

BUILDINGENERGY BOSTON

Designing the Future of Learning: Insights from Passive Schools

Kate Bubriski, Arrowstreet

Ryan Dirks, Perkins Eastman

Jess Farber, CMTA

Nicole Peterson, Thornton Tomasetti

Curated by Ashley Wisse and Harshika Bisht

Northeast Sustainable Energy Association (NESEA) | March 24, 2026



Kate Bubriski
Principal | Director
of Sustainability
& Building
Performance

ARROWSTREET



Ryan Dirks
Senior Associate |
Sustainability
Specialist

**PERKINS —
EASTMAN**



Jess Farber
Vice President |
Mechanical Engineer

 **CMTA**
A **LEGENCE** Company



Nicole Peterson
Senior Associate |
Sustainability &
Resilience

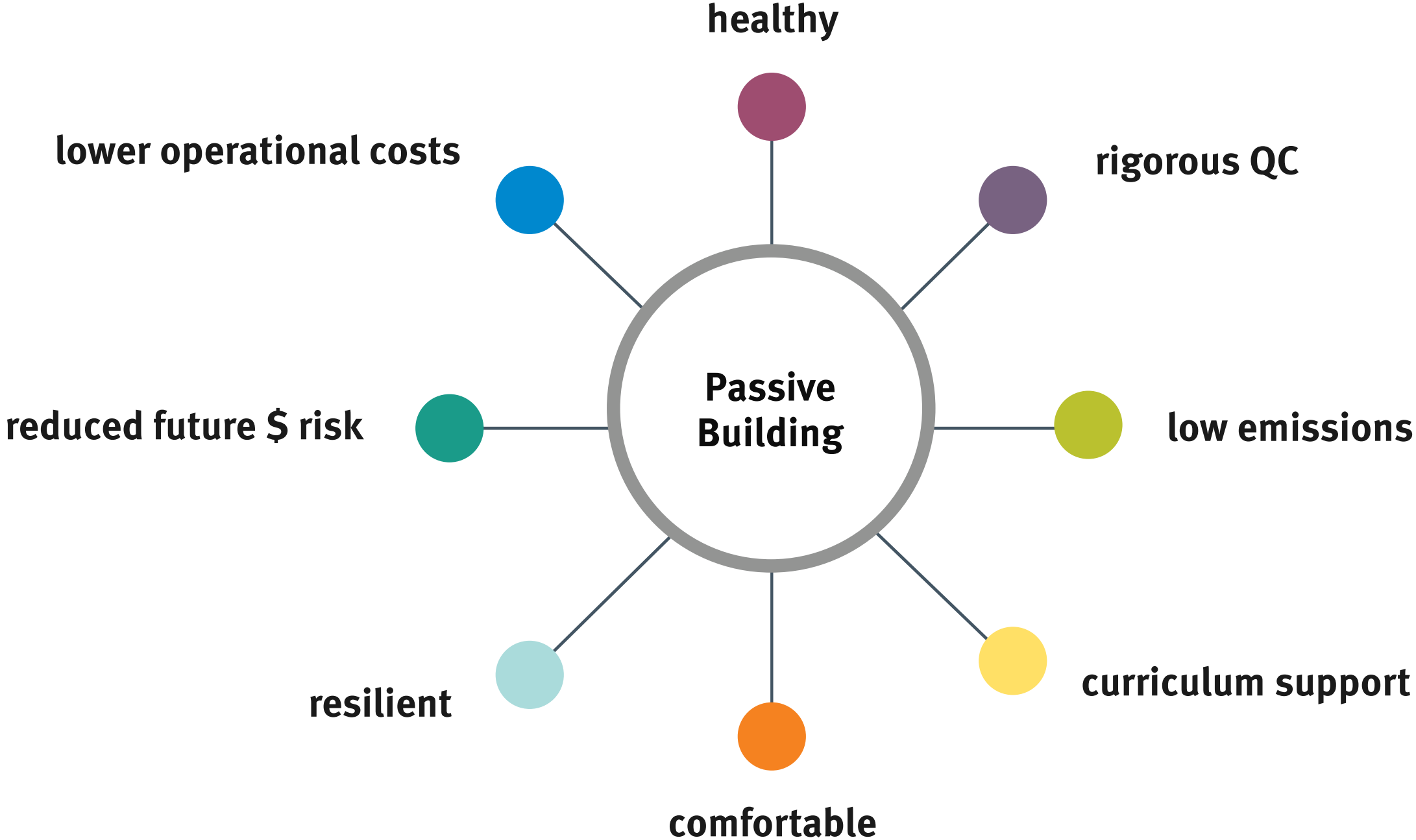
Thornton Tomasetti

LEARNING OBJECTIVES

- Describe the differences and how to choose between Certified Performance and TEDI Stretch Code pathways.
- Recognize unique Passive Building strategies for schools that are different from other building types.
- Develop specific exterior assemblies for schools pursuing Phius certification.
- Implement WUFI Passive modeling with school building considerations and challenges.

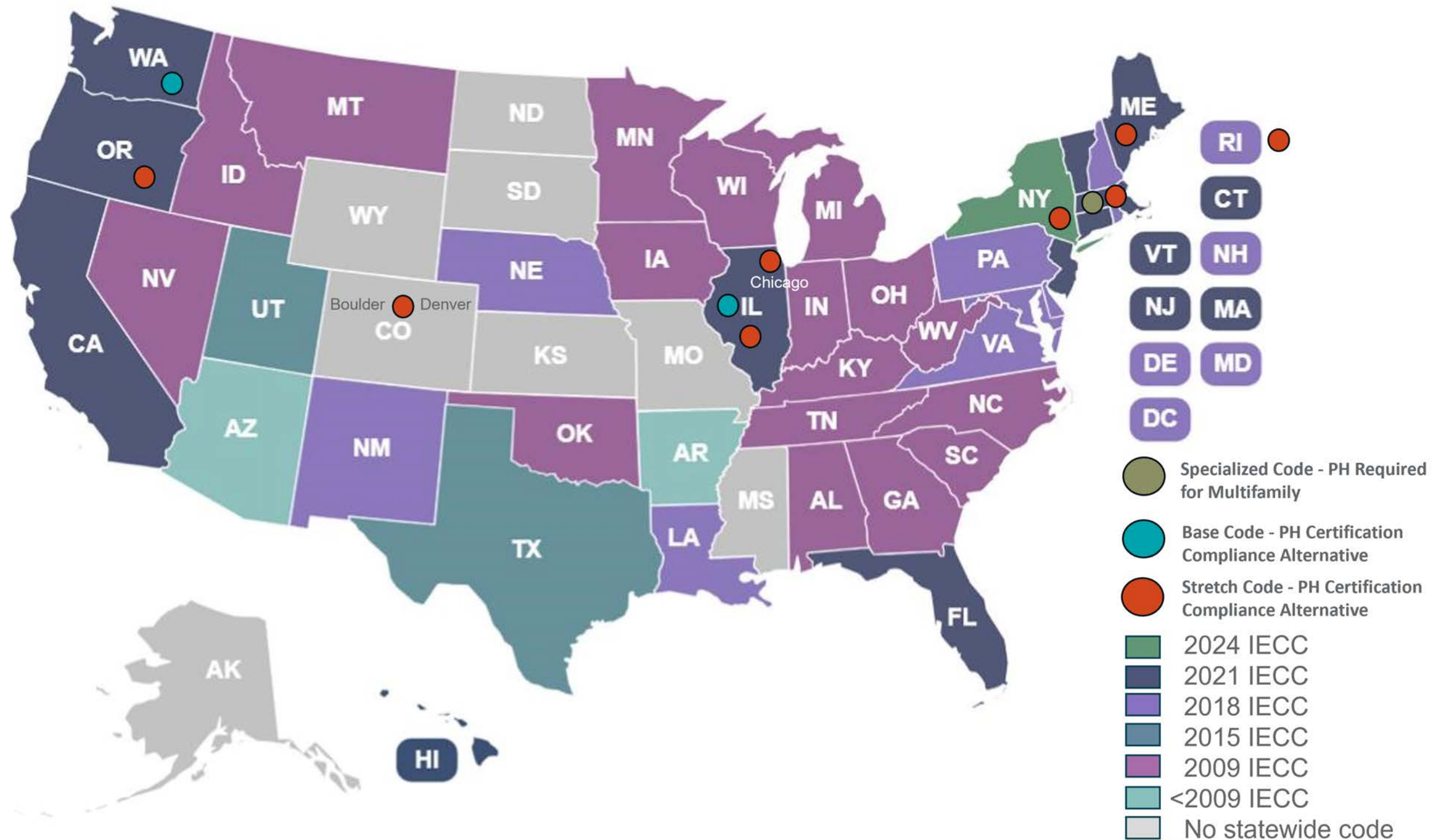
WHY PASSIVE BUILDINGS FOR SCHOOLS

BENEFITS OF PASSIVE BUILDING

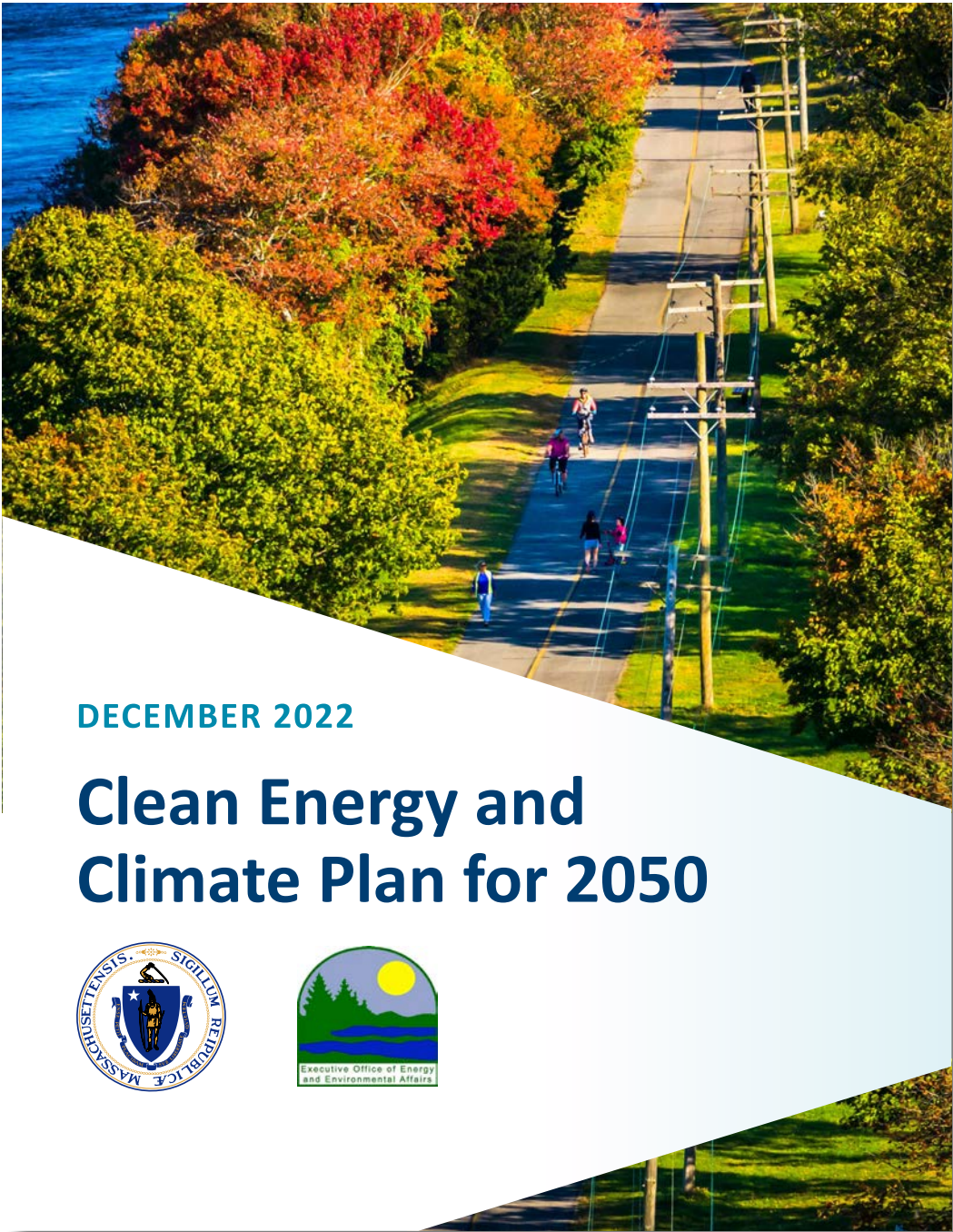


POLICY INFLUENCING PASSIVE BUILDING

PASSIVE HOUSE CERTIFICATION COMPLIANCE IN CODES





WHAT'S HAPPENING IN MASSACHUSETTS



DECEMBER 2022

Clean Energy and Climate Plan for 2050



Executive Office of Energy and Environmental Affairs



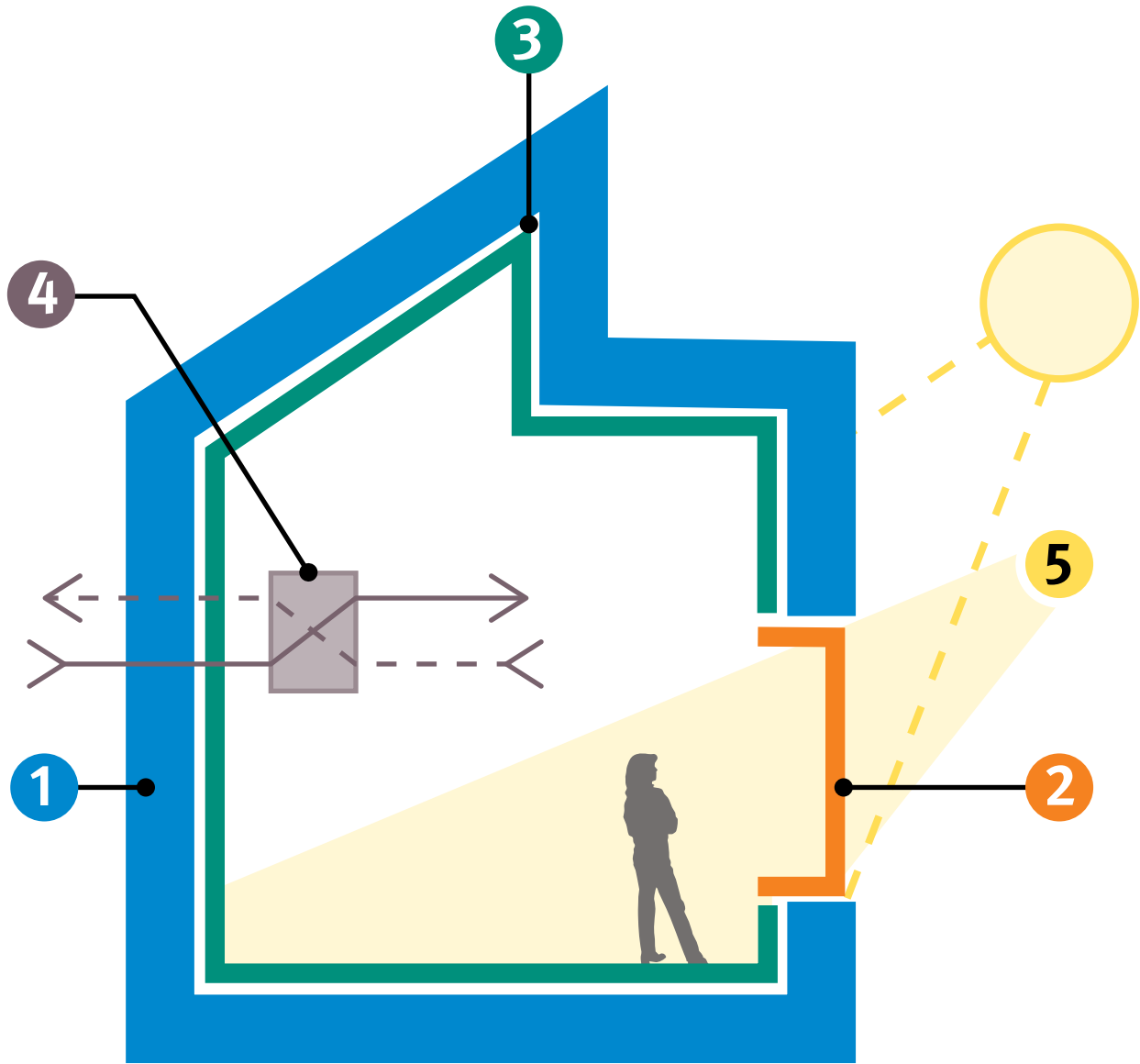
2023 TECHNICAL GUIDANCE

MASSACHUSETTS STRETCH ENERGY CODES



A reference and instructional guide for Massachusetts Energy Stretch and Specialized Codes

