388 Skeena - The Heights

85 Suite Mixed Use Market Rental Housing in Vancouver, BC
Brixton Flats

56 Suite Mixed Use Market Rental Housing in Vancouver, BC
388 Skeena - Design PH Model
388 Skeena – Annual Energy Balance

Energy balance heating (annual method)

- **Non-Useful Gains**
  - External Wall: 2.5
  - Roof/Ceiling: 4.2
  - Floor Slab: 0.0
- **Solar Gains** (windows gain on the south)
  - Internal Heat Gains (About 50% of the total required heating energy)
  - Heating Demand (supplied by heating system)
- **Ventilation**
  - Heat flows [kWh/yr] 7.4
- **Windows**
  - Heat flows [kWh/yr] 10.8
- **Exterior Doors**
  - Heat flows [kWh/yr] 4.0
- **Thermal Bridges**
  - Heat flows [kWh/yr] 1.8
- **Losses**
  - Heat flows [kWh/yr] 20.2

**Daten für Diagramm. Wegen Übersetzung hinter dem Diagramm lassen, nicht in den ausgeblendeten Bereich ... loss**

**Ventilation**

**Solar Gains**

**Internal Heat Gains**

**Heating Demand**

**Losses**

**Gains**
### Specific building characteristics with reference to the treated floor area

<table>
<thead>
<tr>
<th></th>
<th>Treated floor area m²</th>
<th>4201.0</th>
<th>Criteria</th>
<th>Alternative criteria</th>
<th>Fullfilled?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space heating</strong></td>
<td></td>
<td></td>
<td>≤ 15</td>
<td>≤ 10</td>
<td>yes</td>
</tr>
<tr>
<td>Heating demand kWh/(m²a)</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating load W/m²</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Space cooling</strong></td>
<td></td>
<td></td>
<td>≤ 10</td>
<td>≤ 20</td>
<td>yes</td>
</tr>
<tr>
<td>Cooling &amp; dehum. demand kWh/(m²a)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling load W/m²</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Frequency of overheating (&gt; 25 °C) %</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Frequency of excessively high humidity (&gt; 12 g/kg) %</td>
<td>0</td>
<td>20</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td><strong>Airtightness</strong></td>
<td></td>
<td>0.3</td>
<td>≤ 0.6</td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Pressurization test result n₅₀ 1/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Moisture protection**

Smallest temperature factor fₛₜ ≥ 0.2 m³/m³·h

**Thermal Comfort**

All requirements fulfilled? yes

| U-value | W/(m²K) | ≤ 1.03 | yes |
| U-value | W/(m²K) | ≤ 1.23 |     |
| U-value | W/(m²K) | ≤ 1.35 |     |
| U-value | W/(m²K) | ≤ 1.63 |     |

**Non-renewable Primary Energy (PE)**

PE demand kWh/(m²a) 118 ≤ 120 yes

**Primary Energy Renewable (PER)**

Generation of renewable energy (in relation to projected building footprint area) ≥ 100 -
388 Skeena – Basic Specifications

- Walls: U 0.104 (~ R35)
- Roof: U 0.075 (~ R45)
- Floor: U 0.171 (~ R25)
- Windows: Ug 0.70 W/(m2 K) (~ R8)
- Thermal Bridge Free Detailing
- Fresh Air with high efficiency Heat Recovery (85%)
- Air Tightness .6 Ach/hr @50 Pa

Euroline ThermoPlus was the only locally made Passive House certified window
Wall Options: Interior Insulated

- Advantages
  - Most of the air sealing is one trade working in dry conditions
  - Fairly conventionally framed
  - Conventional siding installation

- Disadvantages
  - Interior wall awaits install of exterior moisture barrier for drying
  - Wiring will commence before the exterior wall is ready
388 Skeena – Shading
388 Skeena – Domestic Hot Water

Boiler
- 3- AO Smith Condensing Boilers
- 96% efficient
- 58 KW capacity each

DHW Distribution
- Grundfos MLE Pump Motors
- Variable Frequency Drive for Efficiency
- Fully Insulated Recirculating DHW system
  - 25mm of Insulation (38mm on mains)

High Efficiency Plumbing Fixtures
- 5.7 LPM Kitchen Faucet
- 9.5 LPM Shower
- 1.9 LPM Lavatory
388 Skeena – Auxiliary Electricity

Elevator
• Low Standby Power Consumption
• Efficient Motors
• Regenerative Braking

Common and Architectural Lighting
• LED Security Lighting
• Limited LED Architectural Lighting
• Motion Sensors on Common and Amenity Lighting
Ventilation Deep Dive - Fundamentals

Ventilation Strategy: Use simple higher efficiency units with fewer interacting systems.

