



U.S. Department of Energy Solar Decathlon – **Project Report**

RYERSON UNIVERSITY

Office Building Division



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SITE LOCATION

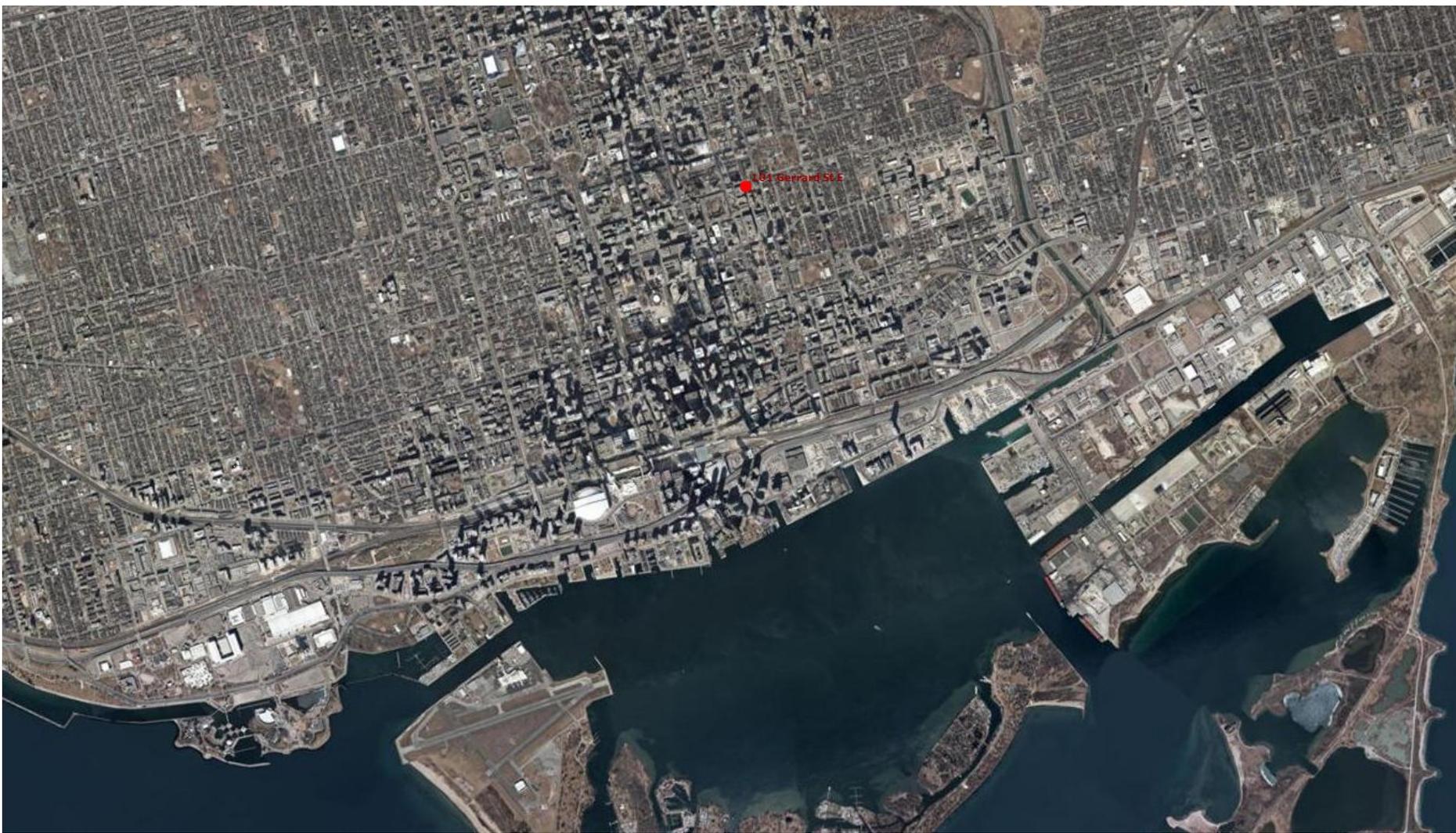


SITE LOCATION



(Covarrubias, 2007)

SITE LOCATION



(City of Toronto, 2018)

SITE ANALYSIS



DEMOGRAPHICS_Ward 13 (Toronto Centre)



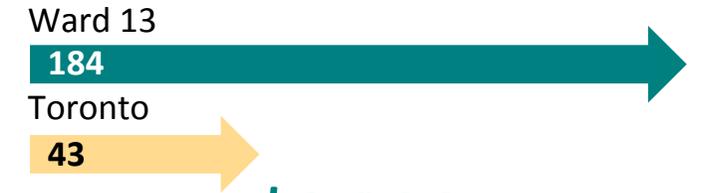
Occupied private dwellings by structure type
Source: City of Toronto, Census 2016

Ward population **103,805**

Population growth (2011-2016)



Density (people/hectare)



Average rent **\$1,214**

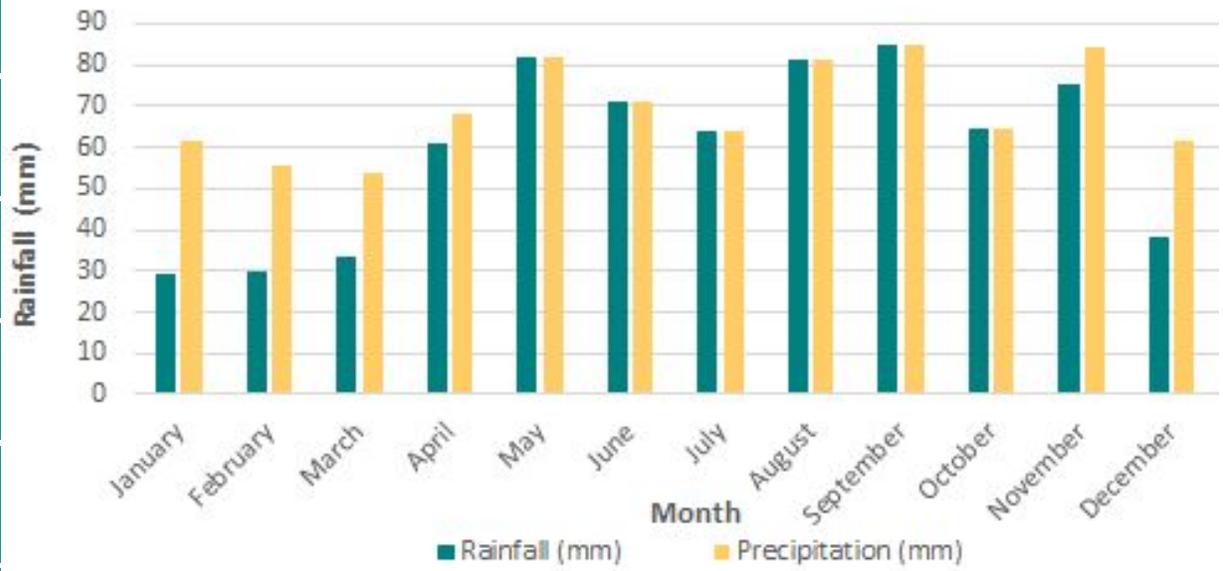
Tenure



Unemployment rate **8.8%**

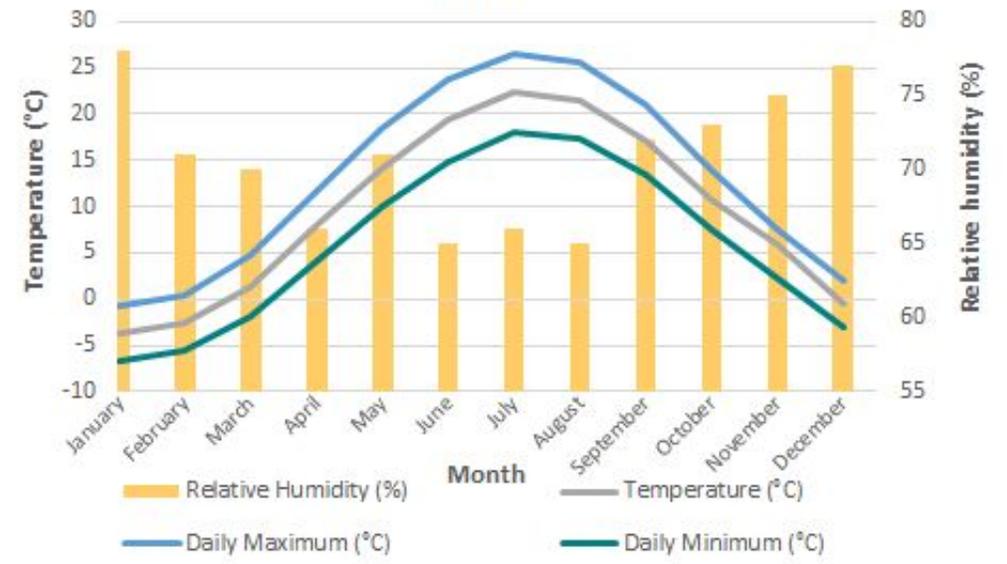
WEATHER CONDITION

Monthly average rainfall of Toronto



Source: Toronto Rain Station Data

Monthly temperature and relative humidity of Toronto



Source: Toronto Rain Station Data

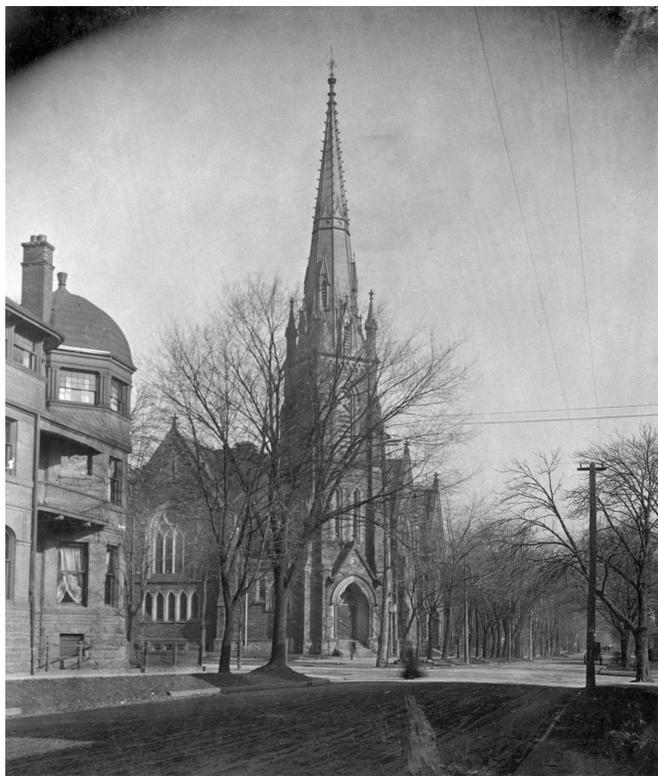
Semi-continental climate
 - warm, humid summer
 - cold winter
Climate zone: 5A

Average temperature: 9.4 °C
Annual precipitation:
 831.1 L/m²/yr
Elevation: 112.5 m

Average HDD (18°C): 3560
Average CDD (18°C): 380
Latitude: 43°39'36.3"N
Longitude: 79°22'35.5"W

Average annual wind speed:
 14.7km/h
Extreme Global - RF1
 35 MJ/m²

OUR VISION



The Past
(Blakey, 1907)



The Present
(2020)

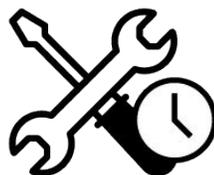


The Future
(2026)

DESIGN GOALS



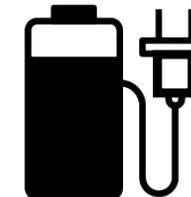
HEALTH AND WELL-BEING



REDUCED CONSTRUCTION TIME

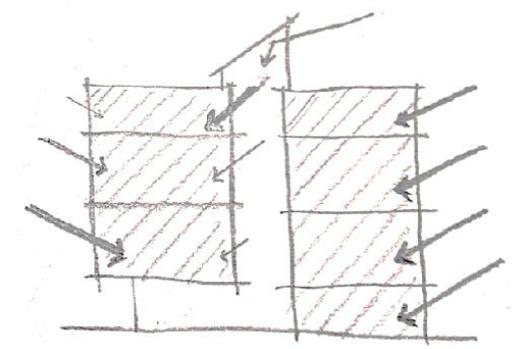
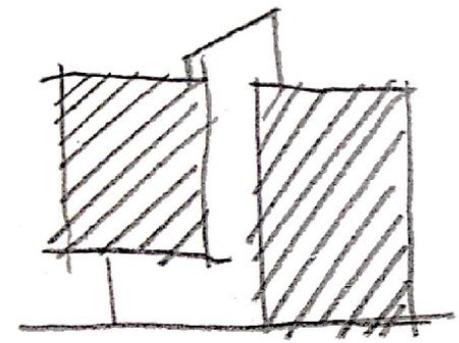
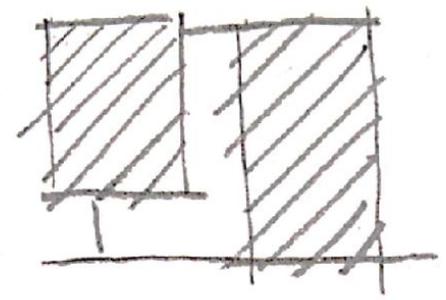


