Beyond Energy Efficiency: A more sustainable two-unit design that adapts to changing families, changing technologies, and a changing world.

Site: NE 6th Avenue and Webster Street, Alberta Street Neighborhood, Portland, Oregon

Guiding Principles

Flexibility
Americans move every 5 years, but only 1/3 of those leave their county.[1]
We spend over $175 billion on remodeling each year[2] which generated more than 31 million tons of waste in 1996.[3] What if a house allowed people to grow in place through different stages of life? What if walls, doors and rooms could easily be rearranged?

Efficiency
Our impending energy crisis has obvious implications on the practice of both architecture and engineering. As technology improves so will our building systems, but what about the building itself? What solutions exist to lessen the embodied energy and life-cycle costs of an architectural design while leaving room for evolving energy efficient systems and technologies? How can we respect the site and better use the resources that it provides?

Community
North Americans are creating more new buildings now than they ever have, but are becoming increasingly detached from the act of building itself. What if the opportunity for interaction was intrinsic to the design and construction of a new space? Can the architecture allow the owner to truly take ownership of the place that they call home? What if walls could be built with a few hand tools?

Integration
Architectural decisions are often quick responses to a very specific problem. Could a building to be shaped by a holistic understanding of the social, environmental, and contextual forces of a site so that each element contributes in multiple ways to a more harmonious whole?

Precedents

Timber Frame Houses and Barns
A structural frame made of bents and girders allowsAnon-load bearing skin and walls to be reconfigured over time.

The Japanese House
A wood frame supports a sheltering roof; rooms created by movable panels; room sizes based on the module of the tatami mat; strong connection to outdoors.

The Grow Home
Avi Friedman developed an affordable row house concept quickly adopted by Canadian builders that provided simple, compact houses with unfinished second floors and optional basements.

Regional Vernacular Homes[4]
Provide courtyards
Shallow floor plate for daylighting
Open to the outdoors
Modular, understandable

Design Concepts

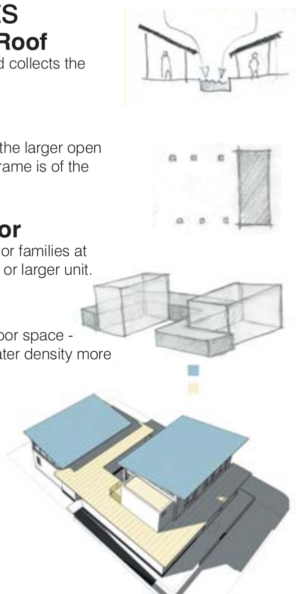
Sheltering, Collecting Roof
A wide, sloping roof both protects and collects the sun and rain.

Bar and Frame
A service bar supports and connects the larger open volumes. The bar is of the earth; the frame is of the trees and sky.

2 Units: Major and Minor
Allows for multi-generational families, or families at different life stages to rent the smaller or larger unit.

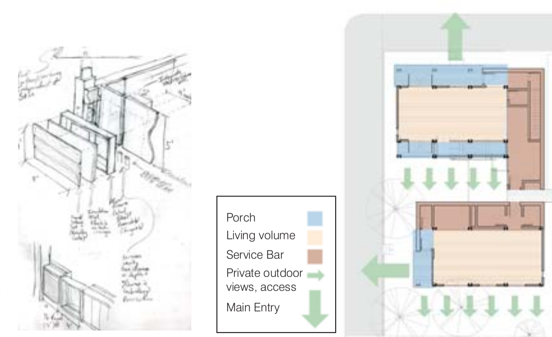
Outdoor Spaces
Each unit has protected, private outdoor space - essential for families and making greater density more livable.

East-West axis
To provide solar access and cross ventilation even on a constrained site.



Adaptable Space
The large clear span volumes have structure that can support movable, interior walls. Rooms can be added, removed, resized with minimal disruption and construction skill.

