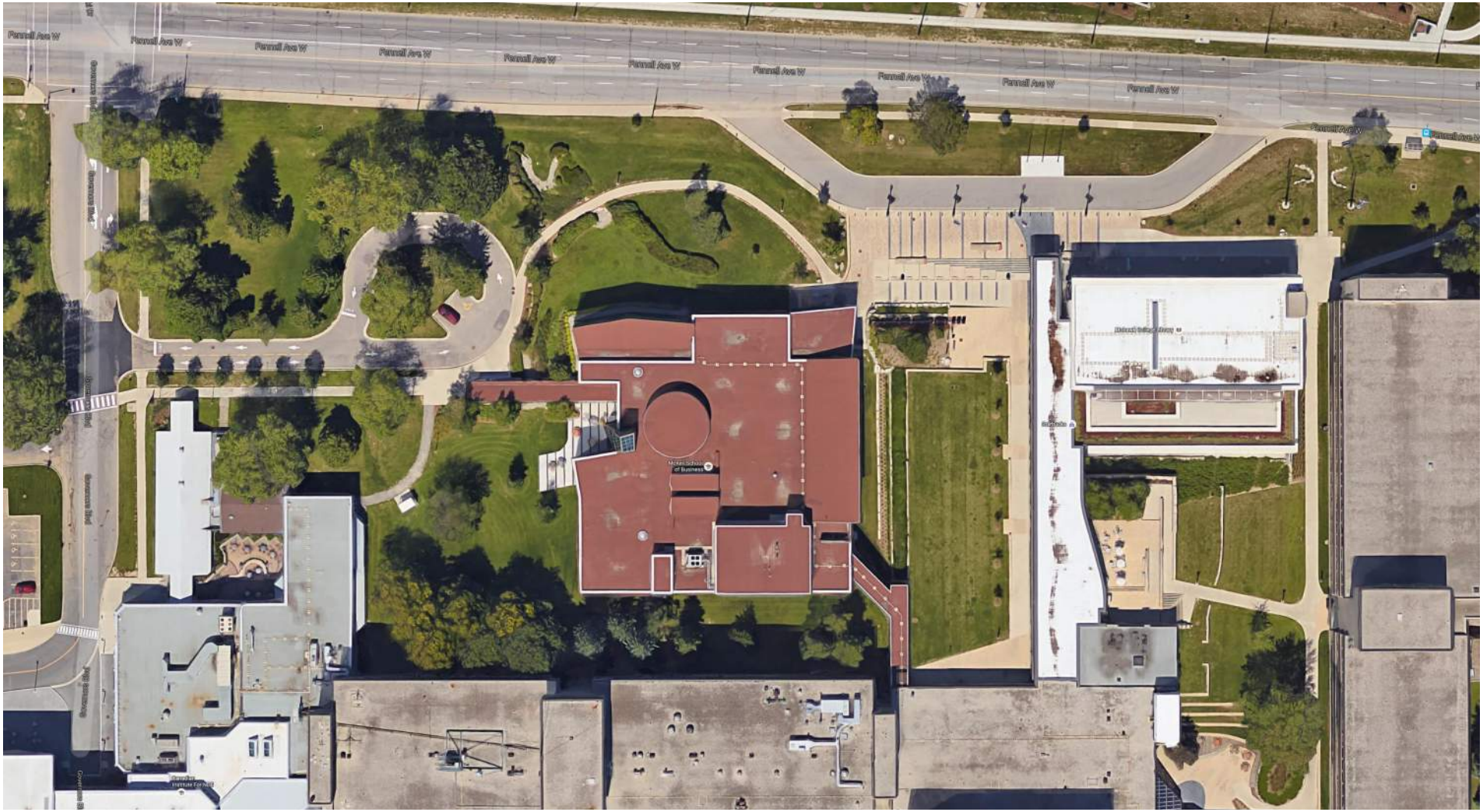
NetZero Design: A How to Guide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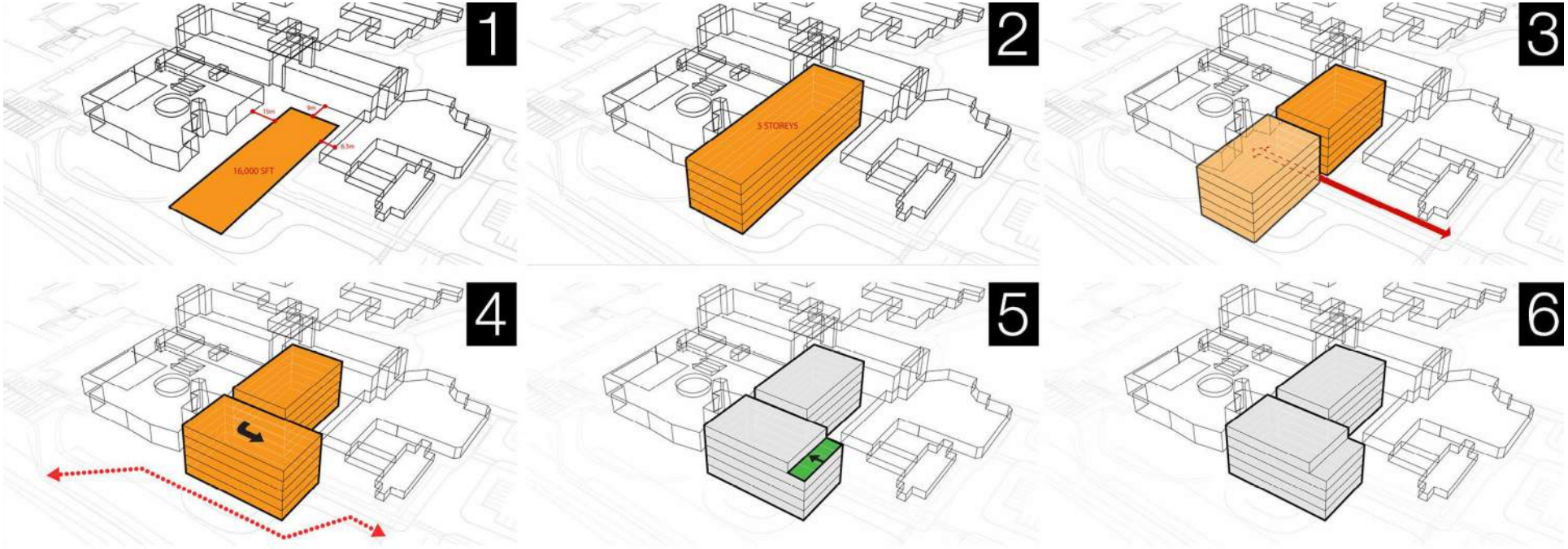
Michels School of Business

The Site



The Site

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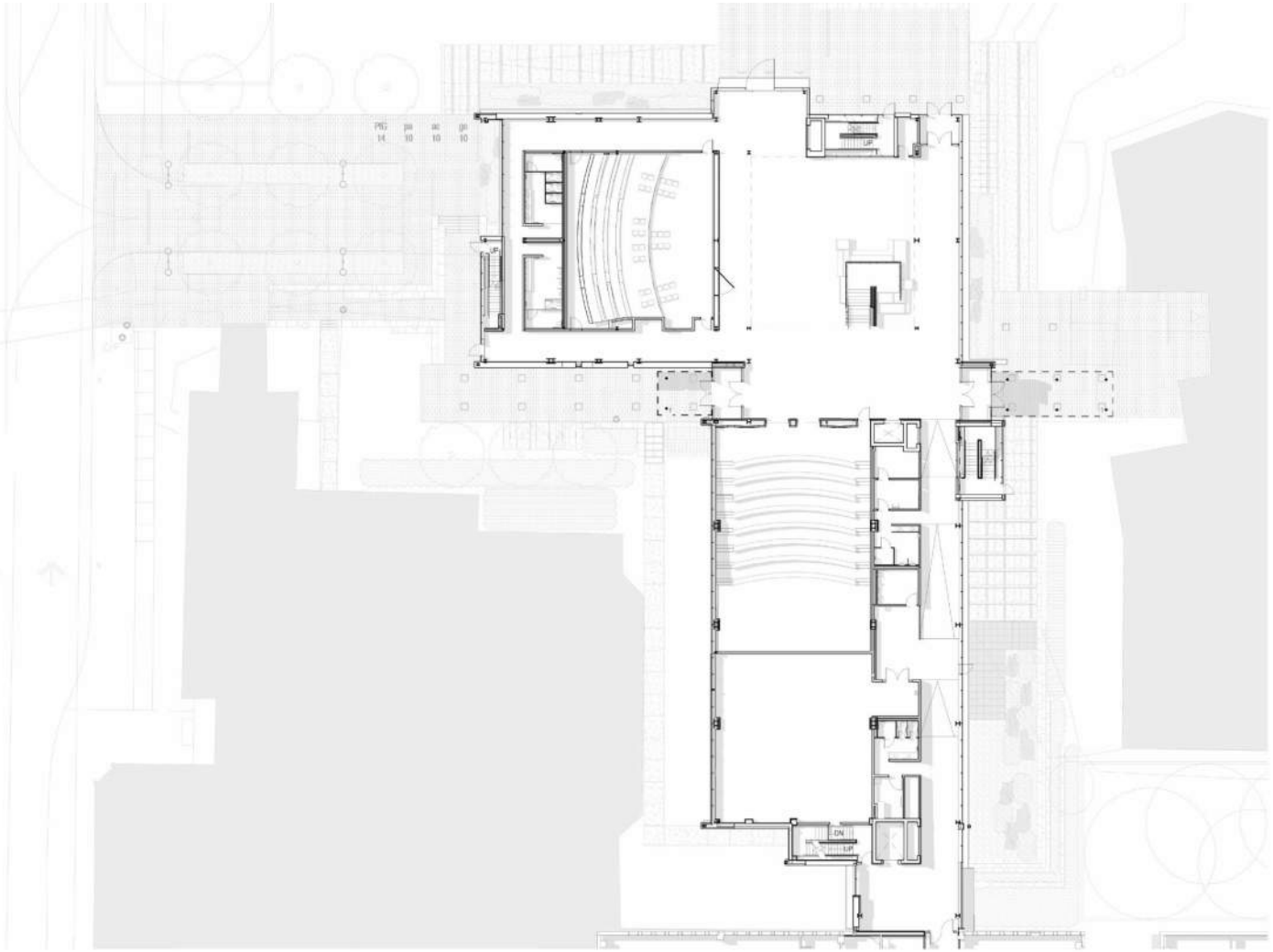

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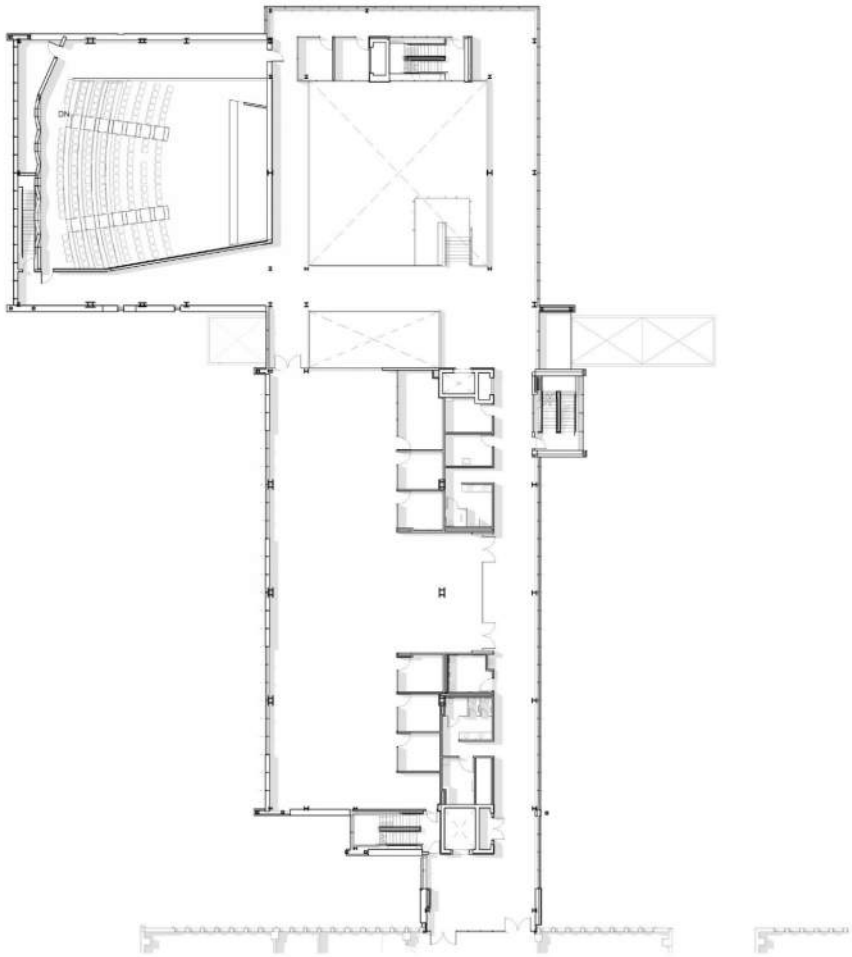

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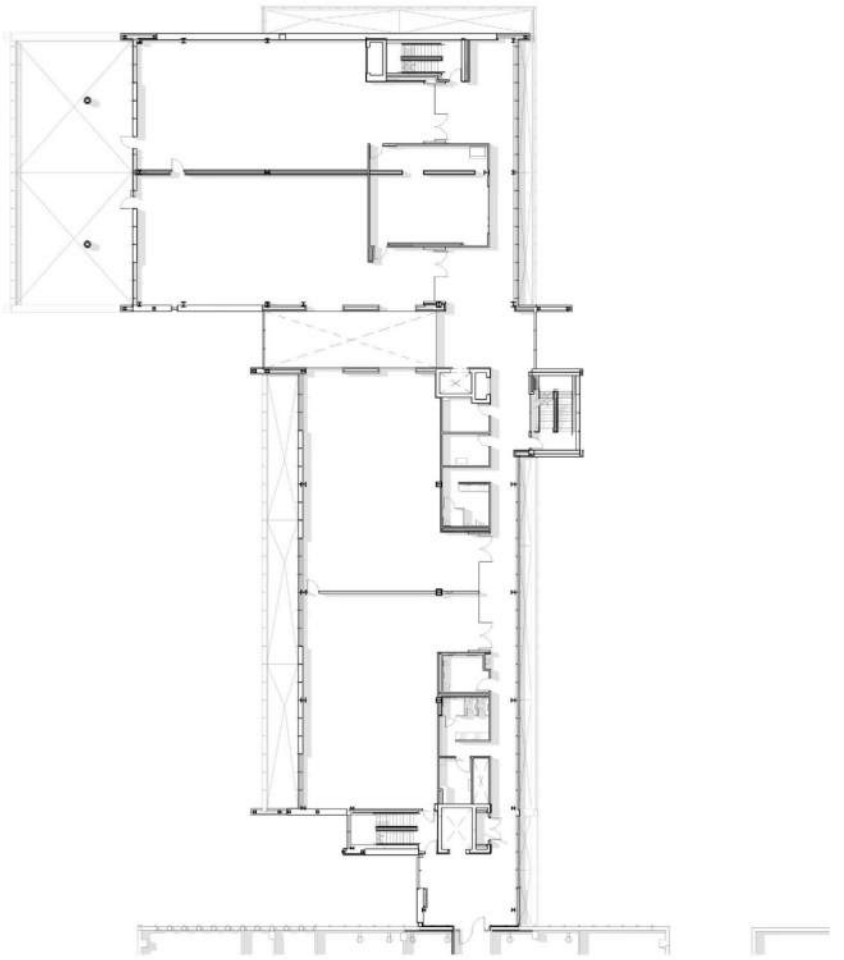

