

# Harmony House EQuilibrium™ Project



Chris Mattock MRAIC Principal  
mattock@helix.net

Habitat Design + Consulting Ltd. Vancouver B.C.



HD+C Ltd.

# Harmony House EQuilibrium™ Project

*Designed & built to the next-generation green building standards*

## Features include:

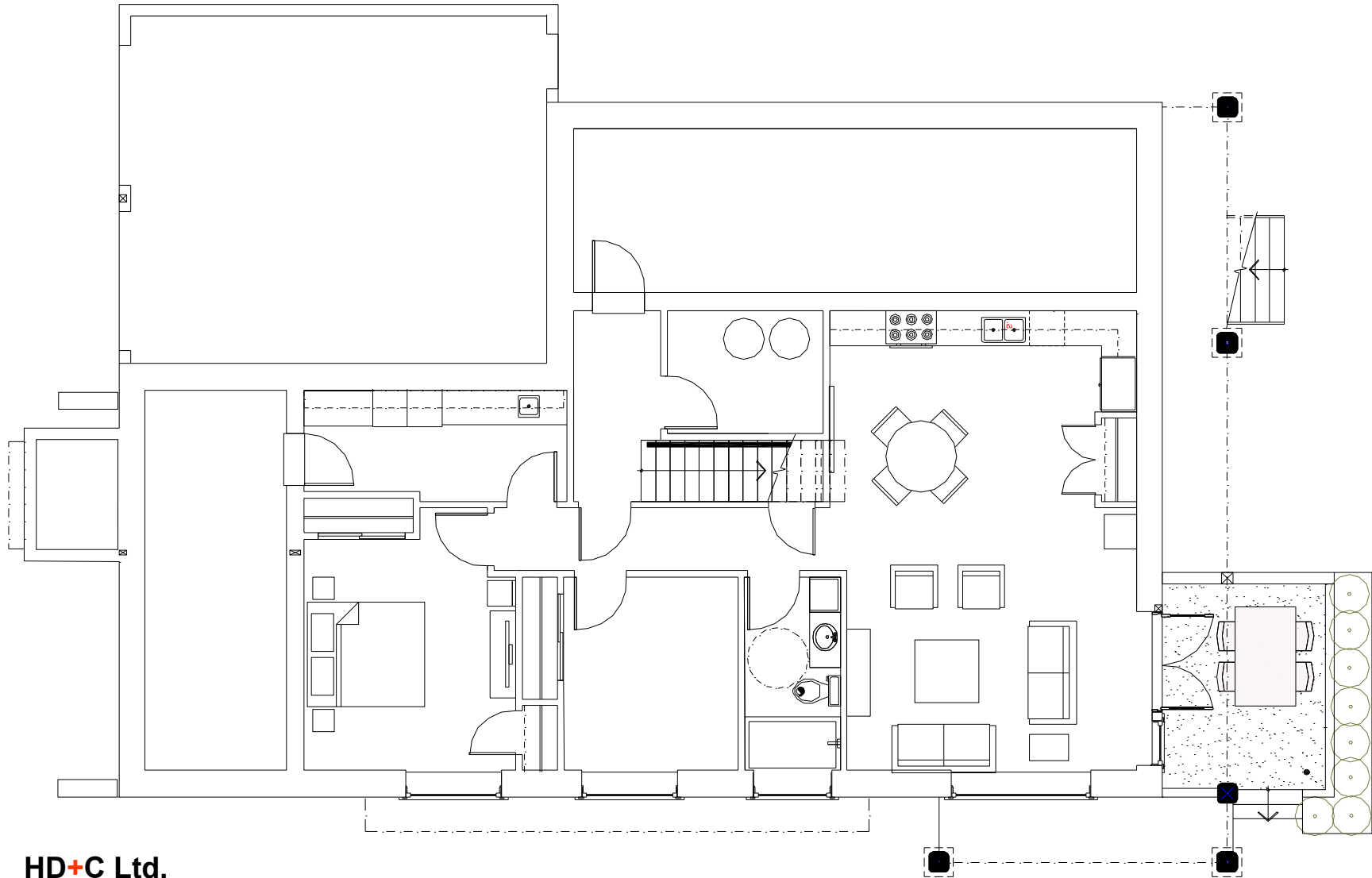
- healthy + comfortable indoor environment
- high levels of energy efficiency
- low environmental impact
- reduced water use
- on existing transit line
- production of as much energy per year from on-site renewable systems, as is consumed (Net Zero Energy) for both house and electric car

Net Zero Energy (zero net carbon) has been set as a target for future buildings by regulatory agencies and professional organizations around the world.