LOW CARBON FOOTPRINT



LOW-ENERGY

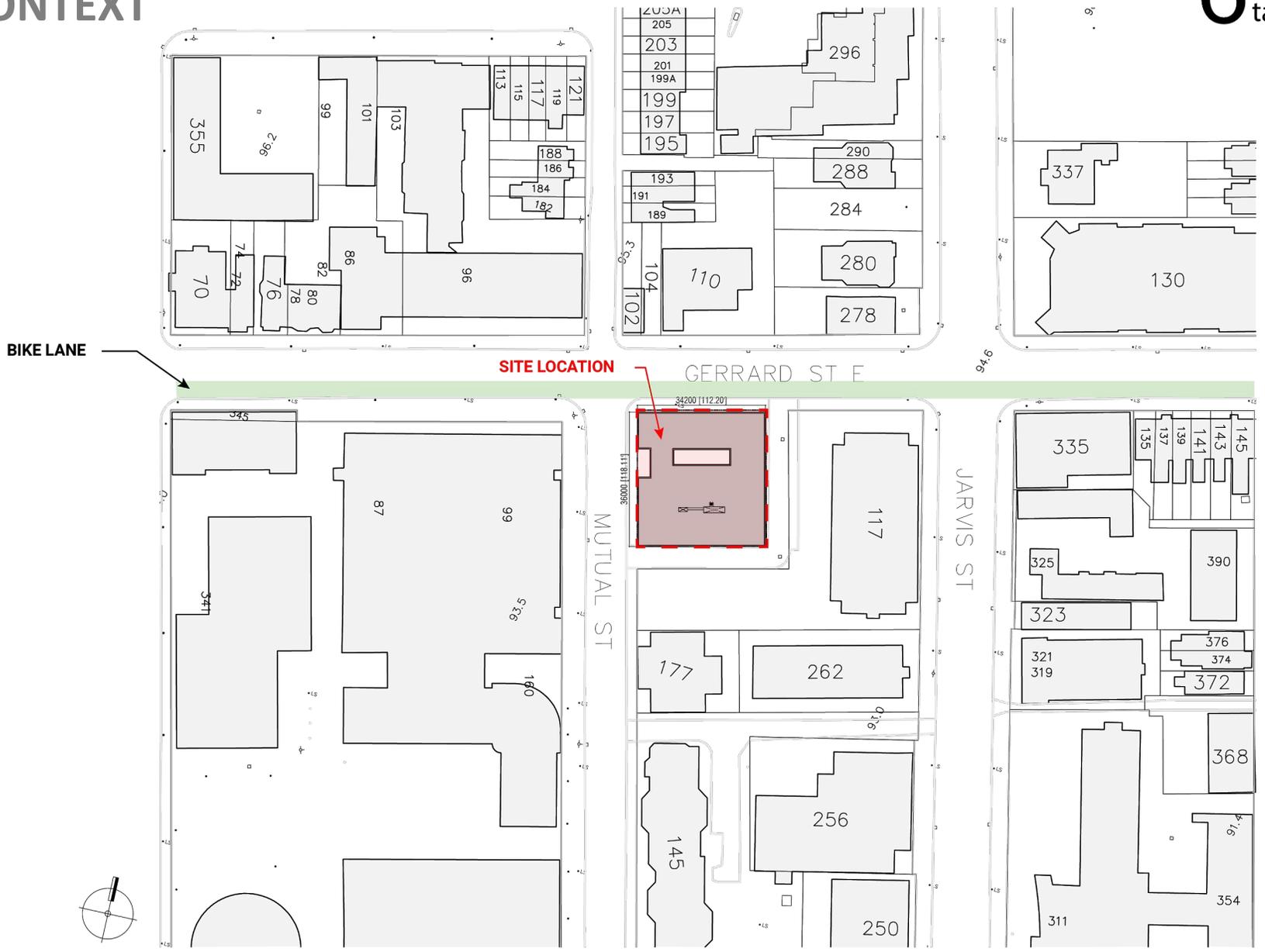
PARTI EVOLUTION



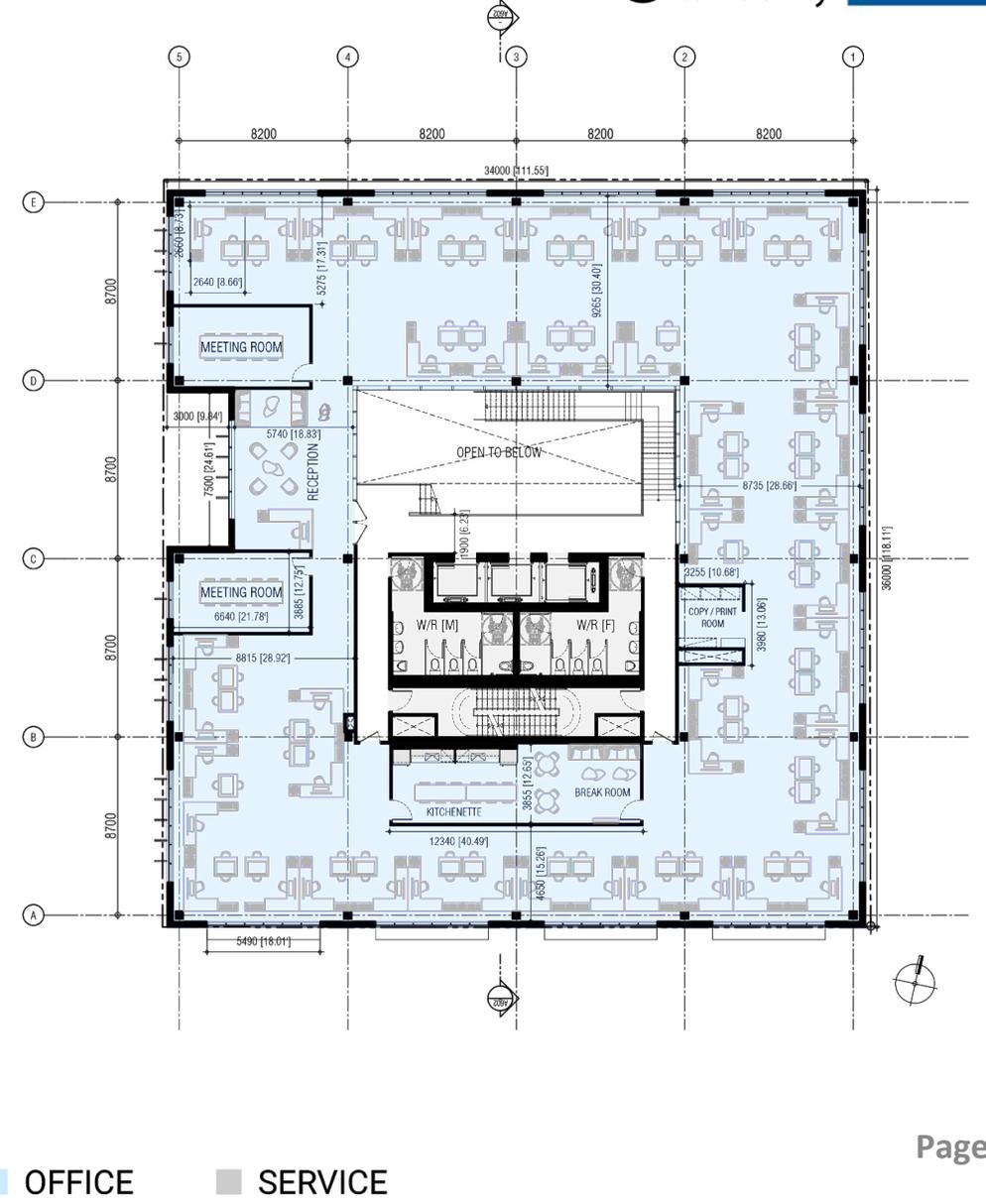
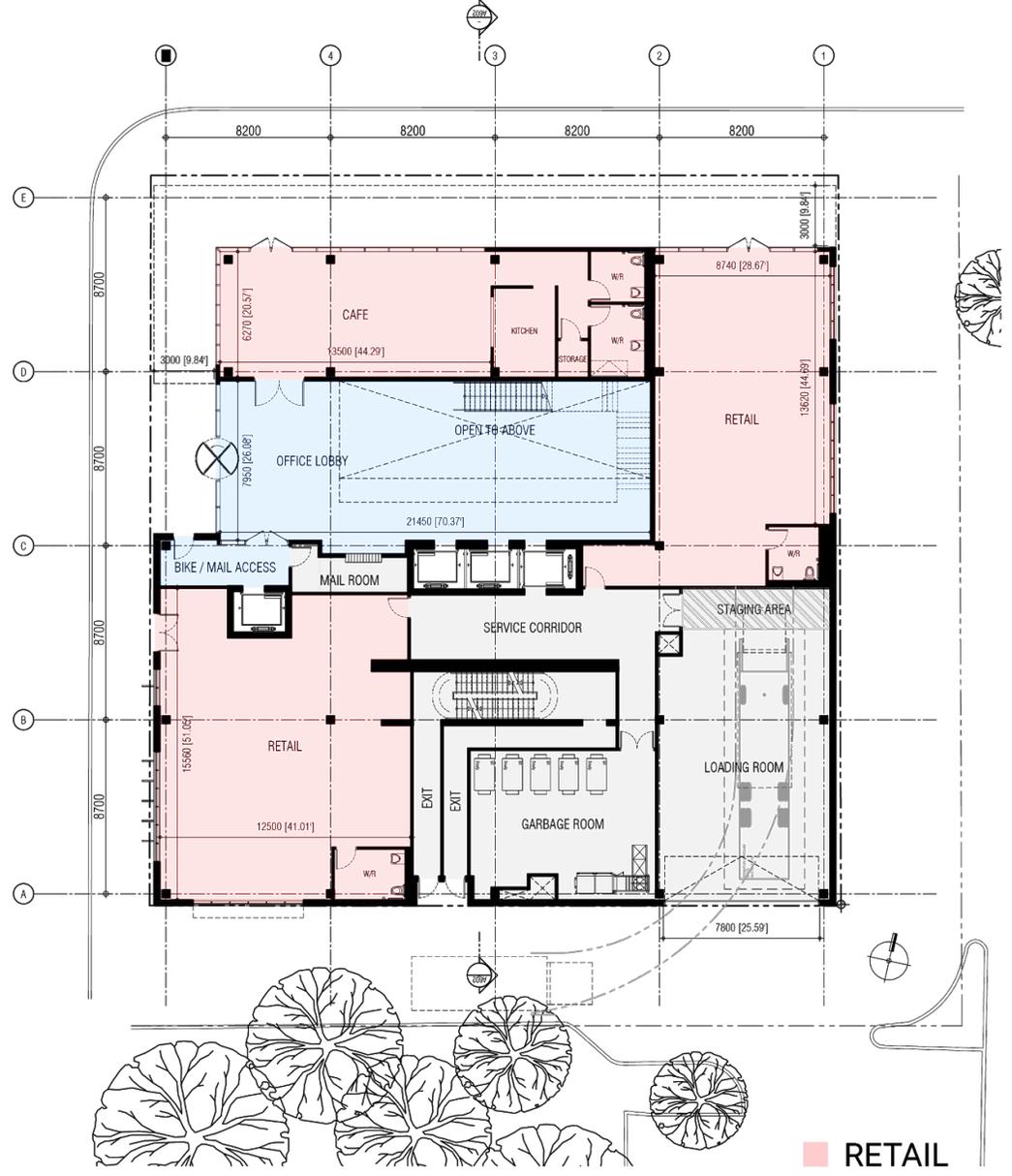
EXTERIOR DESIGN



SITE CONTEXT

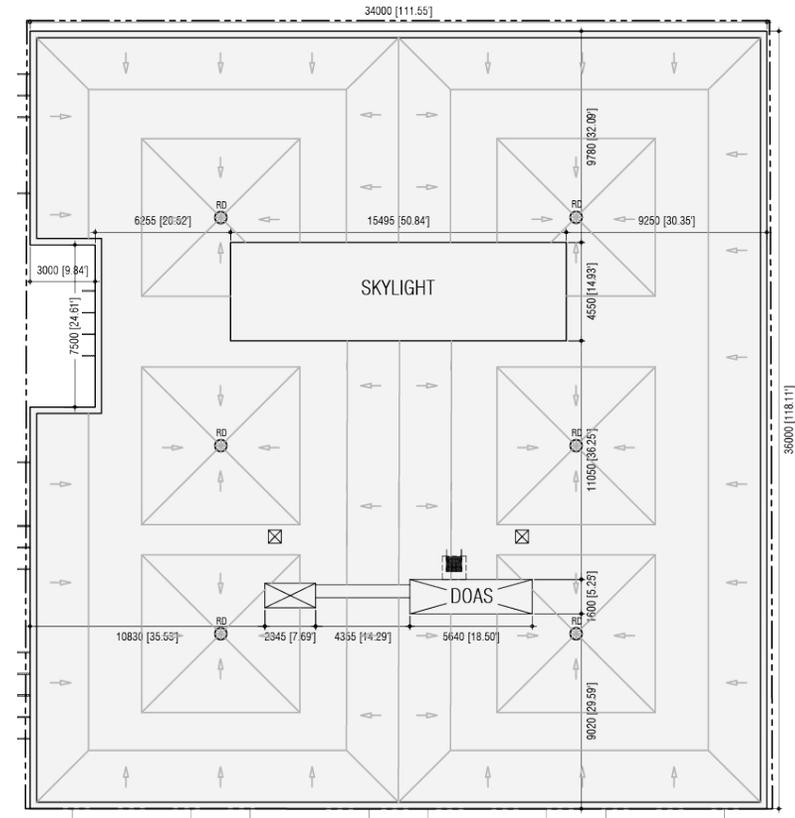
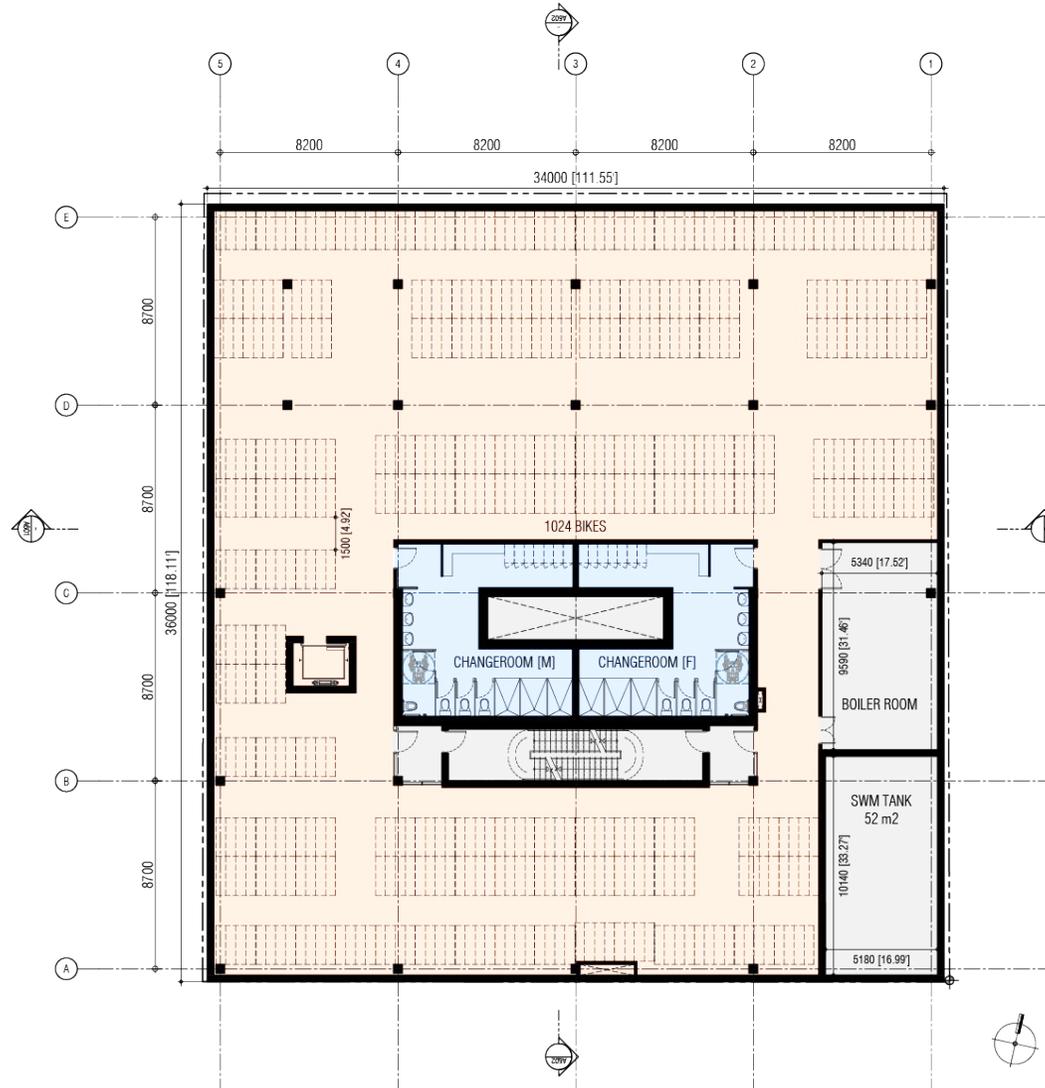


GROUND AND OFFICE FLOOR PLAN



RETAIL OFFICE SERVICE

BASEMENT AND ROOF PLAN



■ RETAIL
 ■ OFFICE
 ■ SERVICE
 ■ RYERSON

NATURAL LIGHTING



ATRIUM DESIGN

- Energy
- Engineering
- IEQ
- Operations
- Innovation
- Resilience
- Financial feasibility
- Market Potential
- Embodied energy
- Conclusion



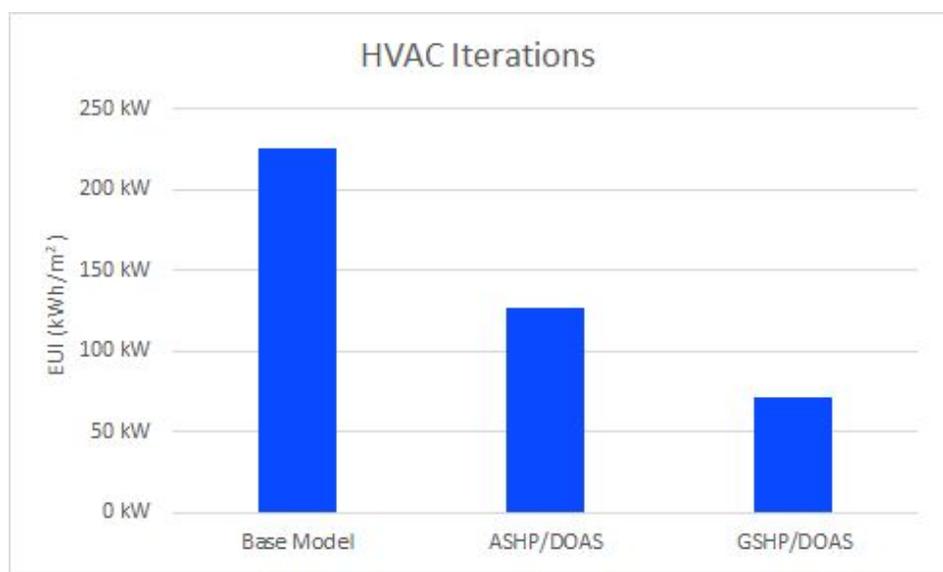
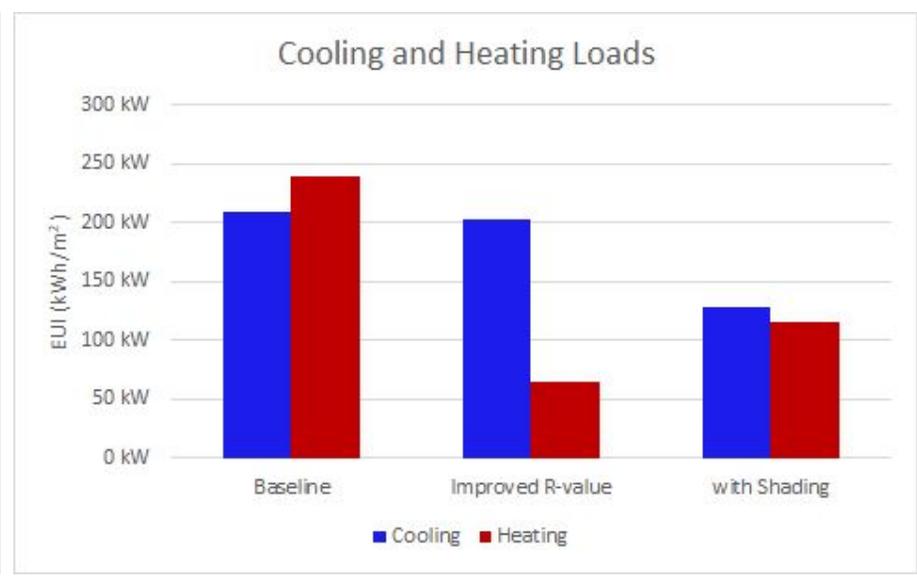
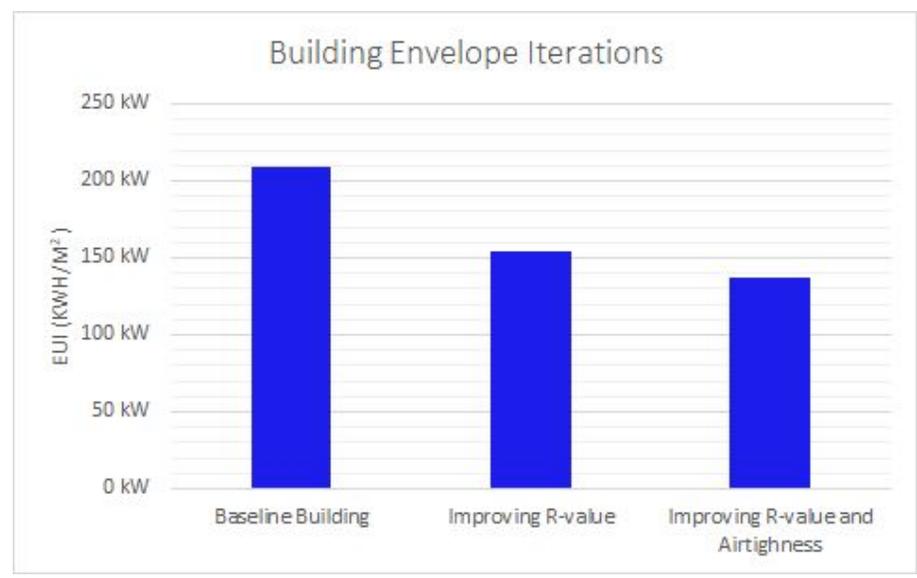
OFFICE SPACE DESIGN



