Net Zero New Construction Design:

Toronto Paramedic Services Multifunction Paramedic Station

TORONTO

Agenda

1. Land Acknowledgement
2. Introductions:
    1. City of Toronto
    2. Diamond Schmitt gh3
3. Net Zero / TGS Version 4
4. Presentation by Diamond Schmitt gh3
5. Question & Answers

Land Acknowledgement for Toronto

We acknowledge the land we are meeting on is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit.

Introductions

Host:

Panelists:

Net Zero / TGS Version 4

Net Zero by 2040

On December 15, 2021, City Council adopted the TransformTO Net Zero Strategy, an ambitious strategy to reduce community-wide greenhouse gas (GHG) emissions in Toronto to net zero by 2040 – 10 years earlier than initially proposed

Leading by Example

"All City Agency, Corporation and Division-owned new developments are designed and constructed to applicable Toronto Green Standard (TGS) Version 4 standard achieving zero carbon emissions, beginning in May 2022"

Toronto Paramedic Services Multifunction Paramedic Station

300 Progress Ave, Toronto

Toronto Paramedic Services Multifunction Paramedic Station

- Performance targets
- Building design
- Analysis and responses
- Unique challenges/solutions

TARGETING ZERO EMISSIONS & NET ZERO ENERGY

Proposed NZEE Building	**EUI 139.1 (kWh/m2)**	**TEDI 39.4 (kWh/m2)**	**GHGI 5.6 (kg CO2e/m2)**
SB-10 Building Benchmark Building	297.6	156.5	34.6
TGS Tier 2 Baseline Building	190.5	63.2	16.0

For supporting & additional info please refer to submitted Net Zero Energy & Emissions Feasibility Study.

South Elevation

TORONTO PARAMEDIC SERVICES
MULTIFUNCTION PARAMEDIC STATION

Along the McDonald Cartier Expressway in Scarborough, Ontario, a suburban industrial area populated with big box store retail, a new building emerges, identifiable even at high speeds. A roof form, optimally angled and rotated for solar orientation, creates a dramatic profile silhouetted above the trees and announces a building of prominence and significance. Scarborough's new Multifunction Paramedic Station, targeting Zero Emissions and Net Zero Energy, is reducing embodied energy with a mass timber structure. A direct response to energy requirements resulted in a design specific to this building type and to this site, while creating a sculpted profile visible from high-speed traffic on the McDonald Cartier Expressway.

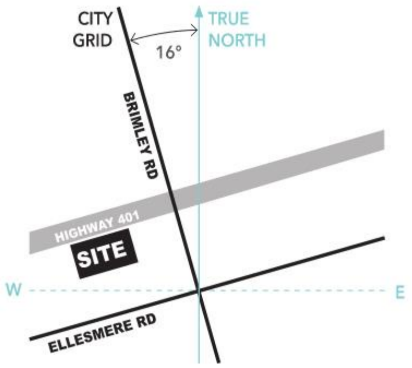
This project goes beyond the city's mandate of zero emissions to propose an exemplar – a signal to the rest of the emergency divisions and the city at large – that stringent energy and program objectives are not misaligned with aesthetic design ideals. A unified architectural idea developed from net-zero strategies, and became a framework for site position, landscape design, cladding materials and building form. Design is intrinsically tied to performance in terms of orientation, capacity, operation, and material on both the interior and exterior of this project.

The dramatic roof supporting photo-voltaic arrays, optimally sloped for solar capture, also enables clerestory windows, allowing natural light to all interior spaces, and projecting light as a lantern at night when the building is seen along the adjacent highway. The cladding and wall design absorb heat and the layout of pedestrian and vehicular entries maintains that heat. The building is designed for operational efficiency, and this is leveraged for the comfort and wellbeing of the many staff and employees who work in this post-disaster facility, all year and around the clock.

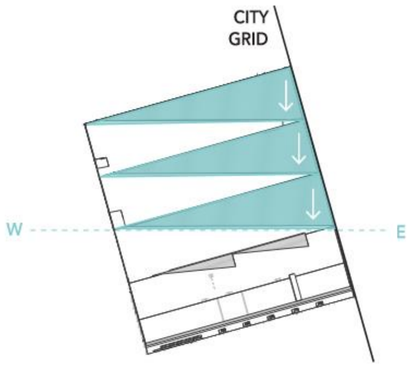
URBAN CONTEXT / ORIENTATION

The unique location of this site, between an existing police facility and Highway 401, presents an opportunity to create a distinct design that is visible from the local area and to drivers on the highway, signaling that compelling architecture and landscape strategies can distinguish an otherwise overlooked site. This design embraces the inherent challenge of merging intense programmatic functionality with a mandate for net-zero energy use on a remnant site in a largely suburban area east of downtown Toronto.

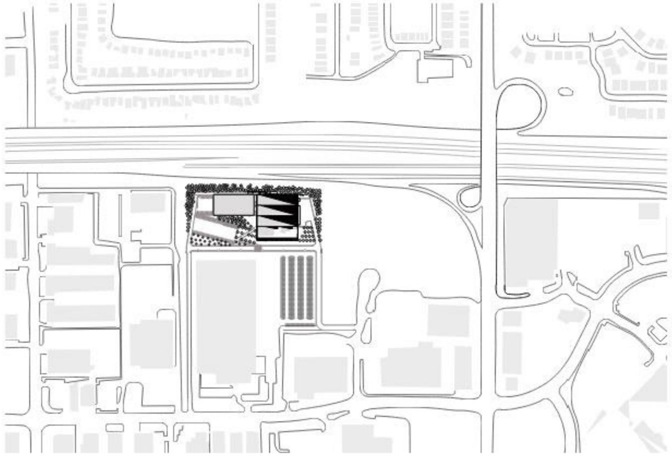
Finding the Light - Optimizing solar gain was a primary organizing principle for the site design, building placement and orientation. The building's footprint aligns with Highway 401 and the orthogonal grid of the surrounding streetscape. However, the urban grid of the Greater Toronto Area is shifted 16° off of true north. To maximize solar gain, this 16° rotation is 'reversed', introducing a secondary geometry that directs the building's roofscape to face south, the ideal positioning for the photo-voltaic arrays.



GTA GRID ORIENTATION vs TRUE NORTH



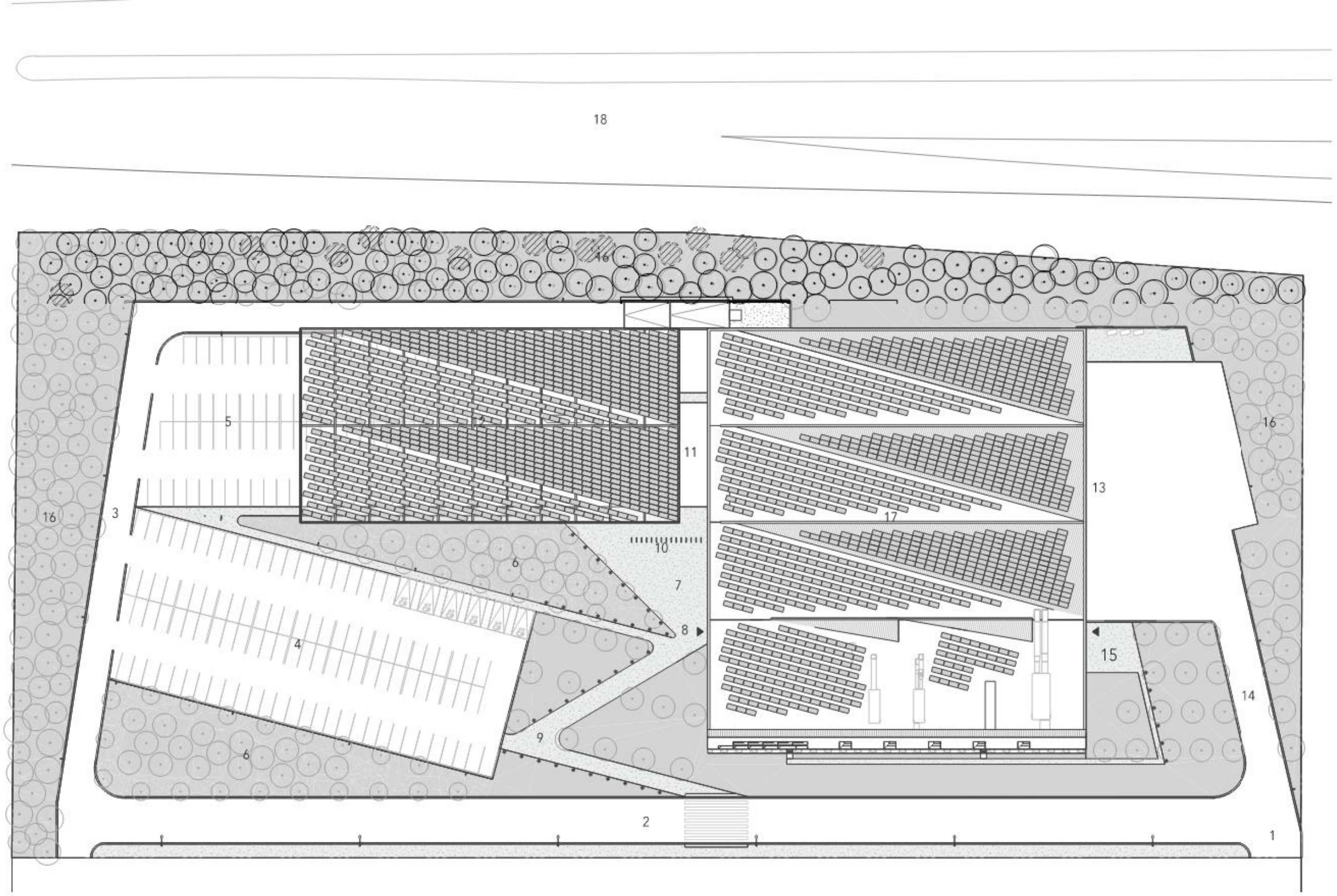
BUILDING ALIGNS WITH CITY GRID / ROOFSCAPE TILTS ORIENT SOUTH



URBAN CONTEXT PLAN

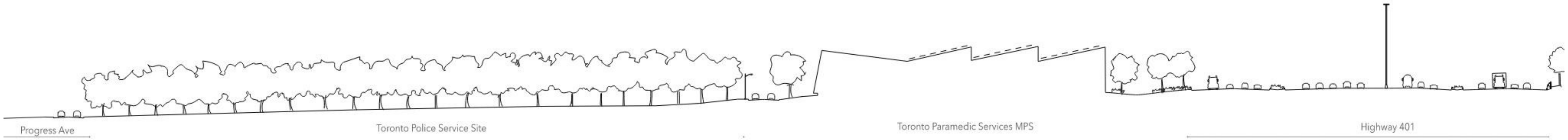
SITE ORGANIZATION

The angles derived from the 16° roof line rotation extend into the landscape in form and function with roof drainage feeding large rain garden detention basins that punctuate the site with distinct swaths of native trees and shrubs in shapes that complement the building form. The building program, with its required vehicular infrastructure, including parking, ramped driveways and large-bay garages is nestled within a native Carolinian Forest perimeter. Iterative consultation between architects, engineers, landscape architects and energy experts enabled a site and building design that is innovative in its expression of energy efficiency and environmental resilience.



SITE PLAN

1 MAIN SITE ACCESS
2 SOUTHERN ACCESS ROAD
3 AMBULANCE RETURN RAMP
4 LOWER PARKING LOT
5 UPPER PARKING LOT
6 RAIN GARDEN BASIN
7 ENTRANCE COURT
8 MAIN BUILDING ENTRANCE
9 PEDESTRIAN ACCESS
10 BICYCLE PARKING
11 AMBULANCE RETURN (UNDER CANOPY)
12 SOLAR PV CANOPY
13 AMBULANCE EXITS
14 AMBULANCE EXIT RAMP
15 PARAMEDICS PATIO
16 PERIMETER WOODLAND
17 MAIN BUILDING
18 HIGHWAY 401



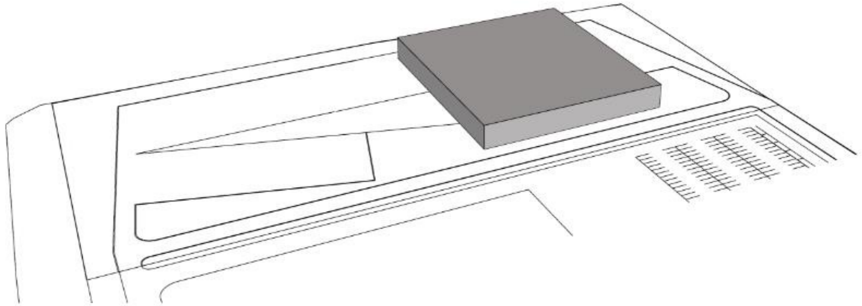
URBAN CONTEXT SECTION (N/S)

