

Earthship Hype and Earthship Reality

Should you build your house out of old tires, rammed earth, and empty cans?

Posted on May 23 2014 by [Martin Holladay, GBA Advisor](#)



An earthship in Taos, New Mexico. Pull-down interior shades are needed to keep this earthship from overheating during the summer.

If you are a [hippie](#) from Taos, New Mexico, you know what an earthship is. It's an off-grid earth-bermed [passive solar home](#) with exterior walls made of old tires packed with dirt.

Although many people assume that the term “earthship” is generic, like “straw-bale home” or “underground house,” it isn't. It's a trademark owned by a for-profit company, [Earthship Biotecture](#). The company was founded by a Taos architect named Michael Reynolds, who began developing his earthship construction principles in the 1980s. Over the years, he gradually refined these principles and shared them with the public in several books and articles.

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Michael Reynolds is an architect, custom home builder, and real-estate developer. His business activities include new home construction, consulting, the sale of earthship plans, and the promotion of Earthship communities.

Reynolds does not live in an earthship, however. In his book *Off the Grid*, journalist Nick Rosen describes several encounters with Mike Reynolds. “When I asked to visit him in his own home Mike was surprisingly reluctant,” Rosen wrote. “I found out where the Reynolds house is located and was brought there by a local guide. ... And it’s on the grid — all of the grids: power, water, sewage, even cable.” [Author’s postscript: According to Alex Leor, Michael Reynolds now lives in an earthship; see Comment #17 below.]



The stucco on this earthship in Brighton, England, has been painted a cheerful shade of pink. -

The defining characteristics of an earthship

According to Reynolds, earthships have the following six characteristics:

- Some of the building materials consist of [discarded or recycled items](#), including old vehicle tires (typically used to build earth-bermed walls). Interior partitions are sometimes made from discarded aluminum beverage cans (used as “bricks”) and mortar.
- The homes are oriented according to passive solar principles (and in some cases use earth tubes as ventilation ducts).

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- In most cases, the homes are [off-grid](#), producing their electricity on site with a PV array, a wind turbine, or a gas generator.
- The homes usually include a [cistern](#) to store water gathered from the roof.
- The homes [treat sewage on site](#) rather than being hooked up to a municipal sewer system.
- The homes include a greenhouse capable of growing food.

Earthships have a strong appeal to a certain category of green builders. The elements that Reynolds emphasizes — the use of discarded materials and dirt to build walls, the focus on passive solar design principles, and the use of renewable energy systems — are aligned with popular ideas about environmental stewardship.

One possible problem with a wider adoption of earthship construction methods: foundation walls made from tires packed with dirt do not meet most building codes.



Earthships with sloped glazing are more likely to overheat than earthships with vertical glazing.

Comfortable in all climates?

Like Wolfgang Feist, Reynolds suggests that his design and construction principles are universal enough to apply everywhere; in fact, the [official Earthship website](#) brags that “earthships maintain comfortable temperatures in any climate.” Yet some of Reynolds’ requirements — including the requirement for a cistern — don’t seem particularly universal.

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In New Mexico, where Reynolds' principles were first developed, water can be scarce; in that climate, a cistern connected to a water filtration system may be useful. In well-watered areas like northern New England, however, where rural homes commonly draw water from surface springs or drilled wells, installing a cistern to gather rainwater from the roof is usually an unnecessary expense.

Setting off a reader's "exaggeration alert system"

Most intelligent readers have an E.A.S. — that is, an exaggeration alert system (also known as a bullsh*t alarm). Unfortunately, Reynolds' statements frequently set off my E.A.S.

For example, in [a video promoting his earthship designs](#), Reynolds introduces the topic this way: "Imagine living in a home that costs you nothing to heat or cool. ... Imagine no utility bills. ... The three-foot thick massive walls and the method of incorporating them into the earth create living spaces with a thermal dynamic that results in a stable room temperature."

In an article called "[Australia falling for Earthship marketers.](#)" journalist Nick Rosen reports that Reynolds told an Australian audience that earthships are "buildings that heat and cool themselves." He also claimed that "an Earthship home has no utility bills."