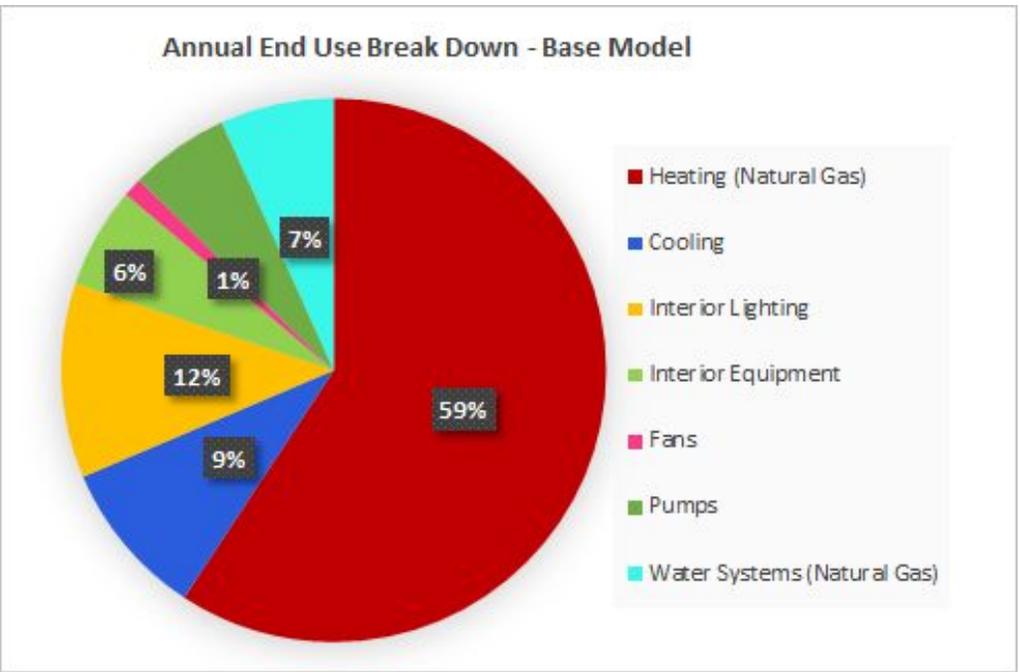
INTERIOR MATERIALITY



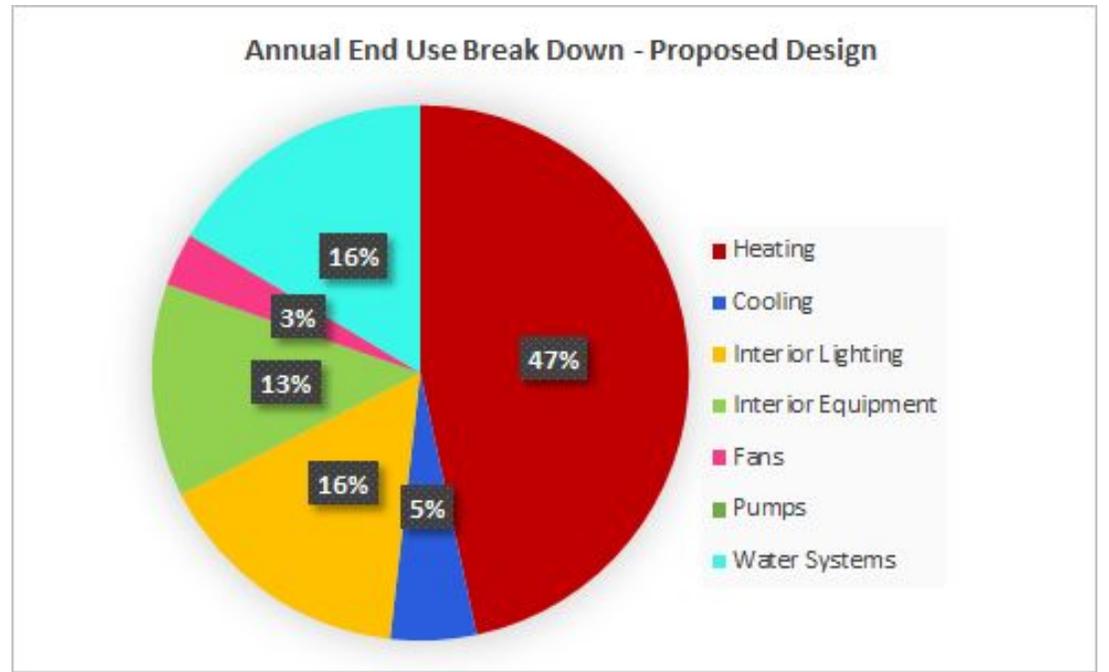
ENERGY CONSUMPTION



ENERGY CONSUMPTION

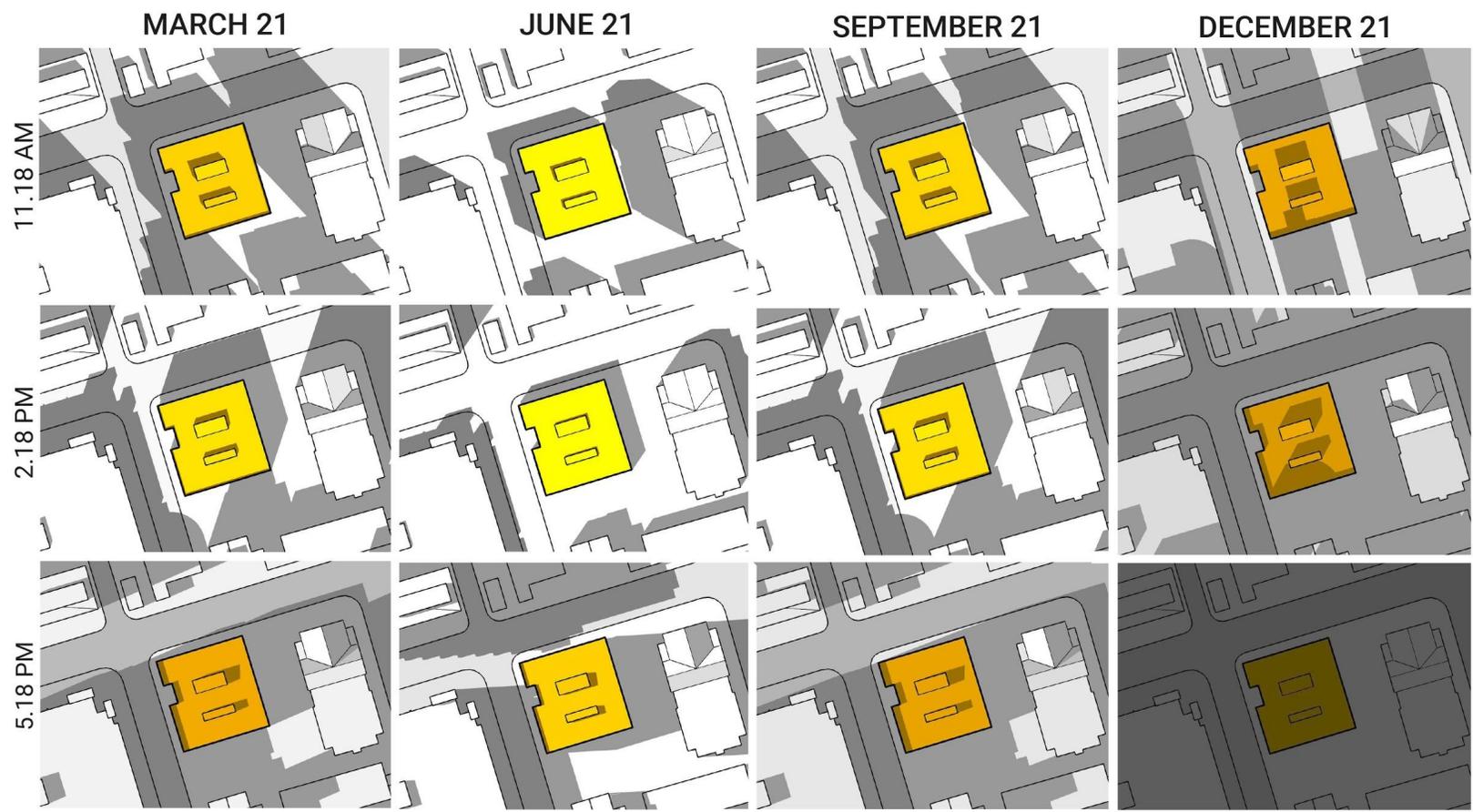


EUI: 226 kWh/m2/yr (71.7 kBtu/ft2/yr)

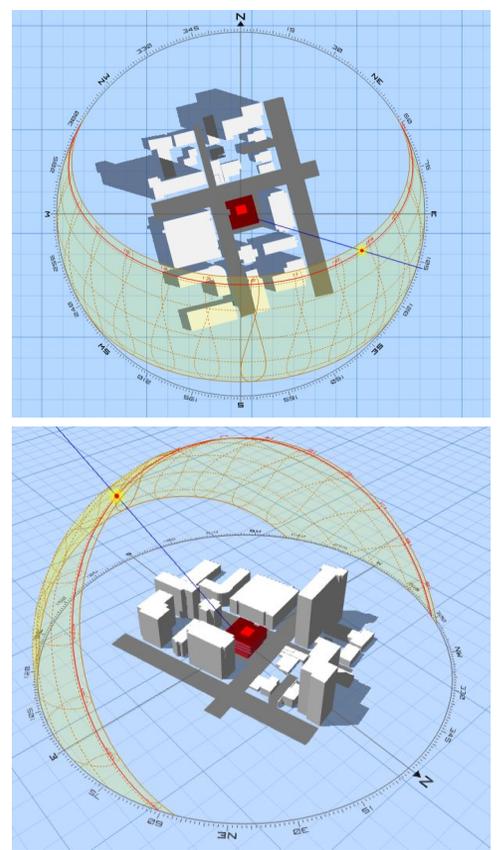


EUI: 71 kWh/m2/yr (22.5 kBtu/ft2/yr)

RENEWABLE ENERGY



Shadow analysis



Sun path diagram (Sun path 3d, 2020)

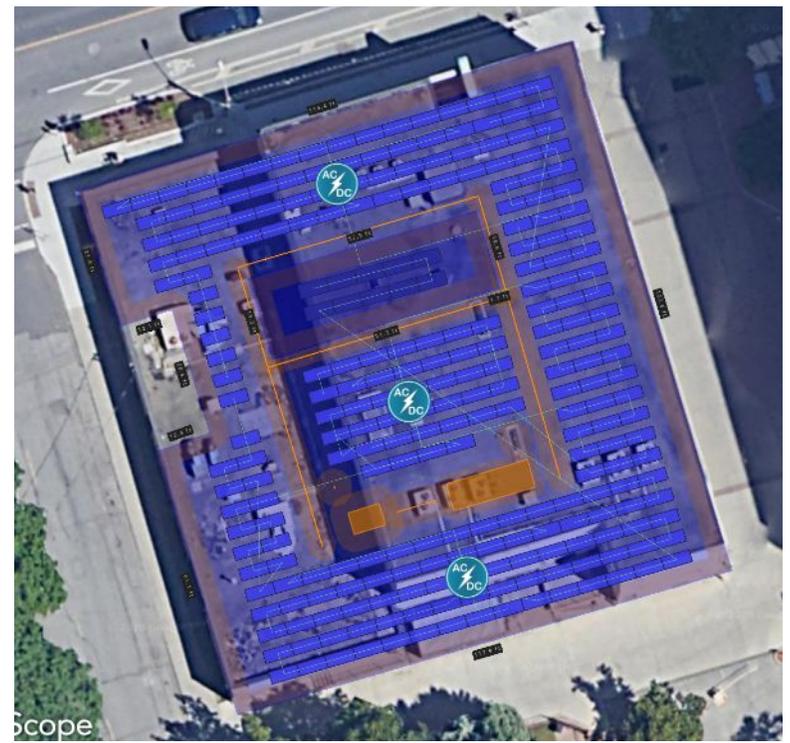
RENEWABLE ENERGY

Office building roof area:
Approximately 1200 m² (12916.7ft²)
 Additional PV array potential from adjacent building-

- Architecture building**
- Pitman Hall Residence**

Office building:
 No. of PV panels- **206**
 PV array size-
92.7 kW (316.3 kBTU/hr)
 Tilt angle- **32°**

Additional PV array:
 No. of PV panels- **580**
 PV array size-
261 kW (891 kBTU/hr)
 Tilt angle- **32°**



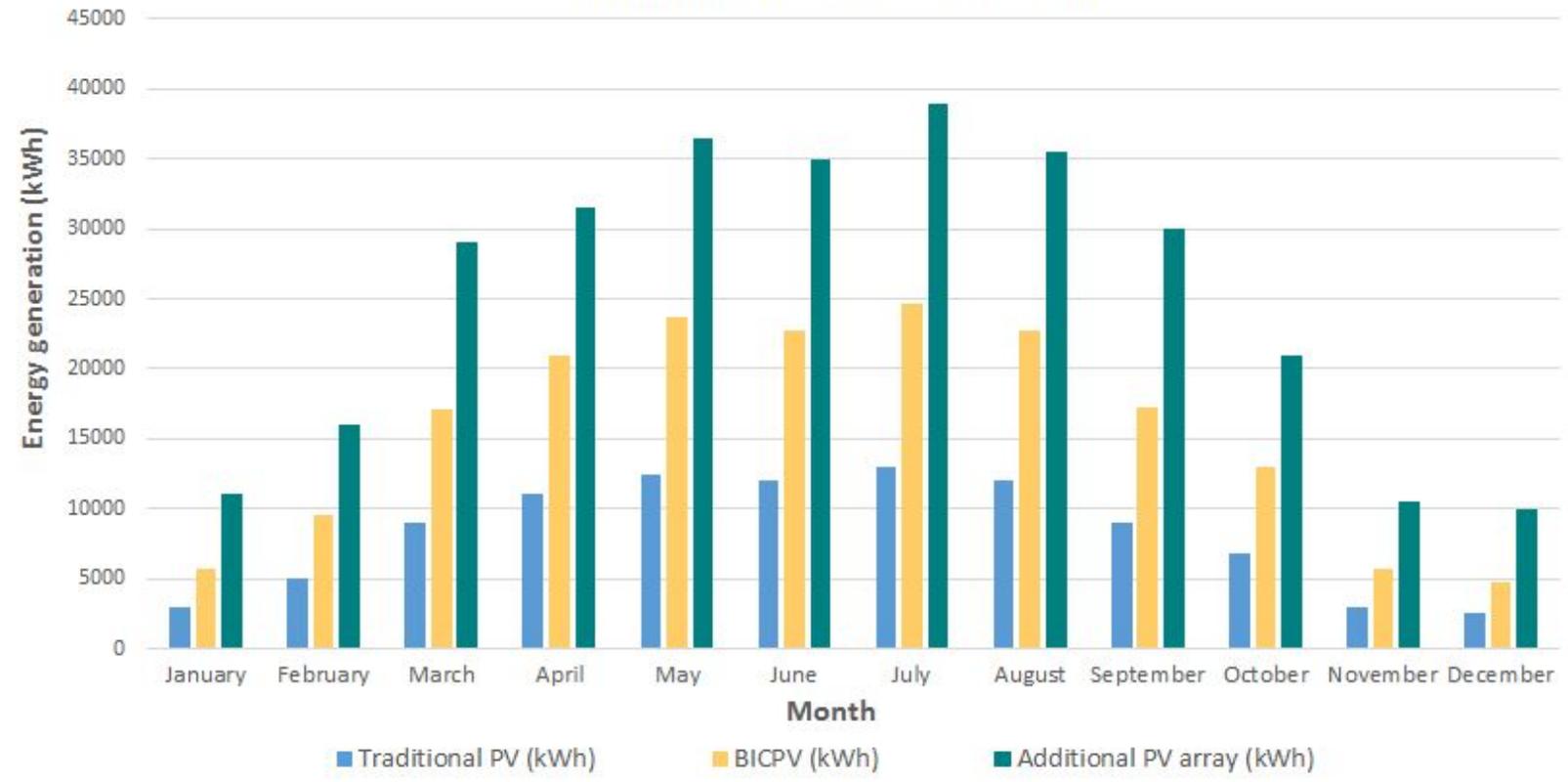
PV array layout (Helioscope, 2020)



Additional PV array layout (Helioscope, 2020)

RENEWABLE ENERGY GENERATION

Monthly energy generation



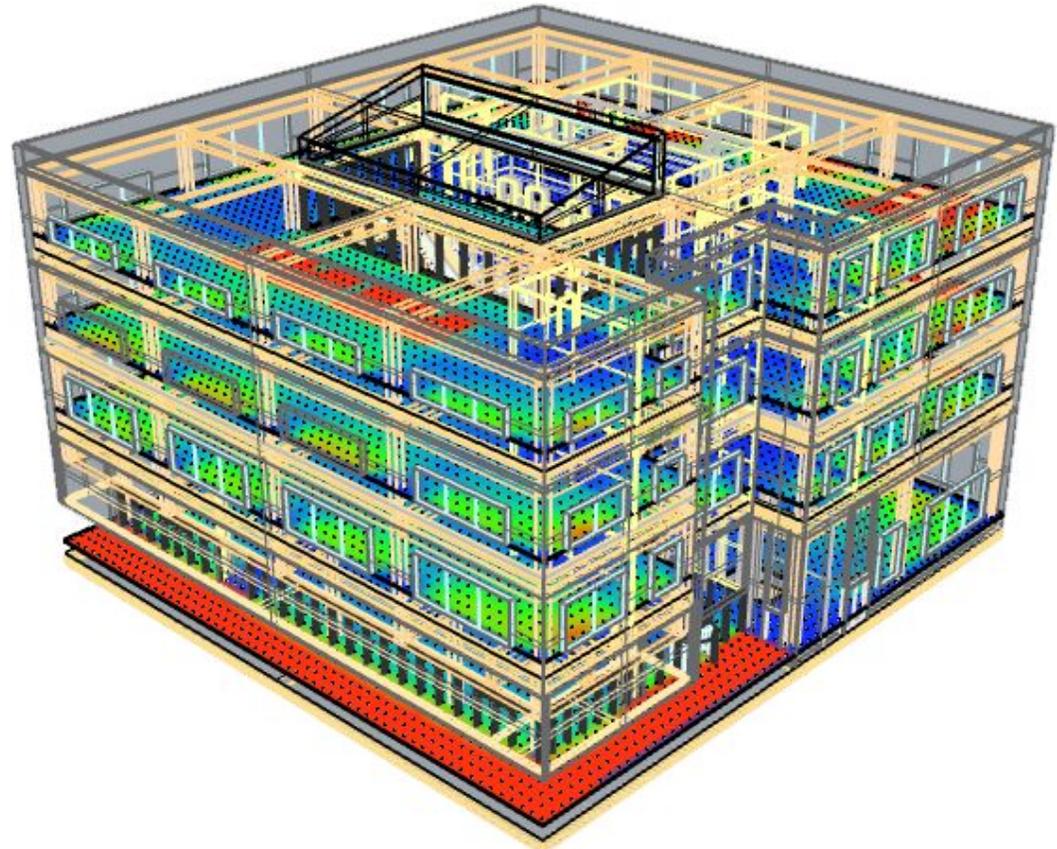
Traditional PV panel:
 Annual energy generation-
100.6 MWh (343261.4 kBTU)
 Energy offset (EUI)-
18.86 kWh/m² (5978.6BTU/ft²)

BICPV:
 Annual energy generation-
201.2 MWh (686522 kBTU)
 Energy offset (EUI)-
37.72 kWh/m² (11957.2BTU/ft²)

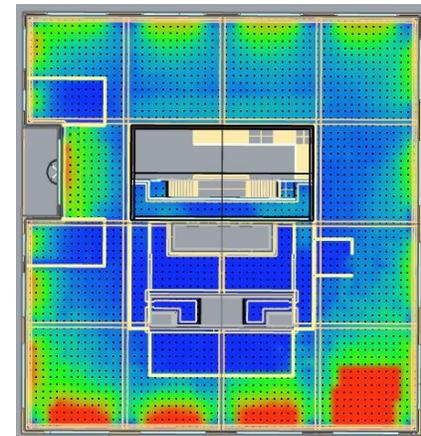
Additional PV array:
 Annual energy generation-
312 MWh (1064588.2 kBTU)
 Energy offset-
54.23 kWh/m² EUI.