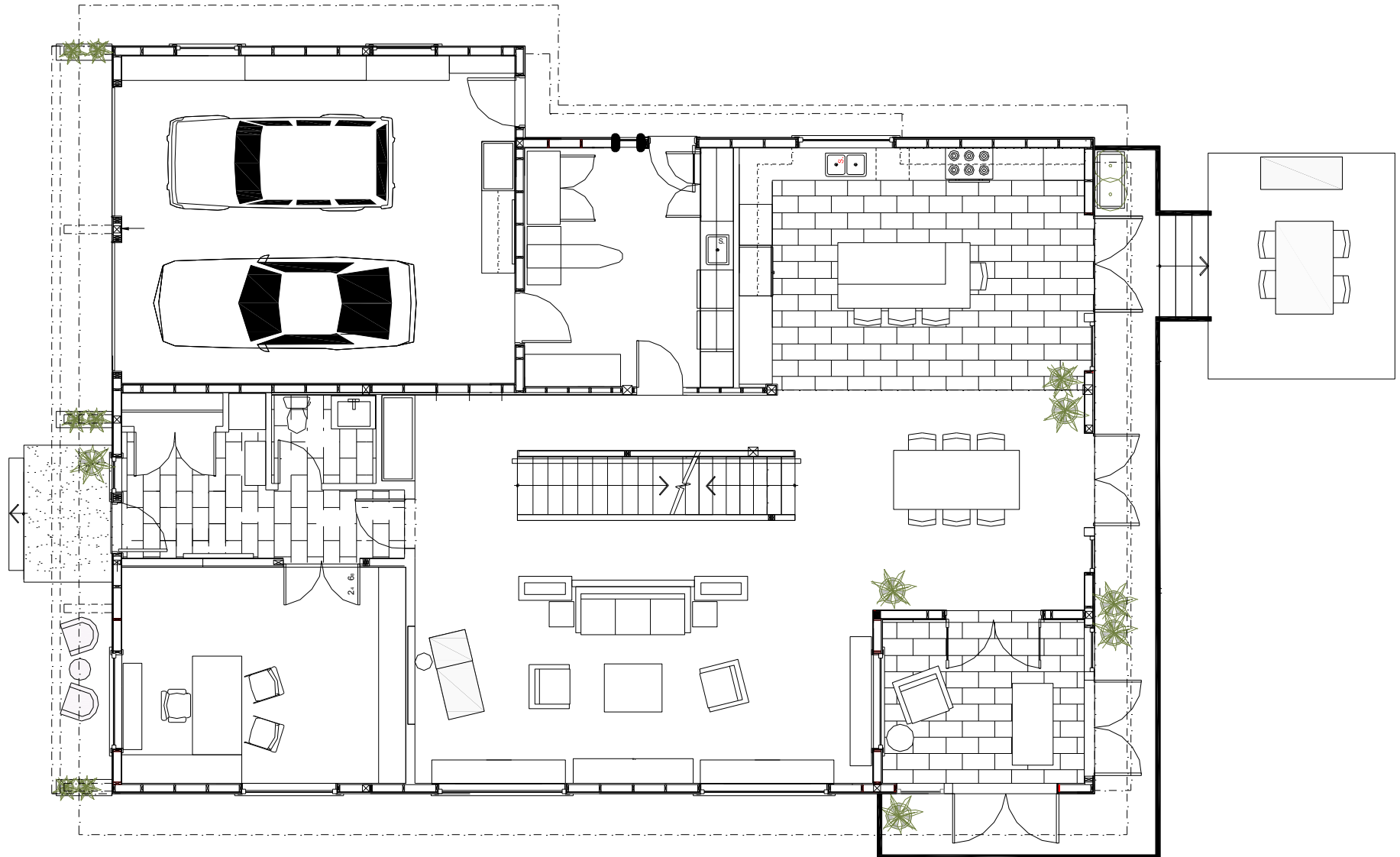
**HD+C Ltd.**



# Basement Plan



# Main Floor Plan

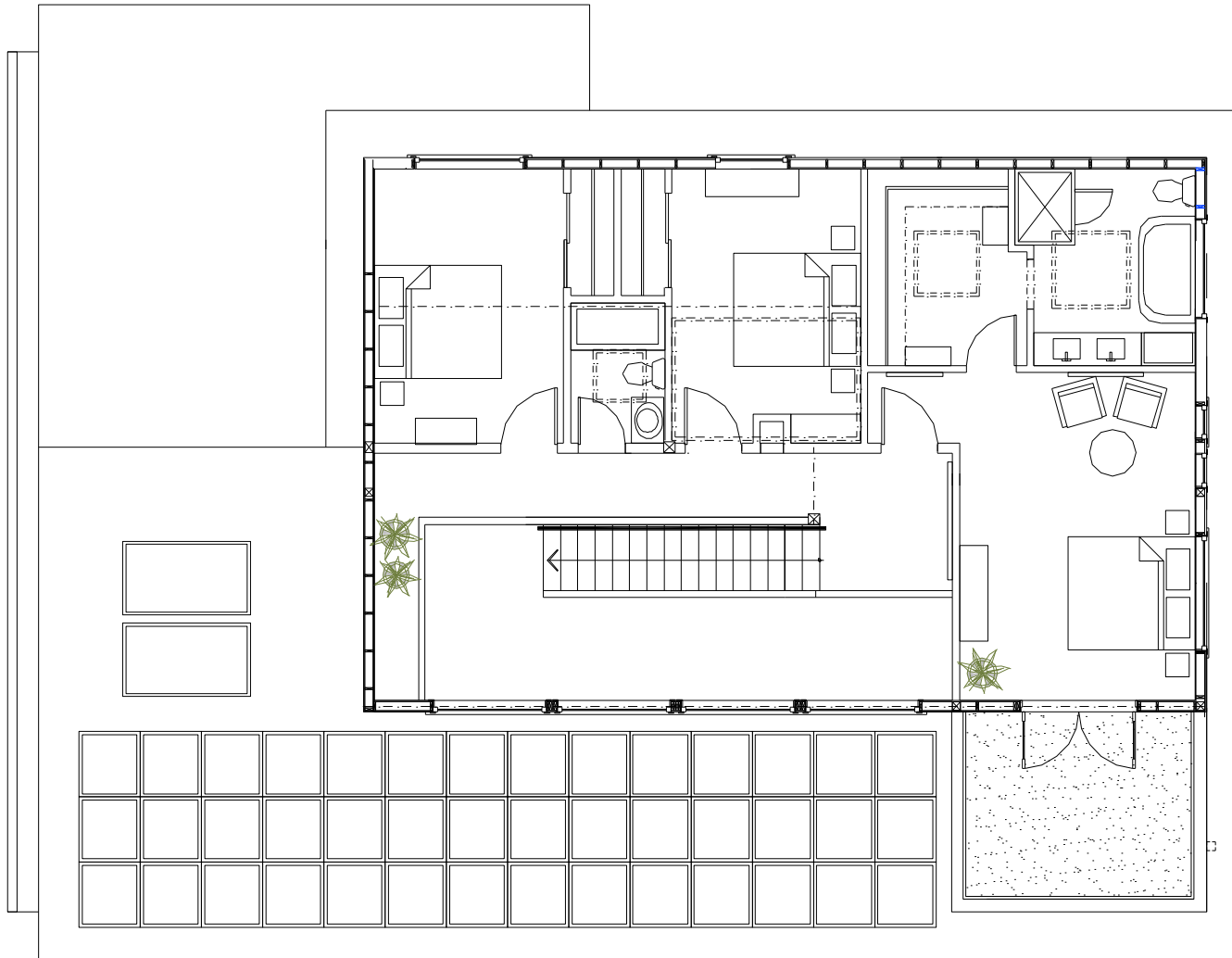


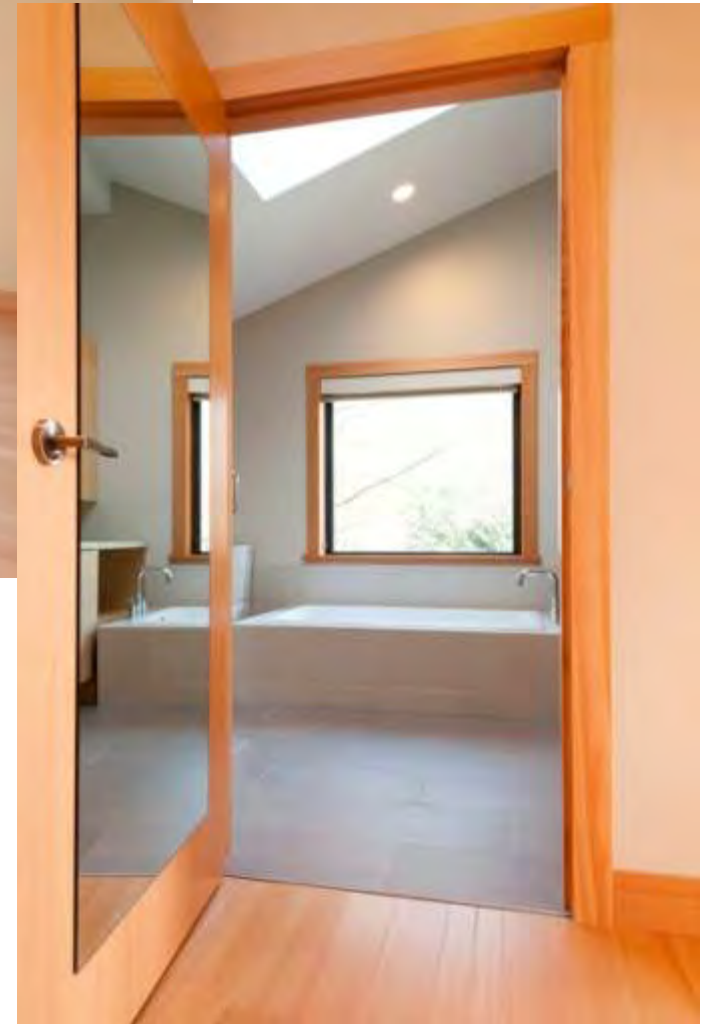




HD+C Ltd.

# Top Floor Plan





HD+C Ltd.



# South Elevation

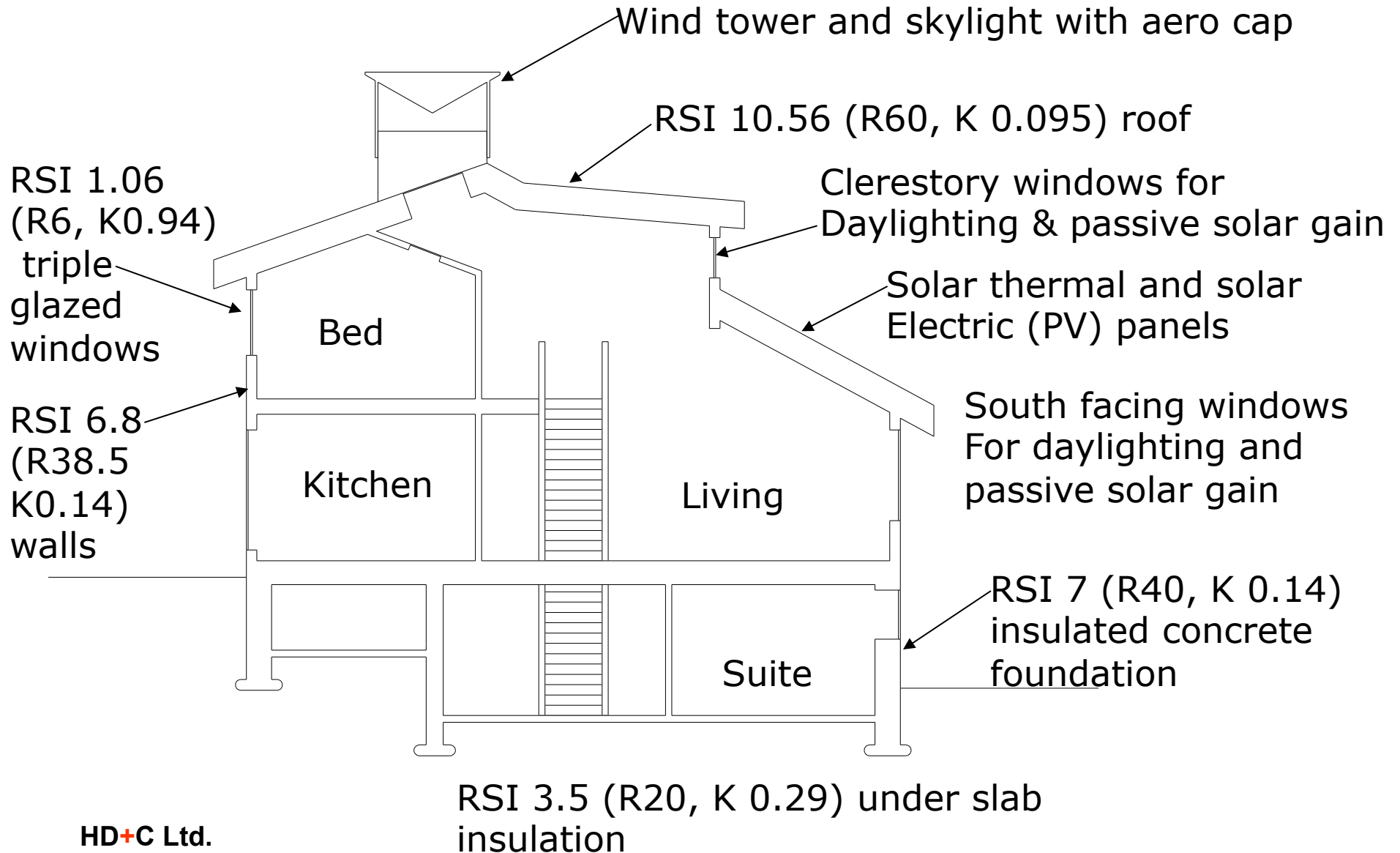


HD+C Ltd.

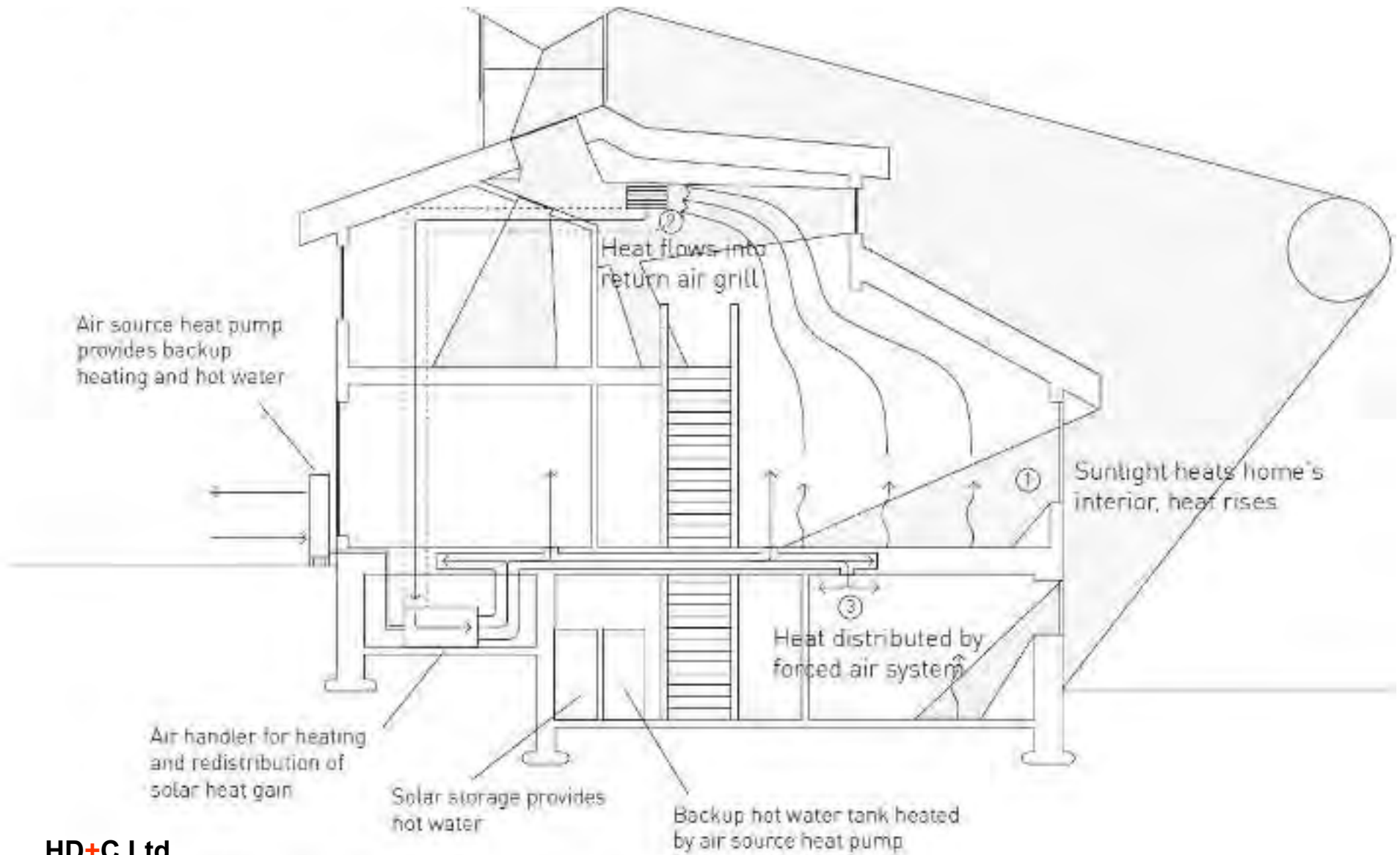
# East Elevation



# EQuilibrium™ Demonstration: Harmony House



# Winter Day:





# Passive Solar

- Windows distributed across south façade
- 4.6% of heated floor area in south-facing windows (not including solarium)
- Window sizing minimizes overheating while maximizes heat gain for mass level and insulation levels
- Forced-air heating system for redistribution of solar gains
- Use inherent mass of building
- Predicted to contribute 20% of the space heating on an annual basis

