Shifting Gears: A Passive House Car Dealership in the Making

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PHI CPD Credits

PHNW conference seminars are approved for PHI and AIA CPD Credits

https://service.passivehouse.com/en/profis/advanced_training
Project Background

• **Client:** The Scottsville Group
• **Building:** Car dealership and repair shop
• **TFA:** 1,500m² (16,000 ft²)
• **Location:** Red Deer, Alberta
• **Design Temp:** -29°C (-20°F)
The Client

• **Business:**
  – Owns several dealerships: GMC, Buick, Nissan
  – “Service + Value + Integrity”
  – 50th anniversary of their GM store

• **Corporate:**
  – PH aligns with Subaru environmental strategy
    E.g. Partial Zero Emission Vehicles (PZEV)
  – Inspired by Subaru of Indiana Automotive assembly plant
    First zero-landfill factory in the U.S.
Project Requirements/Goals

• **Performance:**
  – Owner not environmentalist
  – Recognized importance of looking beyond BAU
  – Saw PH as a better way
  – “Important statement to the industry and the country [flowing from the land of oil and gas]”
    – Garrett Scott

• **Long-term benefits:**
  – legacy project that will cost us virtually nothing to heat and cool the building

• **Service:**
  – PH should not disrupt service – to customers or vehicles
Cold Climate Overview

• **Cold temperatures**
  – Every decision matters more
  – Airtightness has huge impact
  – Frost protection, (low) humidity become problematic
  – Design temps influence functionality of equipment

• **Product Availability**
  – No local manufacturer of cold climate products
  – Very few on EU market
  – Some EU companies won’t export

• **Design:**
  – we walked a fine line to meet the targets
Ground Floor

- Showroom
- Circulation/Reception
- Sales/Office
- Service
- Dropoff Area
Building Design

- 2 storeys
- Typical Car Dealership aesthetic
  - Corporate image guidelines were non-negotiable
- Compact Form
- Highly glazed front facade
  - West: 55% (showroom: 65%)
  - Other: 1-17%

Southwest Facade
West Glazing

- Highly glazed façade must face West entrance
- Alberta is sunny!
  - 50% more West radiation than Germany
- Overhangs not permitted
  (Corporate guidelines)

<table>
<thead>
<tr>
<th>City</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calgary, Alberta</td>
<td>2396</td>
</tr>
<tr>
<td>Winnipeg, Manitoba</td>
<td>2353</td>
</tr>
<tr>
<td>Edmonton, Alberta</td>
<td>2345</td>
</tr>
<tr>
<td>Regina, Saskatchewan</td>
<td>2318</td>
</tr>
<tr>
<td>Saskatoon, Saskatchewan</td>
<td>2268</td>
</tr>
<tr>
<td>Thunder Bay, Ontario</td>
<td>2121</td>
</tr>
<tr>
<td>Hamilton, Ontario</td>
<td>2111</td>
</tr>
<tr>
<td>Victoria, British Columbia</td>
<td>2109</td>
</tr>
<tr>
<td>Ottawa, Ontario</td>
<td>2084</td>
</tr>
<tr>
<td>Toronto, Ontario</td>
<td>2066</td>
</tr>
</tbody>
</table>
West Glazing

- Low amount natural shading
  - 1-2 storey
  - Low tree lines

- Tree Planting
  - Blocked too much sun – jeopardized space heating demand target
West Glazing

• Operable external Blinds
  – Too windy!
  – Up to 103 kph (64 mph) from West
    • Canada’s windiest: St John’s 137 kph
    • Toronto: 61 kph
  – Average doesn’t matter for durability
  – Integration with tall curtain walls is difficult
  – Client concerned with aesthetics
West Glazing

- **Electrochromatic Glazing**
  - Expensive
  - Solar characteristics not suitable for meeting space heating demand target or window comfort criteria
  - \( \text{SHGC: } 0.09-0.41 \text{ max} \)
  - \( U_g = 0.8 \text{ W/m}^2\text{K (0.14 Btu)} \)
West Glazing

• Solution
  – Automated operable internal blinds (with manual override)
  – Insulated Spandrel panels in top row
  – Deal with additional peak cooling load
Windows

- Comfort Requirement: $U_{w,\text{installed}} \leq 0.61 \text{ W/m}^2\text{K (0.11 BTU)}$
- Only **one** certified cold climate window available
  - Price was comparable to cool-temperate certified windows
- **No** certified cold climate curtain wall
- Relied on **window heating**
- Wicona series
  - C/W: Wicline 50HI
  - Windows: WL/WS 75 Evo
  - Doors: Wicline 95
Overhead Doors