View from the Southeast

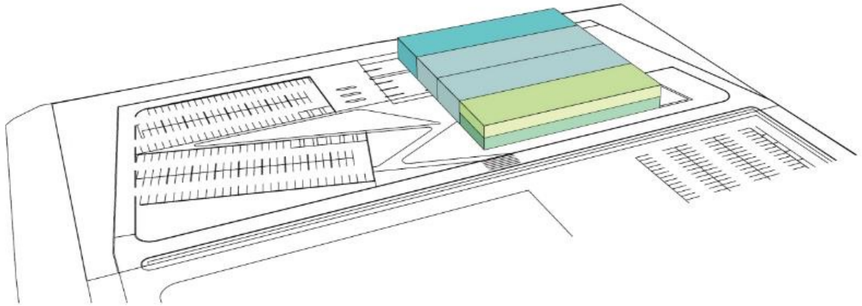
MASSING & PROGRAM DISTRIBUTION

The large form required to accommodate the building program is broken into 4 principal bays, each relating to the primary functional areas of the brief as follows:

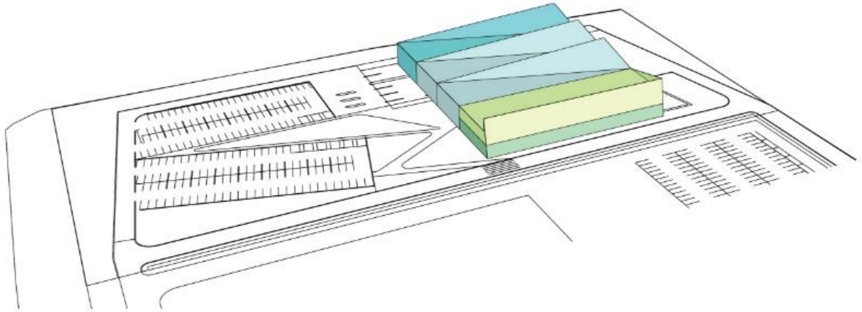
- AMBULANCE BAYS & LOGISTICS
- SUPERVISOR VEHICLE BAYS & LOGISTICS
- PARAMEDICS & DISTRICT 2 HUB
- EDUCATION & ADMINISTRATION



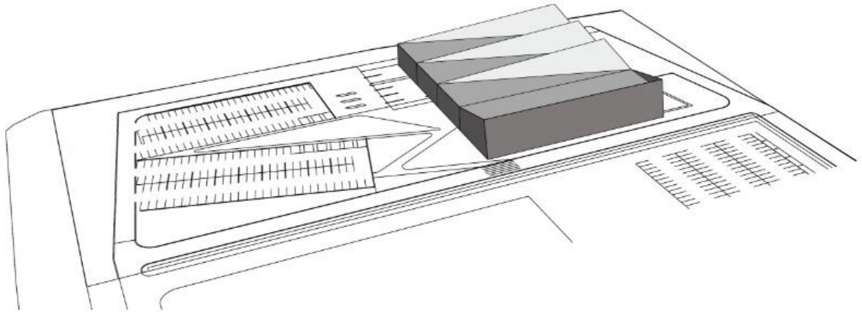
1. BASE BUILDING MASSING



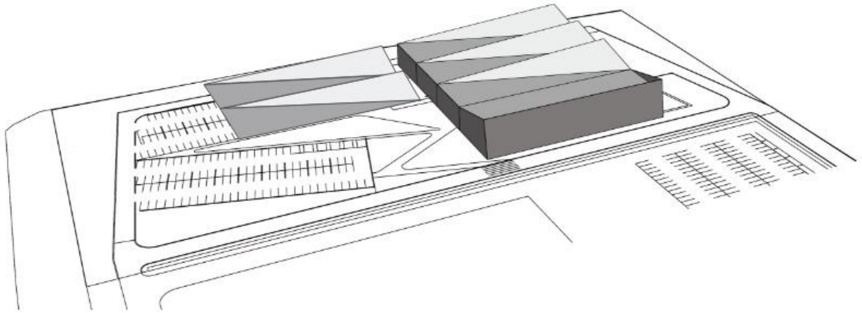
2. PRINCIPAL PROGRAM DISTRIBUTION



3. ROOFSCAPE MANIPULATED FOR DAYLIGHTING AND PV ARRAYS



4. FINAL BUILDING FORM UNIFIED WITHIN A SINGLE SKIN



5. PV CANOPY ADDED TO NORTHERN PARKING LOT

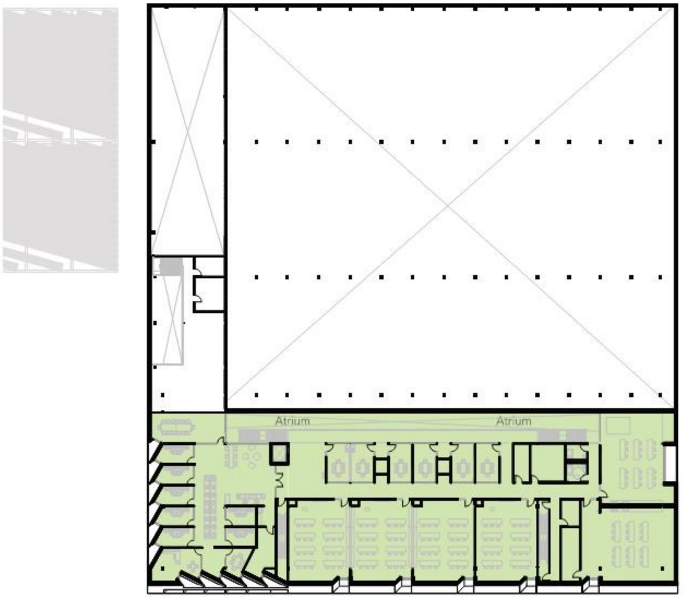
PHYSICAL ORGANIZATION, MASSING & FORM

The functional requirements of an emergency facility of this type are stringent and required input and consultation from administrators and future building users. Access to natural daylight was a priority as reflected in the generous apertures in the walls and the clerestory fenestration facilitated by the tilted roofscape.

Organized around a linear atrium, the building consists of vehicle bays to the north and an adjacent administrative and education block to the south. The vehicle bays contain spaces for 40 ambulances and 20 supervisor vehicles, with support spaces for logistics technicians. The District 2 Hub is strategically placed near the principal entrance on the ground floor of the administrative block, adjacent to the atrium, key drop and logistics area. From the atrium, paramedics can access the vehicle area, the command post, offices, the parade room, a kitchen and lounge, a flexible meeting room, lockers for 700 staff and visitors, showers, fitness facilities and stairs to the second floor.

Continuing education, recruitment, and special training programs take place on the second floor, with learning spaces that can be configured as four separate classrooms or one larger space for events. Two labs, one of which includes the rear of an ambulance, provide space for hands-on training. Six seminar rooms and administrative spaces round out the program. Support spaces are designed for use by on-duty and limited duty paramedics. Recognizing the stress and challenges of being a first responder, the lobby, lounge, seminar and meeting rooms are generously sized for paramedics to use while in reduced assignments.

MAIN LEVEL PLAN



SECOND FLOOR PLAN

- AMBULANCE BAYS & LOGISTICS
- SUPERVISOR VEHICLE BAYS & LOGISTICS
- PARAMEDICS & DISTRICT 2 HUB
- EDUCATION & ADMINISTRATION

ENVIRONMENTAL PERFORMANCE

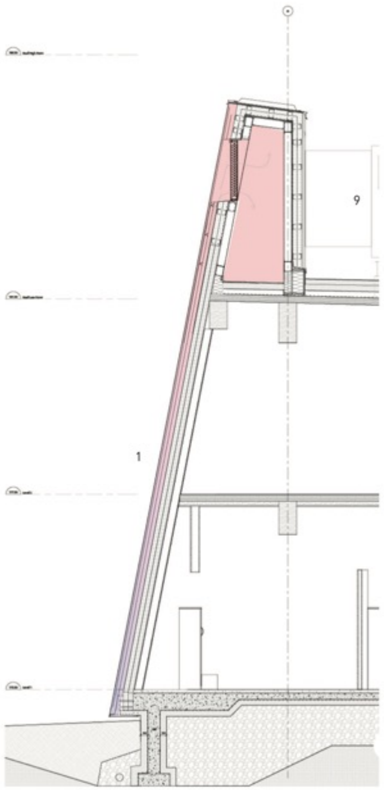
Performance targets for energy efficiency shaped the design strategy for this building.

Seven critical steps were necessary to meet the targets:
1. a very high-performance building envelope;
2. triple glazing;
3. a well calibrated window to wall ratio;
4. interior daylighting through clerestories;
5. decoupled ventilation;
6. hydronic floors to heat and cool the building from geothermal wells, and;
7. displacement ventilation throughout.

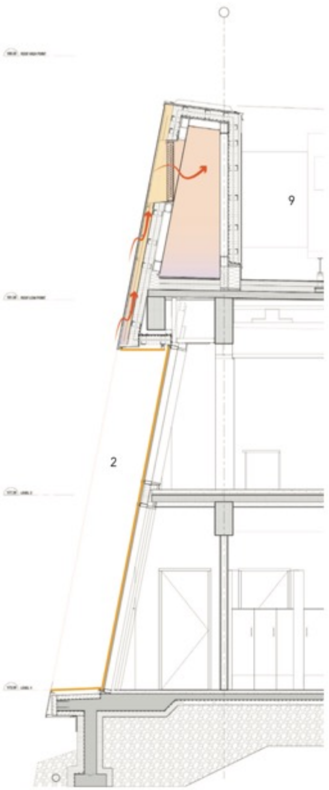
But in this building type, those measures only achieve 70% of the goal: the design must also address losses through the 12 overhead vehicle doors and heat required to temper the large volumes of make-up air for the vehicle bays. For the overhead doors, interior vestibules were introduced on both sides of the vehicle bay, the first ambulance facility in Canada to do so. This design feature conserves 15% of the entire building's energy.

Architectural Expression - The DNA of the building is informed by the tilt of the south facing solar wall (8), which conserves a further 15% of the entire building's energy. Fresh air is warmed by the south sun on the dark metal cladding, rising into energy recovery ventilators (ERVs) on the roof (9). The ERVs deliver the heated air to the vehicle bays through low level displacement ventilation cabinets. High level return air ducts draw air back to the rooftop ERVs, using latent heat to further preheat incoming air.

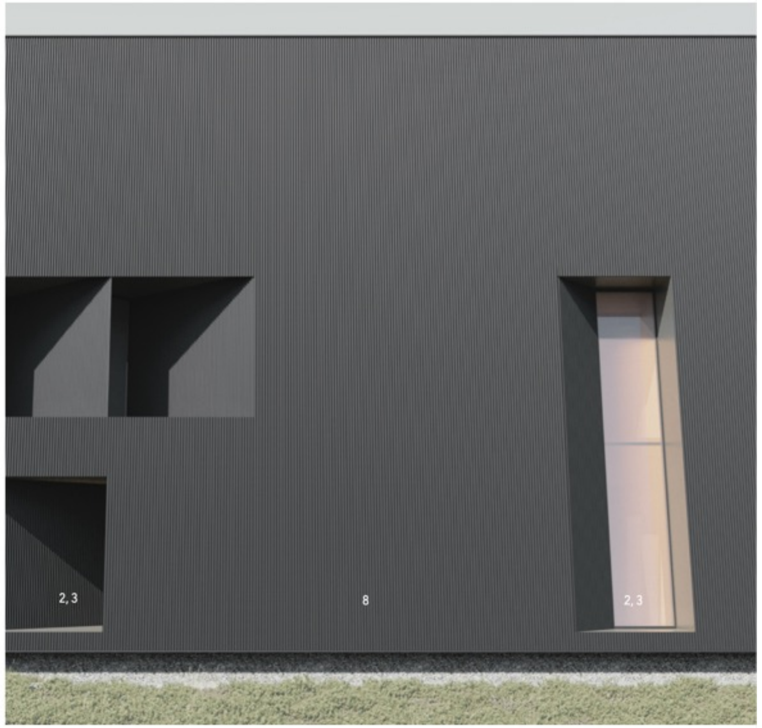
The building is on track to achieve an energy use intensity (EUI) of 139, a remarkably low number for this type of facility. The project is a signal to designers and clients that it is possible to have provocative design that is informed by energy systems.