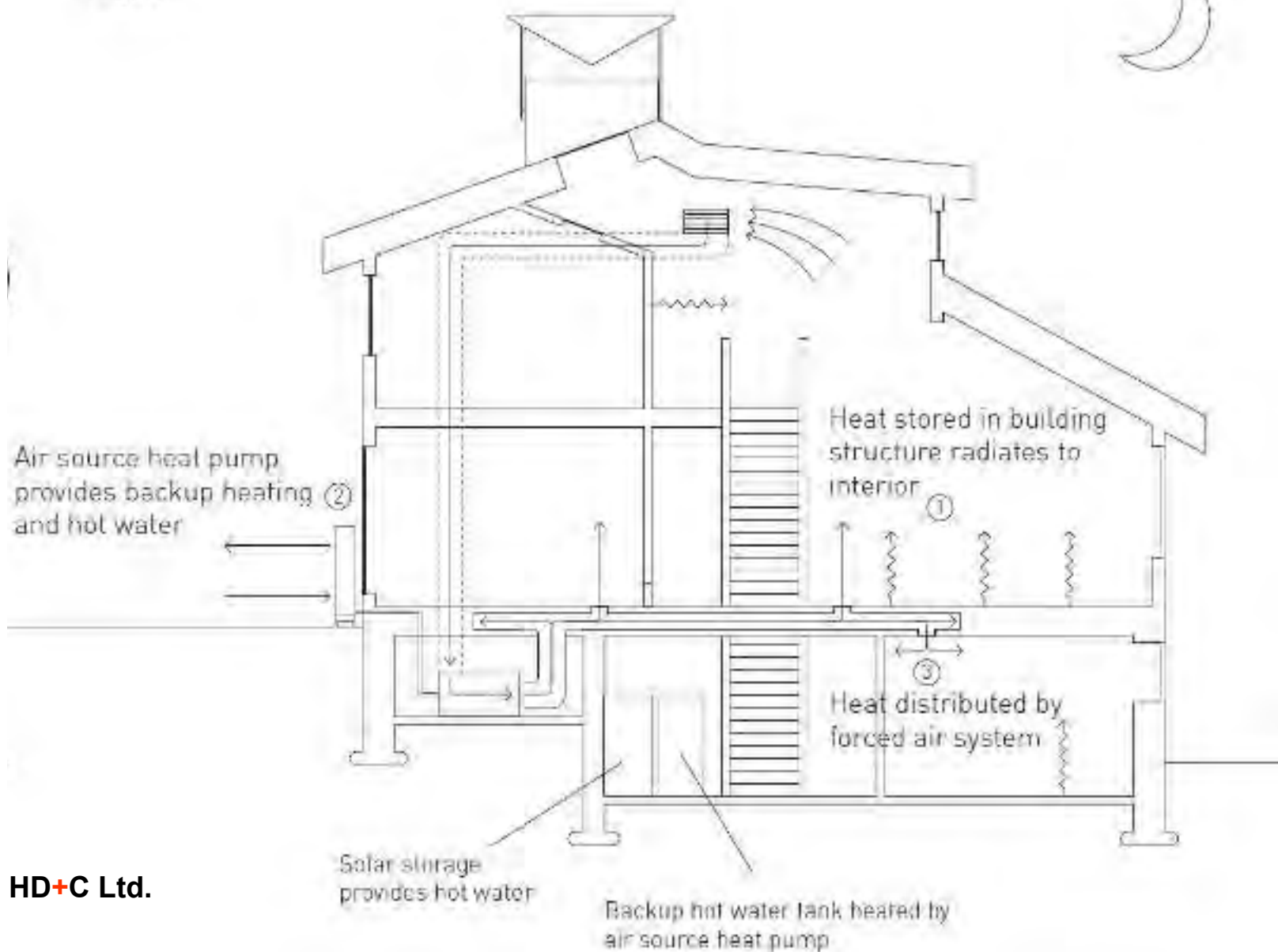
HD+C Ltd.





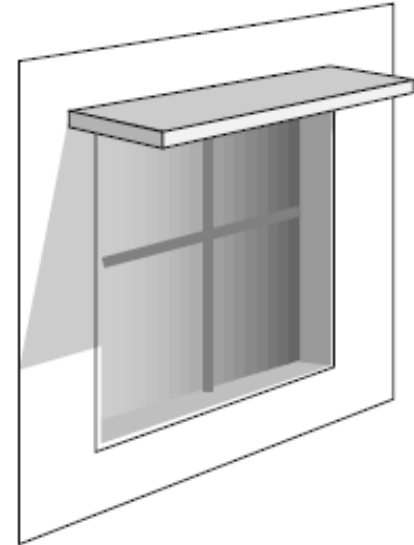
# Winter Night

Night



# Reducing Cooling Loads

Correctly-sized horizontal shading provided for all south-facing windows



Minimized west windows

Vegetation for seasonal shading



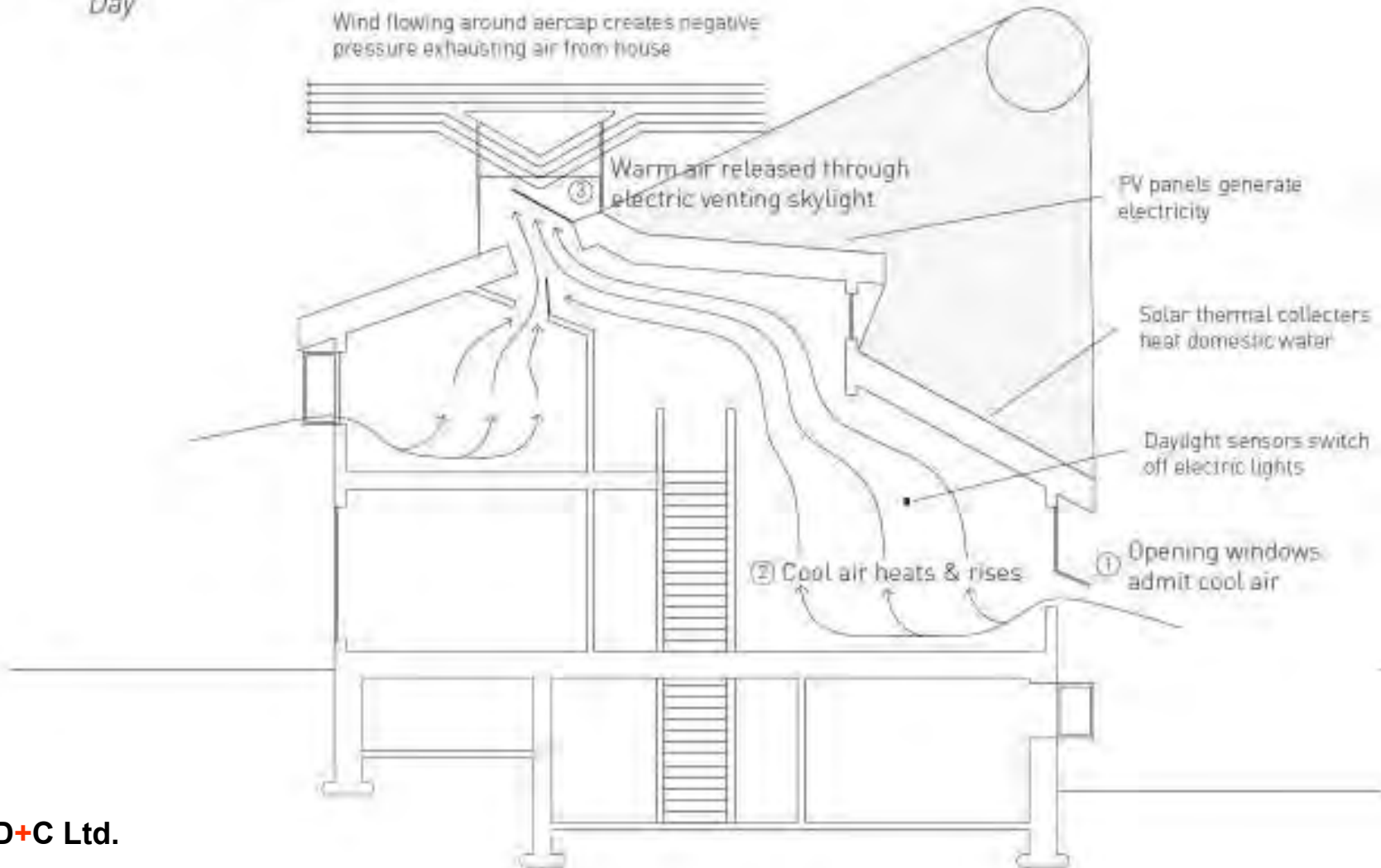
Ceiling insulation



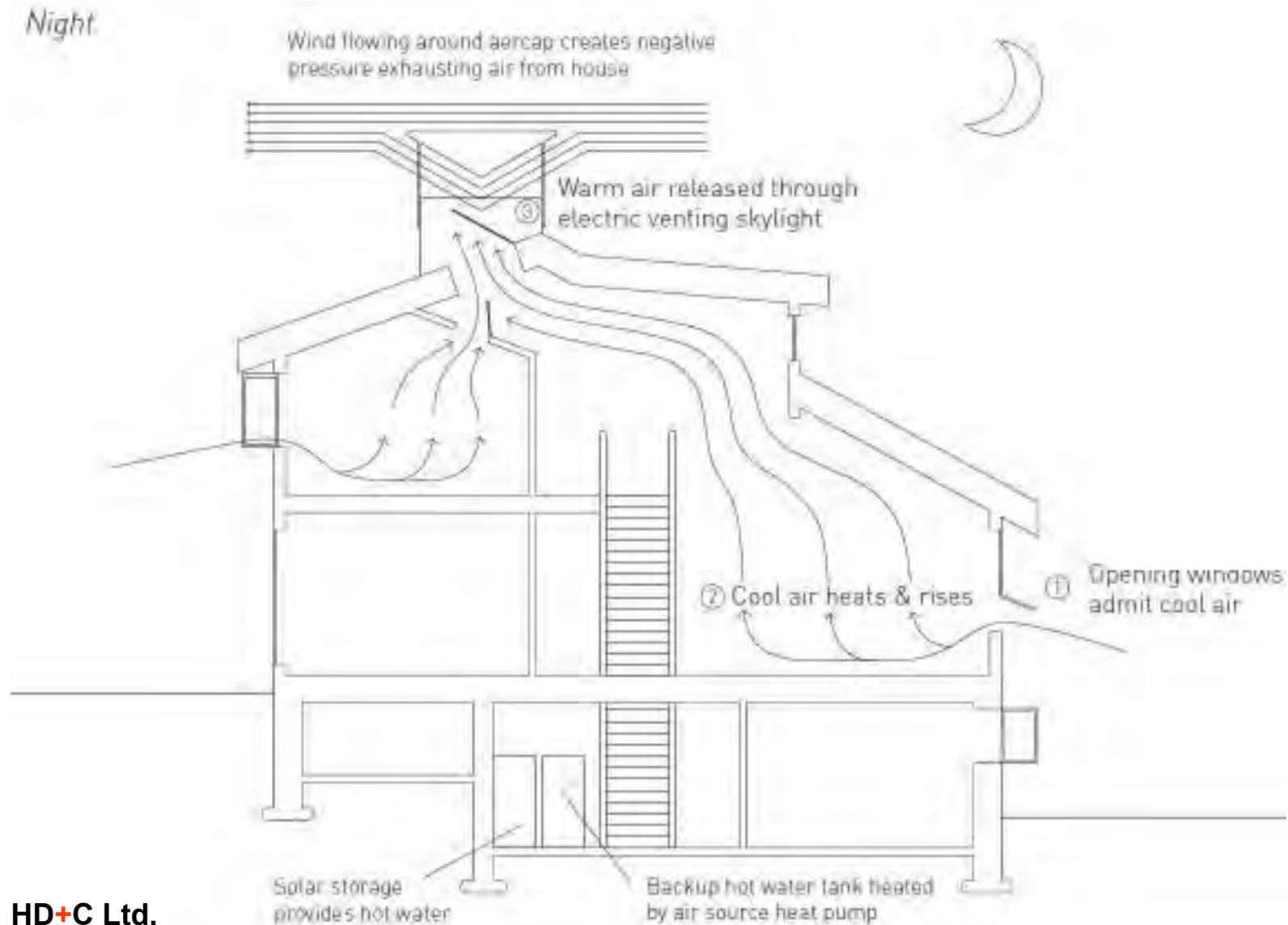
# Summer Day: Reducing Heat Gain & Natural Cooling