Zehnder CA 500 HRV
84% effective (PHI) 325 CFM
Ventilation Deep Dive - Fundamentals

Ventilation with Heat Recovery

Fresh Outside Air
0°C (32°F)

Stale Exhaust
21°C (70°F) Bath

Exhaust to Outdoors
1.68°C (35.2°F)

Supply to Rooms
19.3°C (66.7°F)

PHI Rated 92% Efficiency

Exchanged once every three hours!
Ventilation Deep Dive - Semi Centralized System Strategy

• Semi-Distributed Approach
  • Simple reliable HRV/ERV with few moving parts (3).
  • Simplified continuous ventilation (w/ boost) design approved by PHI. No need for complicated flow responses in distribution system.
  • Low initial equipment cost.
  • Simplified controls.
  • HRV Core (no moisture recovery) is better suited to Vancouver climate.
  • “Low tech” requirement for maintenance by building staff.
Connect units to the exterior by going up through the roof.

- *Units are vented directly through the roof membrane into a “dog house”.*
Set fresh air supply as far above roof deck as practical
Connect units to the exterior by going up through the roof.

- *Create 8” diameter risers that drop to the bottom of the residential floors. Stub out a connection per floor to serve a single suite.*

Reduced fan energy due to no lateral duct runs.
Distribution design for supply and return ducts
Supply flows in bedroom transition through dining area into bath

Living room flows transition and mix with kitchen and are drawn to bath by negative pressure.

0.32 – 0.4 ACH turns over air in living space continuously every 3 hours.

Ventilation Deep Dive- Semi Centralized Suite Layout
Continuous Balanced Ventilation with Boost

Living room flows transition and mix with kitchen and are drawn to bath by negative pressure.

0.32 – 0.4 ACH turns over air in living space continuously every 3 hours

30% BOOST!
Adding Silencers, Smoke Dampers and Balancing Dampers
Ventilation Deep Dive - Looking At The Semi Centralized Installation

HRV placed on level 6

- Interior flows serving level 6 unit
- Filters on both sides of the HRV Core
- Zehnder ComfoAir 550 HRV Left
- Condensate drain
- 8” diameter riser to 5 lower floors. Average flows 180 CFM continuous with < 0.8” WC = Reduced fan energy (Approx. 42 watts).
Ventilation within the suite

- Smoke damper at fire separation (not visible)
  Typically located in 12” drop bath or entry
  Balancing damper used to permanently set continuous flows per suite.
- Supply silencer/manifold
- Return silencer/manifold
Ventilation Deep Dive- Looking At The Semi Centralized Installation

- Exhaust
- Direction of flow
- Balancing damper
Ventilation Deep Dive- Looking At The Semi Centralized Installation

No trunk lines.
All ducts are home run from manifold/silencer
Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System

Vent Riser Sheets show rates per riser and total demand for building less 1\textsuperscript{st} floor

3500 CFM at normal flow rate demand
Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System

Vent Riser Sheets

Unit Capacity at 0.8” WC:
100% = 325 CFM
70% = 190 CFM
60% = 140 CFM

30 CFM
30 CFM
30 CFM
30 CFM
30 CFM
Total 150 CFM
Passive House Ventilation Commissioning

Heat Recovery reaches highest efficiency stated in energy model with balanced flows.

Design flows maintain humidity levels and comfort.