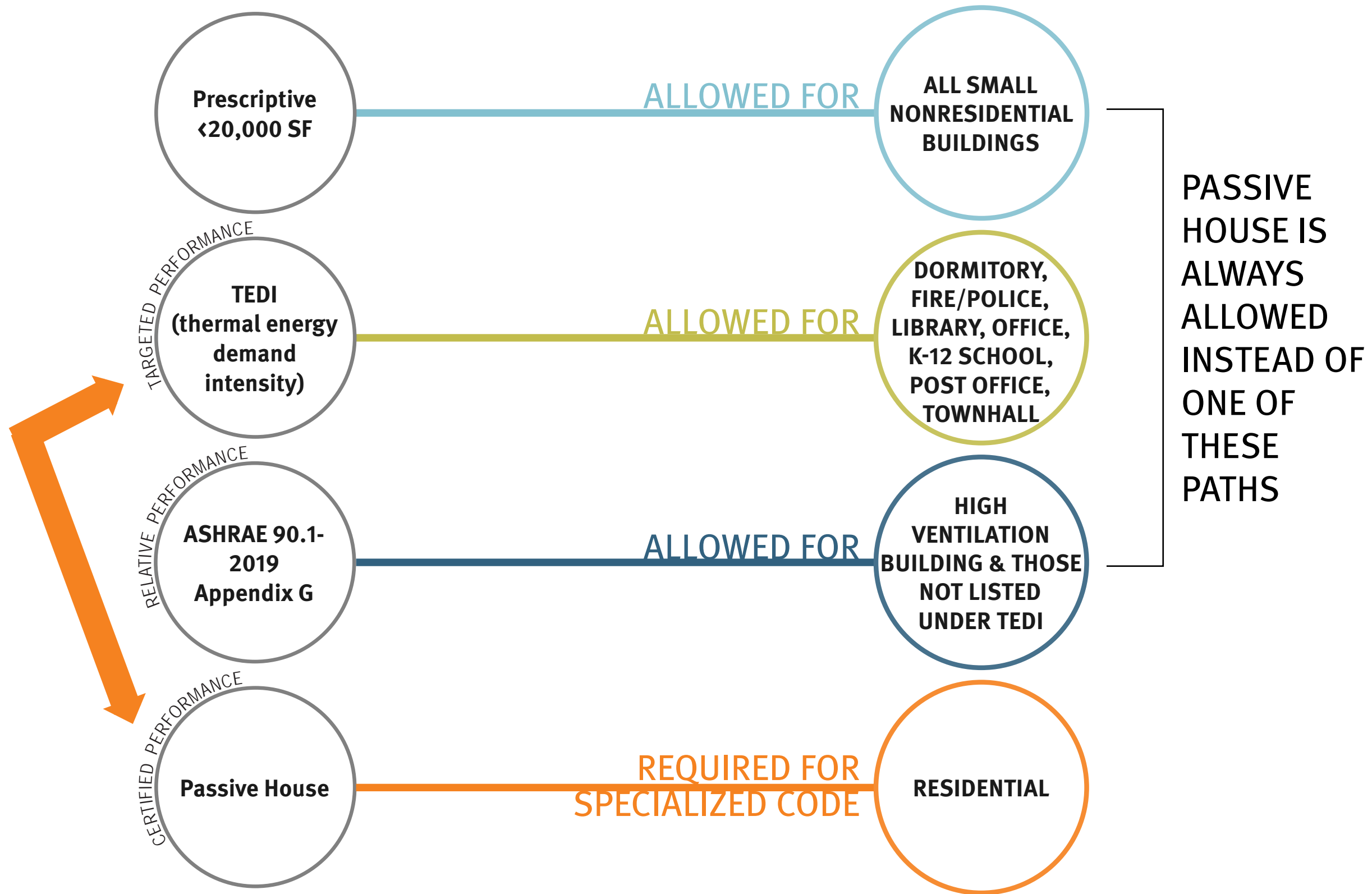
MA STRETCH ENERGY CODE



- 1. Continuous High R Insulation
- 2. High Performance Windows
- 3. Air Tight Enclosure
- 4. Balanced Ventilation with Heat Recovery
- 5. Optimized Solar Orientation

MA STRETCH ENERGY CODE

PATHWAYS FOR SCHOOLS



MA STRETCH ENERGY CODE

		Passive House	TEDI
Heating/ Cooling	Heat Pump / VRF	X	X
	Gas Fired/DX Cooling ¹		X
Hot Water	Heat Pump	X	X
	Elec Resistance	X	X
	Gas ¹	X	X
Envelope	Triple Glazed Windows	X	X
	Highly Insulated	X	X
	Thermal Bridge Mitigation	X	X
	Prescriptive Metric		X
EV Ready		X	X
Solar Ready		X	X
Construction Verification	Air Leakage ²	X	X
	Basic Envelope Cx	X	X
	MEP Cx	X	X
	Add'l Testing	X	
Third Party Certification		X	
Mass Save Incentives		no difference	no difference

1. If >50% glazed wall system must be all-electric. If following Additional Efficiency measure than must be heat pump h/c. If following Specialized Code need to be electric or predesign/prewire for. If in Fossil Fuel Free Pilot Community can not use gas.

2. PH rate 0.06 cfm/sf, TEDI flexible but ~ ≤0.15.

Phius FOR COMMERCIAL



- PEAK HEATING LOAD**
- ANNUAL HEATING DEMAND**
- PEAK COOLING LOAD**
- ANNUAL COOLING DEMAND**
- ANNUAL SOURCE ENERGY**
- AIR TIGHTNESS**

BASED ON CLIMATE,
ENVELOPE & FLOOR
AREA, OCCUPANCY

ALLOWANCE/SF

0.06 CFM50/SF

- Moisture control
- Glazing comfort/condensation
- Water efficiency
- EV Ready
- PV Ready
- Low emitting materials

Phius FOR COMMERCIAL

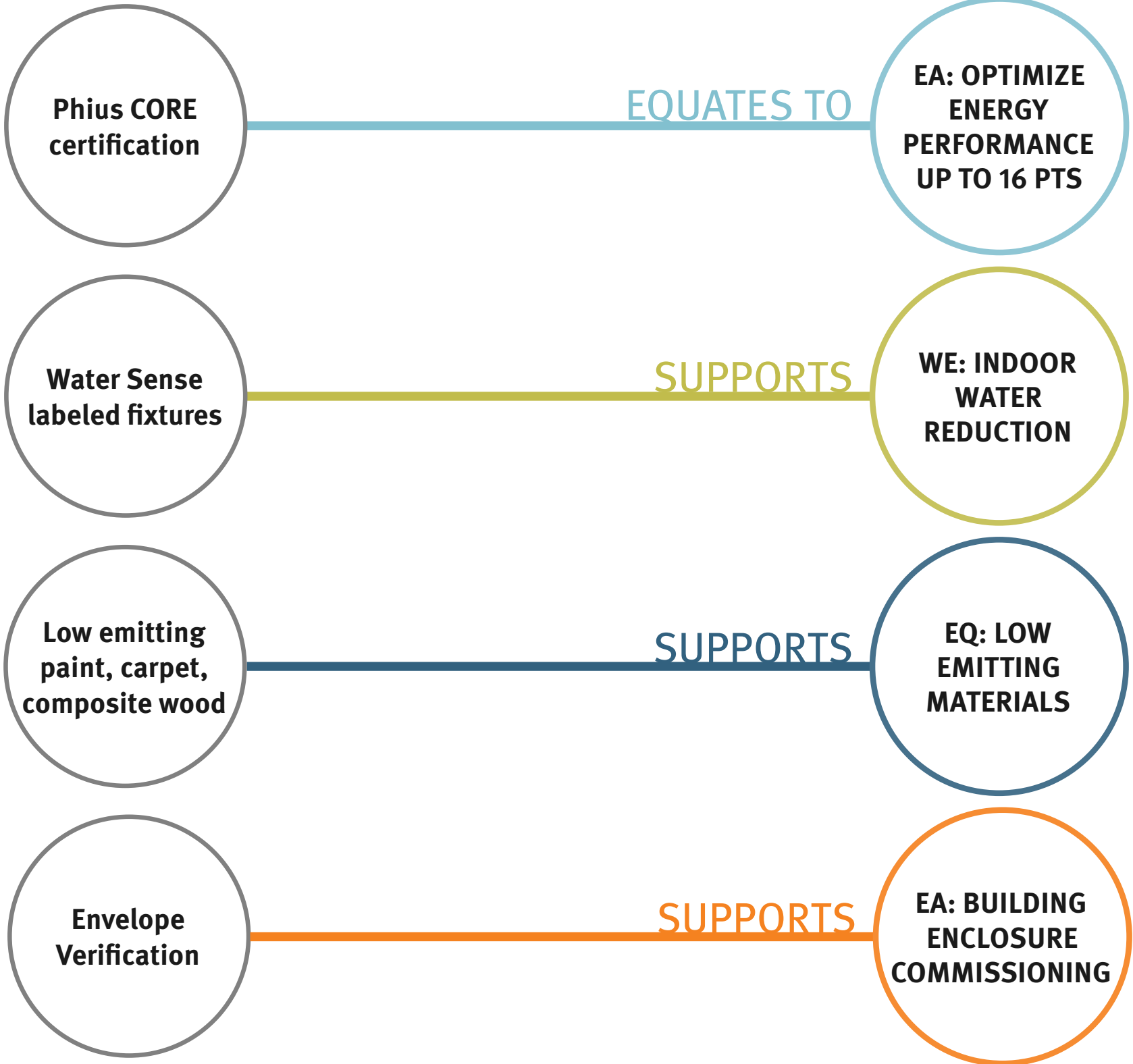
Unlike residential, commercial projects do not gain additional certifications but components of those programs need to be met



CERTIFICATION ALIGNMENT

PHIUS

LEED



FEASIBILITY STUDIES

PHIUS FEASIBILITY STUDIES



IMAGE INSPIRATION: PASSIVE HOUSE ACCELERATOR

ENGAGING PHIUS EARLY PUTS PROJECTS IN THE RIGHT DIRECTION

Evaluation of key questions:

Squantum ES flat vs pitched roof

Reverse HS ER%

+ All non-residential atypical situations

PHIUS FEASIBILITY STUDIES

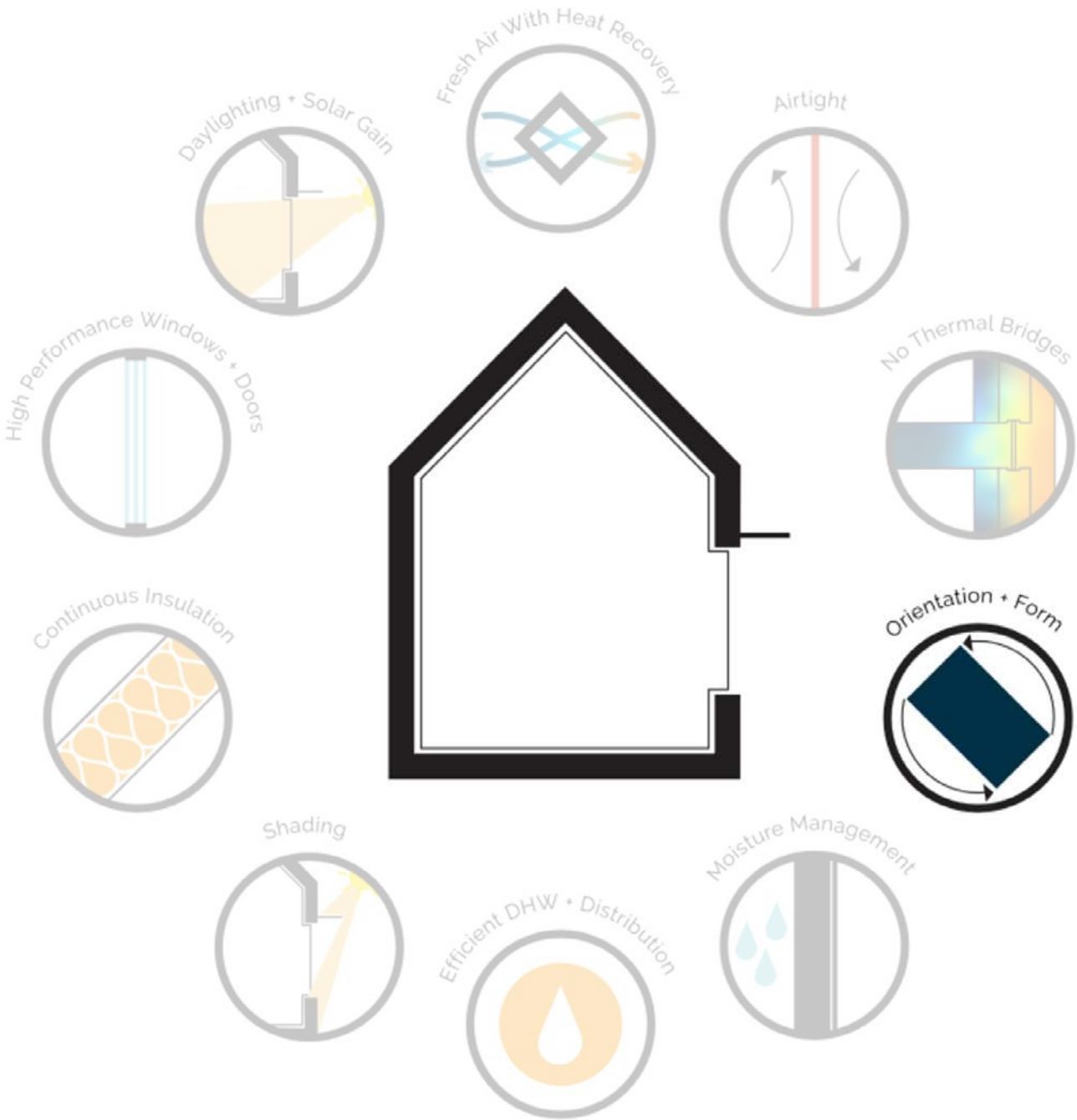


IMAGE INSPIRATION: PASSIVE HOUSE ACCELERATOR

ENGAGING PHIUS EARLY PUTS PROJECTS IN THE RIGHT DIRECTION

Geometry development
Custom climate data

PHIUS FEASIBILITY STUDIES



IMAGE INSPIRATION: PASSIVE HOUSE ACCELERATOR

ENGAGING PHIUS EARLY PUTS PROJECTS IN THE RIGHT DIRECTION

- Geometry development
- Custom climate data
- Window comfort criteria**
- Comments on envelope optimization**