## Energy Flows—Summer

*Day*



# Summer Night: Natural Cooling

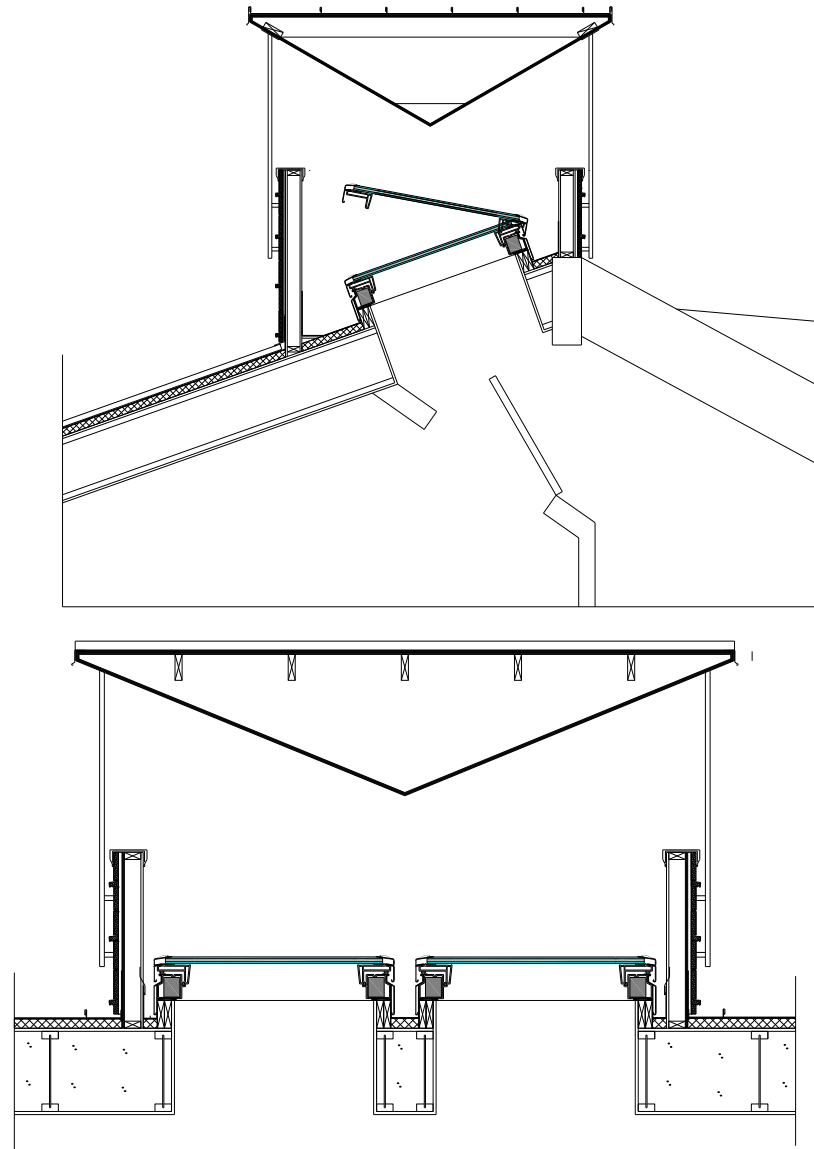


# Wind Tower

- Inverted pyramid causes negative pressure at top of tower regardless of wind direction
- Two remote control electrically operated Velux opening skylights with rain sensors control air flow
- Source of daylight as well as ventilation



HD+C Ltd.



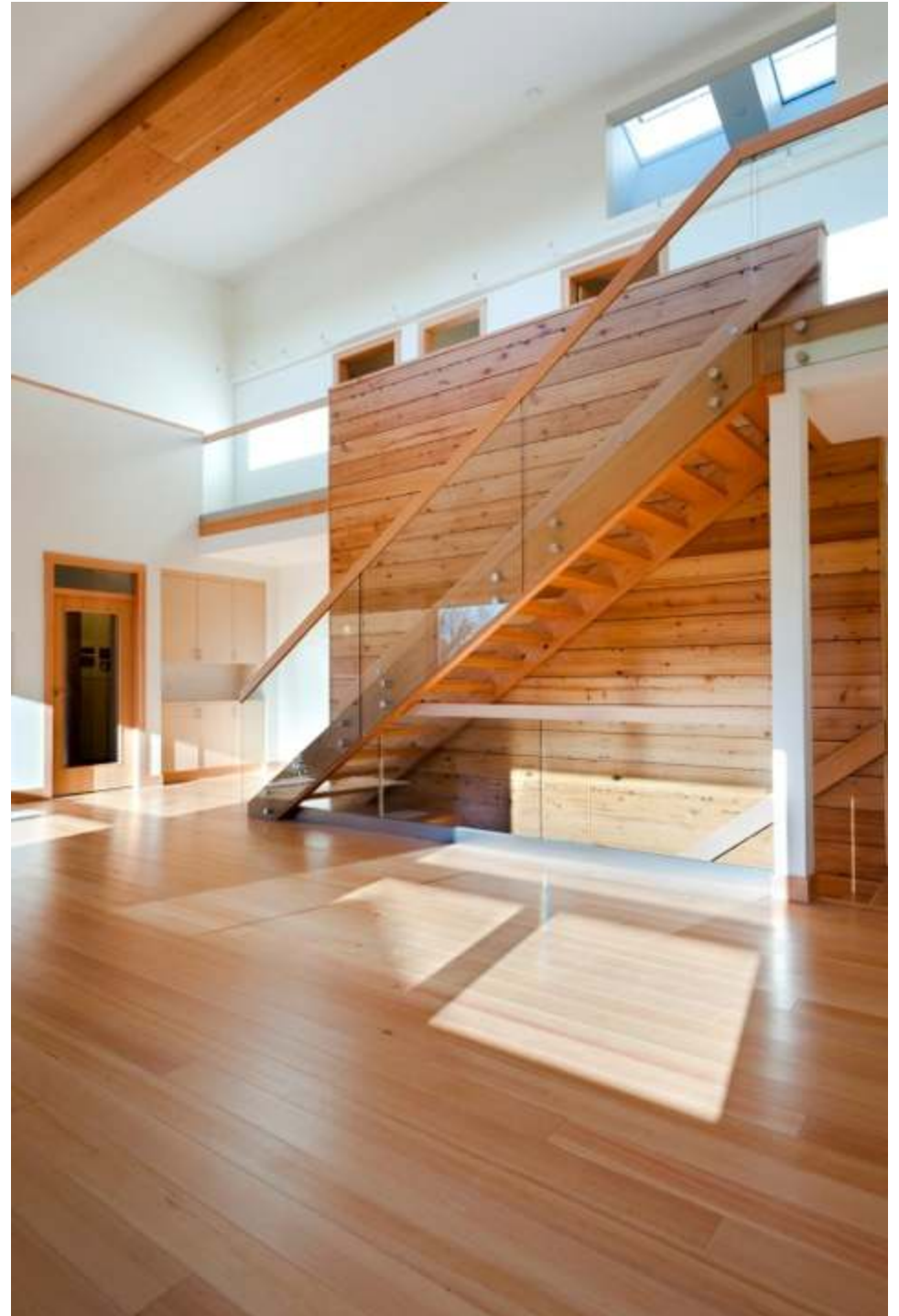


# Daylighting

Exploit daylighting as much as possible

- Tall windows
- Clerestories
- Skylights
- Light from two directions
- Light coloured upper walls and ceilings
- Light coloured exterior surfaces

Daylight sensing controls vary electric lighting levels to allow daylight harvesting



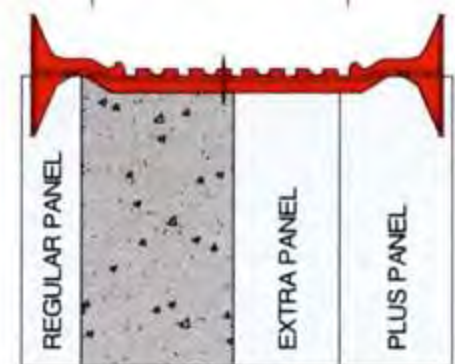
# Basement / Crawlspace Walls & Sub-Slab Insulation

*Walls RSI 8 (R45) (K 0.125)*

*Slab RSI 3.5 (R20) (K 0.28)*

- Fab Form Monopour™ fabric footing system
  - Minimizes concrete waste
  - Minimizes entry of concrete water into the water table and
  - Eliminates moisture entry through footings
- Quad-Lock ICF's provide formwork and stay in place super insulation
- Concrete wall and footing poured at one time reducing cost, construction time and embodied energy
- Dow SM non-ozone-depleting extruded polystyrene foam insulation beneath all slabs

HD+C Ltd.





# ICF Foundation Construction Sequence



4" (100mm) thick gravel pad



Bottom two rows of ICF prefabricated



Monopour fabric footing laid out  
HD+C Ltd.



Bottom 2 rows of ICF assembled

# ICF Foundation Construction Sequence



Step in ICF foundation



Fabric footing form screwed to ICF



ICF wall assembled  
HD+C Ltd.



ICF wall bracing using 2x4's and plywood





# ICF Foundation Construction Sequence



Final bracing



Concrete poured and vibrated



HD+C Ltd.



2' (600mm) of concrete poured in footing and allowed to firm up before rest of pour



# ICF Foundation Construction Sequence



Concrete set and bracing removed



Waterproofing with plastic membrane and drainage mat  
drainage pipe run around footing  
and connected to sewer



Foundation back filled  
HD+C Ltd.

# Floor Framing



Main floor open web floor joists



Open web floor joists from basement



Allows for high insulation levels  
beneath solarium  
HD+C Ltd.



Heating, ventilation, plumbing  
and electrical services run  
through open web joists



# Floor Framing



Wood I joists used for 2<sup>nd</sup> floor framing



Wood I joists supported by LVL using galvanized steel hangers



Floor sheathing  $\frac{3}{4}$ " (19mm) plywood  
HD+C Ltd.



# Exterior Wall Assembly:

*Nominal: RSI 11.07 (R62.9) (K 0.09)*

*Composite: RSI 6.78 (R38.5) (K 0.147)*



Wood fiber reinforced cement lapped siding painted with Benjamin Moore Regal Select exterior latex paint

13mm ( $\frac{1}{2}$ ") thick preservative treated vertical plywood strapping forming rain screen cavity

Dupont Tyvek commercial wrap weather resistant barrier

13mm ( $\frac{1}{2}$ ") thick plywood wall sheathing

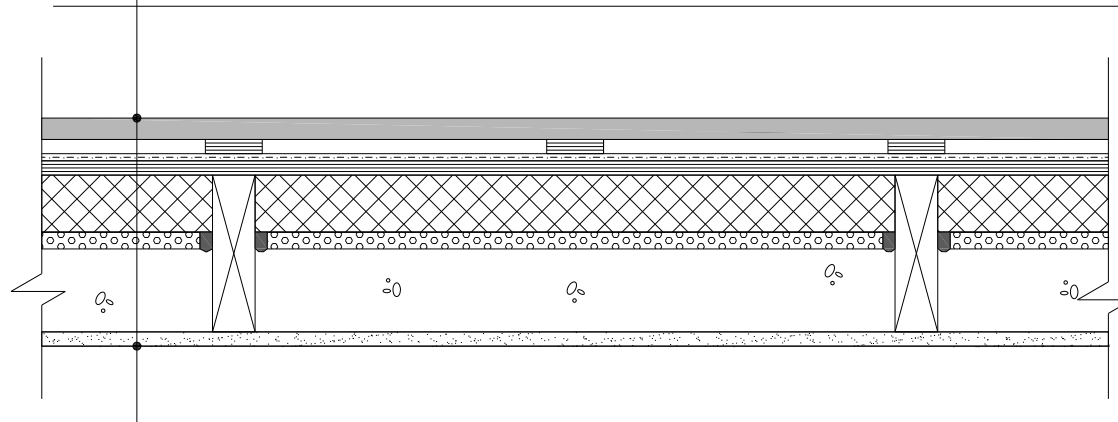
38mm x 140mm (2x6) studs at 610mm (24") O.C.

