Harmony House EQuilibrium™ Project

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Habitat Design + Consulting Ltd. Vancouver B.C.
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.

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South Elevation
East Elevation

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EQuilibrium™ Demonstration: Harmony House

- Wind tower and skylight with aero cap
- RSI 10.56 (R60, K 0.095) roof
- Clerestory windows for Daylighting & passive solar gain
- Solar thermal and solar Electric (PV) panels
- South facing windows For daylighting and passive solar gain
- RSI 7 (R40, K 0.14) insulated concrete foundation
- RSI 3.5 (R20, K 0.29) under slab insulation
- RSI 1.06 (R6, K 0.94) triple glazed windows
- RSI 6.8 (R38.5 K 0.14) walls
Winter Day:

1. Sunlight heats home's interior, heat rises.
2. Heat flows into return air grill.
3. Heat distributed by forced air system.

- Air source heat pump provides backup heating and hot water.
- Air handler for heating and redistribution of solar heat gain.
- Solar storage provides hot water.
- Backup hot water tank heated by air source heat pump.
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
Winter Night

Air source heat pump provides backup heating and hot water

Heat stored in building structure radiates to interior

Heat distributed by forced air system

Solar storage provides hot water

Backup hot water tank heated by air source heat pump

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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

Wind flowing around aerocap creates negative pressure exhausting air from house

Warm air released through electric venting skylight

PV panels generate electricity

Solar thermal collectors heat domestic water

Daylight sensors switch off electric lights

Cool air heats & rises

Opening windows admit cool air
Summer Night: Natural Cooling

Wind flowing around aeroplane creates negative pressure exhausting air from house

Warm air released through electric venting skylight

Cool air heats & rises

Opening windows admit cool air

Solar storage provides hot water

Backup hot water tank heated by air source heat pump
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
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

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ICF Foundation Construction Sequence

4” (100mm) thick gravel pad

Monopour fabric footing laid out

Bottom two rows of ICF prefabricated

Bottom 2 rows of ICF assembled

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ICF Foundation Construction Sequence

Step in ICF foundation

Fabric footing form screwed to ICF

ICF wall assembled by HD+C Ltd.

ICF wall bracing using 2x4’s and plywood
ICF Foundation Construction Sequence

Concrete poured and vibrated

Final bracing

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

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ICF Foundation Construction Sequence

Concrete set and bracing removed

Waterproofing with plastic membrane and drainage mat and connected to sewer

Foundation back filled
Floor Framing

Main floor open web floor joists

Allows for high insulation levels beneath solarium

Open web floor joists from basement

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

Wood I joists used for 2nd floor framing

Wood I joists supported by LVL using galvanized steel hangers

Floor sheathing ¾” (19mm) plywood

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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 (⅝") thick preservative treated vertical plywood strapping forming rain screen cavity
Dupont Tyvek commercial wrap weather resistant barrier
13mm (⅝") 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 (⅝") drywall painted with Benjamin Moore Natura no VOC paint
Vacuum Insulation Panels

**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.**

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

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

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

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

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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

Castor bean oil based spray foam Rim joist air sealed with foam and covered with vapour barrier paint
VIP Installation

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VIP Installation

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Wall Rain Penetration Control

- Durable materials
- Deflection
- Drying to inside and outside
- Drainage
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

Vapour permeable water proof membrane

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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:  \textit{RSI} 10.83 (R61.5) (K 0.09)  
Composite: \textit{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

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Airtightness

- Icynene LD-R-50 Castor Bean Oil spray-foam primary air barrier
- Target: NLA 0.35 cm²/m² @ 10 Pa (0.75 ACH @ 50 Pa)
  (1/2 the R-2000 standard)
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
## 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 |
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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 m² (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
- 110.3m² (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

Close up of PV Panels
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Lower PV Array

PV System Inverters

South Elevation
Harmony House Predicted Annual Energy Consumption kWh/yr

<table>
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<th>Category</th>
<th>kWh</th>
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<td>Auxiliary Domestic Water</td>
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<td>Ventilation</td>
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<td>Lighting and Appliances</td>
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</table>
Harmony House Predicted Annual Energy Production kWh/yr

- Natural Cooling System
- Passive Solar Heating
- Solar Water Heating
- Photovoltaic (Solar Electric)
- Total Annual Renewable Energy

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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

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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

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

Gutter with leaf and debris guard provides water filtration

Overflow to storm sewer

960 imperial gallon tank polyethylene rain water storage tank

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

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Exterior Site Water Management

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

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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

*Marmoleum*
- Linseed oil based linoleum
- Made from renewable plant resource
- No petroleum content
- Extremely durable
- Wide range of colours
- Can be inlayed 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
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

Cascadia Windows & Doors
Dow Building Materials
ICynene Inc.
Mitsubishi Electric
Panasonic
DuPont
Velux
BCHydro 50
PowerSmart
Interstyle
K. Ito & Associates Ltd
Samsung
Day 4 Energy
Echoflex
FAB-FORM
Build healthy from the ground up
EnerReady Products Ltd.
JRS Engineering Limited
Building Envelope Consultants
Thanks

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