Lexington High School

MEP Systems & Sustainable Design Focus Group

03/10/2025

smma DORE + WHITTIER Turner

Agenda

1 Intro

2 Project Update

3 Schematic Design Recommendations

Introduction / Design Team

Lorraine Finnegan
Principal in Charge/
Project Manager

Brian Black
Project Designer

Thomas Faust
Project Architect

Rosemary Park
Educational Planner

Phil Poinelli
Educational Planner

Sarah Sopelak
Interior Designer

Martine Dion
Sustainability Lead

Erin Prestileo
Civil Engineering
Lead

Michael Dowhan
Landscape Architect
Lead

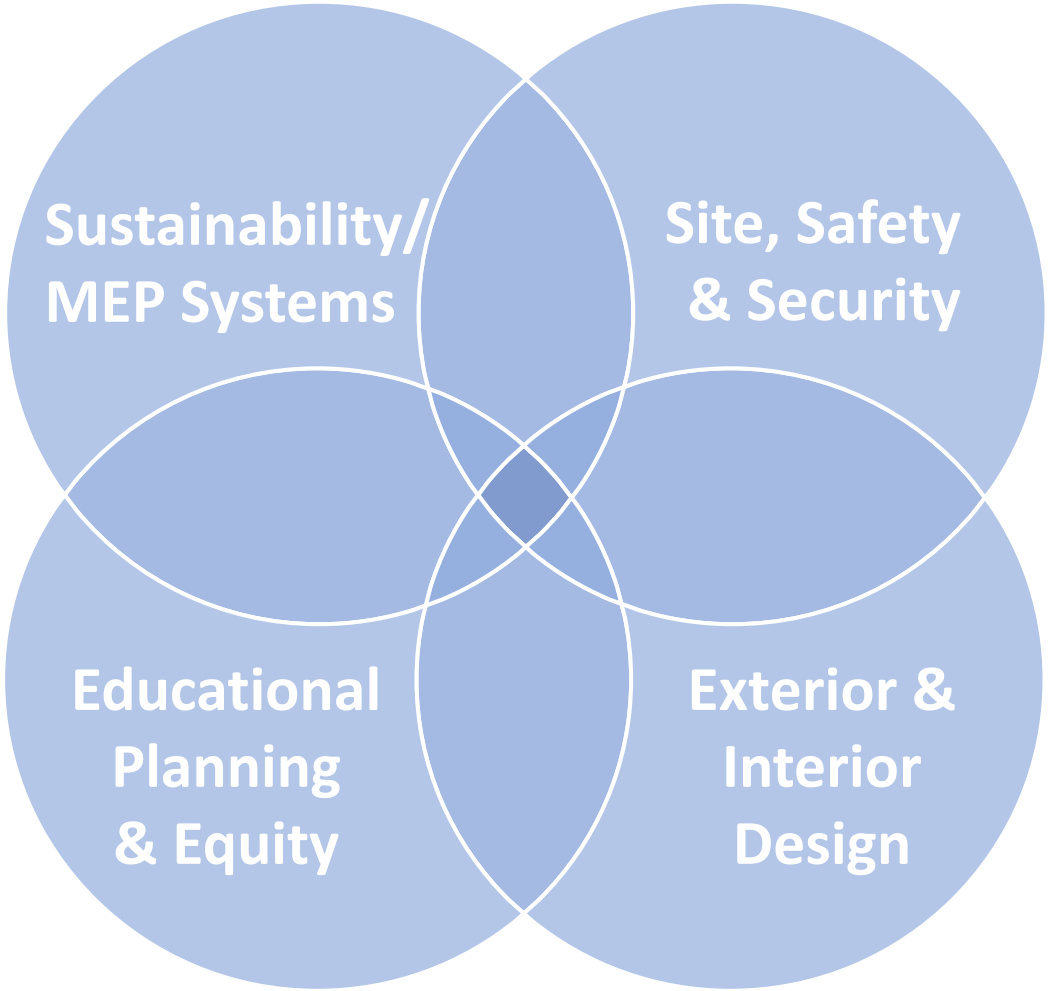
Anthony Jimenez
Electrical Lead

Andy Oldeman
HVAC Lead

Paul Elliot
Plumbing Lead

Reviews preferred MEP systems, Integrated Design Policy and sustainable design features and components, healthy materials; site design and landscape features for environmentally friendly design.

Reviews overall goals from educational planning perspectives, educational programming meetings and visioning sessions.



Reviews development of the site design for traffic, circulation, safety and security. Includes conversations about parking, driveways and circulation, fields, and offsite improvements and coordination with Town Departments.

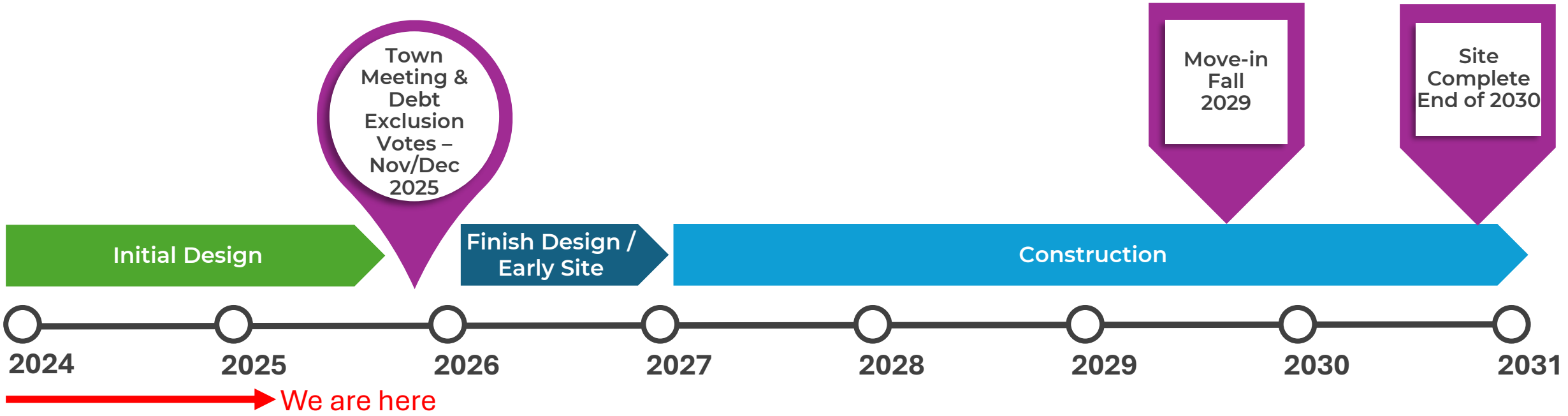
Reviews exterior design concepts including composition of form and material selections such as brick, precast, metal panels etc. Review of the products and materials selected for finishes such as flooring, tile, ceilings, wood paneling, paint colors etc.

General Topics of Discussion / MEP Systems & Sustainable Design

1. Net Zero Energy and Renewable Energy
2. Sustainable Transportation and Electrification of Transportation
3. MEP Systems
4. Sustainable Materials and Healthfulness [IAQ/IEQ]
5. Climate Preparedness and Adaptability
6. General Sustainability and MEP Design Planning
7. Sustainable Sites
8. Environmental Literacy

Project Update

Anticipated Overall Project Timeline

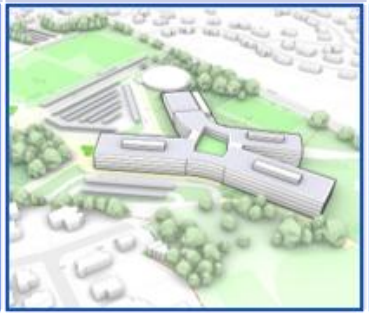


All dates after local vote in November / December 2025 are subject to change based upon the selected option.

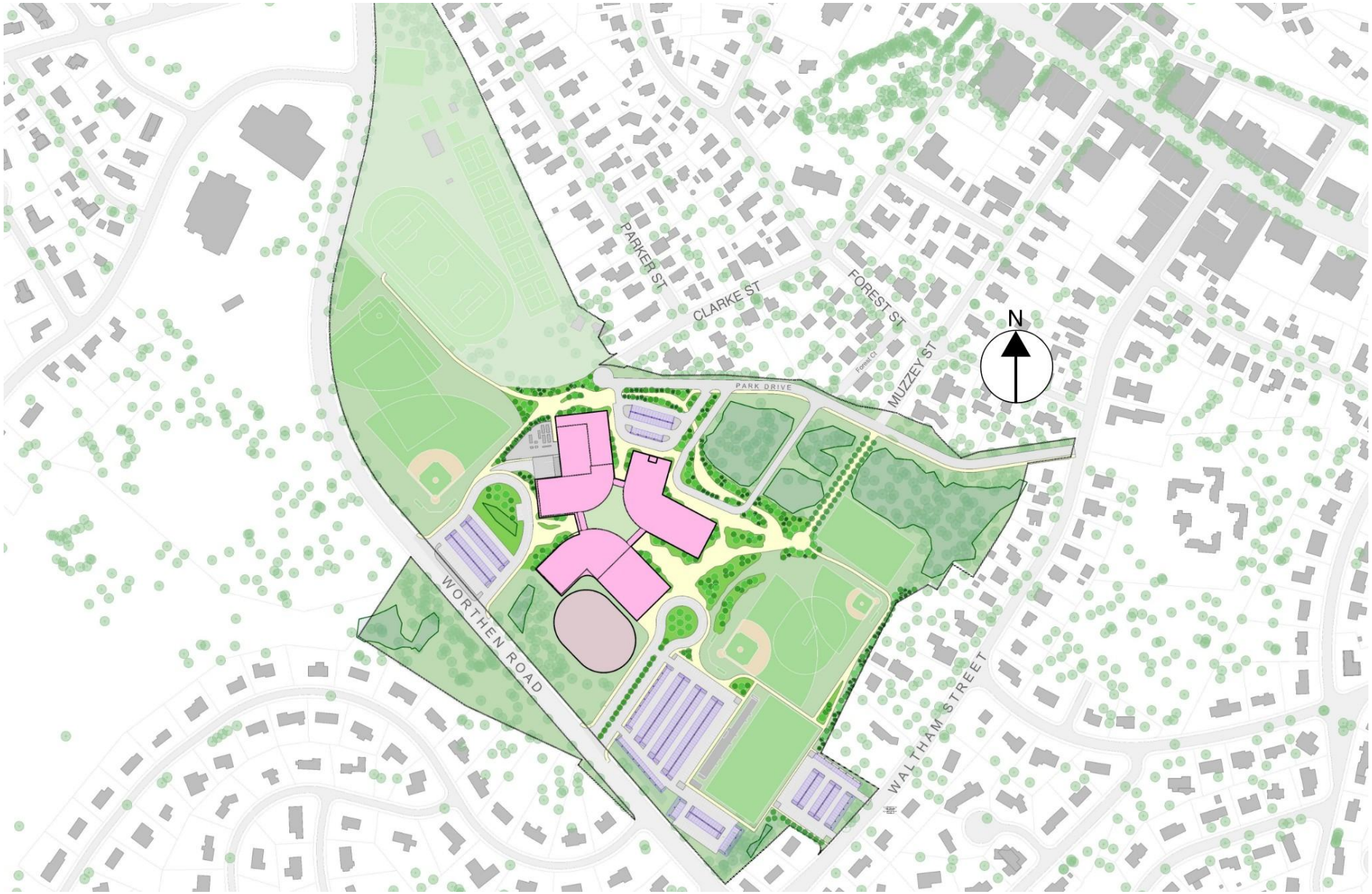
Construction duration is shown to provide a potential range. Final duration will be determined toward the end of initial design.