50mm (2") thick Dow Thermax isocyanurate foam board

Panasonic 15mm (0.59") vacuum insulation panel

Icynene LD-R-50 castor bean oil based spray foam insulation and air barrier

13mm ( $\frac{1}{2}$ ") drywall painted with Benjamin Moore Natura no VOC paint



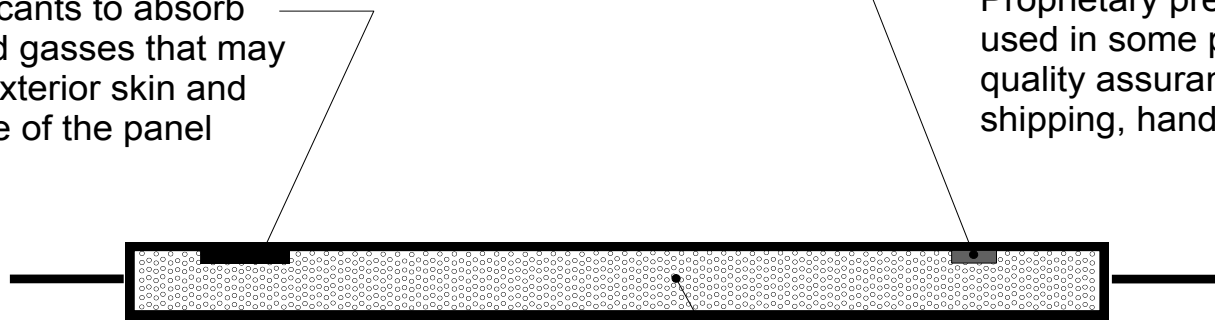
# Vacuum Insulation Panels

Getter and desiccants to absorb water vapour and gasses that may diffuse through exterior skin and joints over the life of the panel

Proprietary pressure sensor used in some panels to provide quality assurance during manufacturing, shipping, handling and installation

Exterior skin of aluminum foil or plastic / aluminum composite heat sealed or glued at all joints. Flanges maybe folded to allow for butting of panels

Gas porous core of foam, fiberglass board, aerogel or compressed silica with opacifiers  
initial vacuum less than 5 mbar



## Panasonic VIP





# Exterior Wall Assembly Advanced Framing



2x6 studs at 24" OC (610mm)



LVL let into top of studs to support floor joists and allow continuous insulation and eliminate window lintels



HD+C Ltd. Two stud corner



Parallam window lintels for large spans

# Exterior Wall Assembly Insulation



Exterior wall before insulation



2" (50mm)  
Thermax



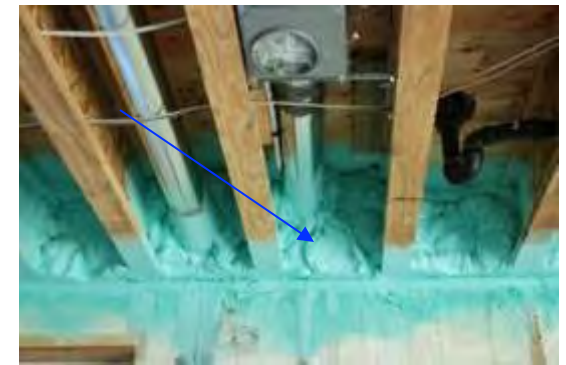
Vacuum insulation panels  
foamed in place



HD+C Ltd.



Castor bean oil based spray foam



Rim joist air sealed  
with foam and  
covered with vapour  
barrier paint



# VIP Installation



HD+C Ltd.

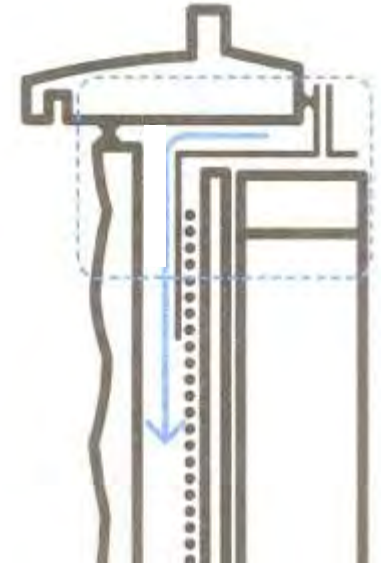
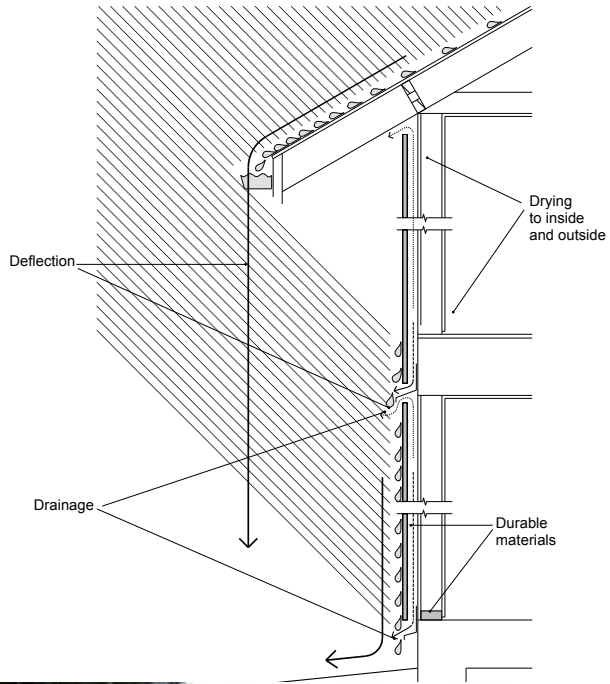


# VIP Installation





# Wall Rain Penetration Control



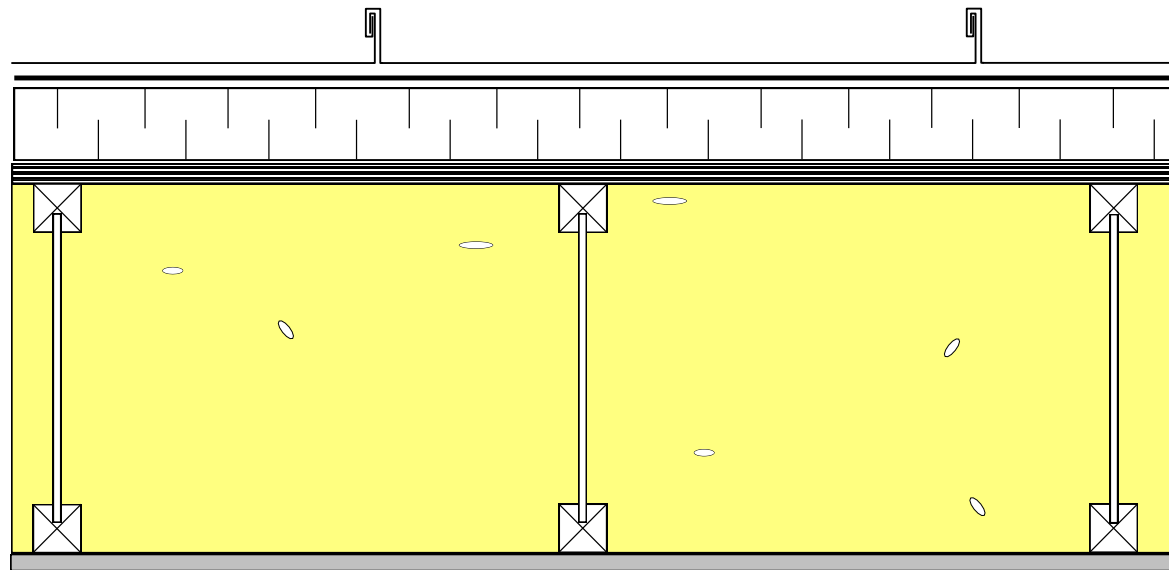


# Open Roof Assembly:

*Nominal: RSI 12.53 (R71.2) (K 0.08)*

*Composite: RSI 10.56 (R60) (K 0.09)*

400mm (16") deep wood I joists with  
low density castor oil based spray foam  
insulation and foam board insulation



# Roof Construction



Central Parallam beam  
supporting wood I ceiling joists



Wood I joists over living room  
HD+C Ltd.



Vapour permeable water proof membrane

# Roof Construction



Upper roof showing joists and sheathing



Standing seam sheet metal roof



Upper roof cavities filled with castor bean oil based spray foam covered with vapour barrier paint

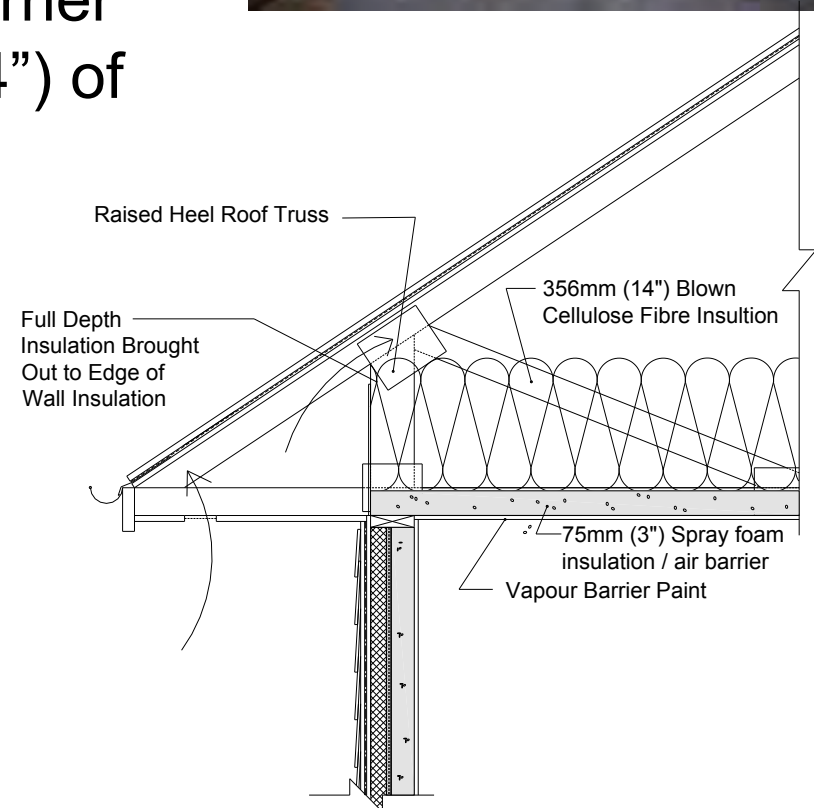


# Attic Roof Assembly:

*Nominal: RSI 10.83 (R61.5) (K 0.09)*

*Composite: RSI 10.56 (R60) (K 0.09)*

Raise heel trusses with 75mm (3") of castor bean oil based spray foam insulation providing both air barrier and insulation and 356mm (14") of blown cellulose fiber insulation





# Windows & Glazed Doors

*Average RSI 1.05 (R6) K 0.95*

Cascadia Pultruded Fiberglass Frame Windows

triple-glazed

double-low E

insulated spacer bar

argon gas fill

fiberglass frame

casement opening



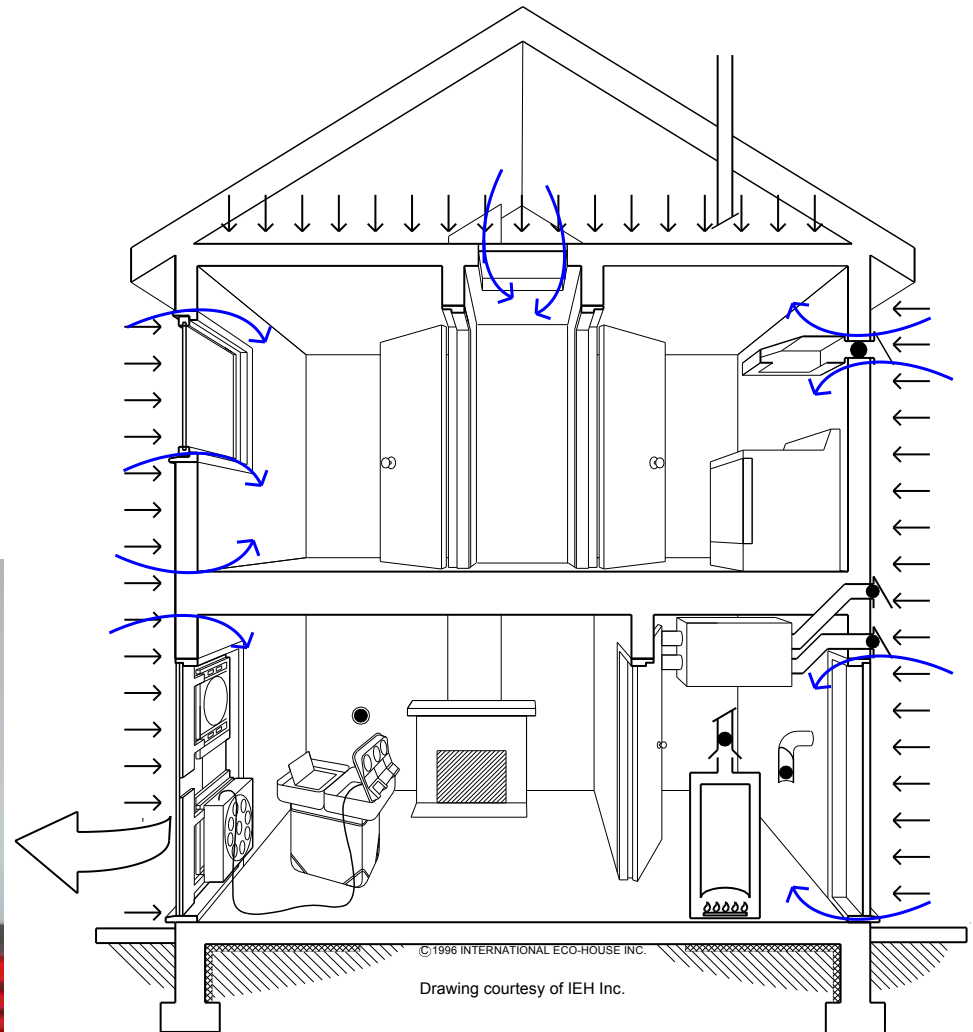
HD+C Ltd.

