Durable, Energy Efficient Dome Homes

What if thinking outside the box meant literally getting out of the rectangular boxes that most of us call home?

by Carol Lanham

CHUCK SNYDER

Chuck and Louise Snyder moved into their dome house, overlooking the Alaska Kasilof River in 1998. The house stayed warm for days even though they ran out of oil and outside temperatures dropped to -30°F.

Most people would agree that if you want a truly energy-efficient home, you have to be willing to think outside the box. Whether you explore alternative heating-and-cooling methods or innovative building techniques, it pays to get out of the mainstream and be willing to consider unconventional approaches. But what if thinking outside the box meant literally getting out of the rectangular boxes that most of us call home? In fact, what if it meant living in a round building instead? That's exactly what a small but growing group of homeowners has been doing for the last several decades. They have been moving into Monolithic Dome houses, and achieving extraordinary energy savings as a result.

As their name implies, Monolithic Domes are one-piece, round structures that have no roof, no joints, and no seams. Their surface is smooth and unbroken like that of an egg, with the exception of windows, doors, and vents, which are all carefully sealed to prevent unnecessary air flow. The monolithic nature of the structures is one of the factors that account for their energy efficiency. The materials used in the homes' construction also help conserve energy. Specifically, Monolithic Domes are made out of concrete, and are insulated with 3 inches of polyurethane foam on the exterior of the building. This provides a thick layer of insulation that protects the concrete from extreme temperature variations. Like the building itself, the insulation is monolithic, with no gaps, cracks, or breaches except for the openings that are specifically designed into the structure.

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Introducing Bruco

Like many Texans, I had seen Monolithic Domes while driving along Interstate 35 between Dallas and Austin. Beside the freeway, about 30 minutes south of Dallas, sits a giant caterpillar made up of seven interconnected domes, and affectionately nicknamed Bruco. It serves as a landmark for the Italy, Texas-based Monolithic Dome Institute (MDI), which is dedicated to raising awareness about these unusual structures. MDI's president, David B. South, built the nation's very first Monolithic Dome home back in the 1970s in Idaho. Today, the unusual round structures can be found in 45 states and several foreign countries, with dozens of domes in the small town that South now calls home. The buildings are also used as schools, churches, performing arts centers, storage facilities, and assorted other commercial structures.

South and his team train would-be dome builders at the institute at five-day workshops held each fall and spring. In addition to classroom time, attendees get hands-on experience building a dome. Even when workshops are not in session, there is plenty of activity at MDI. Many of the buildings are open daily for tours, both for curious passersby and for those who call ahead for an appointment. Bruco—the caterpillar—serves as a manufacturing facility for the Airforms used to build the domes.

Dome Home Details

An Airform is a giant tarp made of superstrong single-ply roofing material. During the construction process, it is attached to special hooks on the circular foundation and inflated using giant fans to create the shape of the dome. Work then moves to the interior, where crews bring the plumbing and electrical wiring in through the floor and frame in windows and doors by fastening treated wood to the Airform. They then spray the rest of the Airform with polyurethane foam, reinforce it with steel rebar, and coat it by spraying on several inches of Shotcrete, a brand of concrete that is sprayed in place. Once the Airform is solid, crews cut out the tarp for the window and door frames along with the vents, and then seal them by foaming around openings and covering the edges with a fabric boot made out of the same material as the Airform.

Interior walls are generally erected using steel studs and Sheetrock, but other options include concrete blocks, brick, or sprayed-up concrete. Wood is


SUNNY CUSHNIE

This Monolithic Dome home sits nestled in a forested area near Lake Huron in Southhampton, Ontario, Canada.

another alternative, but it is considered the least desirable because of the fire hazard it introduces to these virtually indestructible homes. The curved Shotcrete sides of the dome can be troweled to make them smooth or left in their rough and varied natural state. The exterior finishes of Monolithic Domes also vary. The Airform can remain in place for as long as five to ten years, but it eventually deteriorates. Coating options include exterior house paint, silicone, ceramic tile, rock, or 2 inches of concrete reinforced with chain link and coated with silicone. Modified stucco with colorant or silicone is currently the most popular choice. (See Figure on p.35 for a schematic showing typical dome home construction details.)


MDI

Designed by Larry Byrne, vice president of marketing and design for the Monolithic Dome Institute, this home graces the cover of *Dome Living,* a book of more than 115 Monolithic Dome house plans.