PHIUS FEASIBILITY STUDIES

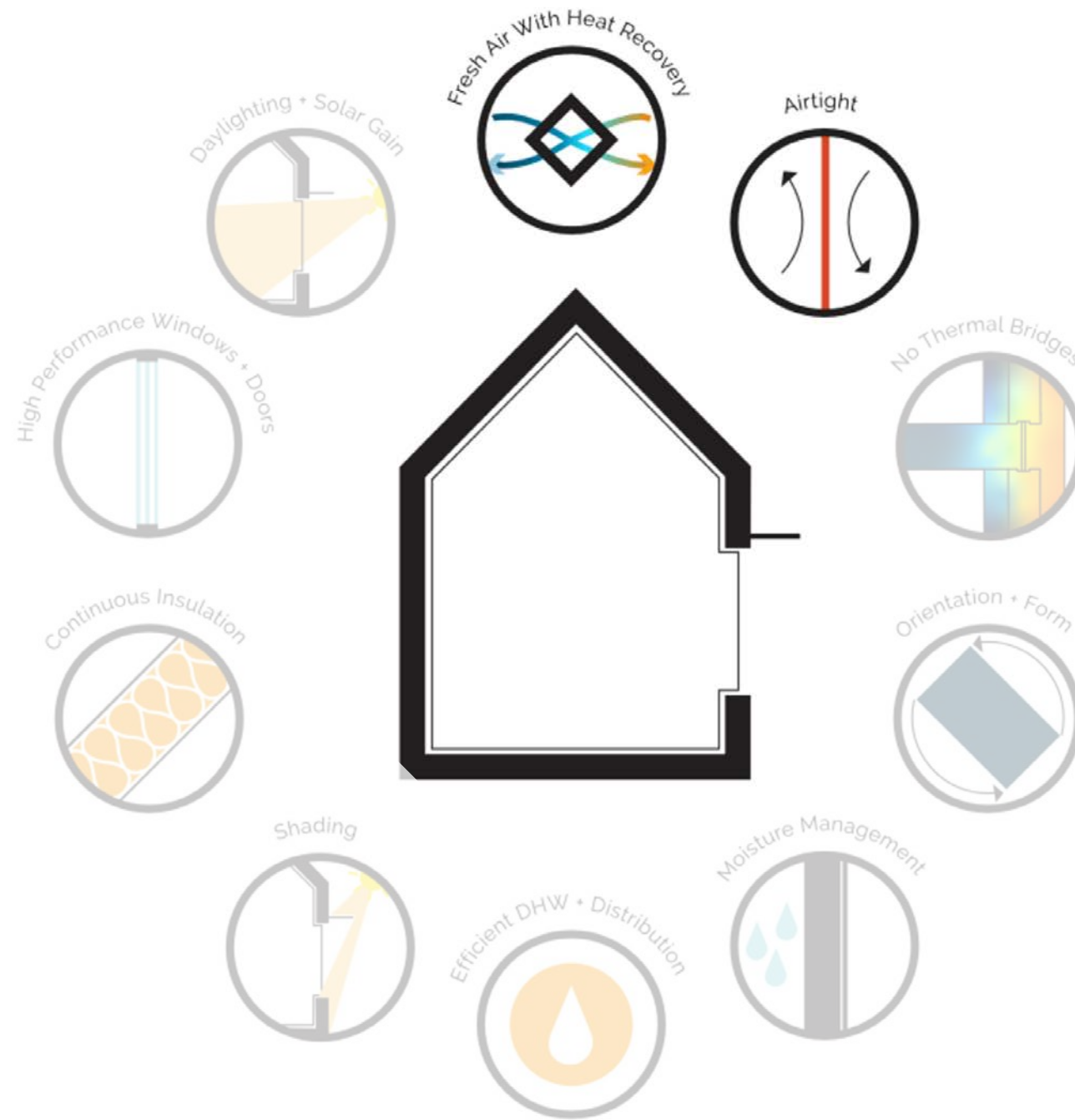


IMAGE INSPIRATION: PASSIVE HOUSE ACCELERATOR

ENGAGING PHIUS EARLY PUTS PROJECTS IN THE RIGHT DIRECTION

- Geometry development
- Custom climate data
- Window comfort criteria
- Comments on envelope optimization
- Coordination on ventilation approach**

PHIUS FEASIBILITY STUDIES

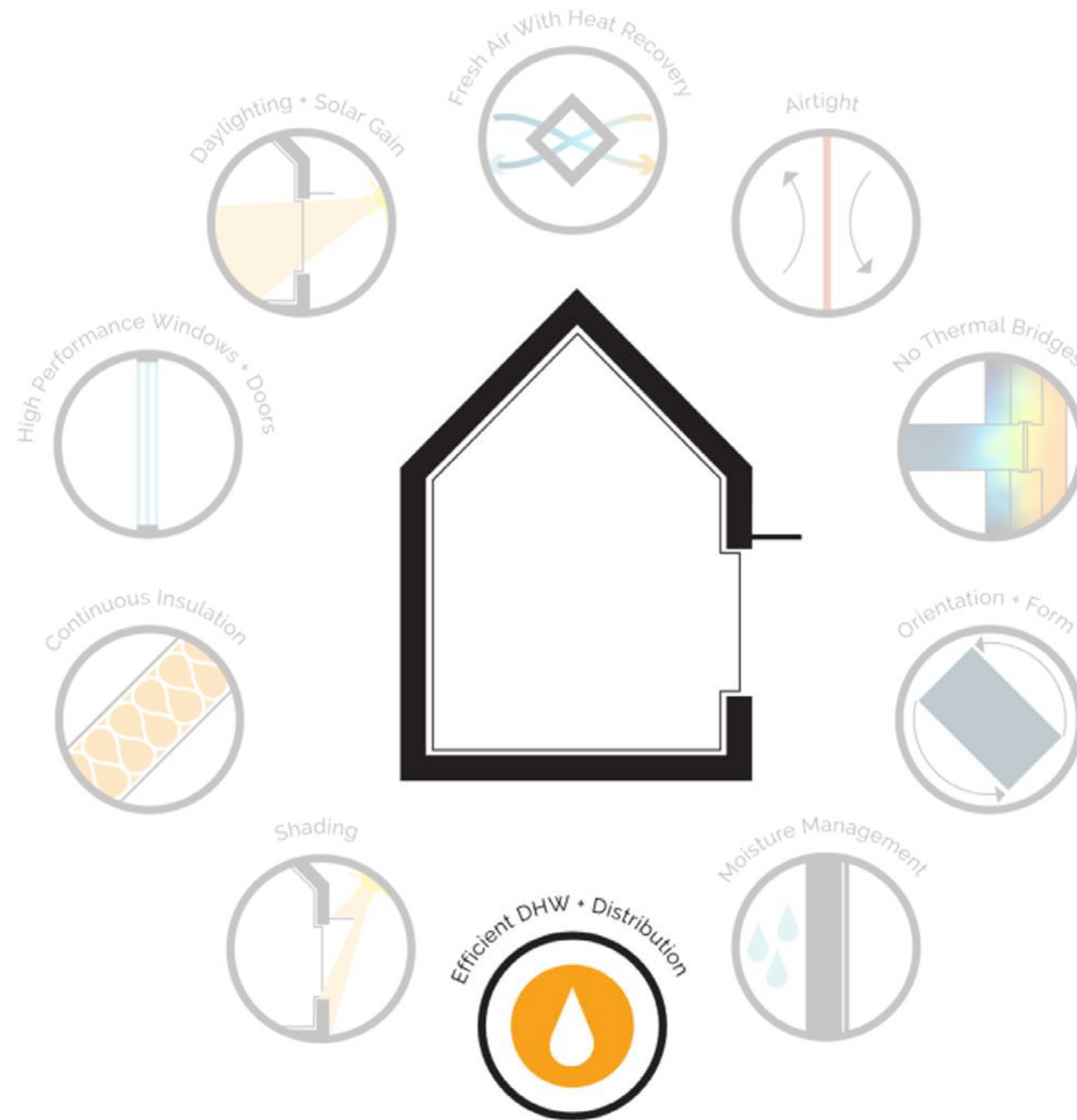


IMAGE INSPIRATION: PASSIVE HOUSE ACCELERATOR

ENGAGING PHIUS EARLY PUTS PROJECTS IN THE RIGHT DIRECTION

- Geometry development
- Custom climate data
- Window comfort criteria
- Comments on envelope optimization
- Coordination on ventilation approach
- Estimates on office and kitchen equipment**
- DHW usage calculations**

CASE STUDIES

SQUANTUM SCHOOL



Phius CORE COMM 2024
LEED Schools Gold
380 STUDENTS
K-5 GRADES
80,000 GSF, 2 STORIES
COMPLETION 2027

CHARLESWOOD ELEMENTARY



Phius CORE COMM 2021
LEED Schools Gold
1,185 STUDENTS
K-5 GRADES
170,000 GSF, 3 STORIES
COMPLETION 2027

REVERE HIGH SCHOOL



Phius CORE COMM 2024
LEED Schools Gold
2,450 STUDENTS
9-12 GRADES
426,000 GSF, 5 STORIES
COMPLETION 2028

ENCLOSURE

SQUANTUM SCHOOL



20.3% WWR

R-60 ROOF

R-28 WALLS

R-45 FLOOR

R-20 SLABS

U-0.15/SHGC 0.33 FIXED & OPERABLE

CHARLESWOOD ELEMENTARY



18.7% WWR

R-54 ROOF

R-25 WALLS

R-15 SLABS

U-0.19 FIXED

U-0.22 OPERABLE

REVERE HIGH SCHOOL



11.2% WWR

R-63 ROOF

R-28 WALLS

R-35 FLOOR

U-0.17 FIXED

U-0.27 OPERABLE

* Wall R-values include clear field but not linear derating

SYSTEM HIGHLIGHTS

SQUANTUM SCHOOL



- Ground Source Heat Pumps
- Displacement Ventilation w/
- Energy Recovery & Demand Control
- Radiant Heating
- Heat Pump Hot Water
- Daylight Controls & LED Lighting
- On-site PV

CHARLESWOOD ELEMENTARY



- Distributed Ground Source Heat Pumps
- Dedicated Outside Air System w/
- Energy Recovery & Demand Control
- Electric Resistance Hot Water
- Daylight Controls & LED Lighting
- On-site PV

REVERE HIGH SCHOOL

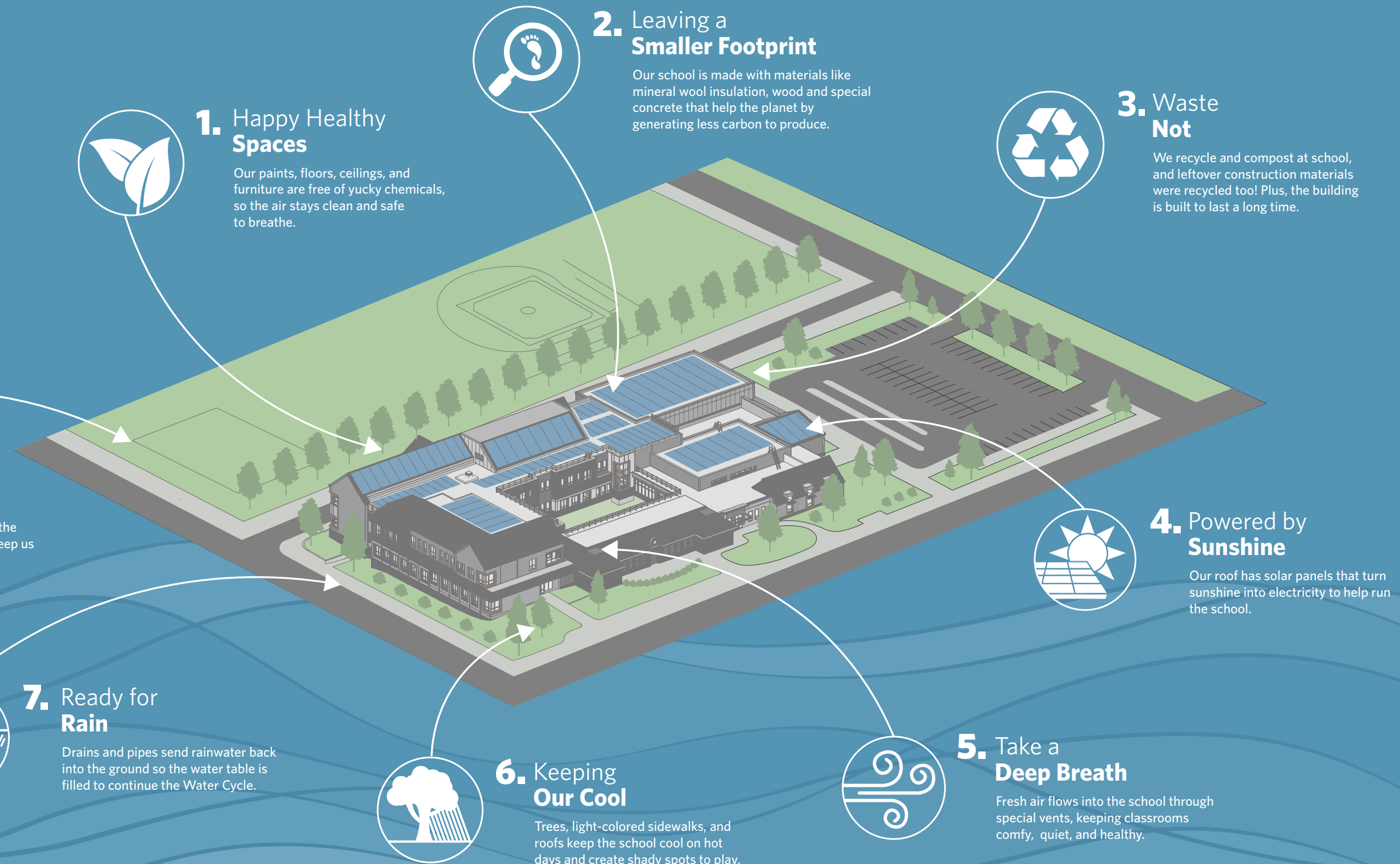


- Distributed Ground Source Heat Pumps
- Dedicated Outside Air System w/
- Energy Recovery & Demand Control
- Ground Source Hot Water
- Daylight Controls & LED Lighting
- On-site PV

SQUANTUM SCHOOL

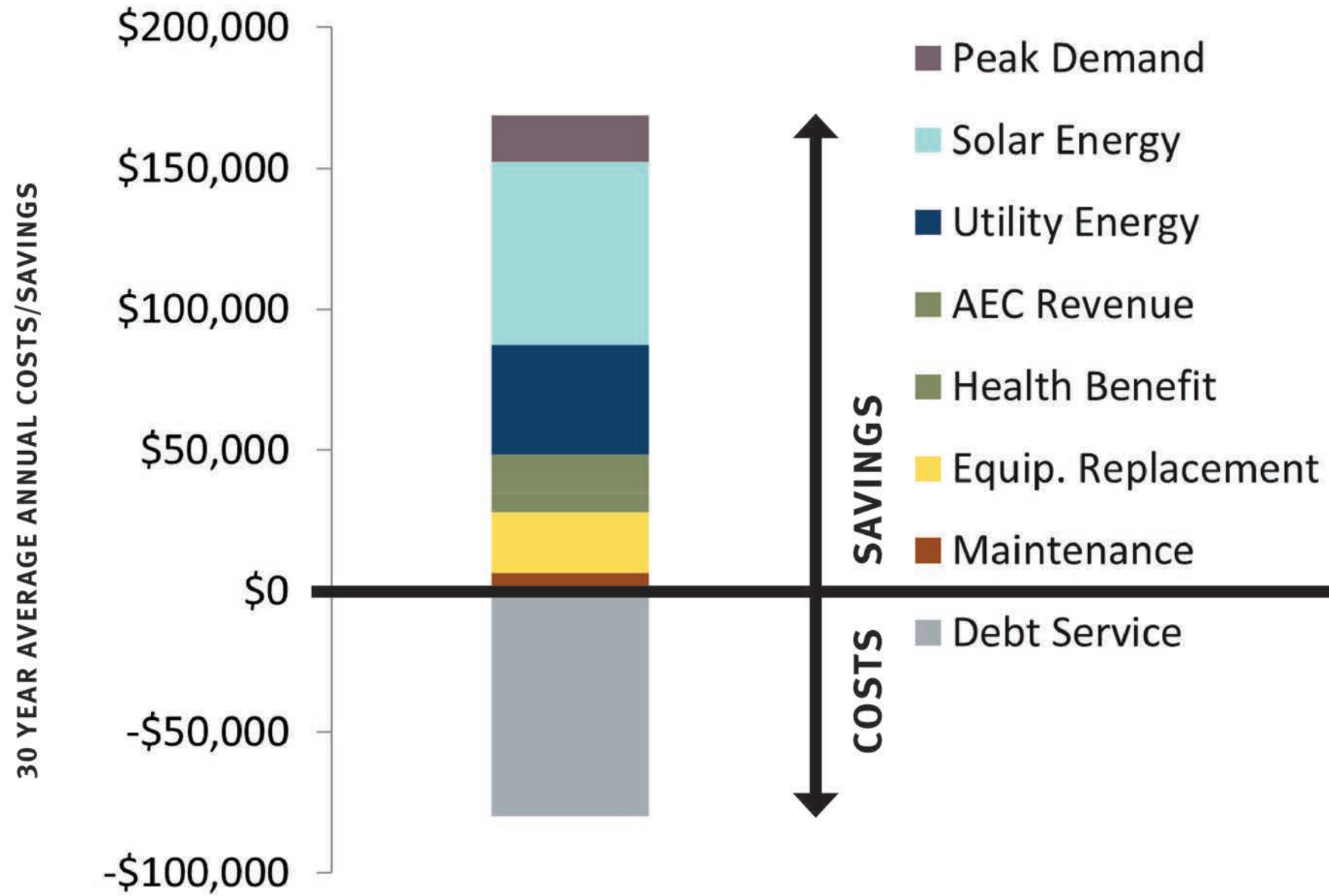
Squantum School is designed with the **environment** in mind.

