



# *Solis House*

*- Urban Single Family -*



THE UNIVERSITY  
OF BRITISH COLUMBIA

student leads

Architecture



Jasmine Lee

Energy & Electrical



Wenoa Teves

Water



Alicia Hobamier



Quinn Klassen

Civil / Geo



Shea Mills

Structural



Mandi Unick

Mechanical



Milan Jaan



Jade Lissel



Zoe Le Hong



Aleesha Hsu

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faculty support

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## Civil / Geo

**Shea Mills**  
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Lauren Lee  
Ben Wahl

# Partnerships

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THE UNIVERSITY OF BRITISH COLUMBIA  
Applied Science



THE UNIVERSITY OF BRITISH COLUMBIA  
Civil Engineering



ENGINEERS &  
GEOSCIENTISTS  
BRITISH COLUMBIA



Engine



## Vancouver, BC, Canada

- Climate zone 4 (mild, temperate)
- High precipitation
- Low solar insolation

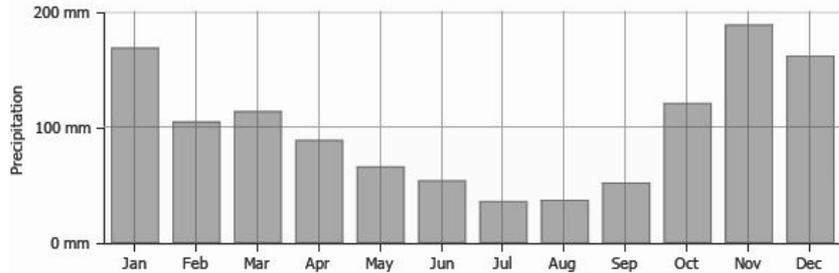


Figure 1: Annual average precipitation in Vancouver (weather-and-climate.com)

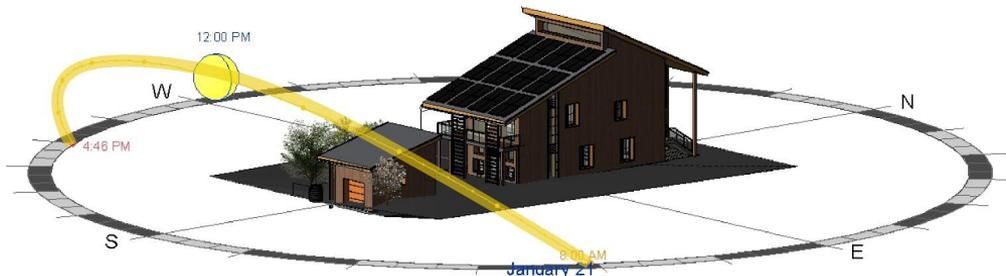


Figure 3: Sun-path on shortest day of the year (January 21st)

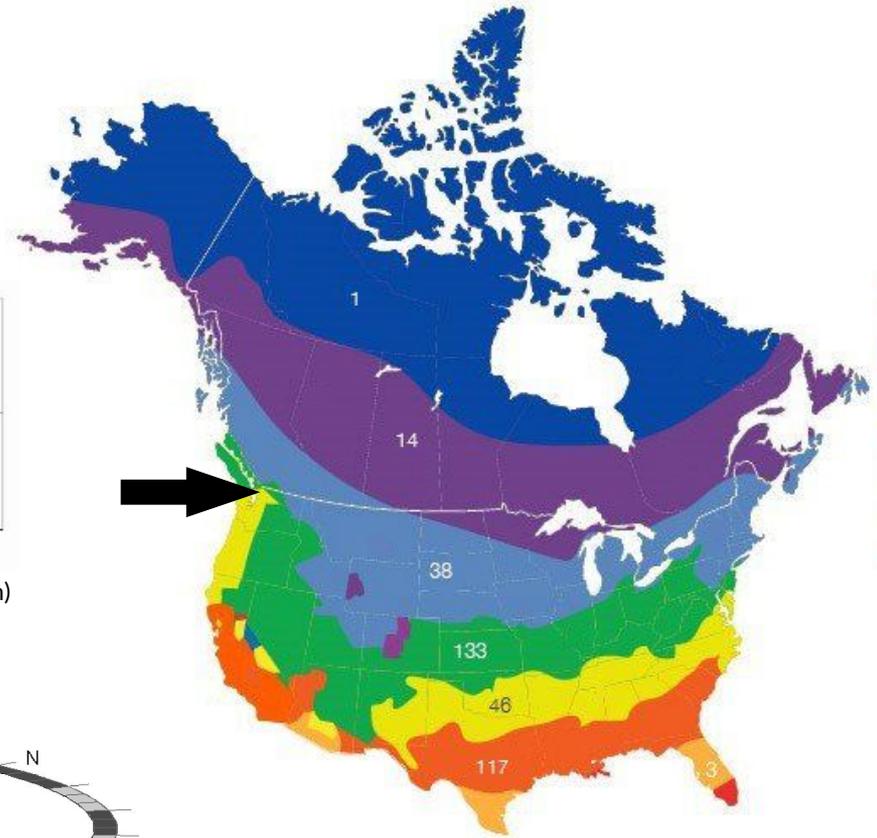
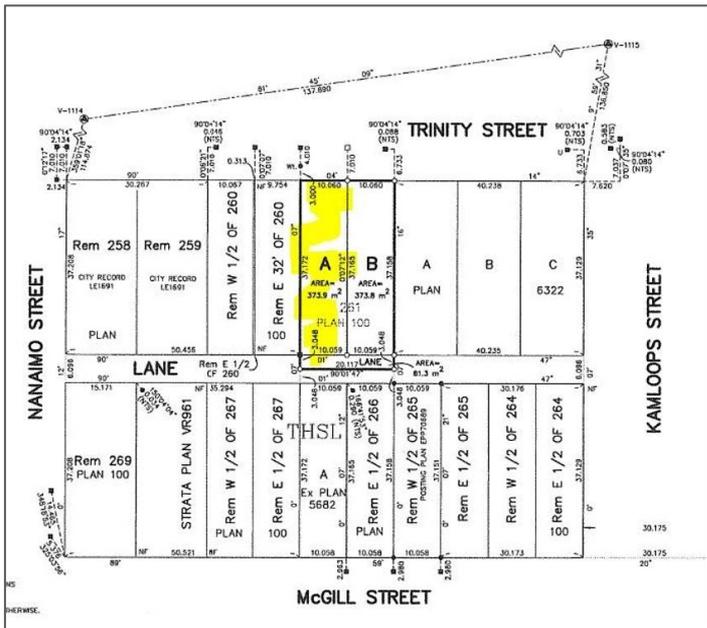


Figure 2: Location of Vancouver on an ASHRAE climate zone map



## VANCOUVER'S HASTINGS-SUNRISE NEIGHBOURHOOD

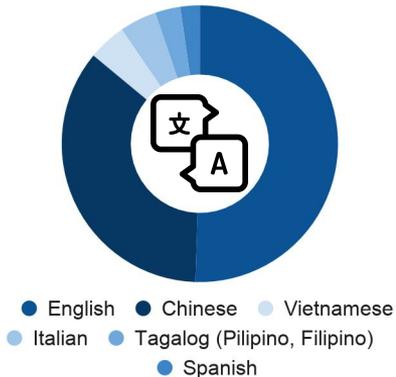
Average Income  
\$86,000

Average Household Size  
2.7

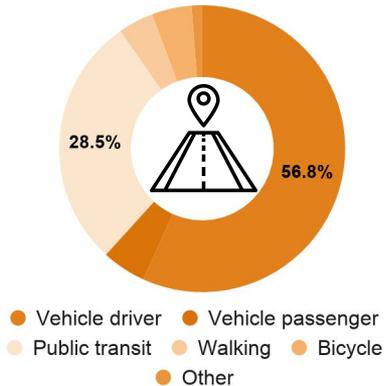
Census Population  
34,575

Population in Low  
Income Households  
19%

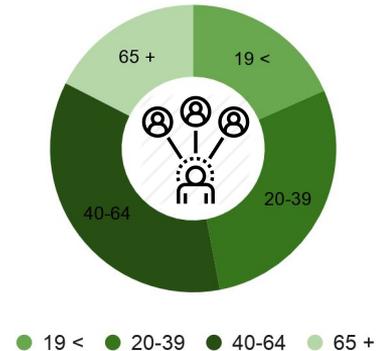
Language



Mode of Travel to Work



Age Groups





# VANCOUVER'S HASTINGS-SUNRISE NEIGHBOURHOOD





**Market Driven Design**

1

- Community centered & competitively priced
- Flawless integration with landscape & community character



**Constructable**

2

- Modular construction
- Mass-timber design



**Self Sufficient & Sustaining**

3

- On-site food & energy production
- Smart-home controls



Earthquakes



Flooding



Climate Change



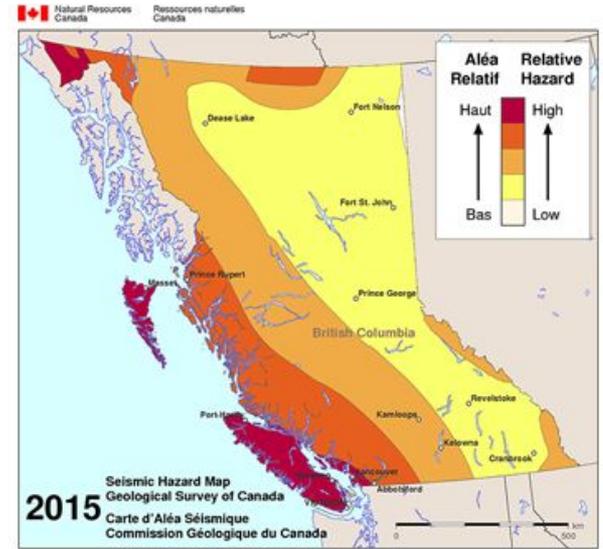
Grid  
Connectivity



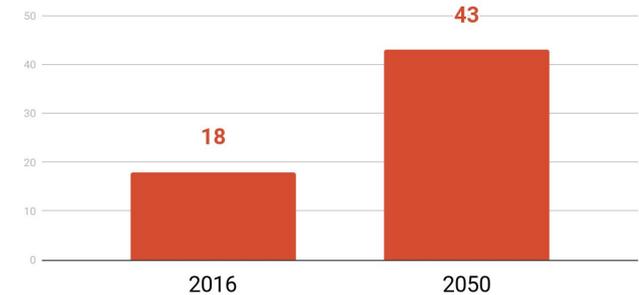
Moisture  
Balance



Income  
Crisis



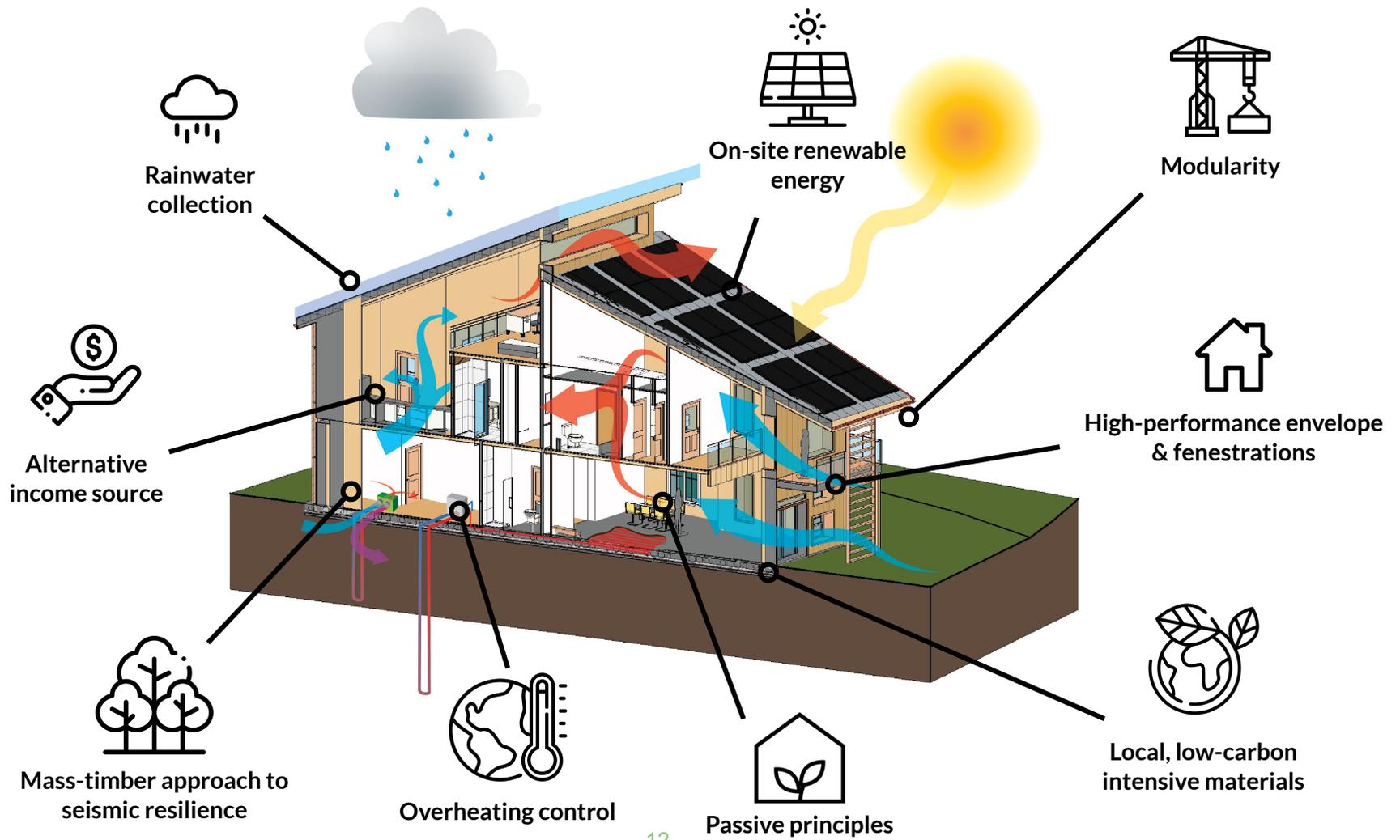
Increase in Cooling Days



# DESIGN CONCEPT

create a dwelling that addresses *all levels of sustainability*: low embodied and operational emissions and long-term resilience.