Paul Norton, senior engineer in the Center for Buildings and Thermal Systems at the National Renewable Energy Laboratory in Golden, Colorado, points out that there are clear advantages to this unusual construction method. "One of the benefits of this construction style is that there are no thermal shorts or thermal bypasses," Norton says. "You don't have all the joints that you find in a normal stick-built home, and it's the joints that cause the leakage." In fact, the buildings are so airtight that MDI recommends installing energy recovery ventilators (ERVs), in every dome home. While air exchange systems often result in higher utility bills, ERVs work a little differently. They recapture most of the heat from the fresh air that is brought into the home, so there is much less need to cool and heat the exchanged air.

At a more basic level, the shape of a dome building offers an energy efficiency advantage. Spherical shapes cover the greatest amount of space with the least amount of materials, giving domes the most favorable ratio of surface area to volume of any structure. Because there is less surface area, not as much heat escapes in the winter or seeps in during the summer. "If you reduce the surface area of a home and get the same living volume, that's an energy attribute," Norton says. Monolithic Domes, however, are actually oblate ellipsoids, or flattened spheres, which reduces the height of the ceilings and cuts down on the amount of unusable space. While some argue

SUNNY CUSHNIE

This is the same home featured in the top photo on p. 33. It was built by The Great Lakes Dome Company.

that the round floor plan and sloping walls are space inefficient, proponents of domes argue that they are actually more efficient than traditional homes because they have much less hall space. Domes also lack attics, which can act as solar collectors.

A dome's passive-solar design is also an important factor in its energy efficiency. Windows that face south and overhangs that allow sun to penetrate in the winter and provide shade in the summer, and judicious use of porches, are key considerations as well. For those who want to use solar energy, domes have an advantage because part of the roof is always aimed at the sun.

The placement of the insulation in Monolithic Domes is another key factor in their energy efficiency. According to the California Energy Commission's *Passive Solar Handbook*, placing insulating material next to the external environment allows significantly less heat into or out of the building. By combining this low heat conductivity with the high heat capacity of the concrete, the little heat that does seep into or out of the building does not change the interior temperature very rapidly. "Simply stated, the concrete acts as a heat sink, which slows the passage of heat back and forth through the wall," South says.

According to the California handbook, the benefits of placing the insulation on a building's exterior are pronounced. For example, a 2.5-inch wood wall with 1 inch of interior insulation would result in a ratio of exterior to interior temperature of 1 to 0.7. In contrast, an 8-inch concrete wall with 1 inch of interior insulation would reduce the ratio of exterior to interior temperature to 1 to 0.5. By placing the insulation on the exterior of the concrete, the ratio would be reduced by a factor of 10, resulting in a 1 to 0.05 ratio. "The ratio demonstrates the change from night to day or month to month, not specific temperatures," says South.

Success Stories

There is plenty of anecdotal evidence for the energy savings associated with Monolithic Domes, especially in harsh climates. Chuck and Louise Snyder, both natives of Alaska, tell how they unknowingly ran out of heating oil for their boiler, which warmed the water for the in-floor radiant heating system in their dome home. Two days passed before they became aware of it, because their home remained comfortable even though the temperatures outside had plummeted to –30°F. They finally realized they were out of heating oil because they were using the same boiler to heat their water and ran out of hot water.

Then there's Charles Brath, who lived in a 700 ft^2 mobile home while building his 1,600 ft^2 dome home in Colorado. He reports using 500 gallons of propane per year for cooking and space heating in his mobile home and 20 kWh per day of electricity for his water heater and lights. Once he moved into his dome home, he reduced his annual propane consumption by half to just 250 gallons, which he used for in-floor heating and hot water. His electricity usage dropped to 13 kWh per day.

The savings are not limited to cold-weather locales. Air conditioning needs are also reduced in Monolithic Domes. While HVAC needs for traditional homes are determined by consulting the ASHRAE standards, or by following the manufacturer's specifications, the same rules do not apply for Monolithic Domes. That's because thermal mass must be taken into account. MDI recommends using 1 ton of air conditioning per 1,000 square feet of living area in warm climates, generally south of the Mason-Dixon line. Because the smallest and least expensive commercially made units are typically at 1.5 tons, any dome home up to 1,500 square feet is usually equipped with a 1.5-ton unit.

Fortunately, there is also empirical evidence that supports the anecdotal stories of energy savings reported by dome owners. As the following two case studies show, owners who have sought Energy Star ratings, or the Canadian equivalent, for their dome homes have received very high ratings.