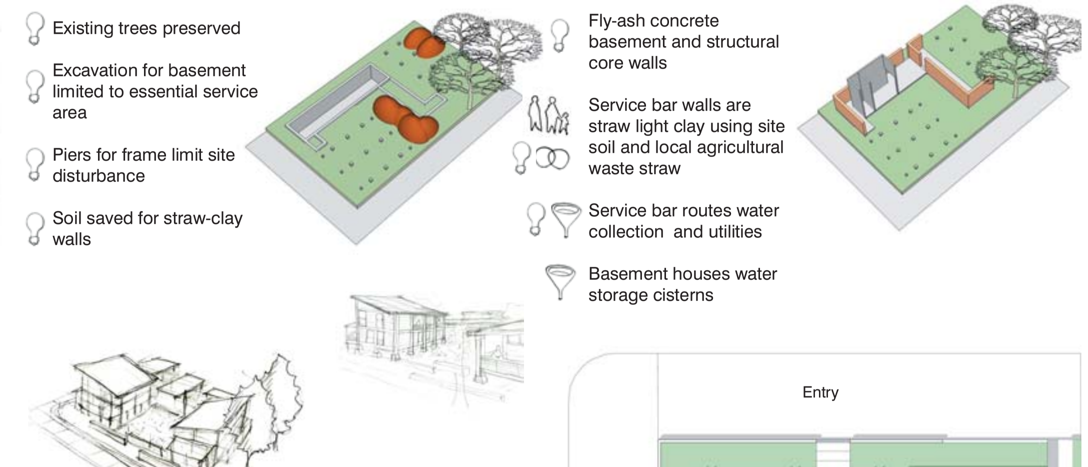
Adaptable Skin
Modular, unitized in-fill wall panels and rainscreen cladding allows repairs, rearrangements, and reuse.

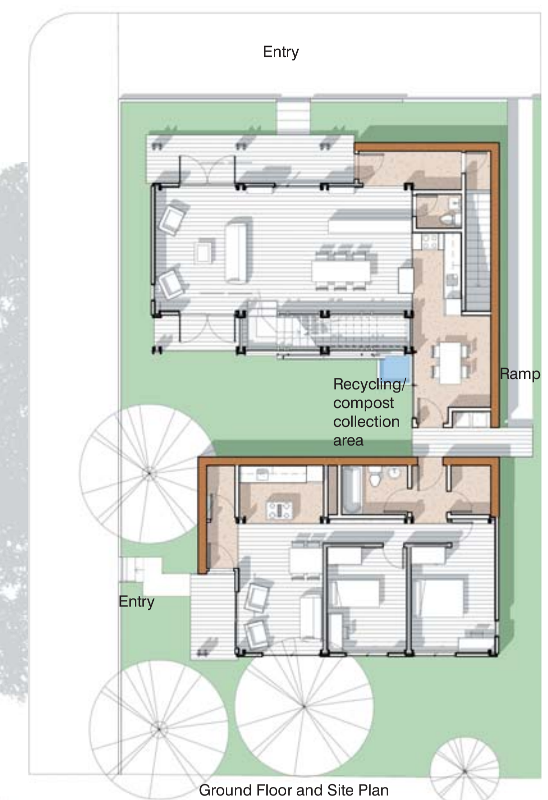


Construction Sequence

1. Excavation and Foundation
- Existing trees preserved
- Excavation for basement limited to essential service area
- Piers for frame limit site disturbance
- Soil saved for straw-clay walls

2. Core and Services Bar
- Fly-ash concrete basement and structural core walls
- Service bar walls are straw light clay using site soil and local agricultural waste straw
- Service bar routes water collection and utilities
- Basement houses water storage cisterns





Ground Floor and Site Plan

Process and Technical Analysis

Site Visits
Photos, sketches, and measurements, of lot, trees, neighboring buildings to assess solar obstructions, vegetation, visual character, scale, character and materials of surrounding buildings.