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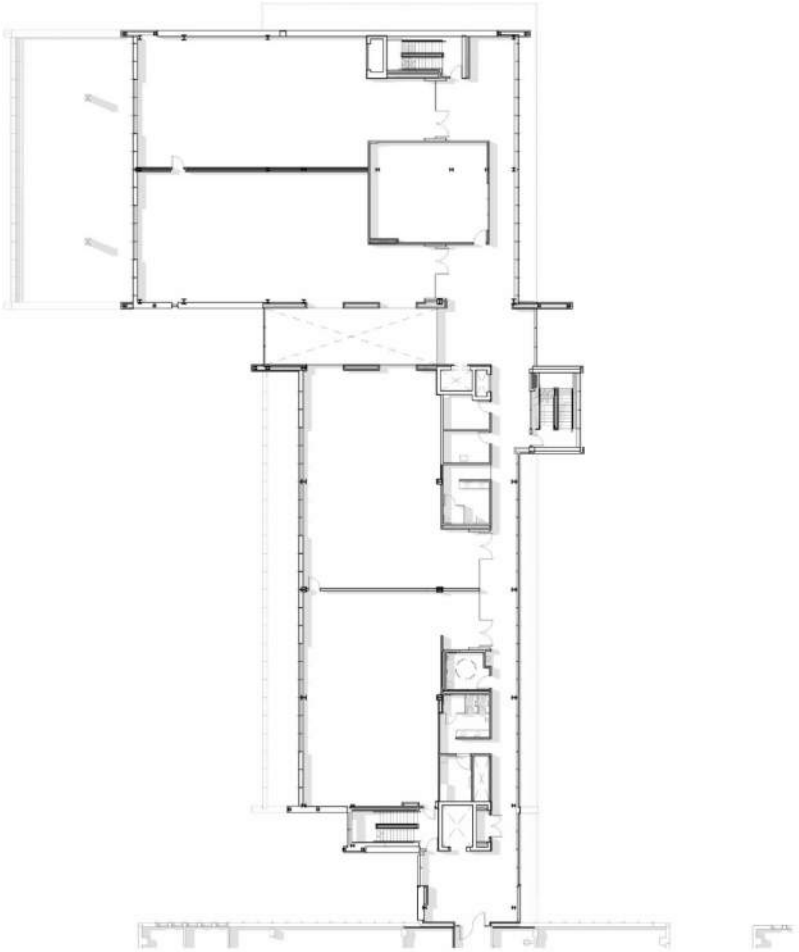

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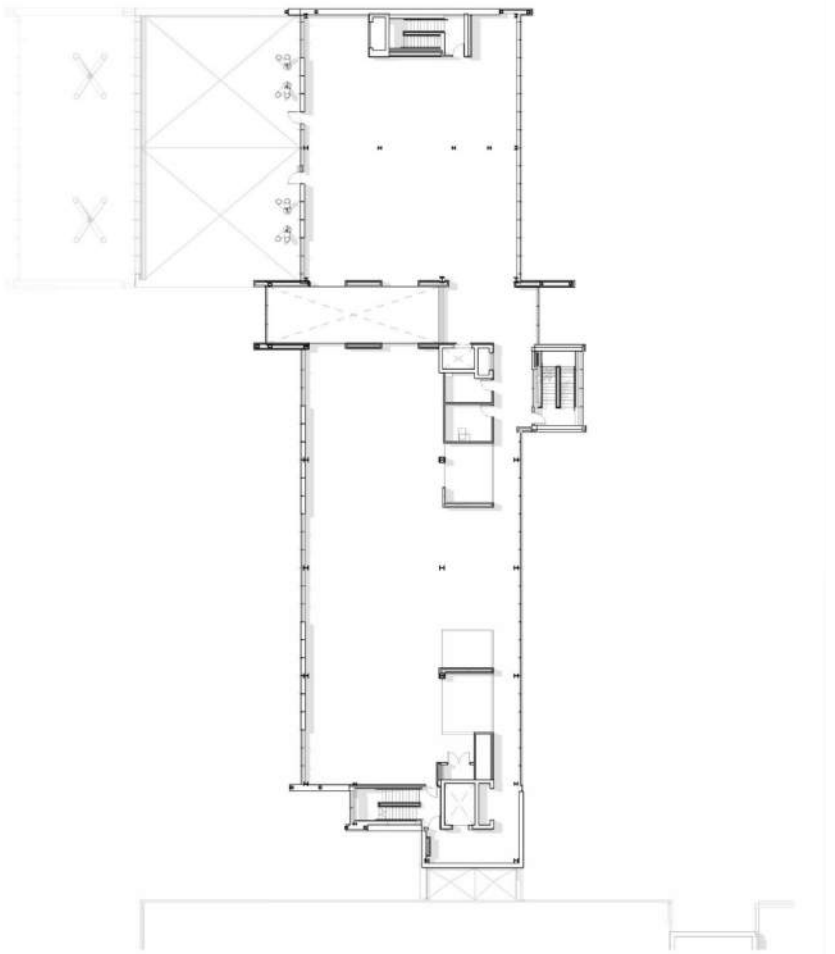
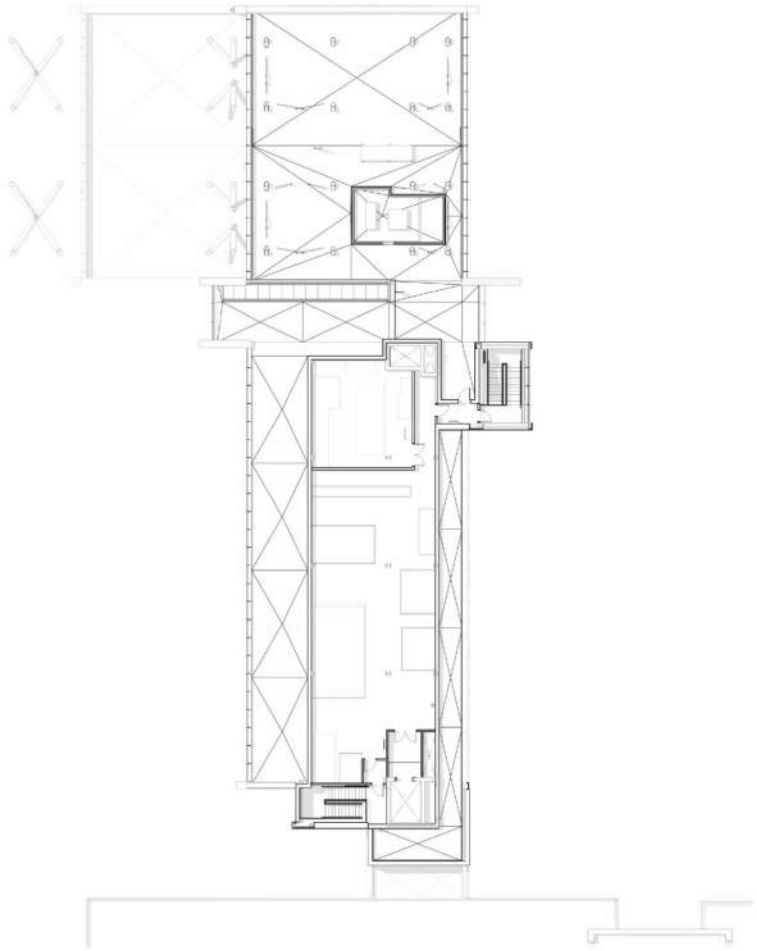
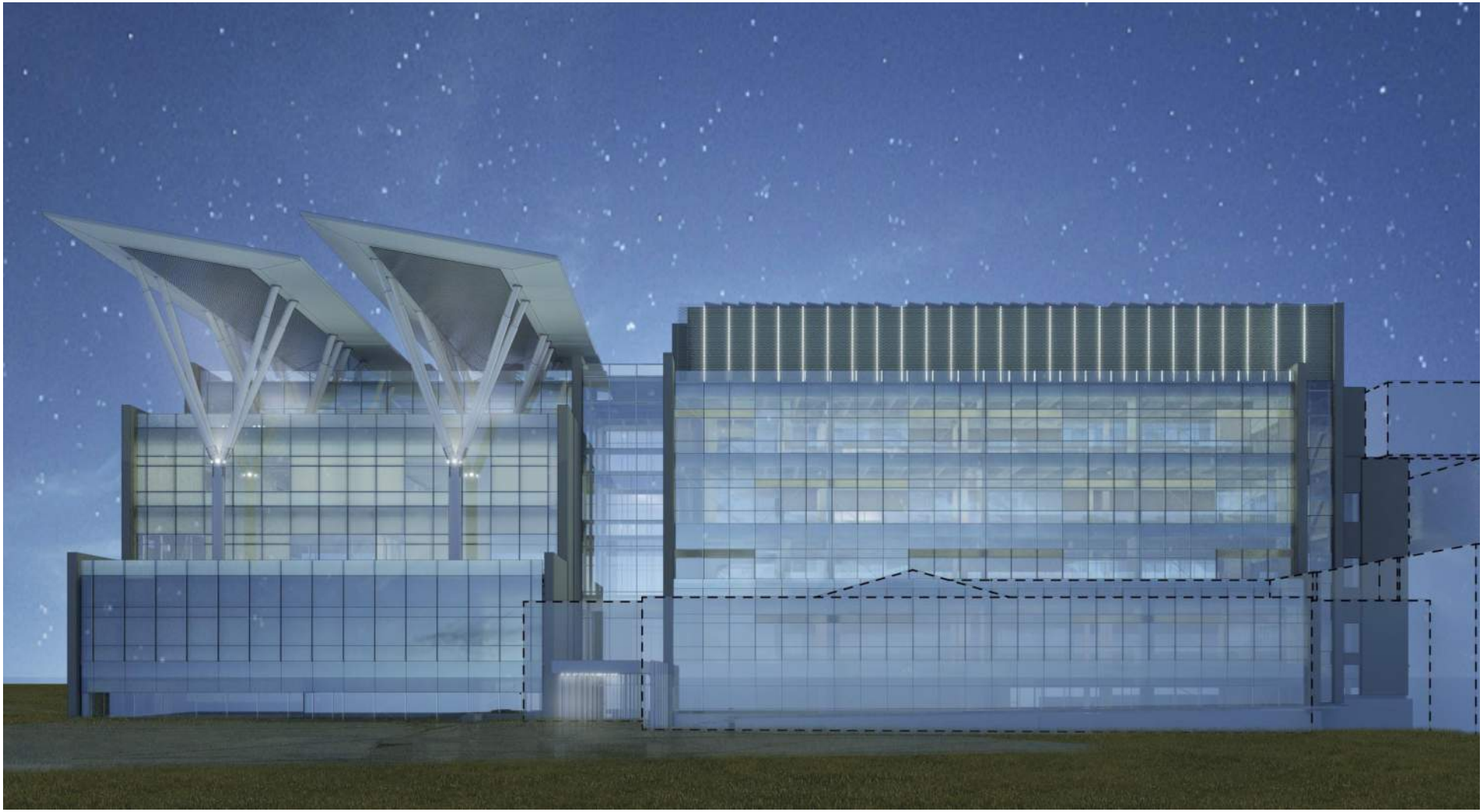


Level 4



Penthouse


THE LOVEE CENTRE
FOR PARTNERSHIPS IN MEDICINE



EUI - Energy Use Intensity
TEDI - Thermal Energy Demand Intensity
GHGI - Greenhouse Gas Intensity

VRF - Variable Refrigerant Flow
DOAS - Dedicated Outdoor Air System
COP - Coefficent of Performance
GSHP - Ground Source Heat Pump

eKwH - Equivalent Kilowatt Hours
CREAM - Cash Rules Everything Around Me

Basics

Generate as much energy as you use annualized over the year.

What is NetZero Energy?

FIT - Feed In Tarriff
Net Metering
Battery Storage

Strategies

Energy Budget
Envelope
Mechanical Systems
Measurement and Verification

Basics

313 kWh/M²/year
NRCAN Commercial Buildings Average

73 kWh/M²/year
JCPIC Building

EUI Final Modeled Value

75 kWh/M²/year

First Meeting Target

Setting the Budget

End Use	Radiant Heating / Cooling + GHSP	Radiant Heating / Cooling + GHSP + Solar Thermal	Water Source VRF + GHSP	Water Source VRF + GHSP + Solar Thermal	Water Source VRF + Boiler / CT	Water Source VRF + Boiler / CT + Solar Thermal	Air Source VRF Heating / Cooling
Lighting	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Misc. Equipment	19.3	19.3	19.3	19.3	19.3	19.3	19.3
Space Heating	17.1	8.6	13.7	9.6	13.0	13.0	21.4
Space Cooling	8.0	8.0	6.4	6.4	6.4	6.4	8.7
Pumps and Aux	9.6	11.0	6.7	8.2	3.4	4.8	**0.0**
Fans	7.5	7.5	11.3	11.3	11.3	11.3	11.3
DHW	4.5	2.3	4.5	2.3	4.5	2.25	4.5
Boiler	0.0	0.0	0.0	0.0	19.5	9.7	0.0
Total (ekWh/m²)	**76.7**	**67.3**	**72.5**	**67.6**	**88.0**	**77.4**	**75.9**
Rank (lowest to highest)	5	1	3	2	7	6	4
Net Solar Thermal Effect (ekWh/m²)		-9.4		-4.9		-10.6	
Total ekWh	578,000	508,000	547,000	510,000	664,000	584,000	573,000
Annual Energy Cost	**$ 69,360**	**$ 60,960**	**$ 65,640**	**$ 61,200**	**$ 65,760**	**$ 63,120**	**$ 68,760**
Size of PV Array (kWp)	525	462	497	464	604	531	521
Size of PV Array (m²)	4,379	3,848	4,144	3,864	5,030	4,424	4,341
Flat Roof Area (m²)	8,758	7,697	8,288	7,727	10,061	8,848	8,682
Cost of PV	**$ 1,320,000**	**$ 1,160,000**	**$ 1,250,000**	**$ 1,160,000**	**$ 1,510,000**	**$ 1,330,000**	**$ 1,310,000**
NREL Recommended O&M / ye	**$ 9,900**	**$ 8,700**	**$ 9,375**	**$ 8,700**	**$ 11,325**	**$ 9,975**	**$ 9,825**
Linear m of Borehole	4,400	4,400	4,400	4,400			
# of 500' boreholes	29	29	29	29			
m² Area of Field using 6 m spaci	1,039	1,039	1,039	1,039			
Cost of Borehole	**$ 440,000**	**$ 440,000**	**$ 440,000**	**$ 440,000**			
Size Solar Thermal Panels (m²) --see note		212		112		242	
Approx. Cost of Solar Thermal		**$ 127,273**		**$ 67,273**		**$ 145,455**	
Net Solar Collector Size (m²)	**4,379**	**4,061**	**4,144**	**3,976**	**5,030**	**4,667**	**4,341**

Note: 60° Slope is preferred for Solar Thermal to prefer winter performance

Energy Budget

End Use	Radiant Heating / Cooling + GHSP
Lighting	10.7
Misc. Equipment	19.3
Space Heating	17.1
Space Cooling	8.0
Pumps and Aux	9.6
Fans	7.5
DHW	4.5
Boiler	0.0
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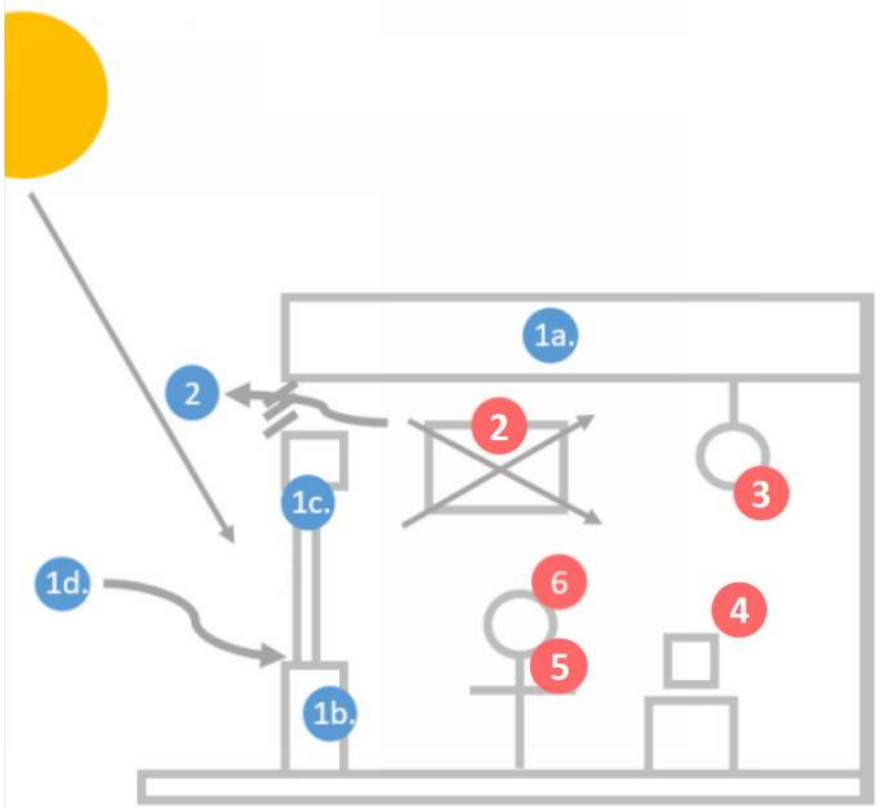
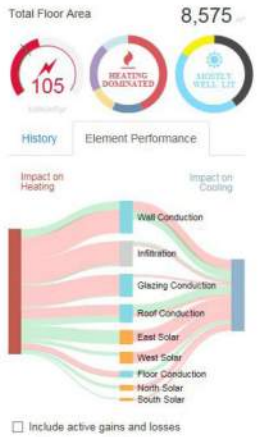
Understanding the Budget



1. Enclosure
2. Ventilation
3. Lighting
4. Plug Loads
5. Occupancy

BASELINE



MOHAWK

Understanding the Loads

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Understanding the Loads

R10 Effective Window +Wall

Ontario SB-10 Climate Zone 5
Requirement R4.7
(U-Value:
Imperial 0.1 BTU/hr-sq ft°F or
Metric 0.5678 W/M^2-K)

Enclosure

$$U_{avg} = \frac{U_1 \times A_1 + U_2 \times A_2}{A_{total}}$$

Calculating U-Values

$$R=1/U$$

$$U=1/R$$

Why inverse relationships are important for calculating mean values.

