Earthships as an Answer to the Manifold Complications of Contemporary Society

“This is not a moral issue, it’s not a spiritual issue, it’s not a political issue, it is a logical issue.”
-Mike Reynolds

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Abstract

To more fully bring about an awareness as to how a living self-sustaining home structure incorporates several aspects of physics to maintain its recipients. From being fossil fuel free and being self-reliant, to having a house made for almost any size of family made of natural and reclaimed materials. Having solar power utilizing the concept of AC and DC (Alternating currents & Direct Currents) flows of electricity, to creating an outer shell invincible enough to withstand friction and weathering from the natural elements, while holding out to the expansions and wrapping of extreme temperature change. Even the legal process is against it. Overcoming all odds!
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According to the Unite Nations Department of Economic and Social Affairs, the current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100 (2015). This exploding population is progressively demanding the industrialization of societies around the world. As a result of the obtuse development of our systems we are now facing a diverse number of complications including but not limited to: the global water crisis, increasing threat of natural disasters, the mounting need for sustainable energy resources, widespread poverty and hunger, a global trash problem, the toxification of the earth, and global climate change. Our current building practices and employment alone consume forty percent of the worlds energy and emit half of the worlds greenhouse gasses (e^2.2006). Needless to say, finding ways to build sustainably is a vital step to curbing the multifarious obstacles of contemporary society. Fortunately, Mikey Reynolds and his team at ‘Earthship Biotechture’ have been addressing these needs for over 40 years, researching, experimenting, and building what are now called Earthships. Earthships are completely sustainable, off-grid dwellings with a zero carbon footprint. They are independently heated & cooled, treat their own sewage, gather their own power and water, as well as grow their own food; all this at the same time as attending to local waste concerns as they use only local, natural building materials as well as trash that would normally stagnate in landfills. All this is possible by simply harnessing the natural laws of physics. Through greater experimentation, use, and production of earthships and other forms of biotechture, we can begin to take the necessary steps towards more sustainable living; And at this point, sustainable building is not a luxury, it is not merely an option, is is an absolute necessity.
Earthship Biotechture Design

Earthships are designed to satisfy 6 fundamental principals of sustainable housing: 1. Thermal mass and solar heating and cooling by convection, 2. Harvesting solar energy and other natural electricity resources, 3. On site sewage use, purification, and containment, 4. The use of reclaimed materials supplemented only by local and natural resources, 5. Water catchment and on site filtration system, and 6. Autonomous food production. By simply applying the laws of physics Reynolds has designed homes that virtually eliminate utility costs, provide its inhabitants with all their 21st century needs, and cost around the same amount as a conventional uneconomical house.

The predominant building material of an earthship is earth packed tires. Battering these ‘rubber bricks’ against a four foot high and four foot deep massive earth packed wall creates a thermal wrap which is key to the passive solar design of the house. The thermal wrap goes around the entire house, uninterrupted except the south facing glass wall. In addition Reynolds recommends an eighteen inch thermal layer beneath the buried portion of the house in order to completely encase the main part of the home; This allows for the highest thermodynamic profit. Furthermore, the flexibility and strength of a rubber lined, dense, earth packed wall is virtually indestructible.

Earthships are able to conservatively rely on energy mostly by exploiting their thermal mass coupled with natural resources like wood burning stoves to heat and convection to cool. In order to understand the heating of an earthship we will begin discussing the Earth’s absorption of

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radiative heat from the sun.

Approximately fifty one percent of the incoming radiation from the sun is absorbed by the land and water and nineteen percent from the clouds and atmosphere. The remaining thirty percent is scattered by the Earth’s surface, clouds, and the atmosphere. The earth continuously releases radiation; if it could not release the radiation that it received, it would heat without end. Due to the Earths relatively low temperature, this radiation is released in long wavelengths into the atmosphere, heating it via greenhouse gasses. This process are what help keep the ground (at your typical earthship house layout)

About four feet deep) at the steady temperature of fifty eight degrees.