Move-in date will be determined after an option is selected. Anticipated move-in currently shown in the fall of 2029.

Preferred Option / Bloom

	B. Renovation & Addition		C. New Construction – On Fields			D. New Construction – Phased in Place
Alternative	B.1 Quad	B.4 Figure Eight	C.1d Branch	C.2b Braid	C.5b Bloom	D.2 Weave
Project Cost School + Add/Reno FH	$690,000,000	$692,000,000	$637,000,000	$636,000,000	$639,000,000	$711,000,000
Project Cost School + Add/Reno FH + Central Office	$713,000,000	$715,000,000	$660,000,000	$659,000,000	$662,000,000	$734,000,000
Construction Duration	6 Years	6.25 Years	4.5 Years	4.5 Years	4.5 Years	6.5 Years
# of Phases	4 + 1	5 + 1	1 + 1	1 + 1	1 + 1	4 + 1
Building Location	Existing Footprint	Existing Footprint	Fields	Fields	Fields	Existing Footprint
Modular Max Required	32	42	0	0	0	48
						

Preferred Option / Bloom



Eye-Level View from Worthen Road Entrance Drive

Eye-Level View from West

Eye-Level View from Clarke Street / Park Drive

Eye-Level View from East Across New Fields

Schematic Design Recommendations

1. IDP/LEED
2. Healthy Materials & Embodied Carbon
3. Net Zero Energy Design
4. Mechanical Systems Selection
5. Domestic Hot Water Systems Selection

Lexington IDP/LEED Update

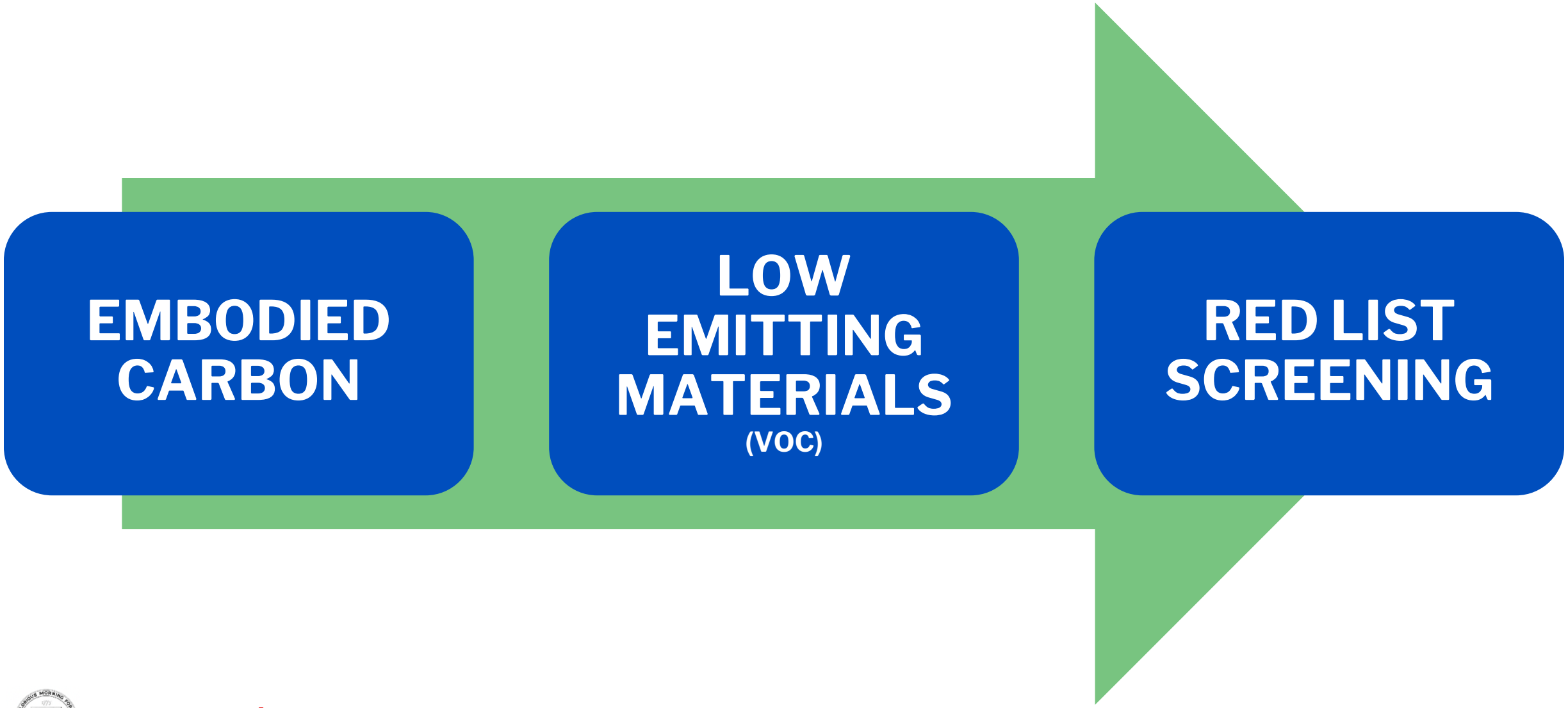
Current Tracking:

- Gold – 67 pts
- Platinum – 80 points
- TBD – 17 points

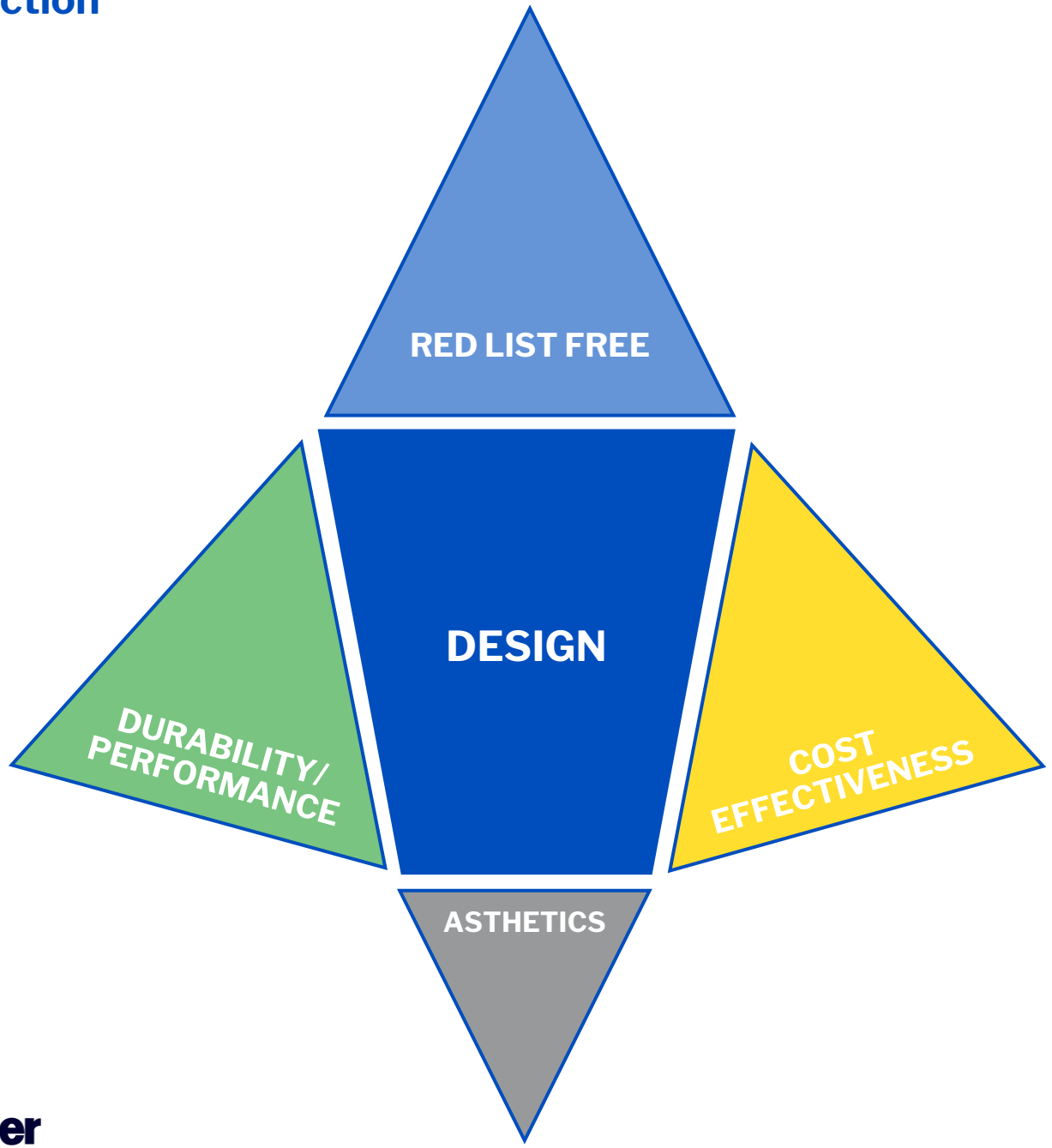
LEED Baseline (Code & IDP)	Lexington Integrated Design Policy	MSBA Green Policy Mandate	LEED Gold	LEED Platinum	Scorecard Tracking (DRAFT)					
					Yes	TBD (?)	No	Description		Credit Type
			24	30	30	1	0	**Energy and Atmosphere**	31	
0		•	Required		Y			Prereq Fundamental Commissioning and Verification	Required	
0		•			Y			Prereq Minimum Energy Performance	Required	
0					Y			Prereq Building-Level Energy Metering	Required	
0					Y			Prereq Fundamental Refrigerant Management	Required	
6	•	•	•	•	6			Credit Enhanced Commissioning	6	
16	•	•	•	•	16			Credit Optimize Energy Performance - IDP = 30% Over ASHRAE 90.1-2019	16	
1	•		•	•	1			Credit Advanced Energy Metering	1	
1	•		• (1)	• (2)	2			Credit Demand Response	2	
0	•		•	•	3			Credit Renewable Energy Production - v4.1 Green Power Credit up to 5 pts	3	
0						1		Credit Enhanced Refrigerant Management	1	
0				•	2			Credit Green Power and Carbon Offsets - v4.1 Green Power Credit up to 5 pts.	2	
0	•				-			LEK_2 Utilize energy storage when cost effective to lower peak demand charges and integrate with onsite solar. Evaluate and report on options for campus micro-grids.		
0	•				-			LEK_3 Evaluate and present options for achieving net zero energy use.		
0	•				-			LEK_3 All electric, zero emissions on site design (excluding fuel for emergency backup power generators). Backup fossil fuel heating systems will require specific approval.		
			7	9	9	2	4	**Materials and Resources**	13	
0			Required		Y			Prereq Storage and Collection of Recyclables	Required	
0					Y			Prereq Construction and Demolition Waste Management Planning	Required	
2			• (2)	• (3)	3	1	3	Credit Building Life-Cycle Impact Reduction	5	
1			•	•	1	1		Credit Building Product Disclosure and Optimization - Environmental Product Declarations	2	
1			•	•	1		1	Credit Building Product Disclosure and Optimization - Sourcing of Raw Materials	2	
1		•	• (1)	• (2)	2			Credit Building Product Disclosure and Optimization - Material Ingredients	2	
2			•	•	2			Credit Construction and Demolition Waste Management	2	

Healthy Materials & Embodied Carbon

Healthy Materials Integrated Selection



Red List Materials Selection



Declaration Status

LBC RED LIST FREE products disclose 100% of ingredients present at or above 100 ppm (0.01%) in the final product and do not contain any Red List chemicals.