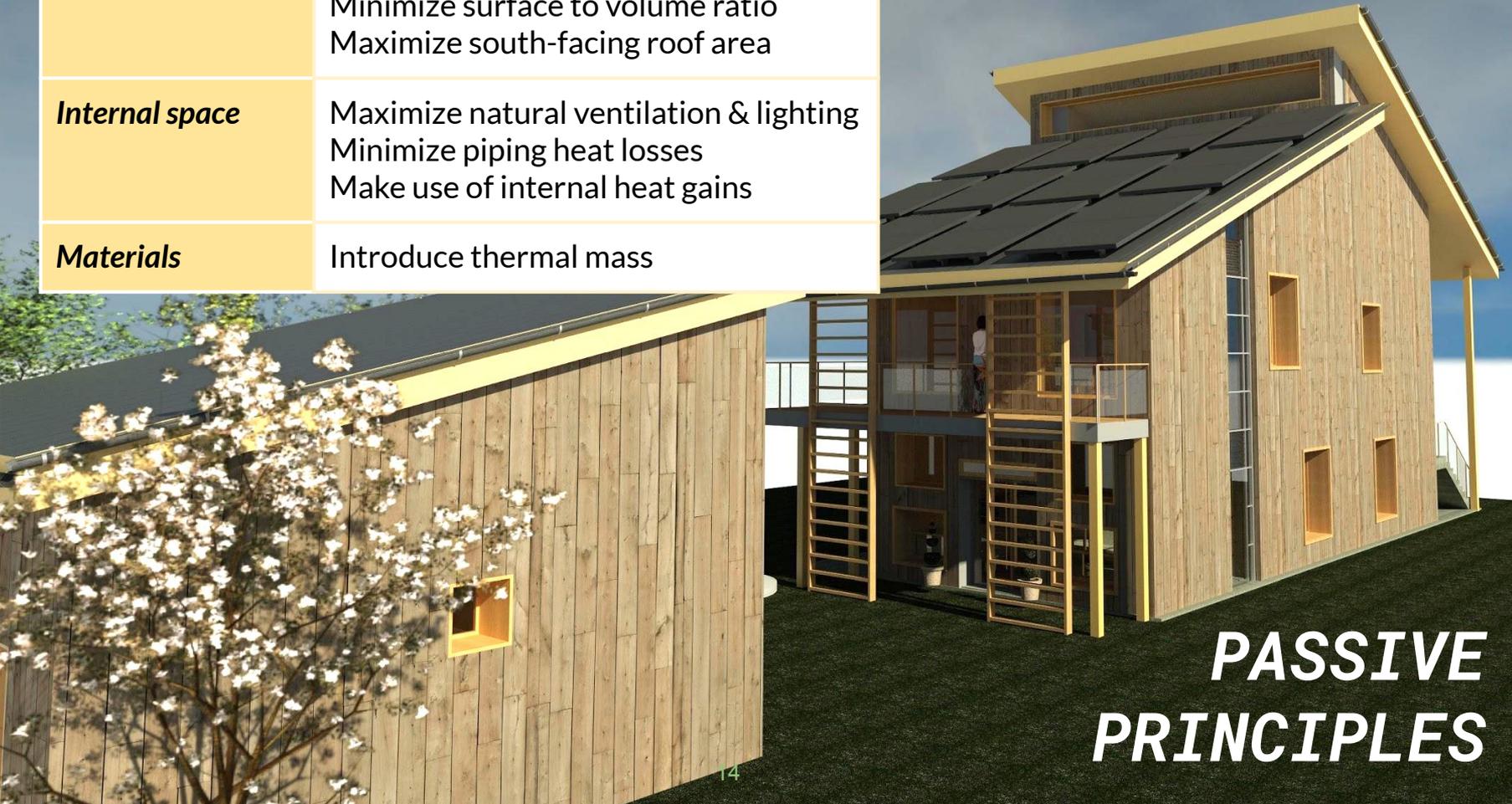
The design will be approached with a *passive systems-first* mentality, and utilising transdisciplinary communication to ensure seamless integration of active systems.



# *ARCHITECTURE*



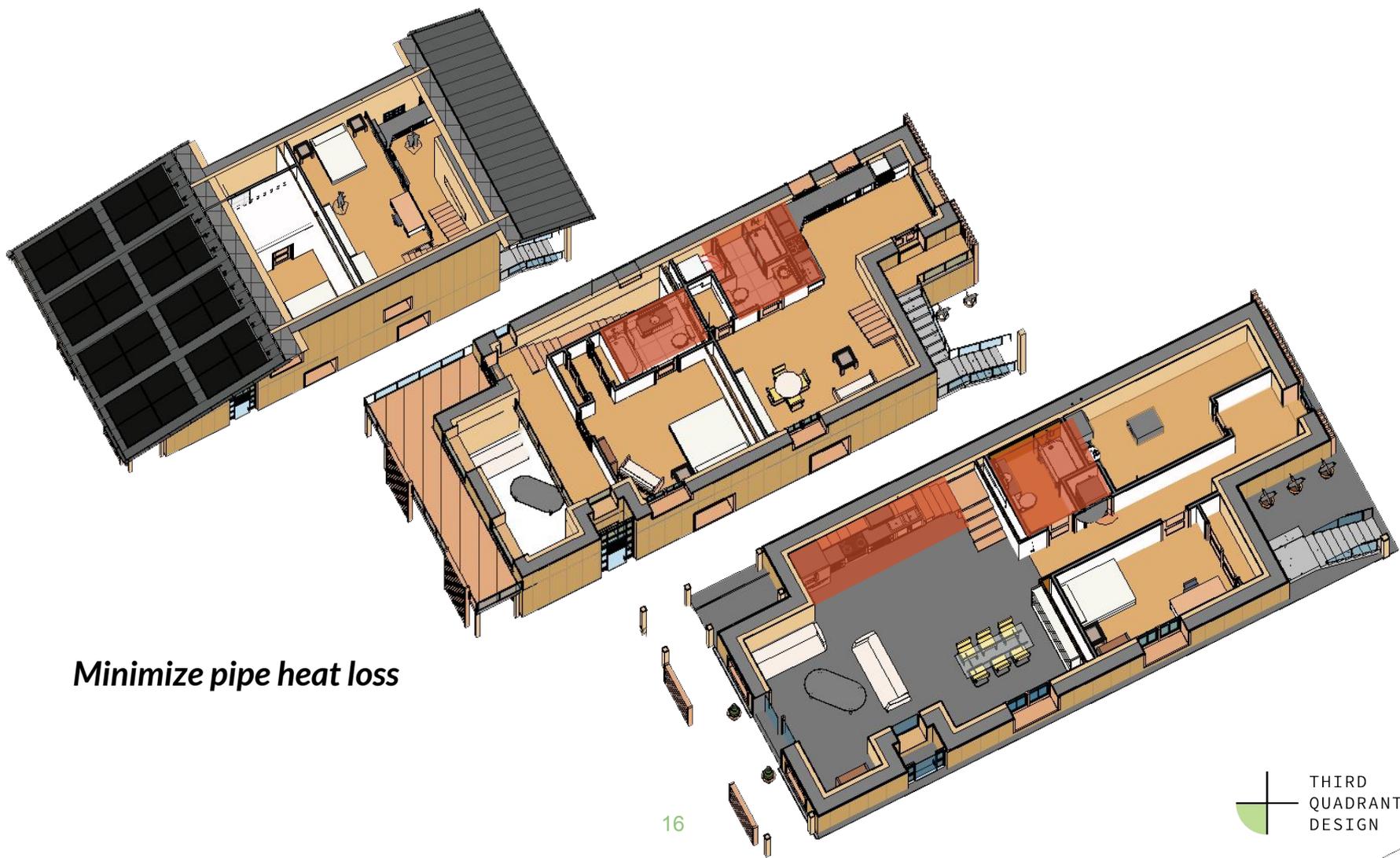
<b>Building form</b>	Simplify building form Minimize surface to volume ratio Maximize south-facing roof area
<b>Internal space</b>	Maximize natural ventilation & lighting Minimize piping heat losses Make use of internal heat gains
<b>Materials</b>	Introduce thermal mass