# Airtightness

- Icynene LD-R-50 Castor Bean Oil spray-foam primary air barrier
- Target: NLA 0.35 cm<sup>2</sup>/m<sup>2</sup> @ 10 Pa (0.75 ACH @ 50 Pa)  
(1/2 the R-2000 standard)



HD+C Ltd.



# Heat Recovery Ventilation

- Eneready Products high efficiency diamond core HRV 80% heat recovery efficiency
- High efficiency DC motors
- Humidity based proportioning controller
- Power grills for zoned ventilation
- Dedicated ductwork to ensure best distribution of filtered outdoor air and collection of exhaust air
- Pre-filter to provide higher level of IAQ



# Heating System

- Mitsubishi Zuba- Central™ high efficiency air source heat pump (HSPF 9.4)
- Forced air distribution
- Allows for redistribution of solar and internal heat gain



Ultra quiet exterior unit



Central air handler unit



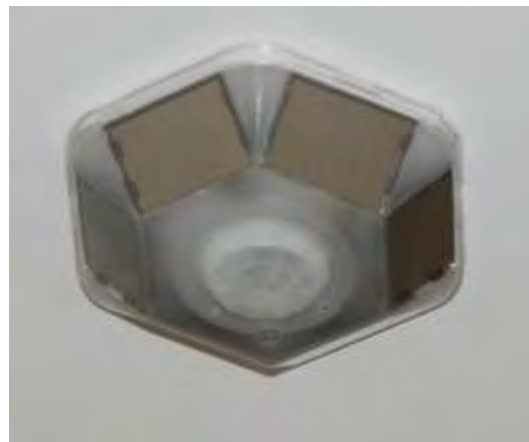


# Electrical Energy Conservation

Home Energy Display System (HEDS)	Monitors and displays current and cumulative energy consumption of various equipment and groups of appliances allowing occupants to modify operation of lighting and appliances Monitors and displays power production of PV array Compares power production with consumption
Smart Metering	Real time tracking electrical energy use
Appliances	Typically 20 to 30% less annual energy use than Energy Star Motion detector-activated power bars
Equipment	Air handler fan - EC motor HRV DC motors Ductwork oversized, to minimize flow resistance
Lighting	Controls to allow daylight harvesting Motion-activated light switches Central Green Switches High-efficiency lighting fixtures CFL's, Linear Fluorescents and LED's

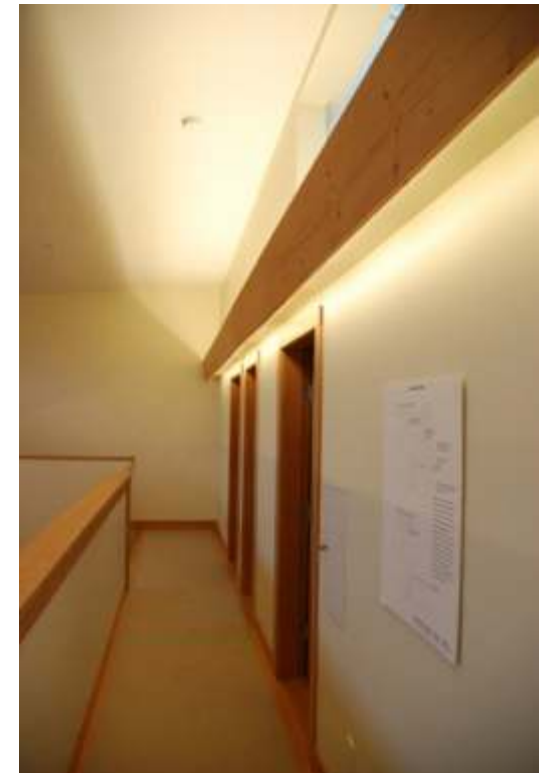
# Lighting and Electronics Controls

- Self Powered Wireless Switches
- Central “Green” Switch
- Self Powered Daylight Sensors
- Self Powered Occupancy Sensors



# Lighting Fixtures and Lamps

- LED Recessed Lights
- Linear Fluorescents
- Compact Fluorescents



# Energy Efficient Appliances

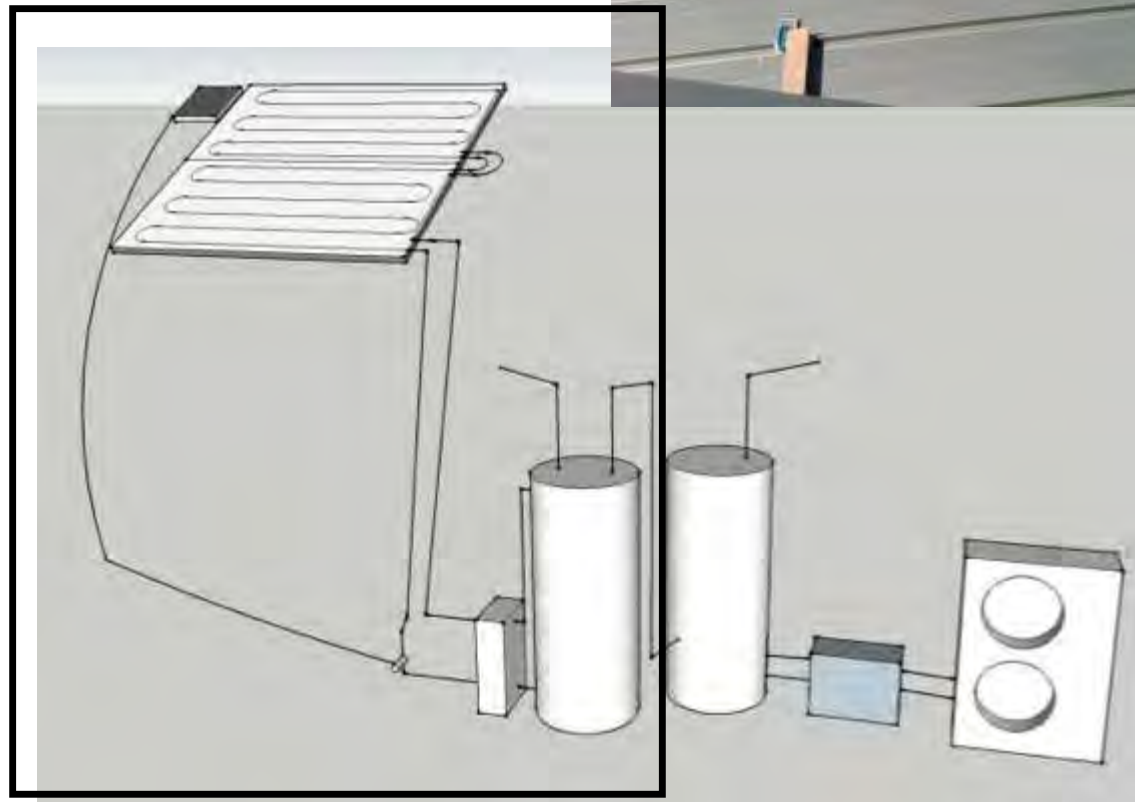
- Energy Star as Minimum
- Many Consortium for Energy Efficiency (CEE) Tier 2 and 3 – 20 to 30% more efficient than Energy Star





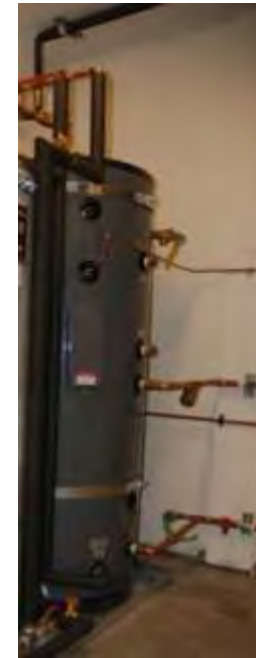
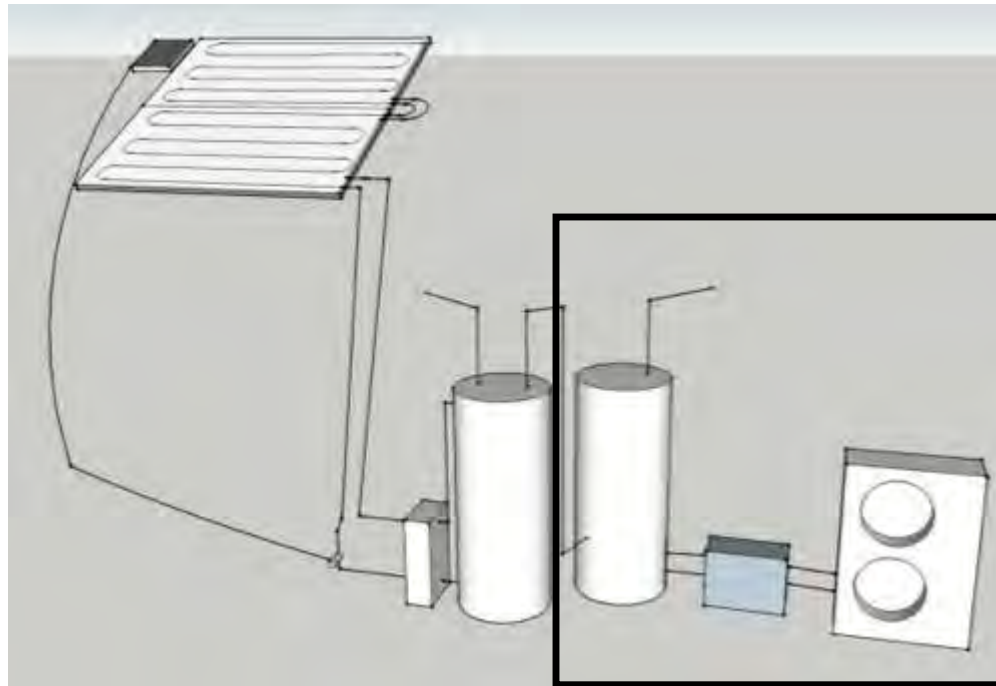
# Solar Domestic Water Heating System

- 6 m<sup>2</sup> (64 sq ft) solar collector array
- PV powered pump / controller
- provides 60% of domestic hot water requirements



# Backup Domestic Water Heating System

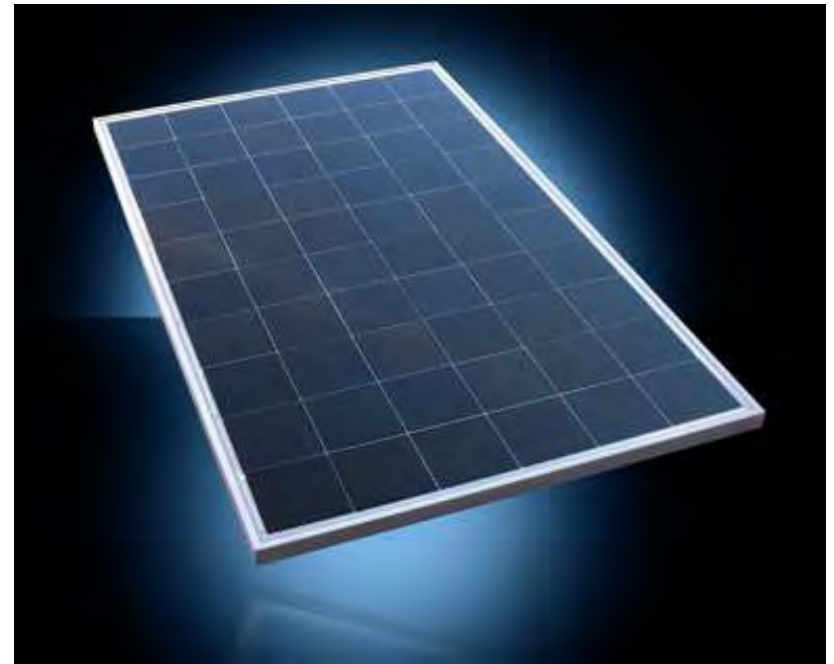
- High Efficiency Air Source Heat Pump :
- Mitsubishi Zuba Hydra-Dan
- Heating capacity 40,000 Btu/h, maximum input 3,670 W
- Heat extracted from outdoor and upgraded
- 3 watts of heat produced for every watt consumed