The earth-bermed walls of an earthship are built with discarded tires. Since each tire has to be packed with dirt by a worker wielding a sledgehammer, this construction method is labor-intensive.

In an article on Earthships published in [Makezine](#), an online magazine, Andrew Terranova reports that “The Earthship team has even designed their own vertical-axis windmill, called the Dynasphere.” Indeed, information on the Dynasphere turbine can be found on [the official Earthship website](#). Since vertical-axis machines are the “insulating paint” of renewable energy equipment, this news is not encouraging. (For a physics-based explanation of why vertical-axis wind turbines underperform their horizontal-axis rivals, see [“Thoughts on Vertical-Axis Wind Turbines.”](#) by Robert Preus. In his article, Preus notes, “There is an all-too-common belief that a VAWT [vertical-axis wind turbine] approach will revolutionize the small wind industry. This seems to be a lot of wishful thinking by people who don’t understand physics.”)

Greenhouses produce food

The typical earthship includes extensive sloped or vertical south glazing that is usually fitted with moveable interior shades. The area behind the south-facing glass can be used to grow crops or ornamental plants. In many cases, these plants are watered with graywater from the home’s shower, bathtub, or washing machine.

When Reynolds speaks publicly about the advantages of earthship construction, he sometimes implies that a residential greenhouse can provide most of a family’s food. (A poster at the earthship visitor’s center in Taos explains that the food production “effort” aims “to produce enough food in one’s home to survive.”)



Most owners of earthships use the area directly behind the south glazing to grow plants.



After a spring blizzard, the south-facing windows on this earthship in Taos, New Mexico, were almost covered with snow. Fortunately, snowy days in Taos are usually followed by sunny weather. In cloudier areas of the U.S., on the other hand, this type of snow can linger for weeks.

A member of the audience at one of Reynolds' lectures in Australia (an architect who blogs anonymously) [reported](#), "The facts of habitation and performance in Mr. Reynolds' presentation were very thin, all glossed over quickly as though they were undisputed truths. Providing your own protein with fish from the tank? He illustrated this with [a video of] a child catching one fish with an overly long rod and then cooking it. The camera panned in to show decorative red carp gliding under the water plants. Are these fish or plants edible? What are the details for fish production? What space is required? What numbers? What is the cycle for sustainability? If a family eats fish three times a week, as some dieticians recommend, then at least a dozen large fish will be required every month; a gross in one year. What infrastructure is required to achieve this outcome? How many banana trees are needed? How many other plants and varieties have to be cajoled to continue production 24/7/52?"

The skeptical tone adopted by this architect represents a fairly typical reaction to Reynolds' claims. (Another reaction, enthusiastic discipleship, is also fairly typical.)

Heating and cooling

In a variety of videos posted on the web, Michael Reynolds can be seen describing an earthship's heating and cooling systems. Space heating is provided by the sun, which shines through the vertical or sloped south-facing glazing. Cooling is provided by earth tubes; the air in the earth tubes is drawn into the house when an operable skylight is opened.



Without the pull-down shades, this bathroom would be flooded with sunlight — perhaps a little too much sunlight.

QUOTES FROM *EARTHSHIP: VOL. 1* by Michael Reynolds

“Too Hot. If you are too hot, it could be from air temperature, direct sun, or both. If direct sun is involved, see the shading section. To cool the air temperature down, you must create a ‘chimney’ for hot air to leave and an inlet for fresh, cooler air to come in.”

“Too cold. Obviously, if you are too cold, you must close all vents, windows and doors. ... If control of venting and/or insulated shades does not provide the comfort level you want, a small amount of backup heat is necessary. ... A fireplace, small wood stove, small ventless gas heater, or warm floor system is recommended here. ... Bathrooms that are not directly on the solar face often require a blast of heat after a shower. This can be achieved with instant electric heaters with fins or small gas units.”

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“When one buys an earthship, there are certain factors relative to performance that one must accept as givens to allow it to be a vessel that will ‘sail on the seas of tomorrow’ where common housing will surely sink.”

