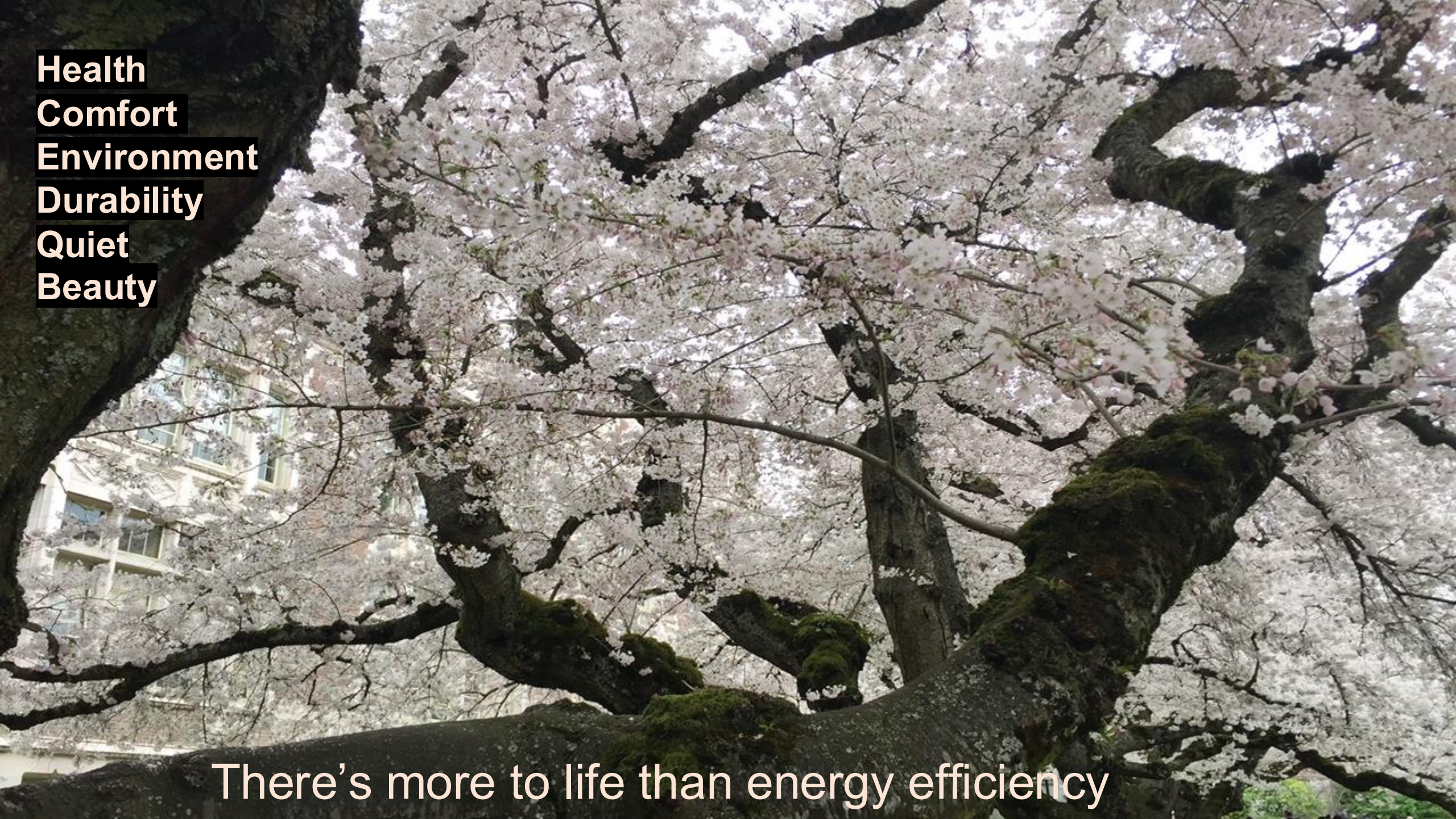
Substantial Alterations: (Also) a sticky situation

Industrial & Commercial Process loads?

Typically not regulated, but *lots* of exceptions:

- Any specific code requirements
  - Like data center cooling
- **C403 HVAC – see these exceptions**
- C404.2, SWH equipment efficiency
- C404.6, Pipe insulation
- C404.13, Service water pressure booster systems
- C405.8 Electric motor efficiency
- C410 Refrigeration systems
- C412 Compressed air systems

- **C403.3.2** HVAC equipment performance requirements – furnaces, HVAC controls, chillers, package and split system equipment, humidification, hot gas bypass…
- **Tables C403.3.2** (1) through (16) inclusive - Equipment
- **C403.3.4.1** Boiler combustion air positive shut-off
- **C403.3.4.2** Boiler system oxygen concentration controls (fan systems)
- **C403.3.4.3** Boiler oxygen concentration controls
- **C403.7.7** Exhaust systems – kitchen, lab, transfer air
- **C403.9.2.1** Condenser heat recovery for service water heating
- **C403.10.3** Piping for HVAC heating and cooling systems
- **C403.11.2** Snow and ice melt systems
- **C403.11.3** Freeze protection (basically heat trace)


Health
Comfort
Environment
Durability
Quiet
Beauty
There’s more to life than energy efficiency

Q & A and closing

- **Questions?**
  - Duane Jonlin, duane.jonlin@seattle.gov, 206-233-2781
  - Ben Rousch, benr@fsi-engineers.com
  - City Light Energy Advisors, SCLEnergyAdvisor@seattle.gov, 206-684-3800
  - Lighting Design Lab, lightingdesignlab@seattle.gov
- **Take the survey!**

THANK YOU

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