Understanding U-Values

$$R_{avg} = \frac{R_1A_1 + R_2A_2}{A_{Total}}$$

$$U_{avg} = \frac{U_1A_1 + U_2A_2}{A_{Total}}$$

$$R_{avg} = \frac{(40)60 + (8)40}{100_{Total}}$$

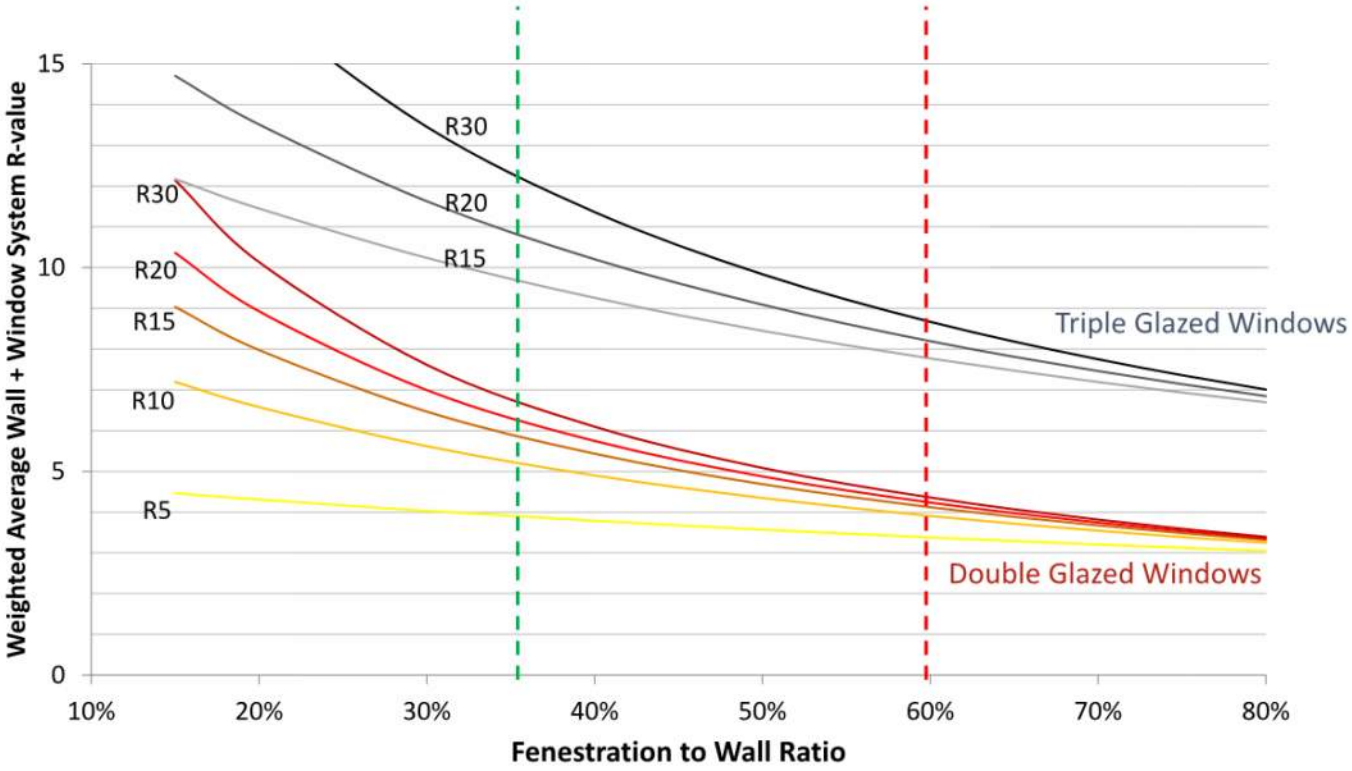
$$U_{avg} = \frac{(1/40)60 + (1/8)40}{100_{Total}}$$