LBC RED LIST APPROVED products disclose a minimum of 99% of ingredients present in the final product and meet the LBC Red List Imperative requirements through one or more *approved exceptions*.

DECLARED products disclose 100% of ingredients present in the final product, but contain one or more Red List chemicals that are not covered by an approved exception.

Declare.

Gold Bond® High Strength Fire-Shield 60® Gypsum Board
Gold Bond Building Products, LLC
provided by National Gypsum Company

Final Assembly: Multiple US Locations
Life Expectancy: 60+ Year(s)
End of Life Options: Recyclable (100%), Landfill

Ingredients:

Gypsum Core: Gypsum; Vermiculite; STARCH; Continuous Filament Glass Fiber, Non-Respirable; Dextrose; Sodium polynaphthalenesulfonate[1]; Boric acid; Polignate Sodium; Metaphosphoric acid (H3P3O9), trisodium salt; Undisclosed (< 0.06%)[2]; Poly(oxy-1,2-ethanediyl), .alpha.-sulfo-.omega.-hydroxy-, C9-11-alkyl ethers, sodium salts; POTASSIUM SULFATE; Glycerine; Sodium bisulfate; **Paper Facing:** Mixed Recycled Paper; Starch; Alkenyl succinic anhydride

[1]LBC Temp Exception RL-009 - Formaldehyde
[2]LBC Temp Exception RL-004b - Proprietary Ingredients in Declare

Living Building Challenge Criteria: Compliant

I-13 Red List:
☐ LBC Red List Free
■ LBC Red List Approved
☐ Declared

% Disclosed: 99.94% at 100ppm
VOC Content: Not Applicable

I-10 Interior Performance: CDPH Standard Method v1.2-2017
I-14 Responsible Sourcing: Not Applicable

NGC-0002
EXP. 01 MAR 2024
Original Issue Date: 2023

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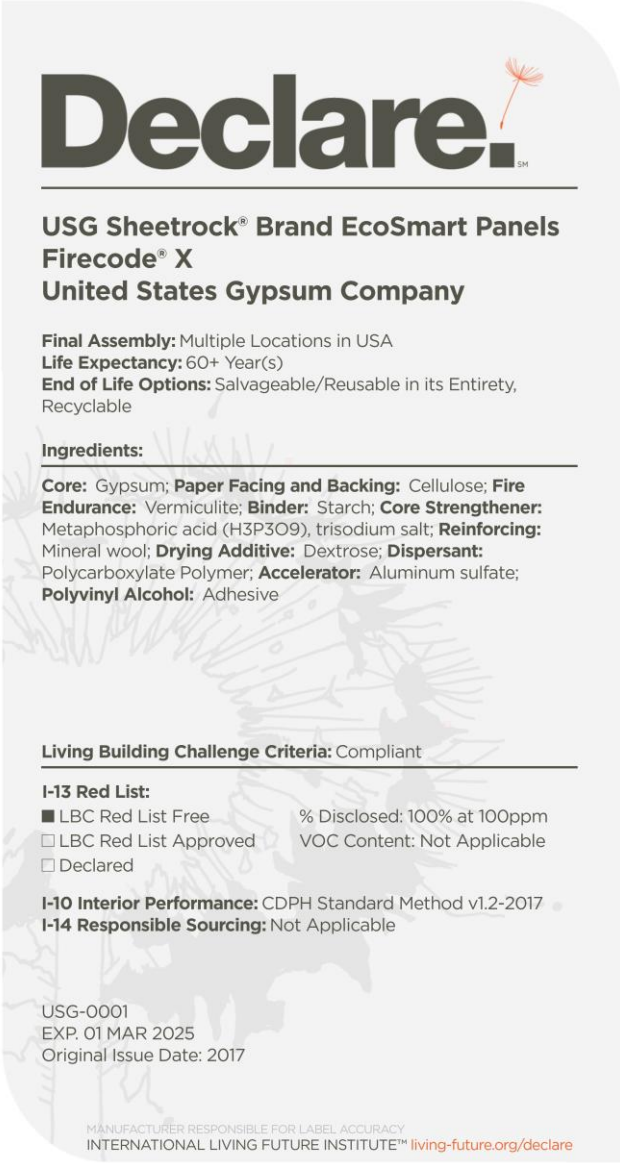

Declare.

USG Sheetrock® Brand EcoSmart Panels Firecode® X
United States Gypsum Company

Final Assembly: Multiple Locations in USA
Life Expectancy: 60+ Year(s)
End of Life Options: Salvageable/Reusable in its Entirety, Recyclable

Ingredients:

Core: Gypsum; **Paper Facing and Backing:** Cellulose; **Fire Endurance:** Vermiculite; **Binder:** Starch; **Core Strengthener:** Metaphosphoric acid (H3P3O9), trisodium salt; **Reinforcing:** Mineral wool; **Drying Additive:** Dextrose; **Dispersant:** Polycarboxylate Polymer; **Accelerator:** Aluminum sulfate; **Polyvinyl Alcohol:** Adhesive

Living Building Challenge Criteria: Compliant

I-13 Red List:
■ LBC Red List Free
☐ LBC Red List Approved
☐ Declared

% Disclosed: 100% at 100ppm
VOC Content: Not Applicable

I-10 Interior Performance: CDPH Standard Method v1.2-2017
I-14 Responsible Sourcing: Not Applicable

USG-0001
EXP. 01 MAR 2025
Original Issue Date: 2017

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Thornton Tomasetti

smma dw DORE + WHITTIER Turner

Red List Materials Category Selection & Prioritization

Material Selection Priorities
(Durability and Cost will be reviewed in DD phase)

Flooring and Base Materials

smma

					Priority 1		Poor, Good, Best Priority 2	Low, Medium, High Priority 3	Dropdown Sustainability	Y/N	Y/N	Low, Med, High	Y/N	
Specification Section Number	**Specification Name**	**Product Type**	**Manufacturer**	**Product Name**	**Red List Status**	**Declare Label Expiration Date**	**Durability/ Performance**	**Cost**	**CDPH v1.2 2017 Compliance**	**HPD**	**EPD**	**Embodied Carbon Content**	**Data extracted from Lexington Police Station Research?**	**Product Info**
096566		Athletic Flooring (Rubber)	Zandur	Vulcanized Rubber Sport Fitness Flooring - Sustain, Sophros & Flex	Red List Free	2/1/2025			Other	N	N		N	https://zandur.com/products/sophros-solid-rubber/
096566		Athletic Flooring (Rubber)	Ecore	Ultratile	Product Research Required				FloorScore	Y	Y	Medium	N	https://ecoreathletic.com/products/rubber/performance/performance-ultratile
096566		Athletic Flooring (Rubber)	Flexco	Tuflex Force Rubber Flooring	Red List Free	Self Declared Red List Free			FloorScore	Y	Y	Medium	N	https://flexcofloors.com/product-category/rubber-tile-samples/tuflex-force-recycled-rubber-tile-samples/
096566		Athletic Flooring (Rubber)	Capri Collections	Fitness & Rec EPDM Rubber Flooring	Red List Free	10/1/2025			FloorScore	N	N		N	https://declare.living-future.org/products/fitness-rec
096566		Athletic Flooring (Rubber)	Ecore International	ECOfit	Product Research Required				SCS Indoor Advantage	Y	Y	High	Y	https://ecosurfaces.com/products/rubber/ecofit
096466		Athletic Flooring (Wood)	Tarkett	Flexlock Wood Sports Flooring	Product Research Required				None	N	N		N	https://professionals.tarkett.com/en_EU/collection-C001408-flexlock
096466		Athletic Flooring (Wood)	Aacer Flooring	Infinity Wood Floors	Product Research Required				None	N	N		N	https://www.aacerflooring.com/
		Carpet (Broadloom)	Milliken	Broadloom Carpet	Red List Free	5/1/2025			CRI Green Label Plus	N	N	High	N	https://fccatalogblob.milliken.com/fccatalogblob/documents/67/F7/Formwork_Brochure.pdf
		Carpet (Broadloom)	Mohawk Group	Comercial Nylon Broadloom	Red List Free	8/1/2025			CRI Green Label Plus	Y	Y	High	N	https://www.mohawkgroup.com/products/soft-surface?product_type=Broadloom
		Carpet (Broadloom)	Godfrey Hirst	100% Wool Broadloom Carp	Red List Free	9/1/2025			Other	N	N		N	https://www.godfreyhirst.com/au/products?type=CPT&subType=wool_cpt
		Carpet Tile	Mohawk Group	Nylon Modular Carpet on E	Red List Free	1/1/2026			CRI Green Label Plus	Y	Y	High	N	https://www.mohawkgroup.com/products/soft-surface?product_type=Carpet%20Tile&red_list_free=True
		Carpet Tile	Milliken	First Sight Sandscape - PVC-Free WellBAC Comfort cushion backing	Red List Free	7/1/2025			CRI Green Label Plus	Y	Y	High	N	https://fcproductcatalog.milliken.com/en-us/search/colors?sort=recent&regionName=Americas&marketName=Contract&catalogName=Products&regionId=76&marketId=73&catalogId=17&totalResults=18&collectionId=599&collectionName=First+Sight
		Carpet Tile	Milliken	First Sight Surface Current - PVC-Free WellBAC Comfort cushion backing	Red List Free	7/1/2025			CRI Green Label Plus	Y	Y	High	N	https://fcproductcatalog.milliken.com/en-us/search/colors?sort=recent&regionName=Americas&marketName=Contract&catalogName=Products&regionId=76&marketId=73&catalogId=17&totalResults=18&collectionId=599&collectionName=First+Sight
		Carpet Tile	Bentley Mills	All Carpet Products (Tile & Broadloom)	Red List Free	2/1/2025			CRI Green Label Plus	Y	Y	Low	N	https://www.bentleymills.com/bentley-publishes-declare-labels-achieves-red-list-free-status-for-all-carpet-products/
096813		Carpet Tile	Bentley Mills	NexStep Cushion Tile - Burn	Red List Free	2/1/2025			SCS Indoor Advantage	Y	Y	Low	Y	https://declare.living-future.org/products/nexstep-cushion-tile
096813		Carpet Tile	Bentley Mills	NexStep Cushion Tile - Reda	Red List Free	2/1/2025			SCS Indoor Advantage	Y	Y	Low	Y	https://declare.living-future.org/products/nexstep-cushion-tile

Snip of SMMA's Healthy Material Matrix (material research is ongoing)

Embodied Cabon Update

Embodied Carbon Analysis

- Preliminary embodied carbon refresher
- Embodied carbon analysis relative to exterior assembly materials
- Mass Timber option not retained (2.24.2025 SBC)

Embodied Carbon Goal: 20%+

- Selective low carbon tiers – Low, Medium, High – per the Carbon Leadership Forum's EC3 database
- Alongside Red List tracking and VOCs.