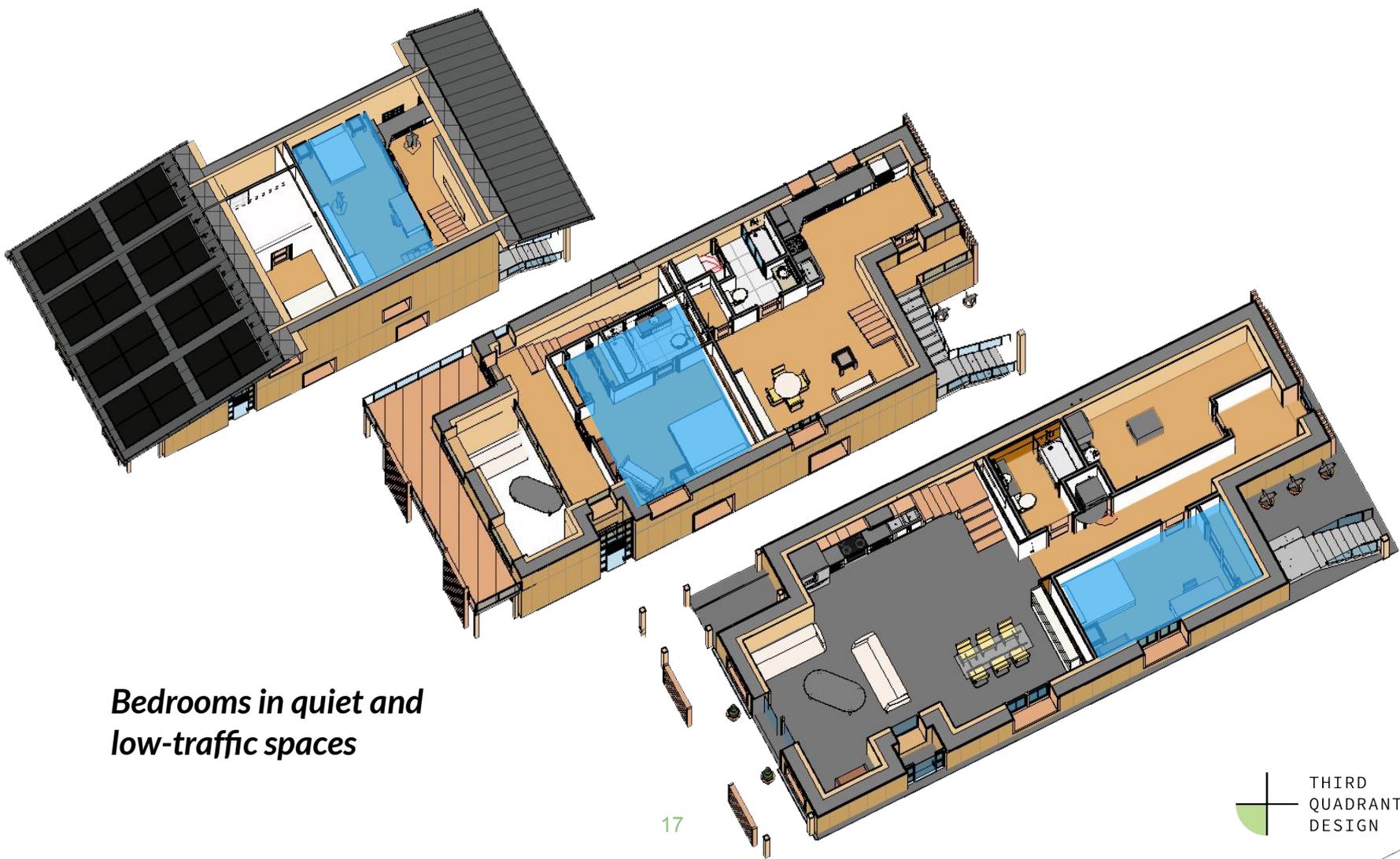
# PASSIVE PRINCIPLES



*Space considerations  
for current and future  
systems*



*Minimize pipe heat loss*

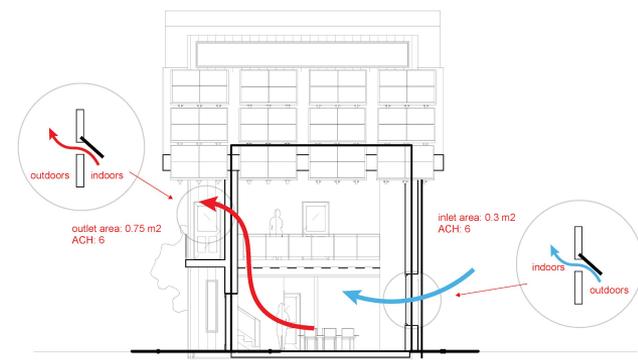
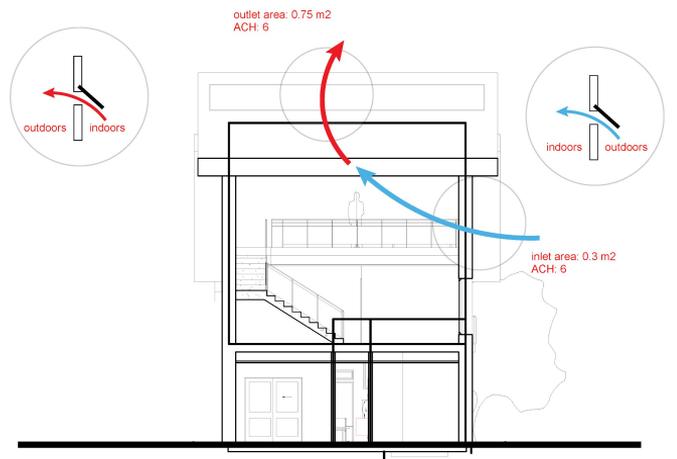
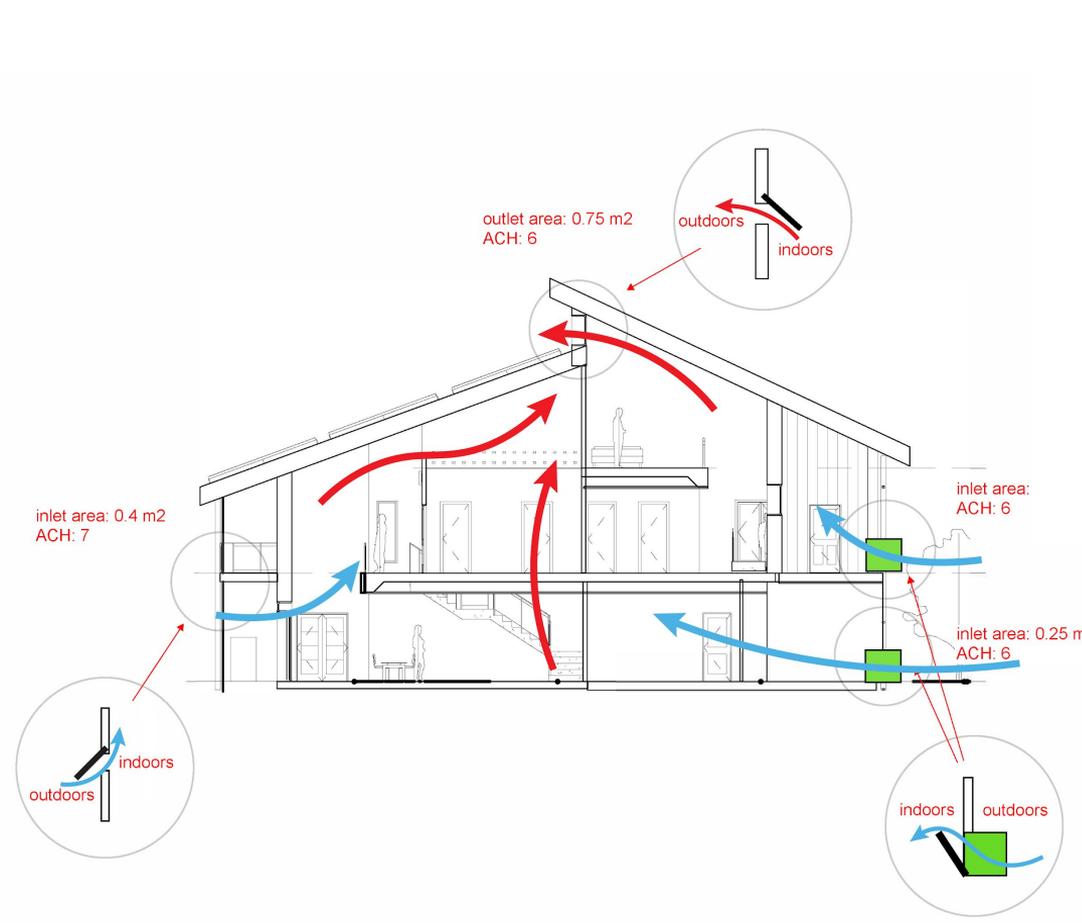


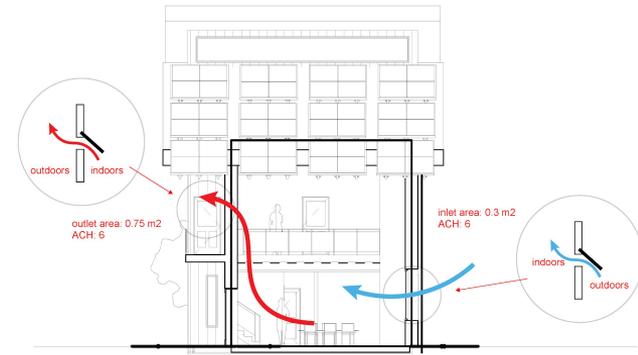
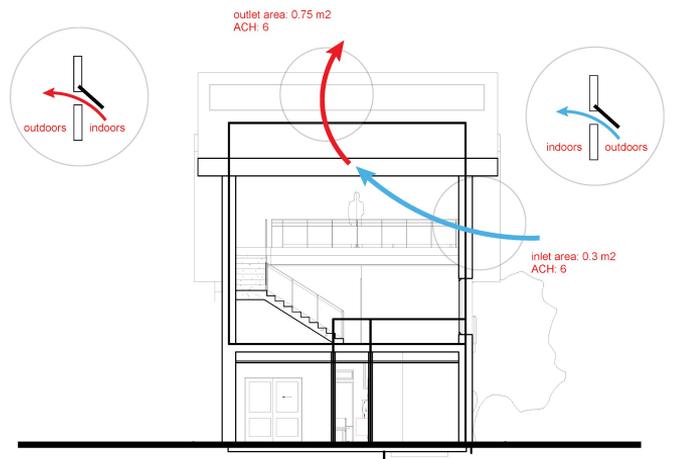
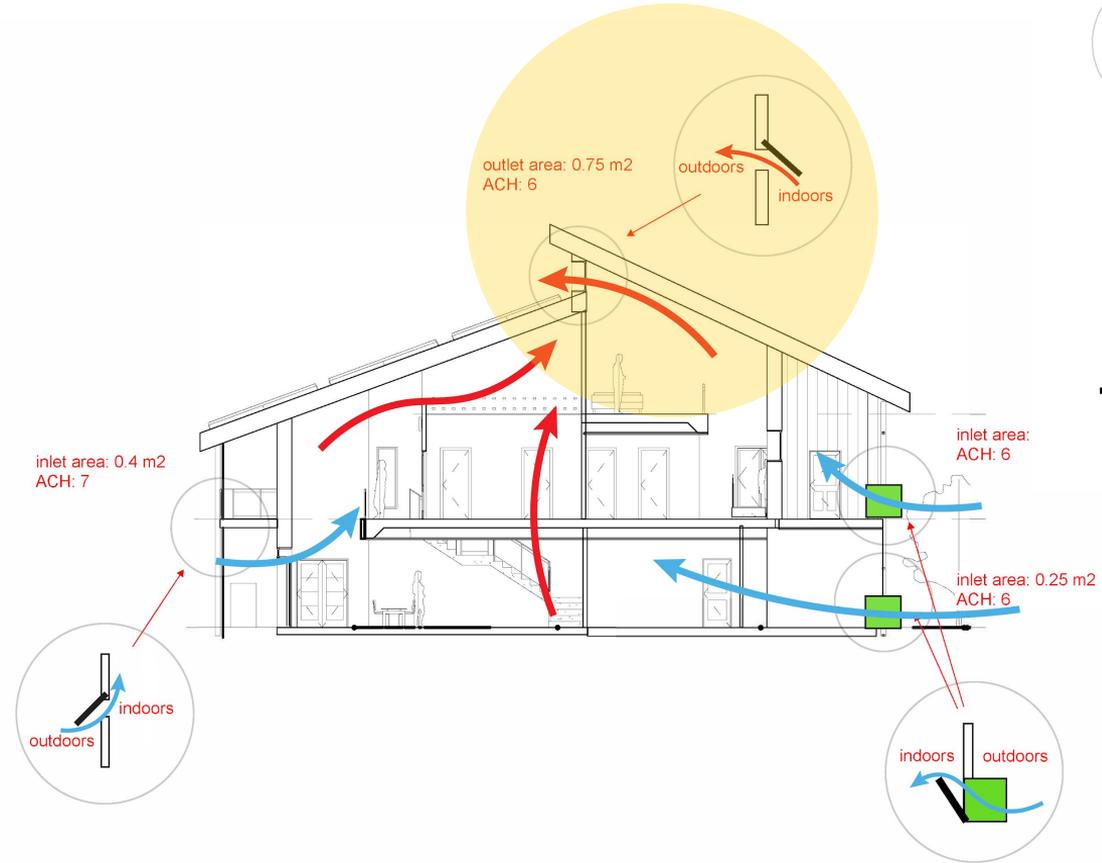
*Bedrooms in quiet and low-traffic spaces*



*Open-plan  
living spaces*

*High-levels of natural  
lighting & ventilation*





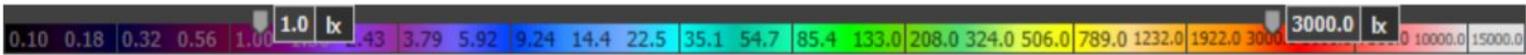
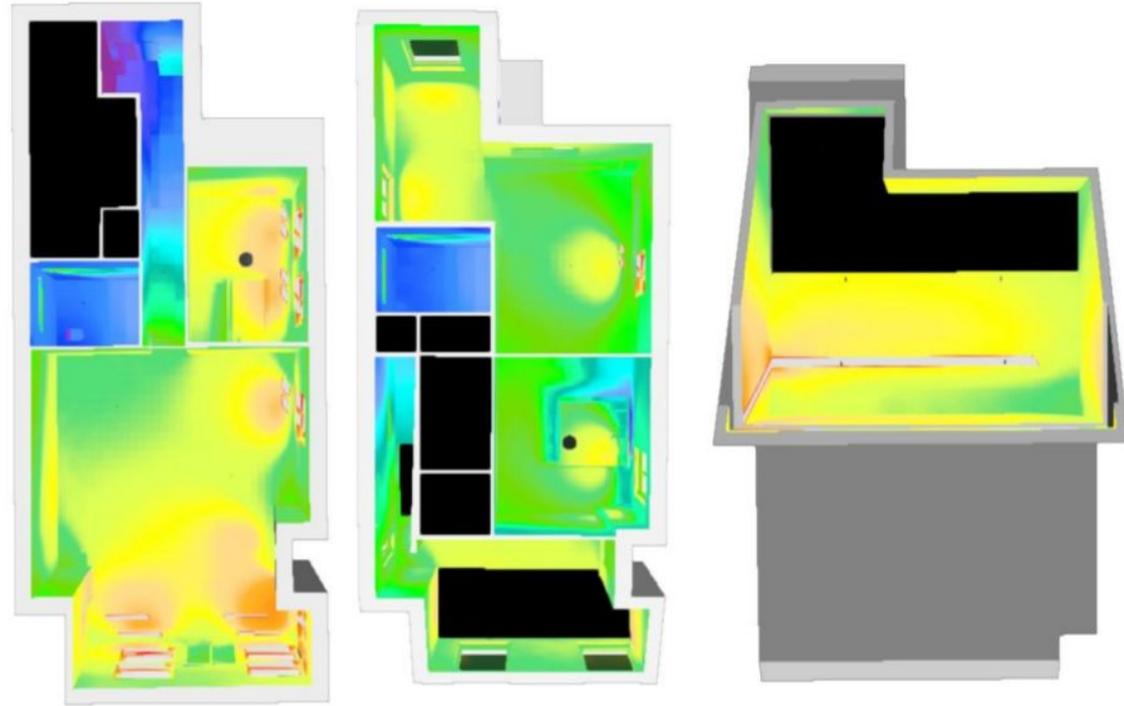