$$R_{avg} = R27$$

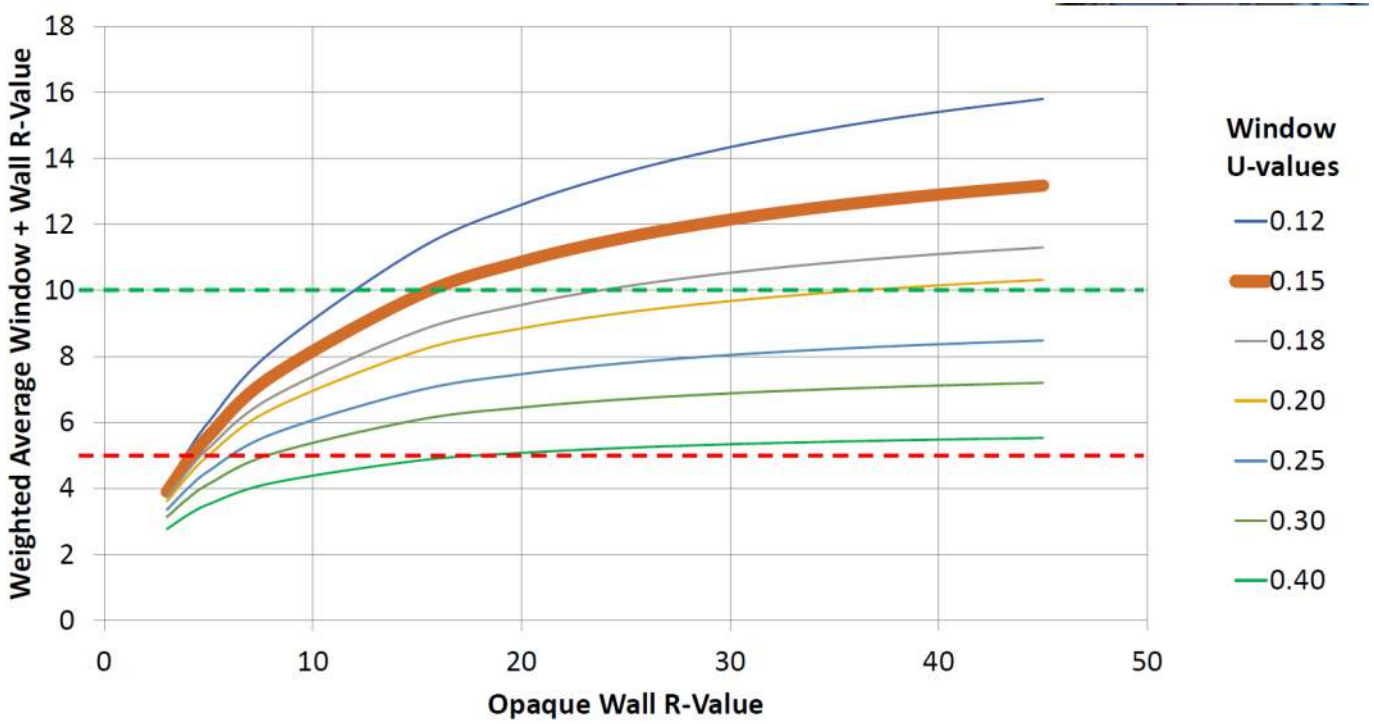
$$U_{avg} = .065$$

$$R_{avg} = 1/.065 = R15.3$$

Understanding U-Values

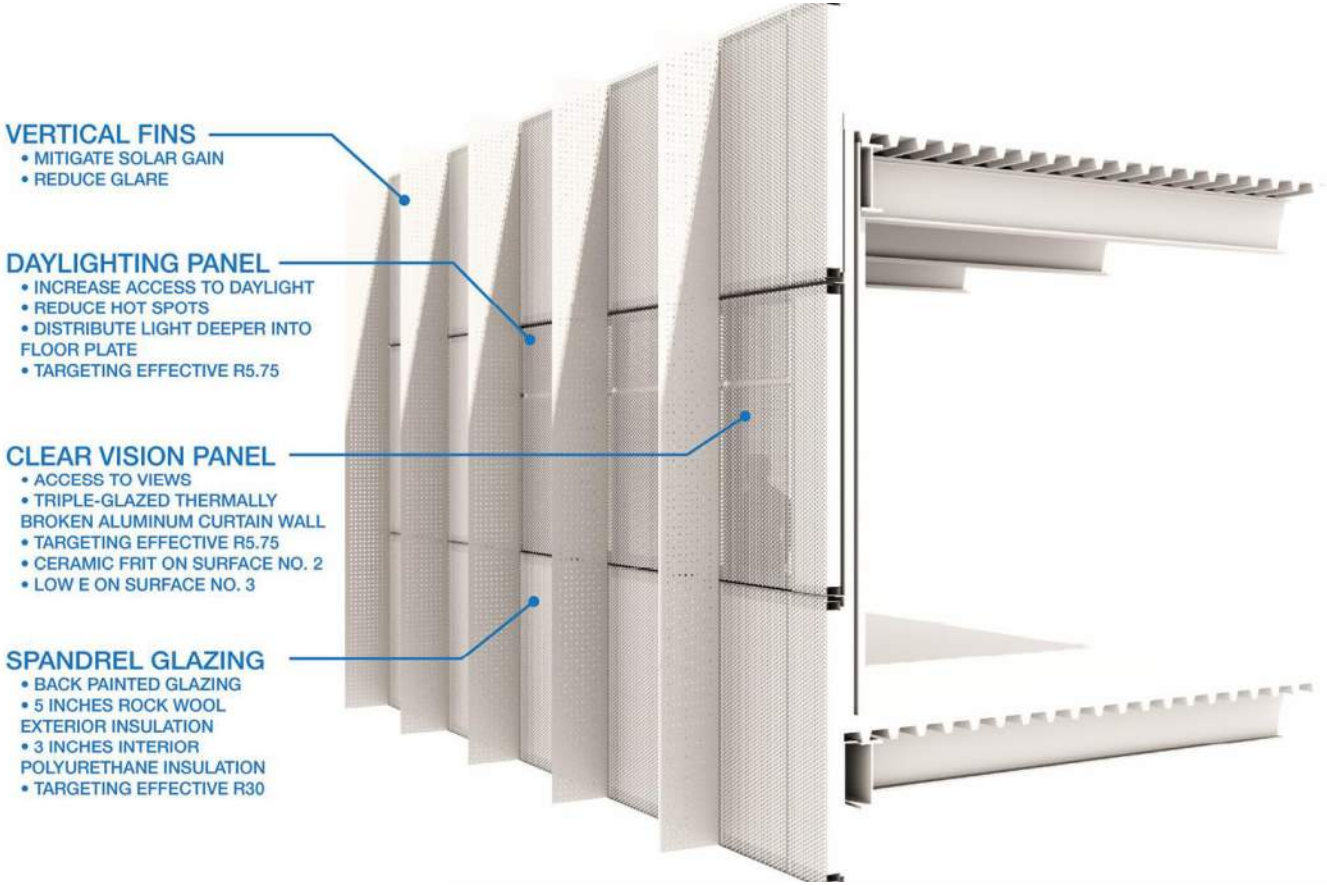


Window to Wall Ratios

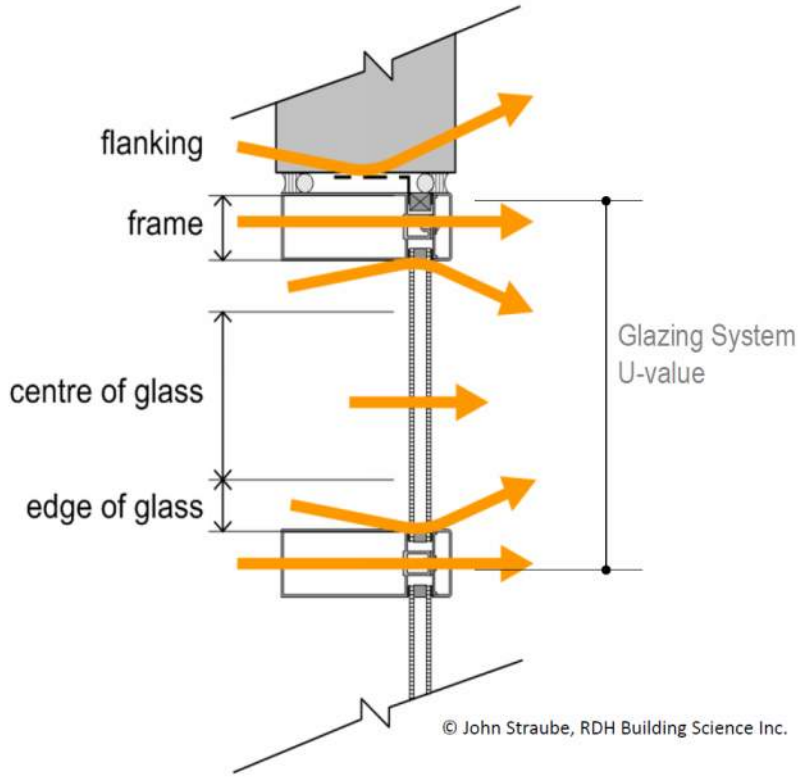


Based on 38% WWR
Total U-Value including Frame losses

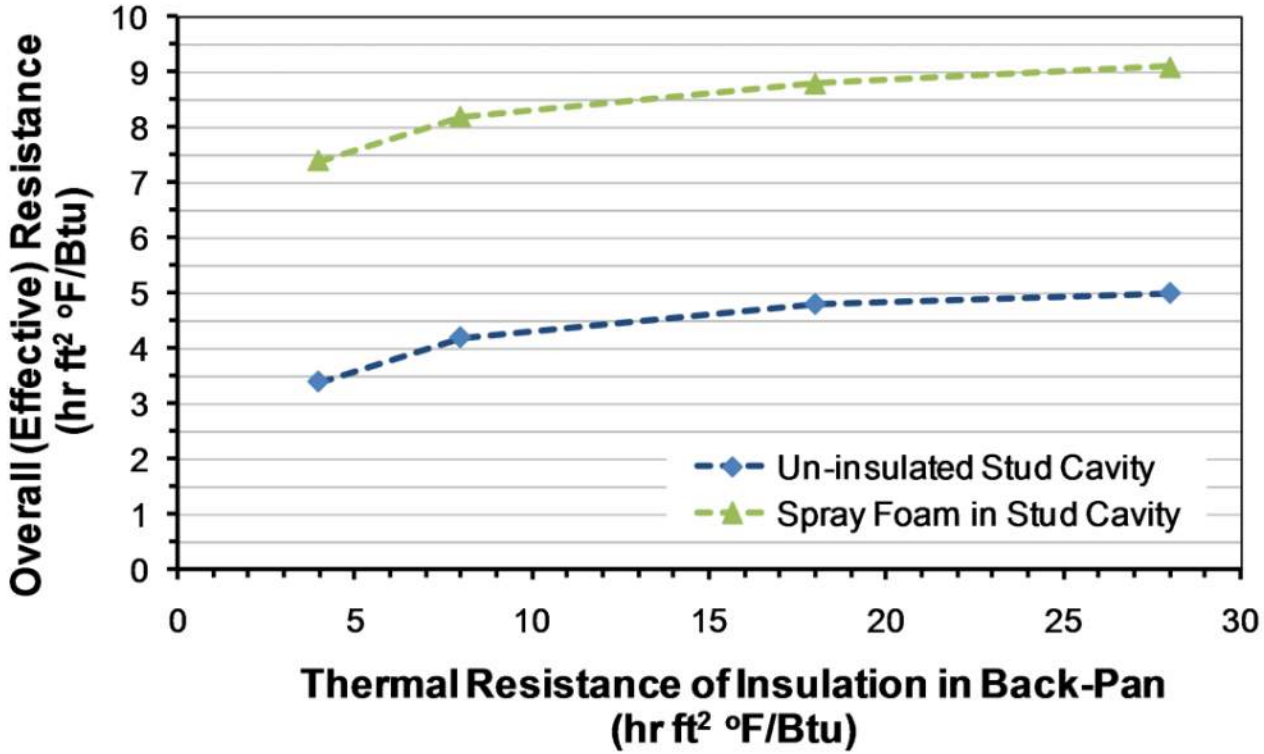
Window U-Values


VERTICAL FINS
• MITIGATE SOLAR GAIN
• REDUCE GLARE
DAYLIGHTING PANEL
• INCREASE ACCESS TO DAYLIGHT
• REDUCE HOT SPOTS
• DISTRIBUTE LIGHT DEEPER INTO FLOOR PLATE
• TARGETING EFFECTIVE R5.75
CLEAR VISION PANEL
• ACCESS TO VIEWS
• TRIPLE-GLAZED THERMALLY BROKEN ALUMINUM CURTAIN WALL
• TARGETING EFFECTIVE R5.75
• CERAMIC FRIT ON SURFACE NO. 2
• LOW E ON SURFACE NO. 3
SPANDREL GLAZING
• BACK PAINTED GLAZING
• 5 INCHES ROCK WOOL EXTERIOR INSULATION
• 3 INCHES INTERIOR POLYURETHANE INSULATION
• TARGETING EFFECTIVE R30

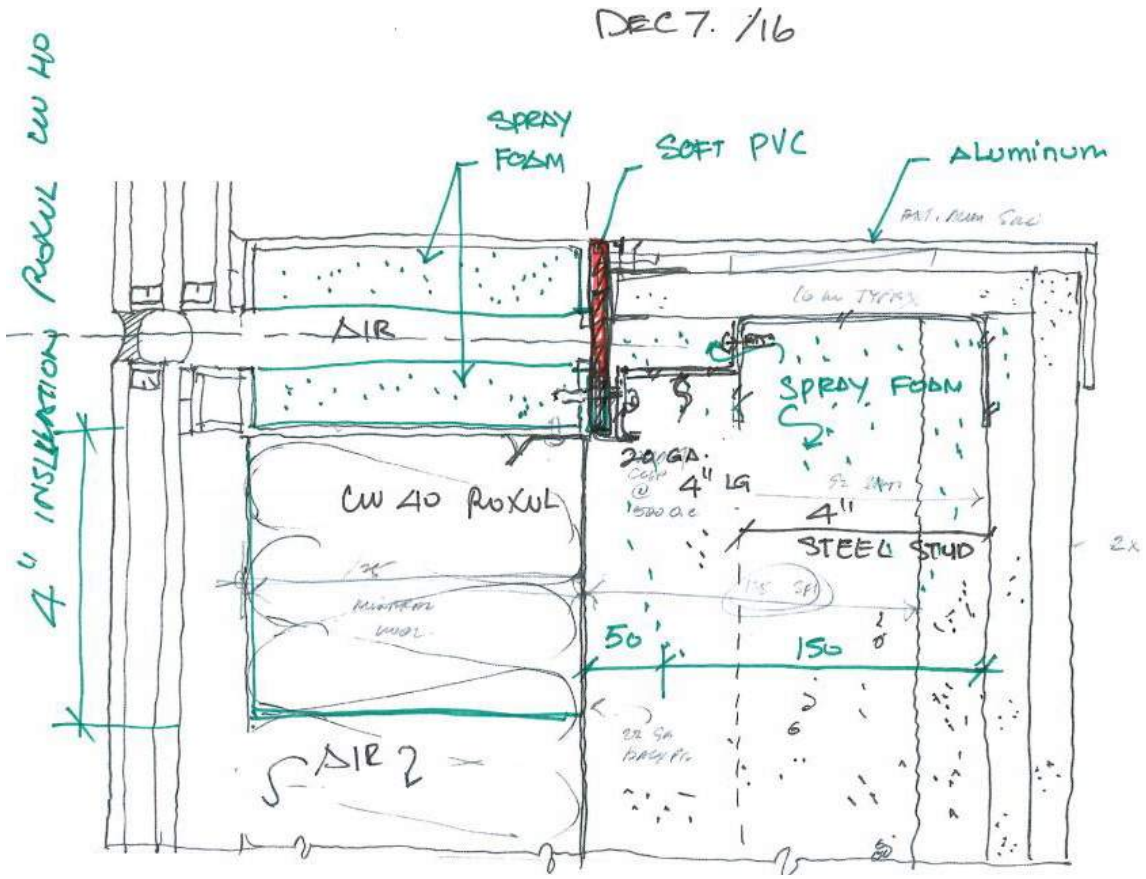
Envelope



Thermal Flanking

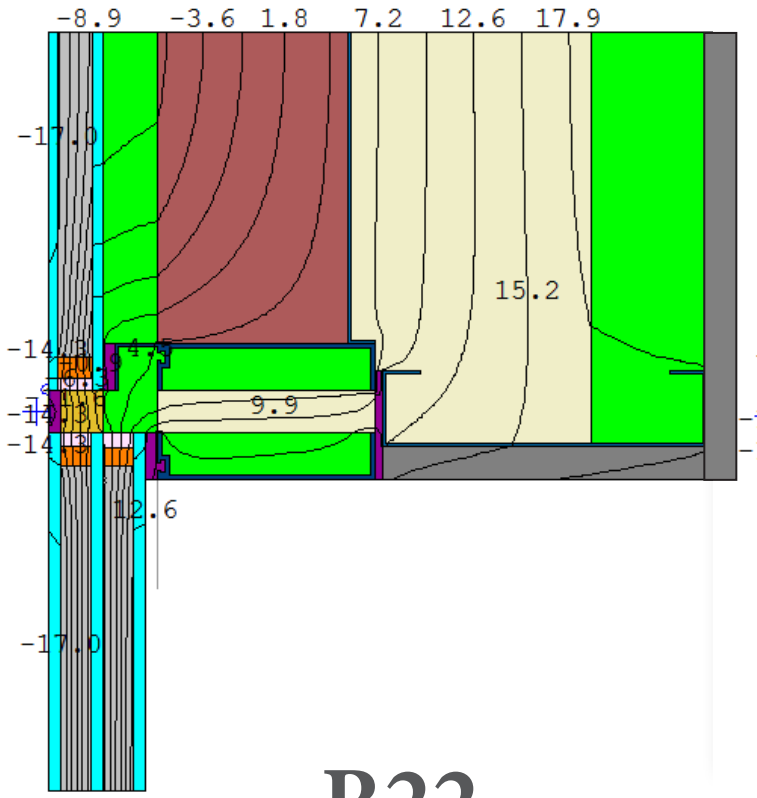


Insulating a Spandrel Panel

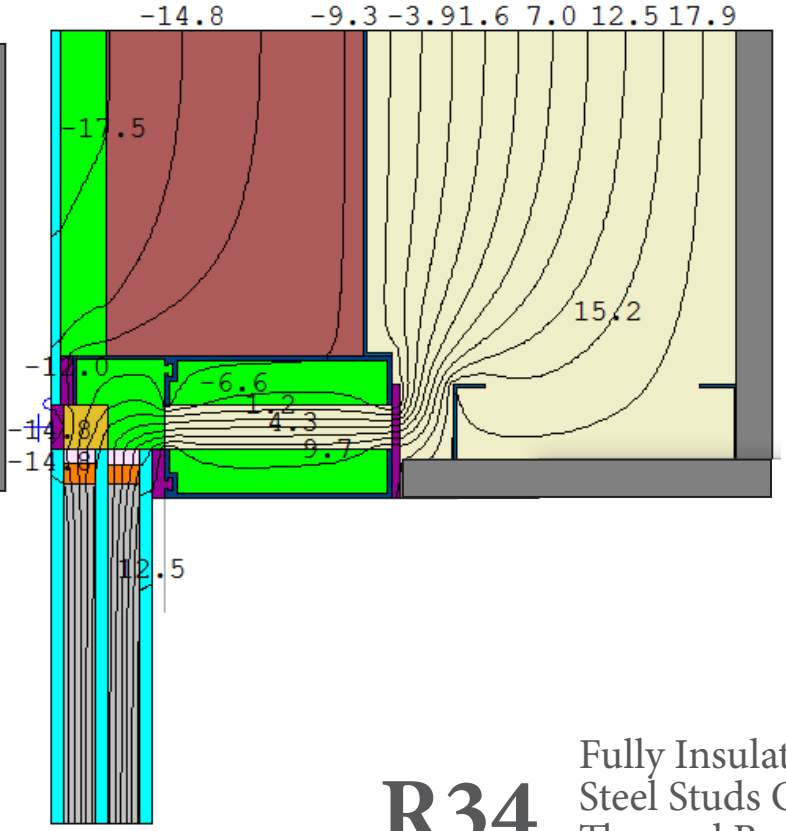


Fully Insulated Backpan
Steel Studs Offset at Cavity Wall
Thermal Breaks to Prevent Flanking

Insulating a Spandrel Panel



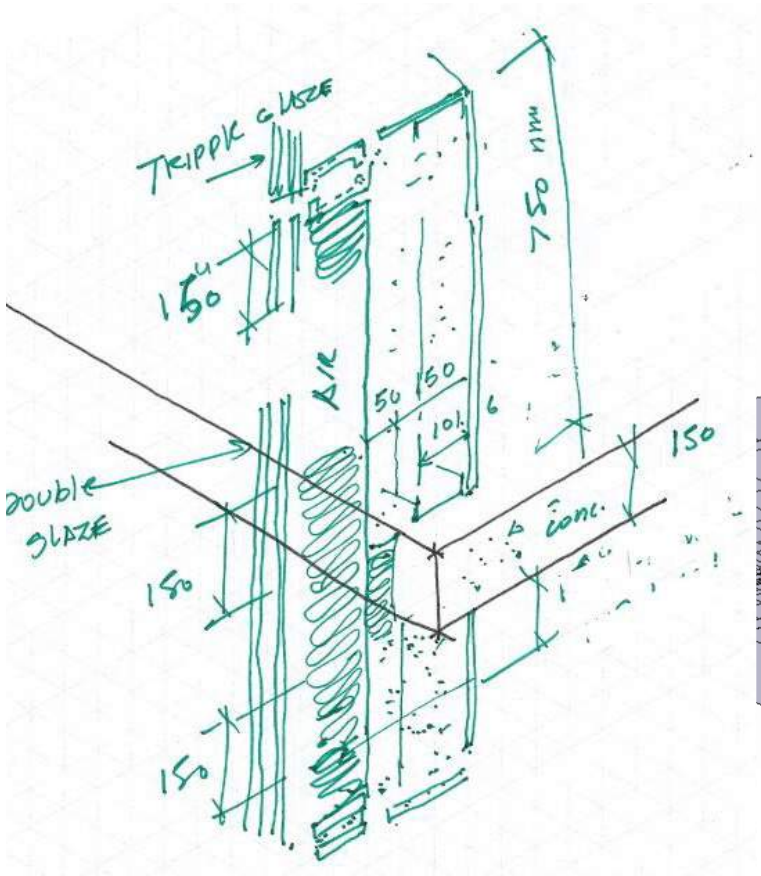
R22

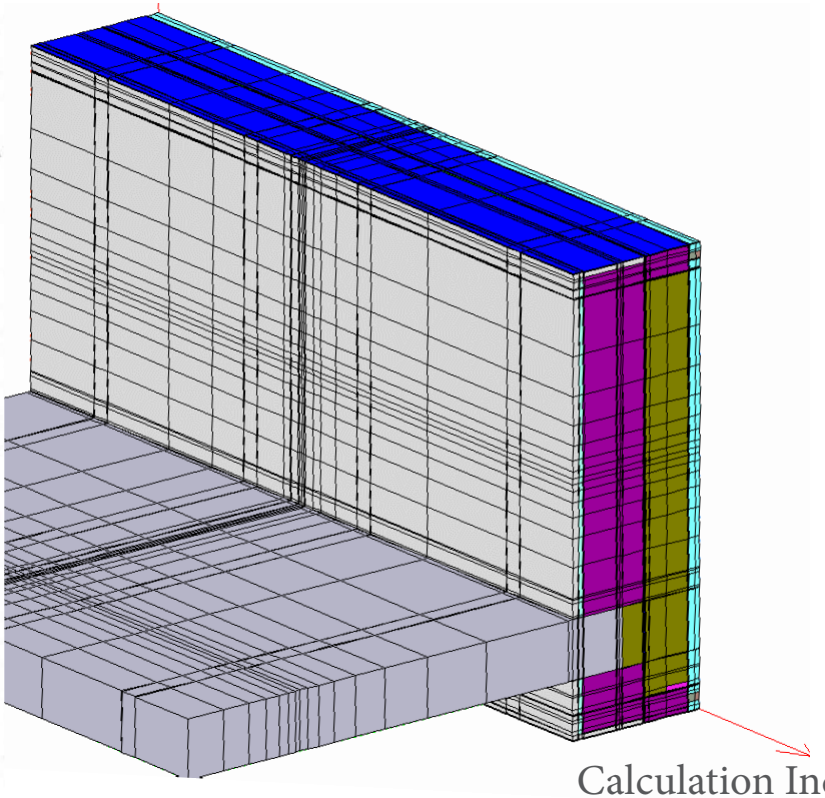


R34

Fully Insulated Backpan
Steel Studs Offset at Cavity Wall
Thermal Breaks to Prevent Flanking