Embodied Carbon – Mass Timber

Structural System Options	Embodied Carbon Reduction from Baseline Model (% tons CO2e)	Incremental Additive Construction Cost (not in current estimates)	LEED Impact
New Construction with Steel/Concrete Structure	-6.0*		3 points (10% reduction goal)
New Construction with All Structure being Mass Timber Superstructure	-19.6	$23M+/-	4 points (20% reduction goal)

Notes:

1. *Preliminary PSR analysis conducted using EPIC early carbon assessment tool (60-year LCA). Modeling tool Baseline model assumes building structure only recycled content, not including Low-Carbon concrete measures and enclosure components towards 10% goal.*

Embodied Carbon

Embodied Carbon Reduction Strategies

- Structural Components:
  - Low Carbon Concrete
  - Recycled Steel
  - *Wood Components (not included 2.24.25)*
- Building Exterior Wall Assembly:
  - Low Carbon Insulation (wall and foundation)
- Building Interior Components:
  - Exposed Ceilings (where applicable)
  - Low Carbon Concrete (exposed floors)
  - Low-Carbon Interior Insulation
  - Low Carbon Gypsum Wall Board

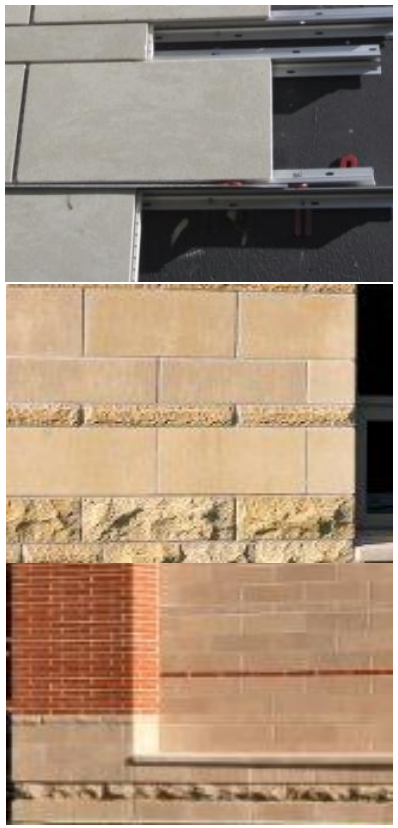
Embodied Carbon Life Cycle Analysis (LCA) Approach and Tools

- PDP/PSR:
  - EPIC (Preliminary Structure / Enclosure)
- Schematic Design:
  - Tally (Whole-Building)
  - EC3/CLF Database (Low-Carbon Materials)

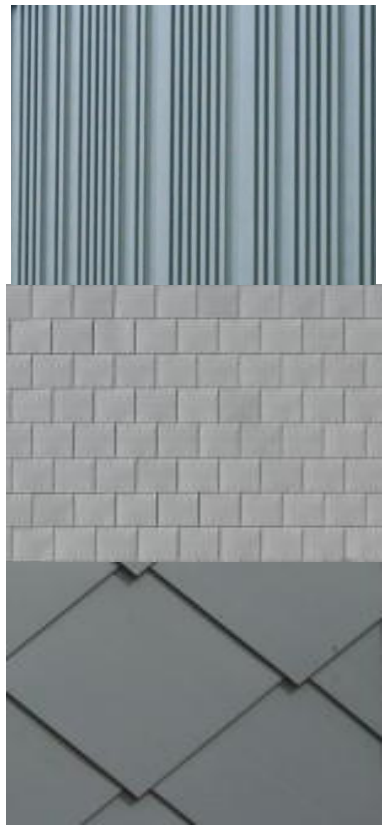
Potential Materials & Systems / Exterior Cladding Options

Brick/Precast/Stone

Thin Mfd. Stone



Metal Panel, Siding & Tiles



Porcelain Panel Phenolic Panel

Terracotta Curtain Wall

Potential Materials & Systems / Exterior Cladding Options – Embodied Carbon

Materials	Embodied Carbon Level (based on IW EPD, in kgCO2e/sf)**	% of Total Enclosure
Brick	4.3	60%
Composite Aluminum Panel	2.6	18%
Formed Metal Panel	1.73 (Aluminum) 1.42 (Steel)	18%*
Terra Cotta	10.31	20%
Fiber Cement	0.67	20%*
Phenolic Panel	2.37	20%*
Porcelain Panel	1.28	20%*
Granite	1.99	2%

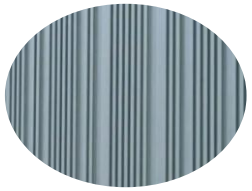
** Values are through Manufacturing. LCA is needed to assess remaining life cycle stages. Rainscreen does not include supporting girts.

*Alternate material option

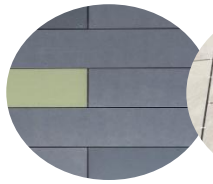
Exterior Cladding Materials / Embodied Carbon Factor

**based on Industry-Wide Environmental Product Declarations, in kgCO2e/sf

Formed Metal 1.73

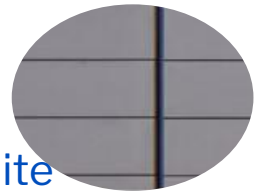


Fiber Cement 0.67



Porcelain Panel 1.28

Composite Aluminum Panel 2.6



Granite 1.99

Brick 4.3

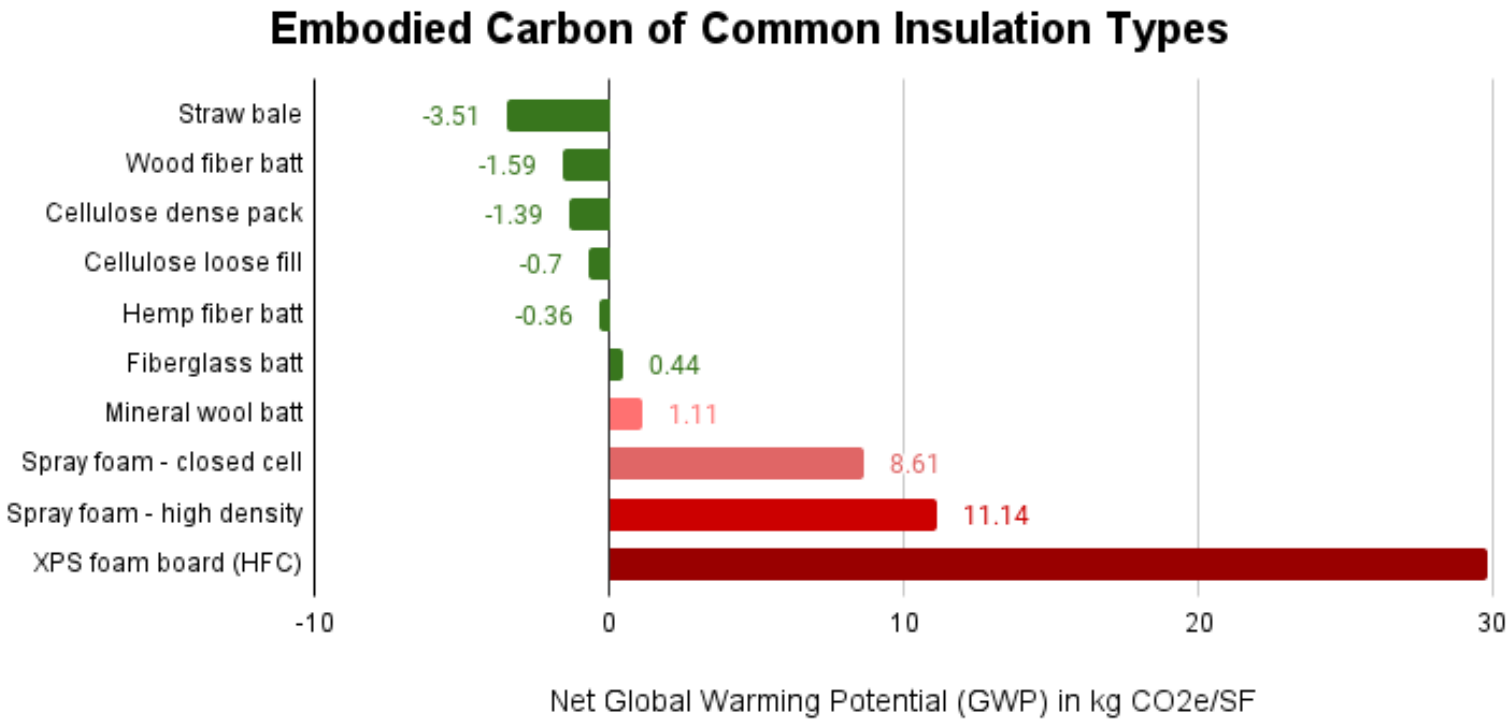
Terra Cotta 10.31

Low — High

Embodied Carbon and Red List / Insulation

Potential Insulation Options

- Opportunity to reduce embodied carbon emissions, both interior and exterior.
- Optimize low-GWP insulation
- Prioritize Red List/Healthy Insulation Materials.



Source: Maine Passive House

Concrete Embodied Carbon Reduction

- Specify high recycled-content in concrete mix (fly ash/slag)
- Options for low-embodied carbon concrete manufacturers.
- Early concrete procurement discussions with Turner Construction.

	2500 psi (17.2 Mpa)	3000 psi (20.7 MPa)	4000 psi (27.6 MPa)	5000 psi (34.5 MPa)	6000 psi (41.4 MPa)	8000 psi (55.1 MPa)	LW 3000 psi (20.7 MPa)	LW 4000 psi (27.6 MPa)	LW 5000 psi (34.5 MPa)
Pacific Southwest	257	279	323	378	401	456	500	546	594
Pacific Northwest	235	261	316	386	408	487	518	575	632
Rocky Mountains	232	255	301	358	379	440	484	532	580
South Central	226	245	286	336	356	409	468	510	555
North Central	241	264	312	372	394	460	487	537	591
Southeastern	247	268	309	360	382	435	478	521	562
Great Lakes	232	255	303	363	383	452	499	551	603
Eastern	240	264	314	378	399	472	517	573	628
National	240	262	308	365	385	446	492	540	588

Notes: All values are Baseline GWP (kg CO_2e / m^3).