Figure 18: Summer Solstice natural lighting (left to right: floor plans 1-3, N direction top of page)



***Local, natural & healthy materials.***



*Cross-laminated Timber*



*Wood Fibre insulation*

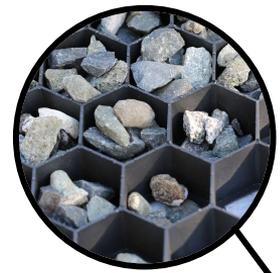


*Recycled Oyster Shell  
Countertops*

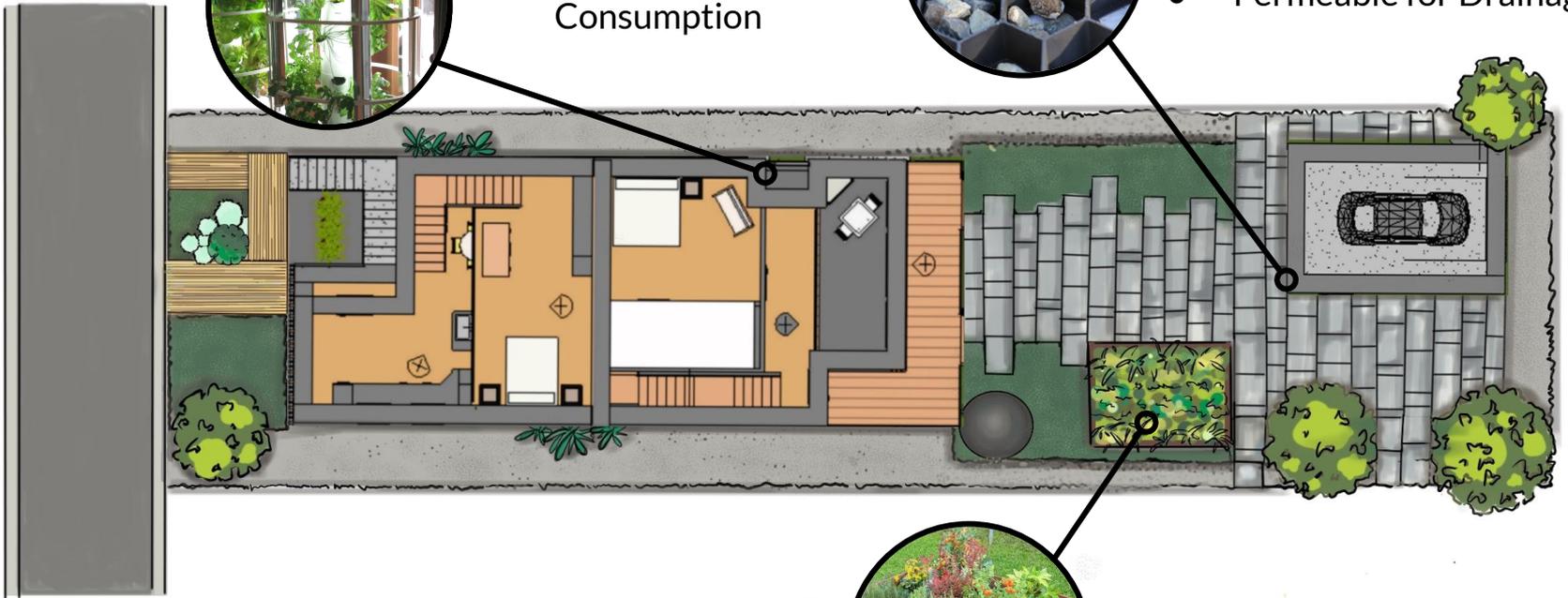
# *LANDSCAPE*



- Vertical Garden
- Optimized Water Consumption



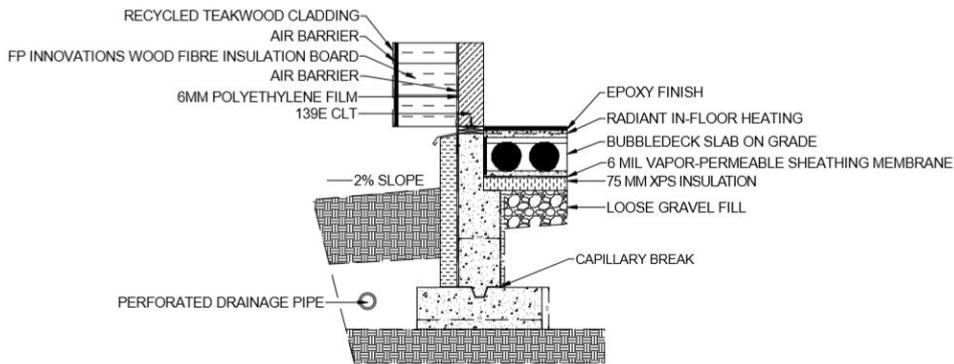
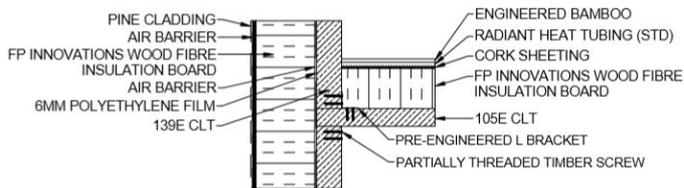
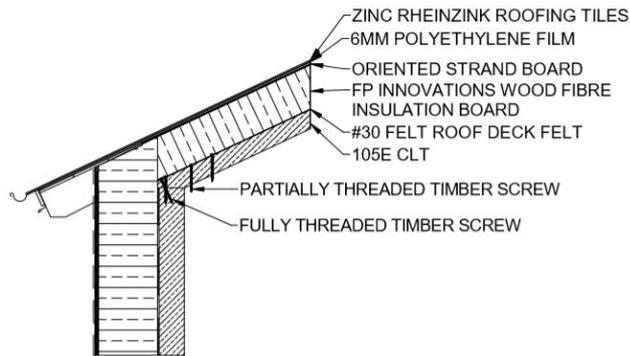
- Recycled Plastic Base
- Permeable for Drainage



- On-Site Food Production
- Rain-Water Irrigated



# ***STRUCTURE***



## Earthquake Resilience

### CLT

- Improved performance given its strength, flexibility, and lightweightness

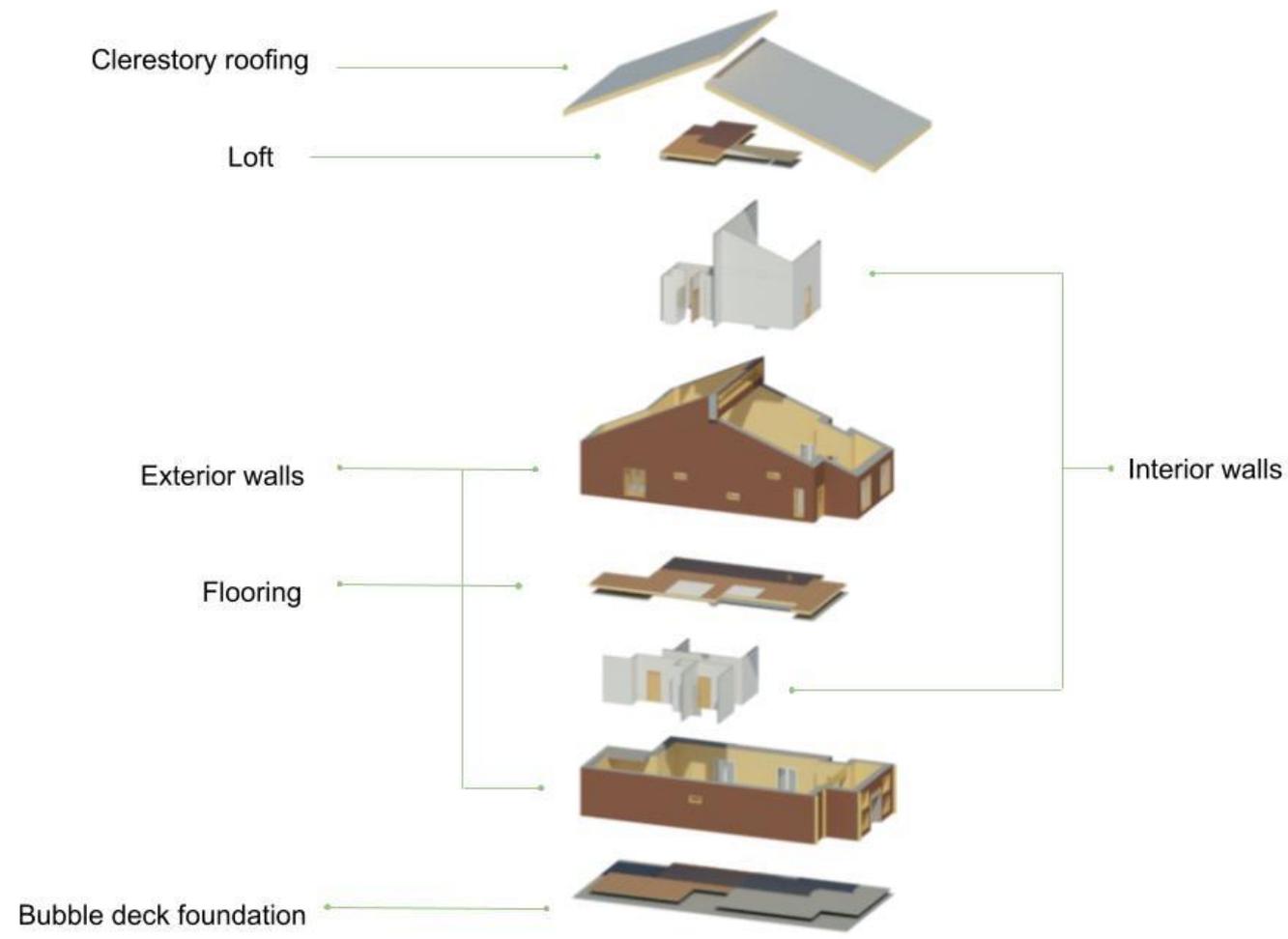
### Bubbledeck slab on grade

- Reduces earthquake loads

### Tie downs

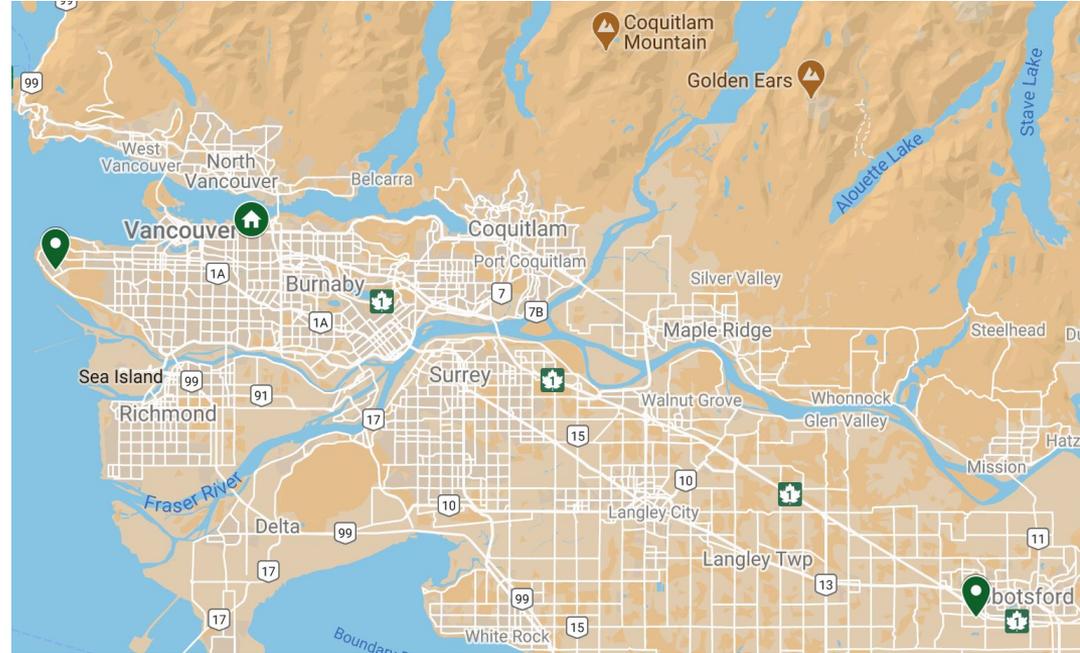
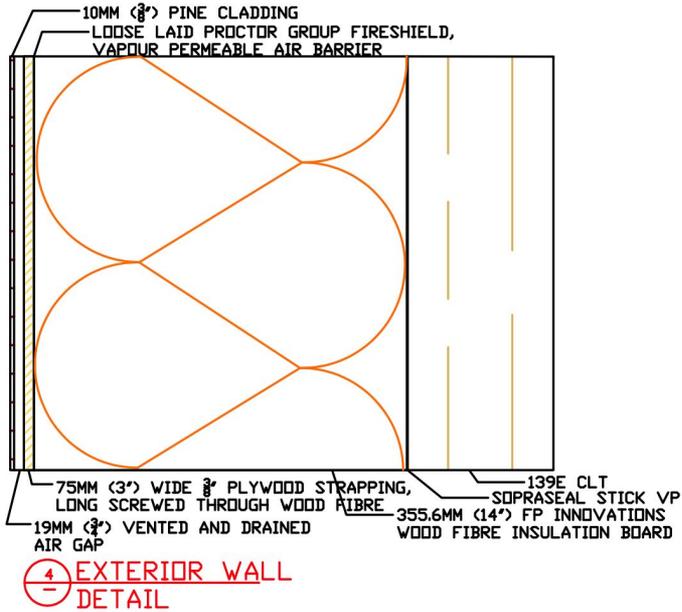
- Resist lateral seismic loads