As the waters of the Neponset River journey to the Atlantic Ocean, our school, too, flows in harmony with nature, conserving energy, honoring resources, and nurturing the well-being of all who learn within.



SQUANTUM SCHOOL

OPERATIONAL SAVINGS



30 Year total
\$2,450,000

Savings start year 1

SQUANTUM SCHOOL

	Technology	Estimated Construction Cost	Rate ¹	Estimated Incentive
Sec 48 Alternative Energy Investment Tax Credit	Solar	\$1,400,000	25.5%	\$357,000
	Ground Source Heat Pump	\$7,189,750	25.5%	\$1,833,386
Mass Save	Path 1 Net Zero Ready			\$814,000
MA EVIP Public Access ²	EV charging	\$56,000	100%	\$50,000

\$8,645,750

Construction Cost Total

\$3,054,386

Potential Incentive Total

\$5,591,364

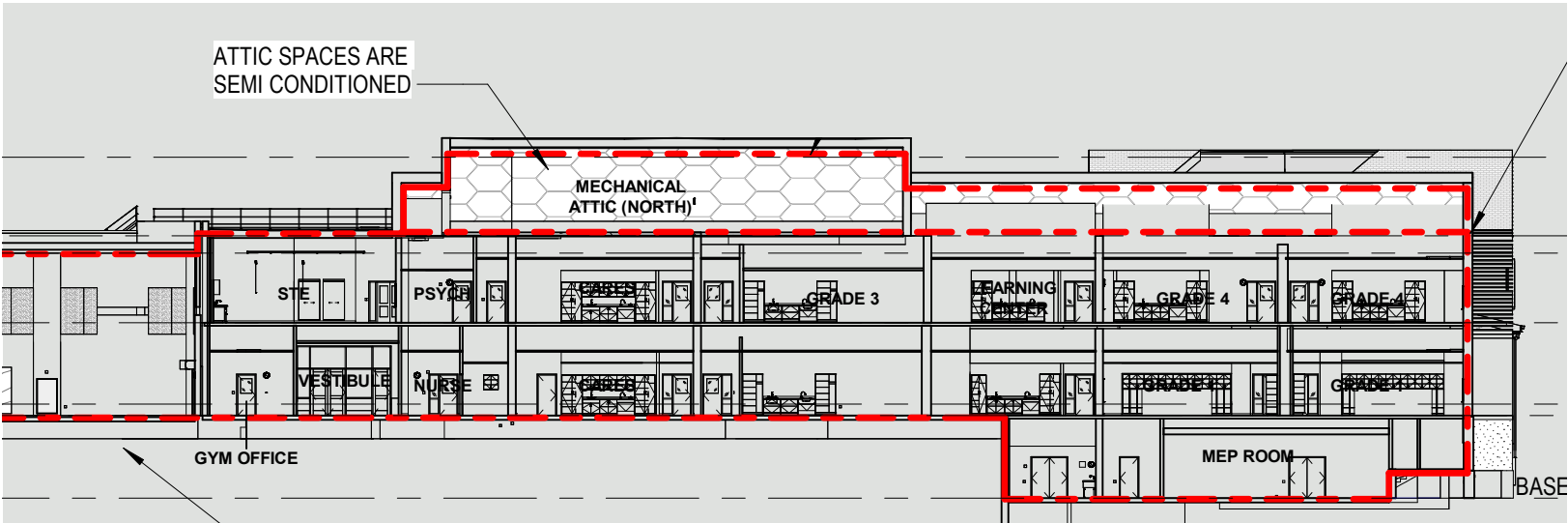
w/ Incentive

1. Assumes using tax-exempt bonds
 2. Assumes supplying 4 dual head EVSE

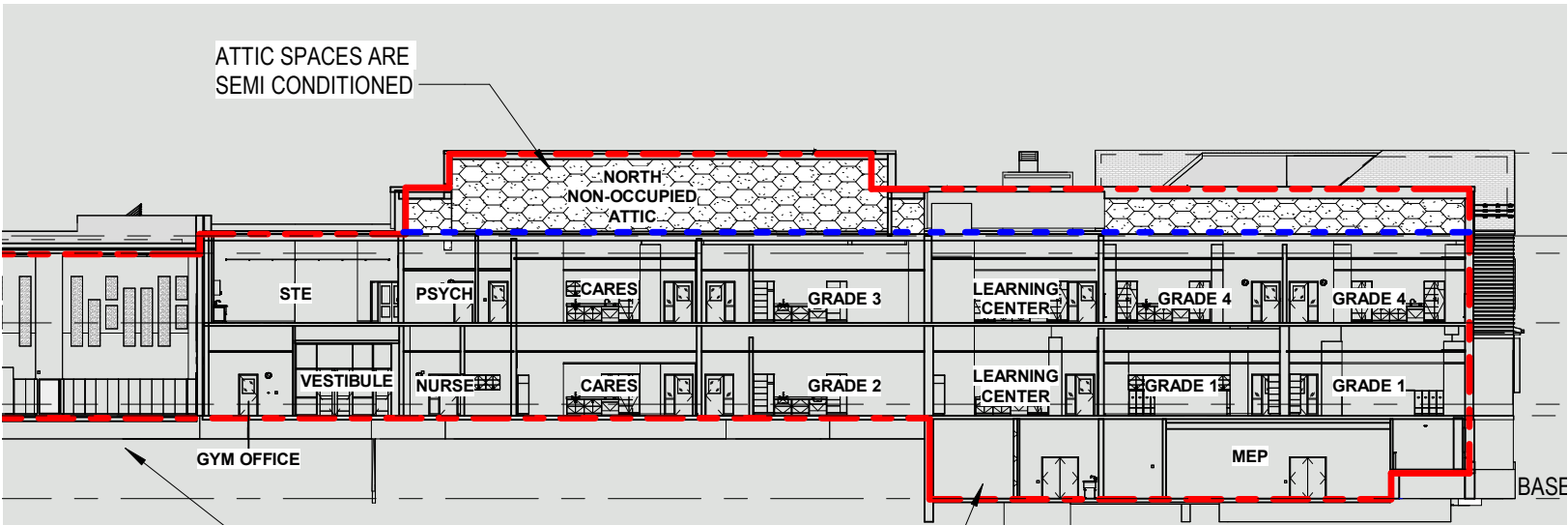
SQUANTUM SCHOOL



THERMAL/AIR BOUNDARY



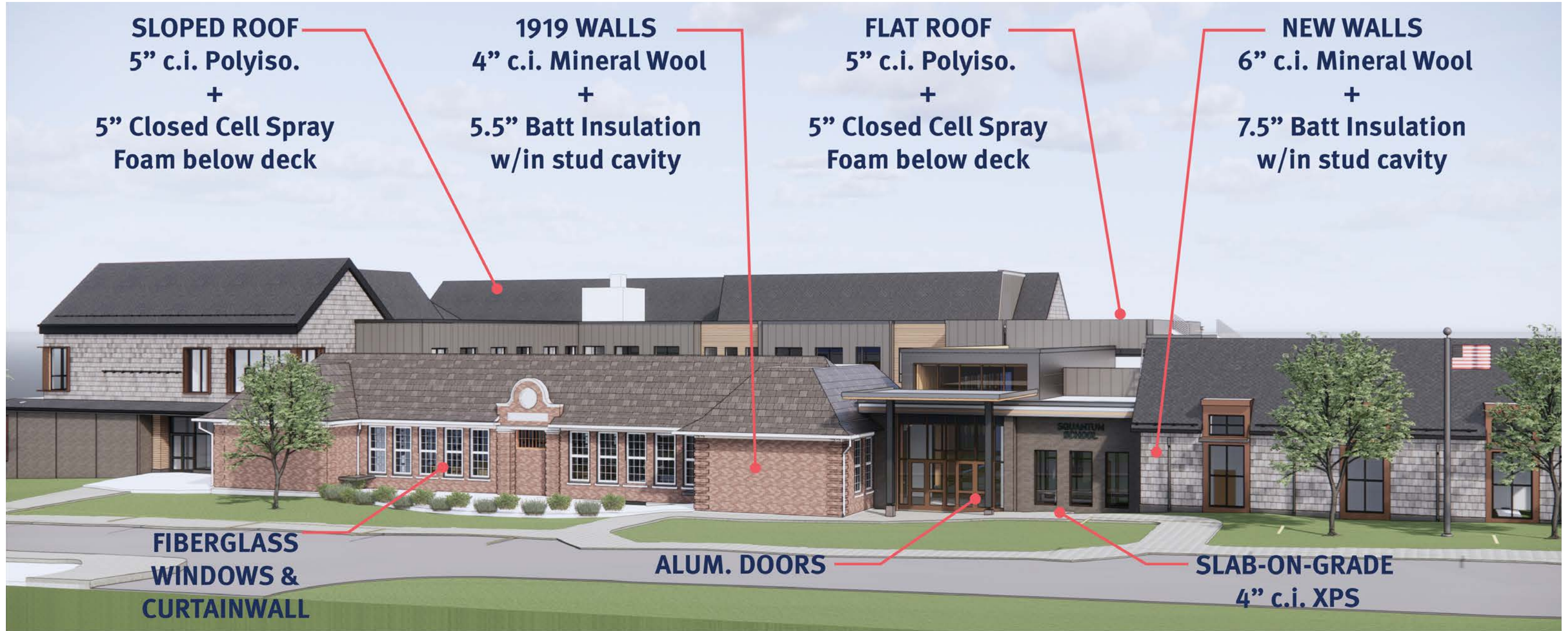
AT FLOOR



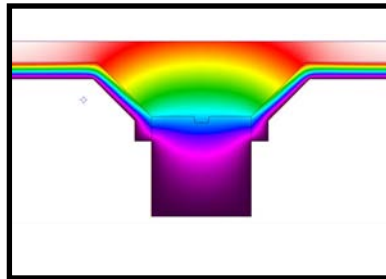
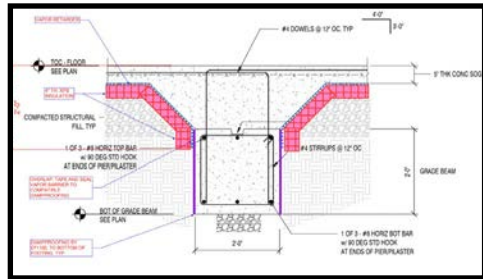
AT SLOPE

SQUANTUM SCHOOL

ENVELOPE ASSEMBLIES

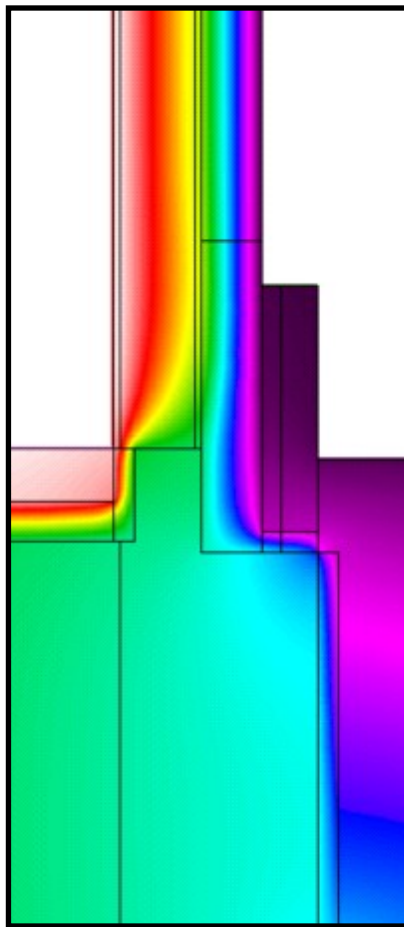
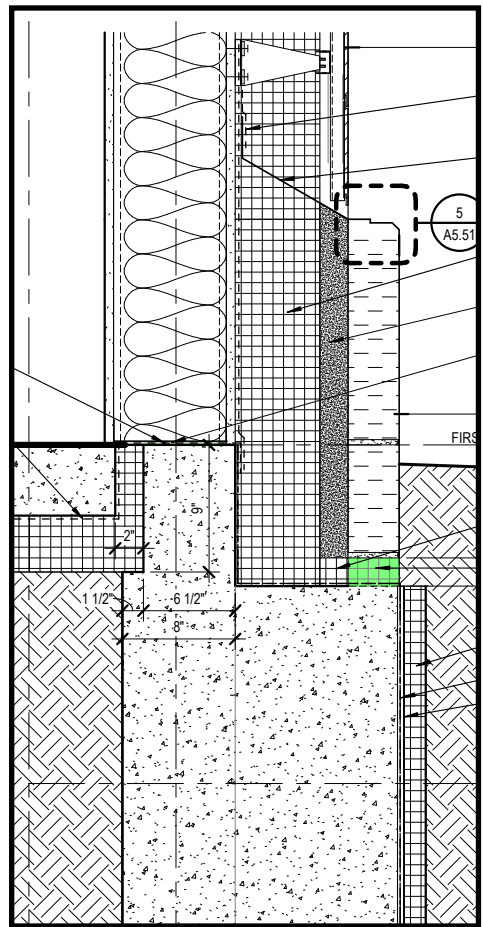


THERMAL BRIDGE MITIGATION



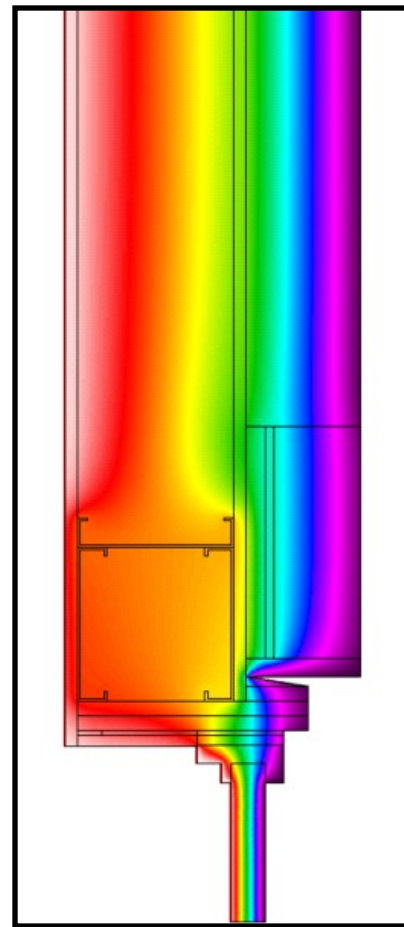
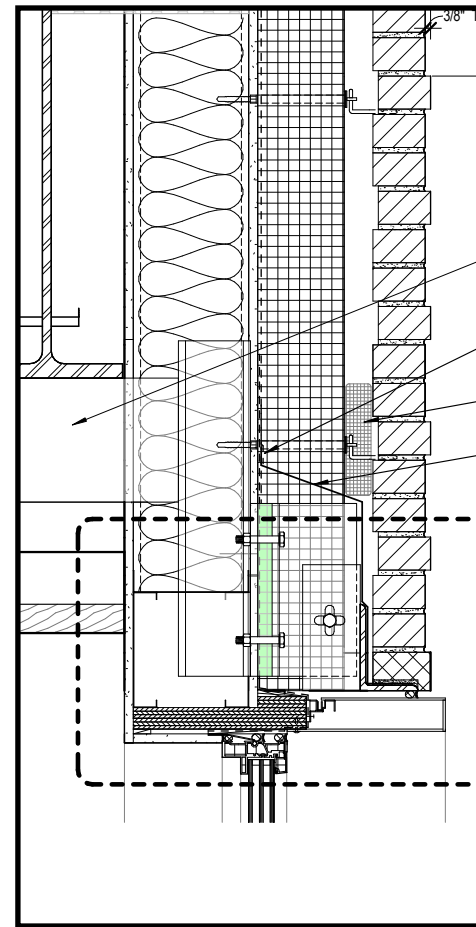
GRADE BEAMS