Data Source: NRMCA. (2022). *National and regional LCA benchmark (industry average) report - v3.2*

Source: 2023 Carbon Leadership Forum Materials Baselines Report

Net Zero Energy Design

75-year Life Cycle Cost Analysis (LCCA)

Schematic Design LCCA in Progress

- 75-year LCCA
- MSBA LCCA requirements for whole building LCCA (50-year)
- Massachusetts Stretch Energy Code Baseline (Specialized Code)
- Installation costs, replacement costs and maintenance costs
- Energy savings
- Incentives tracking:
  - Construction:
    - Utility: NZE and Post-Occupancy (EUI)
    - IRA
  - Occupancy:
    - Utility: Battery storage, peak reduction, Demand Response
    - State: Alternative Energy Certification (AEC)

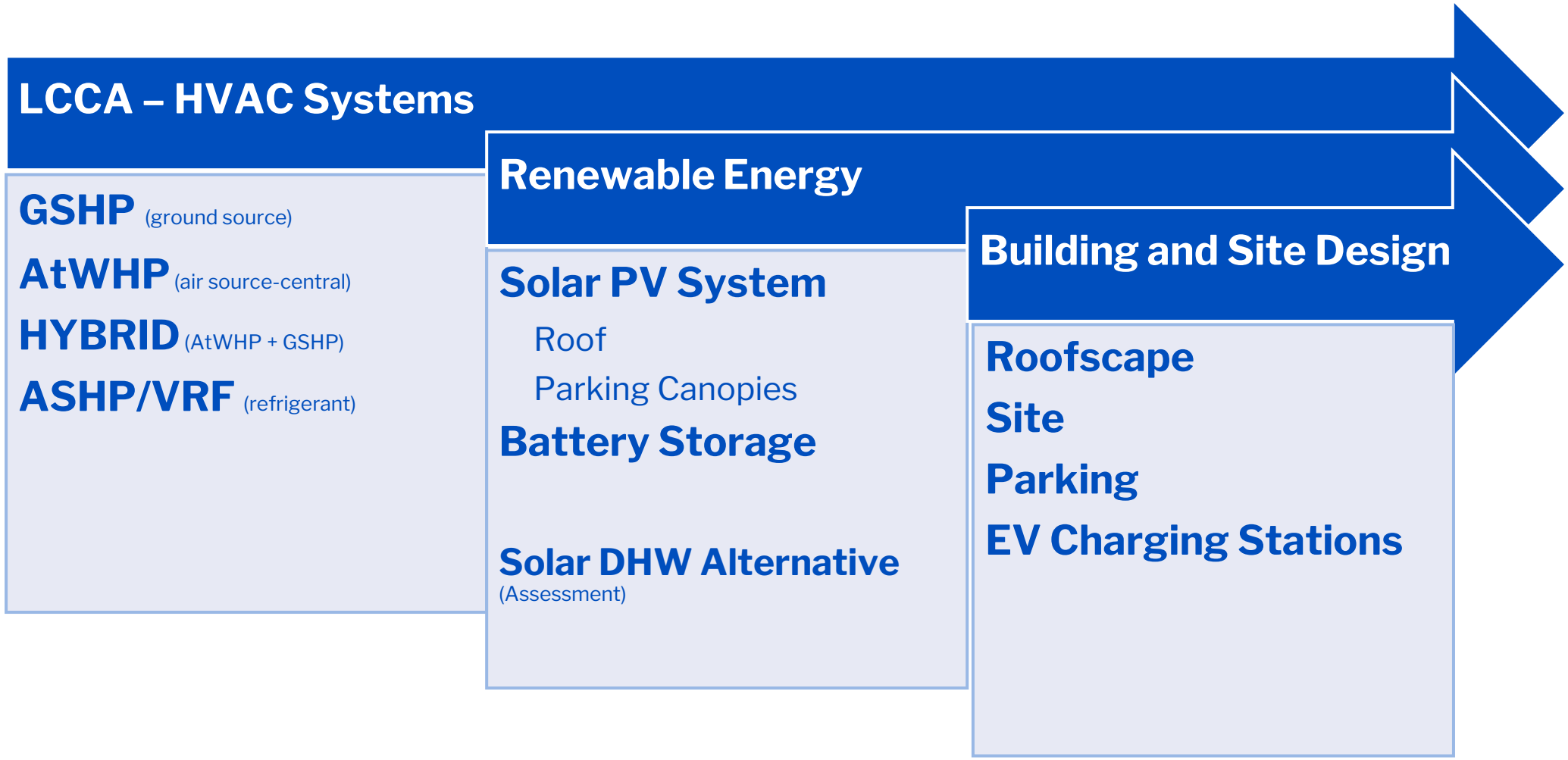
75-year Life Cycle Cost Analysis (LCCA)

SD LCCA Summary Relative to HVAC Systems Code Baseline Costs						
HVAC System	***Incremental Costs***	***Estimated Annual Energy Costs Savings***	***Estimated Incentives***	***Estimated Payback***	**Estimated EUI**	**Operational Carbon Reduction**
GSHP (ground source)						
With IRA						
Without IRA						
AtWHP (air source-central)						
HYBRID (AtWP + GSHP)						
With IRA						
Without IRA						
ASHP/VRF (refrigerant)						

In Progress

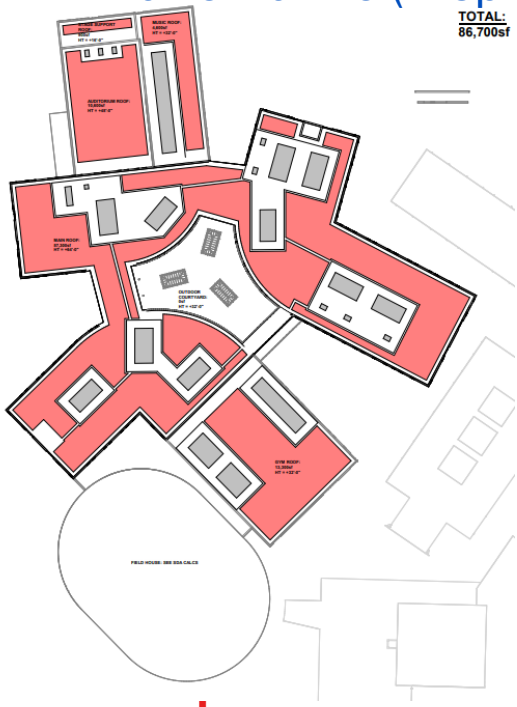
Notes:

1. Energy Savings: based on total annual kWh savings, using the average 2023-24 $0.24/kWh (utility bills). Peak demand savings not included (in progress)
2. Incremental Costs will be based on the PSR Cost Estimates and include materials and labors and are based on a per cost comparison to the analysis system baseline (ASHRAE 90.1-2019 App G).


LCCA – HVAC Systems
GSHP (ground source)
AtWHP (air source-central)
HYBRID (AtWHP + GSHP)
ASHP/VRF (refrigerant)
Renewable Energy
Solar PV System
Roof
Parking Canopies
Battery Storage
Solar DHW Alternative
(Assessment)
Building and Site Design
Roofscape
Site
Parking
EV Charging Stations

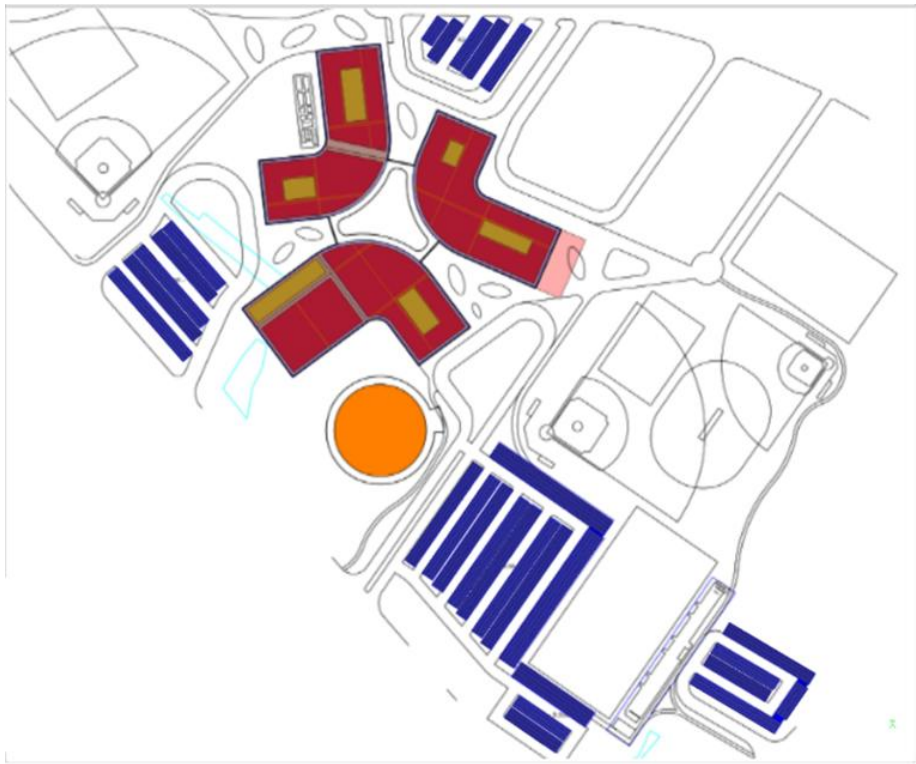
Roof Capacity

- Assess 4 HVAC systems roofscape (SDA)
- Roof Screens have an impact
- GSHP vs. ASHP with roof screens: 7,000-9,000 SF (0.3%)
- Solar DWH alternative (Displaced PV)



Parking Capacity

- Assess parking design options (SDA)
- Consideration for full canopies
- Incremental costs vs. NZE Building sizing

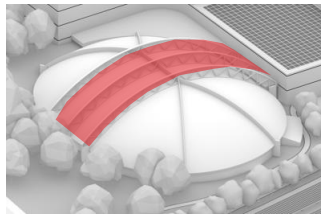


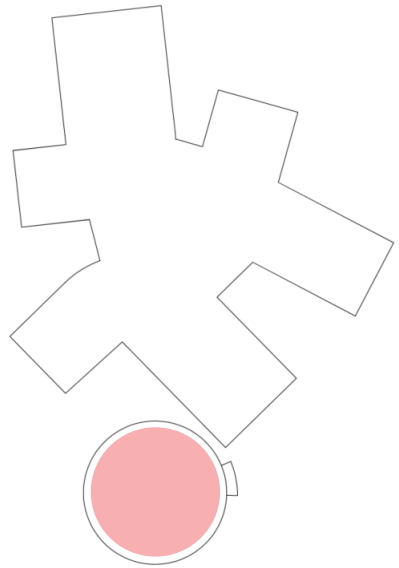
Field House Roof Solar PV Capacity

Estimated Total Annual Solar PV Production			
	Estimated PV Production (kWh)	**% of Field House Energy Use**	**% of NZE School**
Option A	345,305	98%	9%
Option B			
PV + BIPV	571,182	162%	15%
PV only	225,878	64%	6%
Option C	309,544	88%	8%
Option D	734,261	209%	20%

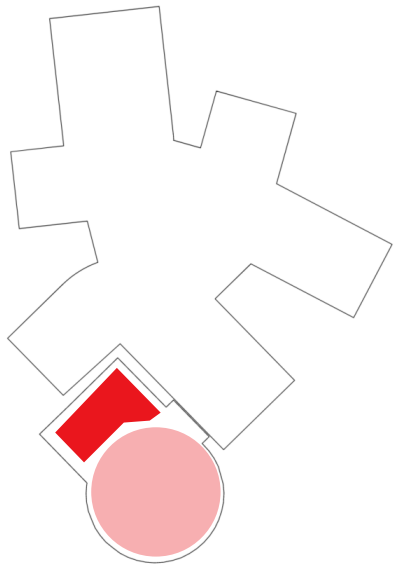
Notes:

- The Estimated Total Annual Production values are PRELIMINARY and represent an optimal yield of the modeled system. Values are subject to change per design layout, stringing, shading, roof equipment screens, etc.
- A 10% margin of error must be accounted for.
- Option A and Option B Existing curved roof consists of a BIPV roof membrane, which is **not recommended**:
  - Provides for approx. ½ of a conventional panel efficiency
  - Procurement is limited.
  - Require additional maintenance
  - Shorter Life Cycle costs.