# Solar Electric System

Grid connected photovoltaic arrays meets home's annual electricity requirements

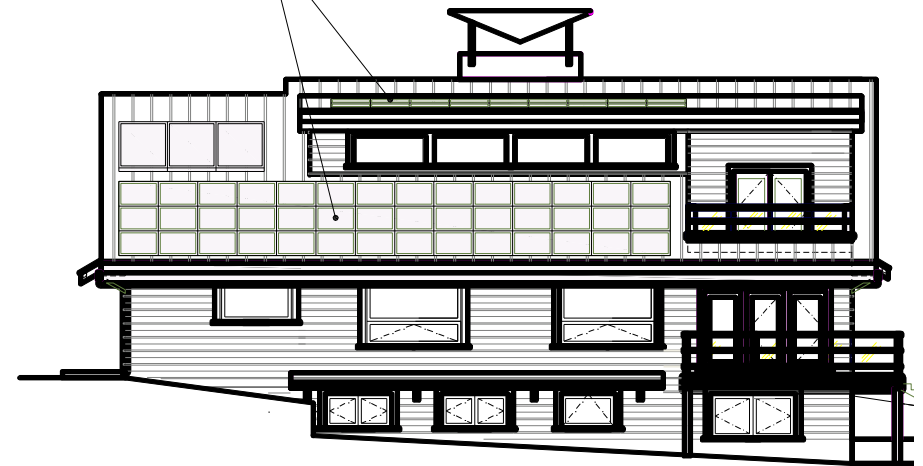
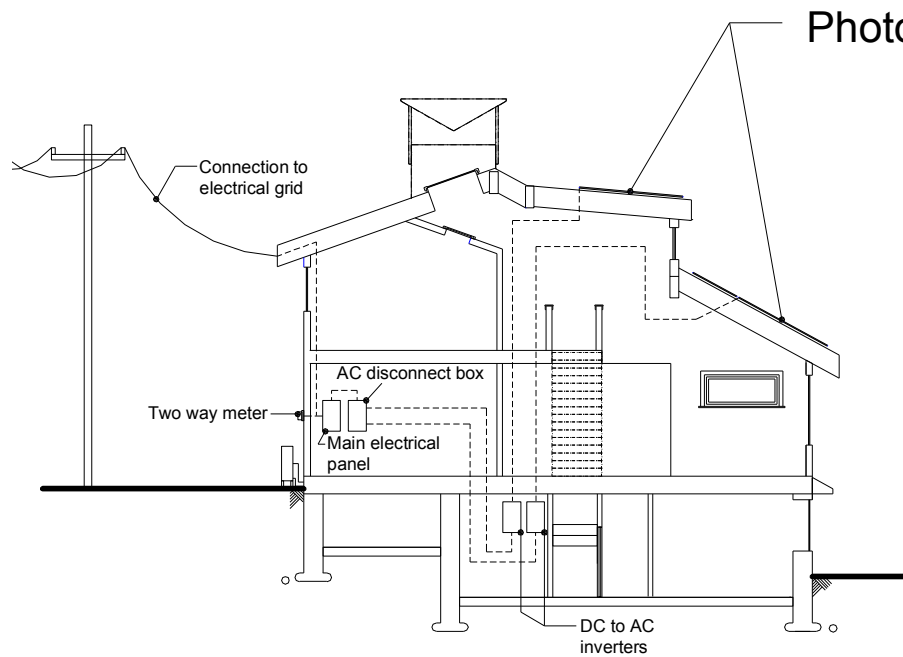
- 110.3m<sup>2</sup> (1187 sq ft) PV array
  - excess power sent to grid
  - draws from grid when needed (e.g. night and during periods of low light levels)
- 66 Day4Energy 60MC-I 225Wp panels rated at 14.8 kW
  - 34 panels at 28 degree slope
  - 32 panels at 5 degree slope
  - Majority of electrical production in the summer when the resource is available
  - "Annual" electrical energy storage using the grid as a "battery"



Day4Energy PV Panel



# Solar Electric System



South Elevation



Close up of PV Panels  
HD+C Ltd.

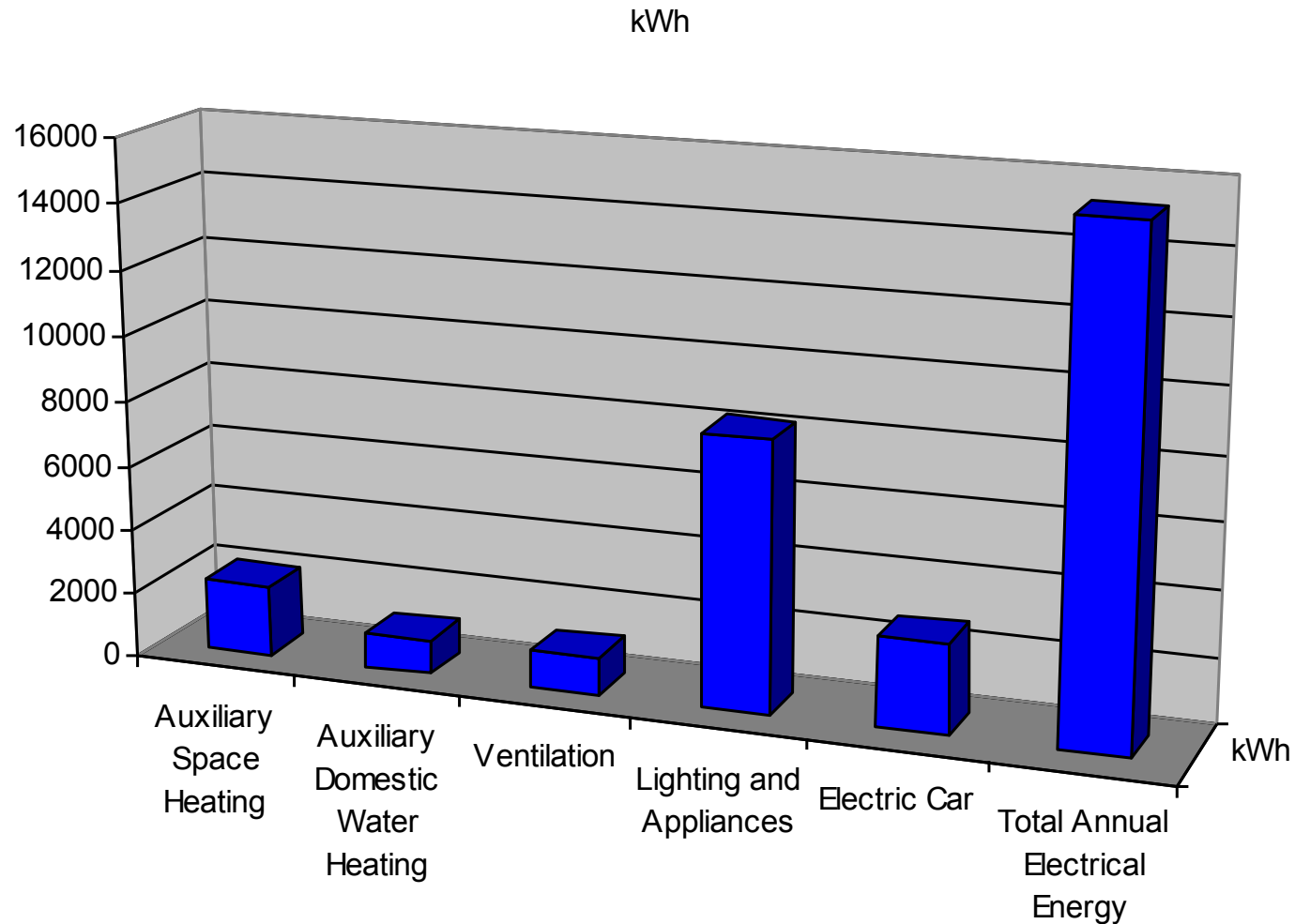


Lower PV Array

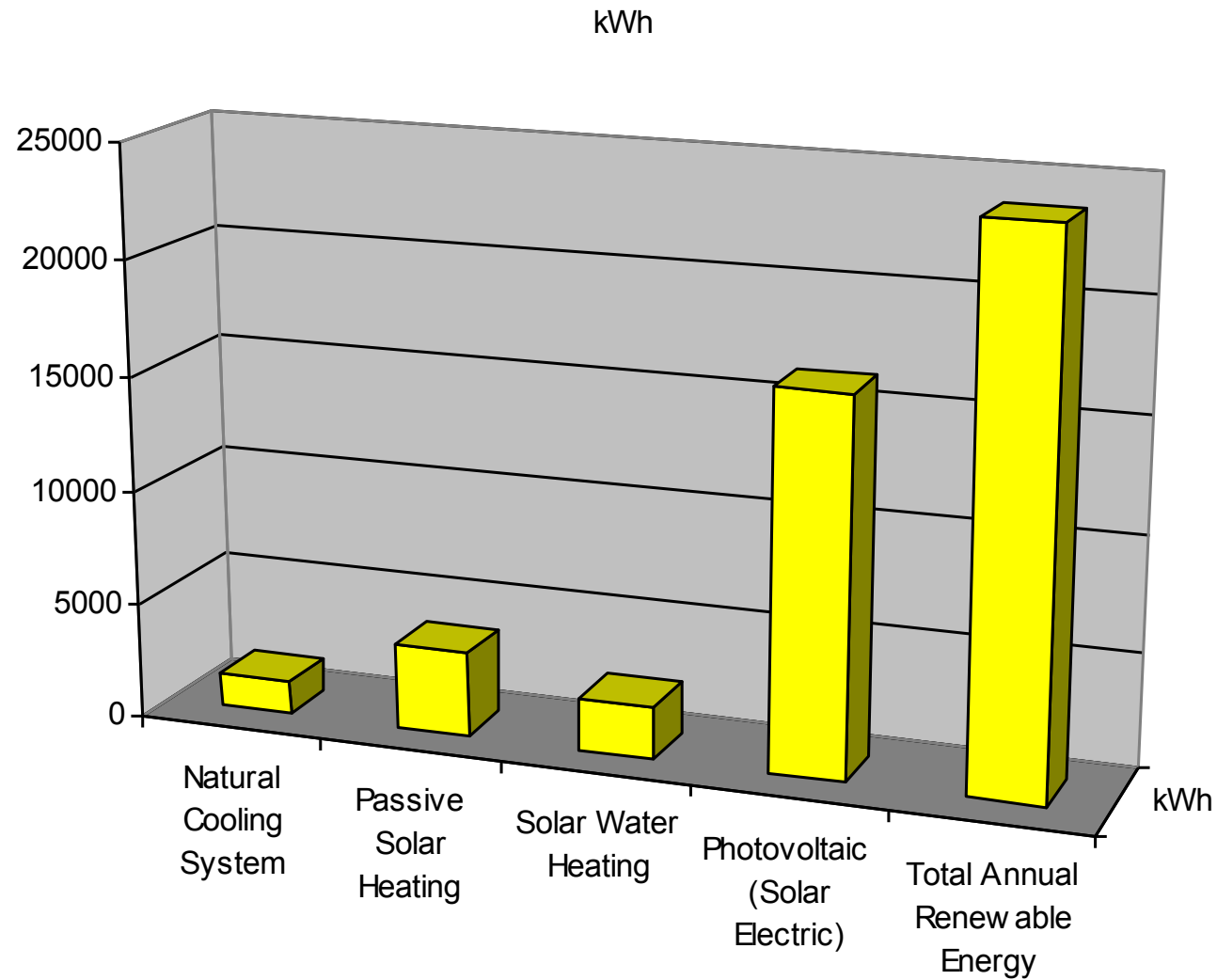


PV System Inverters

# Harmony House Predicted Annual Energy Consumption kWh/yr



# Harmony House Predicted Annual Energy Production kWh/yr





# Water Conservation

- Low-flow shower heads, faucets
- Low / dual flush toilets
- Water efficient clothes washers and dishwasher
- Rainwater harvesting for irrigation
- Use of local drought tolerant landscaping



# Rain Water Harvesting

- Rain water collected from north roof
- Gutter guard screens out debris
- Water collected in 960 gallon polyethylene tank
- Overflow to storm sewer when tank is full
- Yard irrigation by gravity



HD+C Ltd.