PSI 0.684



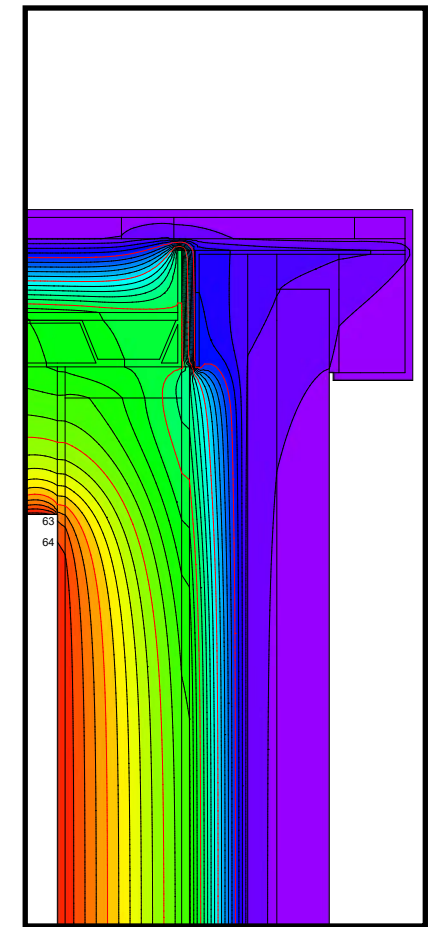
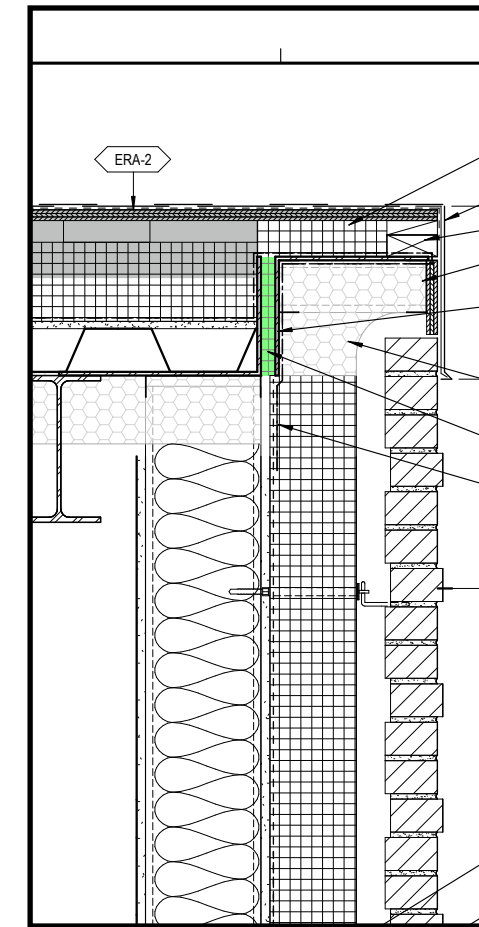
PERIMETER BASE

PSI -0.006



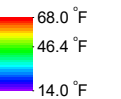
RELIEVING ANGLE

PSI 0.162



PARAPET

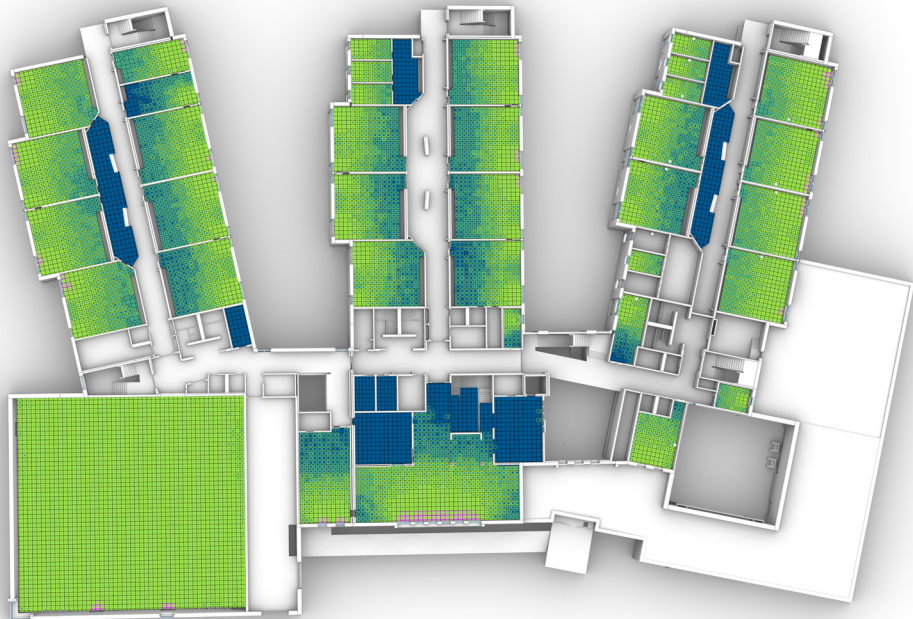
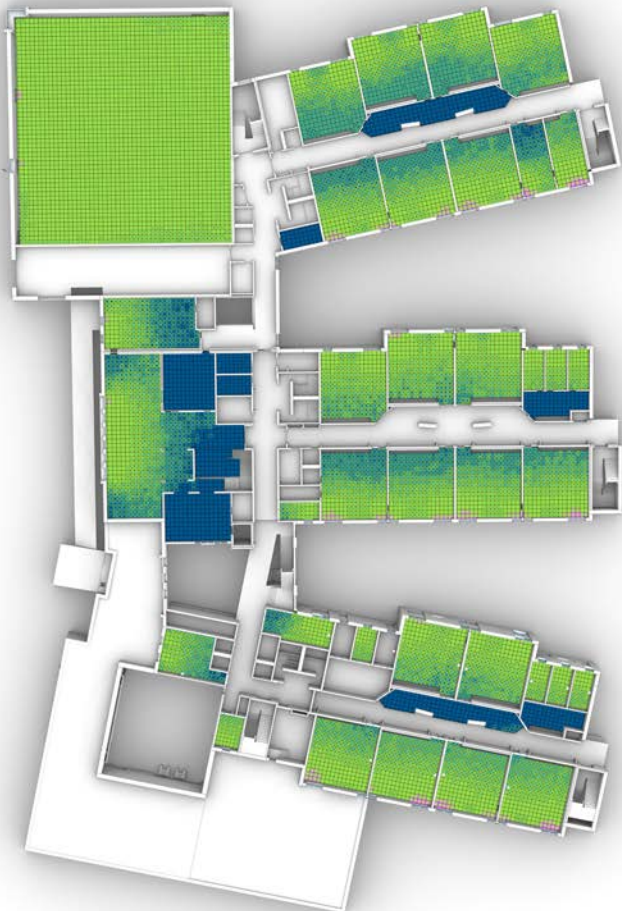
PSI 0.031



**CHARLESWOOD ELEMENTARY &
REVERE HIGH SCHOOL**

BENEFITS OF NORTH-SOUTH FACADE ORIENTATION

CHARLESWOOD ELEMENTARY



Useful Daylight Illuminance (UDI)
+11.7%

Energy Use Intensity (EUI)
-0.3%

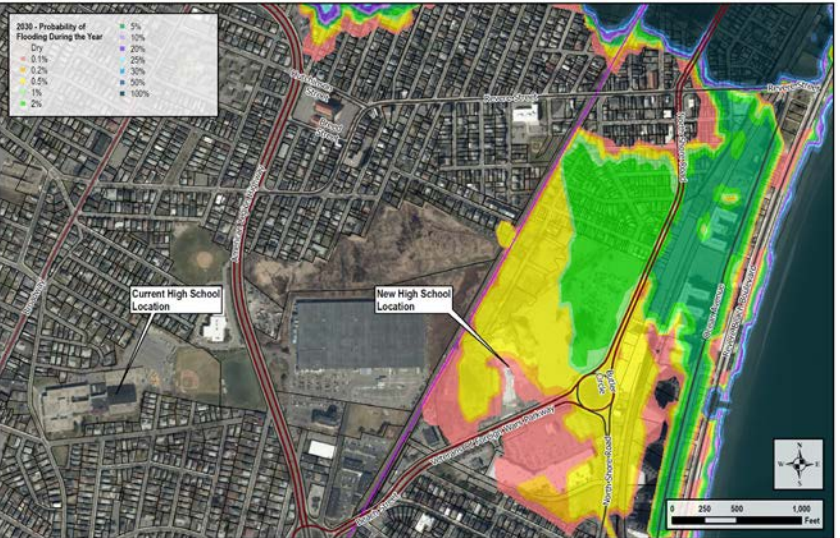
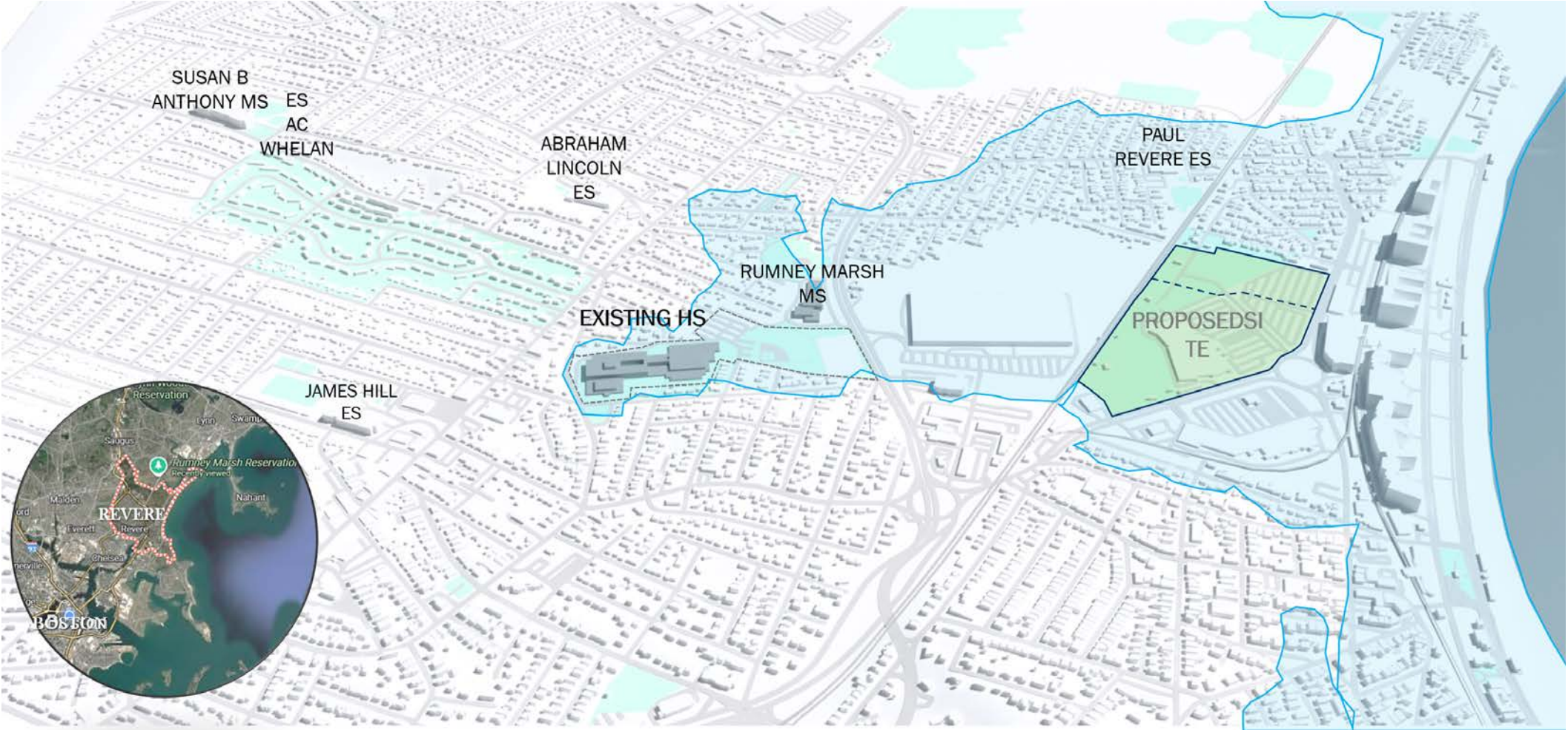
Heating & Cooling Demand
-2.3%