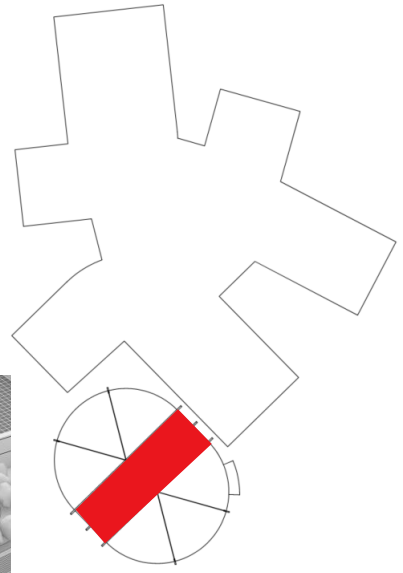




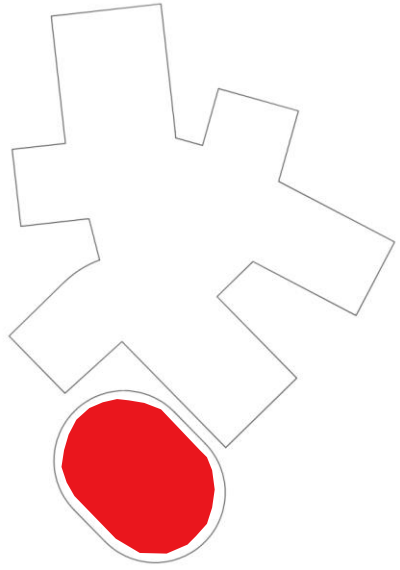
OPTION A



OPTION B



OPTION C



OPTION D

NET ZERO

Building

Based on **EUI**

25

KBtu/SF/Yr.

3,500,000 kWh

Project Scope $

NET POSITIVE

Building

Based on **EUI**

25

KBtu/SF/Yr.

+

50-250 EV Stations

Up to 4,000,000+ kWh

Additional Costs $$$

Mechanical Systems Selections

HVAC System Selection

Goal

- Select at least 3 systems to study
- Fulfill MSBA LCCA requirements

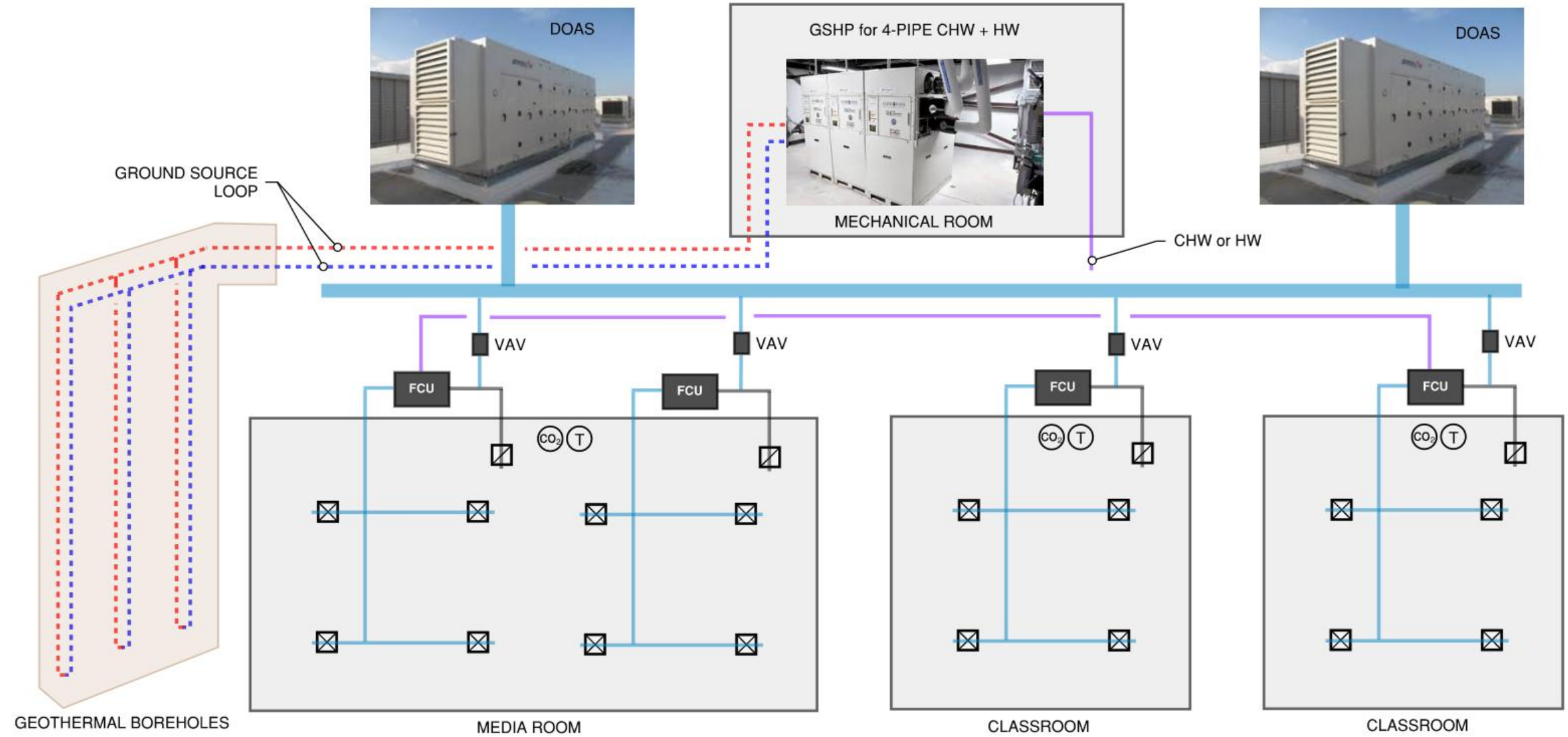
HVAC Systems Types

- Ground Source Heat Pumps (Geothermal, GSHP)
- Air Source Heat Pump (Air to Water-AtWHP, central system)
- Hybrid GSHP and ASHP
- VRF Air Source Heat Pumps

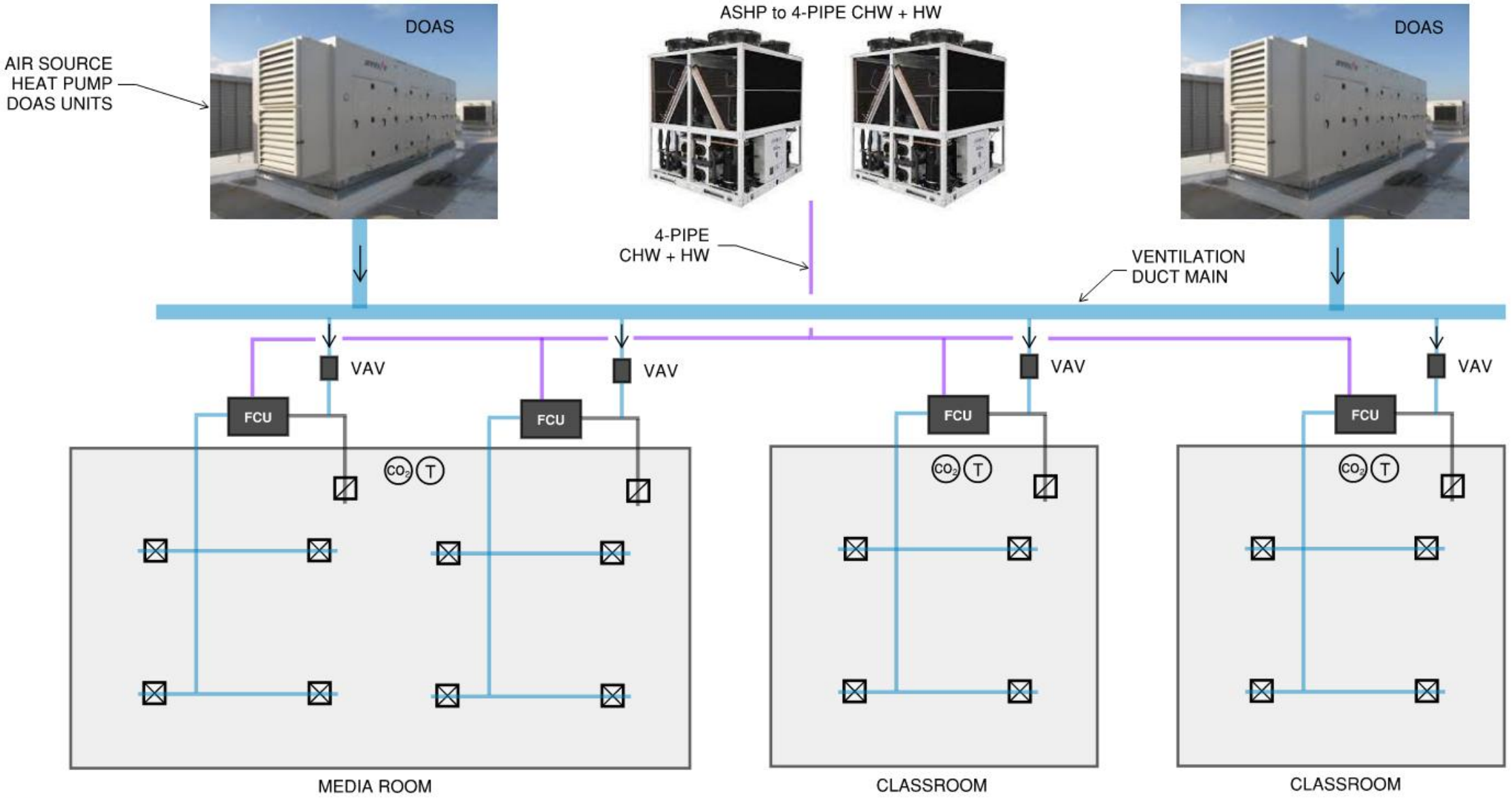
Evaluation Process

- Qualitative – Reliability, Serviceability, Efficiency, Impact on Building
- Quantitative – Construction Cost, Operating Cost, Life Cycle Cost