(Earth tube ventilation might be an important requirement for anyone with allergies. Author Nick Rosen reports the following anecdote: “The late actor Dennis Weaver ... bought a set of Mike’s blueprints in 1980, built an Earthship, and produced a documentary about it. ... Weaver moved out of the Earthship shortly afterward, when he discovered he was allergic to the gas the tires gave off, which seeped through the limestone walls.”)

Many earthship claims — for example, the claim that an earthship is “a house that heats and cools itself” — resemble claims made by some Passivhaus advocates. In both cases, the claims are exaggerations.

[The Earthship website](#) reports, “One of the most recently built Packaged Earthships reports a maximum [I think the author means ‘minimum’] low temperature of 64 degrees (for a brief time) early in the morning before sunrise after two cloudy days.”

That’s all fine and good, as far as it goes. But any Vermonter who reads this sentence is likely to think, “Well, what would the indoor temperature be after *twenty* cloudy days in a row?”

[Describing a presentation given in Australia](#), the architect who had doubts about earthship food production capabilities reported, “Mr. Reynolds ... elaborated on the systems of air extraction and intake, and passive heating and cooling that would keep the home at 21 degrees Celsius [70°F]. His graph seemed to suggest a variation between 19 [66.2°F] to 26 degrees [79°F], but this was never spoken about.”

While many websites trumpet the claim that “[Earthship homes will work in any climate](#),” they rarely note that earthships work a lot better in some climates than others. Earthship owners in cold climates who prefer comfortable indoor temperatures are likely to install a heating system. The owner of [an earthship in British Columbia](#) wisely included a radiant floor heating system, noting, “Our valley gets very little sunlight in December and January.”

Insufficient insulation

Many earthship owners with comfort problems can trace their homes’ poor thermal performance to a lack of insulation. Before Reynolds understood the reason for these comfort problems, many earthships were built without any wall or floor insulation. Oops.

According to [the Wikipedia article on earthships](#), “Some earthships appear to have serious problems with heat loss. ... This situation may have arisen from the mistaken belief that ground-coupled structures (buildings in thermal contact with the ground) do not require insulation.”

One of the many earthships with insufficient insulation was one built in Brighton, England. According to an anonymously authored online article called [“Some Thoughts on Earthships,”](#) “The Brighton Earthship was designed by Michael Reynolds himself and it is an incredible structure. ... It was not by any means a cheap build and mistakes have been made. ... The failure to insulate under the floor (on Reynolds insistence that it was unnecessary) was the result of the success of this strategy in New Mexico. Unfortunately temperature analysis of the Brighton Earthship has demonstrated that the lower ground temperatures in England cause an uninsulated floor to act like a bottomless drain on the internal heat rather than a store for it. The team have learned from this, but it is a mistake that could have been avoided had other advice been heeded.”



Summer overheating

It should come as no surprise that homes in cold, cloudy climates need insulation and heating systems if the homeowners expect to be comfortable during the winter. But it's worth noting that earthships can be uncomfortable during the summer as well as the winter — especially if they have sloped south-facing glazing. When Nick Rosen interviewed Pliny Fisk, the founder of the Center for Maximum Potential Building Systems in Austin, Texas, Fisk “was dismissive of Mike Reynolds’s Earthships: ‘He doesn’t have good criteria for designing his buildings. They totally overheat.’”

“HARD TO MESS UP”

“Though Mr. Reynolds said his do-it-yourself earth-ship formula is ‘hard to mess up,’ the idea that any committed person can build one is certainly debatable. Marsha Campbell, a 49-year-old social worker, moved to Taos from Ohio to build an earth ship in 1991. Her tales are reminiscent of Great Plains pioneer women in sod houses — living in an unfinished dirt house, hauling 40-pound containers of water, dashing to the outhouse in the dead of night. Eventually she reached the end of her \$20,000, unable to complete the project. Along the way, she and her lover broke up.