# ***CONSTRUCTION***



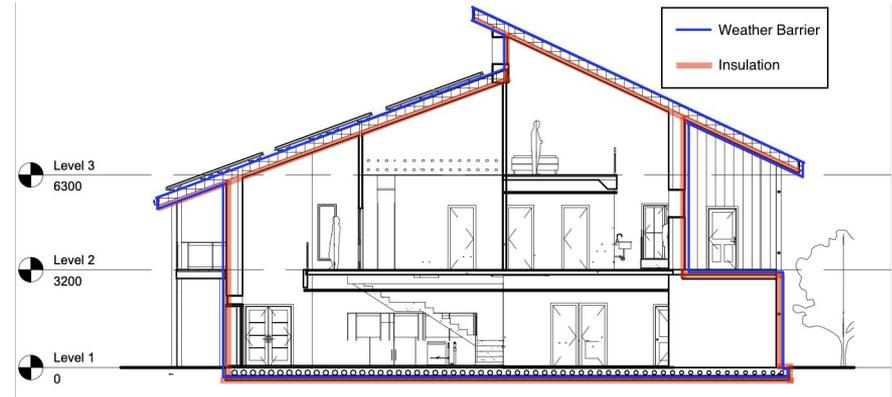
# ***BUILDING ENVELOPE***

# Hyperlocal. Carbon-Sequestering. High Performing.





- Vancouver's biome is classified as a temperate rainforest
  - High levels of rainfall
  - High relative humidity
  - Below 0C (32F) 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



Section	Passive House Min	Solis House R-Value
Roof	60	60
Exterior Wall	40	60
Slab/Ground Floor	30	49

Table 1: Passive House Canada R-Values VS Our Calculated R-Values



# Relative Humidity and Temperature Models

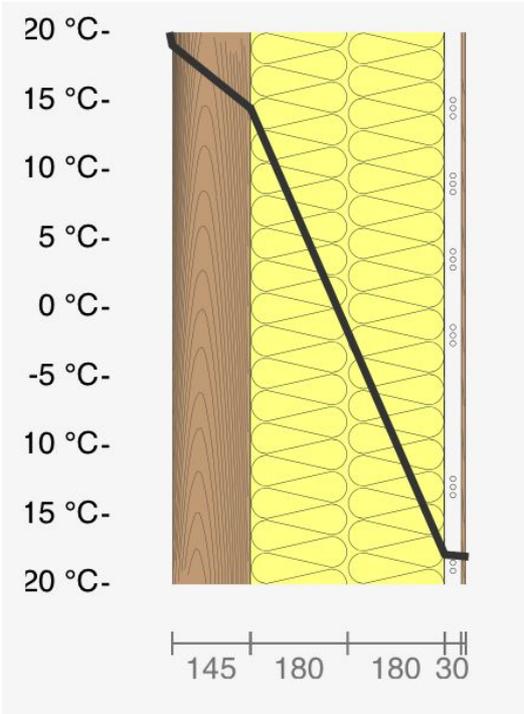


Figure 1: Ubakus temperature gradient model through our exterior wall section. -18C exterior and 19C interior temperatures

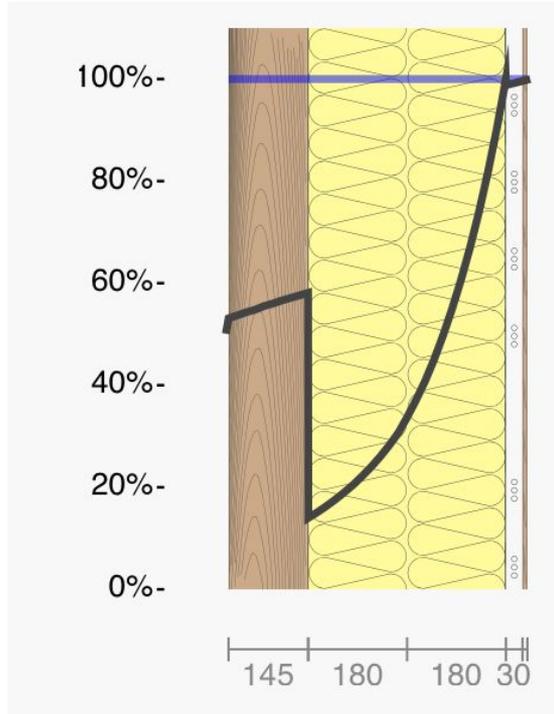


Figure 2: Ubakus Relative Humidity model through our exterior wall section. 100%RH exterior and 50%RH interior conditions

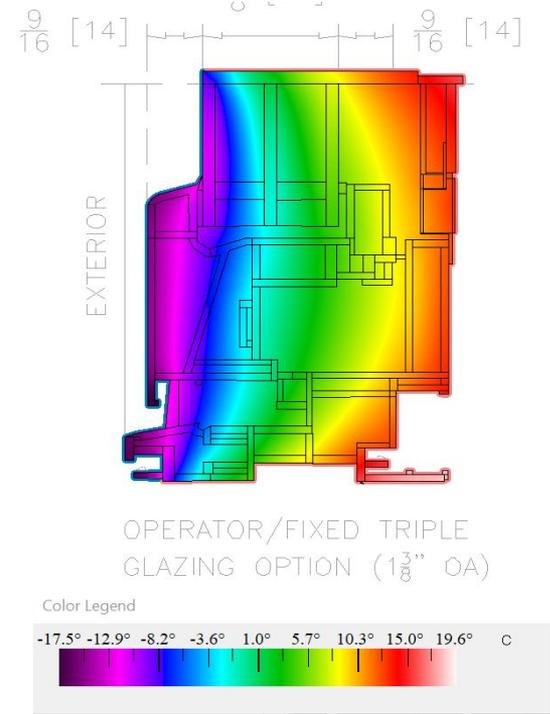


Figure 3: Therm temperature gradient model of a typical triple glazed, fiberglass framed window

# ***ACOUSTICS***

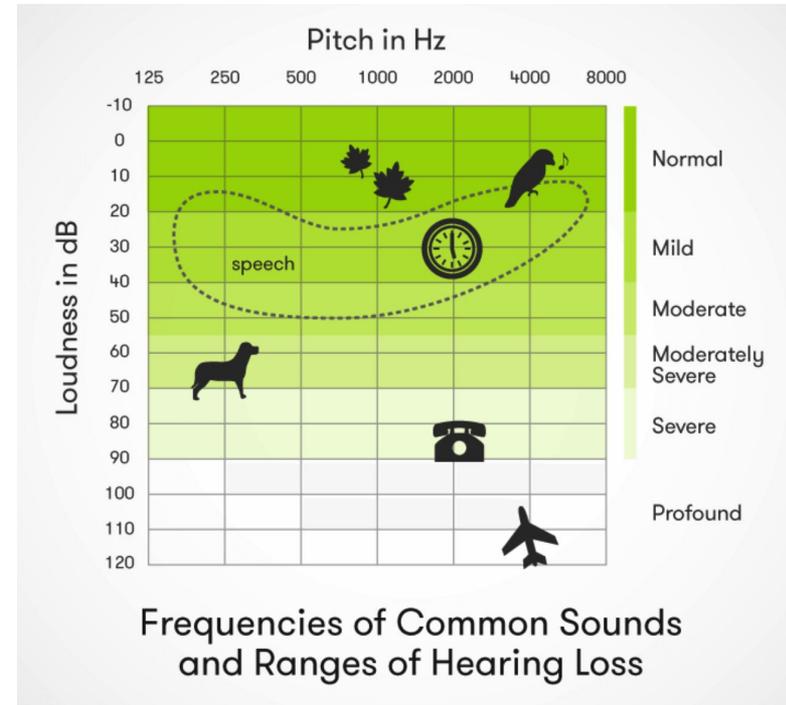
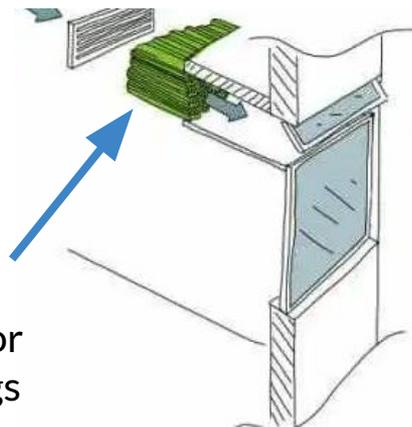


Natural, carbon sequestering materials used for acoustic insulation

### Acoustic Performance of Partitioning Elements

- Int Wall: 58STC<sup>2</sup>
- Ext Wall: 52STC<sup>3</sup>
- Floor: 55STC and 51IIC<sup>4</sup>

