Solis House

- Urban Single Family -
Co-Captains

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Tara Virginillo
Anika Jang
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Civil / Geo
Shea Mills
Eric Hebbard
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Ben Wahl
Vancouver, BC, Canada
- Climate zone 4 (mild, temperate)
- High precipitation
- Low solar insolation

Figure 1: Annual average precipitation in Vancouver (weather-and-climate.com)

Figure 2: Location of Vancouver on an ASHRAE climate zone map

Figure 3: Sun-path on shortest day of the year (January 21st)
LOCATION & CLIMATE
<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Household Size</td>
<td>2.7</td>
</tr>
<tr>
<td>Average Income</td>
<td>$86,000</td>
</tr>
<tr>
<td>Census Population</td>
<td>34,575</td>
</tr>
<tr>
<td>Population in Low Income Households</td>
<td>19%</td>
</tr>
</tbody>
</table>

**Language**

- English
- Chinese
- Vietnamese
- Italian
- Tagalog (Pilipino, Filipino)
- Spanish

**Mode of Travel to Work**

- Vehicle driver: 28.5%
- Vehicle passenger: 56.8%
- Public transit: 8.0%
- Walking: 1.5%
- Bicycle: 0.6%
- Other: 6.6%

**Age Groups**

- 19 <: 20.2%
- 20-39: 27.1%
- 40-64: 30.4%
- 65 +: 12.3%
VANCOUVER’S HASTINGS-SUNRISE NEIGHBOURHOOD

- Reduce reliance on cars
- Encourage two-suite homes
- Improve community safety
- Protect the Environment
- Increase access to shopping
- Retain & enhance character areas

COMMUNITY VISION
MARKET POTENTIAL

1. Market Driven Design
   - Community centered & competitively priced
   - Flawless integration with landscape & community character

2. Constructable
   - Modular construction
   - Mass-timber design

3. Self Sufficient & Sustaining
   - On-site food & energy production
   - Smart-home controls
RISK ASSESSMENT

Earthquakes
Flooding
Climate Change

Grid Connectivity
Moisture Balance
Income Crisis
create a dwelling that addresses all levels of sustainability: low embodied and operational emissions and long-term resilience. The design will be approached with a passive systems-first mentality, and utilising transdisciplinary communication to ensure seamless integration of active systems.
RESILIENT DESIGN GOALS

- High-performance envelope & fenestrations
- On-site renewable energy
- Modularity
- Rainwater collection
- Alternative income source
- Mass-timber approach to seismic resilience
- Overheating control
- Passive principles
- Local, low-carbon intensive materials
ARCHITECTURE
| Building form           | Simplify building form  
|                        | Minimize surface to volume ratio  
|                        | Maximize south-facing roof area  |
| Internal space         | Maximize natural ventilation & lighting  
|                        | Minimize piping heat losses  
|                        | Make use of internal heat gains  |
| Materials              | Introduce thermal mass  |
Space considerations for current and future systems
Minimize pipe heat loss
Bedrooms in quiet and low-traffic spaces
High-levels of natural lighting & ventilation

Open-plan living spaces
ARCHITECTURAL DESIGN: NATURAL VENTILATION

outlet area: 0.75 m²
ACH: 6

inlet area: 0.4 m²
ACH: 7

inlet area: 0.25 m²
ACH: 6

outlet area: 0.75 m²
ACH: 5

inlet area: 0.3 m²
ACH: 6

inlet area: 0.3 m²
ACH: 5
Figure 18: Summer Solstice natural lighting (left to right: floor plans 1-3, N direction top of page)
Local, natural & healthy materials.

- Cross-laminated Timber
- Wood Fibre insulation
- Recycled Oyster Shell Countertops
LANDSCAPE
- Vertical Garden
- Optimized Water Consumption
- Recycled Plastic Base
- Permeable for Drainage
- On-Site Food Production
- Rain-Water Irrigated
- Vertical Garden
- Optimized Water Consumption
- Recycled Plastic Base
- Permeable for Drainage
- On-Site Food Production
- Rain-Water Irrigated
STRUCTURE
Earthquake Resilience

CLT
- Improved performance given its strength, flexibility, and lightweightedness

Bubbledeck slab on grade
- Reduces earthquake loads

Tie downs
- Resist lateral seismic loads
CONSTRUCTION
BUILDING ENVELOPE
- Vancouver's biome is classified as a temperate rainforest
  - High levels of rainfall
  - High relative humidity
  - Below 0°C (32°F) temperatures in the winter

- This biome poses challenges regarding:
  - Condensation
  - Mold
  - Wetting
  - Freeze-Thaw

- Used Passive House Canada for thermal minimums

- Conducted humidity analyses to assure mold free enclosure

<table>
<thead>
<tr>
<th>Section</th>
<th>Passive House Min</th>
<th>Solis House R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Exterior Wall</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Slab/Ground Floor</td>
<td>30</td>
<td>49</td>
</tr>
</tbody>
</table>

Table 1: Passive House Canada R-Values VS Our Calculated R-Values
Relative Humidity and Temperature Models

Figure 1: Ubakus temperature gradient model through our exterior wall section. -18°C exterior and 19°C interior temperatures

Figure 2: Ubakus Relative Humidity model through our exterior wall section. 100%RH exterior and 50%RH interior conditions