The modus operandi of the entire water network mostly relies on gravity to transport and filter water throughout the house with the exception of two low energy dc pumps and a conventional pressure tank. The beginning of the consummate water catchment system is the roof. Made out of metal and positioned on a slanted axis in order to make use of gravity, the roof is designed as a broad base to catch as much water and snow as possible. The smooth surface of

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the metal allows for the least amount of friction with water molecules and encourages a quick and easy decent into the rain gutter and then into the first phase of filtration, the silt catches. Metal is also a great conductor of heat and when paired with solar heated water piped along the underside of the roof, it melts the snow in the winter facilitating additional water retrieval.

After passing through the silt catches the water is gathered in a series of cisterns buried behind the thermal wrap in the berm. If water is not properly stored algae can grow and taint the water. Sun exposure and temperatures above sixty degrees fahrenheit create conditions conducive to bloom. Because the temperature maintained four feet underground is fifty eight degrees fahrenheit, the bermed wall of an Earthship, being over four feet high by four deep, prevents algae bloom in the cisterns.

Employing the authority of gravity again, water is fed from the cistern into the WOM (Water Organizational Module). The WOM begins with a mesh filter that cleans water just enough to not damage the dc pump. The dc (direct current) pump draws its required current from the power system and drives water into a conventional pressure tank within the home. The pressurized water is then sent to a second mesh filter and can here be used as clean, non-potable water for laundry and washing dishes. In all of the sinks within an Earthship there are three water valves: hot, cold, and potable. The hot and cold water is drawn directly from this point. When you need potable water, the stream in the WOM continues to a third mesh filter and then a ceramic filter to remove any and all bacteria. The course for hot water is somewhat different. The water is piped to a solar panel...
on the south facing wall where sun is hitting directly for most of the day. It is then fed to a gas demand water heater that uses propane to run. There is a sensor on the intake valve of the heater that perceives when the water is already hot enough from the solar panel and passes it right though the pump without activating it. When the water is cold, as a result usually of a cloudy day, the sensor reacts and sends it through a heat coil to be flash heated before use.

Another crucial step the earthship takes is multiple use of the water. By doing so, the amount of water needed is dramatically decreased. There are four levels of waste water recycling. The first level is water from laundry, washing, and bathing referred to as grey water. It is delivered to the indoor botanical cells that grow food and clean the water. That is then stored in a chamber within the grey WOM (Water organization module) where another dc pump is activated with the flush of the toilet to fill the bowl. The spent water from the kitchen sink and the toilet is considered black water and is dispensed into a septic tank with a glazed south side to increase solar heat which aids in the anaerobic process. From here the water is piped into the secondary and tertiary botanic cells creating lush landscape for the yard. The plants again clean
the water to levels where nitrates are undetectable and can be released back into the earth with no repercussions.

The botanical cells and greenhouses of earthship can maximize according to preference. For example, extra layers of greenhouses can be added over the exterior cells to create both auxiliary buffer zones to protect from extreme weather and to allow for more year-round food production. Grey water planters are not the only cells that can grow edible food. Black water can be filtered through a cell of plants that are experts at purifying water. These plants are sometimes referred to as biofilters. According to a study by scientist Kalia Firester, plants like Duckweed, Nutgrass, and Water Lilies are known to absorb algae and other plant species, and can clean black water enough produce water that tests similarly to tap water (2012). That being the case, after passing through an initial botanic cell filled with hearty plants such as those, the following cells would be provided with sufficiently clean water to produce more edibles. Reynolds has produced food from black water using these techniques and had that produce tested against market level produce and no variance could be detected. (seminar vid. ii 2009).
Earthships are built of materials from their environment. They are designed to be as eco-friendly as possible. One main principle considered in the construction of an earthship is the minimal use of embodied energy. Embodied energy is the energy expended during construction, the energy used to produce the building materials, and the energy spent to transport building materials from production site to building site. Embodied energy is rarely considered in the cost of construction in spite of the fact that massive amounts of energy are consumed and loads of greenhouse gases are created and expelled.