DAYLIGHTING

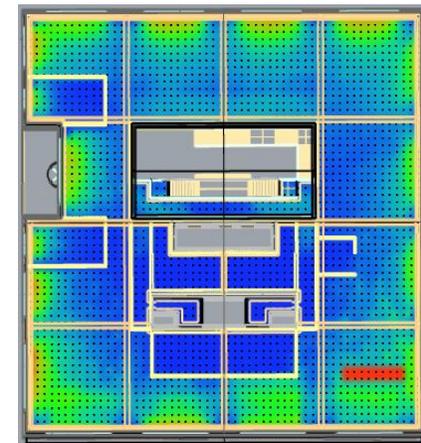
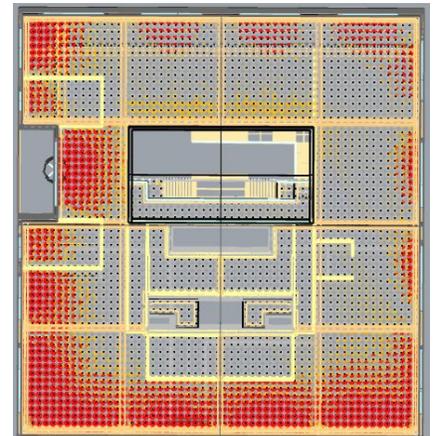
Maximum illuminance: **850 lux** towards the perimeter
Minimum illuminance: **170 lux** towards the interior
(at 11am during winter)



Daylight availability (without passive shading strategies)
(ClimateStudio 2020)



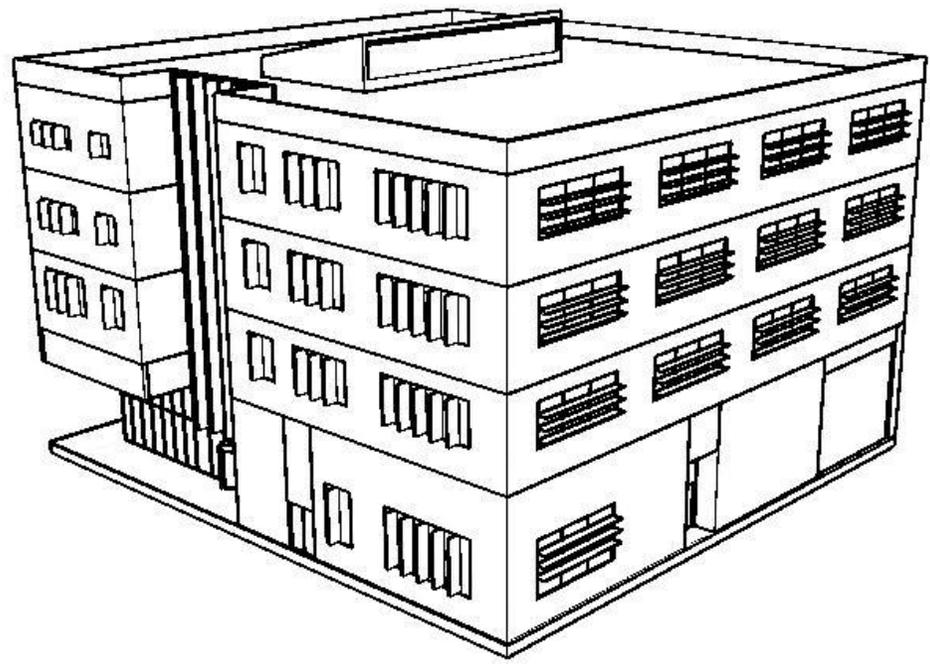
Daylight availability and annual glare (without passive shading strategies)
(ClimateStudio 2020)



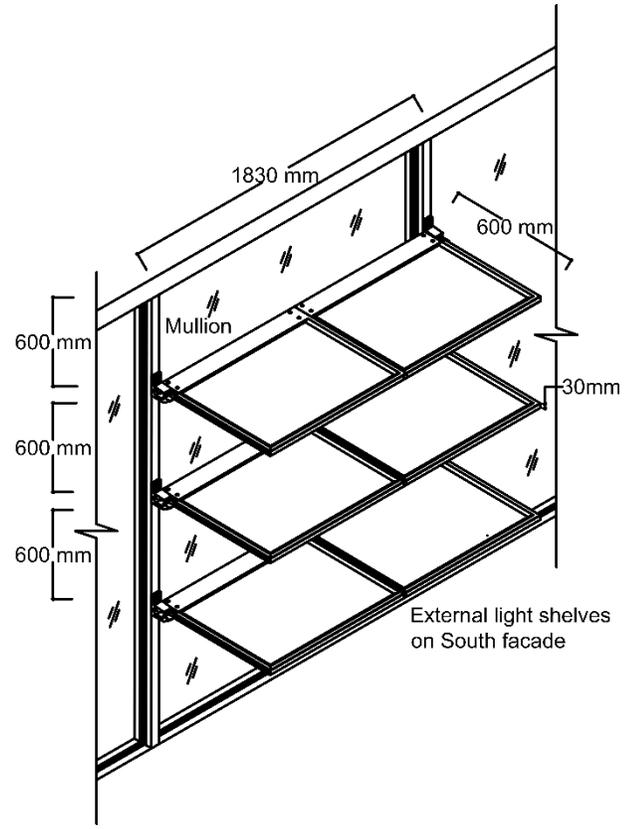
Daylight availability and annual glare (with passive shading strategies)
(ClimateStudio 2020)

DAYLIGHTING_Passive shading strategies

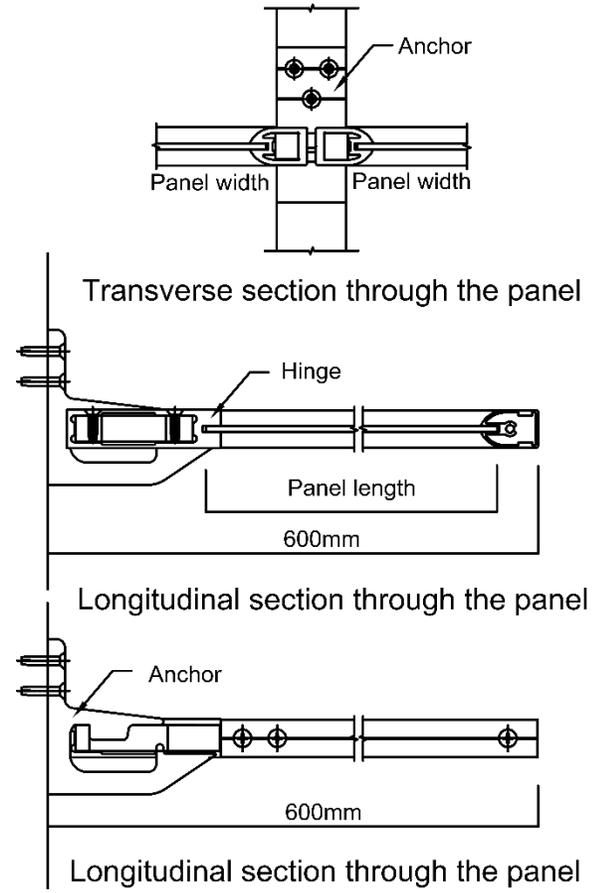
South facade: **External light shelves**
West facade: **Vertical shading**
South and West: **Internal blinds**
Minimize glare on South and West facade.



Exterior light shelves on south and vertical shading on west

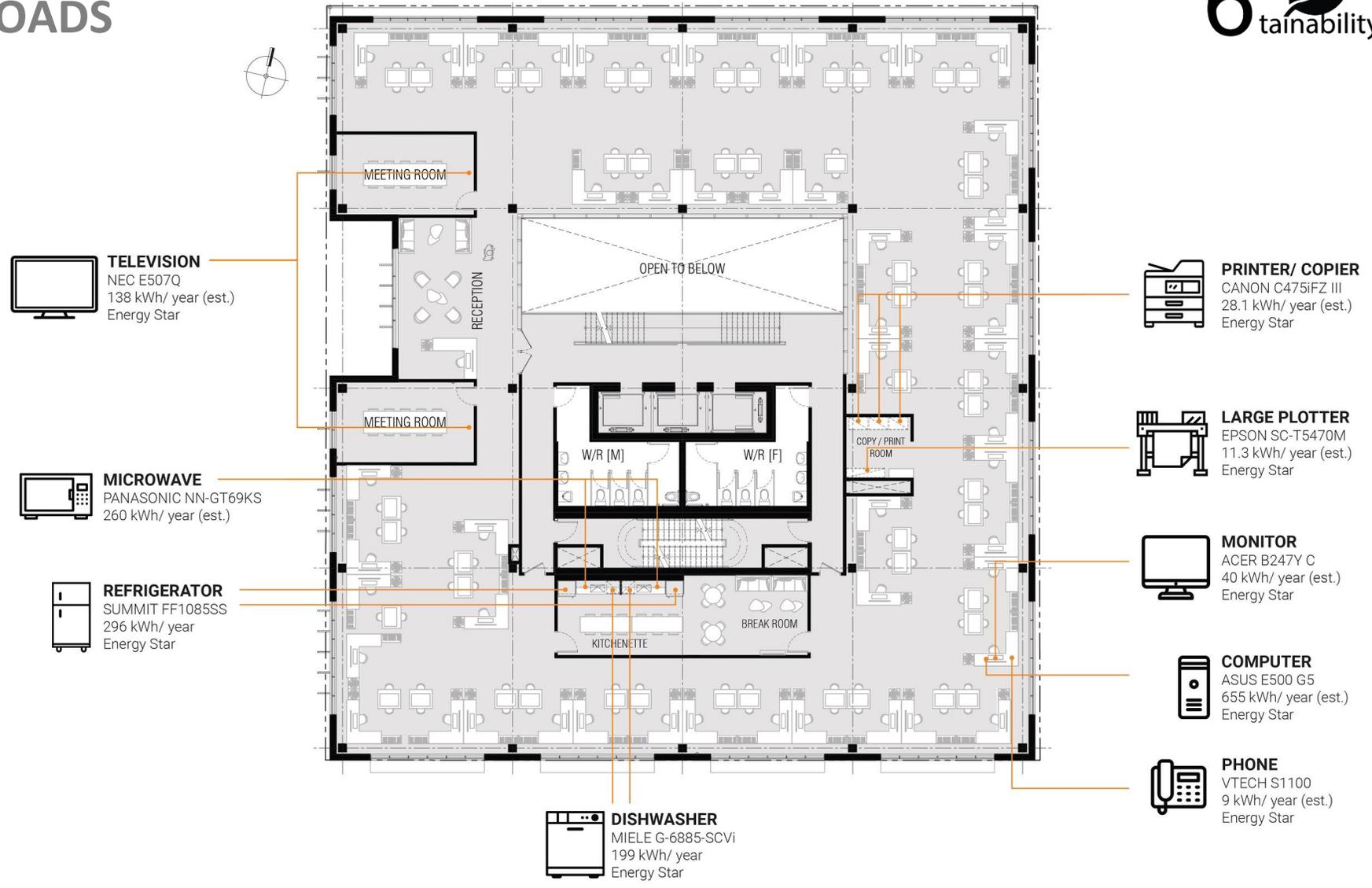


Exterior light shelves panel details



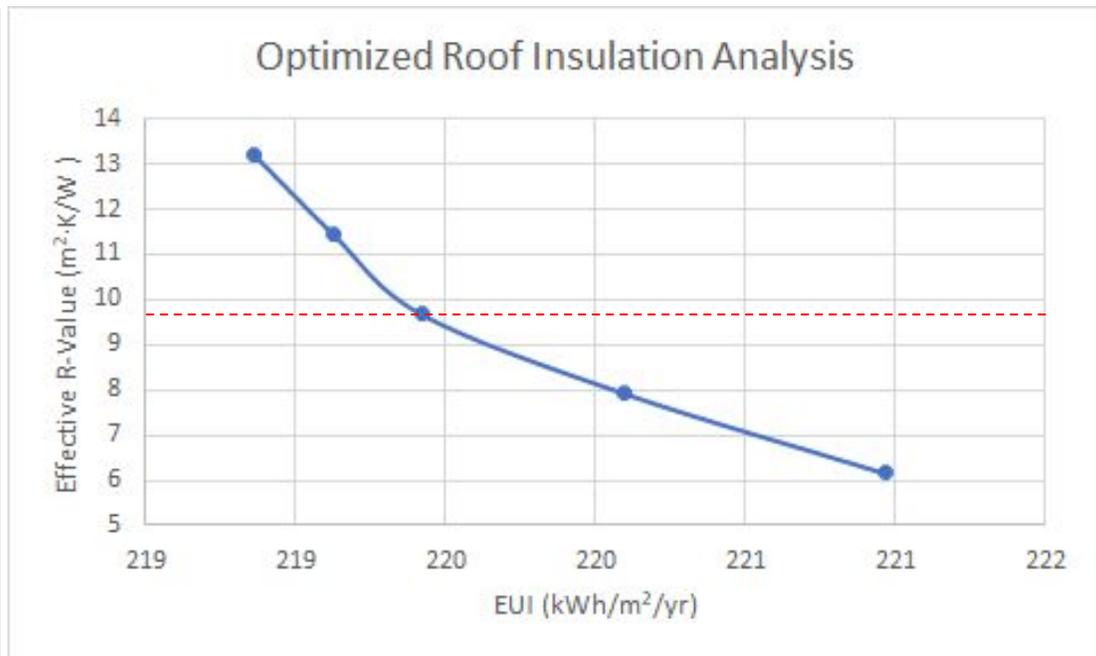
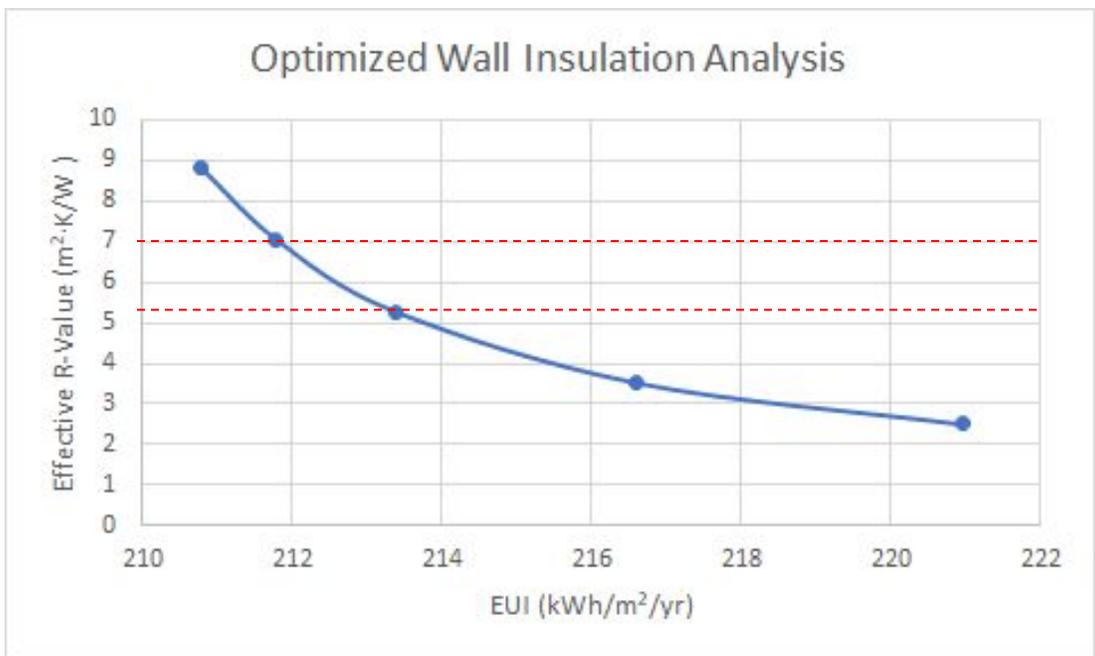
Exterior light shelves panel sections