- Initial Design had 7 doors
- We proposed designed that reduced to 2
- Client thought it would disrupt service
- Ultimately agreed to 4
Overhead Doors

- **Initial concern over heat loss due to operation**
  - Investigation revealed minimum heat loss
    - 15 m³/h/event (9 CFM)
- **Greater concern was standby air leakage**
  - 17% of transparent envelope (4% of wall area)
  - Conventional doors: no regards for airtightness
- **Airtightness classification**
  - Referred to EU system
  - Class 2 would increase AT by 0.08 ACH@50Pa
    - Whole Buildings Target is 0.4! (so 20%)
  - Best we could locate was Class 3 → increase by 0.04 (10%)
  - Manufacturer (Efaflex) could demonstrate performance
Overhead Doors

• Subsequently discovered that a Canadian-made door used on
• Initial investigation did not reveal a PH option from company

Wood Innovation Research Lab
- Prince George, BC
Internal Heat Gains

- Obtained Equipment List from Client early on
  - Impacts Heating & Cooling Demands and PER
  - 55% of IHGs in Repair shop

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>rating</th>
<th>Unit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Compressor</td>
<td>1</td>
<td>25</td>
<td>HP</td>
<td>Intermittent usage. Say 40% duty cycle during operating hours.</td>
</tr>
<tr>
<td>Tire Mounting Machine</td>
<td>1</td>
<td>800</td>
<td>W</td>
<td>Very intermittent, say 5% duty cycle during operating hours</td>
</tr>
<tr>
<td>Hoists</td>
<td>6</td>
<td>2200</td>
<td>W</td>
<td>Very intermittent, say 5% duty cycle during operating hours</td>
</tr>
<tr>
<td>Alignment Hoist</td>
<td>1</td>
<td>2200</td>
<td>W</td>
<td>Very intermittent, say 5% duty cycle during operating hours</td>
</tr>
<tr>
<td>Alignment Equipment</td>
<td>1</td>
<td>500</td>
<td>W</td>
<td>Very intermittent, say 5% duty cycle during operating hours</td>
</tr>
</tbody>
</table>
Internal Heat Gains

• **Temperature Difference**
  – Repair Shop and Dropoff: 18° C (64° F)
  – Showroom: 20° C (68° F)
  – Considered losses between areas

• **Heat gain (and loss) from car engines**
  – Cars brought in warm and cold
    • *Heat flows happened to balance out*
  – Cars engines run during repairs
    • *Exhaust reaches 650° F*
    • *14% of IHGs (could be more if long engine run time)*
Ventilation Systems

- Subaru does not produce diesel cars, but services them

Separate car exhaust system required
- Tubes clipped to car exhaust and direct vented
- 2,400 CFM (400 CFM/service bay x 6 bays)
- Normally, all bays are exhausted if only 1 bay requires exhaust
- Convinced engineer to run each bay on separate extract fan
Heating & Cooling

- **VRF system**
  - Heads installed in suspended ceiling of corridors and ducted to each room
  - Considered residential model
    - Concern over longevity
  - Does not operate at winter design temperature
    - Requires electric backup
Heating System Capacity

Heating

- System size x3 more than conservative estimate of heating load (no gains)

<table>
<thead>
<tr>
<th>Method</th>
<th>Heating Load (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHPP</td>
<td>13</td>
</tr>
<tr>
<td>PHPP w/o gains</td>
<td>21</td>
</tr>
<tr>
<td>Engineer</td>
<td>64</td>
</tr>
</tbody>
</table>

Cooling

- Different story
- Large West facing glazing problematic

<table>
<thead>
<tr>
<th>Element</th>
<th>PHPP</th>
<th>Peak Day - Reasonable gains</th>
<th>Peak Day - worst gains</th>
<th>Peak 3 hours – worst gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar radiation - West (W/m2)</td>
<td>235</td>
<td>235</td>
<td>235</td>
<td>909</td>
</tr>
<tr>
<td>interior shading RF</td>
<td>60%</td>
<td>60%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>net IHGs</td>
<td>1911</td>
<td>4859</td>
<td>9215</td>
<td>9215</td>
</tr>
<tr>
<td>Peak Cooling Load (kW)</td>
<td>10.7</td>
<td>15.4</td>
<td>24.3</td>
<td>52.9</td>
</tr>
</tbody>
</table>