Honeycomb sound attenuators used for ventilation openings

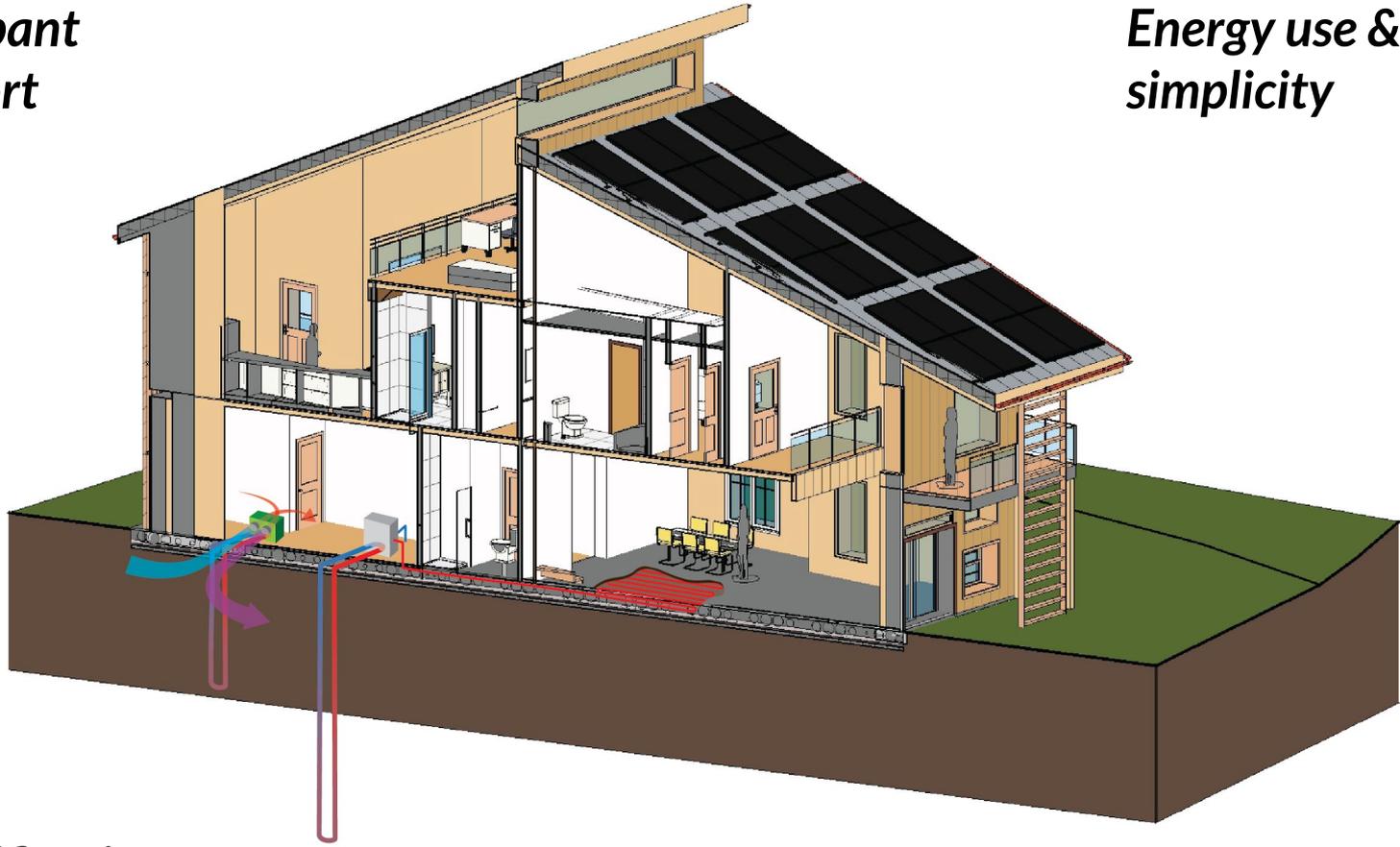


# ***MECHANICAL SYSTEMS***

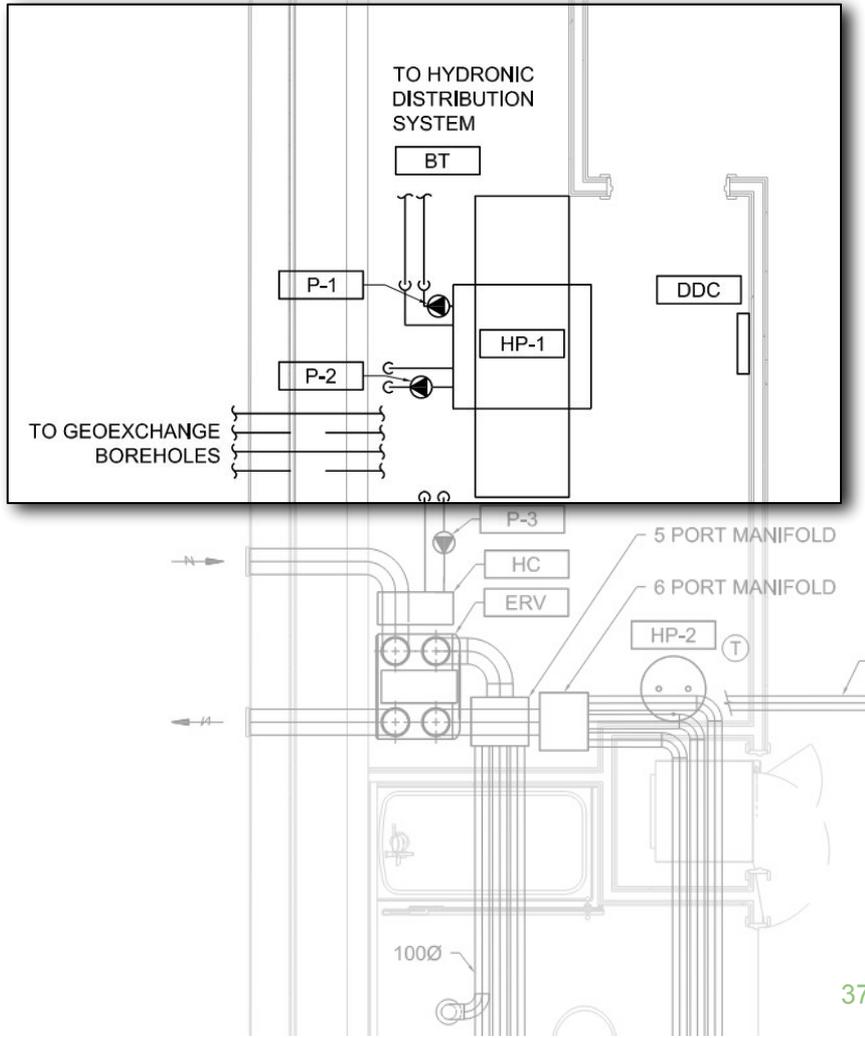


*Occupant  
comfort*

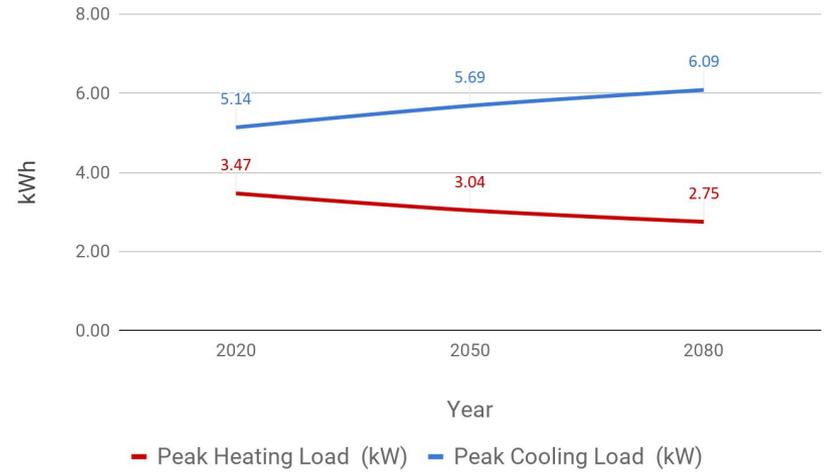
*Energy use &  
simplicity*



*100%  
electrification*

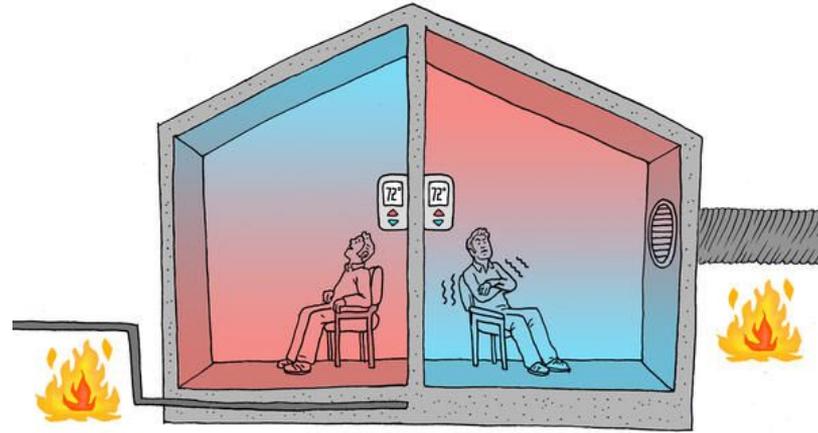


### Peak Heating & Cooling Loads

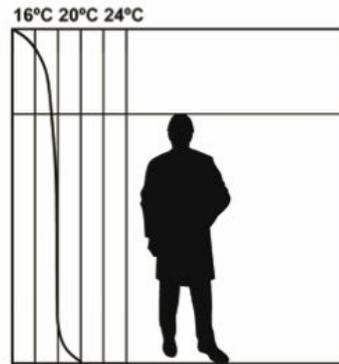


- 6.75 kW Ground Source Heat Pump sized for peak future cooling load
- 120m vertical borehole sized for peak future heat rejection

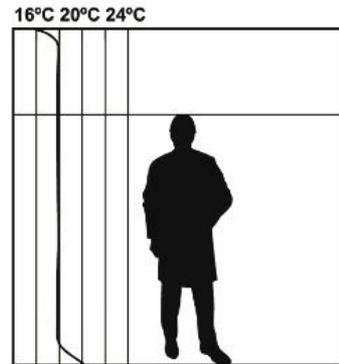




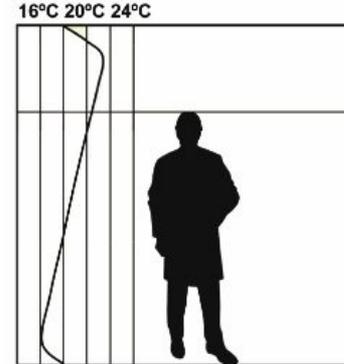
**Figure 1:** Ideal temperature profile

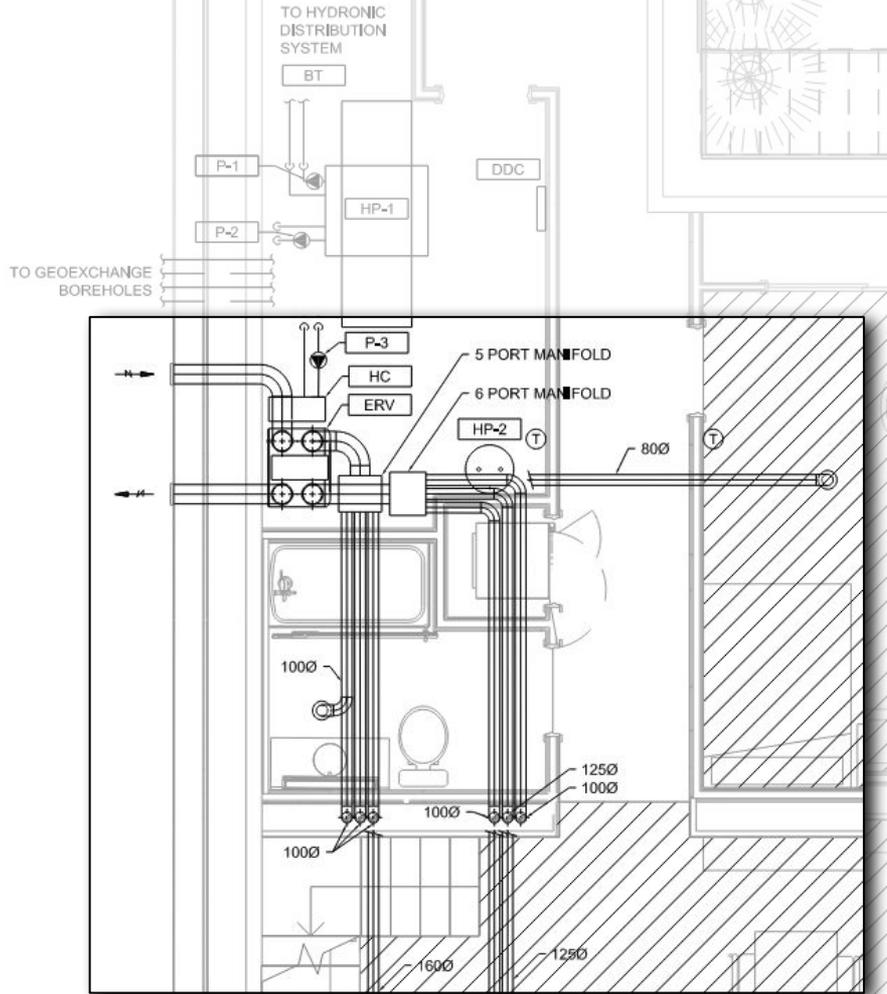


**Figure 2:** Profile for underfloor heating



**Figure 4:** Profile for convector heating

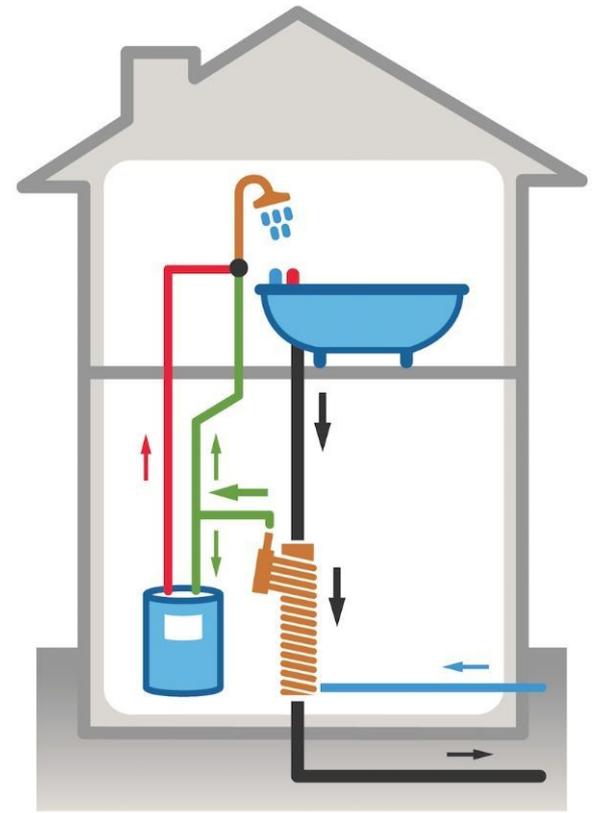
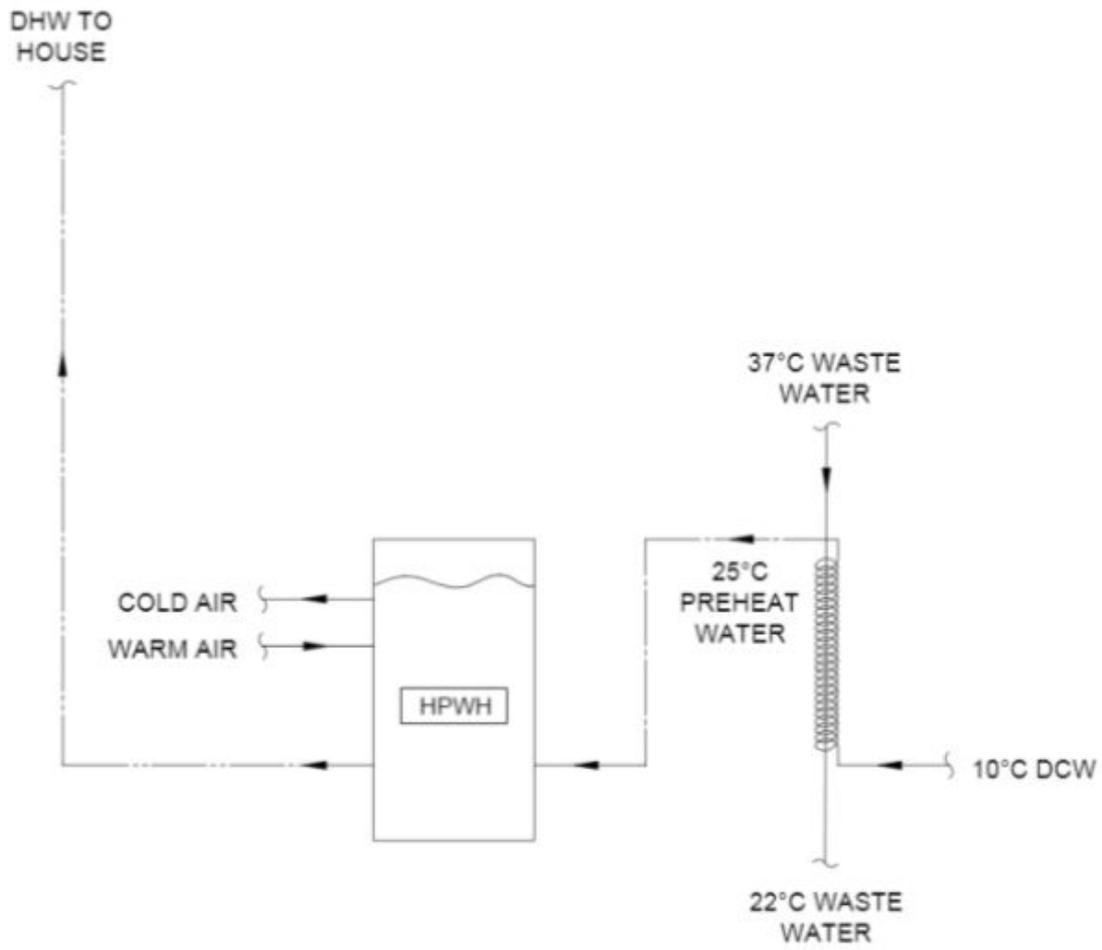