2D Therm Modeling

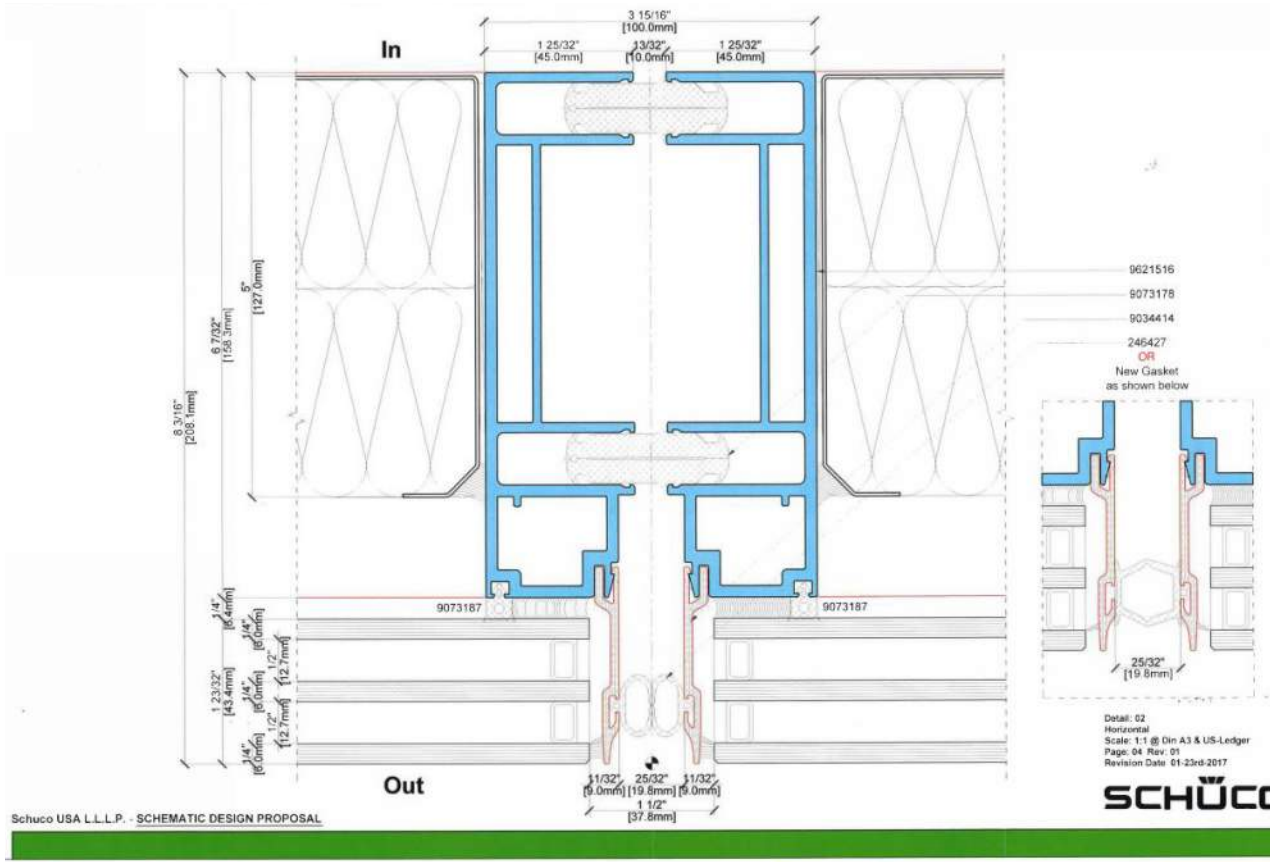




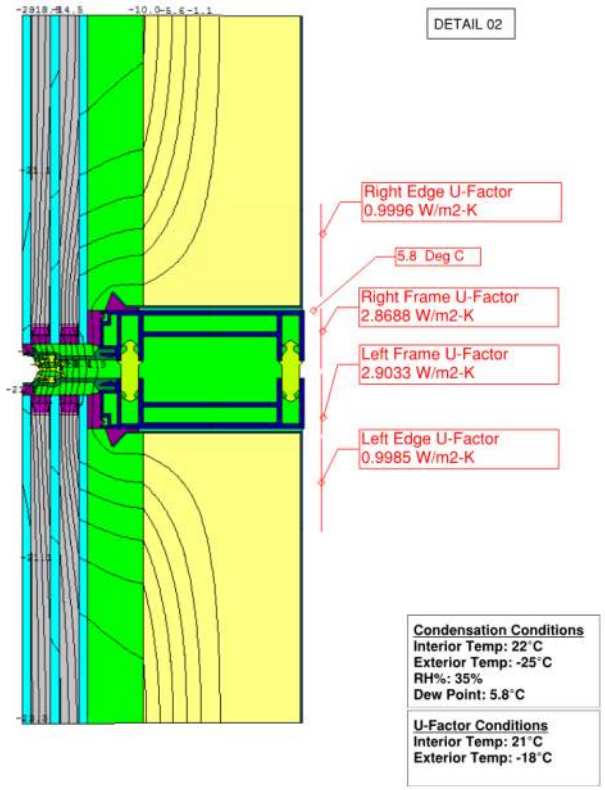
Calculation Includes:
Slab Condition
Potential Flanking at Window Reveal

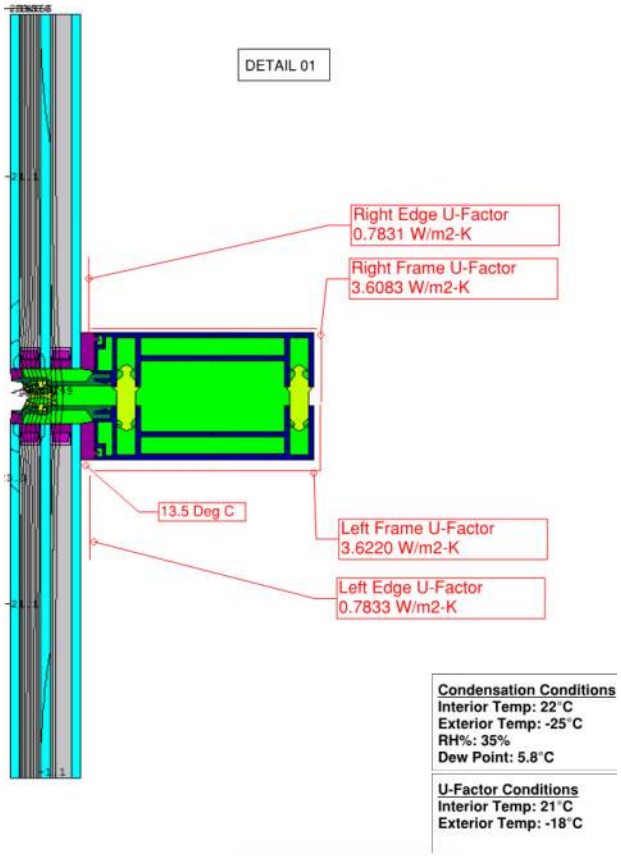
R21

Heat 3D Slab Modeling



Triple Glazed Double Low E





Trade Numbers

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Back to Energy and Mechanical Systems

Radiant Heating / Cooling + GHSP

Radiant Heating / Cooling + GHSP + Solar Thermal

Water Source VRF + GHSP

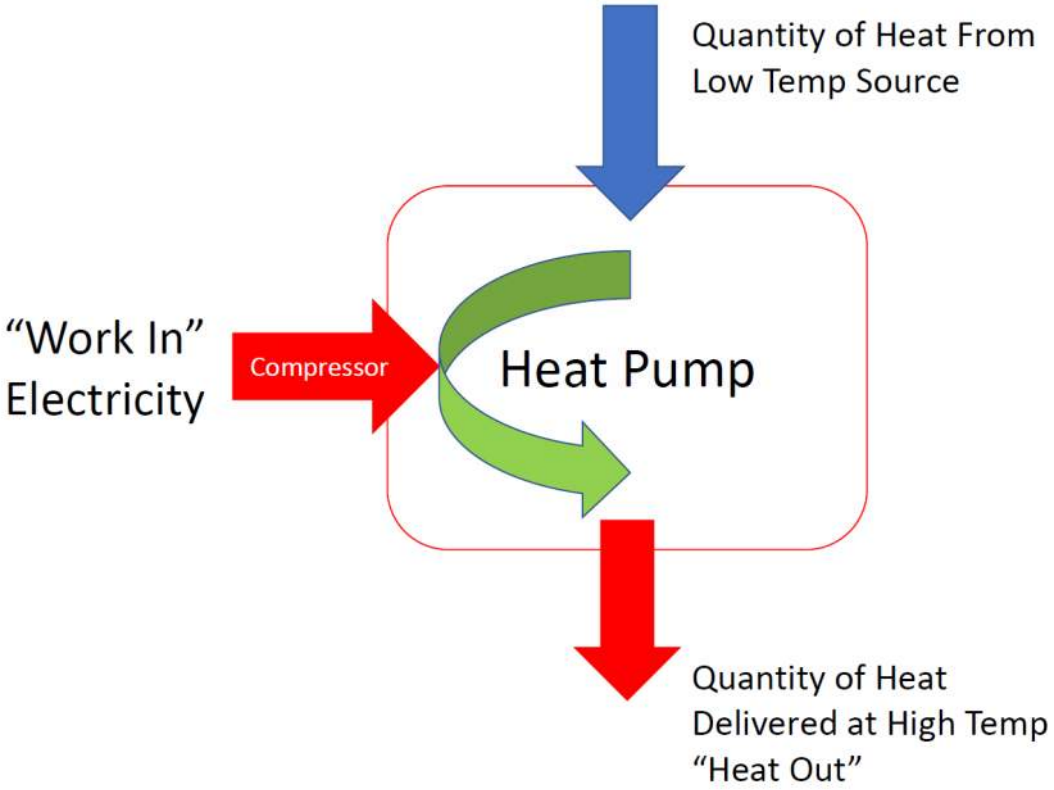
Water Source VRF + GHSP + Solar Thermal

Water Source VRF + Boiler / CT

Water Source VRF + Boiler / CT + Solar Thermal

Air Source VRF Heating / Cooling

Potential Mechanical Systems



$$\text{Eff.} = \frac{\text{Output}}{\text{Input}}$$

$$\text{COP} = \frac{\text{Heat Out}}{\text{Work In}}$$

$$\text{COP} = \frac{50\ \text{kW}}{10\ \text{kW}}$$

$$\boxed{\text{COP} = 5\ (500\%)}$$

COP (Coefficient of Performance)

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Lighting	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Misc. Equipment	19.3	19.3	19.3	19.3	19.3	19.3	19.3
Space Heating	17.1	8.6	13.7	9.6	13.0	13.0	21.4
Space Cooling	8.0	8.0	6.4	6.4	6.4	6.4	8.7
Pumps and Aux	9.6	11.0	6.7	8.2	3.4	4.8	0.0
Fans	7.5	7.5	11.3	11.3	11.3	11.3	11.3
DHW	4.5	2.3	4.5	2.3	4.5	2.25	4.5
Boiler	0.0	0.0	0.0	0.0	19.5	9.7	0.0
Total (ekWh/m²)	**76.7**	**67.3**	**72.5**	**67.6**	**88.0**	**77.4**	**75.9**
Rank (lowest to highest)	5	1	3	2	7	6	4
Net Solar Thermal Effect (ekWh/m²)		-9.4		-4.9		-10.6	
Total ekWh	578,000	508,000	547,000	510,000	664,000	584,000	573,000
Annual Energy Cost	$ 69,360	$ 60,960	$ 65,640	$ 61,200	$ 65,760	$ 63,120	$ 68,760
Size of PV Array (kWp)	525	462	497	464	604	531	521
Size of PV Array (m²)	4,379	3,848	4,144	3,864	5,030	4,424	4,341
Flat Roof Area (m²)	8,758	7,697	8,288	7,727	10,061	8,848	8,682
Cost of PV	$ 1,320,000	$ 1,160,000	$ 1,250,000	$ 1,160,000	$ 1,510,000	$ 1,330,000	$ 1,310,000
NREL Recommended O&M / year	$ 9,900	$ 8,700	$ 9,375	$ 8,700	$ 11,325	$ 9,975	$ 9,825
Linear m of Borehole	4,400	4,400	4,400	4,400			
# of 500' boreholes	29	29	29	29			
m² Area of Field using 6 m spacing	1,039	1,039	1,039	1,039			
Cost of Borehole	$ 440,000	$ 440,000	$ 440,000	$ 440,000			

Breaking Down the Budget

End Use	Radiant Heating / Cooling + GSHP	Radiant Heating / Cooling + GSHP + Solar Thermal	Water Source VRF + GHX	Water Source VRF + GHX + Solar Thermal	Water Source VRF + Boiler / CT	Water Source VRF + Boiler / CT + Solar Thermal	Air Source VRF Heating / Cooling
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Misc. Equipment	19.3	19.3	19.3	19.3	19.3	19.3	19.3
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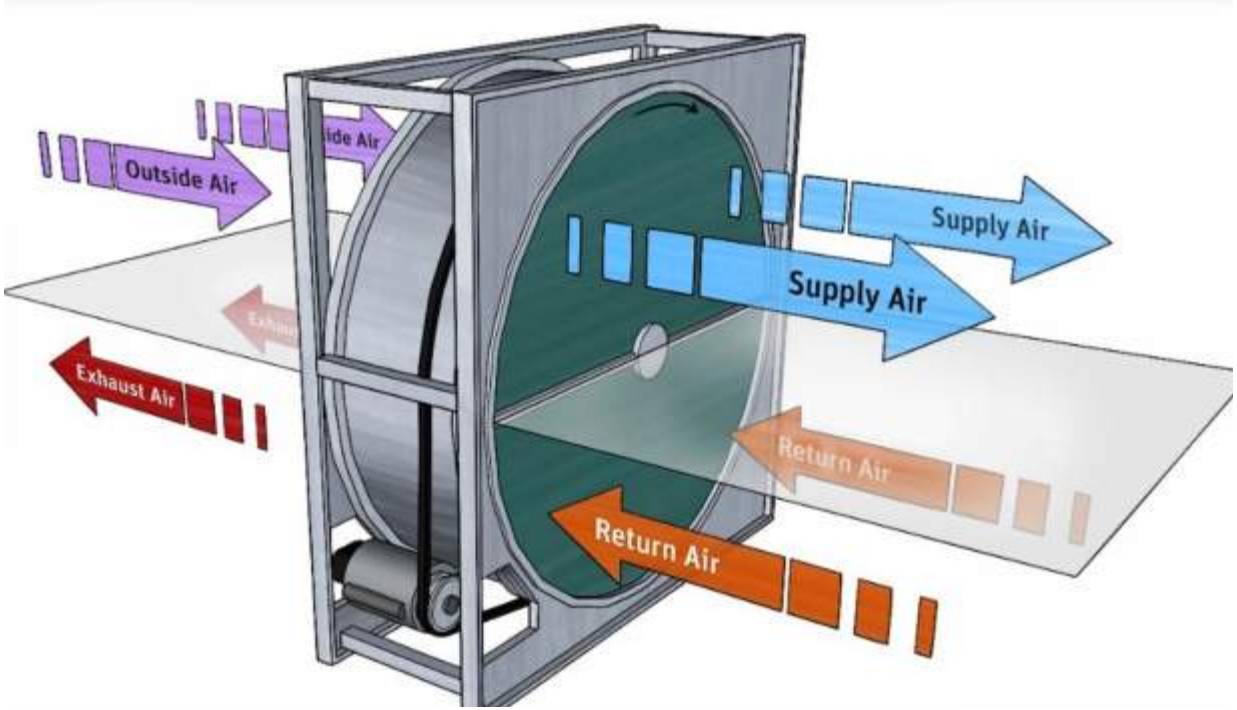
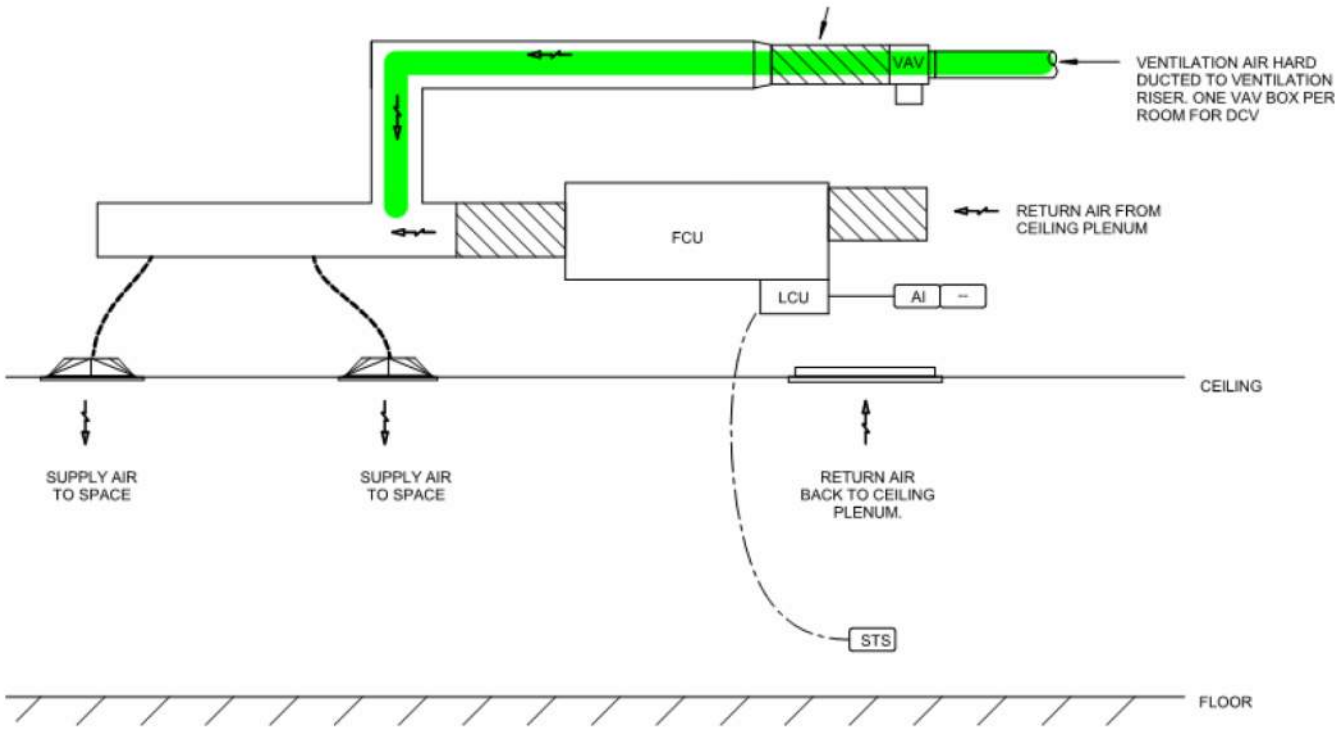
Breaking Down the Budget