**Steps to balance a ventilation system:**

1. Performed by qualified tradesperson.
2. Inspect the overall system and installation.
3. Measure flows at exterior.
4. Measure flows at interior.
5. Calculate difference to note any leakage.
6. Equalize flows.
7. Set normal flows to design.
8. Set additional levels, (boost, low occupancy).
9. Record all settings
Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System

Duct Leakage Testing of Risers

Units are placed on top floor within the thermal envelope. Create 8" diameter risers that drop to the basement to serve a single suite. Reduced fan energy due to no lateral duct runs.
Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System

Adjust balancing dampers
**Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System**

<table>
<thead>
<tr>
<th>Suite</th>
<th>Normal Rate</th>
<th>Supply</th>
<th>Exhaust</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>170 CFM</td>
<td>181 CFM</td>
<td>178 CFM</td>
</tr>
</tbody>
</table>

- **Design** for 170 CFM at normal.
- **Supply** reading 181 CFM
- **Exhaust** reading 178 CFM

**Results are in the +/- 10% range and acceptable.**

**Progress readings on Vent 3**

- Design for 170 CFM at normal.
**Ventilation Deep Dive - Creating a Balanced and Tested Semi Centralized System**

<table>
<thead>
<tr>
<th>Supply</th>
<th>Exhaust</th>
</tr>
</thead>
<tbody>
<tr>
<td>73% Fan Speed</td>
<td>65% Fan Speed</td>
</tr>
<tr>
<td>181 CFM = 1” WC</td>
<td>178 CFM = 0.7” WC</td>
</tr>
</tbody>
</table>

**How much pressure drop is created?**

Total Flow at Fan speed shows Inches WC created by 8” risers over 5 floors, smoke dampers, balancing dampers, silencers, and en-suite distribution.

- Supply: 170 CFM
- 181 CFM
- Exhaust: 178 CFM
Ventilation Deep Dive - Decentralized System Strategy

• Decentralized Approach

• Ventilation Strategy: PHI certified HRV in every suite for individual control, no risers or fire dampers. HRV sized for living unit. – 5 studios revised to share single CA 550 HRV
Ventilation Deep Dive - Decentralized Suite Layout

Residential unit type

2 BDR units - Studio units – 1 BDR units - 3 BDR Units
Ventilation Deep Dive - Decentralized Suite Layout

3 Bed Room Unit
Ventilation Deep Dive- Decentralized Suite Layout

3 Bed Room Unit

1020 Ft2
8160 ft3
68 CFM
= 0.50 ACH
Ventilation Deep Dive - Decentralized Suite Layout

1 Bedroom unit

Zehnder CA 160 HRV
Ventilation Deep Dive - Decentralized Suite Layout

1 Bedroom unit

600 ft²
4800 ft³
40 CFM
= 0.5 ACH

Zehnder CA
160 HRV
Five street facing studio units receive the semi distributed approach horizontally

Smoke Damper at each living unit placed on both supply & exhaust flow

Balancing damper placed at each supply & exhaust flow to adjust correct flow into unit

Zehnder CA 550 HRV flows into hallway trunk line
Ventilation Deep Dive - Looking At The Decentralized Installation

Verify drop height
Ventilation Deep Dive - Looking At The Decentralized Installation
Ventilation Deep Dive - Looking At The Decentralized Installation
Flow tested exterior runs to verify that long run and increase in 90’s did not constrict flow.
Ventilation Deep Dive - Looking At The Decentralized Installation

Original plan to be placed in bath

2x drywall for fire rating living room supply
Ventilation Deep Dive - Looking At The Decentralized Installation
Possible to balance the system accurately

Each motor is individually controllable from the wall control for Commissioning.
Ventilation Deep Dive - Lessons Learned

• The Heights summer 2018

• Brixton Flats late summer 2018

Filters are an important factor in maintaining both equipment function, and IAQ. PHI Requirement is Merv 13 on Supply Flows.
Ventilation Deep Dive - Lessons Learned

Fire and Smoke

Ventilation may be the tool that we use to prepare for “normalized” extreme events.