“ ‘I think Michael Reynolds is a genius,’ she now says, ‘and the idea works if you can hire him to build the house. But if you can’t, you suffer. In my life, I’ve been pretty much able to do everything I set out to do. But I certainly couldn’t build that stupid house.’ ”

— [“Father Earth,”](#) *New York Times*, January 10, 1993

In a [letter to the editor of *High Country News* magazine](#), Beverly Fung, the owner of an earthship in Santa Fe, New Mexico, reported that she “signed an agreement to have Solar Survival Architecture (SSA) and Michael Reynolds manage the construction of our Earthship.” She went on to explain that the indoor temperature in her house reaches “95 degrees with an outside temperature of 90 degrees during the summer with cellular shades on all windows. This house was designed by SSA architectural staff for another client and appears in Volume I of the Earthships manual. We made no modifications to the plans other than those suggested by SSA and their representatives.”

No utility bills?

Reynolds often tells his audiences that off-grid living is cheaper than grid-connected living, because homeowners don’t have to pay for their energy. “Imagine no utility bills.”

It doesn’t take much digging, however, to discover that earthship homes use gasoline to fuel generators and propane for domestic hot water and cooking. [An earthship model advertised on the Earthship website](#) is described as a house that accommodates “solar electricity with capabilities of wind, gas generator or conventional utility backup.” Moreover, the house is equipped with a “gas on-demand hot water [heater] with capability of solar hot water addition.” The kitchen is set up for “gas cooking,” and space conditioning is provided by “solar thermal heating and cooling with option of gas or fireplace backup.”

Off-grid homes require large battery systems, and these batteries need to be replaced every six or eight years; that’s why off-grid electricity is almost always more expensive than grid-supplied electricity. So, once a homeowner squanders money away every month for the battery replacement fund, pays the propane bill, and buys gasoline to feed the generator that provides electricity

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during cloudy weather, the off-grid lifestyle doesn't quite match the one implied by the phrase, “imagine no utility bills.”

In spite of these awkward facts, Reynolds [told an Australian audience](#), “Because Earthships don't need to use fossil fuels to stabilize the temperature in the building and they generate their own electricity, the costs of living are reduced.”

For an ironic capstone to this discussion of whether off-grid electricity is cheap, let's listen to [the words of the owner of a recently completed grid-connected earthship](#) in British Columbia: “We have been asked why we aren't off-grid yet. This is simple. We are building without a mortgage and some systems cost more than we can afford right now.”

How much do these homes cost?

Anyone who thinks that a house built out of old tires, dirt, and discarded aluminum cans must be inexpensive is mistaken. According to most reports, earthships cost just as much to build as a conventional house. A model called the Global Earthship, which [Reynolds calls](#) “our current favorite model,” can be built for \$225 per square foot. [According to Trent Wolbe](#), a journalist who took a course in earthship construction at Reynolds' training center in Taos, the Global Model costs \$300,000 for a one-bedroom, one-bath home, so “it's certainly not for people who don't believe wholeheartedly in the concept.”

Nick Rosen quotes a Taos resident named Bill Reed, who explains that Reynolds' problem “is building at a reasonable amount per square foot. Those tires, they're labor-intensive.”

Reynolds has arranged to build earthships for many wealthy clients, and [he says](#), “If you've got a pocketbook to match, the sky's the limit.”

Of course, owner/builders who can supply their own labor can build an earthship for significantly less than \$225 per square foot. But they had better have strong arm muscles — compacting dirt with a sledgehammer is fairly brutal work — and several months to spare. Moreover, even though old tires and aluminum cans can sometimes be had for free, an owner/builder's bank account still has to be fat enough to cover the costs of roof framing, roofing, insulation, glazing (and lots of it), adjustable window shades, appliances, interior finishes, a complicated plumbing system with more tanks and pumps than a conventional system, and a pricy renewable energy system.

A personality-driven movement

Michael Reynolds believes that the wide adoption of earthship principles will solve many of the world's environmental problems. He is an enthusiastic and self-confident proselytizer. Some methods of residential construction — including straw-bale construction, passive solar construction, and superinsulation — are not personality-driven. Other methods — including Wolfgang Feist's Passivhaus approach and Michael Reynolds' earthship approach — are very much personality-driven, for better or worse.

