THE GREATER WORLD
EARTHSHP COMMUNITY
& EARTHSHP WATER, WASTE AND ENERGY SYSTEMS

A CASE STUDY COMPILED BY
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SUSTAINABLE/ ECOLOGICAL DESIGN
EARTHSHIPS ARE SELF-SUSTAINING DWELLING UNITS

Earthships are completely independent, globally oriented dwelling units made from units that are indigenous to the whole planet. They are designed to reduce our impact on the planet and increase our connection to it in doing so, earthship architecture strives to constantly make small, believable steps toward slowing down and ultimately reversing the negative impact of human development. Earthship “Biotecture” empowers people to make positive changes in their own lives and reduce their personal effects on global warming.

EARTHSHIP CHARACTERISTICS

• Built with natural and recycled materials.
• Solar/ Wind/ Electricity (Thermal heating and cooling).
• Food production
• Water harvesting/ Contained sewage treatment.

CHARACTERISTICS SPECIFIC TO GREATER WORLD EARTHSHIP COMMUNITY

• Manufacturing own bio-desiel fuel.
• Commonly owned community land.
• Minimal automobile impact.
• Slow growth- 20 year plan.

EARTHSHIP ONE

• 2 Bedroom/ Bath
• 1700 SF
• Solar/ Wind Power

EARTHSHIP TWO

• 1800 SF
• Ready to finish shell

EARTHSHIP TWO

• 2 Bedroom/ Bath
• Double Greenhouse Construction
• Interior growing areas
• Fully off-grid systems
GREATER WORLD EARTHSHP COMMUNITY

A sustainable community which contributes to its surroundings in the world at large and is constantly reinforcing the strength of its own existence. Since most earthships are singular in their focus or sustainability, this community is of particular interest due to the fact that it is a conglomeration cohousing philosophy.

BACKGROUND

- Location: Taos, New Mexico
- Size: 634 Acres
- Become a legal subdivision in 1998
- First and only approved utility-free subdivision in the developed world (completely “off-grid”)
- A gravel pit reclamation project in which a water catch-and-reuse system combines with permaculture techniques to trap and direct surface water runoff in order to demonstrate how to rejuvenate/reclaim a formerly worthless piece of discarded land.

SITE

- 634 acres, 347 acres common, natural park land
- 130 total home sites
  - 79 Standard home sites (5 acres mean)
  - 42 Affordable home sites (3 acres mean)
  - 9 Home/ light commercial sites
- 4 Phases of development to occur over 20 year span.

PHASE ONE

(Gravel-Pit Reclamation)

- Housing
- Recreation Area
  - Ampitheater
  - Sport Park
  - Basketball Court
- Recycling/ Transfer Stations
- One major through roads and several smaller arteries.
- Hiking and Horseback riding trails (throughout).

PHASE TWO, THREE and FOUR TO COME

(Proposed)

- Public Education Facility
- Sustainable Living Institute
The greater world’s objective is to reduce the economic and institutional barriers between people and sustainable housing while reversing the negative effect conventional housing has on the planet. Its goal is to interface economics and ecology in a way that immediately/tangibly affects current pressing problems with existing lifestyles.

**SOCIAL FACTORS**

- Land administrated by board of directors elected by community at large.
- Privately owned land/publicly owned community land provide sense of community while preserving personal identity.
- Attainable living through provision of:
  - Different size lots
  - Various densities
  - Owner participation
  - Elimination of utilities
  - Growing own food
  - Recycling
  - Eliminating unnecessary infrastructure.

**ECONOMIC FACTORS**

- Provision of custom high end and affordable housing.
- Light commercial area to promote and encourage “cottage” industries and office/studio space to accommodate future growth.
- No public funding - actual community employment created from region catering to Greater World.

**ENVIRONMENTAL STEWARDSHIP**

- International Institute for sustainable living with public education facility planned for direction of these interested.
- Research will be available internationally through:
  - Schools, seminars, tours, web-site and nightly earthship rentals
  - Earthships will be explored in a fashion that brings them architectural/social economic legitimacy.

**ARCHITECTURAL INSPIRATION**

ADAPTABLE - not singular in application
Most earthship systems provide for two levels of compliance with resource and money saving strategies. Some system strategies are essentially free after initial capital costs, but may require significant changes in lifestyle to be effective. Michael Reynolds, inventor of Earthships, calls this the “fanatic” strategy. Other strategies take a somewhat more relaxed approach to sustainability. These tend to be more consistent with the ways Americans are accustomed to living, but employ methods that reduce utility costs and help promote living in a more environmentally responsible way.
DOMESTIC WATER SYSTEMS - COLLECTION AND DISTRIBUTION

Earthship water systems are a reaction to the paradigm of what most American have come to expect: an “endless” water supply. Any analysis of sustainable water collection and distribution systems must therefore also address current use patterns and how these can be made more conservative. If the human occupants of a dwelling used less water, less water would need to be harvested or collected in order to meet new standard requirements. In addition, the conventional well system used in most American homes has been re-evaluated by proponents of the Earthship. Each of the three alternatives discussed below use far less electricity than a typical water distribution system, especially in the pump startup phase where electrical “surges” can be caused in a standard home.