Soil samples to determine clay content and feasibility for wall construction

Site Resources

Climate:
Heating Degree Days: 4,522 Cooling Degree Days: 371
Average Wind speed 8.1 mph
Jan. Min.: 33.7 Jan. Max: 45.4 Aug. Min.: 56.9 Aug. Max:80.3 (F)
Mean Daily Range: ~ 27 F

Solar Energy:
Insolation: 1,110 Btu/sf/day

Rain
Annual precipitation: 42" Gallons/day/1000 sf roof: 81.6

National Renewable Energy Laboratory Solar Radiation Data Manual for Buildings (Data: 1961-1990)
Western Regional Climate Center web site

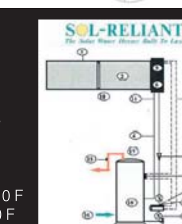
Getting to Zero? System Design: Rainwater Harvest System
Collection Area: 2713 sf
Filter: Flo-True roof washers at each downspout.
Cistern: 10,000 gal concrete cistern in basement
Purification: Atlantic Ultraviolet Biologic purifier

Balancing site coverage, open space, building massing and collection area resulted in a collection area and cistern that can meet the daily water needs throughout a typical dry summer for 5 occupants who are using 30 gallons per day. While this is more water than many in the world comfortably get by using, it is 40-60% of typical US consumption. Grey water reuse of bathroom sinks using the Aqus and minimal irrigation from the shower and laundry drains will extend that supply.

System Design: Photovoltaics
824 sf of PV panels
Assume 1 kW/ sm for schematic sizing
9 kw system
An aggressive conservation strategy will reduce loads: heat gains with shading, heat losses with high performing envelope, daylighting, fluorescent, LED exterior lighting, Energy Star appliances, and high efficient motors and fans, heat recovery ventilation, high performance glazing.

This array can produce 90% of the estimated electricity usage. Solar access to the site is limited by three large trees, so the panels are clustered in the unobstructed area of the site.

System Design: Solar Hot Water
Sol-Reliant
Rheemglas Solaraide HE hot water storage tank;
12 volt DC recirculating pump powered by independent PV panel.
Two hot water tanks are used: one set at 110 F for the solar hot water, and a second at 140 F to provide hot water for a fan coil unit/ furnace that is integrated with a Lifebreath heat recovery ventilator (HRV) .
If a biodiesel hot water boiler becomes available for residential use (commercial scale ones exist today) then this home could reach Net Zero.



Education **Natural Resources Use** **Materials** **Regional Relevance**

U.S. Green Building Council Emerging Green Builders Natural Talent Design Competition

Cascadia Chapter Regional Competition

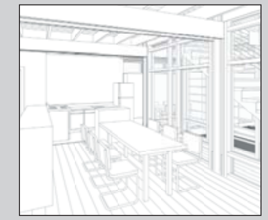
May 25, 2007

Collection

Rain and sun are our most abundant and easily acquired resources, and yet both often go unused. How can an architectural design effectively harvest these invaluable elements and, at the same time, celebrate and express this act of collection and retention?

South elevation - small unit

North elevation - large unit



Large unit living area, court

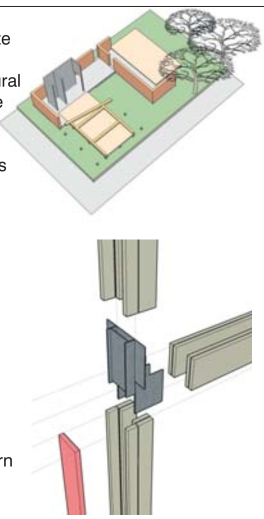
View looking NE from 6th

View looking SW from Webster

View looking SE from Webster

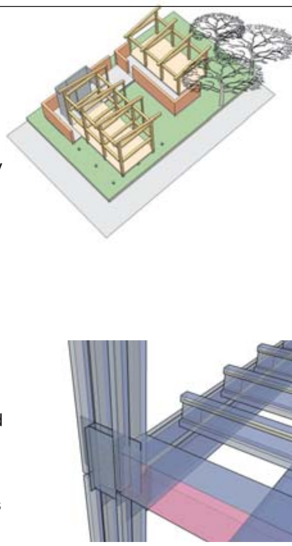
3. Platform and Bents

- Frames rest lightly on site
- Pre-fabrication of structural components easily done off-site
- First floor platform allows on-site assembly of structural "bents"
- Frame assembly uses smaller members, minimizes thermal bridging, and provides utility routing
- Adapted timber framing construction system allows quick raising of frame, and can offer a community-building "Barn raising" event