PLUG LOADS



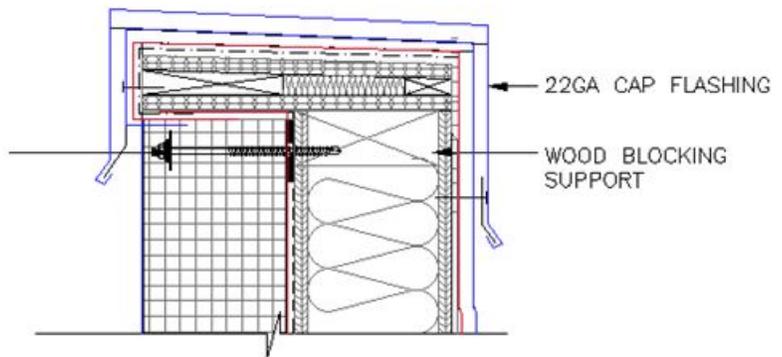
AVERAGE ENERGY SAVINGS = 32%

R-Value Optimization

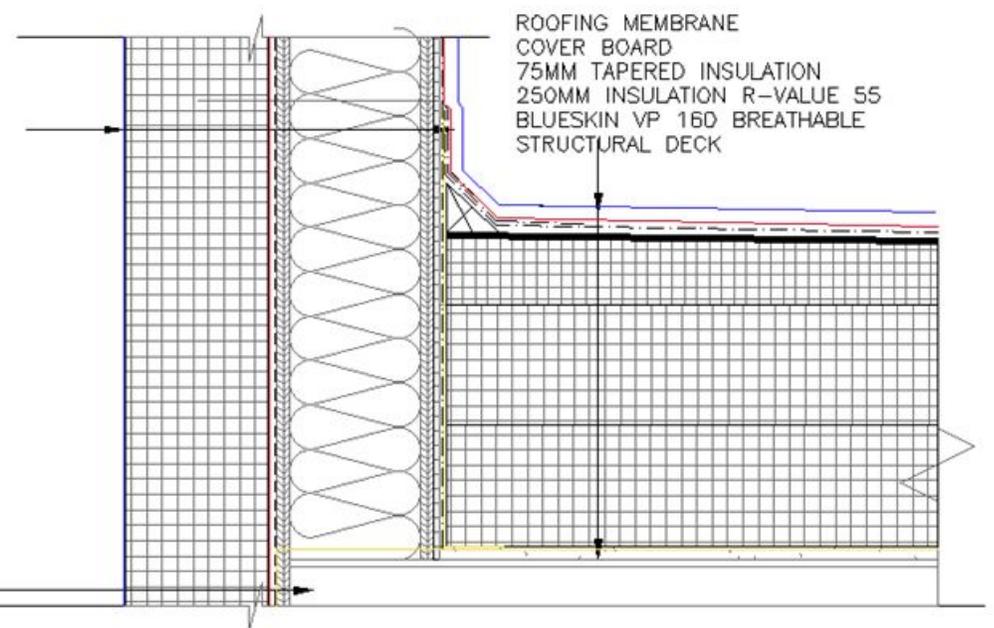


CONTROL LAYERS

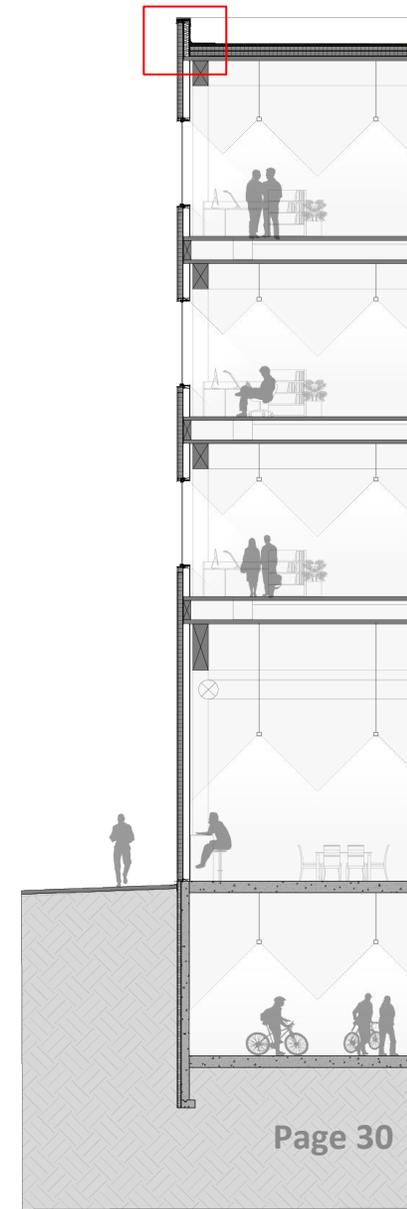
12 GA. STAINLESS STEEL HIDDEN FASTENER CLIP (1 PER PANEL, PER SUPPORT) SET CLIP IN BUTYL SEALANT



ROOFING MEMBRANE
13MM PLYWOOD
152MM STUDS FILLED WITH INSULATION
13MM PLYWOOD
BLUESKIN
150 MM INSULATED METAL PANEL

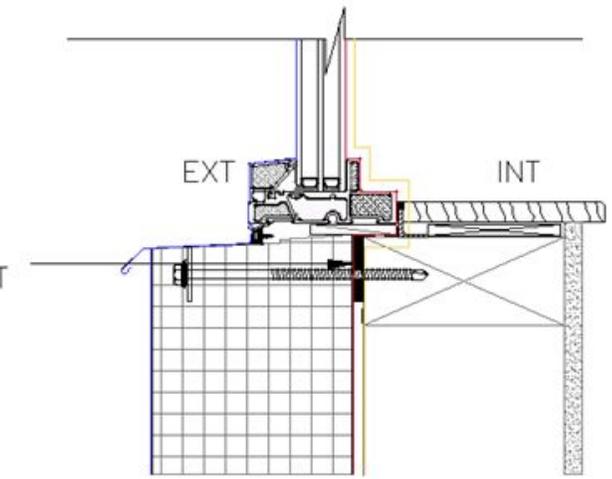
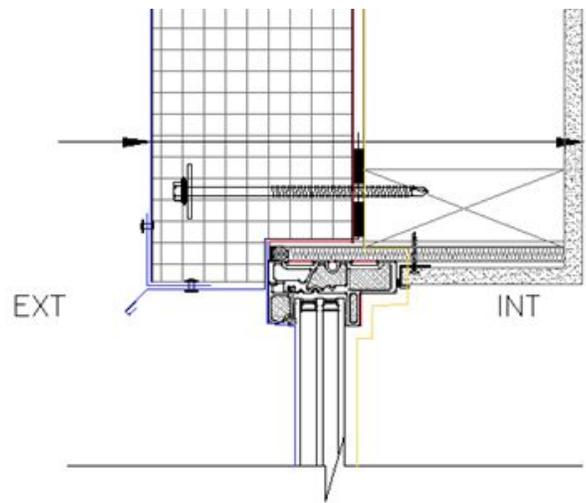


- AIR CONTROL LAYER
- VAPOUR CONTROL LAYER
- BULK WATER CONTROL LAYER

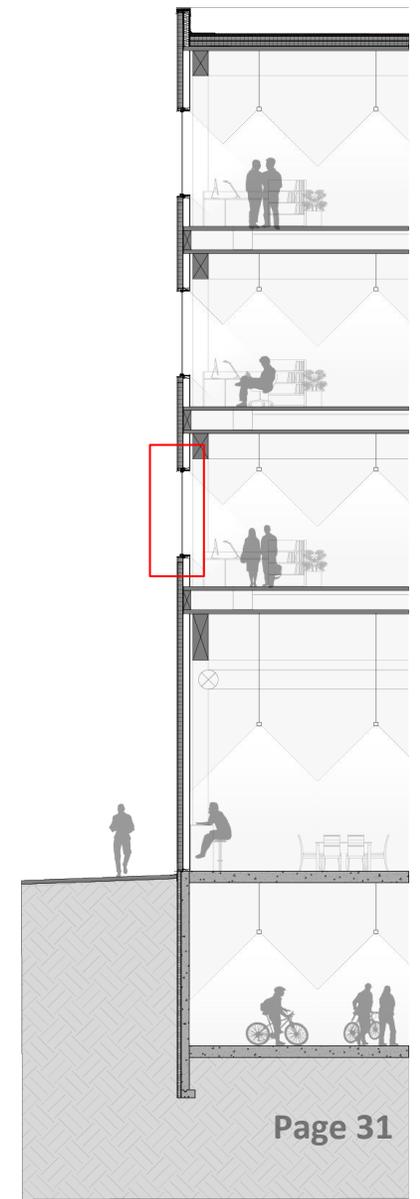


CONTROL LAYERS

13MM GYPSUM
 152MM HORIZONTAL
 WOOD SUPPORT
 150 MM INSULATED
 METAL PANEL



- AIR CONTROL LAYER
- VAPOUR CONTROL LAYER
- BULK WATER CONTROL LAYER

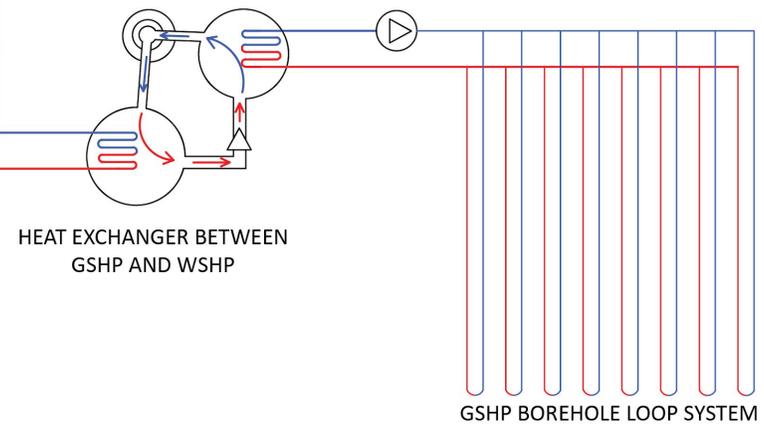
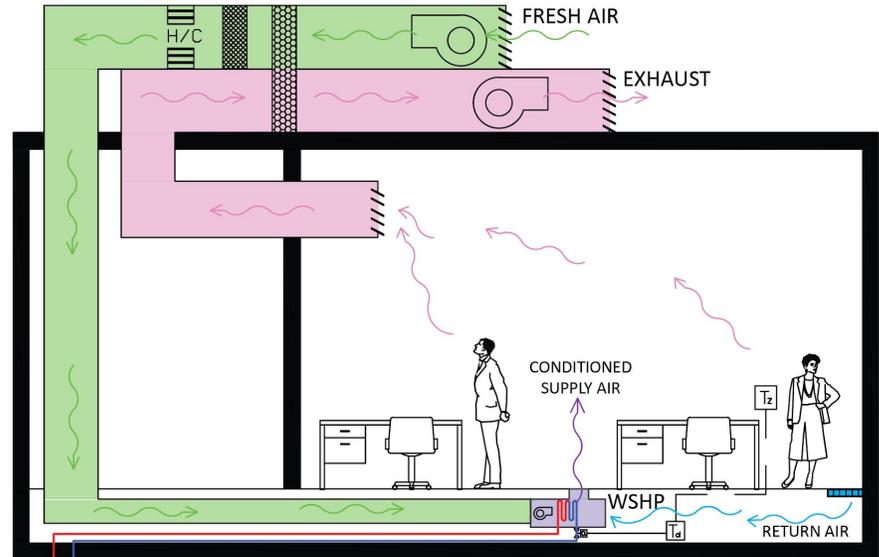


HVAC SYSTEM

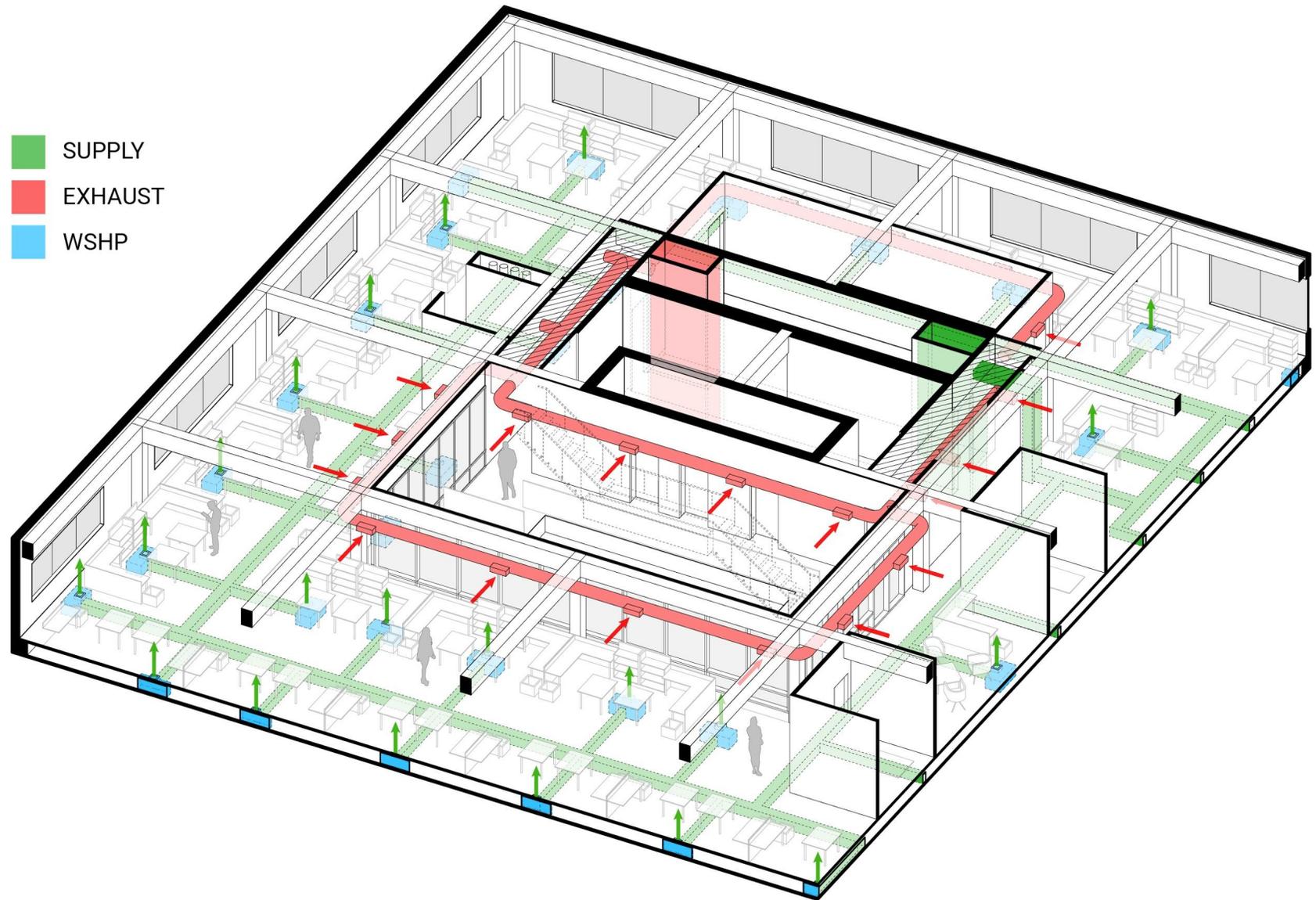
Legend

	Heat Pump Loop
	Air Flow
	Fan
	Zone thermostat
	Discharge thermostat
	Louver
	Piping inside a system component
	Filter
	Heating / Cooling Coil
	Energy Recovery Wheel
	Exhaust Air
	Fresh Air
	Supply Air
	Return Air