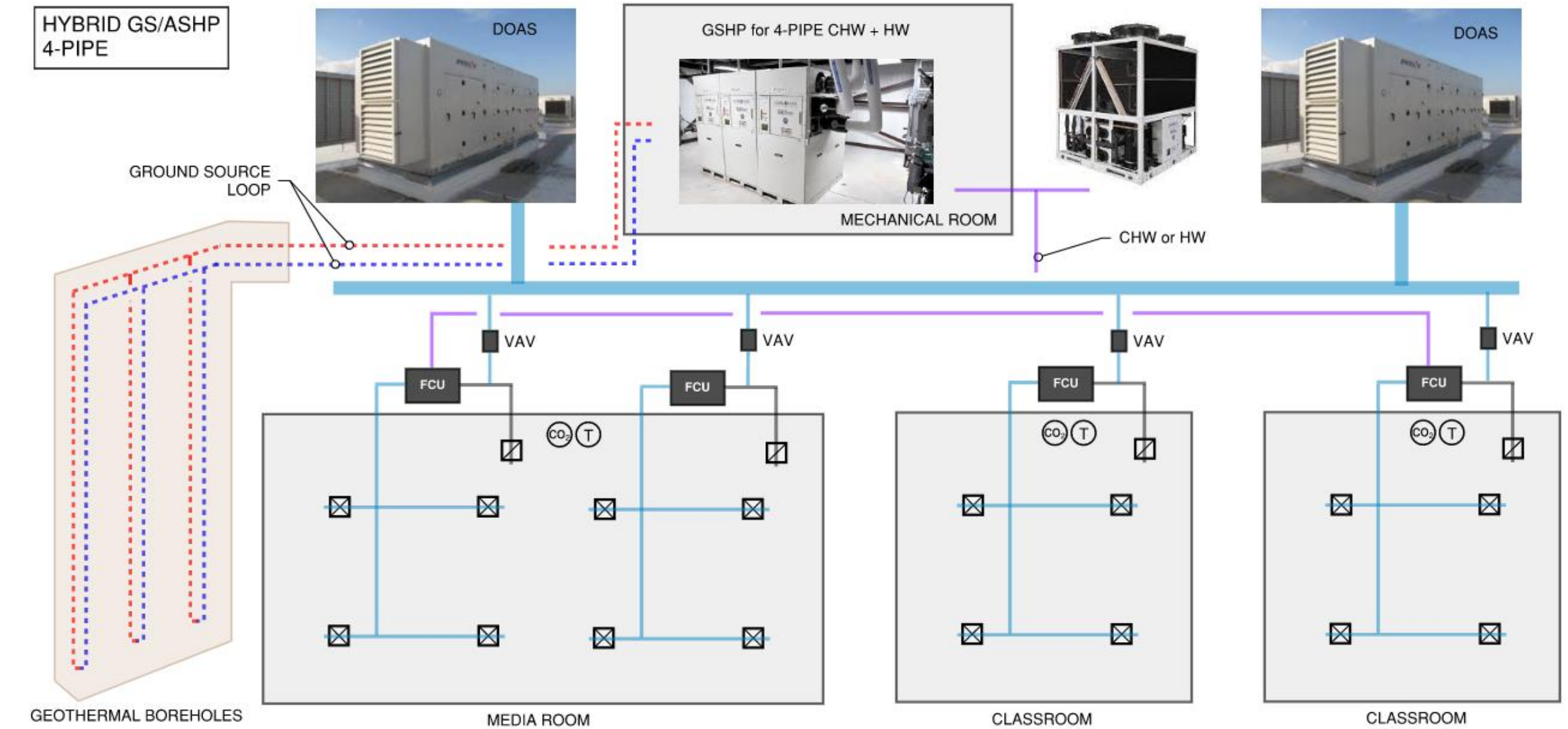
HVAC System Selection / Central Ground Source Heat Pump with 4-Pipe CHW/HW



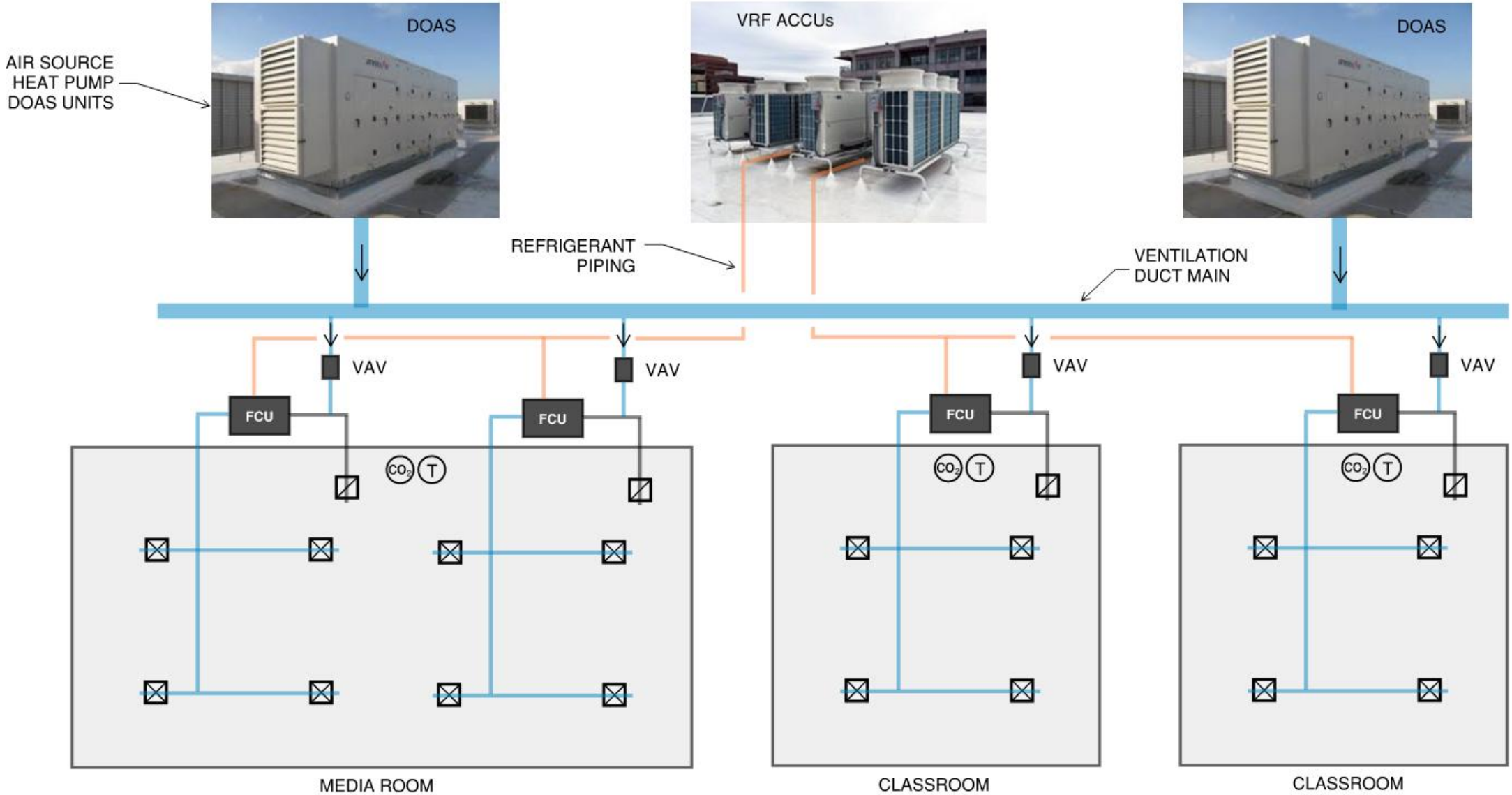
HVAC System Selection / Central Air Source Heat Pump with 4-Pipe CHW/HW



HVAC System Selection / Hybrid Ground Source and Air Source Heat Pumps with 4-Pipe CHW + HW



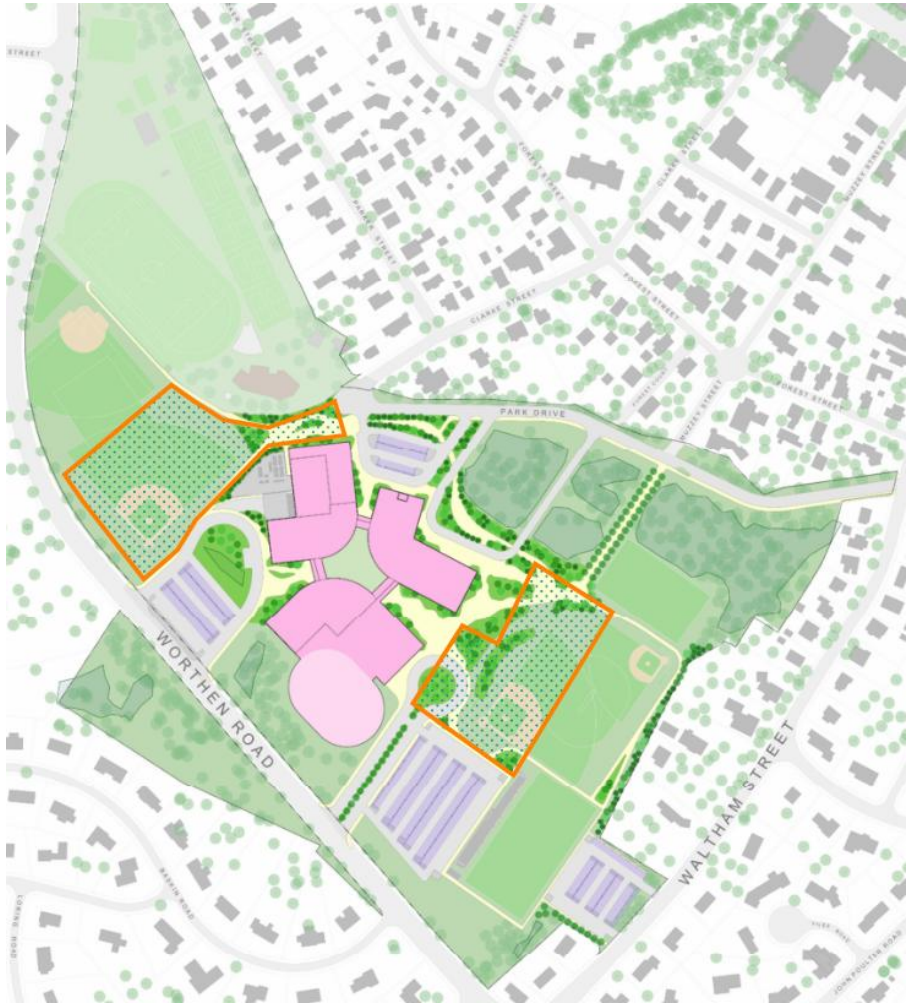
HVAC System Selection / VRF Air Source Heat Pumps with Distributed FCUs



HVAC System Selection / Pros and Cons – Recommended for Study

System Type	Pros	Cons
VRF ASHP + Refrigerant Pipe FCU	Cost effective Very good efficiency Flexible for different installations Offers heating or cooling to each zone Does not require MER space	Extensive refrigeration piping in building New refrigerants are A2L ('low flammability' rating) ASHP require space on roof or on grade VRF defrost cycles disrupt heating function
Central ASHP + 4-Pipe FCU	Efficiency varies - good to very good Central CHW/HW plant simplifies maintenance Modular configurations improve reliability	Less flexibility for heating or cooling to zones Energy efficiency is not as good as some alternatives Defrost cycles disrupt heating function Requires MER space for equipment
Central GSHP + 4-Pipe FCU	Excellent energy efficiency Central CHW/HW plant simplifies maintenance Modular configurations improve reliability Useful life is ~20 yrs IRA incentives may be available.	Less flexibility for heating or cooling to zones Requires substantial MER space to house equipment Geothermal system cost is higher
Hybrid GSHP/ASHP + 4-Pipe FCU	Still geothermal but reduced cost Very good to excellent energy efficiency Central CHW/HW plant simplifies maintenance IRA incentives may be available	Less flexibility for heating or cooling to zones Requires MER space to house equipment Geothermal system cost still an impact System configuration and control is more complex

HVAC System Selection / Geothermal Borehole Field Requirements



Full Geothermal – 225 bh, 3.2 Acres

Hybrid Geothermal – 126 bh, 1.6 Acres

Domestic Hot Water Systems Selections

Domestic Hot Water System Selection

System Types

- Electric Element
- Air Source Heat Pump
- Ground Source Heat Pump
- Solar Thermal