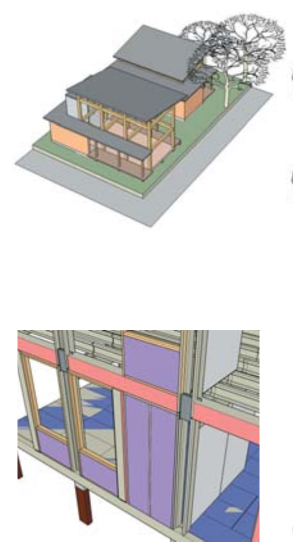
4. Primary Structural Frame

- Service core walls are low and dense for privacy and to anchor lighter frame
- Primary structural frame allows multiple room configurations for flexibility
- 10' x 16' bays provide efficient room sizes or larger undivided spaces
- Floors and rooms can be added later to allow lower initial cost
- Unitized in-fill panel system can be prefabricated and installed on-site
- Lapping of structural members and in-fill panels allows for tighter envelope and rigidity within construction tolerances



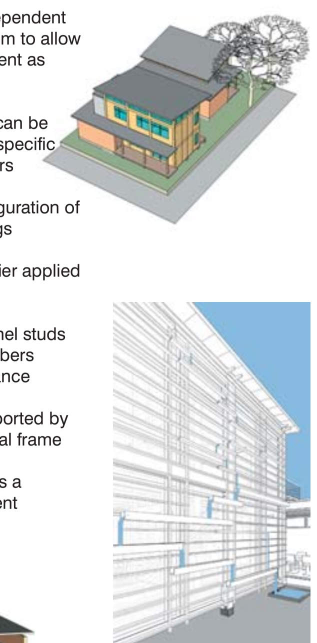
5. Floors, Roof and Systems

- Roof can be installed before walls and floors to provide shelter during construction
- Second floor joists can be added later if additional rooms not yet needed
- Floor joists rest on beams to provide continuous cavity for running utilities
- Roof pitch optimizes power generation from PV panels on unshaded roof
- All roofs provide rain water catchment which flows along courtyard to basement cistern



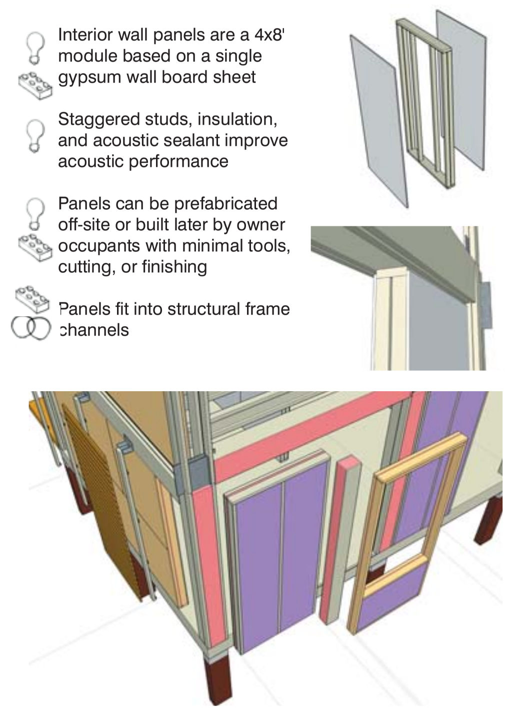
6. Envelope

- Weather enclosure is independent of primary structural system to allow easy repair and replacement as building ages.
- In-fill exterior wall panels can be assembled differently for specific climates and different users
- In-fill panels allow reconfiguration of window and door openings
- Continuous moisture barrier applied outside of panel system
- Thermally broken wall panel studs and structural frame members improve thermal performance
- Rainscreen cladding supported by outer elements of structural frame
- Sunscreen can be used as a rainwater collection element