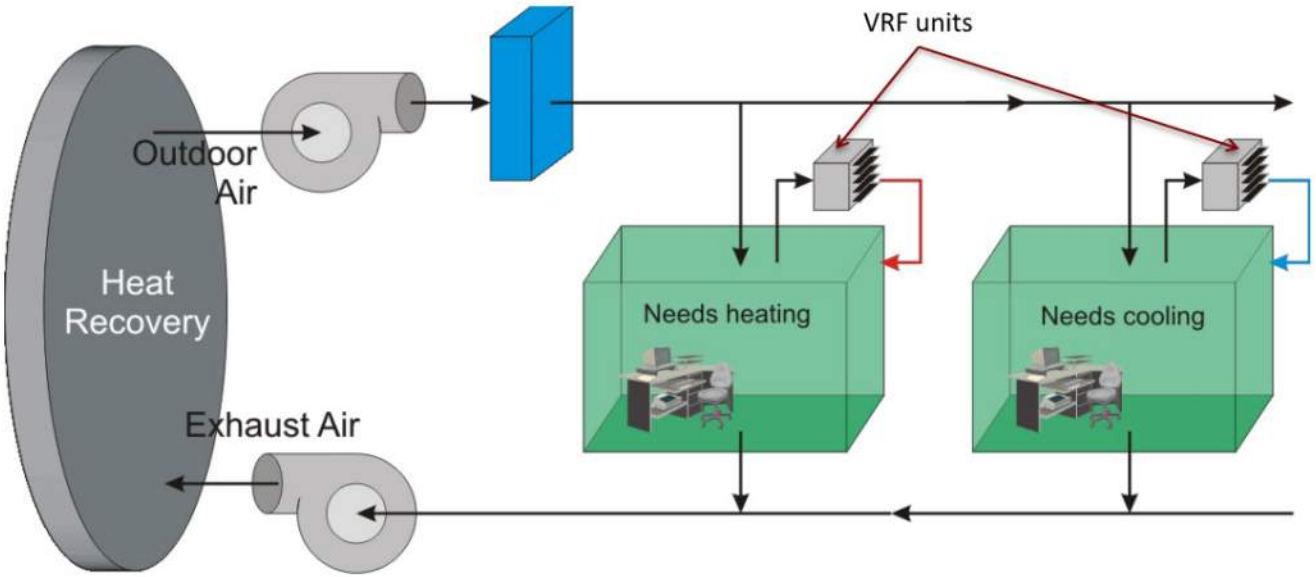


Enthalpy Wheel at 85% Efficiency

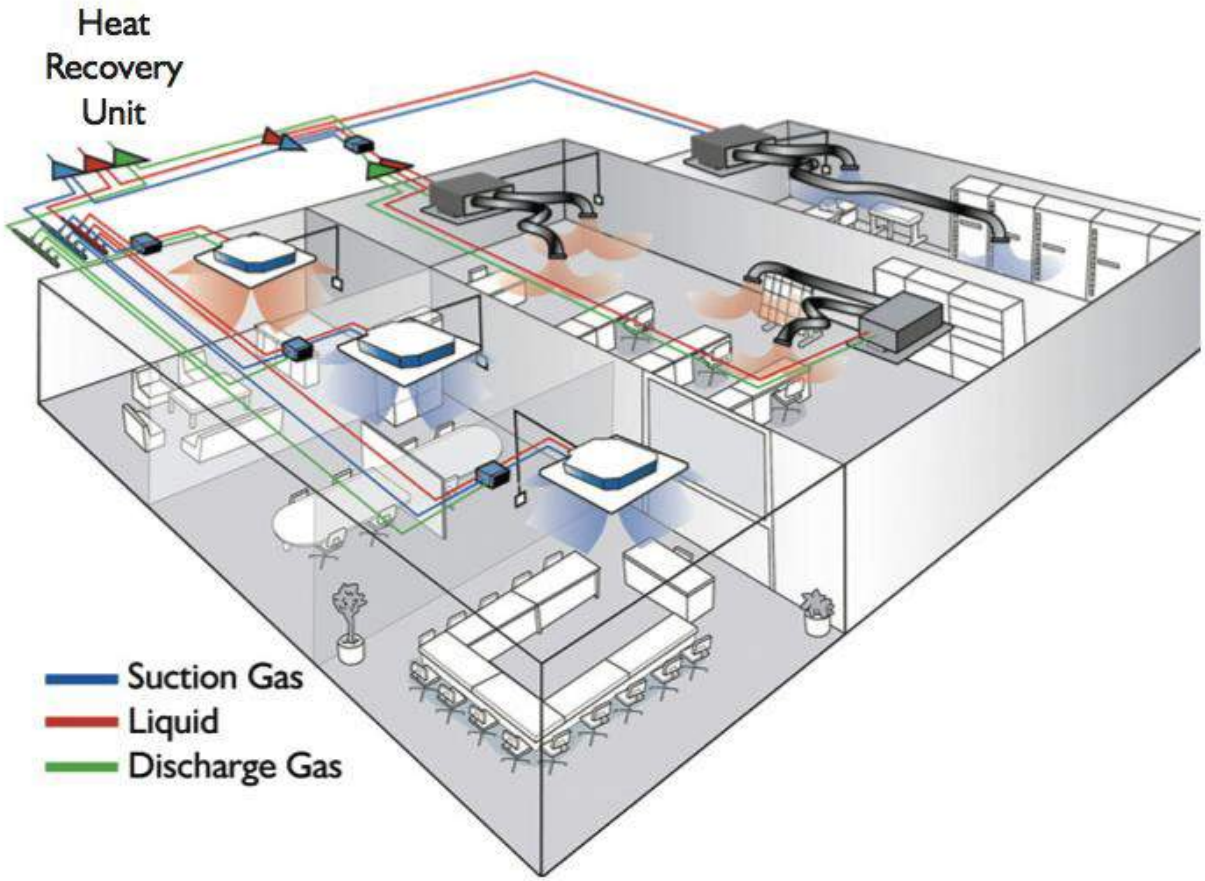
DOAS


VAV
VENTILATION AIR HARD DUCTED TO VENTILATION RISER. ONE VAV BOX PER ROOM FOR DCV
FCU
RETURN AIR FROM CEILING PLENUM
LCU
AI
--
CEILING
SUPPLY AIR TO SPACE
SUPPLY AIR TO SPACE
RETURN AIR BACK TO CEILING PLENUM.
STS
FLOOR

DOAS + VRF


VRF units
Outdoor Air
Heat Recovery
Exhaust Air
Needs heating
Needs cooling

DOAS + VRF



DOAS + VRF

DOAS + AIR SOURCE VRF

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Lighting	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Misc. Equipment	19.3	19.3	19.3	19.3	19.3	19.3	19.3
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Pumps and Aux	9.6	11.0	6.7	8.2	3.4	4.8	0.0
Fans	7.5	7.5	11.3	11.3	11.3	11.3	11.3
DHW	4.5	2.3	4.5	2.3	4.5	2.25	4.5
Boiler	0.0	0.0	0.0	0.0	19.5	9.7	0.0
Total (ekWh/m²)	**76.7**	**67.3**	**72.5**	**67.0**	**88.0**	**77.4**	**75.9**
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Flat Roof Area (m²)	8,758	7,697	8,288	7,727	10,061	8,848	8,682
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Back to the Budget

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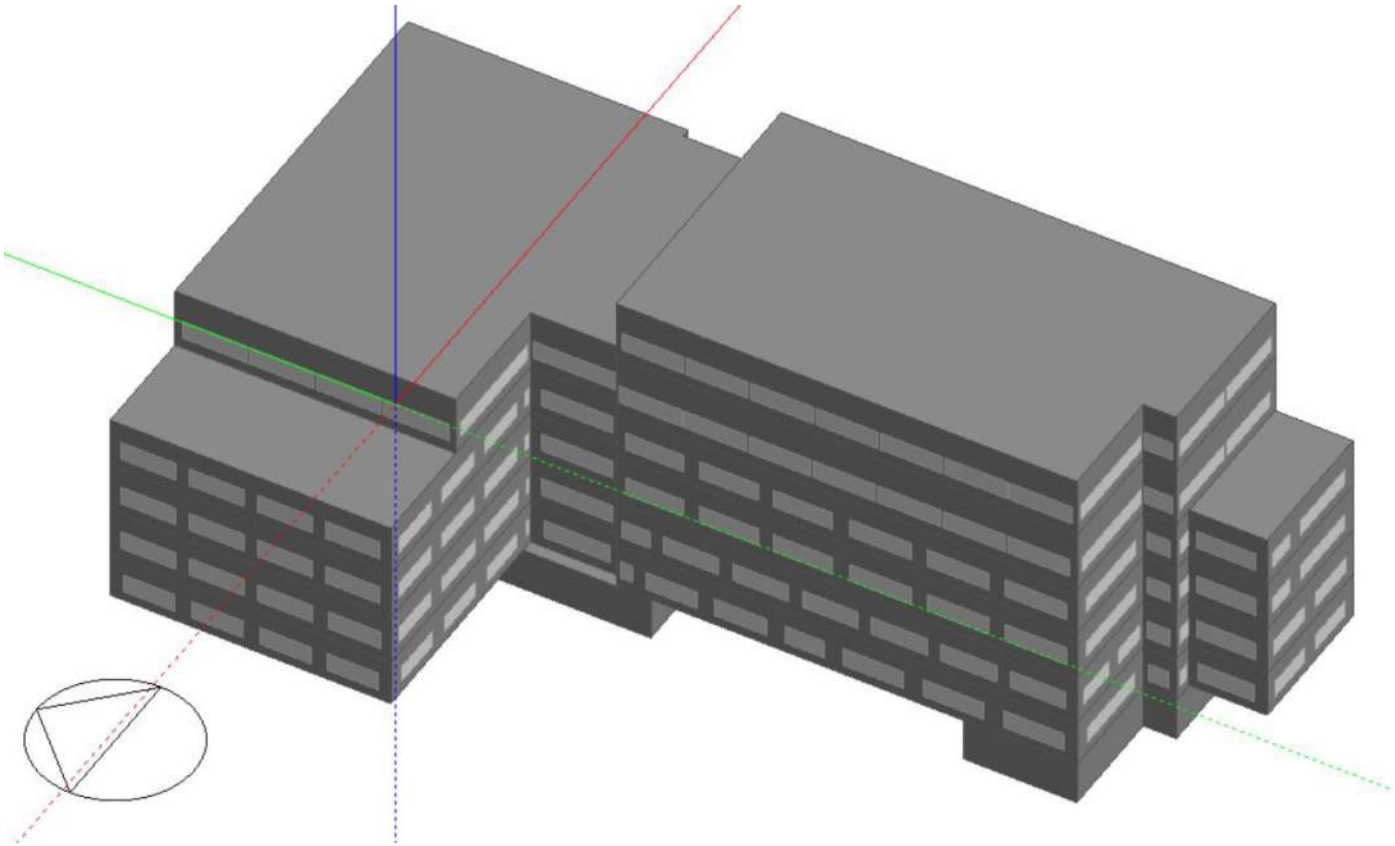
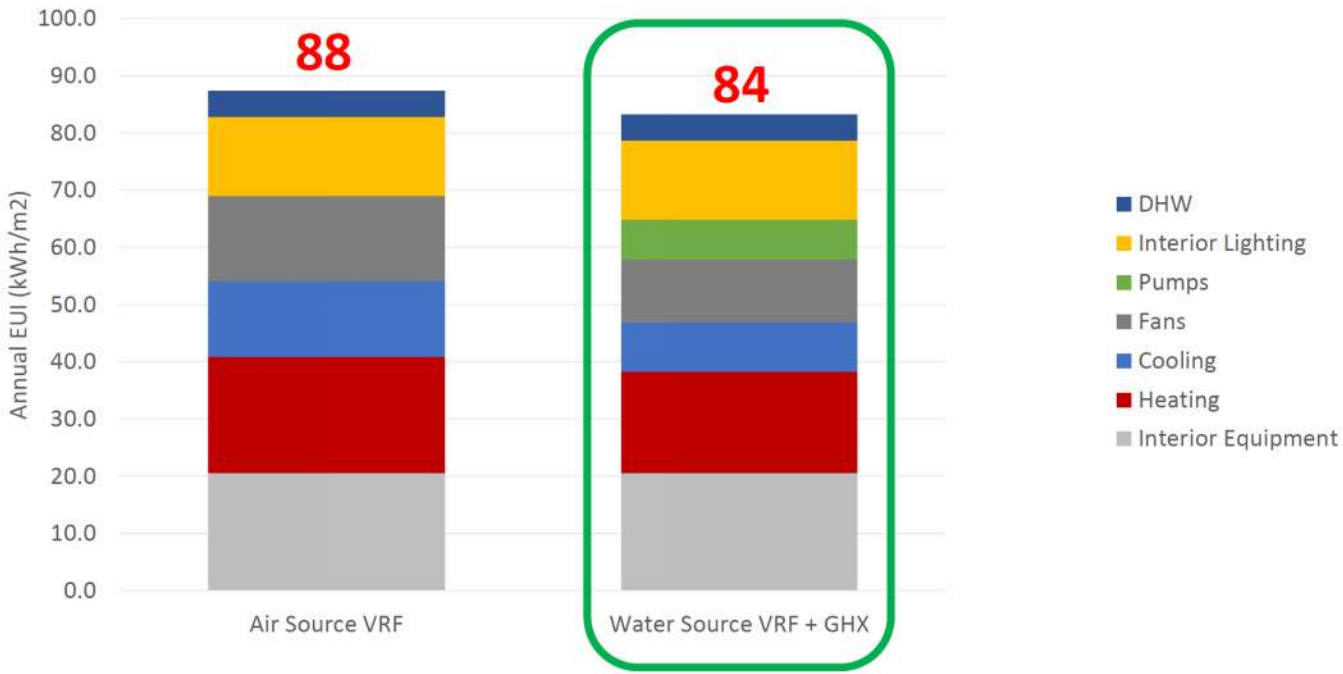
Back to the Budget