Picture taken in Prince George BC at 9AM during 2018 fires.
## Brixton Flats: Flow and Energy

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Units</th>
<th>Avg CFM</th>
<th>Total CFM</th>
<th>Watt h/m3</th>
<th>Watt h/CFM</th>
<th>Total Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 70</td>
<td>5</td>
<td>20</td>
<td>100</td>
<td>0.24</td>
<td>0.14</td>
<td>14</td>
</tr>
<tr>
<td>CA 160</td>
<td>11</td>
<td>48</td>
<td>528</td>
<td>0.36</td>
<td>0.21</td>
<td>112</td>
</tr>
<tr>
<td>CA 200</td>
<td>18</td>
<td>64</td>
<td>1152</td>
<td>0.42</td>
<td>0.25</td>
<td>284</td>
</tr>
<tr>
<td>CA 550</td>
<td>5</td>
<td>100</td>
<td>500</td>
<td>0.31</td>
<td>0.18</td>
<td>91</td>
</tr>
<tr>
<td>CA 350</td>
<td>1</td>
<td>100</td>
<td>100</td>
<td>0.29</td>
<td>0.17</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td><strong>2380</strong></td>
<td><strong>0.324</strong></td>
<td><strong>0.19</strong></td>
<td><strong>519</strong></td>
<td></td>
</tr>
</tbody>
</table>
Ventilation Deep Dive- Lessons Learned

The Heights: Flow and Energy

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Units</th>
<th>Avg CFM</th>
<th>Total CFM</th>
<th>Watt h/m3</th>
<th>Watt h/CFM</th>
<th>Total watts</th>
<th>Watt Draw</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 550</td>
<td>19</td>
<td>180</td>
<td>3420</td>
<td>0.31</td>
<td>0.18</td>
<td>623</td>
<td>33</td>
</tr>
</tbody>
</table>

Total building use!
Ventilation Deep Dive - Lessons Learned

- Brixton Flats - 56 unit individual HRV’s
  - 2350 CFM / 56 units = 42.5 CFM
  - 92% efficient PHI (92% HVI)
  - Maintenance Requirement: 1. Change Filters

- The Heights - 85 unit distributed HRVs’s
  - 3420 CFM / 85 units = 40 CFM unit
  - 84% efficient PHI (90% HVI)
  - Maintenance Requirement: 1. Change Filters
388 Skeena – Post Occupancy Evaluation

Objective
Continue to support ongoing analysis of 388 Skeena to better inform how the building is performing relative to its modeled performance. Use that comparison to inform building design in Vancouver to further improve the success of Passive House in North America.

Strategy
• Collect building performance data
  • Thermal Comfort
  • Common space and whole building electricity consumption
  • Whole building gas consumption
• Partner with ownership and occupants to outline and implement a strategy for improving building performance
  • Discuss the occupant’s experience
  • Develop an understanding of the occupant’s use of their space
  • Develop a program to reduce energy consumption
388 Skeena – Understand Thermal Comfort

- Temperature sensors were provided in building to monitor thermal comfort conditions
- Instances of interior temperatures over 25°C were recorded in all the spaces
  - North averaged +/-59% of July over 25°C
  - North-East averaged +/-54% of July over 25°C
  - South averaged +/-89% of July over 25°C
  - West averaged +/-97% of July over 25°C
- 25°C does not necessarily mean overheating
388 Skeena – Understand Thermal Comfort

North-East Facing Lower Suite

South Facing Lower Suite

West Facing Lower Suite

North Facing Lower Suite
388 Skeena – Planning for Thermal Comfort

• How is the building being used?
  • Are operable windows being maximized?
  • Are there more internal heat gains than anticipated?
• Are the systems performing as designed?
  • Is the solar shading working as planned
  • Are the HRVs using their nighttime bypass mode properly?
  • Could boost mode be utilized to move more air into the space when advantageous?
388 Skeena – Acting for Thermal Comfort

• What lessons are we taking away from the experience?
  • How important is the need for mechanical cooling?
    • Modelling for thermal comfort outside of PHPP
    • Considering PHPP Climate models and the climate change models
  • What sort of hand-off are we providing to tenants to better inform their behavior?
• How can we adapt the current system or design for adaptability in future projects?
  • Selecting intelligent systems with the programming responsiveness like the ConfoAir
  • HRVs being fit with a small cooling coil?
388 Skeena – Understanding Whole Building Energy Consumption

- Approaching 10 month of building occupancy

- Residential Suites Electricity Consumption forecasted to be **46 kWh/m2/yr**
  - Modeled consumption **26 kWh/m2/yr** (44% difference)