7. Interior Walls and Finishes

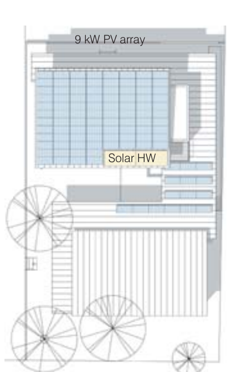
- Interior wall panels are a 4x8' module based on a single gypsum wall board sheet
- Staggered studs, insulation, and acoustic sealant improve acoustic performance
- Panels can be prefabricated off-site or built later by owner occupants with minimal tools, cutting, or finishing
- Panels fit into structural frame channels



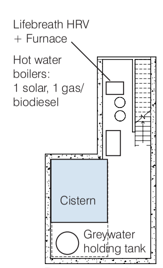
Room Layout Variations

Balcony only · Small mezzanine · Large mezzanine · Large mezzanine · Small mezzanine · Large mezzanine · 1 large bedroom · 1 large, 1 small bedroom · 3 bedrooms · 4 bedrooms

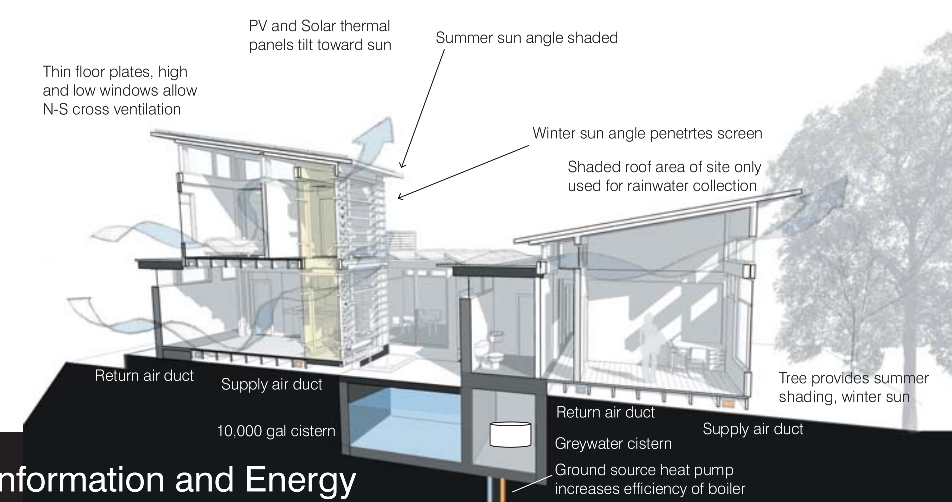
Second Floor

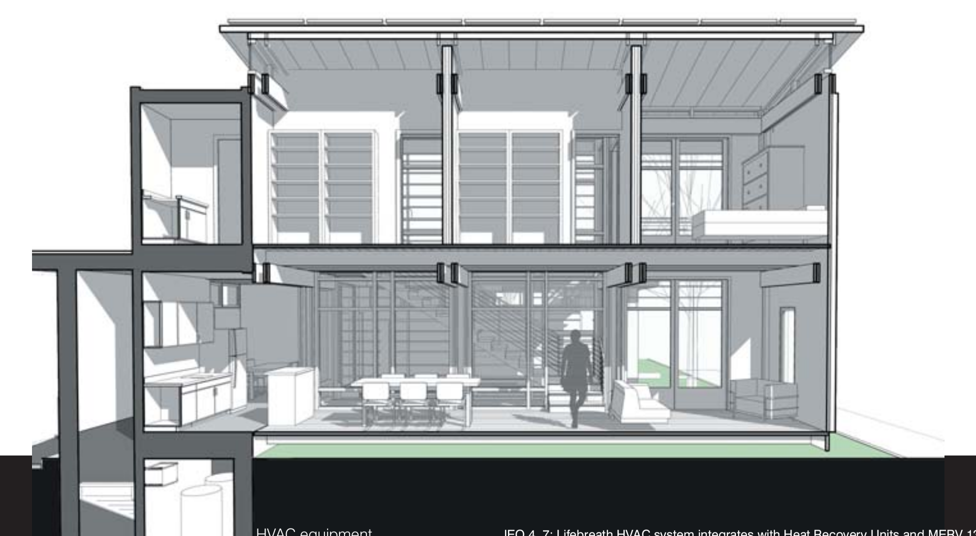


Roof Plan



Basement plan

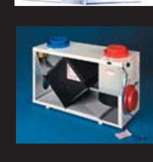




System Design: HVAC

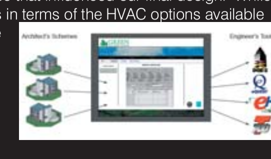
Weighing the advantages of water distribution (radiant) heating systems vs. air distribution systems (ducted) we choose a ducted system. Since a tight envelope will require fan assited ventilation for much of the year, we found it less redundant to have an ducted system deliver conditoned as well as fresh air that could be filtered to high IAQ standards using MERV 13 filters.

This also allows the Heat Recovery Unit to be integrated with the furnace as found in the Lifebreath system.



Building Information and Energy Modeling (BIM + GBS)

The concept of integration influenced both our design and our process. Through the use of the Building Information Modeling (BIM) program REVIT, we created a model that not only helped visualizing the house but also gave us valuable information concerning energy efficiency. Using the online energy modeling service provided by Green Building Studios our model was able to provide us with hard data concerning the building's energy performance which led to valuable fenestration and materials advice that influenced our final design. While this service did have a few shortcomings in terms of the HVAC options available and occupancy adjustability (which were constraints of the particular program that we were using) it was an extremely valuable exercise and a powerful new tool that brought us even closer to true integrated design.



LEED for Homes Compliance

ID 2: In-fill wall panels and rainscreen allow inspection, replacement, repair of wall assembly without compromising the structure for greater durability
