Beyond Design: Verifying Zero Through Operations

Mohawk College’s Joyce Centre for Partnership and Innovation

Steve Kemp M.A.Sc., P.Eng, LEED® Fellow
Anthony Cupido Ph.D., P.Eng.

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Post Secondary Institutions Strategic Infrastructure Fund (S.I.F.)

- Initiated in Spring 2016
- Mohawk College - Total Project Value: $54.25M

$ 4.25 M Renovations to E-Wing
$50.00 M New Building
$20M Grant Received
Post Secondary Institutions
Strategic Infrastructure Fund (S.I.F.)

Project Value: $50M  ($47M Construction)

Estimated Building Size: 90,000 SF

Estimated Unit Cost: $525/SF  (rounded)

JCPI Final Costing Detail

• Final Cost (Construction): $47,610,000
• Final Area: 96,700 square feet
• Final Unit Cost: $492/sq.ft.
<table>
<thead>
<tr>
<th>Building Type (Altus Group)</th>
<th>$/Sq. Ft. – GTA (Altus Group)</th>
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<tbody>
<tr>
<td>Universities &amp; Colleges Teaching/Lecture Hall</td>
<td>395 - 520</td>
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<tr>
<td>Universities &amp; Colleges Laboratories (L1 &amp; 2)</td>
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<td>Joyce Centre for Partnership and Innovation (Adjusted for Altus Cost Index of 1.04)</td>
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Campus Perspective
Penthouse

- Mechanical Penthouse (<3000 sq. ft.)
- Student Teaching Area - Roof

Plan to Achieve Net Zero and Challenges

- Energy Targets & Model
- Building Envelope Design
- Mechanical Systems
- Solar PV and Solar Thermal Systems
- Measurement & Verification
- Change in Culture
Any project can be Net Zero

Provided you have enough $$$

Or modest expectations for:
- Comfort
- Environmental Quality
- Amenities
- Etc.

Energy Targets – Design Meeting #1

75 ekWh/m²-yr (24.2 kBtu/ft²-yr)

CIEBUS College/University Average: 211 ekWh/m²-yr (68.1 kBtu/ft²-yr)

R10 window + wall

Ontario SB-10 Climate Zone 5 Requirement: R4.7
Energy Targets – Design Meeting #1

24.2 kBtu/ft²-yr

CIEBUS College/University Average: 68.1 kBtu/ft²-yr

R10 window + wall

Ontario SB-10 Climate Zone 5 Requirement: R4.7

### Design Meeting #2

“Energy Model”

At 8,600 m² and 5 storeys, our roof area is estimated at 1,720 m²
Unique Thermally Broken Curtain Wall to reduce thermal flanking at spandrel to vision transitions
HVAC Systems Used

- Heat Pump system - Water Cooled VRF
- Geothermal field
- Dedicated outdoor air system (DOAS)
- Solar thermal for preheating DHW
- Heat pump “templifier” for aux DHW heating
Water Cooled Geothermal VRF System

- Central geothermal condenser loop
- Heat recovery between heads on a circuit and between compressors
- Daikin VRF System

Mechanical Systems

- Condensers inside mechanical suite on penthouse
- Evaporative cassette units distributed throughout building
- Heat exchanger
- Ground source heat loop
- 28 ground source wells at 180 metres deep (heat sink)
Heating Water System

• Entrance heat and remote terminal heat
• Backup for DHW solar thermal

DOAS System

• Central dedicated outdoor air system
• Local VAV boxes for demand based ventilation
• Carefully placed ventilation connection to fan coils
• Heat Recovery Wheel
Energy Model Progress

Energy Use Intensity (ekWh/m²-yr)

- DHW
- Snow Melt
- Heating
- Cooling
- Interior Lighting
- Exterior Lighting
- Interior Equipment
- Fans
- Pumps
- Elevator Estimate
- DC Microgrid Losses
- VRF Branch Selector Boxes

First Detailed Model
Design Basis
Skylights in Atrium
As-Built
Build experience, question your assumptions and MEASURE

Are my operating schedules realistic? Weekday / Weekend Summer / Winter

“One accurate measurement is worth a thousand expert opinions” – Admiral Grace Murray Hopper (Dec 9 1906 to Jan 1 1992)

PROCESSES OF ESTIMATING RECEPTACLE/PROCESS LOADS AND SCHEDULE

1. Review Program and Spaces
2. Create Table and Categorize Likely Receptacle Loads
3. Measure Loads with Surrogates
4. Review Schedule Assumptions with Client
5. Compare with Expectations
6. Refine Assumptions
7. Re-Review with Client
Measure Loads with Surrogate

Gaming Computer: Avg ~215 W
~35 W (charging)
~18 W (charged)

Avg ~63 W

75kWh/mo
Avg 104 W

PV array

PV ARRAY MODULES

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<td></td>
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<tr>
<td>TOTAL</td>
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PV array

PV array

Back up option
Solar Thermal

- Used to generate DHW and to augment condenser water loop heating
- Safeties for low load/no load conditions
- Viessmann panels, tanks and controls
CaGBC Zero Carbon Design Certification

- Embodied Carbon:
  - 482 kg CO2eq / m² (96 lb CO2eq/sqft)

- Operating Carbon:
  - -17.7 kg/m²-year (-3.5 lb CO2eq/sqft)

Performance Monitoring - Is It Working?

- Motivation
  - Living Lab
  - Course Integration

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First Year of Operation

• September 15 2018 to September 15 2019
• Top floor not fully occupied
• Whole building and PV generations reporting
  • Some weeks missing in the continuous monitoring
  • Check meters work just fine!
• Submetering challenges – only a few months of data
• Calibrated energy model to be complete in early 2020
• Have identified further operating savings
  • Lighting controls
  • Temperature setbacks
Whole Building Measured Results

We are Net Positive!!

Building Consumption 20% less than expected.
PV Production is 2% less than expected

Monthly Analysis

Prorated where data is missing
To Do: With a year of submeter data...

• Full Circle Energy Modelling
  • Weather
  • Schedules
  • Receptacle Loads

• Calibration (ASHRAE Guideline 14)

• Troubleshoot and Share

Changing the Culture
Building performance will translate to grades

Project Successes

Process:
• Establishing the Energy Budget

Technology:
• Integrating proven technologies with innovative high performance building envelope

Impacts: Net Zero Targets Achievable
• Net Zero Energy
• Net Zero Carbon
Project Challenges

• Commissioning Net Zero
• Metering Software
• Skilled Labour Trades Understanding & Awareness
• Staff Training
• Staff & Student Culture

Thank you!
Questions?

skemp@rdh.com
tony.cupido@mohawkcollege.ca