The greenhouse gasses in our atmosphere consists of carbon dioxide, water vapor, methane, nitrous oxide, and ozone. Water vapor is the most prevalent greenhouse gas in the
atmosphere and Carbon dioxide is the next runner up. Carbon dioxide is well known because it is a greenhouse gas that has been proved to have increased in Earth’s atmosphere due to human activity. The greenhouse effect is caused by an offset in the equilibrium between the amount of radiation the earth absorbs from the sun and what it releases back into space.

On planets such as Venus, there is what is called the runaway greenhouse effect. It is believed that there may have been water in the early history of Venus, but because of the runaway greenhouse effect the waters evaporated. This is possible because an increase of greenhouse gasses raises the overall temperature of a planet which then evaporates surface waters; This process compounds on itself when more water is evaporated into the atmosphere the greenhouse gasses increase, evaporating even more water into the atmosphere. If this process happens in “minimal” amounts it’s called climate change but left unchecked, greenhouse gasses will continue to increase until the runaway greenhouse effect is initiated.

To really understand how the earth is heated by greenhouse gasses it is necessary to talk about infrared radiation wavelengths and visible radiation wavelengths. Infrared is radiated through long wavelengths and visible radiation through short wavelengths. Everything radiates; The type of radiation emitted by a particular object is dependent upon its temperature. High temperature objects emit infrared radiation. Low temperature objects emit visible radiation.

Objects can be either transparent to light, meaning they let light pass through them in straight lines, or they are opaque to light, letting the light in without letting it pass through. Air is generally transparent to long and short wavelengths. Unless, there are too many greenhouse gasses in specific water vapor and carbon dioxide, then they air becomes opaque to infrared light and traps the heat instead of letting it pass straight through, resulting in an increased temperature of the air.
A good example of this process on a much smaller scale is an actual greenhouse. Glass is transparent to short wavelengths but opaque to long wavelengths. The long wavelengths are therefore trapped inside giving the greenhouse an overall warmer inside temperature in contrast to the outside temperature.

![Solar energy transmitted though glass](image)

Earthships consume much less energy in their construction and maintenance, in other terms they use a relatively low amount of embodied energy in comparison to a traditional home. Earthships have less of an impact on the environment than a home built of wood, powered by standard electrical power lines, using water from underground aquifers and releasing polluted, chemical water back into the environment. A reduction in embodied energy as well as consumption of less energy minimize the emissions of greenhouse gasses Earthships emit resulting in the primary way earthships are so eco-friendly.

Photovoltaic Solar Panels are the primary method used to power earthships. The photovoltaic effect is the conversion of solar energy into DC electricity (Direct current electricity). The conversion happens right on the solar panel with a two-step process. The first
A step uses a phenomenon called the photoelectric effect. Many metals eject electrons when light hits them creating what are called photoelectrons.

Solar panels are made of a bunch of photocells. A traditional photocell consists of an evacuated tube, with two pieces of photo emissive metals fixed to each end of the tube, and connected by wiring a circuit. One of the metals is placed so that it receives direct sunlight. When photons from the sun, each with energy, bombard the electrons on the exposed piece of metal from a photocell this energy heats the metal causing electrons that are not strongly fixed to the metal to be set free giving the first piece of metal a positive charge. Because the two pieces of metal are connected by a circuit the second metal plate also ejects electrons and becomes positively charged. Because all of this is occurring in an evacuated tube, the positively charged plates would then attract the negatively charged electrons causing the process to then repeat. From this first process a second electro chemical process occurs, which creates an electrical current.
Earthships are designed to provide humans a comfortable home as well as all their basic domestic needs for little to no cost over the course of their lives. They are built from resilient material, provide extremely low cost utilities, as well as provide healthy food. In effect, Earthships have the potential to be exceedingly valuable in the fight against poverty and world hunger. It is common knowledge that the poorest people in the world are mostly in developing nations. What is less understood is the level of poverty within industrialized nations and particularly in the United States. The relative poverty rate in the U.S. in the late 2000’s was 17.3%, close to 49 million people. And the child poverty level at the same time was a whopping 23.1%. That equates to nearly 124 million people impoverished in the United States alone (Gould & Wething, 2012). That is 124 million people who do not have enough food to eat, may not have adequate housing or utilities. When you are connected to the municipality, if you cannot pay your bills, they turn off your electricity; they turn off your gas. If Earthship communities were provided in place of low-income, low-grade housing, poverty would have much less of a burden. And it is possible to take sustainable building to developing nations as well. Non-profit agencies need to approach aide in a more intelligent and holistic approach. When all of the costs of building and living are taken into account, such as embodied energy, social and cultural obligations, utilities, maintenance of house, etc, Earthships reveal that they are one of the most economical and rational choices.