NORTH-SOUTH

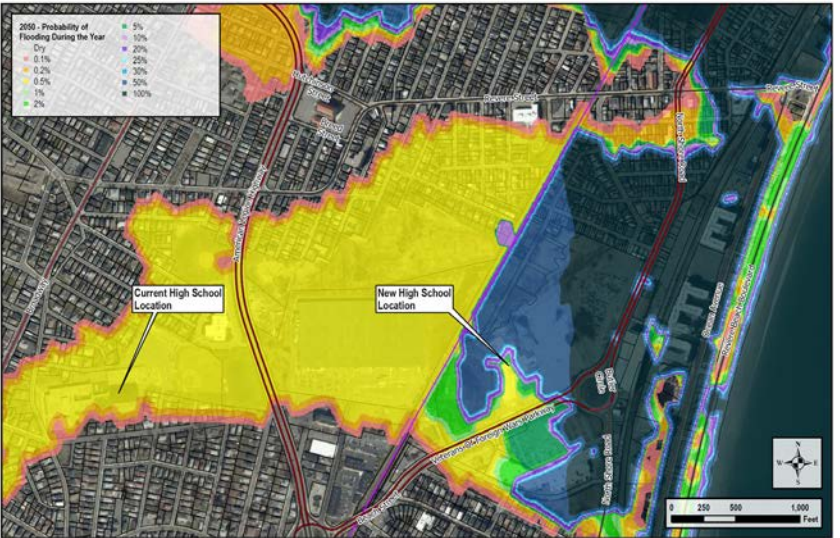
EAST-WEST

REVERE HIGH SCHOOL

FLOOD RESILIENCE



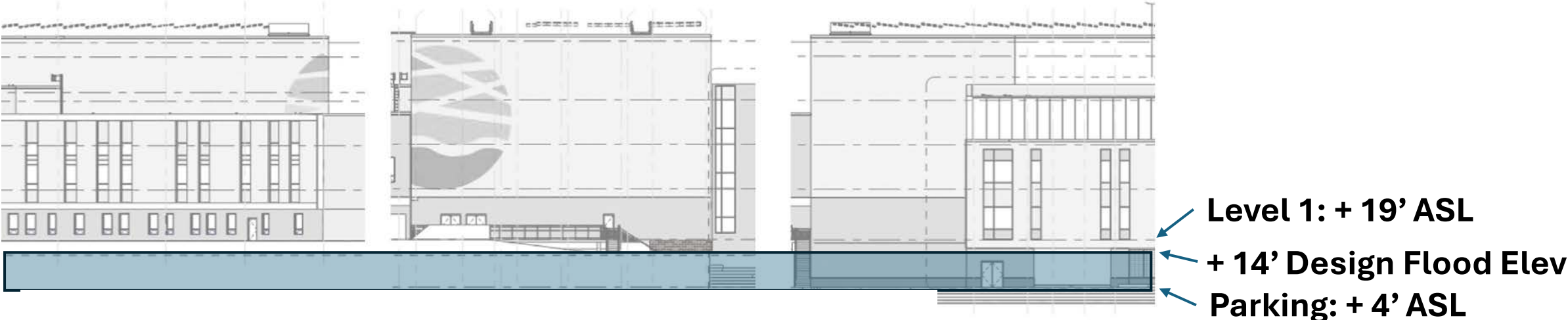
2030 Flood Probability



2050 Flood Probability

REVERE HIGH SCHOOL

FLOOD RESILIENCE



Engineered Flood Vents

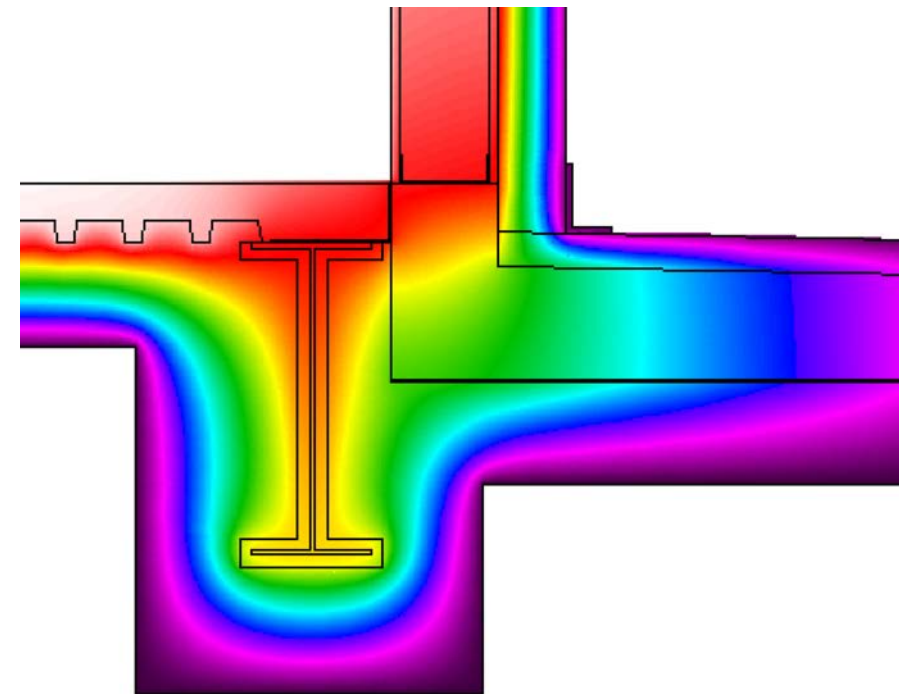
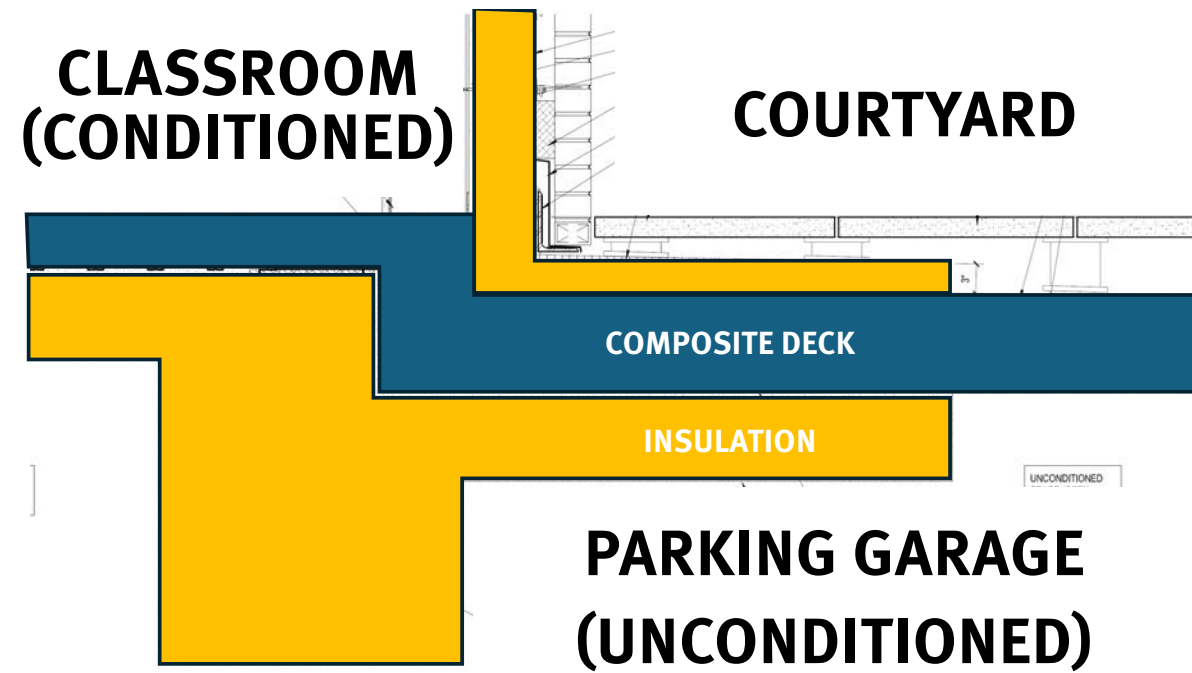
SMART VENT PRODUCTS, INC.



Flood vents protect enclosures by allowing automatic bi-directional water flow that equalizes hydrostatic pressure.

REVERE HIGH SCHOOL

THERMAL BRIDGE CHALLENGE

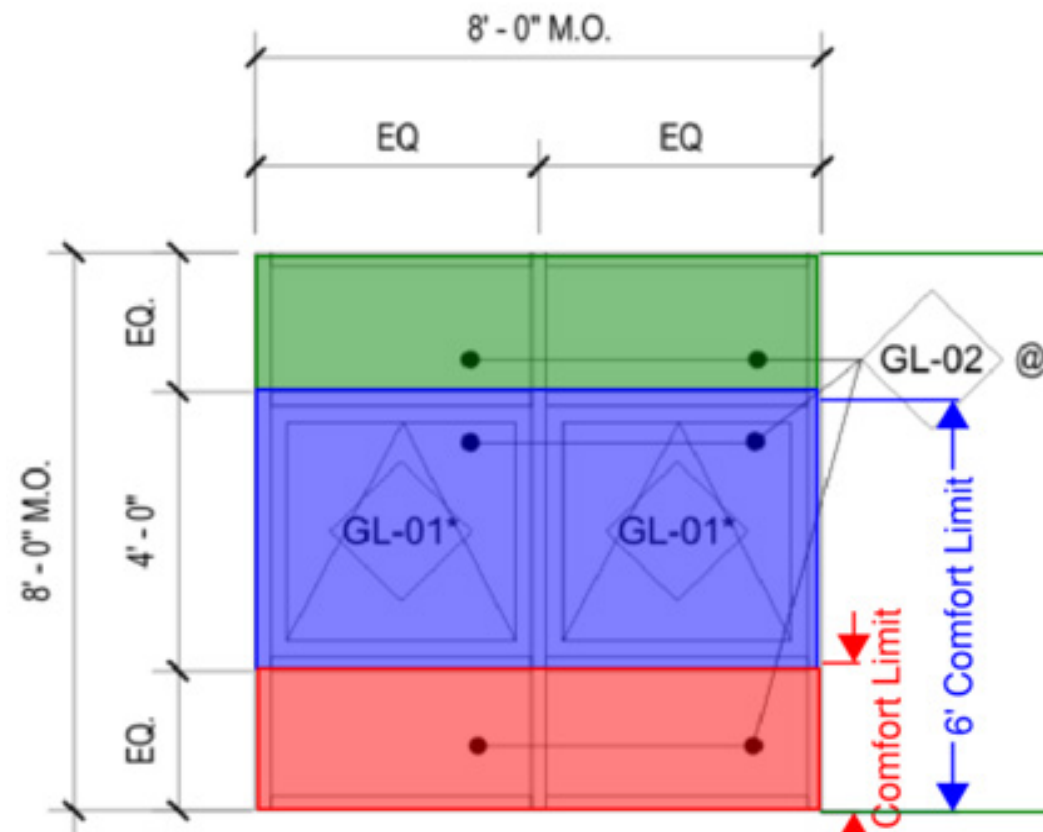


Psi
0.237

Linear Feet
581

Site EUI Impact
0.01

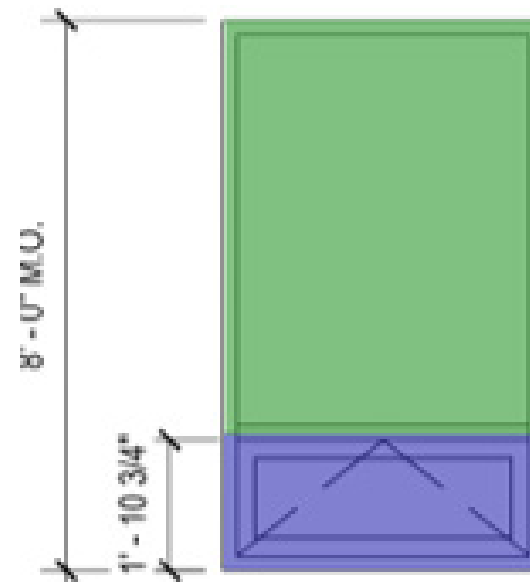
FENESTRATION



CHARLESWOOD

MAX. WHOLE WINDOW U FOR DIFFERENT HEIGHTS

- 2': u-0.28
- 4': u-0.21
- 6': u-0.18



REVERE

CHALLENGES FOR WINDOW COMFORT CRITERIA

Window-specific (not NFRC) U-factors needed - difficult to get before bid award

Advantageous to use products in Phius database – but small deviations (changing IGU type, different mullion configuration) mean you can't use the data

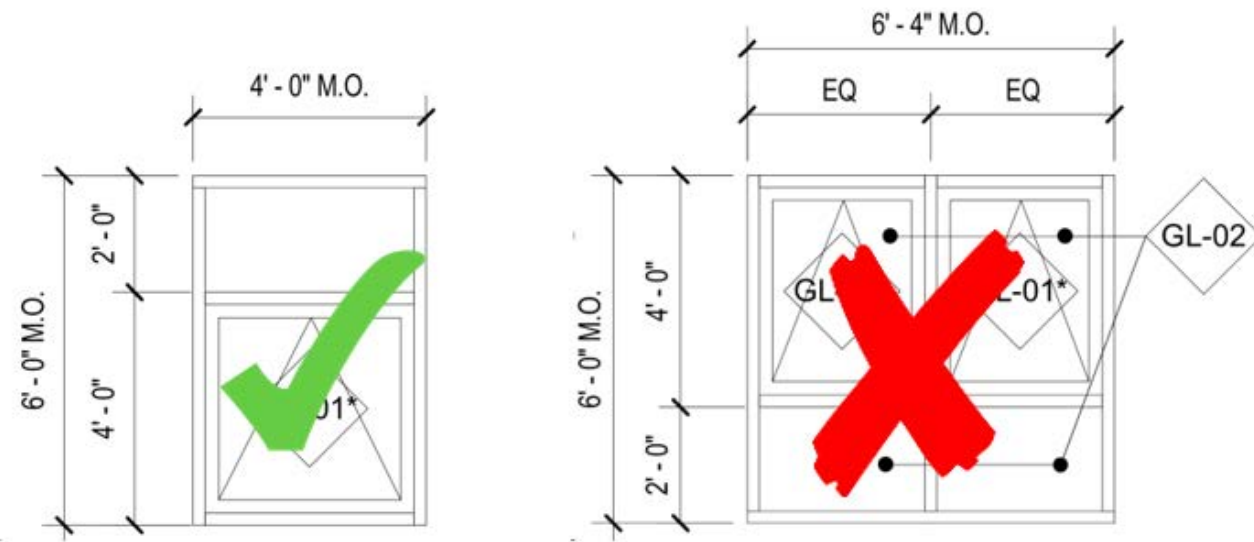
Different manufacturers have different capabilities for casement/awning

Criteria is additive, measure down from each individual window

Custom climate files stricter than expected

FENESTRATION

DESIGN & SELECTING SYSTEM



CONSIDER LOCATION AND HEIGHT OF OPERABLE LIGHTS

Use punched windows instead of curtainwall (cost) or storefront (performance)

Consider uPVC or fiberglass

IF USING ALUMINUM

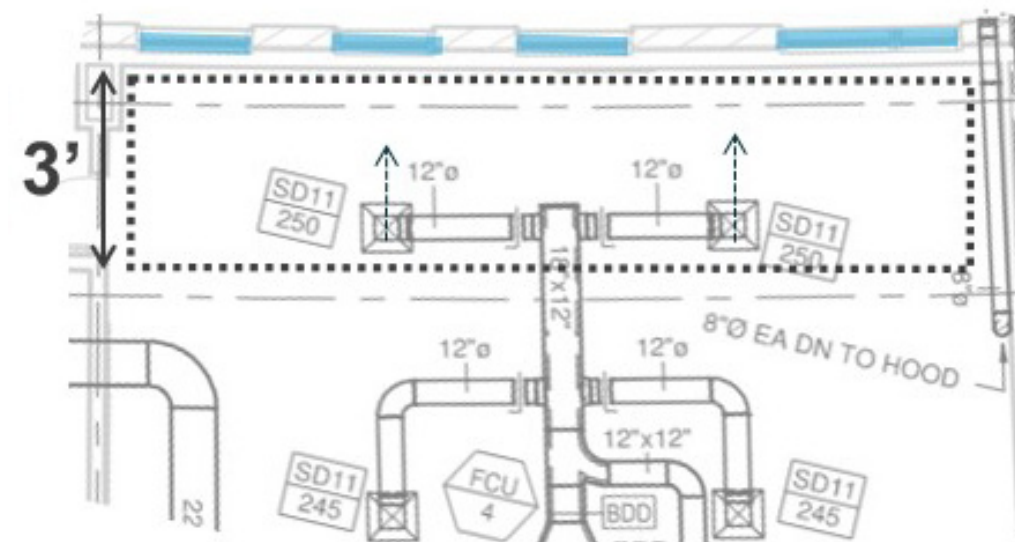
In cold climates, windows no taller than ~6' (whole opening)

Operable Windows:
Locating it below fixed is better
Keep height around 3' max

FENESTRATION

School	Type of window frame	Window selection	Window U-value passes comfort criteria?
Squantum ES	fiberglass	Cascadia	Yes
Charleswood ES	aluminum	Peerless	No for top fixed panes & operable windows
Revere HS	aluminum	Peerless	Yes

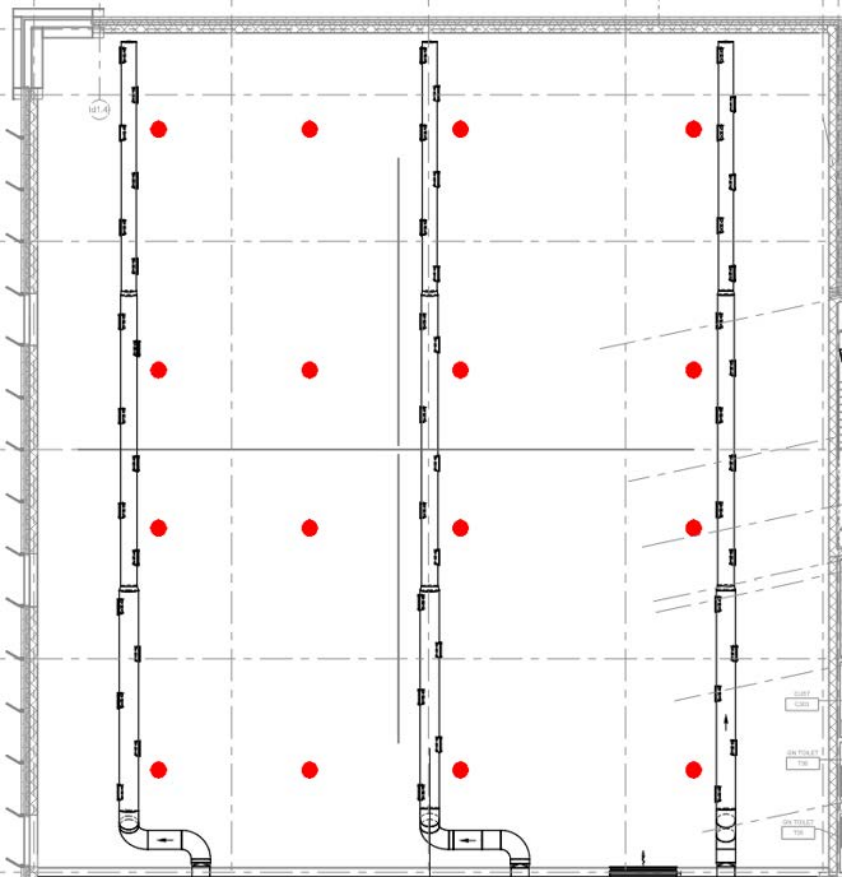
If window does not pass comfort criteria must provide perimeter heating. Diffusers within 3ft of window or sufficient throw to be farther away.