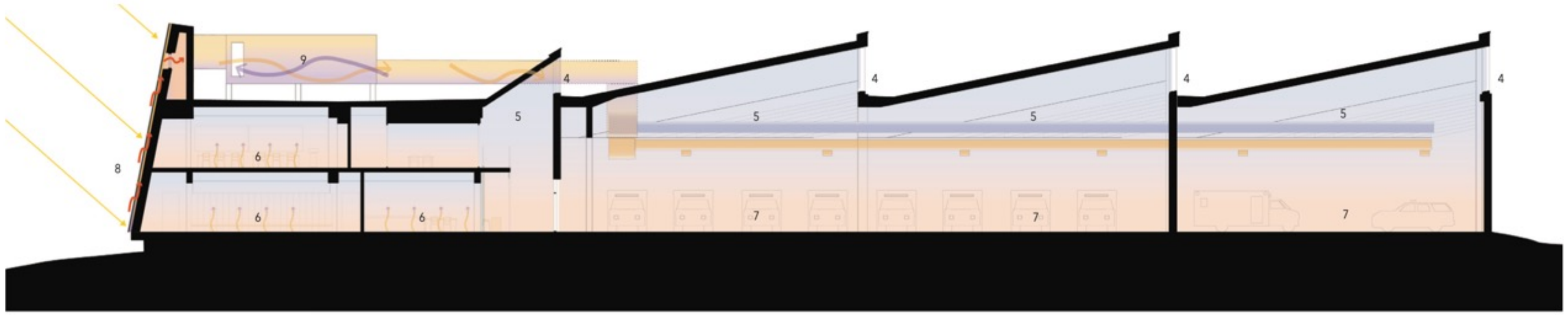
SECTION THRU SOLAR WALL (NTS)



SECTION THRU VERTICAL WINDOW (NTS)



PART ELEVATION OF SOLAR WALL



BUILDING SECTION - ENERGY SYSTEM

Cladding and window detail, south elevation

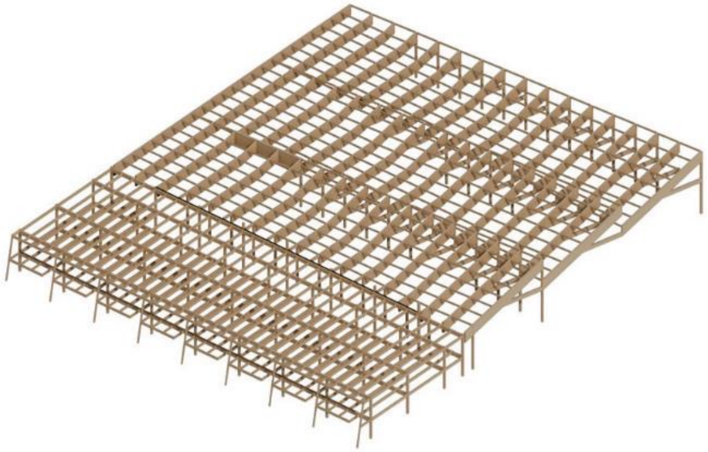
INNOVATION

Mass timber columns and beams together with CLT decking are used throughout the building to reduce embodied carbon. Since we are targeting CaGBC Net Zero Carbon certification, the design team performed an embodied carbon analysis, using a typical structural bay in the vehicle area of the project.

We compared the embodied carbon of the steel design from the SD stage to the current timber design, and found that, even while excluding the impact of sequestered carbon in the wood structure, there was a 34% savings in CO2e in a timber superstructure compared to a steel superstructure. When the effects of C02 sequestration in the wood are included, the reduction in CO2 is 233%.

While the overarching principles for the project result from an intense understanding of energy requirements, the building is fundamentally designed for the first responders that will use it as their second home. A calming environment and a sense of respite from hectic job demands is fostered by the integration of interior amenity zones with access to natural daylight and views of the rich four-season planting as well as adjacent canopy-protected exterior landscape spaces.

The building is organized to be socially and spatially equitable, and inherently inclusive for visitors, staff, and administrators alike. As with all aspects of the project, the environmental mandate was leveraged to meet multiple ambitions, in this case to create positive and architecturally uplifting spaces for people.



MASS TIMBER PRIMARY STRUCTURE AXONOMETRIC

Embodied Tonnes CO2e per typical bay in vehicle garage		***% Reduction vs steel***
Steel Structure	*31.8*	
CLT/Glulam Structure (assume no carbon storage in wood)	*21.1*	*34%*
CLT/Glulam Structure (assume full carbon storage in wood - sustainably managed forests etc)	*-423*	*233%*

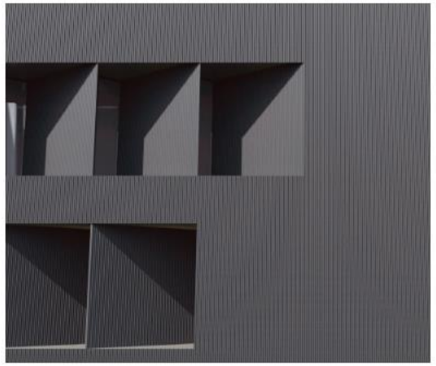
EMBODIED CARBON ANALYSIS

Atrium at ground floor looking east

Atrium at second floor looking east

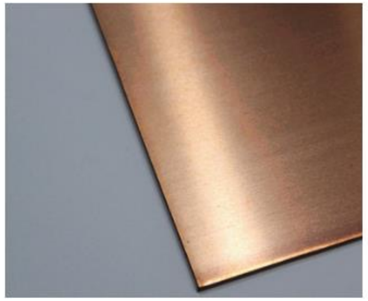
MAIN BUILDING ARCHITECTURE - MATERIALS & SPECIFICATIONS

EXTERIOR ENVELOPE



ARCHITECTURAL CORRUGATED CLADDING

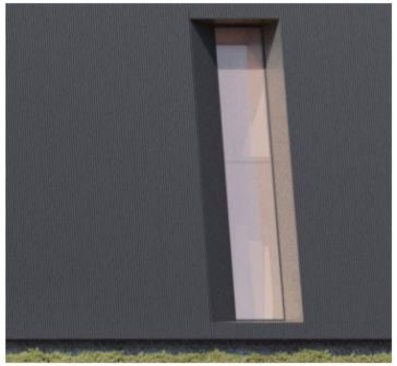
Application:
Majority of exterior envelope - note, southern facade cladding to be perforated per Solar-Wall requirements



COMPOSITE PANEL RAIN-SCREEN CLADDING

Application:
Soffits, areas between garage doors, inside faces of glazing shading fins

CURTAIN WALL GLAZING



CURTAIN WALL GLAZING W/ LIGHT/ HEAT REFLECTING FILM

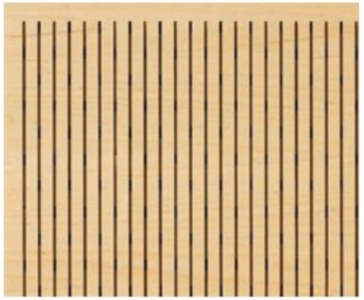
Application:
South facing curtain wall glazing

STRUCTURE

MASS TIMBER STRUCTURE

Application:
All primary structure including beams, columns, decks etc

INTERIOR FINISHES



WOOD ACOUSTIC PANELS

Application:
Select interior walls and ceilings in areas requiring acoustic treatment. Interior partitions otherwise typically painted drywall

Approaching Zero

approaching net zero

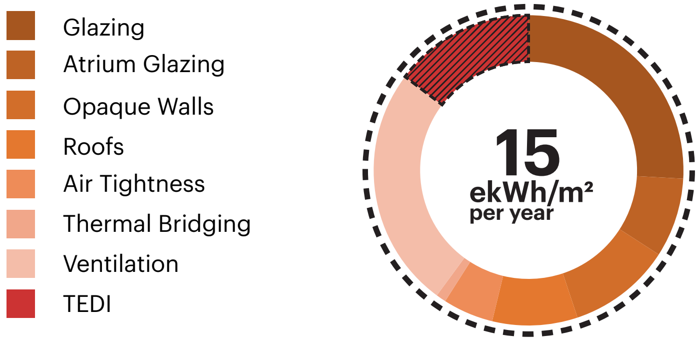
understand TEDI, GHGI, EUI

What is TEDI?

The annual heat loss from the building envelope and ventilation. This is the amount of heating energy delivered to the project, per unit of gross floor area. It's used to ensure resilient buildings and improve both occupant comfort and thermal energy performance. TEDI measurement is ekWh/m²/year.

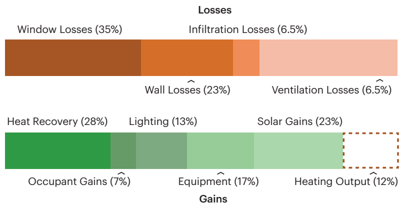
What is A Good TEDI Score?

A good TEDI is dependent on the climate zone that your building is in. As an example, a great target is from the Zero Carbon Framework in the figure to the right. Toronto Green Standard (TGS) has a list of minimum TEDI targets in accordance with building typology. There is more information on the city website. Passivehouse has even more aggressive TEDI targets to achieve.



So You Want a Low TEDI?

A One Page Document on Thermal Energy Demand Intensity



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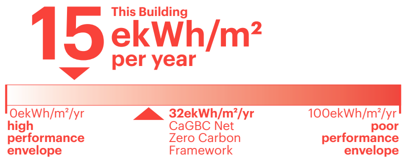

1ekWh is approximately equal to using a toaster for 40 minutes.

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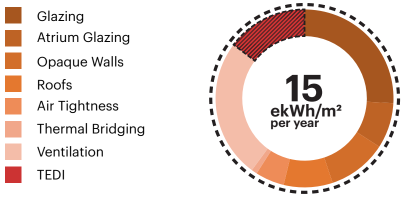


300 000ekWh/year*
*Estimated Value

How Can I Lower my TEDI Score?

Want the best TEDI? These are the six things that will help you lower your TEDI score:

1. Shape of Your Building
2. Reduce Your Glazing Percentage (<35%)
3. Implement Your Heat Recovery Strategy
4. Increase Envelope Performance
5. Eliminate Thermal Bridging
6. Increase Your Air Tightness

Why is TEDI Hot?

1. Reduces Energy Consumption
2. Increases Resilience
3. Improves User Comfort
4. Reduces Perimeter Heat

DSAI Targets* per Building Typology:

		TEDI (ekWh/m²/year)
Warehouse	Storage, Warehouse, Big-Box Re tail	5
MURB	Multi Unit Residential Building	15
Leisure	Sports, Recreation, Athletic	15
Retail	Commercial, Retail	18
Office	Office Buildings - any size	20
Institutional	Education, Library, Public Safety, Religious	18
Lodging	Hotel, Hospitality	21
Performing Arts	Theatres, Entertainment Venues	25
Medical	Clinic, Nursing, Assisted Living	30
Lab	Science, Research, Laboratory, Inpatient Medical	55

*Targets numbers are subject to change
*Targets numbers to be reviewed on each project
* The 'e' in ekWh is for equivalent. This gives us a simpler metric to use when understanding and referencing different fuel sources

diamond schmitt

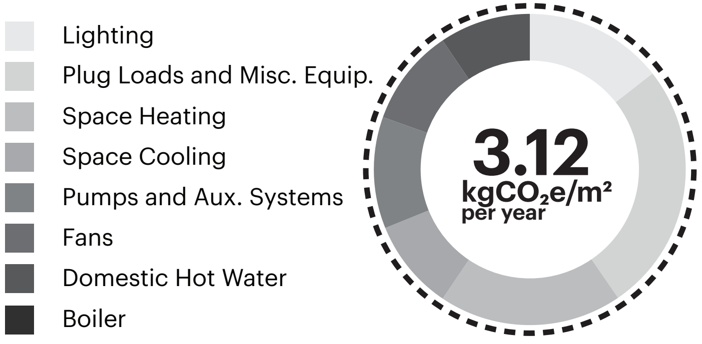
understand TEDI, GHGI, EUI

What is GHGI?

The total greenhouse gas emissions associated with all energy use on the building site on a per area basis. It is reported in grams of CO_2-equivalent per square meter per year ($kgCO_2e/m^2/year$) and includes emissions associated with area-based electricity generation.

What is A Good GHGI Target?

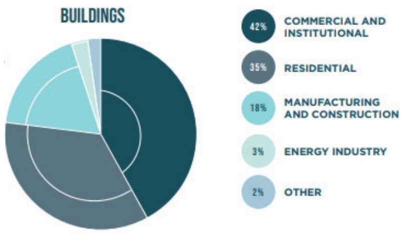
GHGI is dependent on the energy grid that your building is on. As an example, a building in Calgary would have a higher baseline GHGI than one in Montreal due to the heavy GHG intensity of the electricity grid.



62 328 $kgCO_2e$/year*

So You Want Low GHGI?

A One Page Document on Green House Gas Intensity



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Estimated Annual Green House Gas Emissions: **60 000 $kgCO_2e$**
1 Litre of Gasoline produces 2.3kg of CO_2e.

Green House Gas Intensity (GHGi) is expressed in $kgCO_2e$ or kilograms of carbon dioxide equivalent. It is the amount of carbon dioxide released from the building during operation.

What is A Good GHGI Target?

GHGI is dependent on the energy grid that your building is on. As an example, a building in Calgary would have a higher baseline GHGI than one in Montreal due to the heavy GHG intensity of the electricity grid.

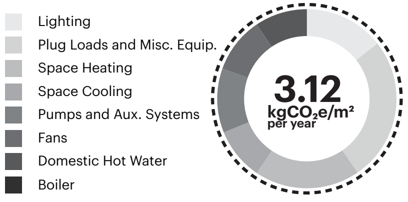
How Can I Lower my Building's GHGI?

Want the best GHGI? These are the top four things that will help you lower your GHGI:

1. Add Renewable Energy Production On Site
2. Increase Your Envelope's Thermal Performance
3. Increase Your Air Tightness
4. Include Heat Recovery (ERV's)

Why is GHGI so intense?

Because it establishes a global standard that enables comparison, benchmarking and accountability. Real GHG emission targets help owners make better decisions about the actions they are taking to reduce emissions and enable the tracking of emissions over time.