Figure 3: Therm temperature gradient model of a typical triple glazed, fiberglass framed window
ACOUSTICS
Natural, carbon sequestering materials used for acoustic insulation

Acoustic Performance of Partitioning Elements
- Int Wall: 58STC
- Ext Wall: 52STC
- Floor: 55STC and 51IIC

Honeycomb sound attenuators used for ventilation openings
MECHANICAL
SYSTEMS
Occupant comfort

Energy use & simplicity

100% electrification
- 6.75 kW Ground Source Heat Pump sized for peak future cooling load
- 120m vertical borehole sized for peak future heat rejection
Figure 1: Ideal temperature profile

16°C 20°C 24°C

Figure 2: Profile for underfloor heating

16°C 20°C 24°C

Figure 4: Profile for convector heating

16°C 20°C 24°C
### Ventilation

<table>
<thead>
<tr>
<th>Tag</th>
<th>Location</th>
<th>Service</th>
<th>Flow Rate (L/s)</th>
<th>Standard</th>
<th>Boost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERV</td>
<td>Main House Mech Room</td>
<td>Whole Home</td>
<td>115.50</td>
<td>149.99</td>
<td></td>
</tr>
</tbody>
</table>
WATER SYSTEMS
REDUCE

water  power  materials
ELECTRICAL
SYSTEMS
Lighting power density (LPD): 1.57 W/sqm

Lighting Controls:
- Manual control
- Daylight harvesting
- Vacancy sensing

Lighting Control Zones:

- **Zone 1:**
  - Primary ON/OFF: Manual Switch

- **Zone 2:**
  - Primary ON/OFF: Manual Switch
  - Secondary OFF: Daylight (Photocell) Sensor

- **Zone 3:**
  - Primary ON/OFF: Manual Switch
  - Secondary OFF: Occupancy Sensor
ENERGY PERFORMANCE
Energy Performance Metrics

- Est. Energy Consumption: **8,000 kWh/yr**
- EUI: **48.34 kWh/m²**
- Est. Utility Bill: **$240 CAD/yr**

![Energy Performance Metrics diagram]

**Estimated Annual Energy Consumption**

- Heating
- Cooling
- Water Heating
- Light & Appliances
- Total

![HERS® Index chart]
Energy System Metrics

Nameplate Capacity: 8.8 kW

Expected Yearly Output: 8,600 kWh

Battery Size: 13.2 kWh

<table>
<thead>
<tr>
<th>Index</th>
<th>Item</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solar Panel</td>
<td>Canadian Solar CS3K-315MS &gt; 315 Watt</td>
</tr>
<tr>
<td>2</td>
<td>Combiner Box</td>
<td>Midnite Solar MNPV12-250</td>
</tr>
<tr>
<td>3</td>
<td>Inverter/Charge Controller</td>
<td>FLEXpower Radian 8 kW with 2x flexmax 100 charge</td>
</tr>
<tr>
<td>4</td>
<td>Shutdown Switch</td>
<td>IMO FireRaptor Shutdown Switch for FRS-01</td>
</tr>
<tr>
<td>5</td>
<td>48V Battery Lithium Ion Battery</td>
<td>Discover Battery 260AH 48VDC w/ Xanbus 13,200 Wh (2)</td>
</tr>
</tbody>
</table>
FINANCIAL FEASIBILITY
Vancouver Housing Market

- 2nd least affordable
  - Avg 2 storey: $2.3million
- Sunrise-Hastings: Land Cost - $150-200/sqft
- Average home debt to income ratio
  - Canada: 177%
  - Vancouver: 208%

**Rental Unit = Passive Income**
- Offsets homeownership costs
- Provides increased density low volume market

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**Solis House**

**Construction Costs**
- Total Cost $1,739,012.47
- Land Value at Market Rate $1,350,000.00
- Land Cost $389,012.47

**Mortgage**
- 20% down payment $347,802.49
- Remaining Capital $1,391,209.98
- Average mortgage payment (25 yr - 5 yr 2.44% fixed IR) $6,191.00
- Homeowner Debt to Income Ratio 47.93%
EMBODIED CARBON
LCA Scope: 100 years

Trade-offs
High levels of insulation balance low operational emissions

Global Warming, kg CO2e - Resource Types

- Insulation
- Concrete
- Wood
- Metals
- Doors & windows
- Utilities
- Gypsum, plaster & cement
- Plastics, membranes & roofing
- Glass

[ kg CO2e ]
0 20000 40000 60000
Embodied Carbon Impacts

- 169 Tons CO₂e
- 8 kg CO₂e / m² / yr
- $12,868.85 CAD social cost of carbon

Global Warming (kg CO2e) - Life-cycle stages:
- A1-A3 Materials
- A4 Transportation
- B1-B5 Maintenance and replacement
- B6 Energy
- C1-C4 End of life
INNOVATION
MATERIAL SELECTION
- Recycled Plastic Honeycomb
- BubbleDeck Slab on Grade
- Oyster Shell Composite
- Cross-laminated Timber
- Wood Fibre Insulation

SELF SUFFICIENCY
- On-site Energy Production
- Rainwater Harvesting

ONSITE FOOD PRODUCTION
- CityBeets Community Garden Partnership
- Indoor Vertical Greenhouse
Thank you.

- Solis House -