Rain water harvesting is not only beneficial because its free. It is more important that it is not dependent on municipal pipelines. For one, the privatization of water supplies around the world prevents many low-income households from having access to clean water. For two, water networks can be contaminated, and lastly, water is simply becoming more and more scarce in many regions of the world due to global warming. In some cases the water tables are being depleted without any water gain and in other cases, the tables are being salinated because of
flooding. These are both culprit of global warming. Because of global warming, droughts are expected to increase substantially due to of decreased precipitation as well as increased evaporation and the severity of storms will continue to increase, causing more flooding of water tables (NASA. n.d.). There are many more reasons why water is unavailable to millions of people around the world. But to further illustrate the importance of being able to catch relatively clean water and be able to filter any contaminants through the WOM (water organization module) filtration system, I’d like to elaborate on the contamination of water networks.

Expressly, I’d like to expound the hazard of polluted water sources in our own country, where we like to believe we are protected from seemingly third world problems like scarcity of potable water.

There are two sources of water corruption in the U.S. that I will point out. The first is the water everyone drinks on a daily basis. Tap water across the country has been tested for pharmaceuticals and has been found to have trace amounts of many kinds of drugs that our water plants are not equipped to treat. Although they are trace amounts, scientists have no way of knowing at this point what the long term effects of accumulation will have on our bodies (Donn, Mendoza, & Pritchard. n.d). Considering we require substantive amounts of water on a daily basis to live, even trace amounts are likely to have an effect. The only way we know how to clear water of these types of contaminates right now is distillation, which the atmosphere does for us before it delivers it back as rain and we then catch with our Earthship.

Unfortunately, there have been many cases of seriously poisoned water being supplied to large amounts of people. The most recent example of this is Flint, Michigan where lead is present in dangerously high concentrations and has been detected in the blood supply of many residents, especially their children, and is also implicated in a recent break out of legionnaires disease (AlHajal, 2016). But the most well known case of ground water contamination came to
our attention when a blockbuster movie was made depicting the true story of legal clerk Erin Brockovich who found high levels of hexavalent chromium in the water supply in Hinckley, California. In these types of cases it is irresponsible and careless industries poisoning the municipal networks that people like you and I pay for. Being disconnected from municipal water frees us from the vulnerability of our natural dependency on water.

The wellspring of water contamination is industry; Namely, the industries of energy-Coal, Oil, and Natural Gas. The coal industry is responsible for significant CO$_2$ emissions contributing to global warming as is the burning of fossil fuels. Science has proven within the past 20 recent years these fossil fuel emissions have been eating away at the earth’s precious ozone shielding in our atmosphere. With less emissions being emitted (thanks to earthships) we can piece by piece breathe fresher air and bring back the earth’s protection. In an earthship you can use any and every type of renewable resource your region has to offer. Often you need more than one type. Sometimes you have enough sun to use only solar panels other times one must combine efforts to get sufficient power. Earthships start with Solar Panels and supplement with wind and sometimes hydro-electric energy to give people enough electricity to live the modern day life of computers, televisions, electric coffee makers, etc. that we are all accustomed to. One of the benefits of living in an earthship is the zero carbon footprint, but this benefits not only you, it contributes to the greater effort to reduce carbon emissions in order to combat global warming.
As expressed previously, embodied energy plays a significant role in the unsustainability of current building practices. The production of building materials puts a huge strain on the environment, not just by adding co2 emissions, but by creating more potential waste. The global community has a major trash problem. Landfills around the world are over capacity. The air within and around them is toxic because trash breaks down and off-gases harmful fumes and the governments attempt at dealing with these issues is making matters worse. Burning large amounts of trash is yet another big contributor to global warming. I think it goes without saying, we absolutely must find ways to stop producing more trash. Earthships not only refrain from creating new materials, they use spent tires, bottles, and cans that would normally stagnate in landfills. Earthship Biotechture as a company make it a point to reuse trash in every way they can think of.