LL 2,3,4: In-fill, previously developed site with existing infrastructure
LL5: 1 block to bus lines, neighborhood stores
SS 1,2: Small basement for utilities and storage limits site excavation and disturbance to "service bar"
SS 1: Excavated soil re-used for light straw clay walls and landscaping features

SS 2: Drought tolerate, native and adaptive plantings for landscaping
SS 3: Deciduous trees provide summer shading over large area, greater solar access in winter
SS 4: Stormwater overflows through landscaped swales to infiltrate on site

WE 1: Rain water harvest system collect all water from roof area
WE 1, 2: Greywater reuse from sinks for toilet flushing and from showers, laundry for minimal landscape irrigation

EA 2: Thermally broken studs and structure and exterior insulation at structure
EA 4: Screen and double wall of stairs creates solar shading and buffer zone for temperature swings and stack venting in summer
EA 5: Ducts use service bar, joist cavities to reduce distribution losses
EA 6: Lifebreath fan coil unit with ground source heat pump
EA 10: PV panels on roof provide 9 kW of power

MR 1: Modular wall panel systems based on 2' or 4' x 8' modules minimizes waste from framing and gypsum wall board
MR 1: Moment connections in structural frame and cross bracing uses less sheathing to brace lateral loads
MR 2: Lumber locally available from FSC certified forests
MR 2: Composite woods in panels, cabinets use no added urea formaldehyde

IEQ 4, 7: Lifebreath HVAC system integrates with Heat Recovery Units and MERV 13 filters to provide filtered out side air with less heat loss; Air-based distribution ensures optimal ventilation
AE 1, ID 3: Modular structural system, timber frame-style "barn raising," modular in-fill wall panels and interior partitions, straw light clay service bar, and renewable water and energy systems can be easily accomplished by work shop participants, volunteer groups, owner-builders, and educational programs. Both on- and off-site construction activities possible. Roof is in place before walls and some floors allowing sheltered construction activity. Collection area for recyclables and compost located in service bar by ADA compliant shared ramp.

1. James Jasper, Restless Nation 2000
2. http://www.arbor-house.com/Green%20Sense%20Column%20-%20Green%20Remodeling.pdf
3. http://www.naturalhomemagazine.com/article/2007/05/defeat-the-debris.html#storycontinues
4. David Miller lecture May 2007