FENESTRATION

PERIMETER HEATING ALTERNATIVE APPROACH

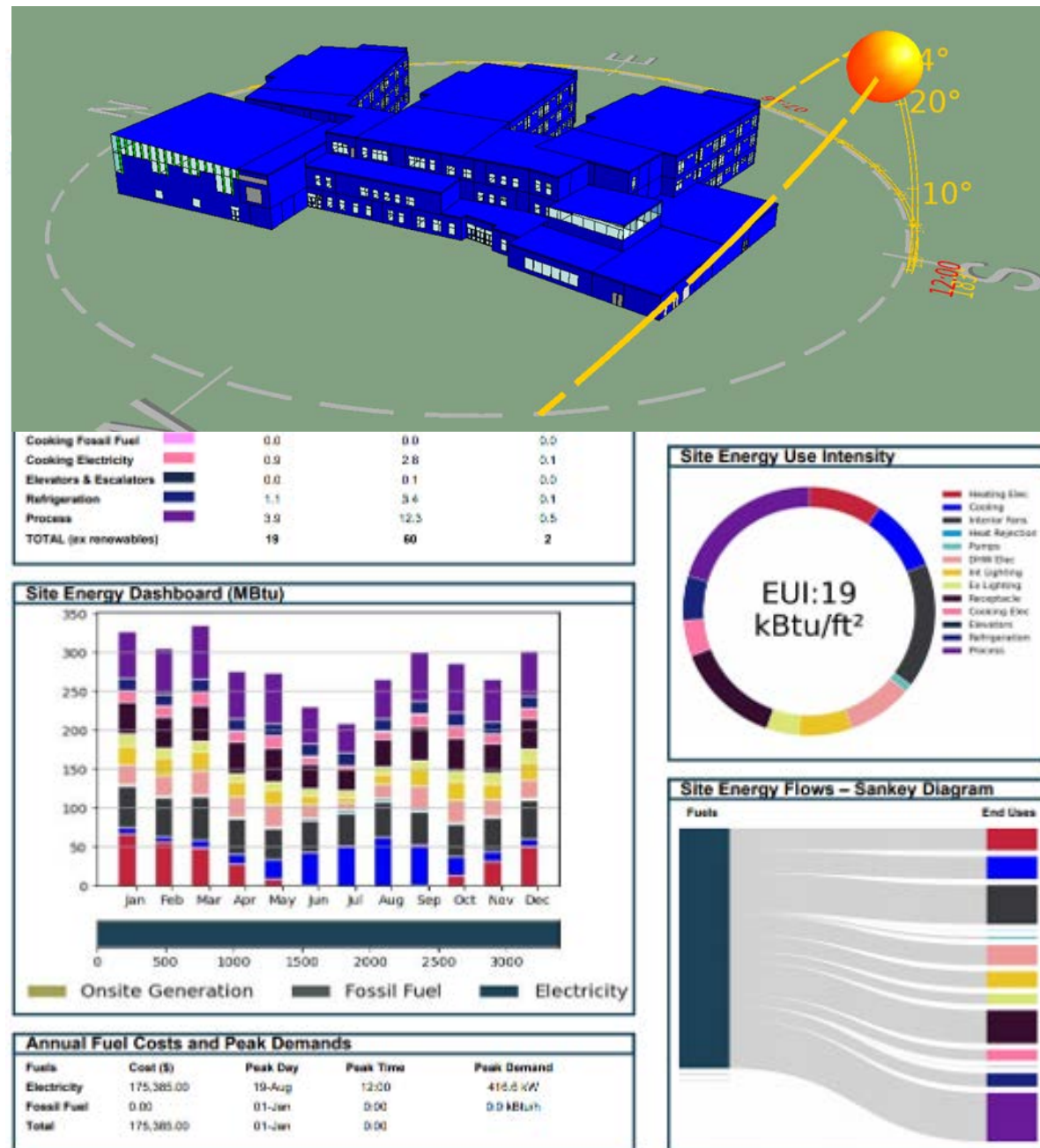
De-stratification



OTHER MEP CONSIDERATIONS

MECHANICAL IMPACTS - ENERGY MODELING

8760 MODEL TIE-IN TO WUFI PASSIVE

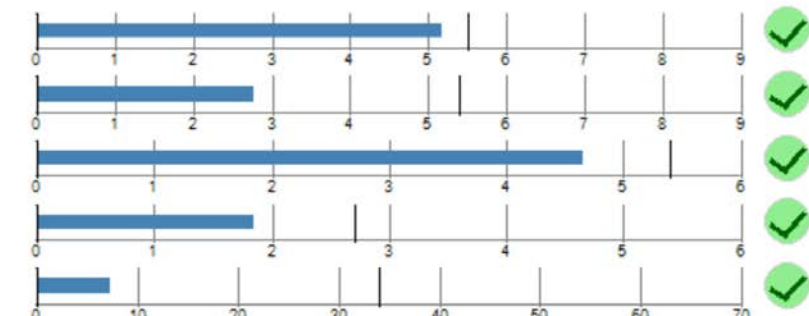


IES-VE OUTPUTS

Equipment
Lighting
Schedules



Heating demand: 5.18 kBtu/ft²-yr
Cooling demand: 2.76 kBtu/ft²-yr
Heating load: 4.65 Btu/hr ft²
Cooling load: 1.85 Btu/hr ft²
Source energy: 7.27 kBtu/ft²-yr



VENTILATION & ENERGY RECOVERY



INPUT CONSIDERATIONS

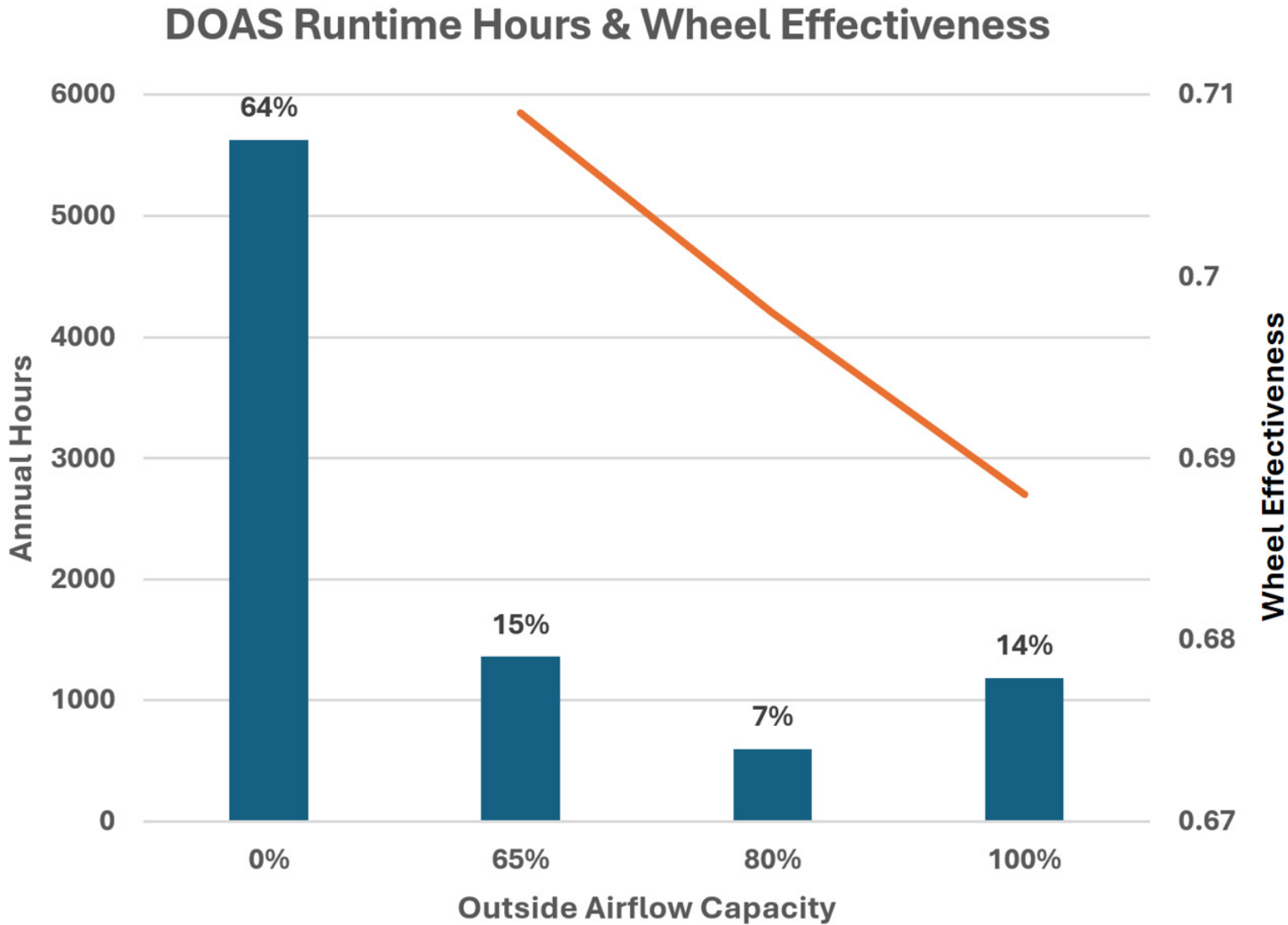
Dedicated Outside Air System

Energy Recovery Wheel
Effectiveness

Demand Control Ventilation

VENTILATION & ENERGY RECOVERY

INPUT CONSIDERATIONS



Dedicated Outside Air System

Energy Recovery Wheel
Effectiveness

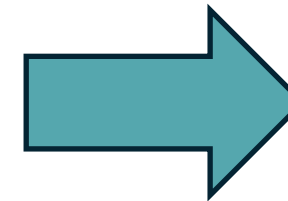
Demand Control Ventilation

Phius **MODELING**

OCCUPANCY & UTILIZATION PATTERNS

Calculating Occupancy in Non-Residential Phius projects

Occupant Quantity	210	<i>For input in WUFI the Occupancy > Occupant Quantity</i>
Maximum Occupancy	1,341	<i>For input in the Phius 2021 target setting calculator</i>



Phius Criteria & Internal Loads

- Calc early + update
- Phius occ ≠ code occ

Utilization Patterns for WUFI & Occupancy Inputs

Type of Space	Begin Utilization	End Utilization	Annual Utilization Days	Relative Absence	Occupant Quantity for Pattern
Classrooms	7	16	235	0.25	1184
Admin Offices	7	17	235	0.30	8
Janitorial	5	22	235	0.90	5
Food Prep	7	16	180	0.25	9
Gym Staff + Students	0	0	180	0.00	0

Maximum Occupancy per day

Spaces		Start Hours	End Hours	Weeks/yr	Relative Absence	M-F	Wknd
Students in Classrooms	Classrooms	8	15	32.5	0.25	1200	
Teachers in Classrooms	Classrooms	7	16	32.5	0.25	119.4	
Office Workers	Offices	7	17	40	0.3	7.5	0
Cafeteria Workers	Food Prep	7	16	35	0.25	9	
Janitorial Staff	Janitorial	5	22	40	0.9	5	
Gym Staff + Students	Gym	15	22	32.5	0.5	63.6	

VENTILATION APPROACH

	Whole Building Energy Model?	Performance Criteria Buffers	Ventilation Approach
Squantum ES	OpenStudio	None	DCV Protocol
Charleswood ES	IES-VE model	Moderate	Utilization patterns by space type using IES-VE model
Revere HS	Not yet	High	Utilization patterns by device (and space type) using logical early estimates

UNDERSTAND AND MODEL TYPICAL OPERATION

- Different space types
- Diversity of space use (unlike residential)
- + Project criteria & buffer

VENTILATION APPROACH #1: UTILIZATION PATTERNS

Space Type	Max cfm	# of spaces	Total cfm	# of days/week	# of weeks/yr	Hours at 0%	Hours at 50%	Hours at 75%	Hours at 100%	total hours "on"
Admin/Office	30	50	1,500	7	38	16	0	8	0	8
Classroom	340	54	18,360	7	38	18	1	5	0	6
Gym	6,700	1	6,700	7	38	17	6	0	1	7
						Hours at 0%	Hours at 33%	Hours at 66%	Hours at 100%	
Cafeteria	3,500	1	3,500	7	38	16	4	2	2	8
						Hours at 0%	Hours at 25%	Hours at 65%	Hours at 100%	
Kitchen	4,845	1	4,845	5	38	21	1	2	0	3

Utilization pattern	Rooms ventilation	Summer ventilation	Exhaust ventila
		Operating days per week [d/week]	Operating weeks per year [week/a]
Admin/Office		7	38
Classroom		7	38
Gym		7	38
Cafeteria		7	38
Intermediate results			
Supply air due to persons [cfm]		3762	
Total extract air demand [cfm]		30060	
Design air flow rate [cfm]		30060	
Average air flow rate [cfm]		4470.93	
Average air change rate [1/hr]		0.12	
Additional data: Admin/Office			
Setting	Daily operation schedule [h]	Fraction of design air flow [-]	
Maximum	0	1	
Standard	8	0.75	
Basic	0	0.50	
Minimum	16	0	

VENTILATION APPROACH #2: DCV PROTOCOL

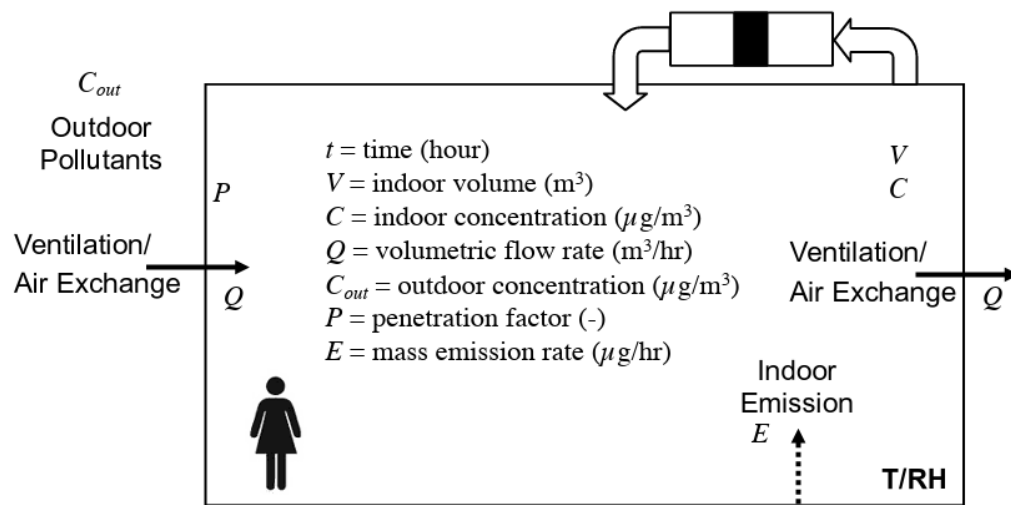
Step 1: Phius (Al Mitchell) developed DCV protocol spreadsheet

Goal: model DCV, adjusting based on needs rather than max

Process:

- Simple mass balance equation
 - “Mini-environments” per room:
 - Room size, occupancy activity, airflow rates
 - Pollutants and CO2 generated
- GitHub Repo/python = dynamic iterative loop

Outcome: minimum ventilation needed for CO2 to be < safe PPM



$$V \frac{dC}{dt} = PQC_{out} - QC + E$$

```

for row in range(0,39,1):
    rm = roomData['Rm'].iloc[row]
    vol = roomData['Vol m3'].iloc[row]
    mg_hr_gen = roomData['ppm'].iloc[row]
    ct_1 = oa_ppm

    c_list = []
    achs = []
    print("solving room number " + str(rm))
    for hour in range(0,8759,1):
        occ = schedules['Gen Occ'].iloc[hour]
        ach = initACH
        c = ct_1 + ((1*ach*oa_ppm) - (ach*ct_1) + ((mg_hr_gen*occ)/vol))
        while c > ppm_target:
            if ach < 40:
                ach = ach + 0.1
                c = ct_1 + ((1*ach*oa_ppm) - (ach*ct_1) + ((mg_hr_gen*occ)/vol))
            else:
                break

        achs.append(ach*vol)
        c_list.append(c/1.8)
        ct_1 = c
        print(c)
        print(ach)
    
```