Building The Energy Model



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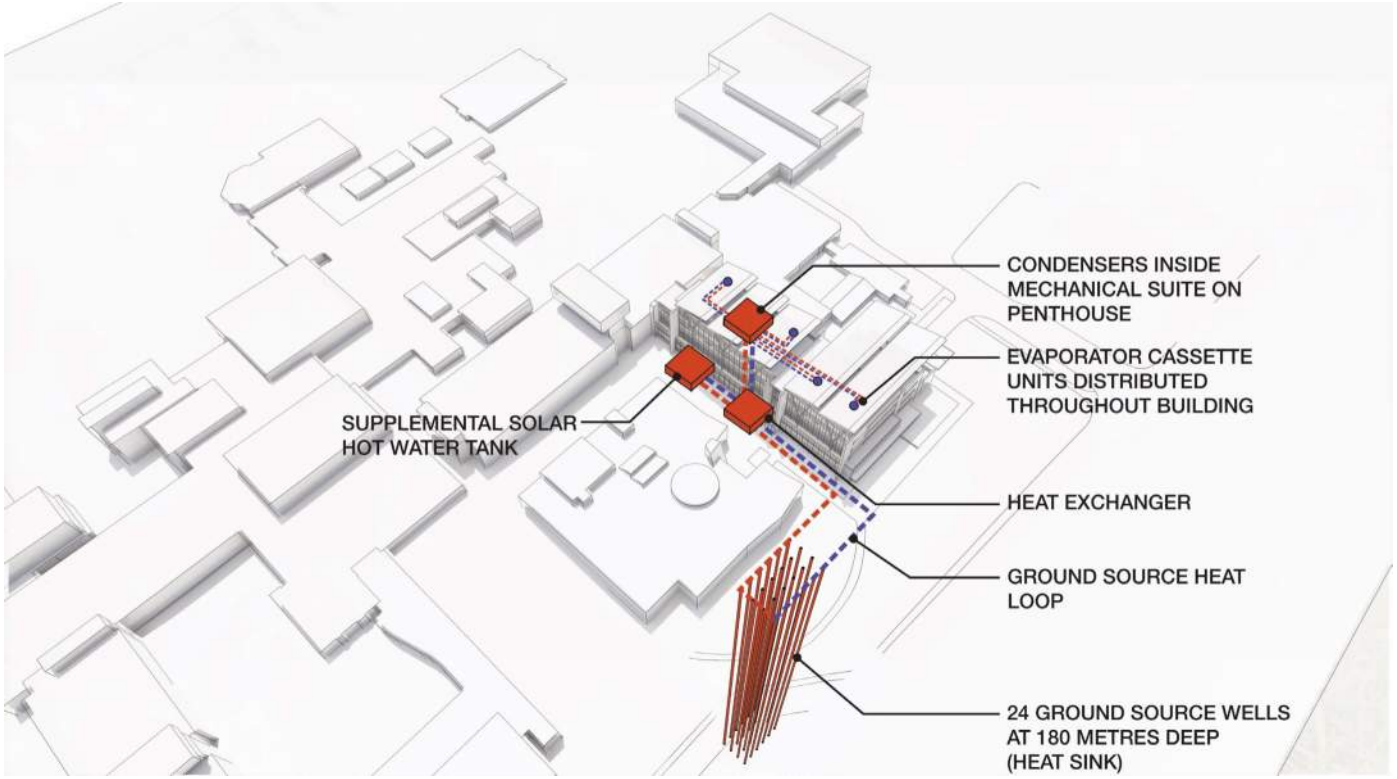
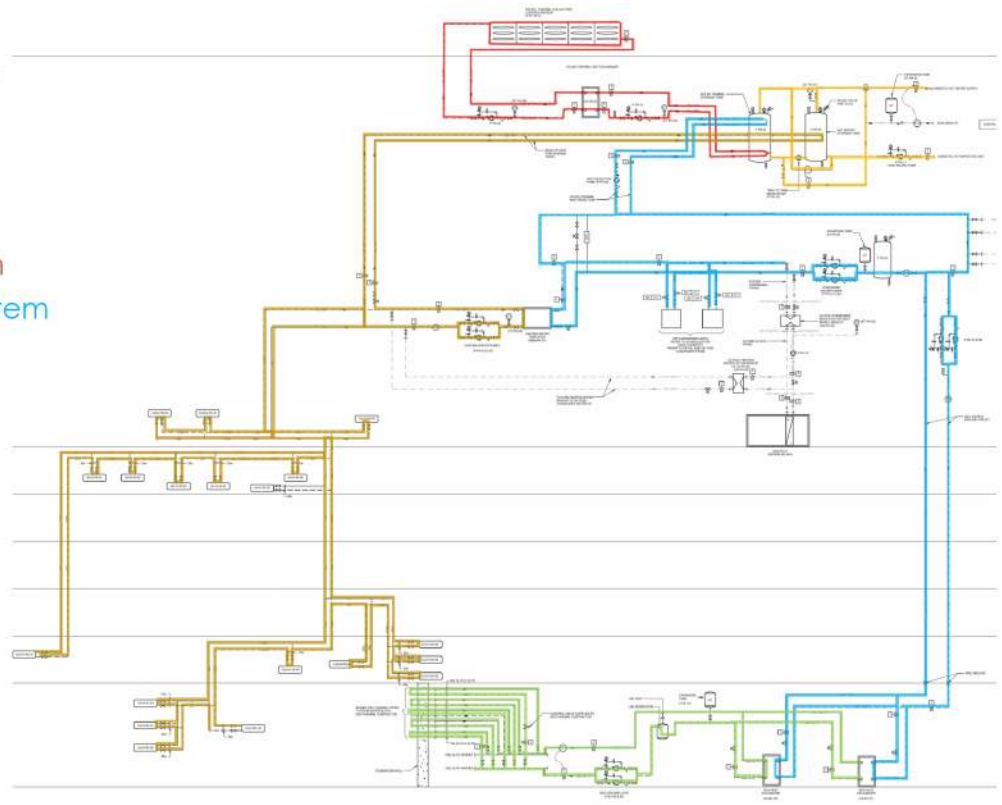


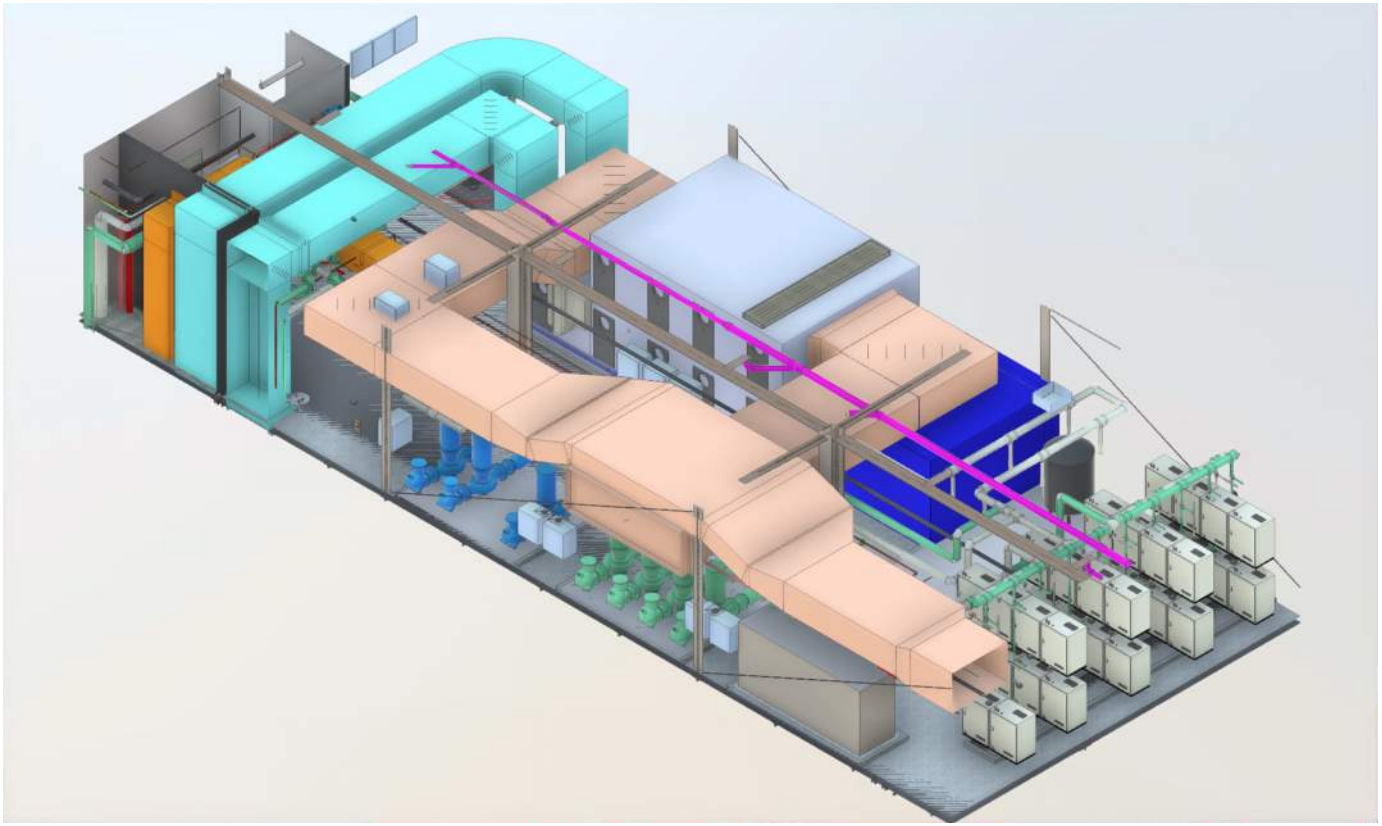
Building Systems Integration

System Schematic

- Solar Thermal
- Domestic Hot Water
- Heating Water System
- Condenser Water System
- Geothermal Loop



Building Systems Integration



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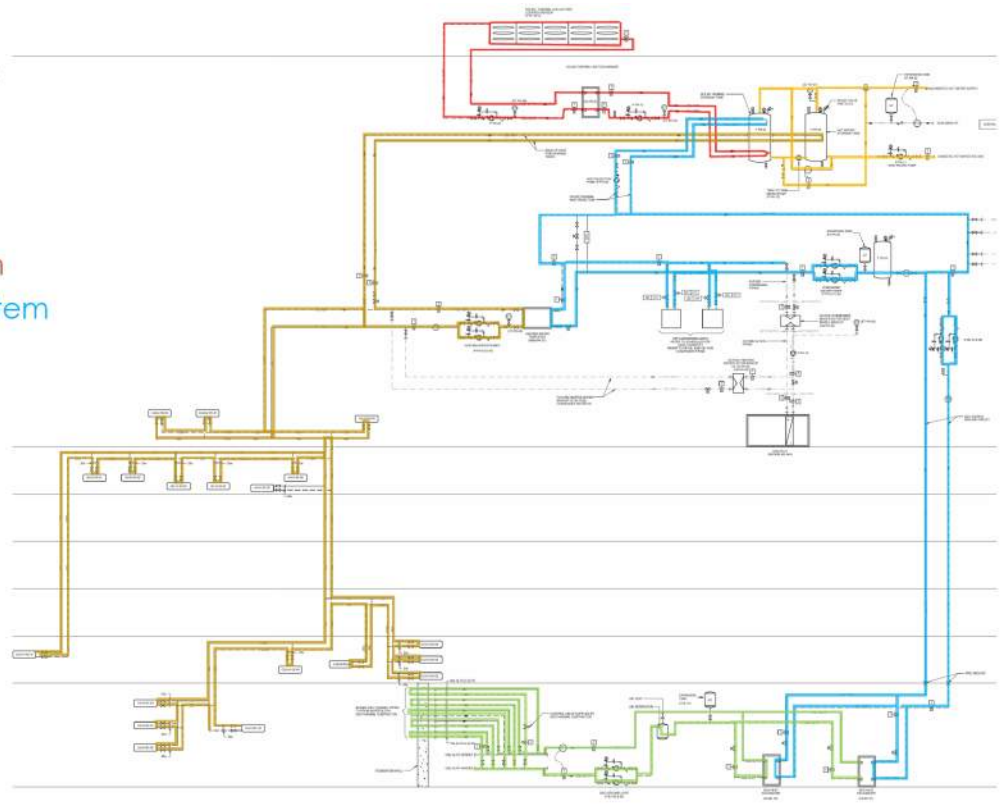