## Ventilation

Tag	Location	Service	Flow Rate (L/s)	
			Standard	Boost
ERV	Main House Mech Room	Whole Home	115.50	149.99

# ***WATER SYSTEMS***



- Blue line: Cold Water
- Red line: Hot Water
- Green line: Pre-Heated Water
- Black line: Drain Water

renewability.com





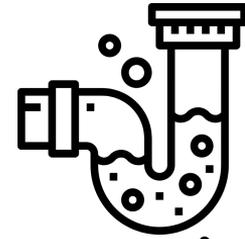
# REDUCE



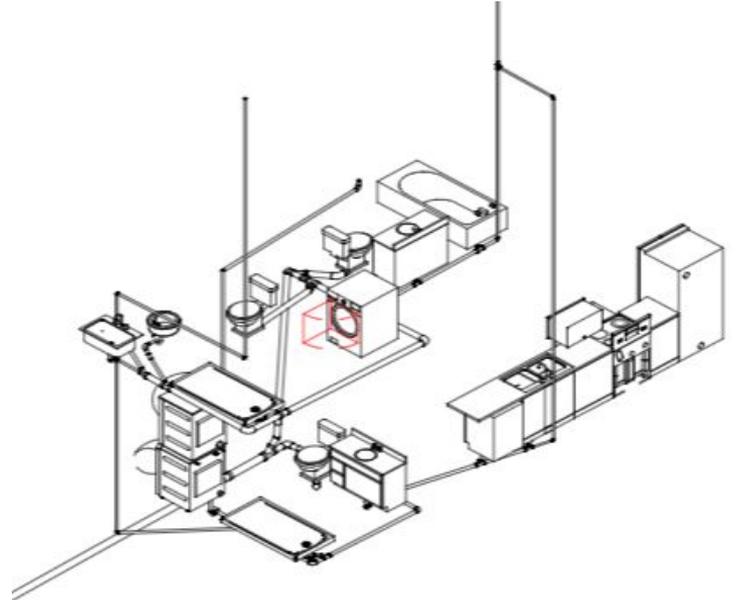
*water*

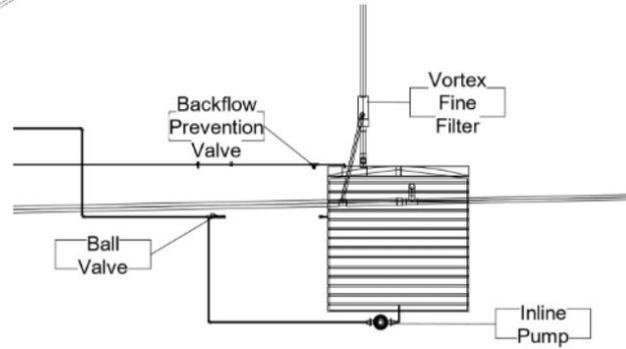
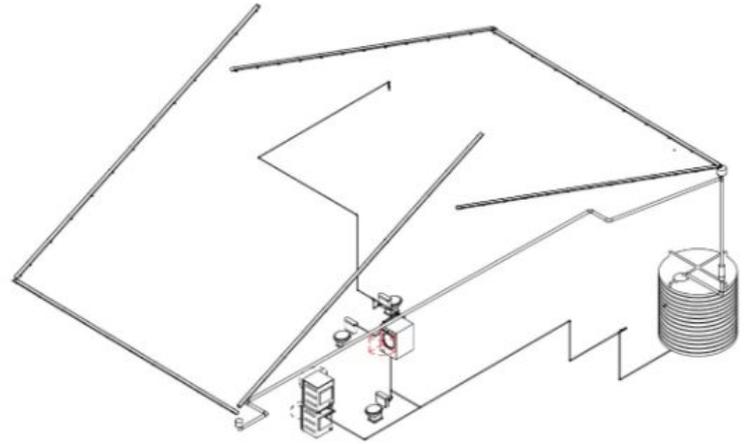
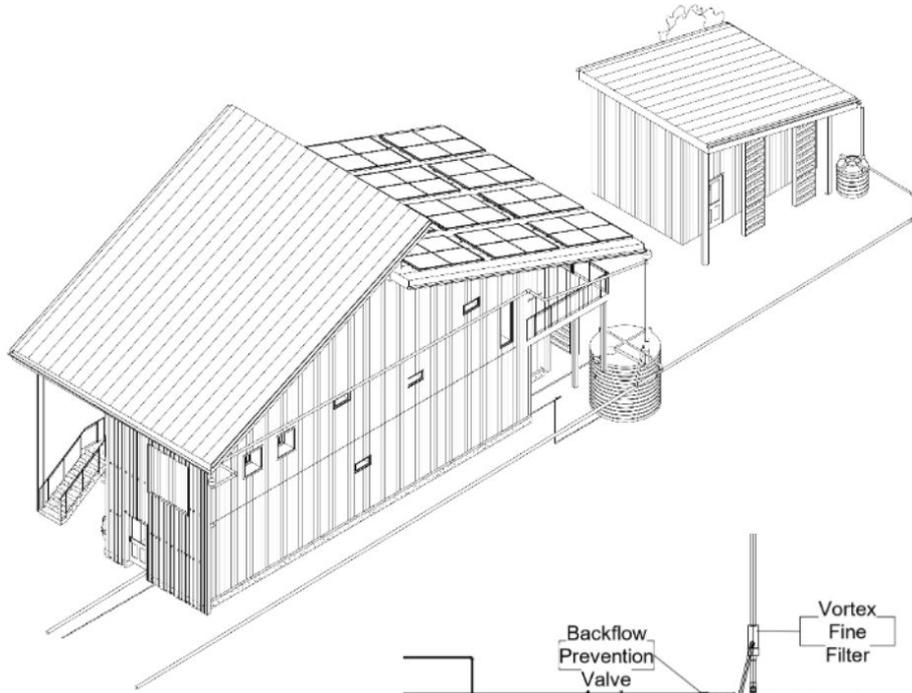


*power*



*materials*





# ***ELECTRICAL SYSTEMS***



Lighting power density (LPD):  
1.57 W/sqm

Lighting Controls:

- Manual control
- Daylight harvesting
- Vacancy sensing

Lighting Control Zones:

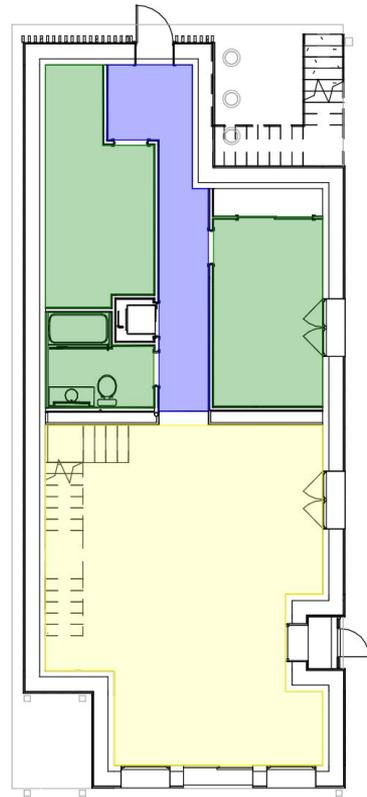
Zone 1:  
Primary ON/OFF: Manual Switch

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

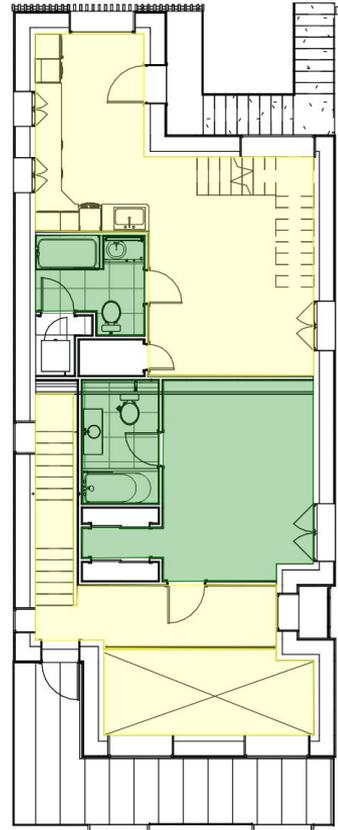
Zone 3:  
Primary ON/OFF: Manual Switch  
Secondary OFF: Occupancy Sensor



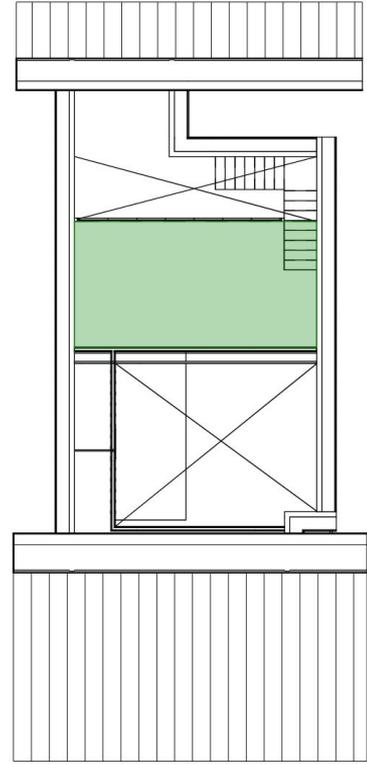
# LEVEL 1



# LEVEL 2



# LEVEL 3





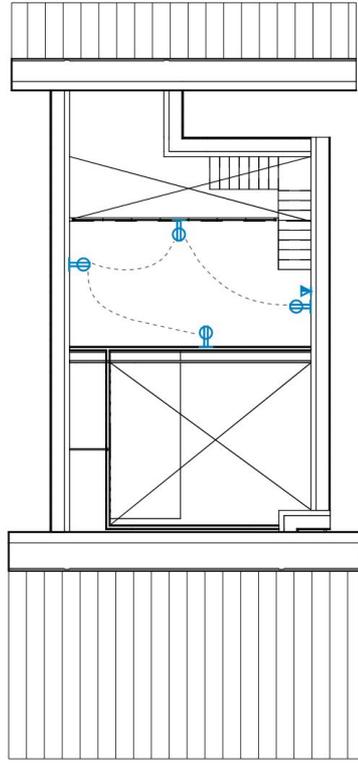
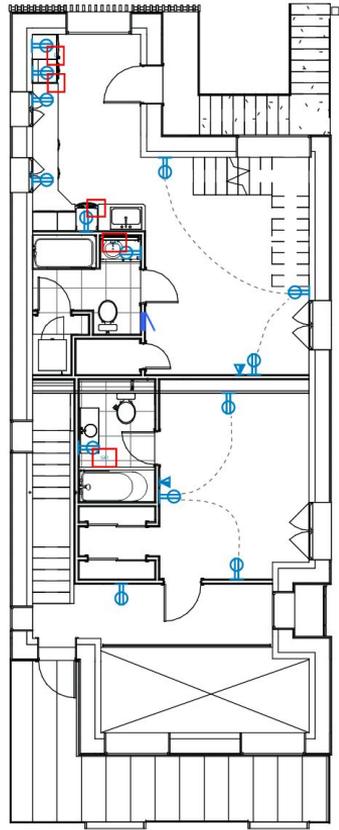
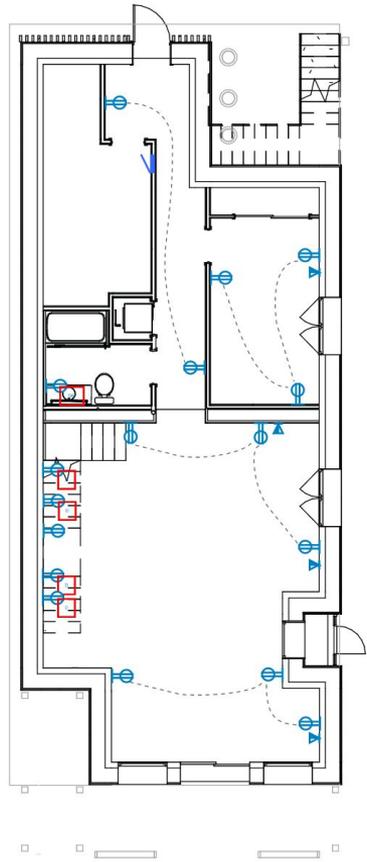
# LEVEL 1