62 328 $kgCO_2e$/year*
*Estimated Value

DSAI Targets* per Building Typology:		GHGI ($kgCO_2e/m^2/year$)
Warehouse	Storage, Warehouse, Big-Box Re tail	1.0
MURB	Multi Unit Residential Building	3.0
Leisure	Sports, Recreation, Athletic	3.0
Retail	Commercial, Retail	3.0
Office	Office Buildings - any size	3.0
Institutional	Education, Library, Public Safety, Religious	4.0
Lodging	Hotel, Hospitality	4.0
Performing Arts	Theatres, Entertainment Venues	5.0
Medical	Clinic, Nursing, Assisted Living	6.0
Lab	Science, Research, Laboratory, Inpatient Medical	12.0

*Targets numbers are subject to change
*Targets numbers to be reviewed on each project

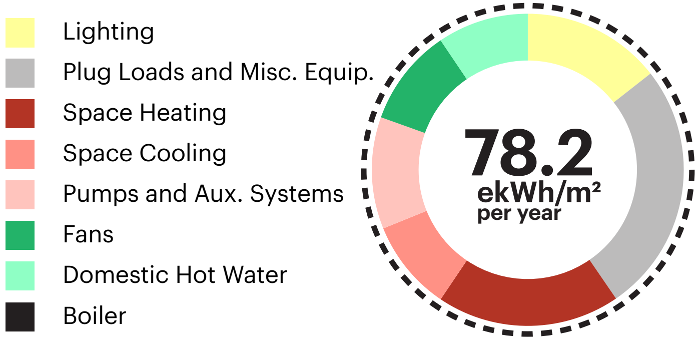
diamond schmitt

understand TEDI, GHGI, EUI

What is EUI?

The Energy Use Intensity (EUI) is an annual measure of the total energy consumed in a building over a year. This includes the energy used by the building's mechanical system and plug loads (appliances, electronics, and lighting). EUI is calculated by dividing the total energy consumed by the building in one year (kWh) by the floor area of the building.

Total energy use per year ÷ Floor area = EUI
9,000ekWh per year ÷ 200m² = 45ekWh/m²/year

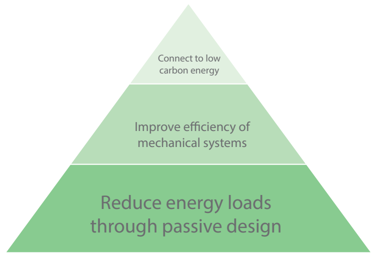


1 564 000ekWh/year*

*Estimated Value

So You Want a Low EUI?

A One Page Document on Energy Use Intensity



*The City of Toronto Zero Emissions Buildings Framework

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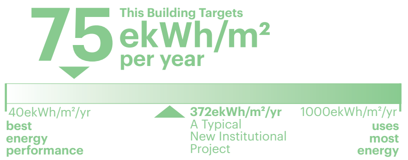
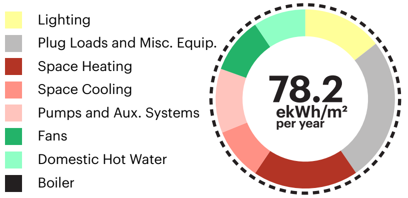


Estimated Total Annual Energy Use: **1 500 000ekWh**
1ekWh is approximately equal to watching 7 hours of television.

Energy Use Intensity (EUI) is defined as the measurement of a building's annual energy consumption relative to its gross area.

What is A Good EUI Score?

In addition to DSA targets, Toronto Green Standard (TGS) has a list of minimum EUI targets in accordance with building typology. There is more information on the city website.



1 564 000ekWh/year*

*Estimated Value

How Can I Lower my EUI Score?

The follow items will help to lower your EUI score:

1. Lower your TEDI (see TEDI one pager)
2. High performance MEP Systems
3. Increase glazing performance
4. Daylight Autonomy
5. Reduce Plug loads

Why is EUI so important?

Setting EUI targets for new buildings is fundamental to meeting our climate change targets. By offering a full picture of a building's energy use, a total energy demand target can encourage more efficient choices in the selection of all energy-related building components, including domestic hot water heating, space conditioning, building envelope strategies and appliances.

DSAI Targets* per Building Typology:		EUI (ekWh/m²/year)
Warehouse	Storage, Warehouse, Big-Box Re tail	10
MURB	Multi Unit Residential Building	65
Leisure	Sports, Recreation, Athletic	70
Retail	Commercial, Retail	70
Office	Office Buildings - any size	75
Institutional	Education, Library, Public Safety, Religious	80
Lodging	Hotel, Hospitality	90
Performing Arts	Theatres, Entertainment Venues	100
Medical	Clinic, Nursing, Assisted Living	125
Lab	Science, Research, Laboratory, Inpatient Medical	215

*Targets numbers are subject to change
*Targets numbers to be reviewed on each project
*The 'e' in ekWh is for equivalent. This gives us a simpler metric to use when understanding and referencing different fuel sources

diamond schmitt

obtain an energy use characterization for your building type

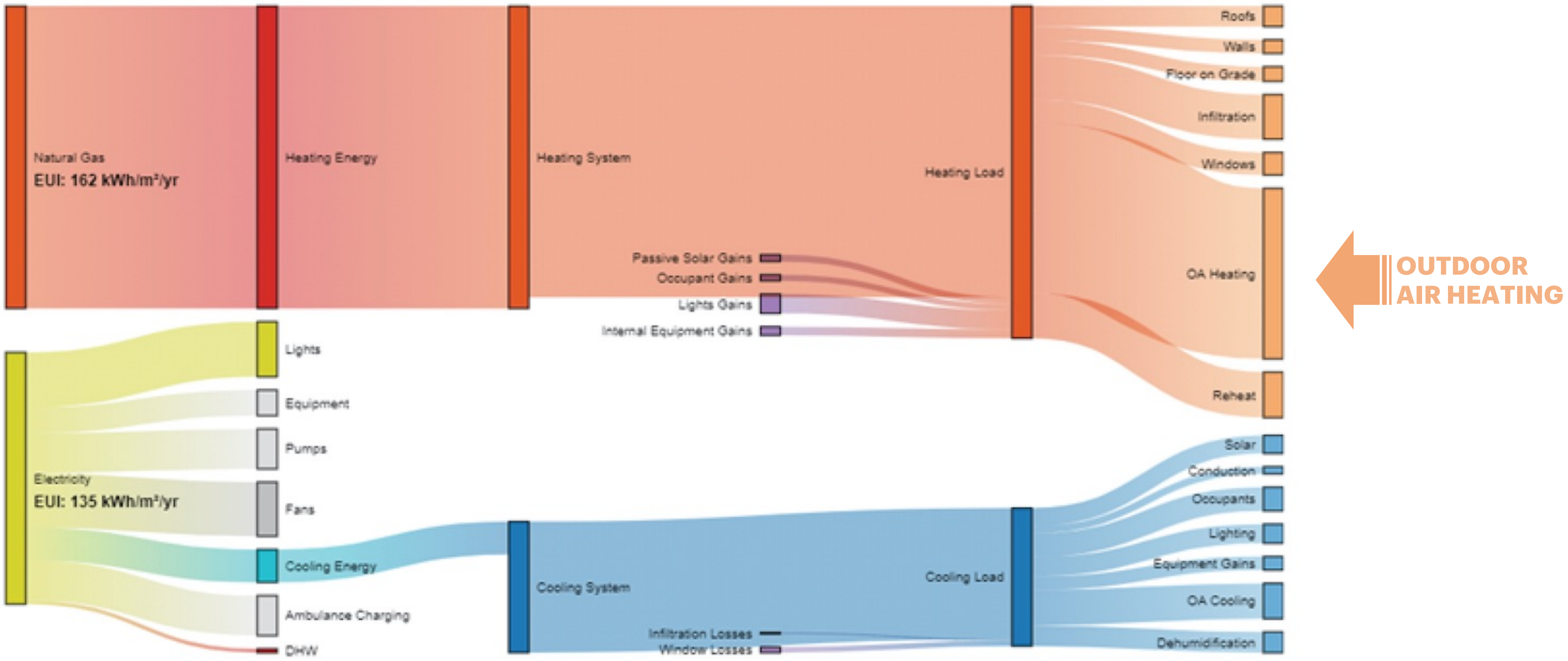


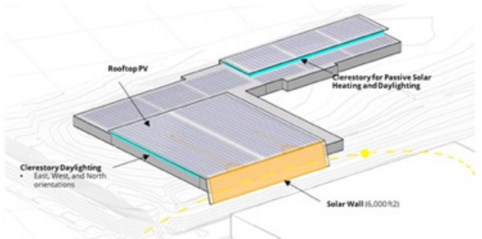
Figure 13 Building energy use characterization, for SB-10 benchmark design.

investigate massing and planning in response to energy use characterization

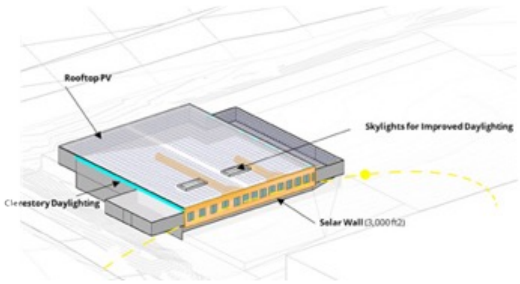
innovate in response to energy use characterization:

DESIGN A SYSTEM TO PRE-HEAT MAKE-UP AIR

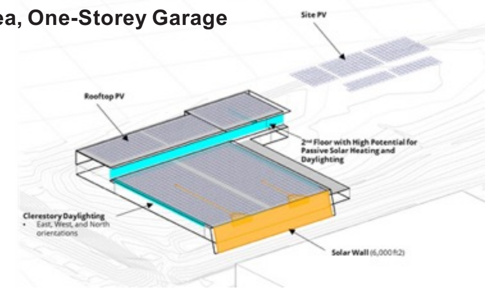
One-Storey Massing



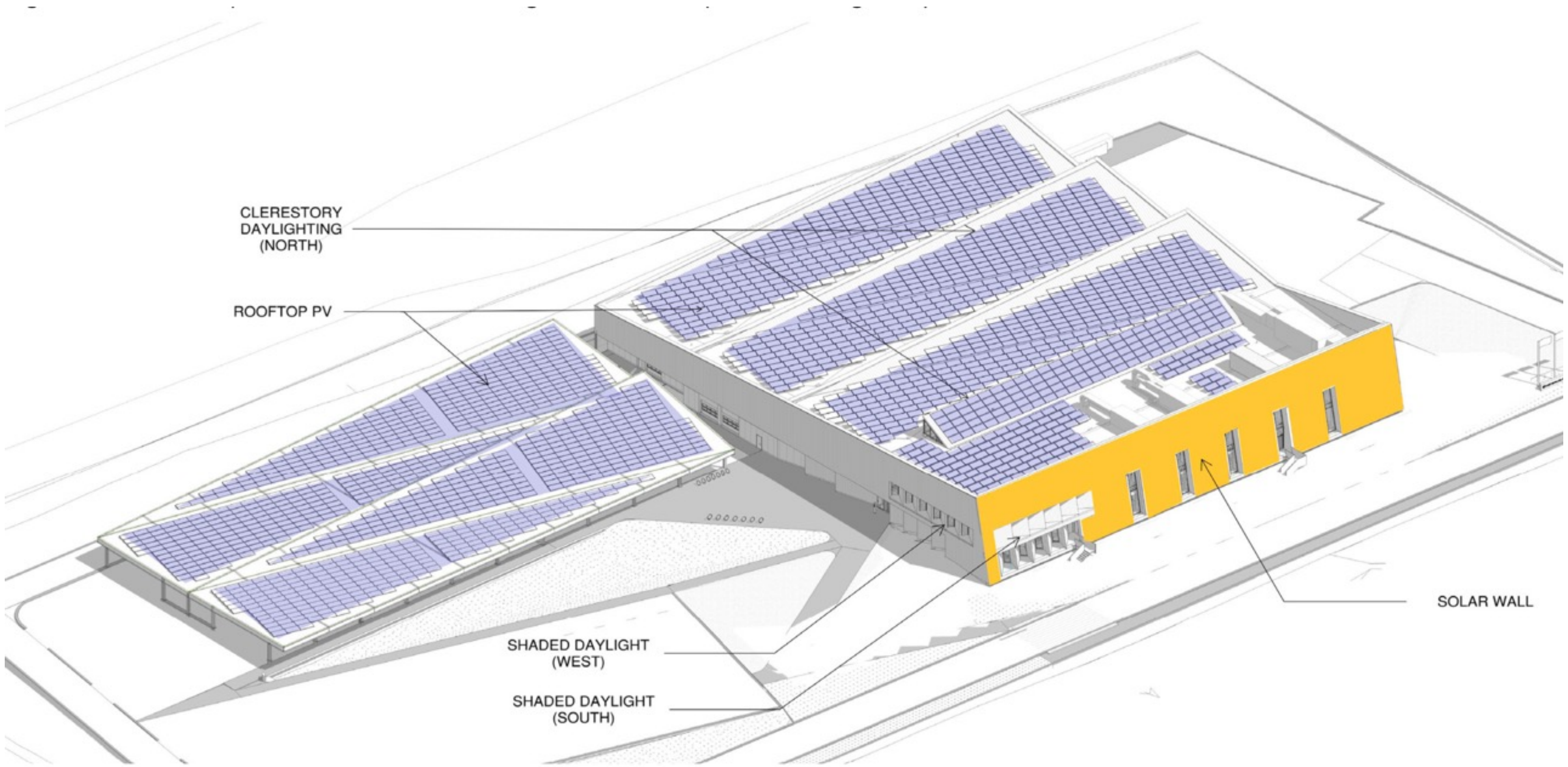
Two-Storey Massing



Hybrid Option 1
Two-Storey Staff Area, One-Storey Garage



Hybrid Option 2
Two-Storey Staff Area, One-Storey Garage

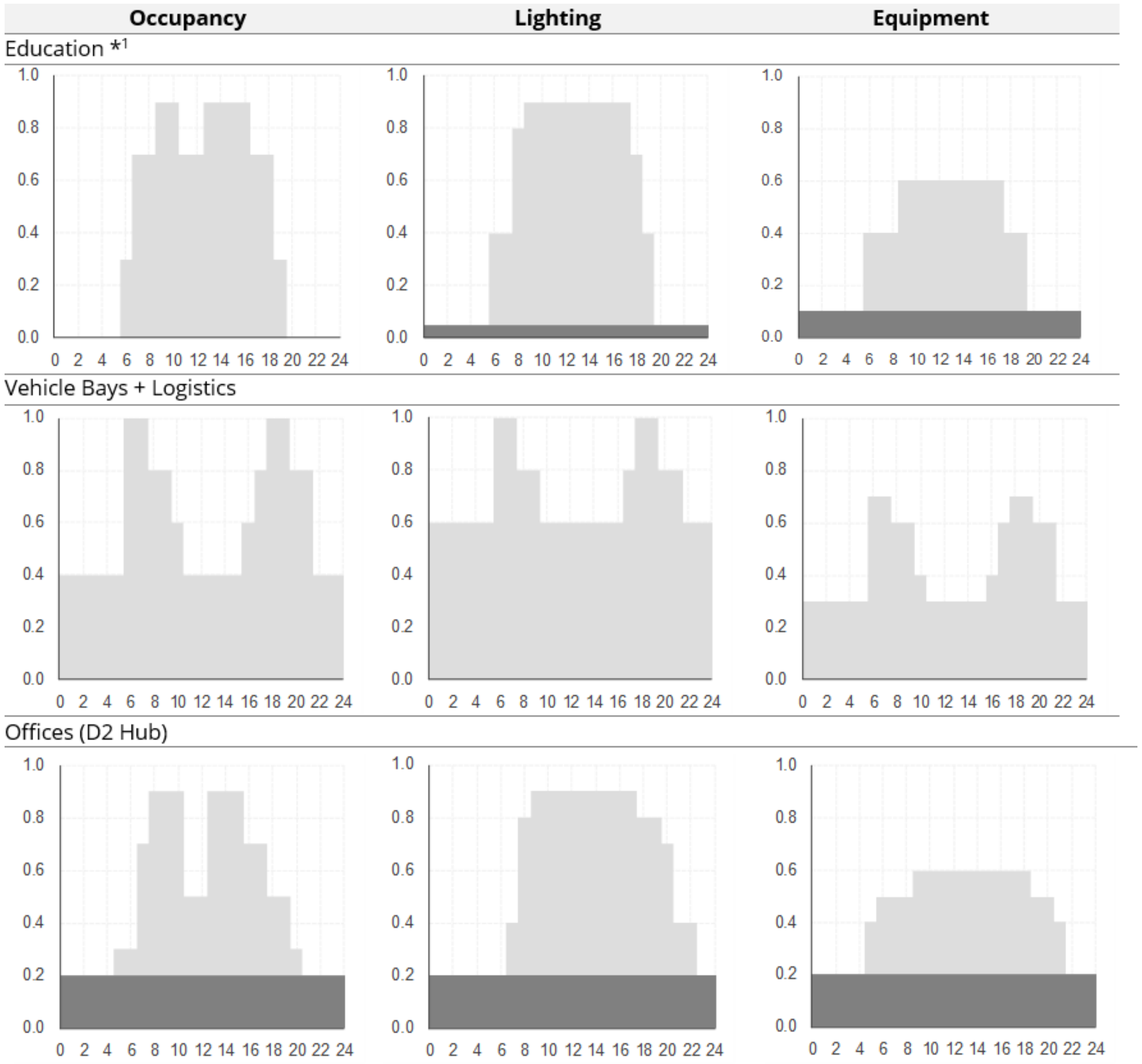


investigate planning and massing in response to energy use characterization

Innovate in response to energy use characterization:

ADD VEHICLE VESTIBULES

develop operating schedules for your client type, user groups and building type



*[1] Classroom spaces occupied seasonally from March to June and September to December

use passive-house level insulation for walls, windows, floors, roofs

Learn the difference between nominal and effective R-Values: effective can be 50% of nominal, depending on your building type, wall types

GENERAL PARAMETERS

Location	Toronto, ON; Canada
Building Type	Medical Facility | Gym | Classrooms | Garage
Conditioned Area	Approximately 83,000 ft^2
Modelling Software	eQuest v3.65 | DOE 2.3

ENVELOPE PARAMETERS

	Baseline Design	Tier 2 / Proposed Design
Exterior Walls	Assembly U: 0.050 Btu/h- ft^2-°F	Assembly U: 0.025 Btu/h- ft^2-°F [R-40]
Roof Construction	Assembly U: 0.029 Btu/h- ft^2-°F	Assembly U:0.020 Btu/h- ft^2-°F [R-50]
Windows	Assembly U:0.35 Btu/h- ft^2-°F; SHGC: 0.40	Assembly U:0.20 Btu/h- ft^2-°F; SHGC: 0.30
Window to Wall Ratio	Same as Proposed Design	Hub, Office, Fitness, Atrium: 45% | Locker Rooms: 15% | Classrooms, Labs: 25%
Infiltration Rates	0.04 cfm/ ft^2-façade area *1	0.02 cfm/ ft^2-façade area *1

*1 Infiltration rate of 3 ACH in the vehicle bays for when the doors are open

SPACE LOAD PARAMETERS

Space Type	Baseline Lighting	Proposed Lighting*3	Equipment	Occupants	Outside Air
Classroom	0.96 W/ft^2	0.67 W/ft^2	1.00 W/ ft^2	20 ft^2/pp	7.5 cfm/pp + 0.06 cfm/ft^2
Offices	0.81 W/ft^2	0.57 W/ft^2	1.00 W/ ft^2	100 ft^2/pp	5 cfm/pp + 0.06 cfm/ft^2
Meeting	1.07 W/ft^2	0.75 W/ft^2	1.00 W/ft^2	20 ft^2/pp	5 cfm/pp + 0.06 cfm/ft^2
Lab	1.20 W/ft^2	0.84 W/ft^2	1.50 W/ft^2	20 ft^2/pp	7.5 cfm/pp + 0.06 cfm/ft^2
Fitness	0.50 W/ft^2	0.35 W/ft^2	1.00 W/ft^2	150 ft^2/pp	20 cfm/pp + 0.06 cfm/ft^2
Circulation	0.66 W/ft^2	0.46 W/ft^2	0.20 W/ft^2	-	0.06 cfm/ft^2
Vehicle Bays	0.41 W/ft^2	0.29 W/ft^2	Ambulance charging *2	8-10 p	0.75 cfm/ft^2 *1
Wash Bays	0.56 W/ft^2	0.39 W/ft^2			0.75 cfm/ft^2 *1
Lockers	0.48 W/ft^2	0.34 W/ft^2	1.00 W/ft^2	150 ft^2/pp	0.50 cfm/ft^2
Lounge	0.62 W/ft^2	0.43 W/ft^2	0.50 W/ft^2	20 ft^2/pp	5 cfm/pp + 0.06 cfm/ft^2
Storage / Comm	0.63 W/ft^2	0.44 W/ft^2	0.20 W/ft^2	-	0.12 cfm/ft^2
Stairs	0.58 W/ft^2	0.41 W/ft^2	-	-	0.06 cfm/ft^2
Elec/Mech	0.43 W/ft^2	0.43 W/ft^2	-	-	0.06 cfm/ft^2
Restrooms	0.85 W/ft^2	0.59 W/ft^2	-	-	50 cfm/fixture

*1 Ventilation setback to 0.4 cfm/ft^2 based on CO sensors
*2 Assumed 9-21 ambulances simultaneously charging at an average charge rate of 5 Amp/vehicle
*3 Proposed lighting assumed to be at least 30% lower than the baseline.

	nominal	effective
Walls	R-40	R-20/30
Windows	R-8	R-5
Roofs	R-50	R-40
Slabs on grade	R-20	R-15
Window to Wall Ratio	15-25%	

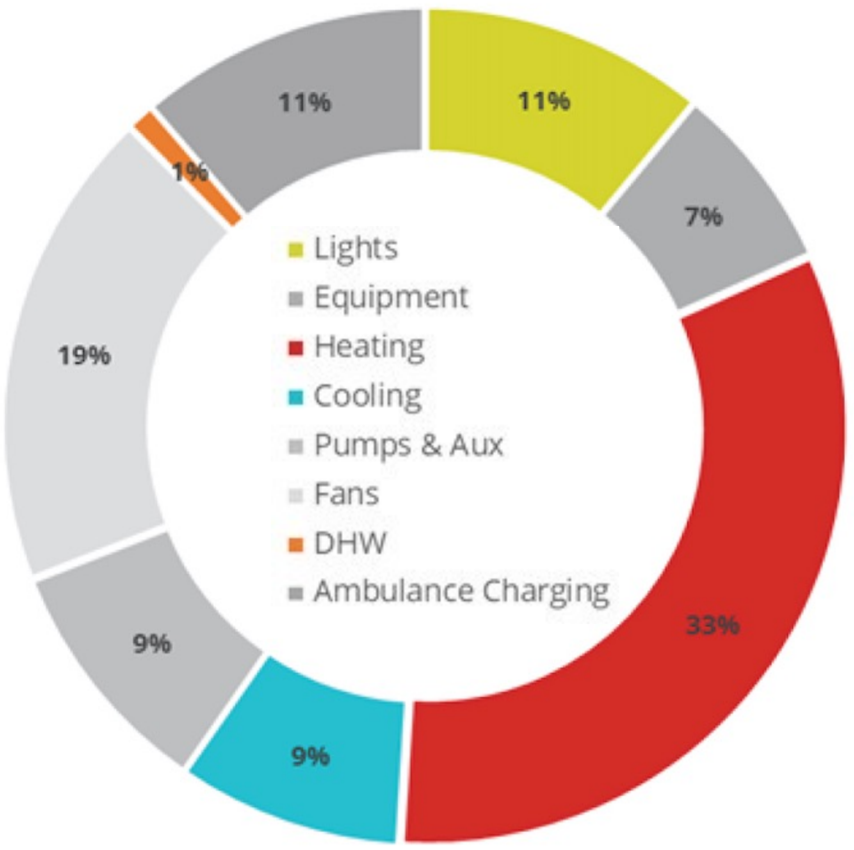
understand the major systems and their contribution to the final option

Learn the difference between nominal and effective r-values: effective can be 50% of nominal depending on your building type, wall types

	SB-10 Baseline	ENV	TIER 2	ASHP	GSHP	HRV
High Performance Env		X	X	X	X	X
Reduced Lighting			X	X	X	X
Vehicle Bay Vestibule		X	X	X	X	X
Decoupled Systems w/ 70% Effective HRV			X	X	X	
Air Source Heat Pumps + Backup Boiler				X		
Ground Source Heat Pumps + Backup Boiler					X	X
Decoupled Systems w/ 80% Effective HRV						X

model the baseline building with options to achieve NZE

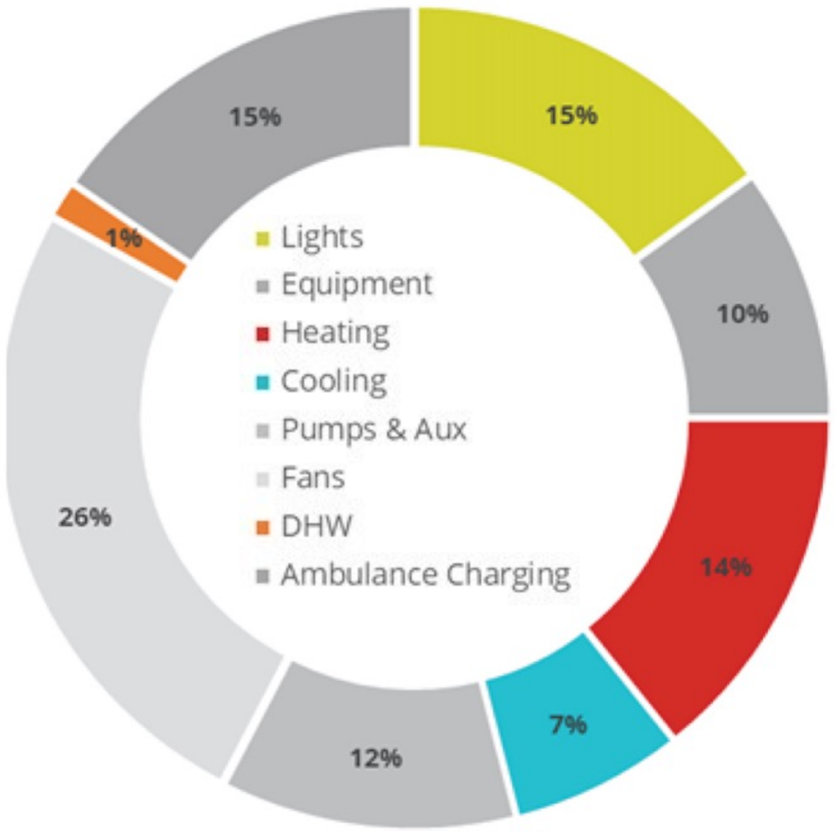
Energy end use breakdown for baseline building