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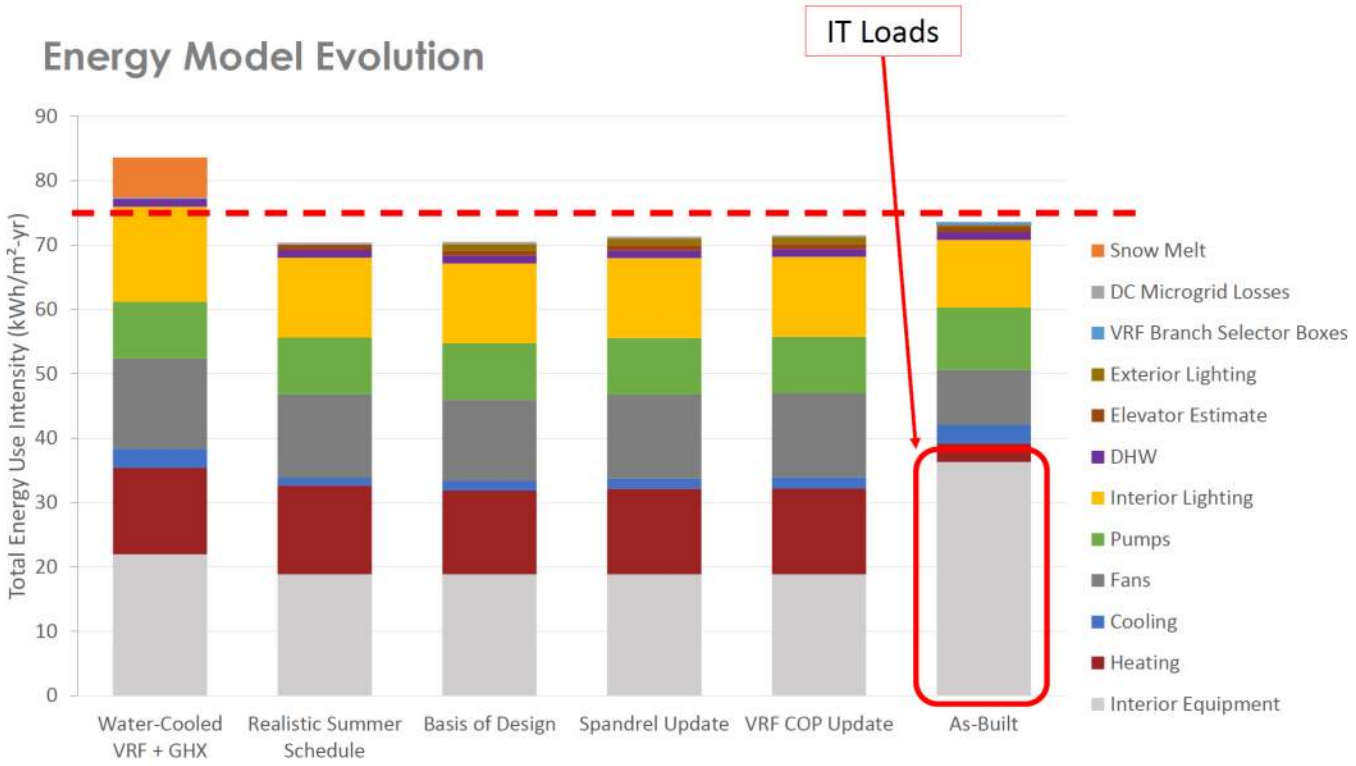
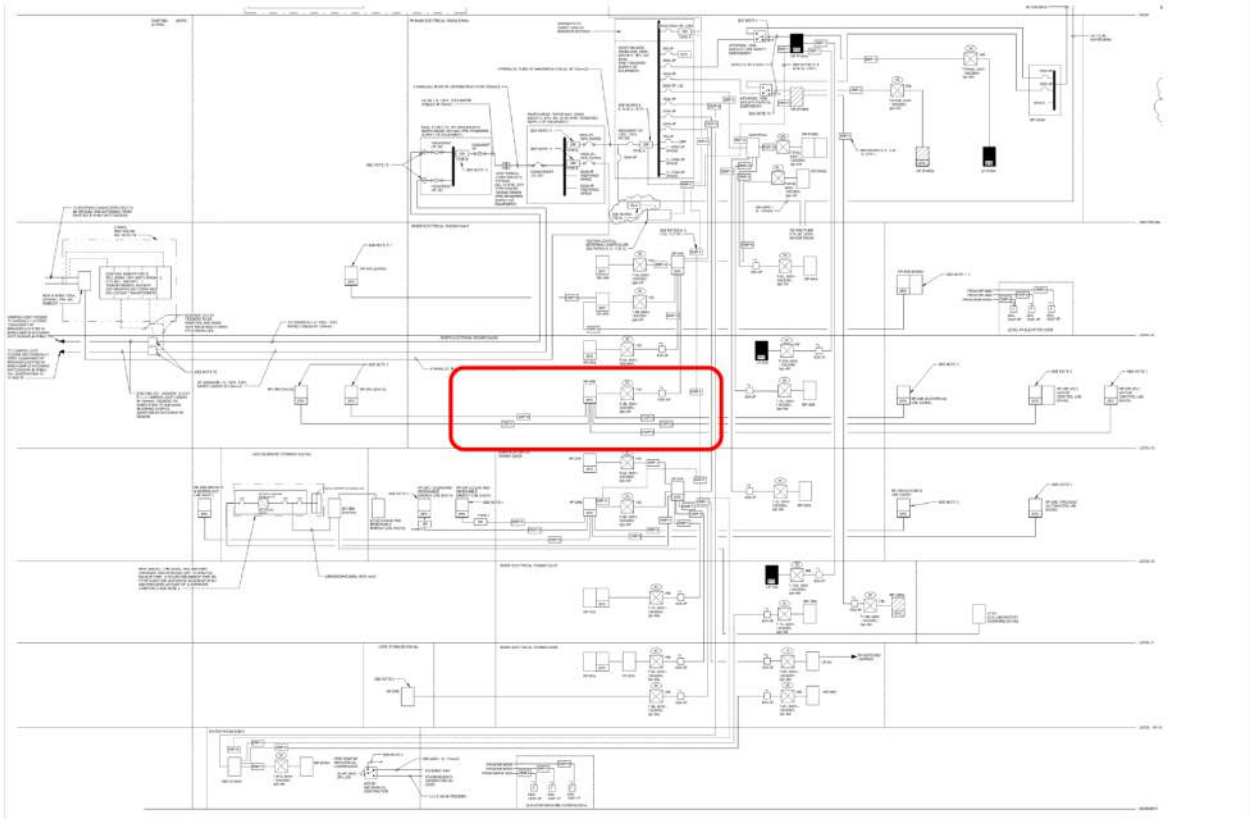
JCPI roof area:
~1200 m²

Building Systems Integration

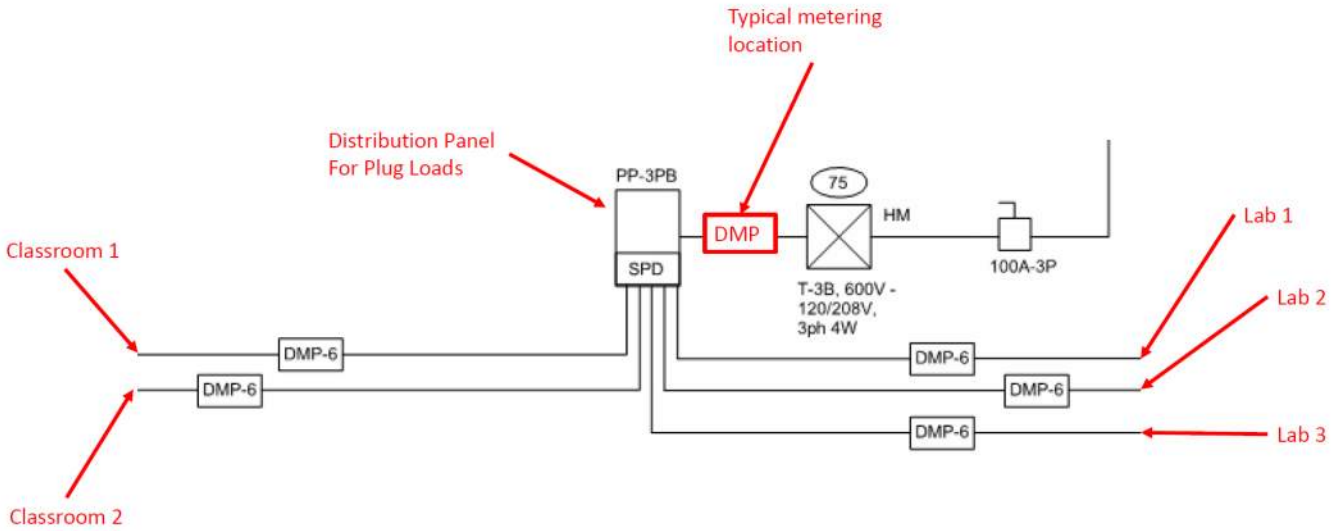


Building Systems Integration

- **Plan Meter Layout – Electrical Measurement**
  - 48 electrical submeter points

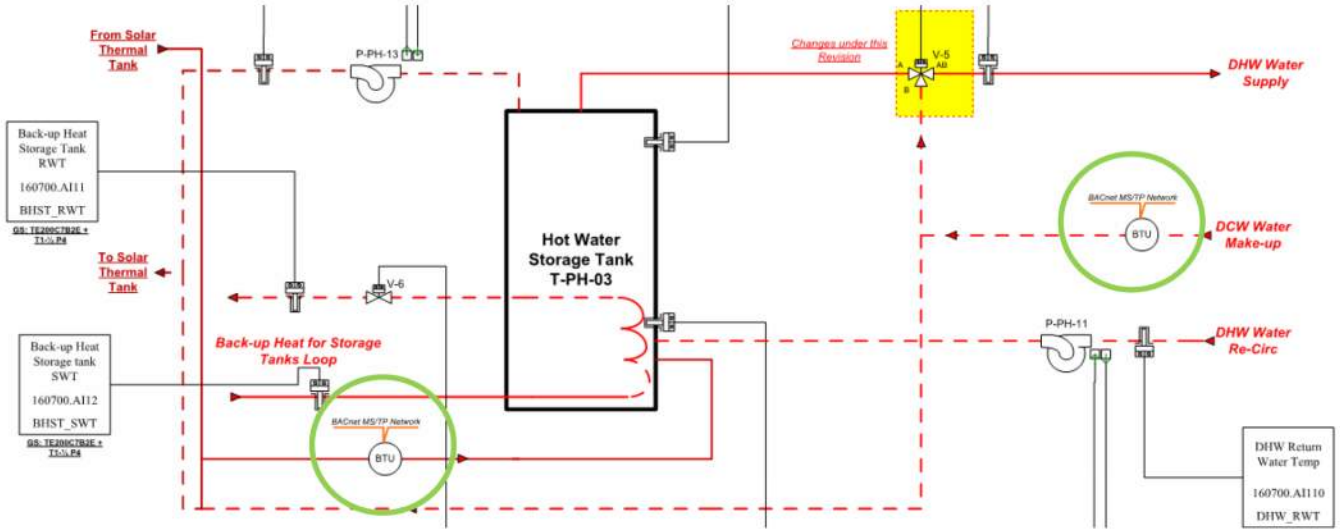


Measurement and Verification



Measurement and Verification

- **Plan Meter Layout – Heat Measurement**
  - 3 Energy (BTU) Meters



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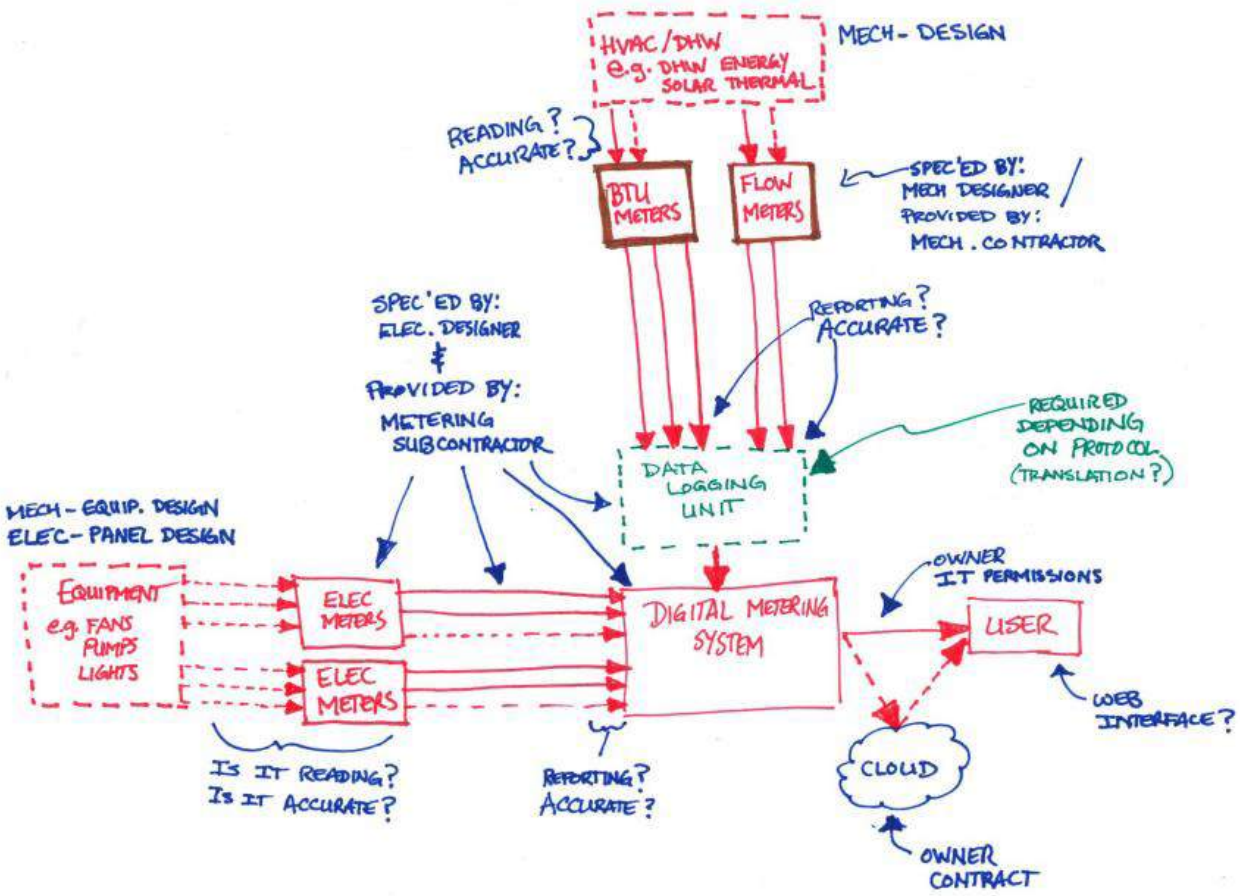
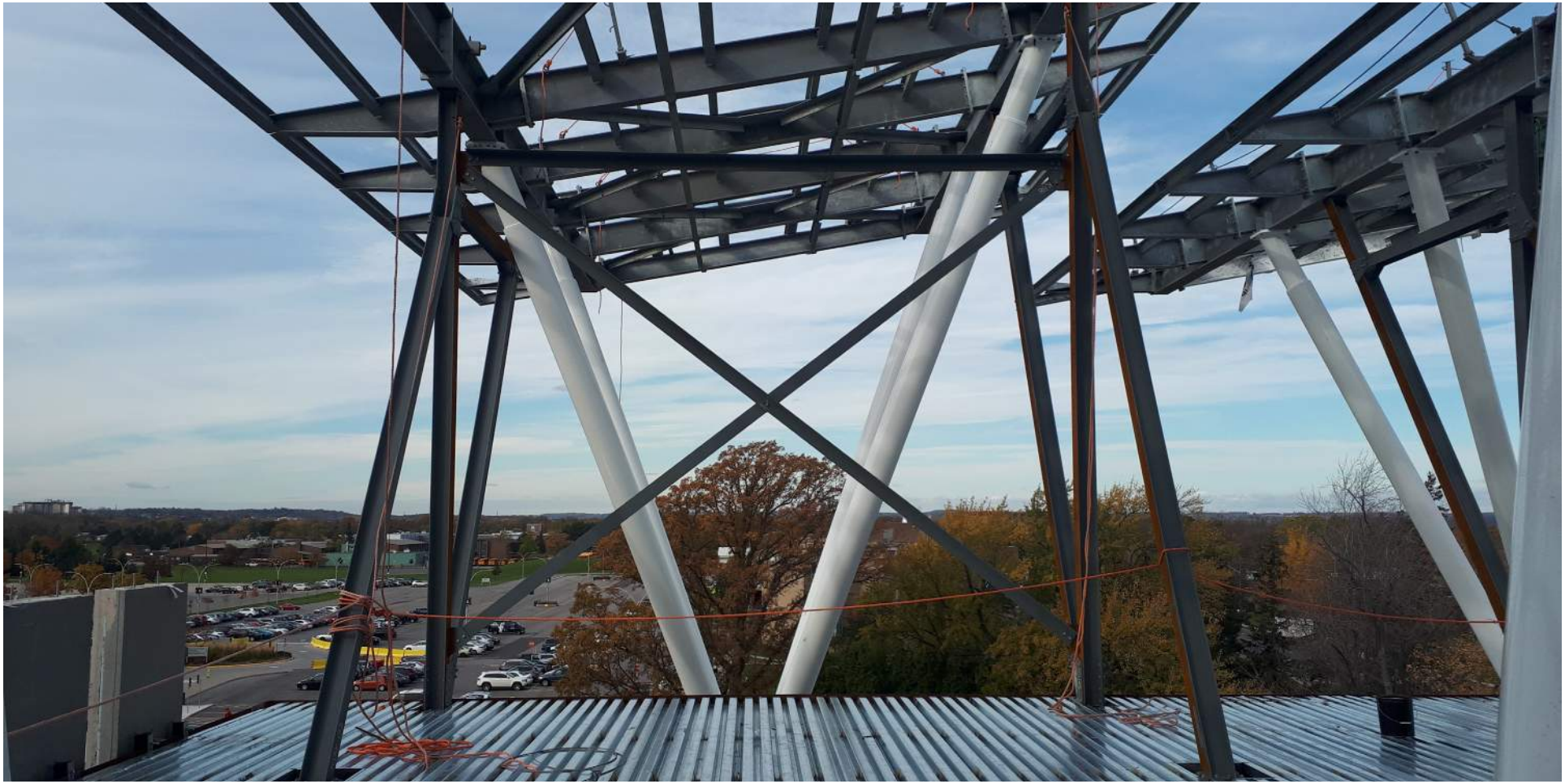


Measurement and Verification

Rendering

Final Product



Final Product

Final Product

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