ALTERNATIVE 1 - SOLAR WELL AND CISTERN - THE STANDARD “OFF-GRID” SYSTEM

• Like conventional well, water is pumped up from the water table but, in this case, is pumped continuously and slowly all day by a small solar powered pump. The pump only operates during daylight hours, therefore limiting electrical “surge” to only once per day.
• Pump connects directly to solar cells instead of through a larger power system, alleviating the need for storage batteries for the pump’s electricity.
• Small pump “trickles” water into cistern. Water then pumped from cistern into conventional pressure tank by a second small pump.
• Both pumps are DC and use far less energy than AC pump

ALTERNATIVE 2 - GRAVITY CISTERNS

• Like a solar well and cistern system but one of the pumps and the pressure tank are eliminated (’free” natural energy from downhill motion/presure)
• Can be used with a cistern or a reservoir (see “water catchment”)

ALTERNATIVE 3 - WATER CATCHES

• Includes both ground and roof catches - eliminates the need for a well and pump
• Ground catches (outdoor) need silt catches to trap dirt and major particles from water. Small dam blocks runoff and lets the water overflow into the cistern after particles have settled to the bottom of the silt catch.
• Can also use rock in decreasing sizes to filter out various scales of particles
• Outdoor cistern will always get some debris on top and silt on the bottom. A “floating intake” keeps the intake pipe away from these hazards.
• Should be placed on the south facing slope in cold climates to catch snow melt. This allows snow to melt and be harvested before it evaporates.
• Can have a structure built over it to create a humid growing space while protecting the water from freezing in the winter.
ALTERNATIVE 1 - COMPLETELY ELIMINATE BLACK WATER

- Many earthships eliminate black water all together by using composting toilets or solar toilets. Technology of these toilets has gotten to the point where they no longer smell or produce undesirable effects.
- Composting toilets require daily addition of peat moss but eventually produce a fertilizer that can be returned directly to the earth.
- Solar toilets produce “ash” which is also used as a fertilizer.

ALTERNATIVE 2 - SEPARATION OF BLACK AND GRAY WATER

GRAY WATER STRATEGIES

- Each source of gray water is separated so there is no large quantity of gray water in any one place.
- Kitchen sinks, bathroom sinks, showers and tubs, washing machines and dishwashers can all be drained into large planting beds.
- This re-uses the water and organic soaps and detergents can be ok for plants.
- Kitchen and bathroom sinks can have planters directly adjacent to the drains, eliminating excessive piping.
- Because of the large volumes of water that showers, tubs and washing machines produce, these are drained to larger planters outside the dwelling.

BLACK WATER STRATEGIES

- If a composting or solar toilet cannot be used, modified traditional septic tanks are the best alternative.
- Solid an liquid waste (and water) drain into a septic tank which at a certain capacity enters a “drainfield” and goes back into the earth.
- Storage of the black water in the tank for a period of time allows all the solids and paper to become sludge and begin an anaerobic process with natural bacteria.
- For Earthships, the reduced amount of water used in the creation of black water allows for smaller septic tanks. Because septic size is typically determined by code, inventor and patent holder Michael Reynolds suggests several “outlaw septics”.
- Two main “outlaws” are the aluminum can and tamped earth/tire septics.
HOT WATER SYSTEMS - INEXPENSIVE HOT WATER DAY OR NIGHT

EARTHSHIP WATER & WASTE SYSTEMS

Production of inexpensive hot water of a consistent temperature presents perhaps the greatest challenge when building sustainably, especially in climates with low levels of sunlight or on cloudy days when solar hot water may not be a good option. Americans have become accustomed to always-on/instantly hot water systems and have been willing to sacrifice $40-$60 a month of electricity to have them.

A typical 2 person dwelling, even with serious conservation measures in place, has need of about 800 gallons per month of non-potable water. Earthships primarily use two methods to heat water. The Solar Batch Heater becomes a good alternative for those who do choose to live in America's “Sun Belt”, an area typically thought of as being in the Southwest and having sun 300+ days a year. For the rest of the country, the Gas Demand Heater takes the typical gas hot water heater one step further, adding the ability to control when water is being heated and when it is not, therefore conserving large amounts of electricity. Both units pay for themselves within a few years with utility cost decreases.