960 imperial gallon tank polyethylene rain water storage tank

Hose bib at base of tank allows for connection to garden hose

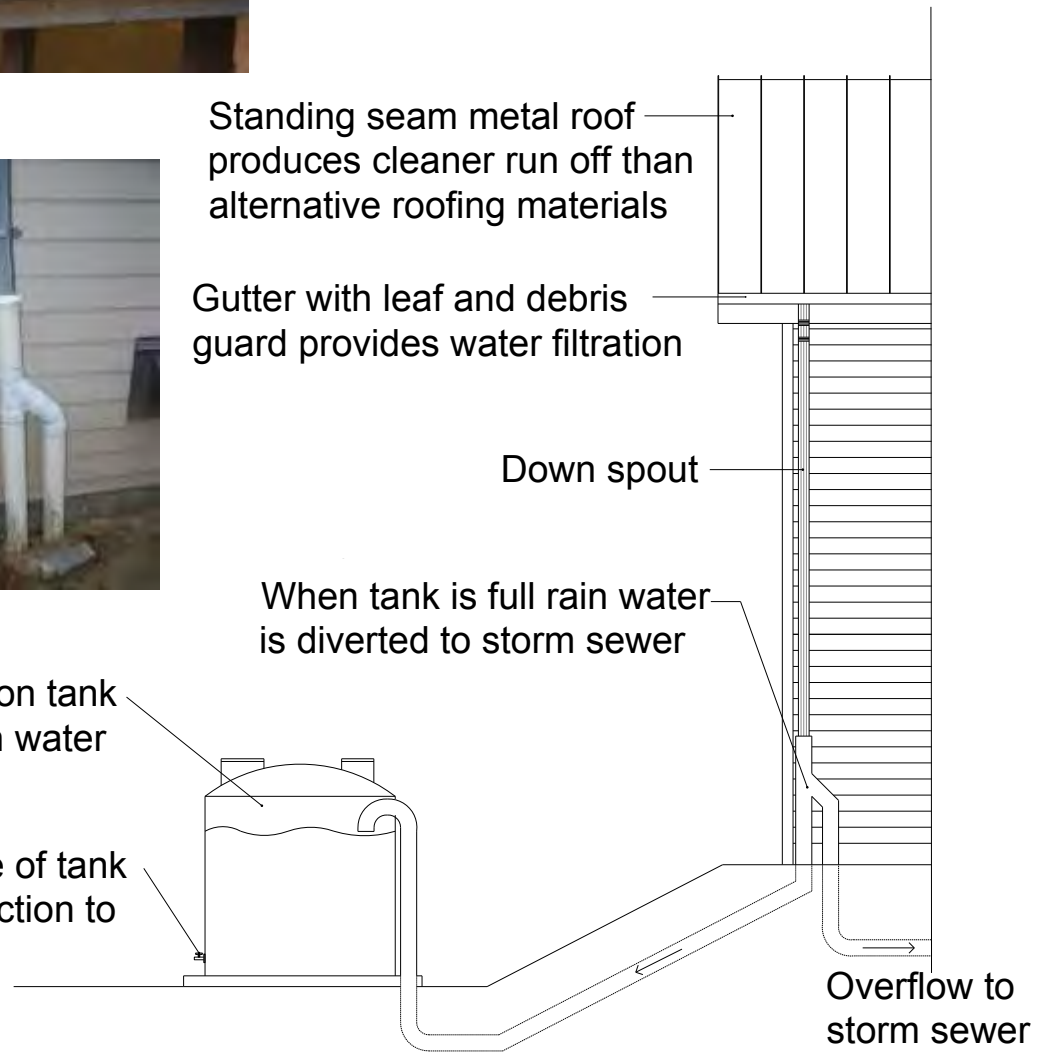
Standing seam metal roof produces cleaner run off than alternative roofing materials

Gutter with leaf and debris guard provides water filtration

Down spout

When tank is full rain water is diverted to storm sewer

Overflow to storm sewer



- Permeable pavers to allow rain to enter aquifer
- Water features for temporary water storage
- High efficiency drip irrigation


$$1/8'' = 1' 0''$$



# Resource-Efficient Building Materials

## *General Guidelines*

### Product Attributes

- Very long life
- Designed for recycling
- Engineered to minimize material use

### Materials

- Recovered materials from demolished buildings
- Renewables (fast growing woods, grasses), OR
  - uses post-consumer waste
  - uses industrial waste
  - uses agricultural waste

### Manufacturing

- Low-pollution process  
(closed-system, ISO 14000-certified, industrial ecology process)
- Minimize transportation footprint

# Healthy Materials

## *General Guidelines*

Minimize chemical off-gassing

Minimize particulate shedding

Minimize growth of:

- bacteria
- fungi
- dust mites
- viruses

Keep interior clean and dry

# Resource-Efficient Building Materials

## Structure

- Engineered wood products  
(wood I-joists, parallel strand beams and posts, open web joists, laminated veneer lumber )



## Roofing - metal roof

## Cladding

- Wood-fibre reinforced cement





# Resource-Efficient & Healthy Building Materials

## *Flooring, Trim and Stairs:*

Recovered Douglas Fir from 80 year old wooden bridges finished with hard wax oil



# Resource-Efficient & Healthy Building Materials

## *Flooring & Counter Tops Flooring & Counter Tops*

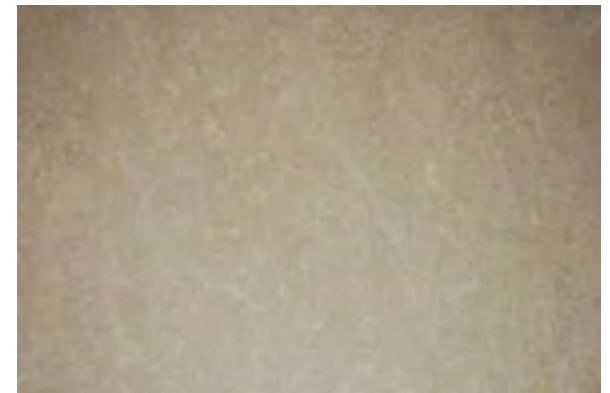
### Marmoleum

- Linseed oil based linoleum
- Made from renewable plant resource
- No petroleum content
- Extremely durable
- Wide range of colours
- Can be inlaid to produce floor designs
- Natural bacteriostatic action (kills bacteria)
- Good for wheel chair access
- Can be formed into cove base
- Can be used in combination with throw rugs
- Safe choice

### Locations

- Basement suite all rooms
- Laundry Room
- Kitchen

HD+C Ltd.



# Resource-Efficient & Healthy Building Materials

## *Flooring & Backsplash:*

### Interstyle Earthen Glass

- Flooring
- Recycled glass powder and local clay

### Interstyle Icestix

- Wall tile
- Made from recycled window glass

### Locations

- Entry
- Kitchen
- Bathrooms





# Resource-Efficient & Healthy Building Materials

- Pacific Rim low emission cabinets using engineered wood veneers from fast growing woods
- Szolyd inert precast counters with recycled glass aggregate





# Healthy Materials

## *Wall & Ceiling Finishes:*

### Painted Surfaces

- Ceilings and upper walls at least 80% light reflectance to enhance daylight distribution
- Low or no VOC paint to minimize chemical off gassing
- Benjamin Moore Natura zero VOC paint
- Do not herbicides (produced in sterile factory)



# Indoor Air Quality

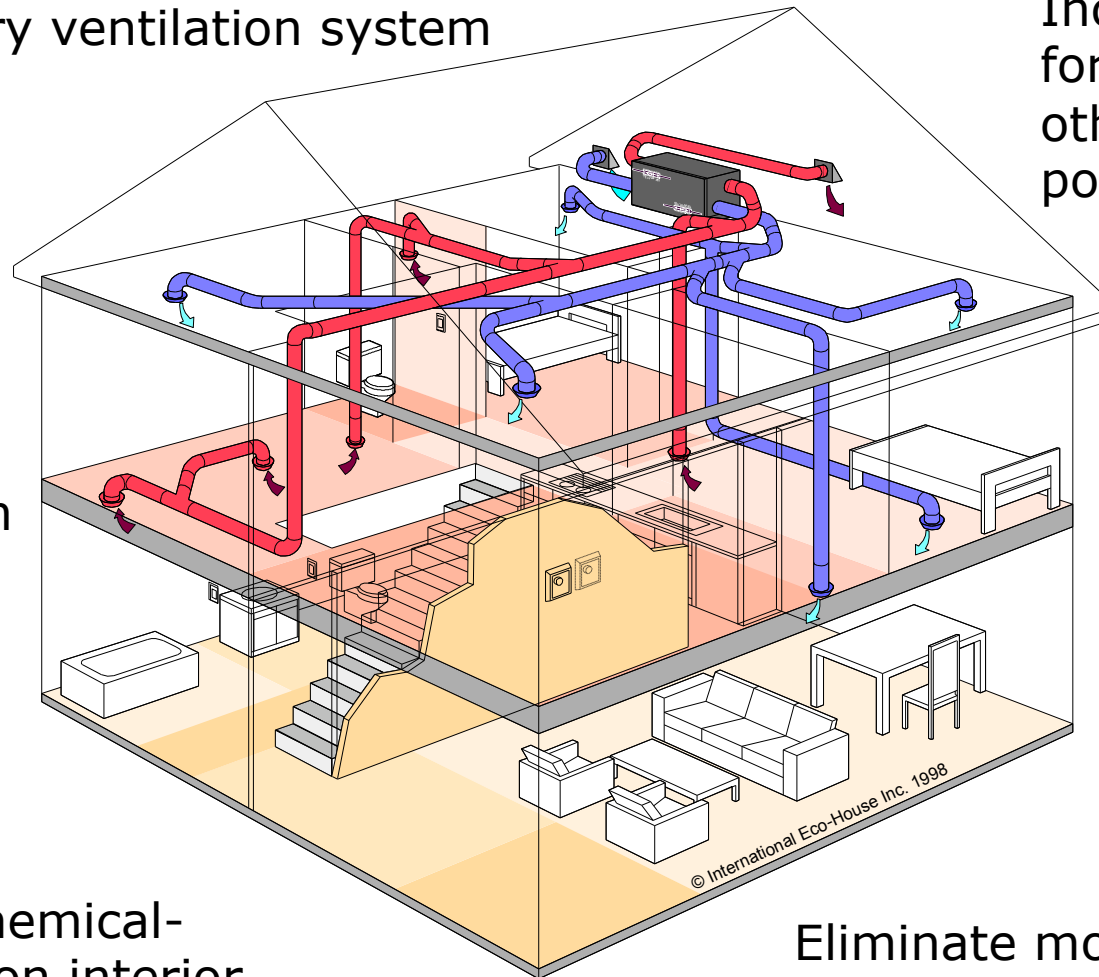
Central, independently-ducted high-efficiency heat recovery ventilation system

Incoming air filtered for pollen, smoke, other outdoor air pollutants

Zoned ventilation

Low chemical-emission interior finishes

Eliminate moisture entry through the foundation



# Electric Car

- Mitsubishi iMiEV
- Powered by PV array
- Seats 4
- Range of 155 km
- Eaton Level 2 reduces charging time to 7 hours



# Industry Partners



*K. Ito & Associates Ltd*

## Insightful Healthy Homes



**FAB-FORM** Build healthy from the ground up

ENEREADY PRODUCTS LTD.





The logo consists of a solid green square. Inside the square, the words "HARMONY" and "HOUSE" are stacked vertically in a white, bold, sans-serif font. "HARMONY" is on the top line and "HOUSE" is on the bottom line.

HARMONY  
HOUSE

Thanks

[www.harmony-house.ca](http://www.harmony-house.ca)