The problem with a movement propelled by a leader with a strong personality is that the leader has a strong personality. Michael Reynolds is no exception to this general rule. In his book *Off the Grid*, Nick Rosen reports that “Mike is admired and despised in equal measure by his clients, who find his brusque style off-putting. And there have been accusations over the years of far worse than rudeness — broken promises and bad workmanship are two of the lesser charges. ... Mike turns out to be a bizarre and socially dysfunctional character.”

Another assessment of Reynolds comes from Trent Wolbe, a journalist who took a course in earthship construction at Reynolds’ training center in Taos. In an article published by [The Verge](#), Wolbe wrote, “I began to pull at every loose thread I could find in the Earthship rhetoric — the main chunk of cognitive dissonance that gnawed at my conscience was how much this emphatically off-the-grid operation depended on very gridlike formations: the internet as a global publicity tool, existing transportation infrastructure for moving raw materials to and from builds, and phone networks to communicate. On the last day of class I brought this up, and Mike, double-fisting a pair of margaritas, conceded that the Internet was very important to his operation, but not vital. To end the conversation he said, with his signature blend of comedy and gravity, ‘F*ck you and your grid,’ and laughed it off with a contemplative sip from a salt-dusted rim. Although he constantly proclaimed that no one knew the answers to everything, he seemed to bristle at any questions that peered closely at the jagged seams of his theories. At times this moral certitude gave off an air of religious evangelism, a blind hippie faith that Earthship devotees sometimes exude.”

A blogger who goes by the *nom de plume* of ChillumJon [reports](#) that the earthship project in Brighton, England “for Reynolds was an experiment that he got paid for and left behind; one in which he ignored advice from local architects who were familiar with the climate. His struggles to get permission to build experimental houses in the U.S. have no doubt forced him to rigidify his thinking and stick to his guns but the result is that when one of his Earthships does not work or [someone] disagrees with his assessment of something, he is all too quick, it seems, to dismiss the client as ‘bitching and moaning’ for not having realized how experimental their home would be, or just not seeing things as clearly as him. ... Mike Reynolds is on a mission. I guess his failure to heed the warnings of others is because in his haste to save the planet he doesn’t feel there is time for him to mess around with checking whether or not something will work in one place just because it did in another.”

Optimizing the design of a passive solar house

For owner/builders with lots of time on their hands who live in rural areas with plenty of winter sun, earthships make sense. Many finished earthships are attractive buildings with plenty of natural light and a generously sized greenhouse. Most earthship owners are happy with the design and performance of their homes.

The on-site wastewater treatment systems that Reynolds has developed, while more complicated and expensive than ordinary septic systems, are undoubtedly useful in drought-stricken regions.

When evaluating the pluses and minuses of the earthship approach, however, it’s important to separate the hype from the facts. Michael Reynolds implies that the thermal performance of an

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earthship can be attributed in part to the excellent thermal storage characteristics of earth-filled tires. He's wrong on that point.

Earthship design principles do not include a magic formula. Experienced passive solar designers know that in most North American climates, below-grade walls and below-grade floors need plenty of insulation to separate indoor conditions from soil temperatures. While thermal mass can be an important element of passive solar design, it must be located on the interior side of the insulation layer to be useful. Building walls from earth-filled tires doesn't alter these facts.

During the 1970s, many designers of passive solar homes specified large areas of south-facing glazing. In areas of the country with plenty of winter sun — including Colorado, Arizona, and New Mexico — south glazing helped these buildings stay warm, even during spells of very cold weather. However, extensive south-facing glazing is a double-edged sword. Its advantages during sunny cold weather are balanced by its disadvantages at night (when its low R-value leads to thermal losses) and during the summer (when daytime solar gain is usually undesirable). Balancing the advantages of wintertime solar gain with the disadvantages of nighttime heat loss and summer overheating is tricky, but designers of low-energy homes have learned a lot since the 1970s. Optimized passive solar designs require less glazing and more insulation than earthships provide.

- See more at: <http://www.greenbuildingadvisor.com/blogs/dept/musings/earthship-hype-and-earthship-reality#sthash.nuMBvX1m.dpuf>