ALTERNATIVE 1 - SOLAR BATCH HEATERS

- Simplest, low-tech and maintenance-free method of obtaining hot water anywhere near the sun-belt. This is not a good option anywhere else in the country unless a backup Gas Demand Heater is installed.
- Called “Batch Heater” because the unit is both the heater and the storage tank for a “batch” of hot water.
- Very thin proportion to allow water to heat fast (maximum surface area exposed directly to the sun).
- Covered with tempered glass which forms a thin “air cavity” between the glass and the tank itself. This air heats up and in turn heats the tank.
- Depends almost entirely on gravity flow for water pressure. Therefore pressure tends to be lower than that typically supplied in a modern home.
- Placed in one of two ways. Toward summer equinox provides maximum performance of the unit. Toward winter equinox makes more sense in cooler climates because you get better winter performance (when you need more hot water) and reduced performance in summer (when demand for hot water is lower).
- Since a “batch” of hot water may be limited in size, many units may be necessary to supply many fixtures.

ALTERNATIVE 2 - “INSTANT-ON” GAS DEMAND HEATER

- Very small wall mounted unit - 18” wide, 13” deep, 36” high. Natural gas produces flame for heating water.
- Located so that exhaust from the unit can be easily vented through the roof, and so that fresh air for combustion of gas can flow freely through the intakes.
- Placed near fixtures they are servicing to minimize the time for hot water to get to the tap. This may, as with the Solar Batch Heater, result in a multitude of units being used throughout the house servicing various fixtures.
- Limitation: too small to service more than 1 fixture at a time (no washing dishes while showering).
- Heat water in a coil as it is called for. Only a pilot burns until you turn on the tap. The tap acts as a trigger for the unit, producing a burst of flame and passing water through the flame in a copper coil. The flame remains on, heating the water in the coil as long as the tap is left on.

ALTERNATIVE 3 - COMBINATION OF SYSTEMS (PREFERRED)

- This is the best solution because it allows you to have free hot water from a batch heater when there is sun, but keeps you covered in case of clouds or bad weather.
The earth is a thermally stabilizing mass that receives energy from the sun. The outer few feet of the earth are heated and cooled in response to surface weather. Around 4-5 feet below the surface temperature is constant at about 58 degrees and this is where the earth can be used to both cool and stabilize temperature of the earthship.

**THE EARTHSHIP WILL PROVIDE ‘COMFORT IN ANY CLIMATE’ THROUGH:**

- A relationship of mass and insulation.
- Interaction with the earth for coolness and to stable temperatures through thermal mass.
- Interact with the sun for solar gain though passive solar gain.
- Orientation of the structure must be east-west with south facing opening.
- Open floor plans for natural ventilation.

**EARTHSHIPS ARE THERMAL MASS FIRST AND PASSIVE SOLAR HOMES SECOND.**

When sunlight strikes a building, the building materials can reflect, transmit or absorb the solar radiation. The basic natural process that are used in passive solar energy that flows in accordance to radiation, conduction and natural convection.

**THERMAL MASS:**

- Thermal mass materials have the ability to conduct and store energy, both hot and cold, and to release that energy back into the living space when it’s needed.
- Heat always moves to colder surfaces. In the solar home, the free solar energy first heats up the air. Since the mass floors and walls are cooler, the heat is absorbed and conducted into these materials. Later, when the sun has set and the room air temperature falls, it will reach a point where the mass materials are warmer than the room air temperature. Since heat seeks out cold, the stored energy will now return to the room. The more mass in the home, the more energy that can be stored.
PASSIVE SOLAR HEATING REQUIRES TWO PRIMARY ELEMENTS:

- South facing openings
- Thermal mass to absorb, store and distribute heat

There are three approaches to passive systems - direct gain, indirect gain, and isolated gain. The goal of all passive solar heating systems is to capture the sun's heat within the building's elements and release that heat during periods when the sun is not shining. At the same time that the building's elements are absorbing heat for later use, solar heat is available for keeping the space comfortable.

DIRECT GAIN:

Radiant heat from the sun admitted directly to the thermal mass floors and walls of the living space through south-facing windows, warming interior surfaces. The thermal mass will temper the intensity of the heat during the day by absorbing the heat. At night, the thermal mass radiates heat into the living space.

INDIRECT GAIN:

An attached thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The thermal mass is located immediately behind south facing glass in this system. Operable vents at the top and bottom of a thermal storage wall permit heat to convect from between the wall and the glass into the living space. When the vents are closed at night radiant heat from the wall heats the living space.