ROOFTOP DOAS SYSTEM WITH A ROTARY HEAT EXCHANGER WHEEL

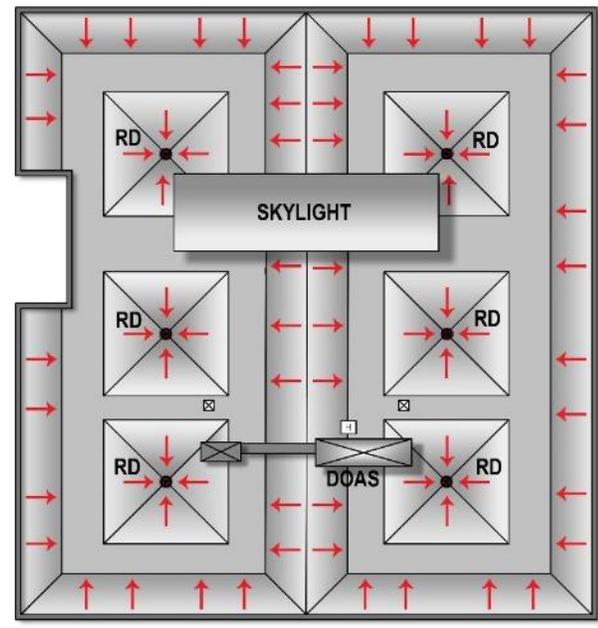


HVAC SYSTEM

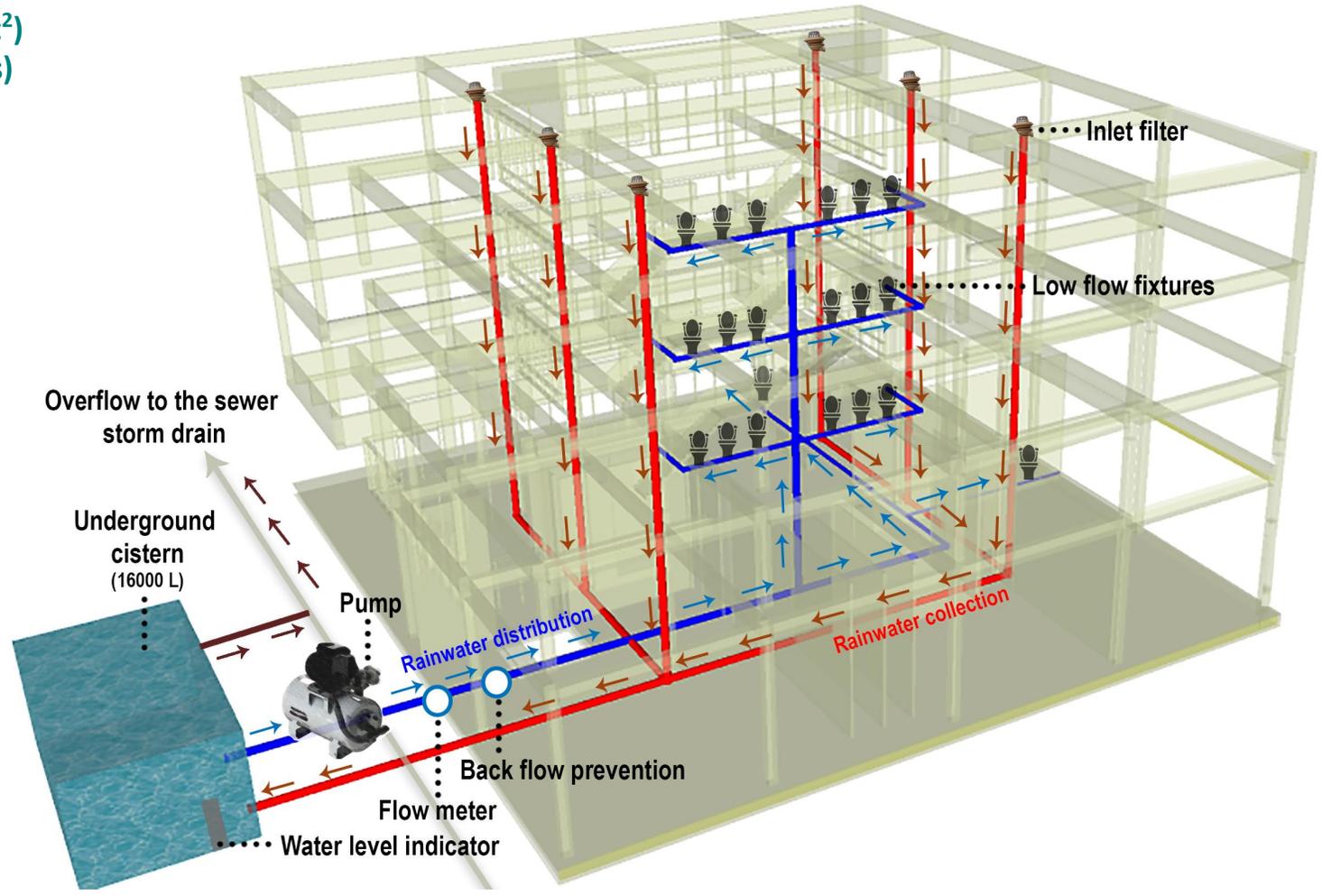


WATER MANAGEMENT

Roof area: **approximately 1200 m² (12916.7ft²)**
 Storage tank capacity: **16000L (4226.7 gallons)**
 Average water use intensity:
700 L/m²/yr (17.2 BTU/ft²/yr)
 Annual precipitation: **831.1 L/m²/yr**



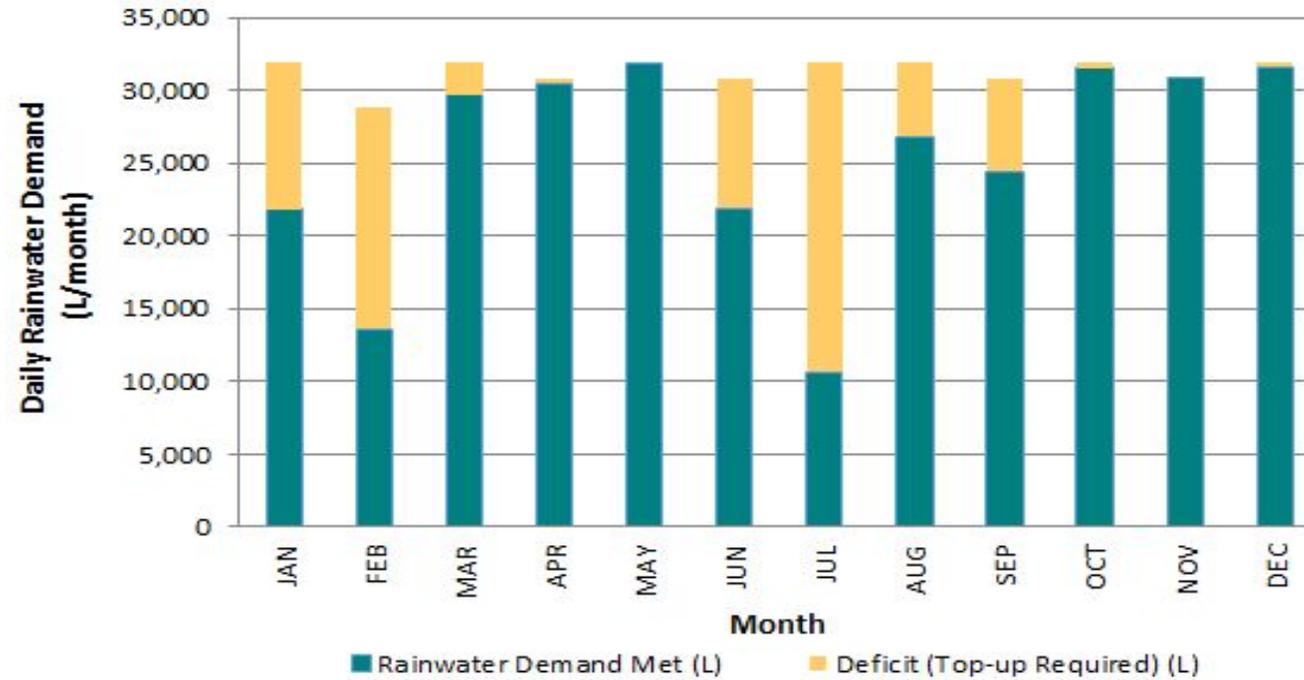
Rainwater drains



Rainwater collection and distribution

WATER MANAGEMENT

Rainwater usage and deficit



Rainwater usage and deficit (STEP Rainwater harvesting and costing tool, 2020)

Total annual water usage L/yr (gallons/yr)	Low Flow Water Use reduction L/yr (gallons/yr)	Annual Rainwater Harvested L/yr (gallons/yr)	Total water use reduction L/yr (gallons/yr)	Annual water usage after reduction L/yr (gallons/yr)	% of reduction
3,275,138 (865,200)	447,053 (118,099)	797,855 (210,771)	1,244,912 (328,871)	2,030,226 (536,329)	38%

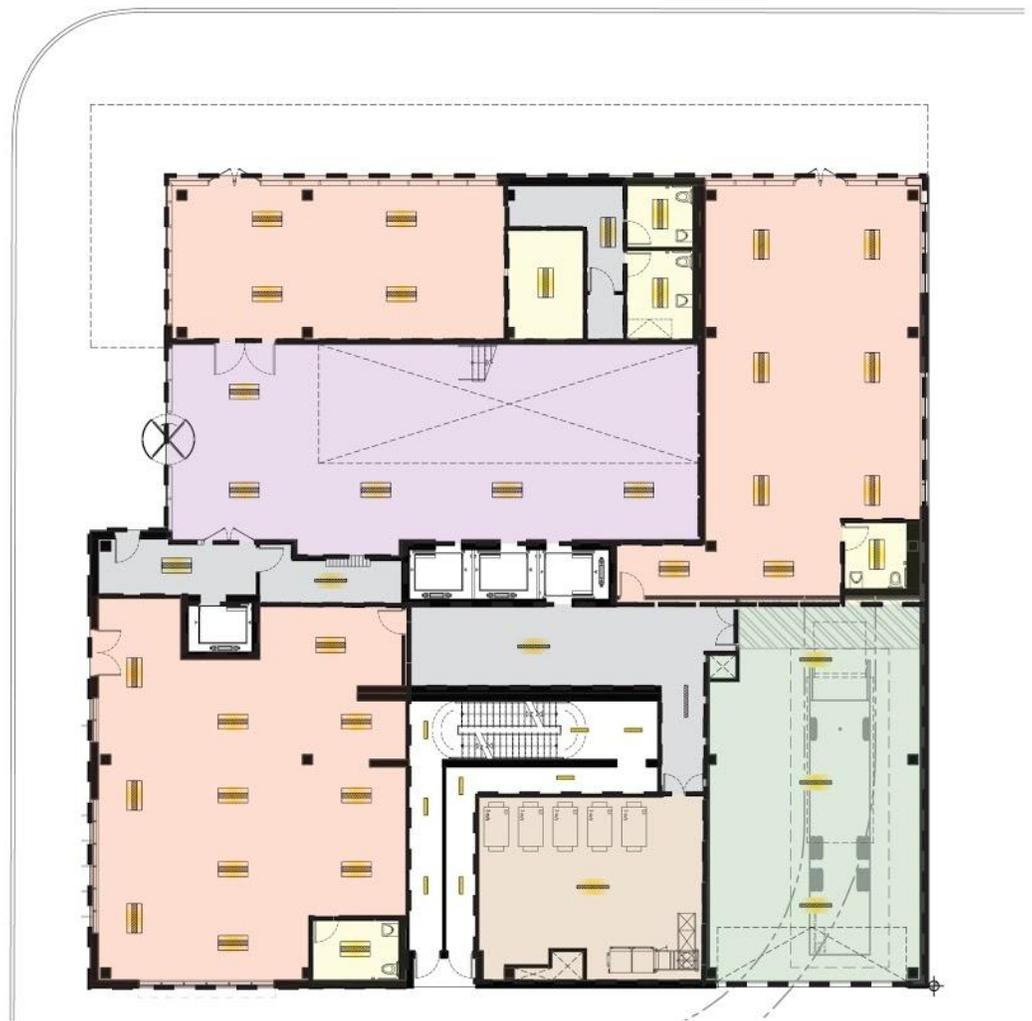
Water usage reduction

LIGHTING DESIGN

GROUND FLOOR:

SPACE TYPE:

- RETAIL
- ATRIUM
- BATHROOM
- CAFE
- LOADING
- GARBAGE
- CORRIDOR

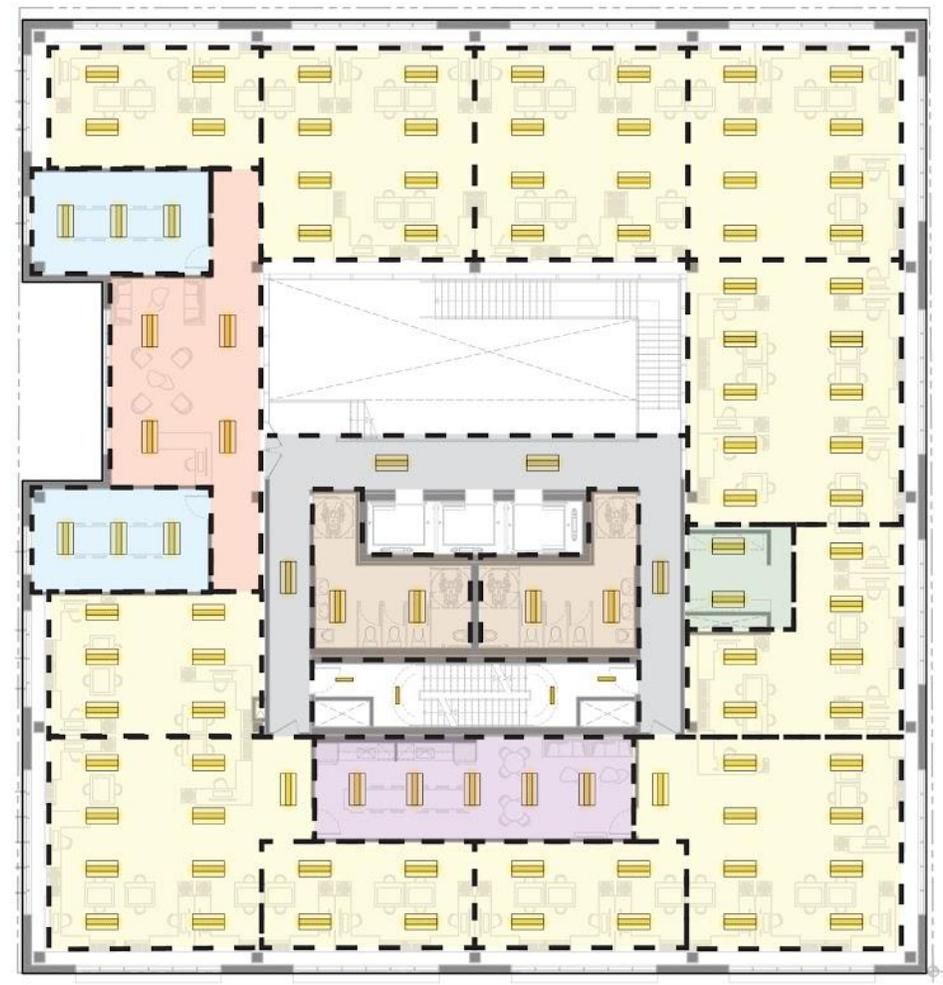


LIGHTING DESIGN

TYPICAL OFFICE FLOOR:

SPACE TYPE:

-  RECEPTION
-  KITCHEN / BREAK
-  OFFICE SPACE
-  MEETING ROOMS
-  COPY ROOM
-  WASHROOM
-  CORRIDOR



LIGHTING CONTROL

TYPICAL OFFICE BAY LIGHTING CONTROL SOLUTION:

- 

MULTI-TECH CEILING MOUNT OCCUPANCY SENSOR
LEVITON OSC20-RMW


- 

PHOTOCELL SENSOR
LEVITON ODC0P-W

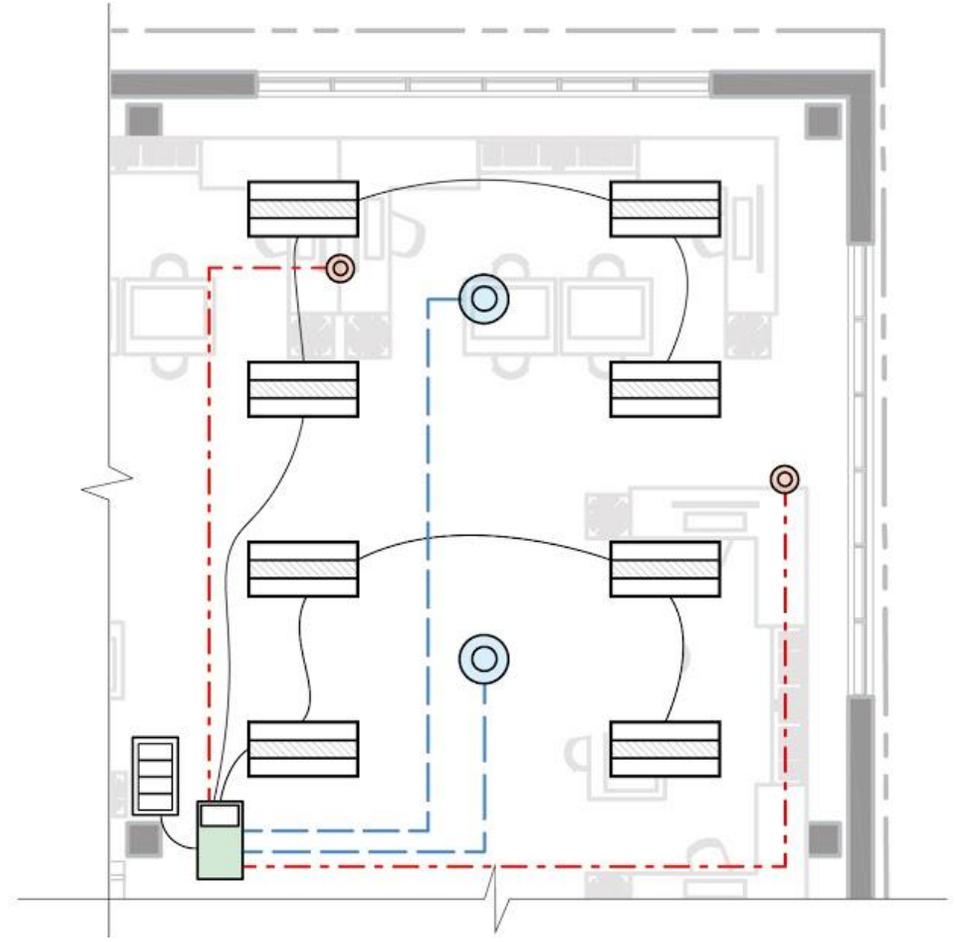

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LIGHTING CONTROL STATION
LEVITON RLVSW-4LW

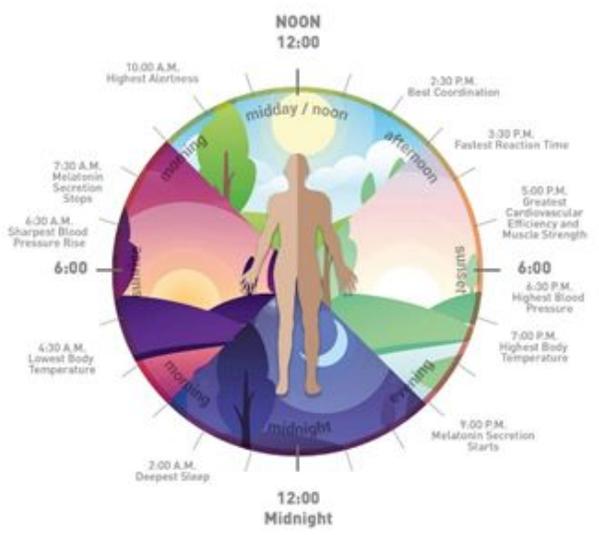

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INTEGRATED ROOM CONTROL DIMMING
LEVITON MZD20-102

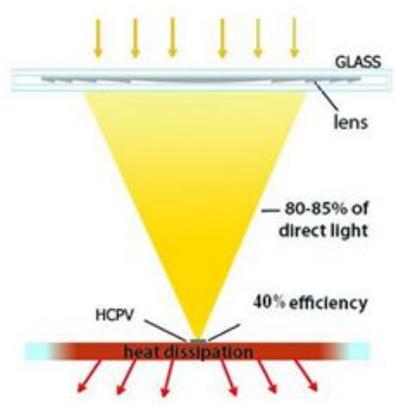




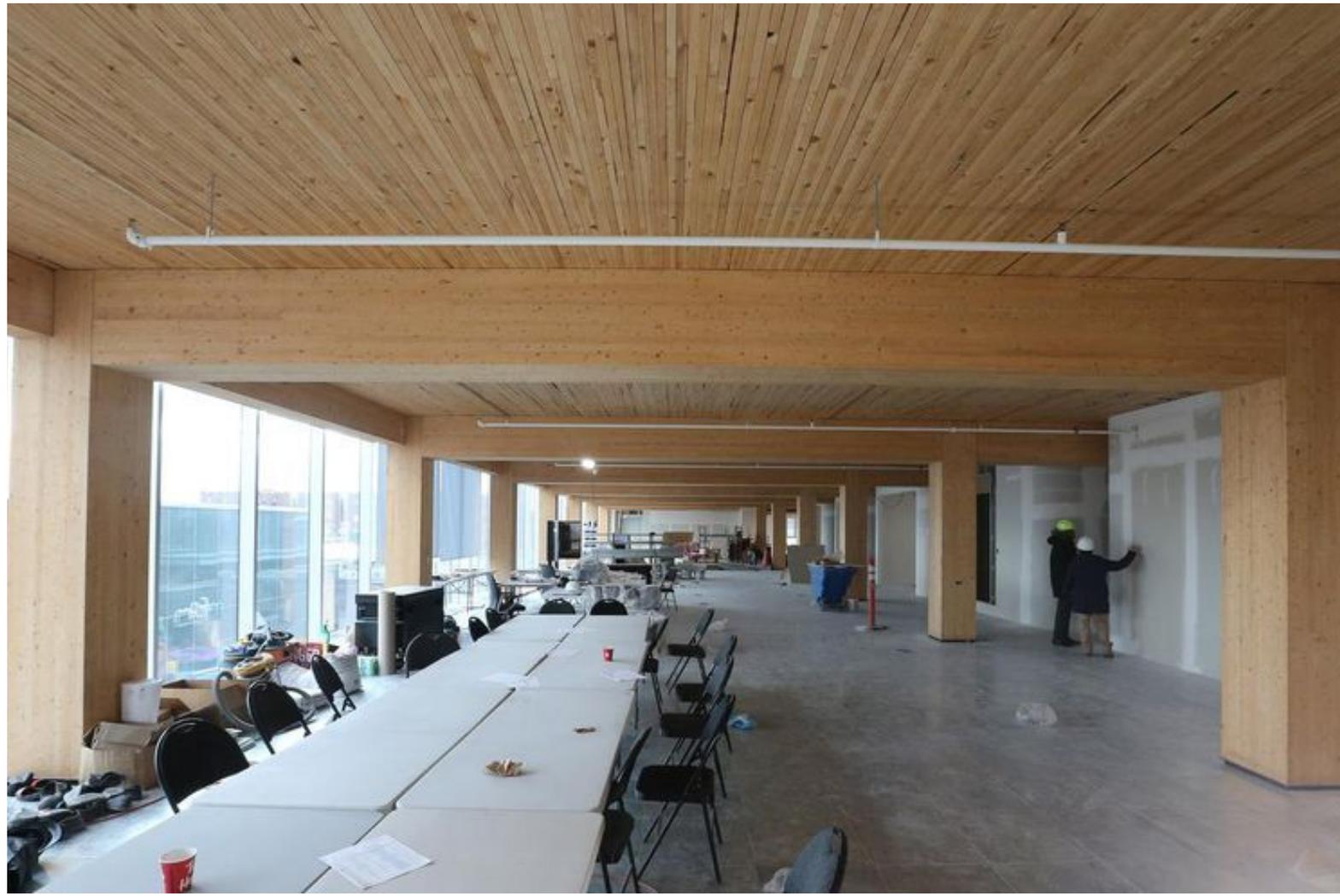
INNOVATIVE BUILDING TECHNOLOGIES



(Architecture & Design, 2020)



(Saleh, 2011)

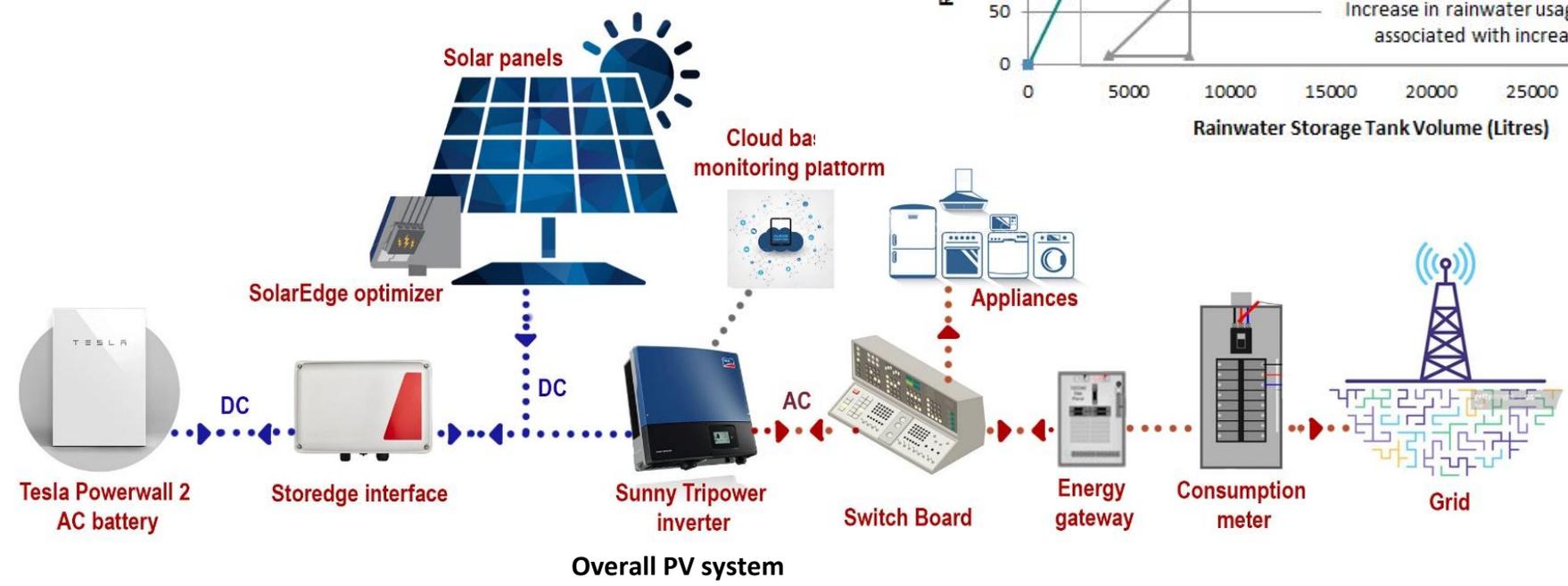
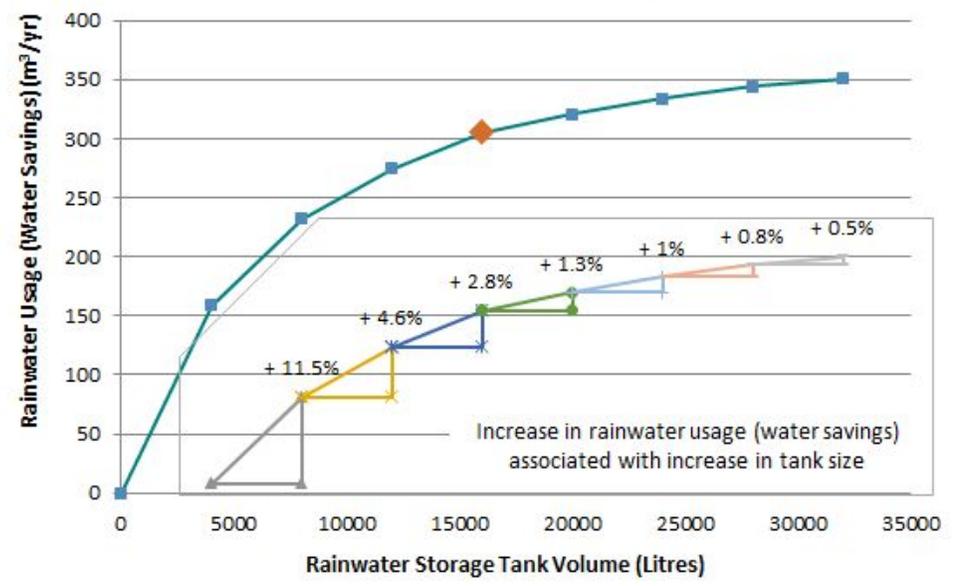


(Vincent, 2020)

RESILIENCE

- **Storage batteries** to provide backup power to the office.
- **Energy gateway** to detect grid outages and response accordingly
- **Rapid Shutdown system** for emergency situation
- Control of **rainwater inflow** into the city's sewers.

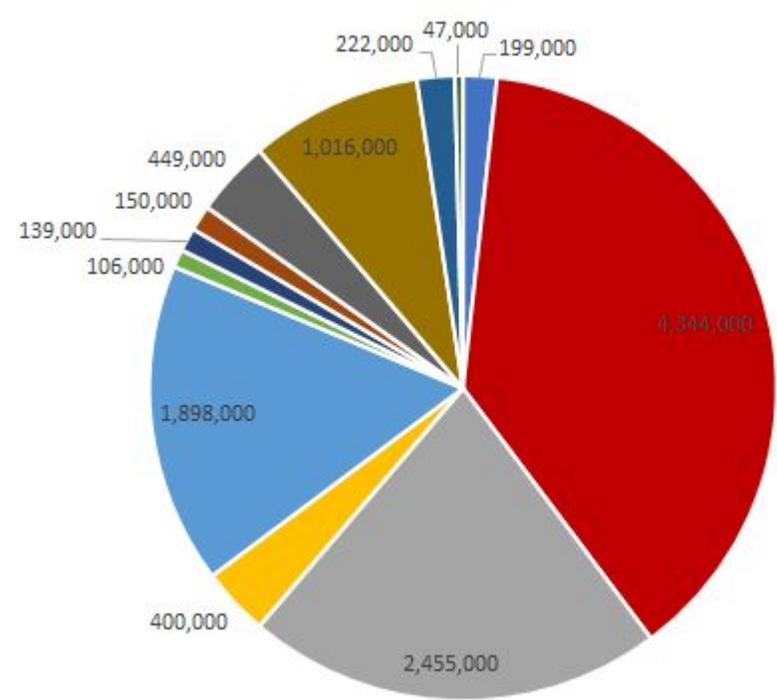
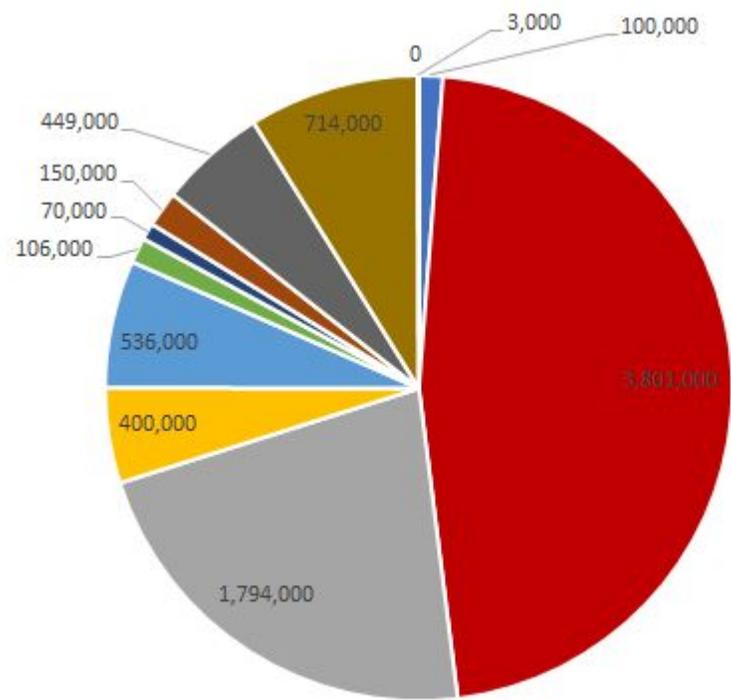
Storage tank size determination



Construction Cost Breakdown

Base Cost:
\$8.1 M total , \$185 PSF

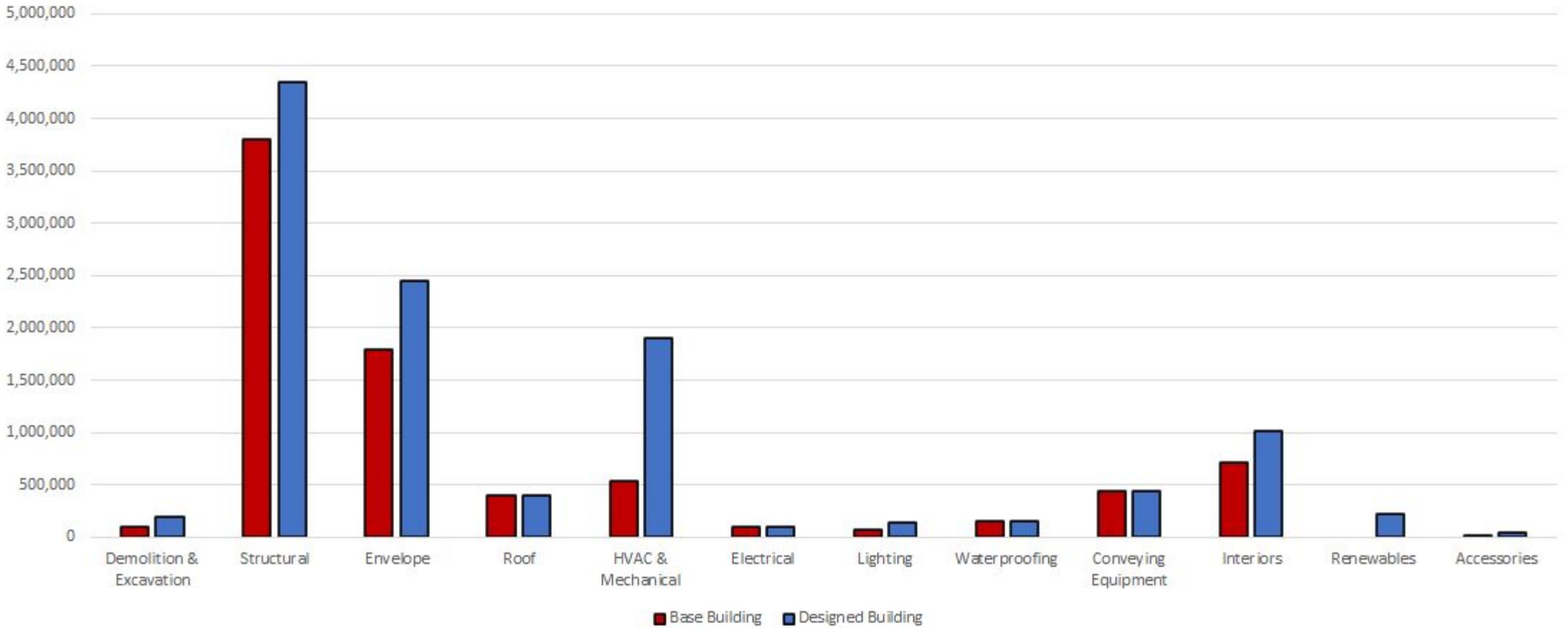
Designed Cost:
\$11.5 M total, \$258 PSF



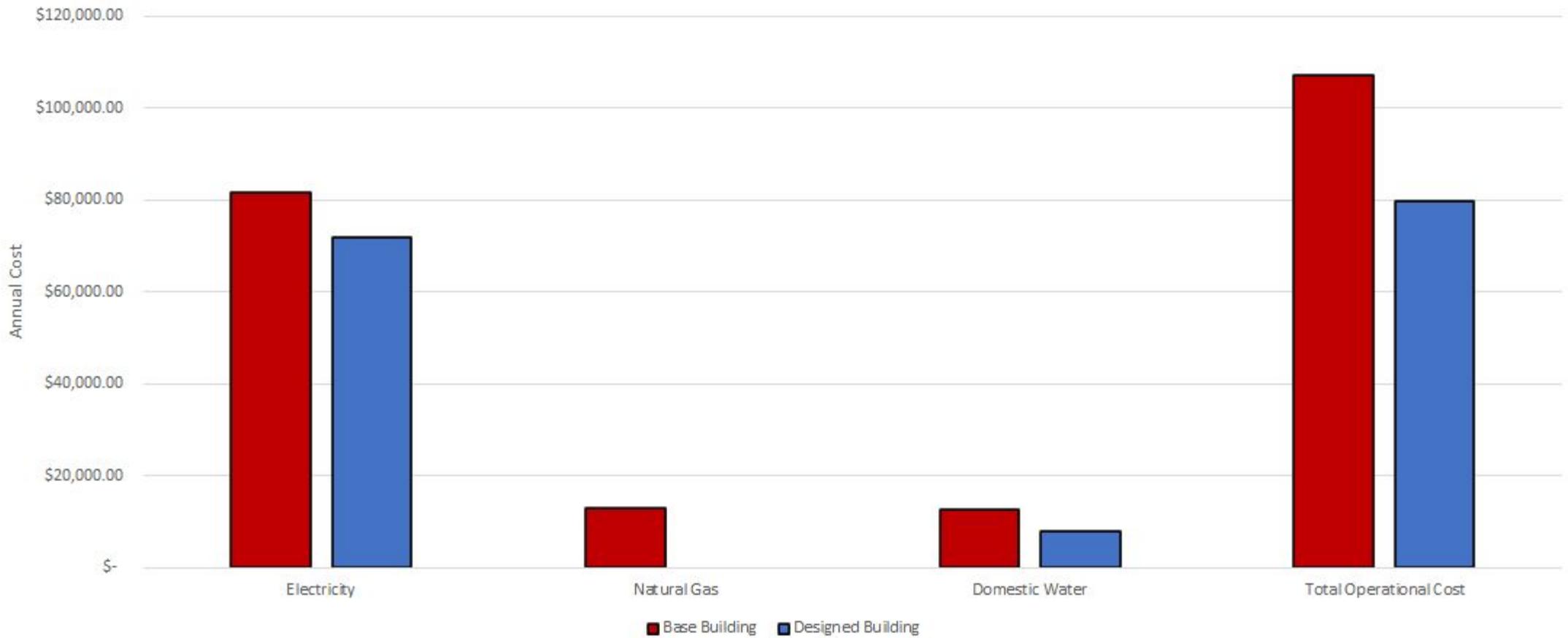
- Demolition & Excavation
- HVAC & Mechanical
- Conveying Equipment
- Structural
- Electrical
- Interiors