Criteria

- Energy Efficiency - COP
- Reliability
- Ease of Maintenance

Domestic Hot Water System Selection

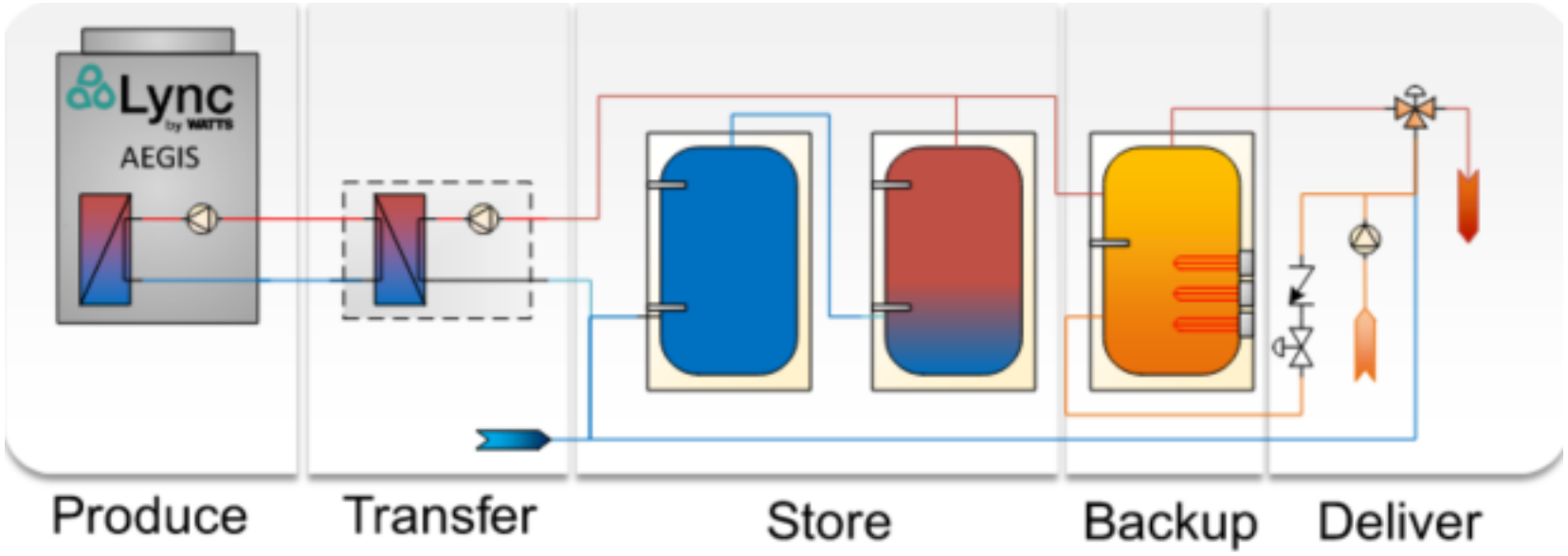
Electric Element DHW Heater

- Central System as base
- Point-of-use as supplemental
- COP = 1

Domestic Hot Water System Selection

Air Source Heat Pump System

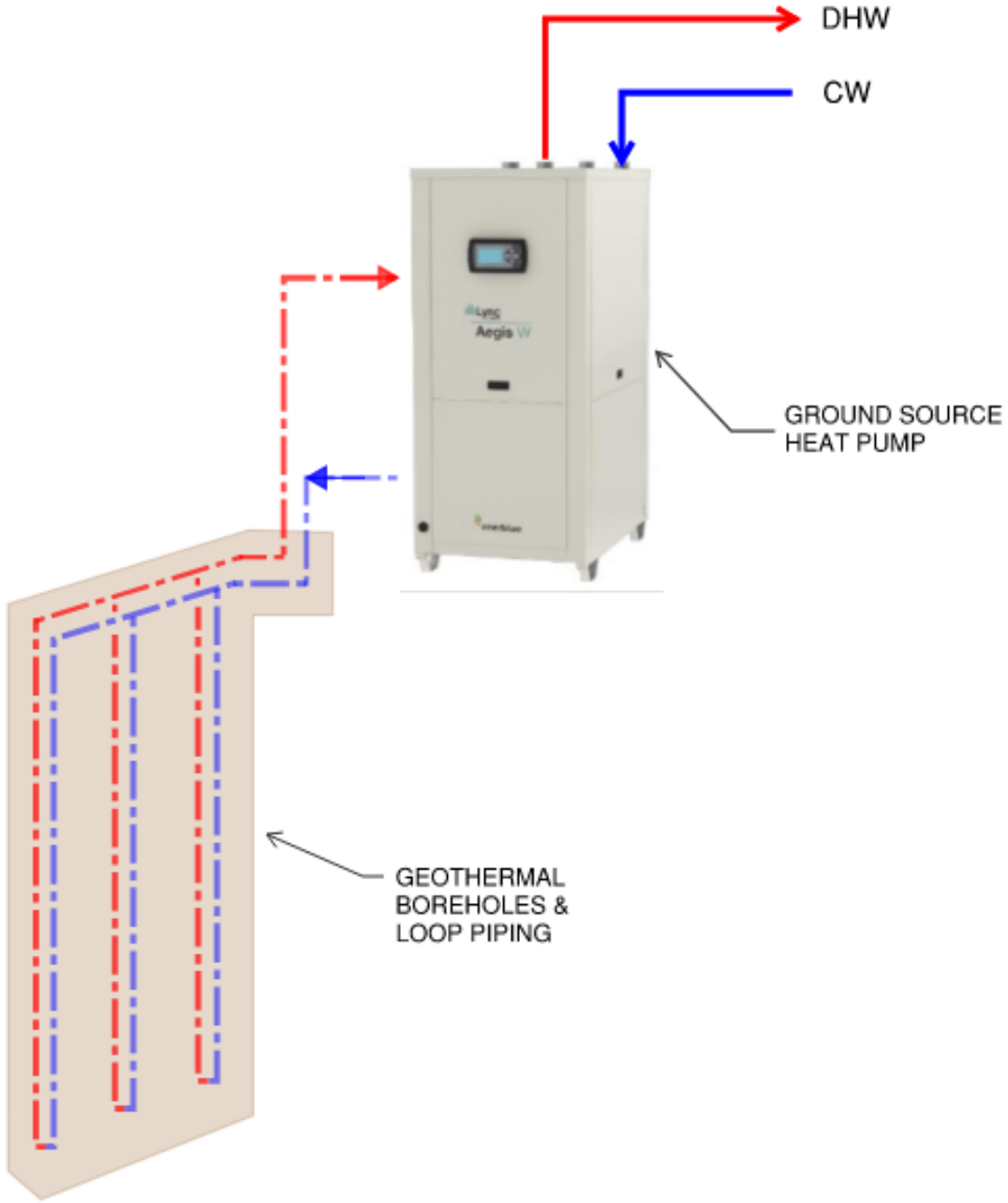
- COP = 3 to 4
- CO2 or R-454B Refrigerants
- Additional storage tanks required
- Electric element type as backup



Domestic Hot Water System Selection

Ground Source Heat Pump System

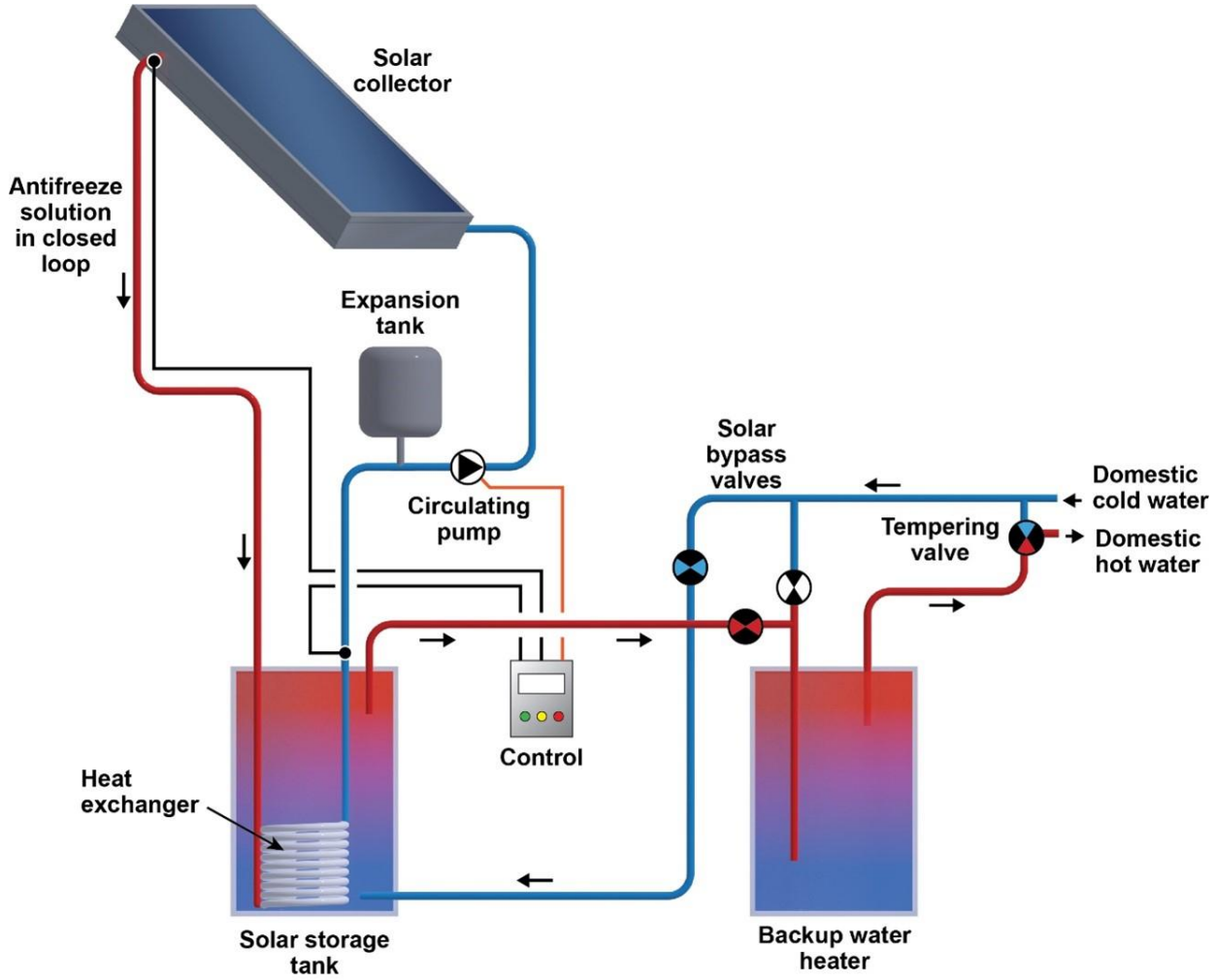
- COP = 3 – 4
- CO2 or R-454B Refrigerants
- Additional storage tanks required
- Electric element type as backup



Domestic Hot Water System Selection

Solar Hot Water System

- Collectors on roof
- Additional storage tanks required
- Electric element type as backup



Domestic Hot Water System Selection / Pros and Cons – Recommended for Study

System Type	Pros	Cons
Electric Element	Cost effective installation Proven technology and simple controls Instantaneous can be used for remote installations	Poor energy efficiency (COP = 1) Requires substantial electric power distribution
Air Source Heat Pump	Very good energy efficiency (COP = 3 to 4) CO2 option is environmentally friendly (GWP = 1)	Higher Costs than electric element Newer product offering in US; not many installations
Ground Source Heat Pump	Very good energy efficiency (COP = 3 to 4) CO2 option is environmentally friendly (GWP = 1)	High Cost, but less than Air Source option Newer product offering in US; not many installations
Solar Thermal	Excellent energy efficiency Can be used to supplement an alternate system	Highest costs Requires a means of rejecting heat when not in use Takes away available space for PV

Thank you