ISOLATED GAIN:

An isolated gain system has its integral parts separate from the main living area of a house. The ability to isolate the system from the primary living areas is the point of distinction for this type of system. Sunrooms employ a combination of direct gain and indirect gain system features. Sunlight entering the sunroom is retained in the thermal mass and air of the room. Sunlight is brought into the house by means of conduction through a shared mass wall in the rear of the sunroom, or by vents that permit the air between the sunroom and living space to be exchanged by convection.
VENTILATION AND COOLING:

Gravity skylights are an integral part of ventilation and cooling of the earthship. The controlled movement of air aligns with a natural tendency of warm air to rise. Gravity skylights therefore should be in the highest possible place to allow warm air to escape. Fresh air must be allowed to enter in the lowest place through operable windows or vents. This creates a natural exchange of air throughout the space. When outside conditions are too hot for comfort, inlets for incoming air can be submerged in the earth. This allows the temperature of the earth to cool the incoming air before it enters the structure.

ALTERNATE POWER SOURCE:

Earthships are not without the need for power to operate appliances, lighting and automatic watering systems. Since the concept is to be “off grid”, alternate sources of power are required. There are two sources of electricity, the sun and the wind. Most commonly used source is the sun due to the complexity and inadequate frequency of wind for harvesting.

PHOTOVOLTAICS

Photovoltaic cells produce electricity directly from sunlight, a free and unlimited energy source. Photovoltaics are distinct from other kinds of solar energy in that it harnesses the sun’s light, rather than its heat. This collected energy must be before it can be utilized in DC battery packs collect the energy and store it as 12 or 24 volt current. Most conventional appliances can not run on DC power so an inverter box is employed to convert energy to AC power for use.
EARTHSHIP COMMUNITY CONCLUSIONS

While it is clear that the Earthship concept has the potential to be one of the most self-sufficient, sustainable systems in the world, the concepts employed within may not always be directly applicable to every geography. In this study we have identified many sociological, economic and practical systems that operate well within existing communities like the Greater World Earthship Community. We will now explore how these concepts can be directly translated for use in the Pacific Northwest.

SOCIO-ECONOMIC PRINCIPLES

• Earthship can become didactic- they inform inhabitants about a sustainable lifestyle that brings a broader awareness of their surroundings.
• Earthships can be adapted to many application, yet in a cohousing context they become quite significant due to their ability to promote social, economic and environmental complexity.
• Earthships are self contained ships that can sail the seas of tomorrow and then into space.

WATER AND WASTE MANAGEMENT SYSTEMS

• Given the amount of rainfall the Portland area receives annually (about 36”), the water collection strategies discussed in this case study seem directly applicable to our region.
• Separation of Gray and Black water should be a relatively easy strategy to implement in all new construction. Though it will add some additional piping and therefore cost, the cost benefit of water savings over time would certainly offset this minimal initial investment.
• Composting and Solar toilets seem like two principles many people may not be willing to implement. Therefore, in the context of our region new “extreme low-flow” toilets seem like a good way to reduce black water.
• Since much of our region is already supplied heat by methods of natural gas, converting existing hot water heaters to On Demand Gas Hot Water Heaters would be an excellent way to reduce monthly electric utility bills.
• Solar batch heaters are probably not a good option for our region due to the number of cloudy days we typically have in a year.

THERMAL COMFORT AND ENERGY SYSTEMS

• To maximize effective comfort from the Earth’s natural phenomenons the structure must be oriented East-West with lots of south facing opening and constructed 4 to 5 feet below ground.
• Since the sun light is scarce and the earth is typically wet in Portland, relying on these natural systems for comfort is not reliable or feasible.
• Earthships could not follow their traditional concept of “off-grid” and alternate sources of power would have to be applied for comfort and running appliances.
• Earthships would not be feasible in an urban setting such as Portland because of close proximity to the ground and need separation between units for limited energy source to be utilized.

CURRENT APPLICATION OF EARTHSHIP PRINCIPLES IN A PACIFIC NORTHWEST CONTEXT - THE KINZER EARTHSHIP NEAR BEND, OREGON

Fortunately, there is precedent for Earthship systems operating within a Pacific Northwest context. Beginning in 1994, Paula Kinzer and her husband Kevin began construction on an Earthship near Bend, Oregon. They chose Bend for the amount of sun the city gets on an annual basis and chose to build an Earthship because of their dedication to living ecologically responsible lives. Construction was finished in 2003 and in an article in the University of Oregon journal FLUX, writer Anne Austin discusses some of the challenges the Kinzer’s have faced while living drastically different lives, as well as some of the rewards they have experienced living “green”.

We are encouraged by these statements made by the Kinzer family in this article from FLUX. While building and living the “Earthship Lifestyle” is no easy task, this family has shown that even in an area with limited sunlight, thermal gain and extra land, it is possible to live much more sustainably than the average American family. 90% savings on one’s monthly electrical bill is no small matter, especially as energy prices continue to climb and supplies of fossil fuels continue to dwindle.
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