Discussion

Earthships are by no means an answer to all of our worldly problems. Earthship Biotechture as a company seek to tackle as many problems as they can, but they have made countless mistakes over the years leading to a considerable amount of lawsuits. Mike Reynolds

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even lost his architecture license in 1990 because earthships violate so many codes. As experimental building goes, oversights and miscalculations will inevitably lead to numerous hurdles.

The limitations of Earthships

One complaint about Earthships is how labor intensive the construction is. Ramming all the tired full of earth not only takes extraordinary human energy but can also take a lot of time if tackled in a D.I.Y. project. In fact, much of the cost of and earthship is the labor required for construction. There is no way around this hurdle, and although it is admittedly a headache, it is not a relevant limitation in regards to sustainability, which is the primary concern of Earthship Biotechture.

A question was raised about the possible dangers of recycled tires as well. Rubber tires, when new, emit noxious gasses that can be detrimental to your health. Some people were concerned that the walls of the earthships would be seeping those fumes into the house and harming the inhabitants over time, but the University of Wisconsin did a study to provide the New Mexico Environmental Department with the necessary reassurance that the use of tires in Earthships is completely safe. The conclusion of this report is available here:

http://earthship.com/offgassing

The limitations of building codes: Earthships do not comply with the majority of building codes. The on site sewage treatment is the biggest offender to health and safety concerns of conventional codes. Because the sewage system in an Earthship is contingent to many of the other systems it cannot change. Through the installation of a septic tank Reynolds has been able to continue with his work. He compensates for the conceivably superfluous septic tank by simply rerouting the water into the botanic cells from the tank instead of directly from

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the toilet and kitchen sink. A leech-field was the another requirement of the code enforcement and to integrate the second unnecessary unit he installed a three way valve in the botanic cell with a diversion to the leech-field that can be turned off.

**Inaccessibility due to cost:** As a result of these costly placations, Earthships cost more than they need be. While Earthship can be affordable when autonomously constructed, the price does increase with the cost of labor, and as I mentioned before, they are incredibly labor intensive. Reynolds claims that the average cost is about the same as a conventional house to build. Even if that is true, the cost of building and Earthship is still out of reach for the communities that need them the most. Although philanthropy can ease the plight of developing communities to some extent, steps have to be taken to make sustainable building truly accessible to those in need.

**Inaccessibility due to remote locations:** Most Earthships are located outside of densely populated areas. One might even say that they are usually ‘out in the boonies’. This is a direct result of building restrictions for radically sustainable building practices. As nonsensical as it is, the fact remains that getting all the permits required to build is absurdly difficult. This prevents a great deal of well intentioned home builders from building extensively sustainable homes.

**Conclusion**

Earthship Biotechture is an imperative establishment of the sustainable building movement. We cannot afford to continue to squander our resources and pollute the earth. Revolutionary progress, like the type Mike Reynolds has risked so much to accomplish, is requisite to the future of humans on this planet. The sustainable building movement is going to require independence from municipal restrictions and building codes if it is going to be able to
evolve with the changes to our climate. Earthships are a great place to start because Reynolds has already been fighting this war for over forty years and has thusly made significant progress.

References