# LEVEL 2

# LEVEL 3

### POWER & COMMUNICATIONS SYMBOL LEGEND

-  SMART DUPLEX RECEPTACLE
-  DEDICATED RECEPTACLE
-  GFCI DUPLEX RECEPTACLE
-  ELECTRICAL PANEL
-  DATA/TELEPHONE COMBO OUTLET



# ***ENERGY PERFORMANCE***



# Energy Performance Metrics



Est. Energy Consumption: **8,000 kWh/yr**

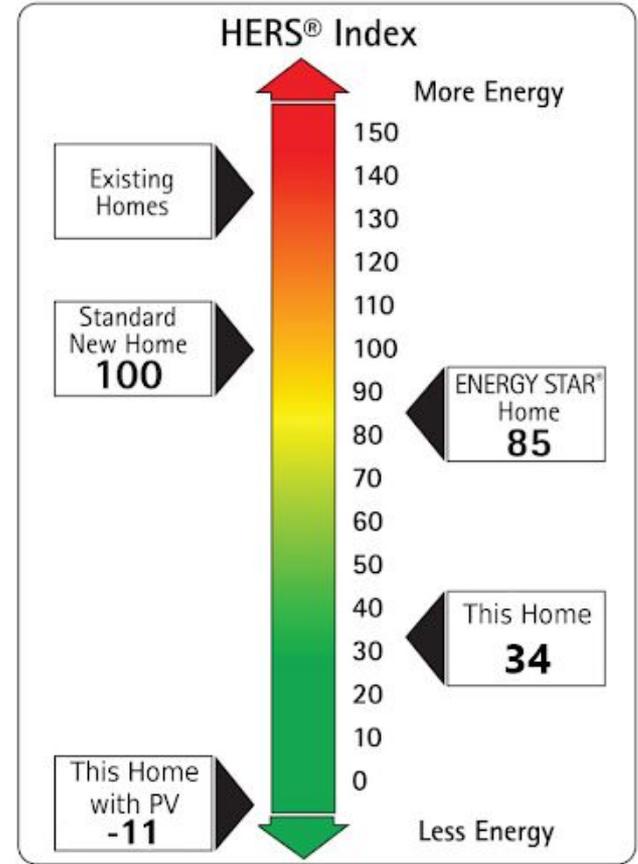
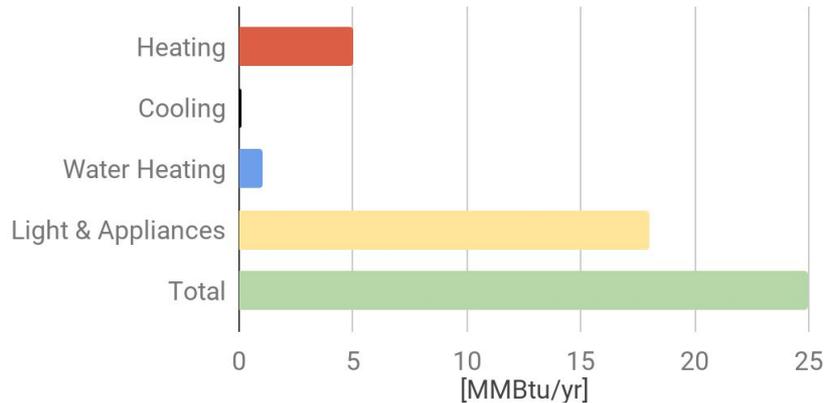


EUI: **48.34 kWh/m<sup>2</sup>**



Est. Utility Bill: **\$240 CAD/yr**

Estimated Annual Energy Consumption



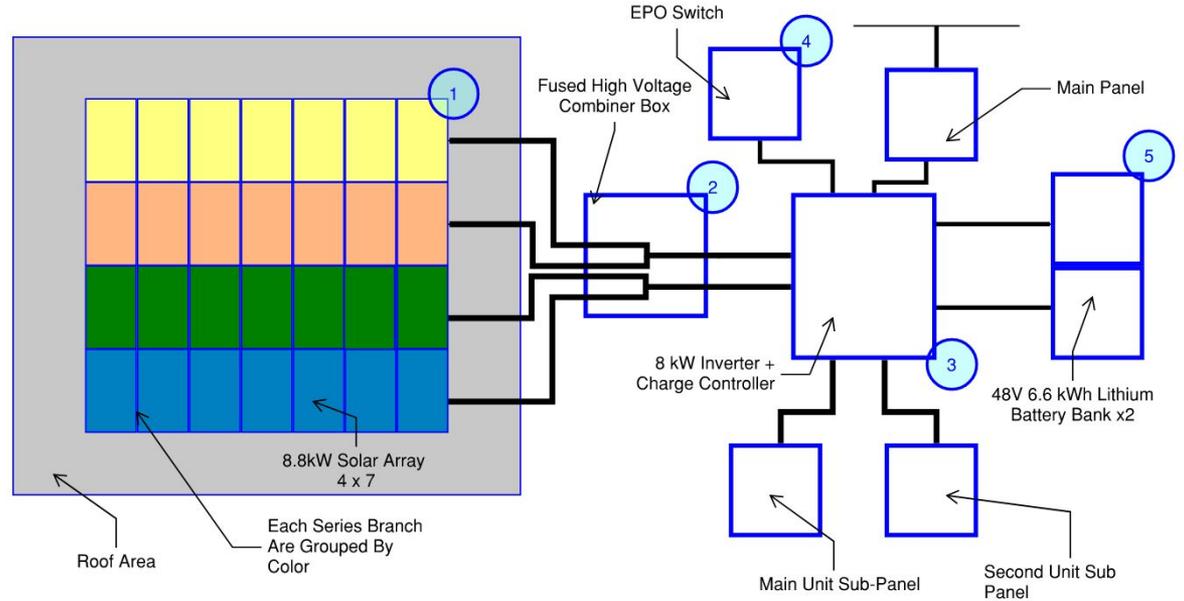


# Energy System Metrics

Nameplate Capacity: **8.8 kW**

Expected Yearly Output: **8,600 kWh**

Battery Size: **13.2 kWh**



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

# ***FINANCIAL FEASIBILITY***



## Vancouver Housing Market



2nd least affordable

- Avg 2 storey: \$2.3million



Sunrise-Hastings: **Land Cost** - \$150-200/sqft



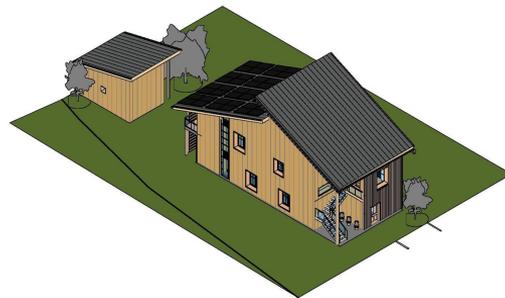
Average home debt to income ratio

- Canada: 177%
- Vancouver: 208%

### *Rental Unit = Passive Income*

- Offsets homeownership costs
- Provides increased density low volume market

## Solis House



Construction Costs

**\$389,012.47**

**Total Cost**  
**\$1,739,012.47**

**\$1,350,000.00**

*Land Value at Market Rate*

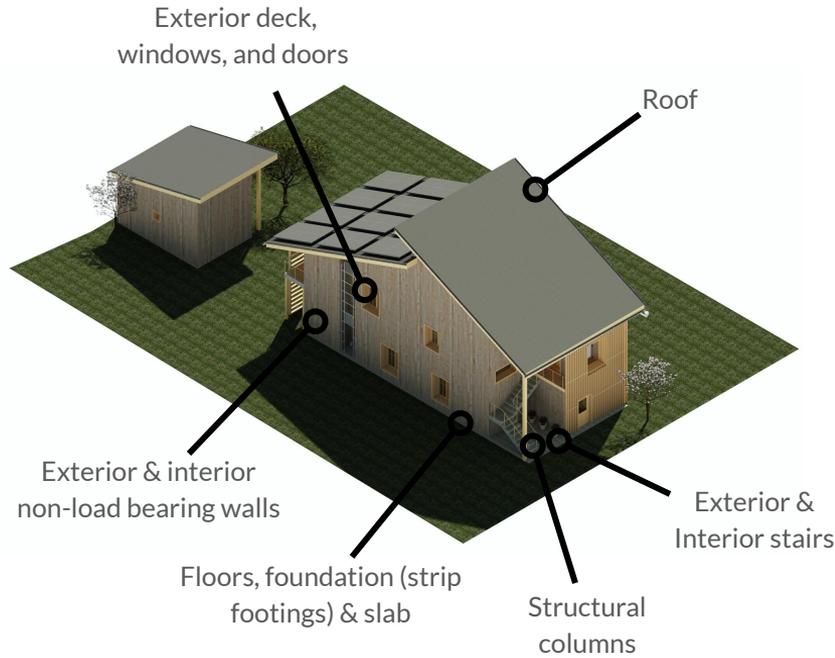
### Mortgage

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***



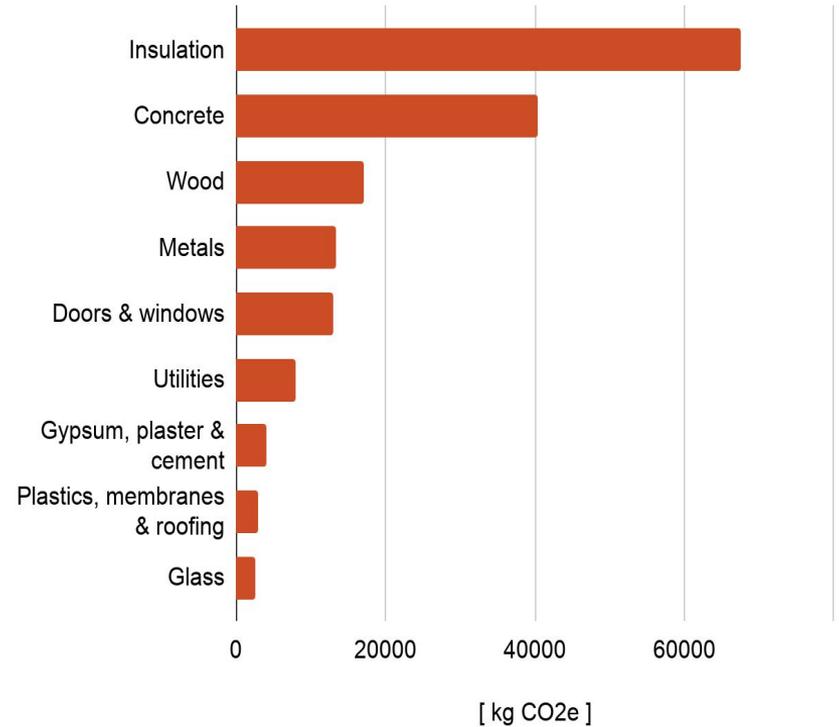
# LCA Scope: 100 years



## Trade-offs

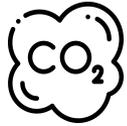
High levels of insulation balance low operational emissions

## Global Warming, kg CO<sub>2</sub>e - Resource Types





# Embodied Carbon Impacts



169 Tons CO<sub>2</sub>e

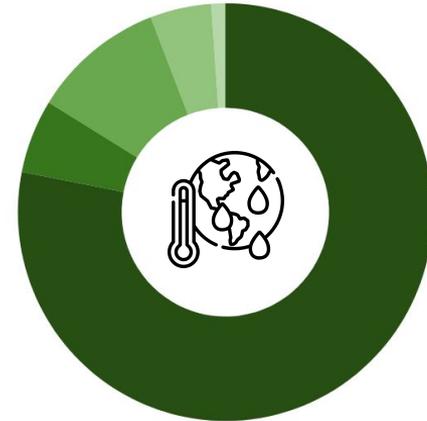


8 kg CO<sub>2</sub>e / m<sup>2</sup> / yr



\$12,868.85 CAD  
social cost of carbon

Global Warming (kg CO<sub>2</sub>e) - 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 -***



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