before

Energy end use breakdown for NZE building

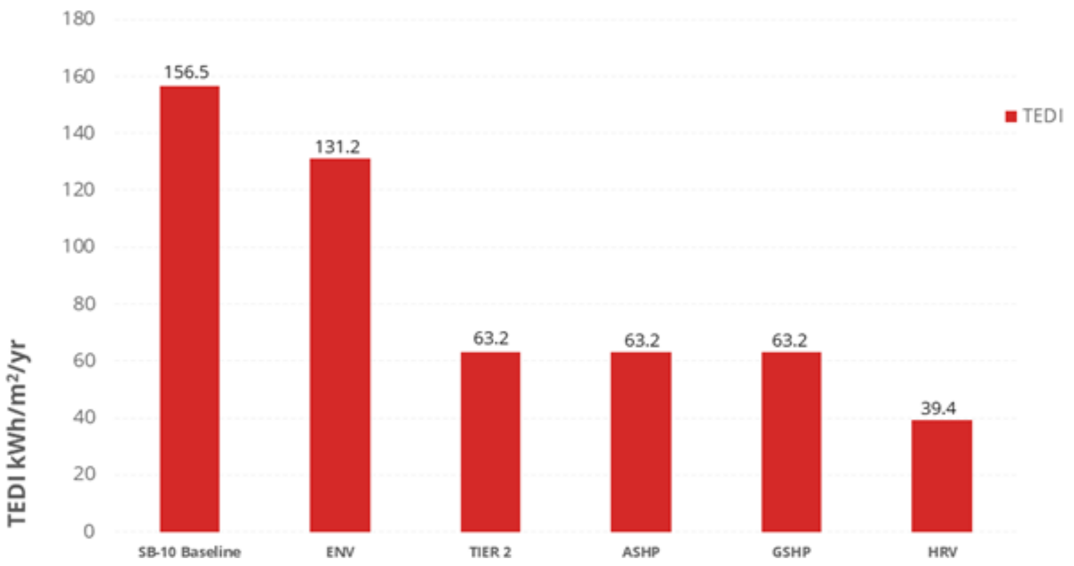
Look for opportunities to reduce energy at each iteration of the energy model

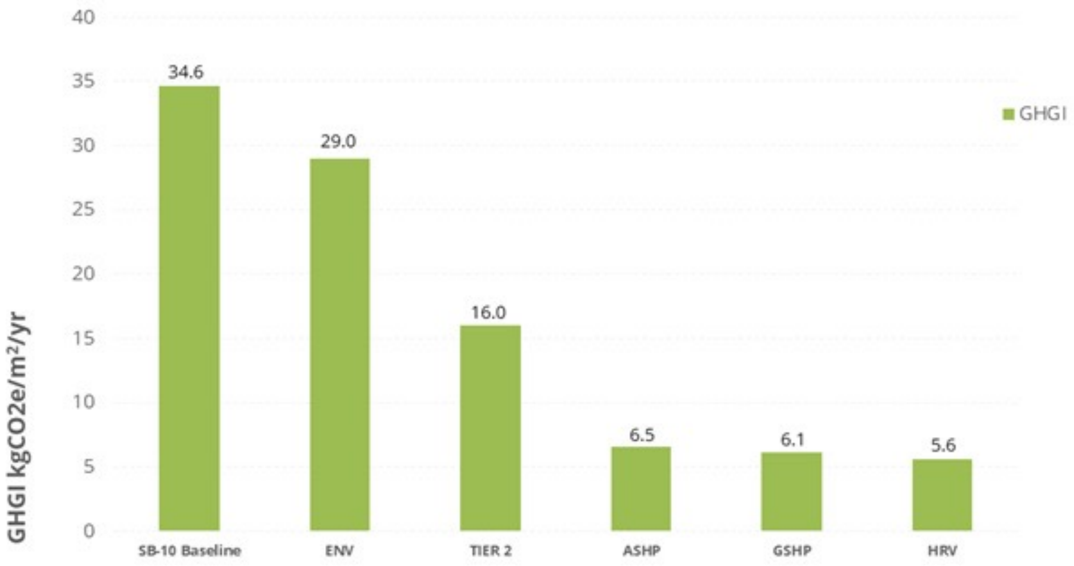


after

compare TEDI & GHGI for different design options

Understand the reasons for the differences, and stay focused on the targets





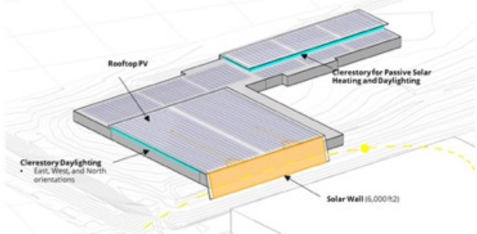
develop a PV analysis

Month	Solar Radiation (kWh / m2 / day)	PV Generation (kWh)	Building Consumption (kWh)
Jan	2.75	59,248	116,836
Feb	3.97	75,562	104,678
Mar	4.70	96,684	101,230
Apr	5.30	102,997	87,829
May	6.03	118,014	84,781
Jun	6.20	116,351	78,425
Jul	6.39	120,623	77,163
Aug	6.12	115,565	75,534
Sep	5.38	100,585	75,840
Oct	3.73	74,133	82,670
Nov	2.61	52,950	83,613
Dec	2.31	49,116	108,474
Annual	**4.62**	**1,081,828**	**1,077,073**

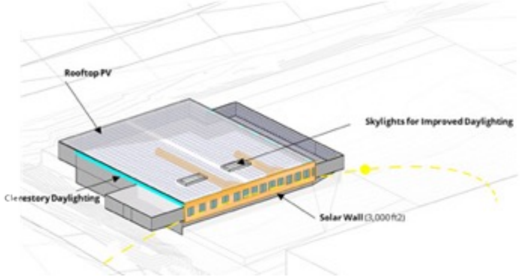
investigate PV options in response to energy use energy use intensity (EUI)

Integrate required PV area with building design

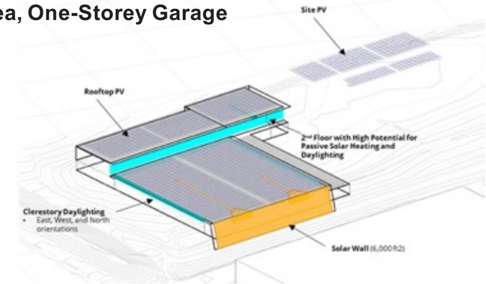
One-Storey Massing



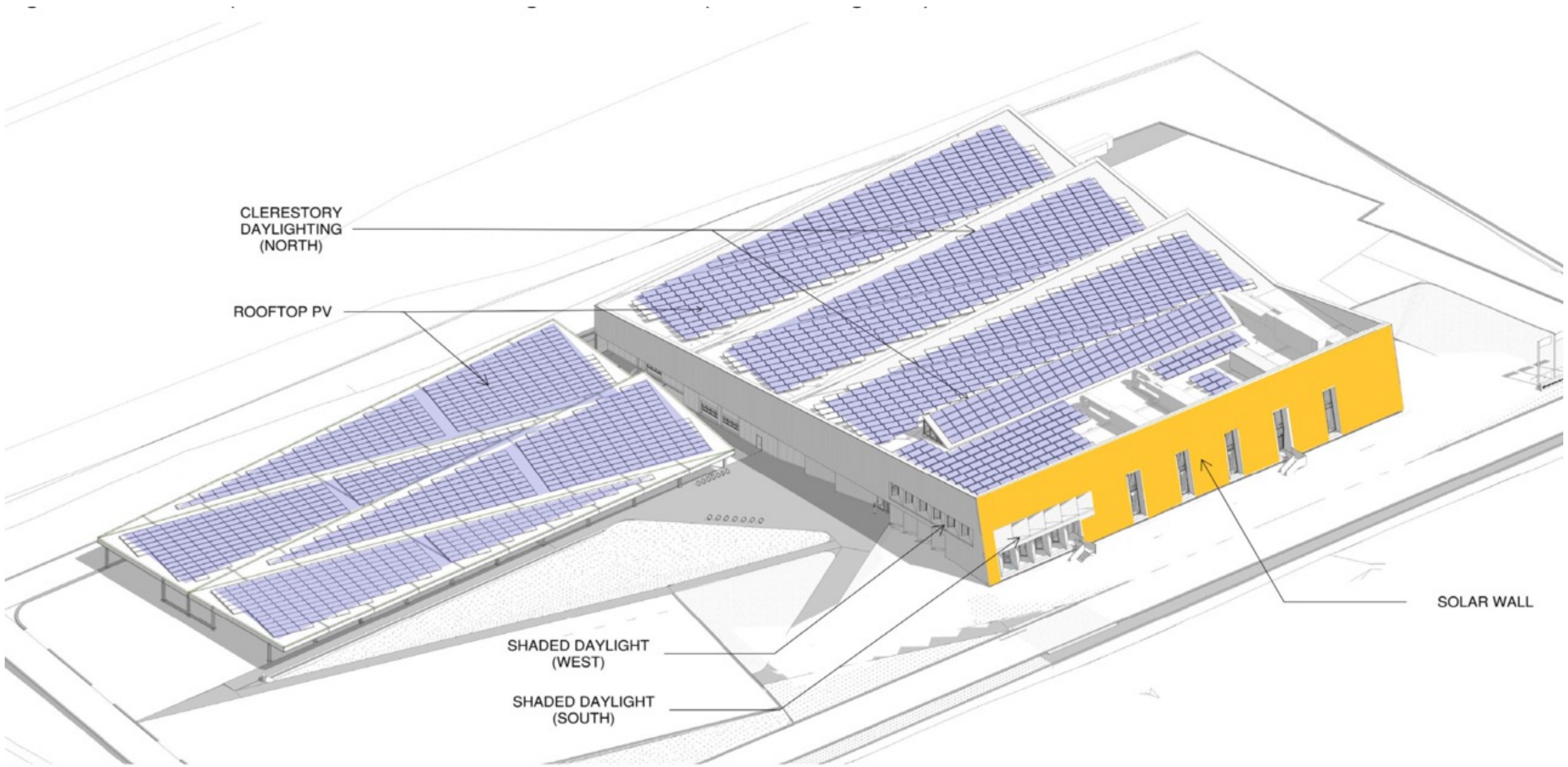
Two-Storey Massing



Hybrid Option 1
Two-Storey Staff Area, One-Storey Garage



Hybrid Option 2
Two-Storey Staff Area, One-Storey Garage



Investigate PV options in response to energy use energy use intensity (EUI)
Integrate required PV area with building design

Rule of thumb:

To achieve net zero with a baseline of EUI 75,
area of photovoltaic panels is 50% of GFA

Therefore:

For one storey building at EUI 75, PV is 50% of roof area
For two storey building at EUI 75, PV is 100% of roof area

Rule of thumb test:

EMS is EUI 139 (or about double 75)
So, PV should require the entire roof area if it was a one storey building

Allowing deductions for the significant roof top equipment on the south (50%)
And the fact that EMS is 75% one storey, 25% two storey

Based on the rule of thumb we will need additional PVs in the parking area
In our case, we need roof area approximately 50% than the building footprint

incorporate low temperature heating systems and reduced fan power supply air systems

USE HYDRONIC FLOORS AND DISPLACEMENT VENTILATION

incorporate low temperature heating systems and reduced fan power supply air systems
USE HYDRONIC FLOORS AND DISPLACEMENT VENTILATION

Radiant heating/cooling

To provide heating/cooling for the spaces, we are proposing a radiant flooring system. Radiant flooring will provide heating at the atrium ground level to condition only the occupied space rather than the full volume of the space. Additionally, water has approximately 3,500 times the heat capacity of air, so distributing hot water to the space is substantially more energy efficient than pushing conditioned air.

The major way in which our bodies reject heat is through radiation. This heat transfer is vastly improved when the surfaces we interact with (mainly floors and ceilings) are conditioned. Hydronic radiant relies on radiative heat transfer to a surface through water as the heating medium. Humans perceive thermal comfort based on air temperature, air movement, relative humidity, and radiant temperature of their surroundings. By controlling the mean radiant temperature of a space via radiant, the radiant slab achieves much higher levels of comfort than an all air system.

Radiant flooring entails PEX tubing buried within a concrete slab. Hot water or chilled water based on the space demand is then pumped through the tubing to heat/cool the floor. The concrete floor then acts as a thermal mass maintaining space temperature much more consistently than an air-based system. Radiant manifolds control the flow of water to the tubing. Coordination of radiant manifolds for each radiant zone will need to occur during design development. Typically, radiant manifolds are in cabinets in minimum 6" walls interior walls (typical size 24" tall by 42" wide).

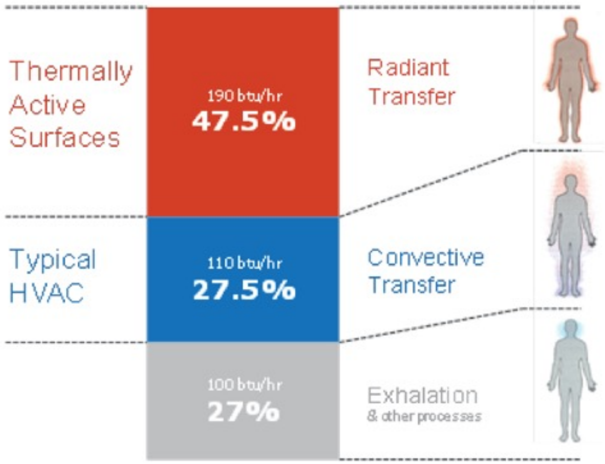


Figure 29 Heat transfer between people and spaces.