- Natural Gas Consumption forecasted to be **52 kWh/m2/yr**
  - Modeled consumption **31.3 kWh/m2/yr** (40% difference)

- Overall, actual energy consumption is **41.2 kWh/m2/yr** greater than anticipated
  - **20.5 kWh/m2/yr** in electricity
  - **20.7 kWh/m2/yr** in DHW consumption

<table>
<thead>
<tr>
<th>Actual</th>
<th>Adjusted Suite Energy Consumption kWh/m2/yr.</th>
<th>PHPP Modeled Energy Consumption kWh/m2/yr.</th>
<th>Difference Between Actual and Modeled Consumption kWh/m2/yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Energy Consumption kWh/m2/yr.</td>
<td>Adjustment for House and CRU Energy Consumption kWh/m2/yr.</td>
<td>Electricity Consumption kWh/m2/yr.</td>
<td>Natural Gas kWh/m2/yr.</td>
</tr>
<tr>
<td>Electricity</td>
<td>95.12</td>
<td>48.73</td>
<td>46.39</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>52</td>
<td>N/A</td>
<td>52.00</td>
</tr>
<tr>
<td>Total</td>
<td>98.39</td>
<td>Total</td>
<td>57.23</td>
</tr>
</tbody>
</table>

% of total Energy Consumption for the Site: 57%
DHW is the only use of natural gas in the building, therefore all additional energy consumption can be tied to it.

- Assuming heat loss as the constant DHW consumption was calculated
- Estimated DHW consumption \(50.07 \text{L/person/day}\)
- PHPP modeled consumption was \(25 \text{L/person/day}\)
- Adjusting for the actual installed fixtures only accounts for \(2 \text{kWh/m}^2/\text{yr}\)
- Boiler efficiency was also reduced
- Occupant DHW consumption is likely the source of the additional gas consumption

### 388 Skeena Net Gas Consumption

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Start</th>
<th>Finish</th>
<th>GJ/day</th>
<th>kWh/day</th>
<th>kWh/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Feb - 06-Mar</td>
<td>32</td>
<td>61.8</td>
<td>1.931</td>
<td>536.5</td>
<td>195,807</td>
</tr>
<tr>
<td>06-Mar - 05-Apr</td>
<td>30</td>
<td>71.4</td>
<td>2.380</td>
<td>661.1</td>
<td>241,306</td>
</tr>
<tr>
<td>05-Apr - 04-May</td>
<td>29</td>
<td>68.3</td>
<td>2.355</td>
<td>654.2</td>
<td>238,789</td>
</tr>
<tr>
<td>04-May - 04-Jun</td>
<td>31</td>
<td>62.5</td>
<td>2.016</td>
<td>580.0</td>
<td>204,413</td>
</tr>
<tr>
<td>04-Jun - 04-Jul</td>
<td>30</td>
<td>63.6</td>
<td>2.120</td>
<td>588.9</td>
<td>214,945</td>
</tr>
</tbody>
</table>

| PHPP kWh/yr | 2.161 | 600.1 | 213,052 | 131,404 |
|            |       |       | 100%    |         |

### Table: Actual vs. Modeled Energy Use

<table>
<thead>
<tr>
<th>Actual Energy Use</th>
<th>Modeled Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh/m²</td>
<td>kWh/m²</td>
</tr>
<tr>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
388 Skeena – Acting Whole Building Energy Consumption

- What lessons are we taking away from the experience?
  - What tools can we use to motivate DHW savings?
  - Is sub-metering for DHW a useful tool for reducing tenant consumption?
- How can we adjust our design approach?
  - Where does the surplus heat go? What are the risks?
  - How can we maintain efficiency through smart system selection?
Following the ambition of the client, there is a plan to conduct a comprehensive Post Occupancy Evaluation:

- Focus on occupant survey and programming
- Attempt to respond to noted discrepancies in modeled and actual DHW consumption
- Utilize established monitoring to adjust and improve thermal comfort performance
- Work with NRCan and CMHC to establish additional metering for major energy using systems.
Q&A
PASSIVEHOUSE CANADA
Build better.
Feel better.