Engineer’s Calculation: 57
DHW

Showroom
- Low demand – handwashing
- Supplied by Sanden CO2 heat pump

Repair Shop
- Each car is washed after maintenance work
- 2020 L/day @ 60°C equiv
  (530 gal/day @ 140°F)
- On-demand gas heater was only option
- Large PER impact
  - 34 kWh/m²/yr (11 kBTU/ft²/yr)
Heat Recovery & Extraction

- Investigated numerous options for heat recovery from car exhaust system
  - HRV
  - Tube in tube
  - Wrap around coil
  - Heat pipe
- None were workable
- Considered earth tube or ground loop
  - 2400 CFM – large capacity would be required
  - Average ground temperate = 4°C (39°F)
DHW heat recovery

- Car wash load was good candidate for heat recovery
  - High volume
  - High temperature (76°C)
  - Frequent use
- Initially identified horizontal shower-type unit
  - Company stopped manufacturing (trade issues)
  - Was willing to create custom unit, but eventually abandoned it
- Eventually settled on vertical unit installed horizontally
  - 10 ft long
Summary

• Think through the details early
  – Estimate equipment & occupant loads
  – Identify all energy flows
  – Not everything is predictable → add some buffer

• Cold Climates demand everything you’ve got
  – Simplified approach is critical

• Find engineers who are willing to explore options

• Cold climate product innovation required

• If you like a challenge, design a Passive House car dealership in a cold climate
Questions?

Thank you for your attention

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Additional Slides
Internal Heat Gains

• Repair shop has high Internal Heat Gains
  – 6.5 $W/\text{m}^2$ (0.6 $W/\text{ft}^2$)
  – Solar gains not beneficial
Ventilation Systems

• We recommended a single ERV for whole building
  – Engineer was not comfortable, due to car exhaust

• Repair Shop
  – Standard background rate is 3 ACH
  – Negotiated down to 2 ACH
  – Run intermittently, tied to air quality sensor

• Showroom
  – Negotiated initial rates down by > 50% (0.6 → 0.29 ACH)

• Issue: Dropoff ERV oversized for background rate
  – Solution: Intermittent operation
Ventilation Distribution

Initial design

- Ventilation air supplied into ceiling plenum
- relied on heat pump fans to circulate ventilation air into each room
- Issue: no heating = no ventilation
- Alternative is to run all the time – Substantial fan energy

Suspended ceilings as plenum chambers
Ventilation Distribution

- Eventually convinced engineer to revise design
- Ventilation air supplied into each space
- No heating = ventilation continues
Cooling Load

- PHI study supports this result 40% glazing

Hourly based cooling load 2x higher than PHPP daily

PHPP conservative for daily load
• Insert graph of PER breakdown
• PER exception
Thermal Envelope
Ground Floor

• Poor soil conditions
  – Prevented insulated raft slab
  – Fully wrapped foundation instead
Foundation work

• How to pour concrete in the middle of winter
Roof

- Initial drawings had stepped roof
- Revised to flat to simplify construction and reduce cost
Window & CW Installation

- **Insulated box** as lintel to reduce timber%.
- Otherwise, fairly conventional Passive House detailing.
## Assembly Performance Summary

<table>
<thead>
<tr>
<th>Element</th>
<th>U-value [W/m²K]</th>
<th>R-value</th>
<th>Insulation Thickness [mm] (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Slab</td>
<td>0.11</td>
<td>R54</td>
<td>305 (12”)</td>
</tr>
<tr>
<td>Basement Wall</td>
<td>0.13</td>
<td>R43</td>
<td>510 (20”)</td>
</tr>
<tr>
<td>Main Wall</td>
<td>0.08</td>
<td>R71</td>
<td>250 (10”)</td>
</tr>
<tr>
<td>Roof</td>
<td>0.03 – 0.04</td>
<td>R122-R177</td>
<td>1340 (52”)</td>
</tr>
</tbody>
</table>

How bout them thick walls!
Airtightness Strategy

- **Basement Floors & Walls**
  - Taped vapour barrier membrane

- **Main Walls**
  - Intello – required to avoid dew point issues
  - Protected by service cavity where services are installed
  - No interruption at intermediate floors

- **Roofs**
  - Taped ½” plywood

- **Windows**
  - Intello taped to window frames/CW

- **Building Target**
  - 0.4 ACH@50Pa – required to meet space heating demand