Figure 30 Radiant floor PEX tubing connection to radiant manifold.

incorporate low temperature heating systems and reduced fan power supply air systems

USE HYDRONIC FLOORS AND DISPLACEMENT VENTILATION

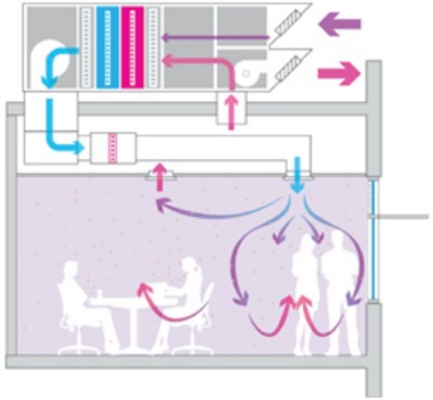


Figure 31 Traditional ventilation system.

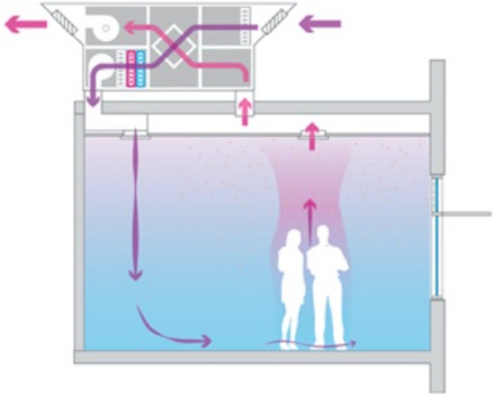


Figure 32 Displacement ventilation.

Overhead displacement ventilation

Areas such as conference room and classrooms can be equipped with traditional looking overhead displacement ventilation as shown in the image below. Fitness rooms and garage bay where the concern of heavy equipment bumping in the ducts can also be alleviated by employing overhead displacement ventilation system.

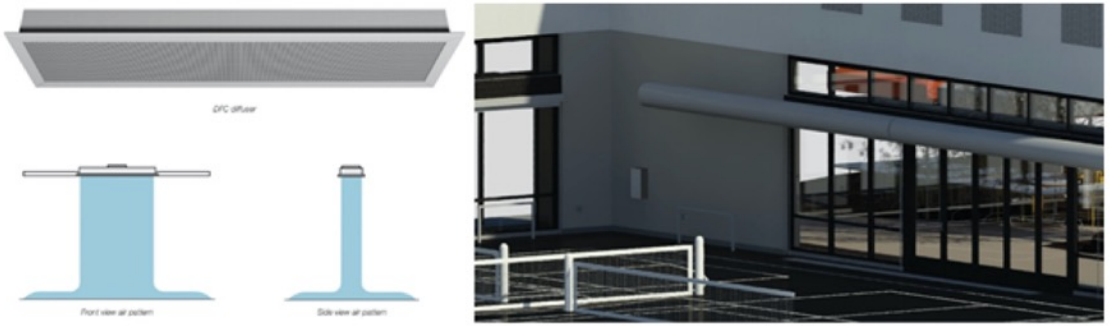


Figure 33 DFC Diffuser and air pattern showing overhead displacement ventilation.

Side Wall Displacement Ventilation

With displacement ventilation, there is an option of supplying the air with the side wall mounted diffusers as well. This can be a great fit for either in wall at the classrooms or even at the side of the garage bay.

Figure 34 Side wall mounted displacement ventilation.

Develop a net present value analysis of 4 options

SB-10 Compliant		
Item	**Description**	**Cost**
PV Panels	Not included	-
PV Sitework	Not included	-
PV Additional Canopy Rough-In	Not included	-
EV Charging	Not included	-
Green Roof	2,332sm (50% of available roof)	$1,515,800
Electrical System	To support conventional mechanical	$3,584,400
Mechanical System	Condensing boiler w/ DHW storage tanks	$5,625,100
Emergency Power System	Diesel generator w/ mobile gen. hook-up	$1,321,800
System Cost		**$12,047,100**
Subtotal (Building + Site + System)		**$51,390,000**
Construction Contingency (5% Allowance)		**$2,569,500**
Escalation Allowance (8.8% to Q1 2023)		**$4,522,320**
GRAND TOTAL		**$58,481,820**

TGS V3 Tier 2 Compliant		
Item	**Description**	**Cost**
PV Panels	45kW system (5% building energy offset)	$144,000
PV Sitework	Not included	-
PV Additional Canopy Rough-In	Not included	-
EV Charging	25% of parking stalls (48)	$384,000
Green Roof	2,163sm (50% of available roof)	$1,405,950
Electrical System	To support conventional mech.	$3,584,400
Mechanical System	Condensing boiler w/ DHW storage tanks	$5,625,100
Emergency Power System	Diesel generator w/ mobile gen. hook-up	$1,321,800
System Cost		**$12,465,250**
Subtotal (Building + Site + System)		**$51,808,150**
Construction Contingency (5% Allowance)		**$2,590,408**
Escalation Allowance (8.8% to Q1 2023)		**$4,559,117**
GRAND TOTAL		**$58,957,675**

Net-Zero Energy and Emissions: ASHP		
Item	**Description**	**Cost**
PV Panels	1125kW system	$3,599,000
PV Sitework	PV parking canopy structure	$936,997
PV Additional Canopy Rough-In	Two (2) further parking canopies	$10,000
EV Charging	25% of parking stalls (48)	$384,000
Green Roof	Not included.	-
Electrical System	With changes to support ASHP	$3,573,300
Mechanical System	ASHP	$5,126,700
Emergency Power System	Tesla Powerpack w/ mobile gen. hook-up	$1,301,000
System Cost		**$14,930,997**
Subtotal (Building + Site + System)		**$54,273,897**
Construction Contingency (5% Allowance)		**$2,713,695**
Escalation Allowance (8.8% to Q1 2023)		**$4,776,103**
GRAND TOTAL		**$61,763,695**

Net-Zero Energy and Emissions: GSHP		
Item	**Description**	**Cost**
PV Panels	960kW system	$3,071,300
PV Sitework	PV parking canopy structure	$464,640
PV Additional Canopy Rough-In	Four (4) further parking canopies	$20,000
EV Charging	25% of parking stalls (48)	$384,000
Green Roof	Not included.	-
Electrical System	With changes to support GSHP	$3,636,500
Mechanical System	GSHP	$6,292,100
Emergency Power System	Tesla Powerpack w/ mobile gen. hook-up	$1,301,000
System Cost		**$15,169,540**
Subtotal (Building + Site + System)		**$54,512,440**
Construction Contingency (5% Allowance)		**$2,725,622**
Escalation Allowance (8.8% to Q1 2023)		**$4,797,095**
GRAND TOTAL		**$62,035,157**

Develop a net present value analysis of 4 options

select the preferred option

20 Year Payback Period Assessment

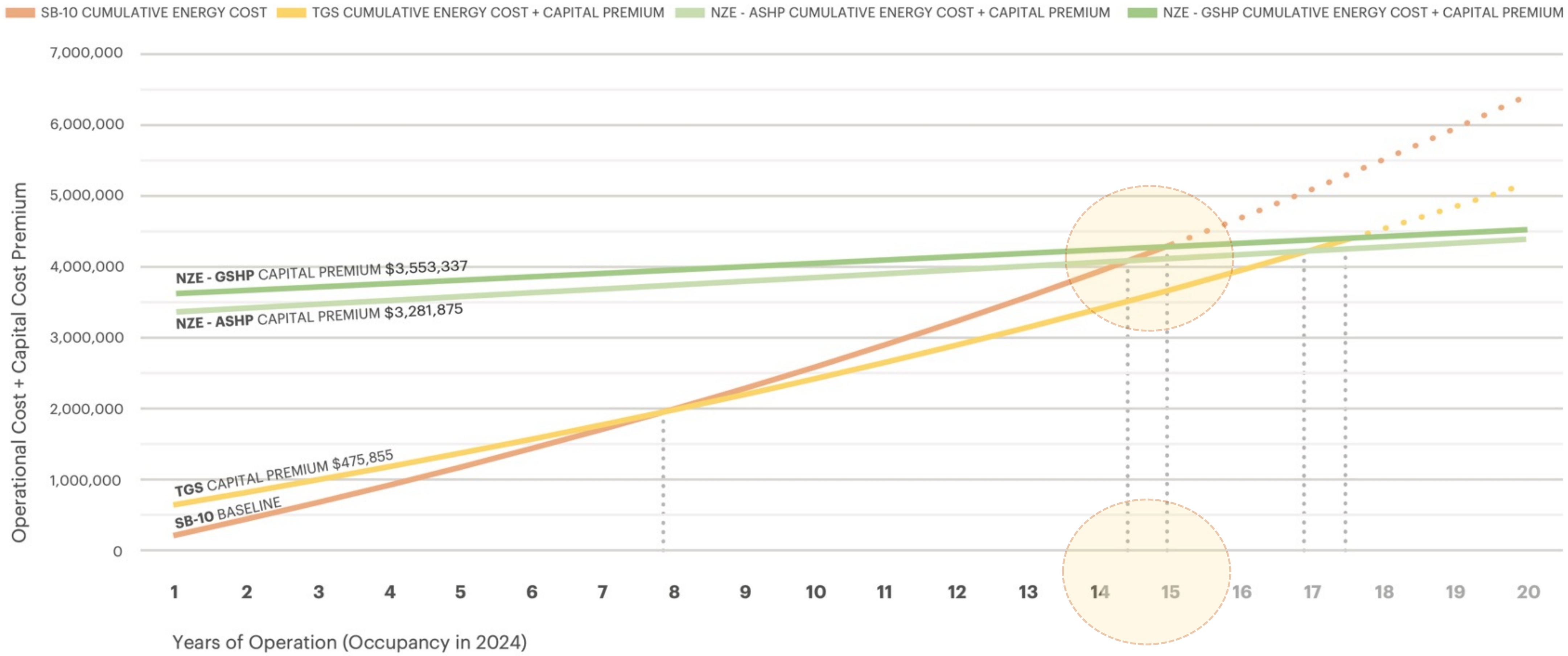
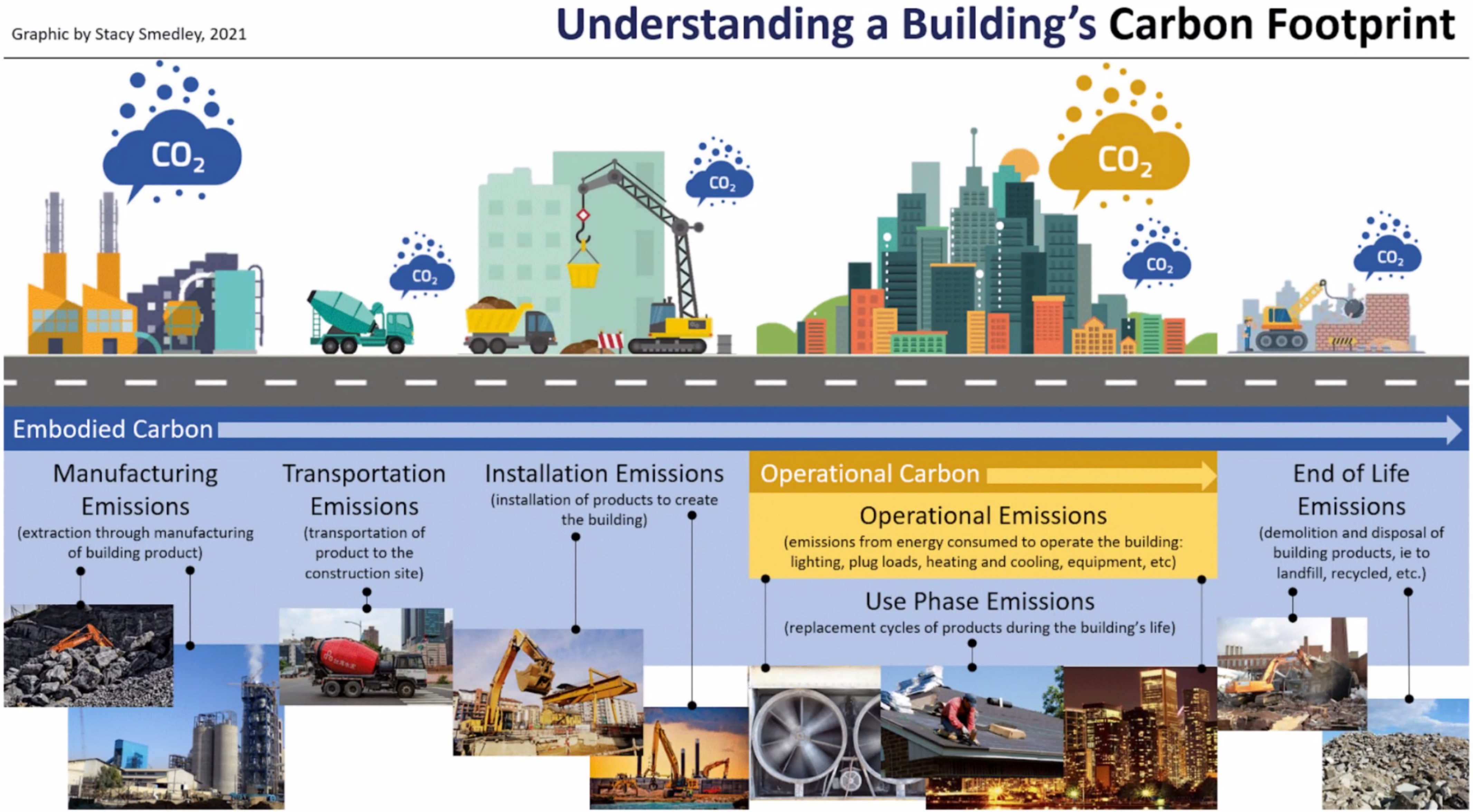
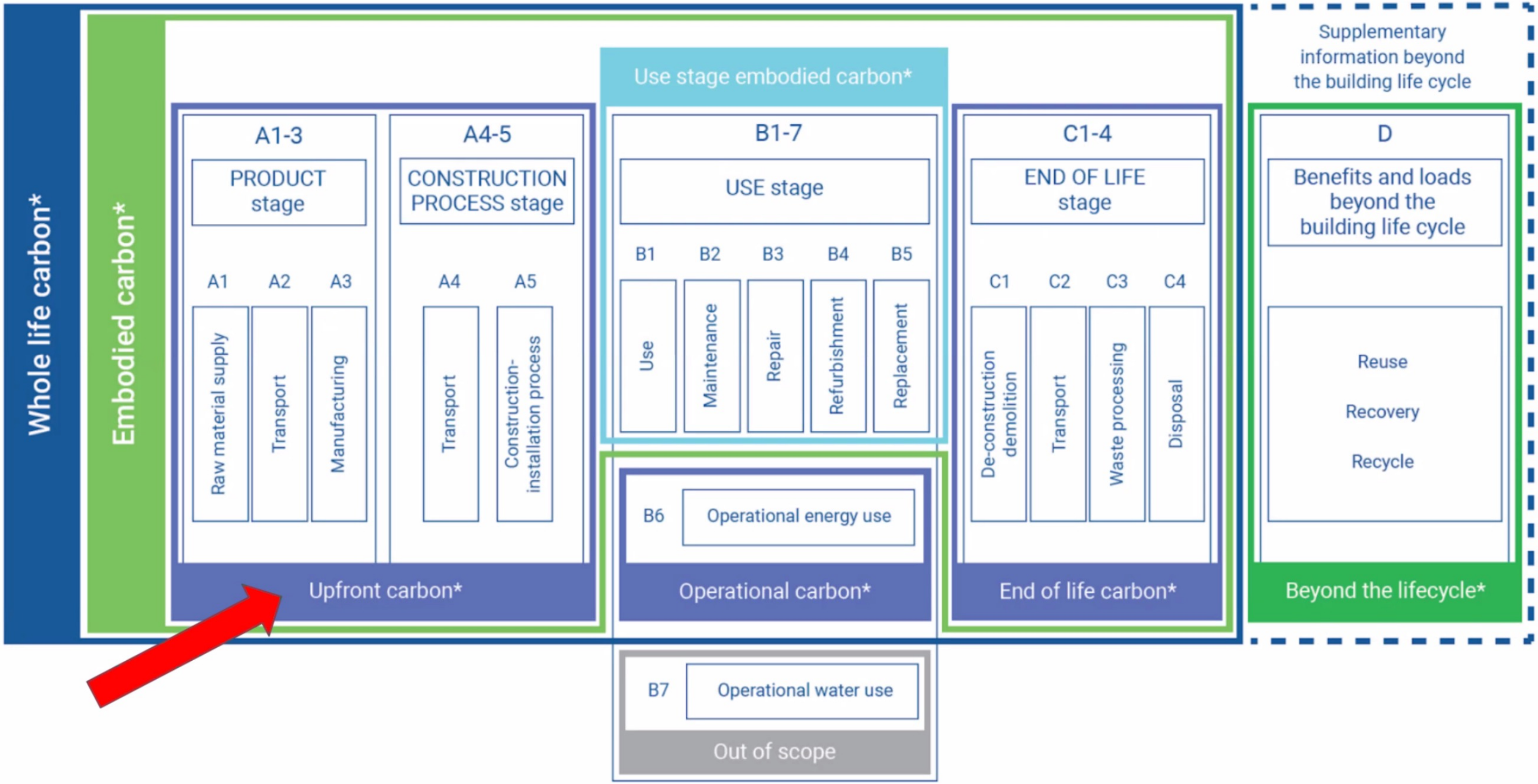