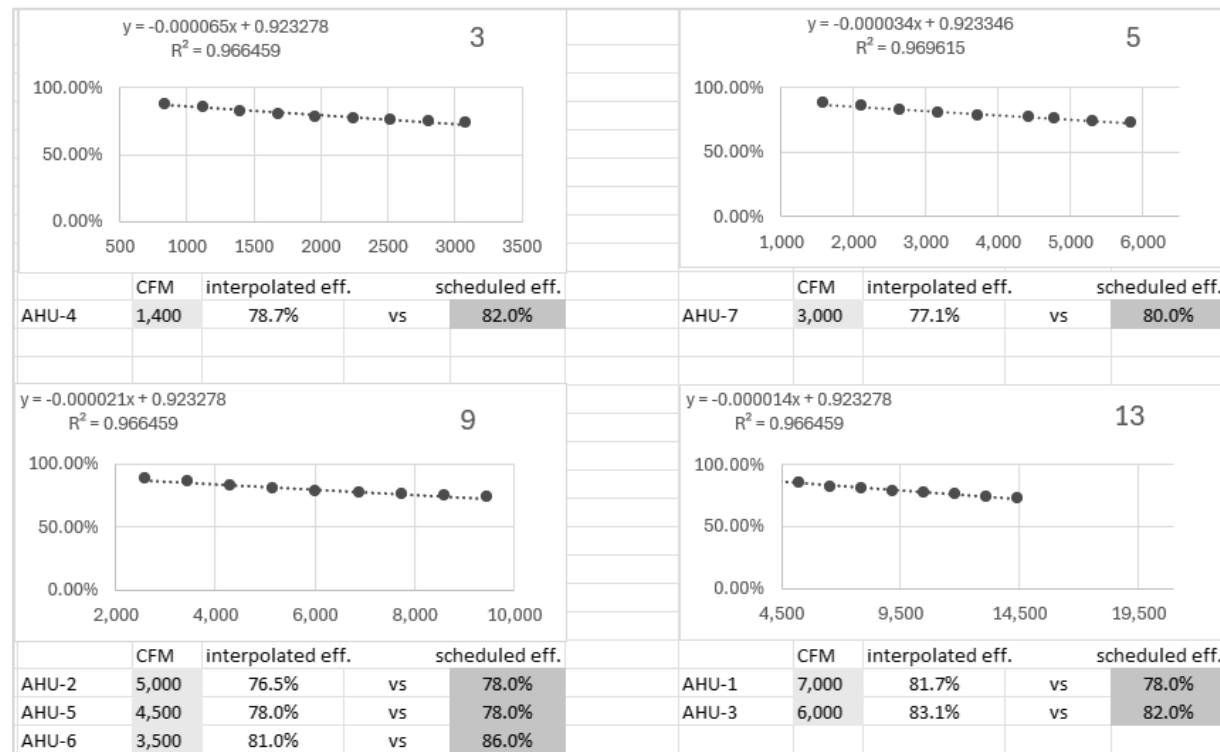
cfm	123.1947536	123.1947536	125.5337472	122.1236337	124.5046597
m3/h	209.3092194	209.3092194	213.2831947	207.4893751	211.534764
	AHU-3	AHU-3	AHU-3	AHU-3	AHU-3
	Room_217	Room_215	Room_213	Room_211	Room_209
0	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
1	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
2	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
3	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
4	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
5	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
6	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
7	30.17358585	30.17358585	32.89285296	29.809148	30.49441577
8	3047.532171	3047.532171	3322.178149	3010.723948	3079.935993
9	452.6037878	452.6037878	493.3927944	447.13722	457.4162366
10	603.471717	603.471717	624.9642062	596.18296	609.8883154
11	603.471717	603.471717	592.0713533	596.18296	609.8883154
12	603.471717	603.471717	592.0713533	596.18296	609.8883154
13	603.471717	603.471717	592.0713533	596.18296	609.8883154
14	603.471717	603.471717	592.0713533	596.18296	609.8883154
15	603.471717	603.471717	592.0713533	596.18296	609.8883154
16	120.6943434	120.6943434	131.5714118	119.236592	121.9776631
17	120.6943434	120.6943434	131.5714118	119.236592	121.9776631
18	120.6943434	120.6943434	131.5714118	119.236592	121.9776631
19	120.6943434	120.6943434	98.67855888	119.236592	121.9776631
20	120.6943434	120.6943434	131.5714118	119.236592	121.9776631
21	30.17358585	30.17358585	32.89285296	29.809148	30.49441577

VENTILATION APPROACH #2: DCV PROTOCOL

Step 2: TT used manufacturer data + spreadsheet to generate new sensible recovery efficiencies (SREs)

EFFECTIVENESS	Model Number: TE (CFM)			
	3	5	9	13
88%	840	1,590	2,580	3,930
86%	1,120	2,120	3,440	5,240
82.5%	1,400	2,650	4,300	6,550
80.5%	1,680	3,180	5,160	7,860
78.5%	1,960	3,710	6,020	9,170
77%	2,240	4,420	6,880	10,480
76%	2,520	4,770	7,740	11,790
74.5%	2,800	5,300	8,600	13,100
73.5%	3,080	5,830	9,460	14,410

per m3/h	AHU-1					AHU-2					AHU-3				
	CFM	Frac	Freq	Bin Eff%	Weighted Eff%	CFM	Frac	Freq	Bin Eff%	Weighted Eff%	CFM	Frac	Freq	Bin Eff%	Weighted Eff%
0.5886	5,430	9,226	6724	88%	67.6%	2,580	4,383	6,724	88%	67.6%	5,430	9,226	8,498	88%	85.4%
	7,240	12,301	1774	86%	17.4%	5,160	8,767	1,174	80.5%	10.8%	7,240	12,301	-	86%	0%
	9,050	15,376	0	82.5%	0%	6,020	10,228	599	80.5%	5.5%	9,050	15,376	208	86%	2%
Hrs	10,860	18,451	0	82.5%	0%	6,880	11,689	1	80.5%	0.0%	10,860	18,451	-	86%	0%
8759	Overflow		261	82.5%	2.46%	Overflow		261	80.5%	2.40%	Overflow		53	86%	0.52%
		Max OA	DCV OA		87.4%		Max OA	DCV OA		86.3%		Max OA	DCV OA		87.9%
cfm		7,000	2,595				5,000	1,929				6,000	1,592		
m3/h			4,409					3,277					2,705		
0			370.76					222.59					276.61		
1			370.76					222.59					276.61		
2			370.76					222.59					276.61		
3			370.76					222.59					276.61		
4			370.76					222.59					276.61		
5			370.76					222.59					276.61		
6			370.76					222.59					276.61		
7			370.76					222.59					276.61		
8			148304.40					89034.97					110644.58		
9			6093.53					4017.85					4166.80		
10			12013.93					10921.05					7115.07		
11			11205.72					8673.43					6540.13		
12			11169.09					8684.02					6562.72		
13			11269.94					8748.63					6540.57		
14			11154.01					8733.36					6597.88		
15			11147.41					8874.90					6584.83		
16			2223.54					1755.28					1328.25		
17			2258.52					1726.35					1328.25		
18			2187.22					1755.28					1328.25		
19			2294.84					1755.28					1295.36		



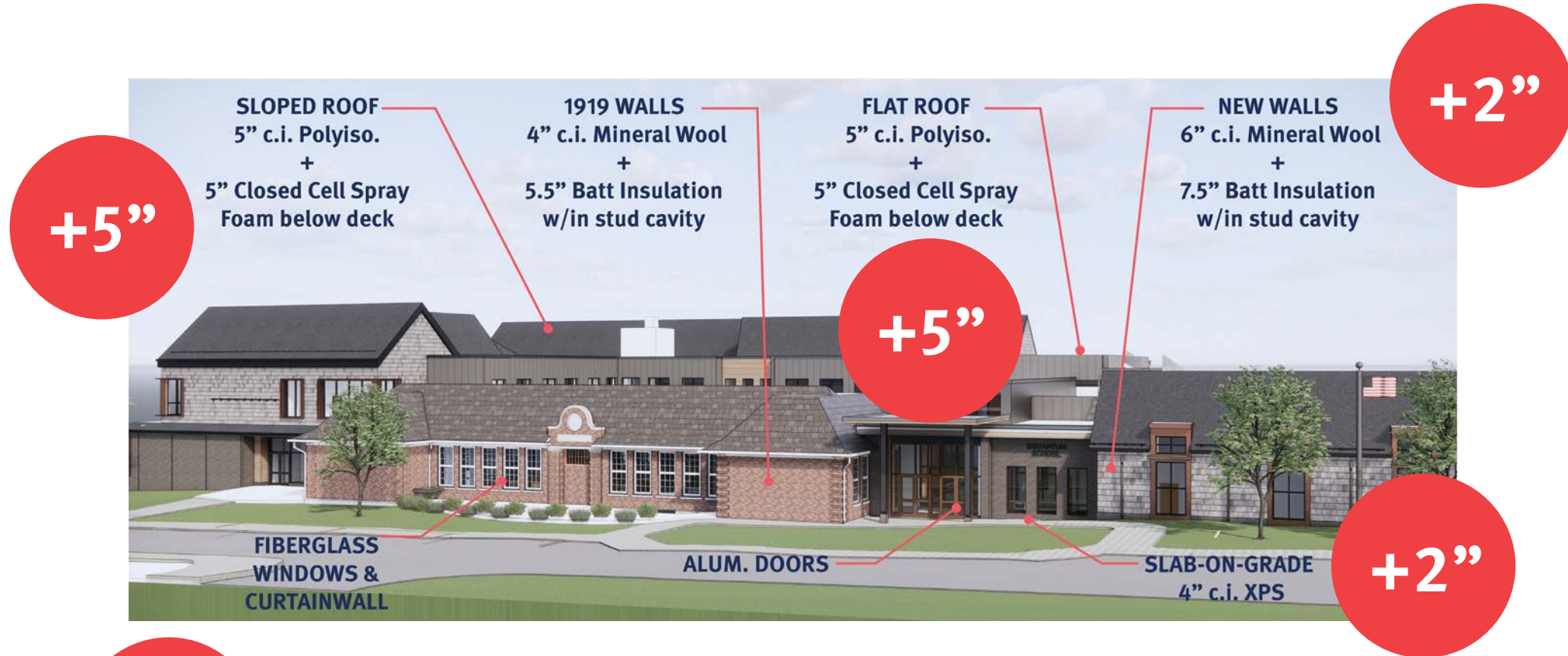
VENTILATION APPROACH #2: DCV PROTOCOL

Step 3: Use new SREs in WUFI Passive

AHU	Design OA CFM	Min OA CFM	Mechanical Schedule SRE	New SRE
1	7,000	2,000	78%	87.4%
2	5,000	1,300	76%	86.%
3	6,000	1,700	82%	87.9%
4	1,400	300	83%	86.7%
5	4,500	1,000	78%	86.3%
6	3,500	1,000	86%	86.7%
7	2,400	750	80%	86.2%

WHOLE LIFE CARBON

SQUANTUM SCHOOL



EMBODIED CARBON IMPACT

Phius design
3,214 MTCO₂e

Typical net zero design
2,956 MTCO₂e



Embodied Carbon: **+ 9%**

Annual Operational Carbon: **- 7%**

Whole Life Carbon: **+ 2%**

CHARLESWOOD ELEMENTARY



DOUBLE TO TRIPLE PANE IGU

-42.4 kgCO₂e/m² Total



R-18 TO R-25 MIN WOOL

-8.8 kgCO₂e/m² Total



ADD R-15 XPS AT SLAB

-14.5 kgCO₂e/m² Total

ENVELOPE EMBODIED CARBON

kgCO₂e/m²

+ 2.2

+ 0.7

+ 4.1

HVAC EMBODIED CARBON

kgCO₂e/m²

- 2.9

- 0.2

- ~6

OPERATIONAL CARBON

kgCO₂e/m²

- 41.7

- 9.3

- 18.6

COMPARED TO IECC 2021 PRESCRIPTIVE CODE OVER 60 YEARS

HVAC EMBODIED CARBON REDUCTION INCLUDES REDUCED GSHP WELLS AND PV PANELS FOR NZE.

OPERATIONAL CARBON REDUCTION ASSUMES CURRENT NEW EMISSIONS FACTOR.

CONSTRUCTION PHASE

CONSIDERATIONS IN CONSTRUCTION

- Any slight change in performance of submitted product must be accounted for in model and calculations
- Contractor to provide detailed schedule with inspections, mockups, pre-testing, testing
- Utilize mockups for performance testing
- Final tested unguarded air leakage must be updated in model

WUFI PASSIVE RESULTS

Annual Heating Demand
Annual Cooling Demand
Peak Heating Load
Peak Cooling Load
Source Energy

SQUANTUM SCHOOL

		Results	Margin
Annual Heating Demand	7.4	4.77	35.5%
Annual Cooling Demand	5.6	1.65	70.5%
Peak Heating Load	5.2	4.96	4.6%
Peak Cooling Load	3.3	2.58	21.8%
Source Energy	30.0	27.77	7.4%

CHARLESWOOD

		Results	Margin
Annual Heating Demand	5.5	3.72	32.4%
Annual Cooling Demand	5.4	3.86	28.5%
Peak Heating Load	5.5	4.08	25.8%
Peak Cooling Load	2.7	1.80	33.3%
Source Energy	24.5	8.92	63.6%

REVERE HIGH SCHOOL

		Results	Margin
Annual Heating Demand	5.1	1.58	69.0%
Annual Cooling Demand	7.1	3.84	45.9%
Peak Heating Load	4.5	3.67	18.4%
Peak Cooling Load	3.7	2.92	21.1%
Source Energy	30.0	29.32	2.3%

BUFFER



BLOWER DOOR TESTING



Plus PROJECTS ARE REQUIRED TO USE THE AVERAGE OF A DEPRESSURIZED AND PRESSURIZED TEST

MUST FOLLOW ASTM E3178 NOT E779

(potential exception for very large commercial buildings)

TWO TESTS TO BE PERFORMED:

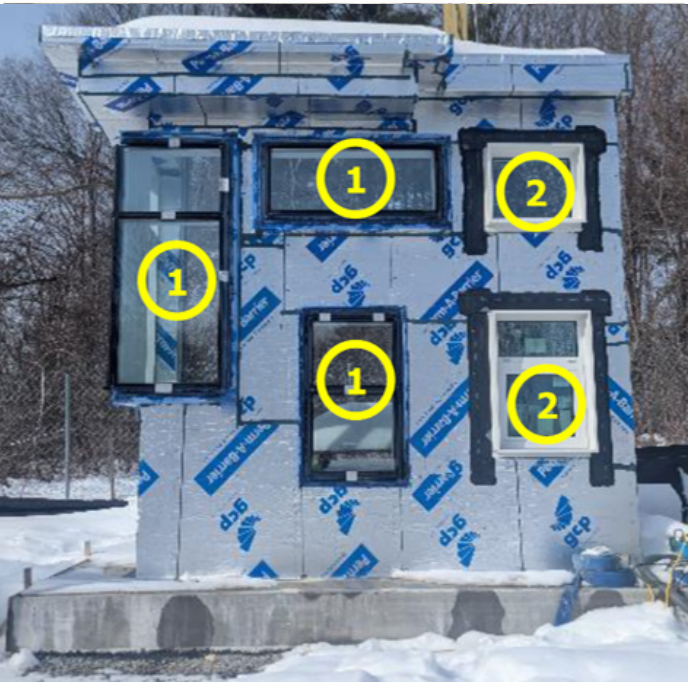
GUARDED TEST

Non-threatening air leakage areas to be taped.
Test must meet 0.06 @50pa or 0.08 @75pa CFM/SF.

UNGUARDED TEST

Nothing can be taped and the performance model must be able to meet the design criteria with the results of this test.

BLOWER DOOR TESTING



MOCK-UP IF POSSIBLE

IN SITU MOCK-UP

SMOKE TEST

MID/PRE TEST

FINAL TEST

THANK YOU!

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BUILDINGENERGY BOSTON

Please fill out an evaluation for this session



or: nesea.org/eval

Northeast Sustainable Energy Association (NESEA)