- Envelope
- Lighting
- Renewables
- Roof
- Waterproofing
- Accessories

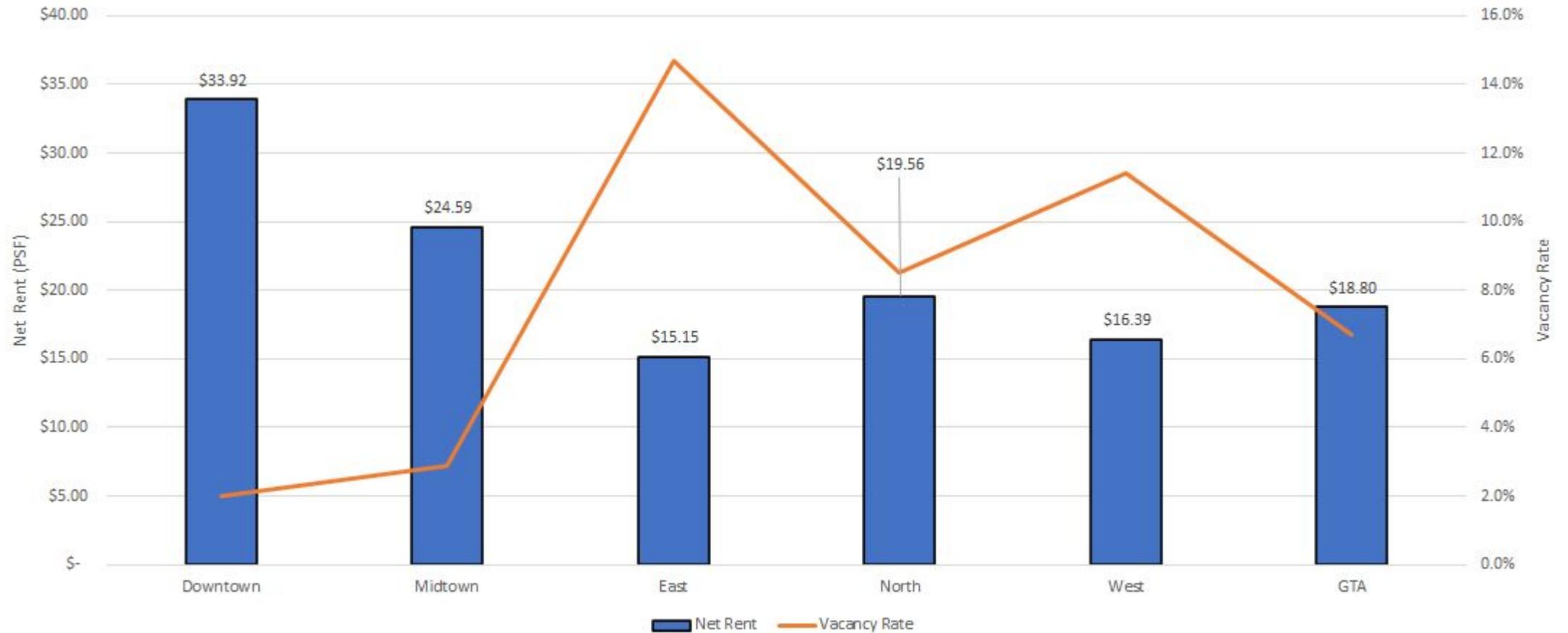
Construction Cost Comparison



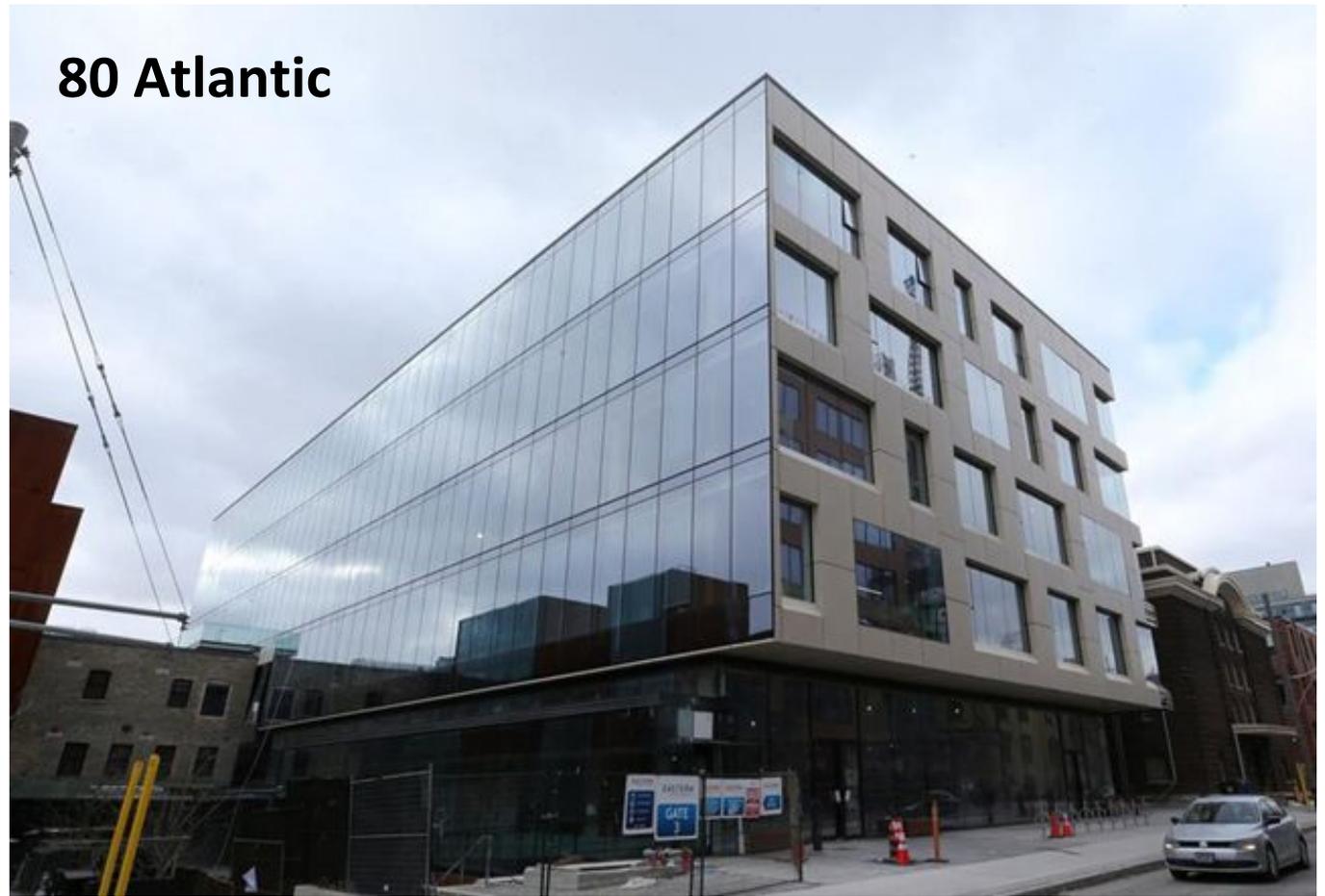
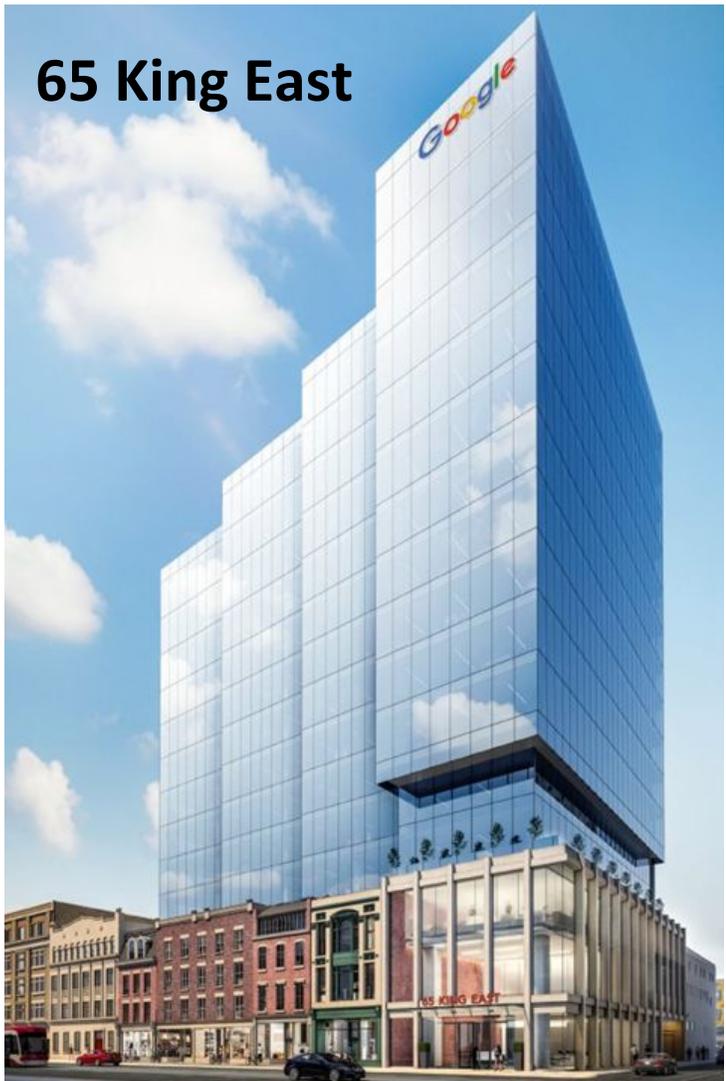
Operational Cost



The State of Toronto's Office Market



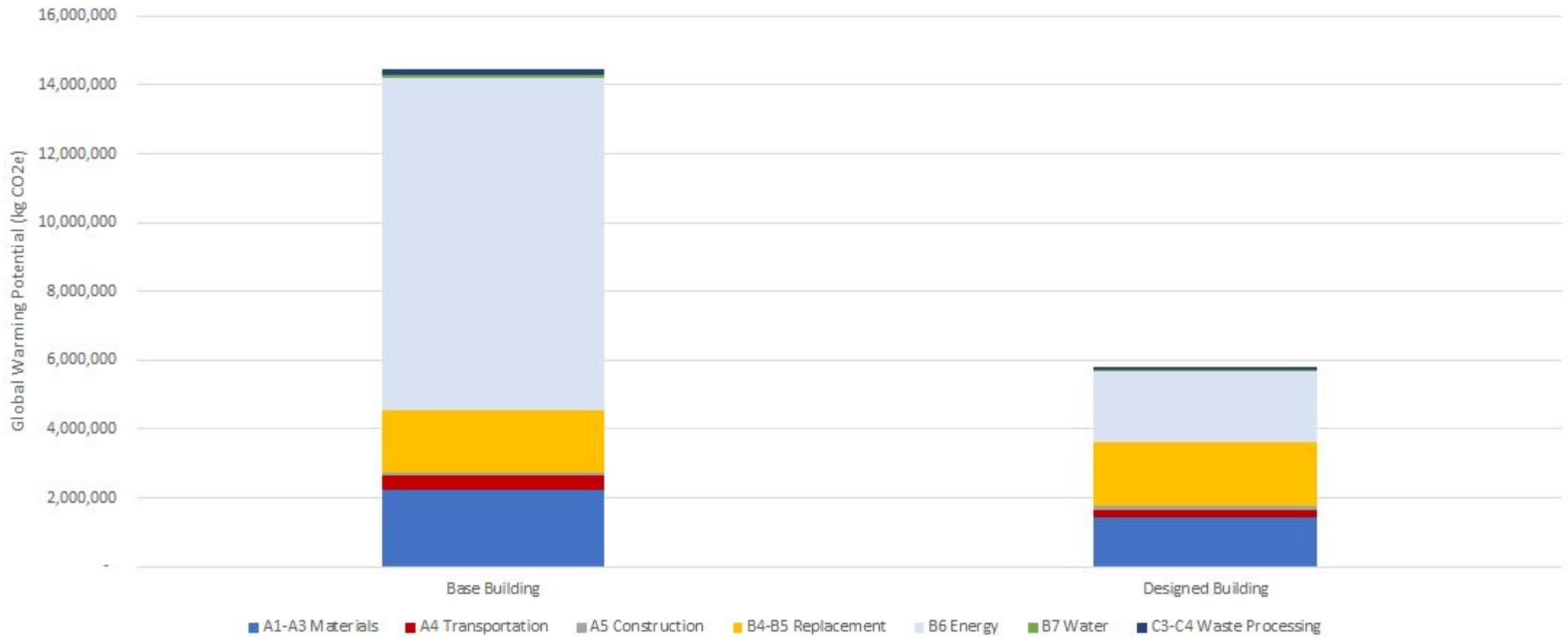
Design Precedent



(DCN-JOC News Services, 2020)

(Vincent, 2020)

Embodied Carbon





Introduction

Architecture

Energy

Engineering

IEQ

Operations

Innovation

Resilience

Financial
Feasibility

Market
Potential

Embodied
energy

Conclusion

TEAM MEMBERS



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Thank you!



References

Architecture & Design. (2020, 3 28). *Lighting the way: Human centric lighting and its contribution to social sustainability*. Retrieved from architectureanddesign.com:
<https://www.architectureanddesign.com.au/sustainability-awards/lighting-the-way-human-centric-lighting-and-its-co>

Blakey, J. A. (1907). *Jarvis St. Baptist Church, Jarvis St., north east corner Gerrard St. E.* Toronto Public Library. Retrieved 04 03, 2020, from <https://www.torontopubliclibrary.ca/detail.jsp?R=DC-PICTURES-R-521>

City of Toronto. (2018). *Aerial 2018 view of 101 Gerrard St, Zoomed out*. Retrieved from http://map.toronto.ca/maps/map.jsp?app=TorontoMaps_v2

City of Toronto Planning. (2018). *Ward 13 - Toronto Centre*. Retrieved from City of Toronto: https://www.toronto.ca/wp-content/uploads/2018/09/8f4b-City_Planning_2016_Census_Profile_2018_25Wards_Ward13.pdf

ClimateStudio. (2020, 3 2). *ClimateStudio*. Retrieved from Solemma: <https://www.solemma.com/ClimateStudio.html>

climateweather. (2020). Retrieved from climateweather.gc.ca:
https://climate.weather.gc.ca/climate_data/hourly_data_e.html?hlyRange=1953-01-01%7C1969-05-31&dlyRange=1840-03-01%7C2017-04-27&mlyRange=1840-01-01%7C2006-12-01&StationID=5051&Prov=ON&urlExtension=_e.html&searchType=stnProv&optLimit=yearRange&StartYear=18

Covarrubias, A. (2007, October 7). *File:North America second level political division 2 and Greenland.svg*. Retrieved from https://commons.wikimedia.org/wiki/File:North_America_second_level_political_division_2_and_Greenland.svg

DCN-JOC News Services. (2020, February 10). *Google signs lease for 18 floors at 65 King East build in Toronto*. Retrieved from
<https://canada.constructconnect.com/dcn/news/economic/2020/02/google-signs-lease-for-18-floors-at-65-king-east-build-in-toronto>

energyhub.org. (2020, 3 22). *Solar energy map Canada*. Retrieved from energyhub.org: <https://energyhub.org/solar-energy-maps-canada/>

Google earth. (2020, 4 9). Retrieved from
<https://earth.google.com/web/@43.66224413,-79.37744197,100.29133503a,1364.04928276d,35y,-0h,0t,0r/data=CkoaSBJCCiUweDg5ZDRjYjkwZDdjNjNiYTU6MHgzMjM1NTU1MDJhYjRjNDc3Gc1y2eic00VAIc01cReG2FPAKgdUb3JvbnRvGAEgAQ>

Helioscope. (2020, 3 1). *Helioscope*. Retrieved from helioscope.com: https://www.helioscope.com/designer/3051779/field_segments

Ryerson University. (2020). *Dr. Mark Gorgolewski - (Profile Photo)*. Retrieved from <https://www.ryerson.ca/architectural-science/people/faculty/mark-gorgolewski/>

Saleh, M. (2011, 2020 03). *Light Farm*. Retrieved 18, from <https://www.mohsen-saleh.com/2011/10/light-farm.html>

References

Sun path 3d. (2020, 3 30). *Sun path 3d*. Retrieved from drajmarsh.bitbucket.io: <https://drajmarsh.bitbucket.io/sunpath3d.html>

Sustainable Technologies Evaluation Program. (2020). *Rainwater Harvesting and Design and Costing Tool*. Retrieved from Sustainable Technologies: <https://sustainabletechnologies.ca/home/urban-runoff-green-infrastructure/low-impact-development/rainwater-harvesting/rainwater-harvesting-design-and-costing-tool/>

University of Toronto. (2020). *Building Energy and Indoor Environment (BEIE) Lab - Jamie Fine (Profile Photo)*. Retrieved from <https://beie.mie.utoronto.ca/members/>

Vincent, D. (2020, March 2). 'The smell is very appealing.' Five-storey timber-based building in Liberty Village has been completed. *The Toronto Star*.