Figure 1 Plotting the cumulative utility cost + capital premium identifies the payback period for each design case.

Embodied Carbon 101

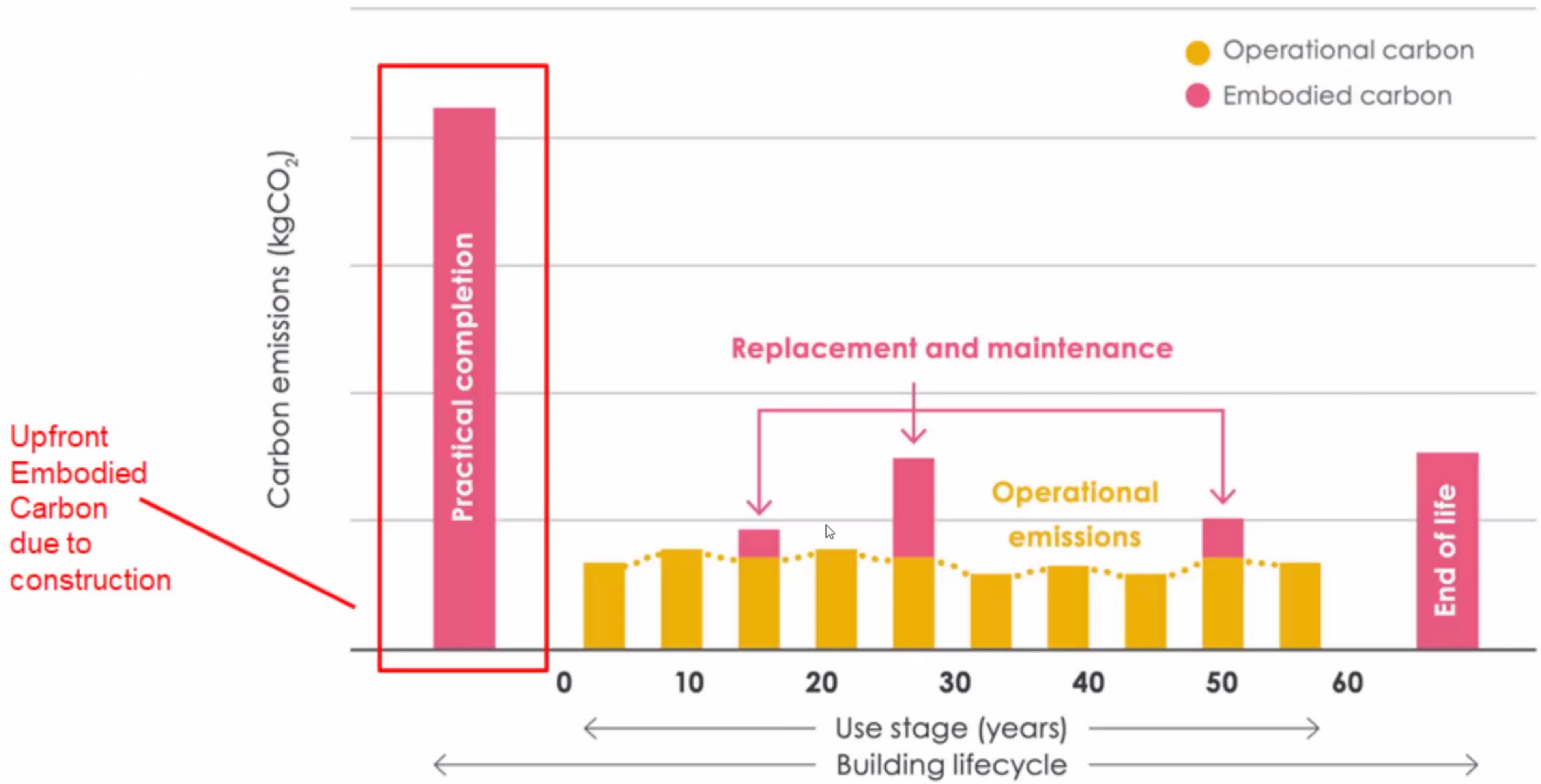


Life Cycle Phases



Source: World Green Building Council.
Bringing Embodied Carbon Upfront. Based on EN 15978.

Upfront Embodied Carbon



Source: LETI Embodied Carbon Primer

Mass Timber (current)

+ 43.32 kgCO2e/m2
+ 358.53 TCO2e

Biogenic Carbon

- 243.29 kgCO2e/m2
- 2013.47 TCO2e

Components
GLT and DLT deck
Glulam columns and beams

Structural steel (original design)

+ 93.49 kgCO2e/m2
+ 773.73 TCO2e

Components
Concrete on metal deck
Structural steel columns and beams

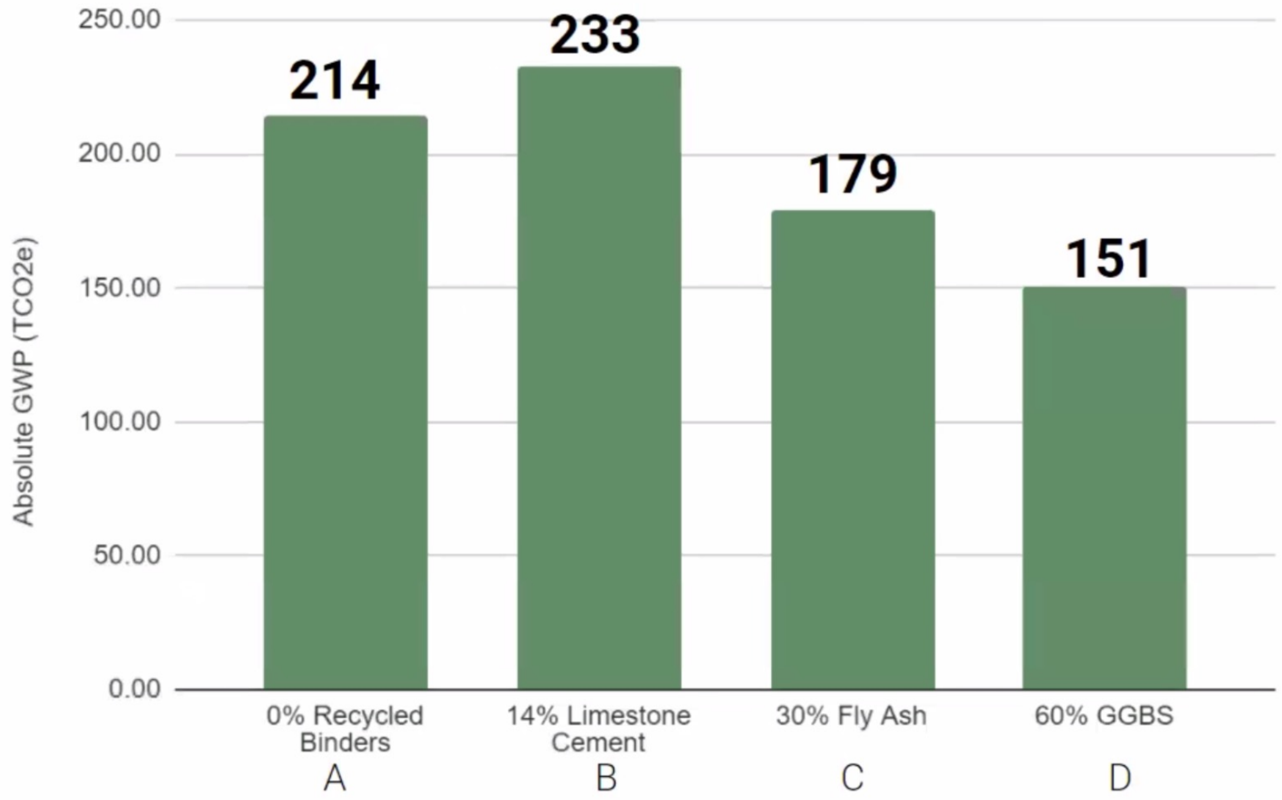
mass timber design
53.66%
savings in carbon emissions

when switching from structural steel to mass timber, without accounting for biogenic carbon

Ready-mix in substructure

includes footings, piers, foundation walls, ground slabs

Concrete	408.33 m3
Rebar (97% recycled)	20.86 m3



special concrete mix
29%
savings in carbon emissions

from Option A (0% recycled content) to Option D (60% GGBS)

Note: Option D is the currently specified concrete mix in the embodied carbon assessment.

Atrium at ground floor looking east

TARGETING ZERO EMISSIONS & NET ZERO ENERGY

Proposed NZEE Building	**EUI 139.1 (kWh/m2)**	**TEDI 39.4 (kWh/m2)**	**GHGI 5.6 (kg CO2e/m2)**
SB-10 Building Benchmark Building	297.6	156.5	34.6
TGS Tier 2 Baseline Building	190.5	63.2	16.0

For supporting & additional info please refer to submitted Net Zero Energy & Emissions Feasibility Study.

South Elevation

Questions & Answers

Thank you for attending!