Moulton Dome Home in Ottawa, Ontario, Canada

The Canadian government, which has a reputation for high environmental standards, developed and financially supports the Energuide for New Houses (EGNH), a rating system based on a scale of 0 to 100. According to EGNH standards, a 0 represents "an uncomfortable house that has major air leakage, no insulation and extremely high energy consumption," while a 100 represents a house that is "very well-insulated, airtight yet well ventilated, and heated by renewable energy sources, such as wind or solar power." After moving into their triple-dome home

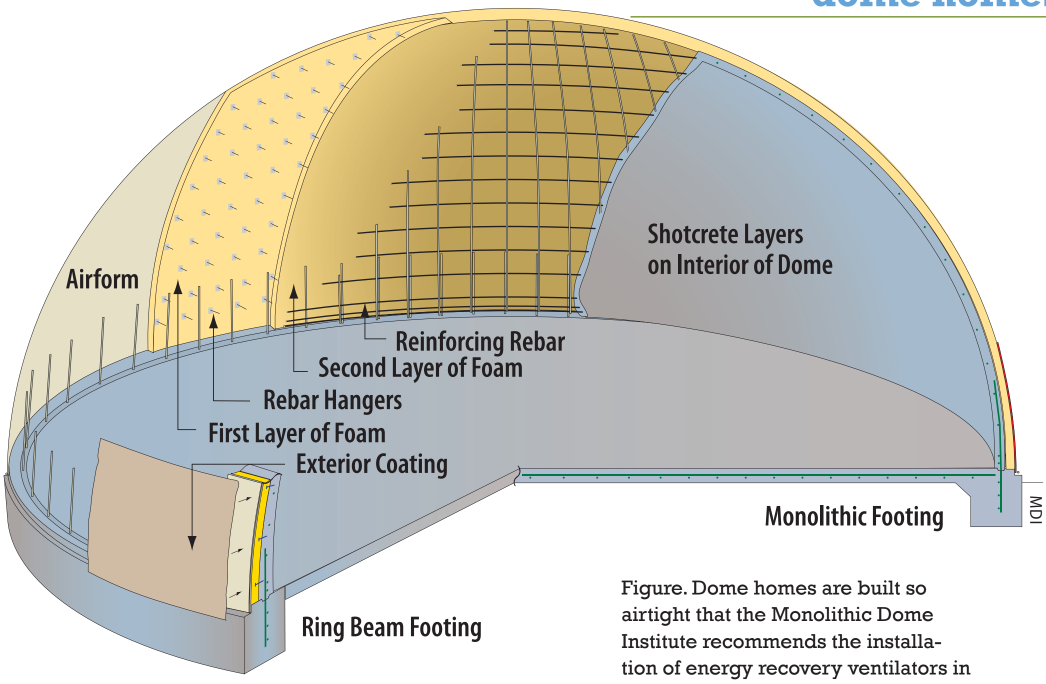

Figure. Dome homes are built so airtight that the Monolithic Dome Institute recommends the installation of energy recovery ventilators in every dome home.

in 2006, Ray and Rebecca Moulton, along with their builder, Great Lakes Dome Company, decided to put the new house to the test. (The Great Lakes Dome Company also built the home shown in the top photo on p.33 and the on p.34) The energy efficiency report they received stated that new homes constructed to building code standards would typically rate between 65 and 70, while a significantly updated energy-efficient new home might rate between 75 and 79. At the top of the scale, with a rating of 80 or more, would be what the EGNH characterizes as a "highly energy-efficient house." The Moulton's dome rated 88 with no special features other than a ground source heat pump.

The report also estimated that the home would consume approximately 6,100 kWh for space and water heating in an average year. An equivalent R-2000 home—considered at the time of the report, 2006, the most energy-efficient and environmentally responsible structure on the market—would use nearly 3 times that much, or just short of 17,000 kWh, according to the report. In their evaluation of the home's emissions of greenhouse gas (GHG), the inspectors determined that the dome home would produce 13.7 tons per year less GHGs than a similar house rated at 68. Considering that the government is challenging Canadians to reduce the amount of their personal annual GHG emissions by 1 ton, the dome home meets the challenge quite readily.

Roberts Dome in La Junta, Colorado

The Energy Star rating system used to rate homes in United States also gives dome homes high marks—once inspectors figure out how to adapt their measurements to a round dwelling. Cheryl Roberts discovered that when she sought an evaluation for her dome home from Energy Rated Homes of Colorado (ERHC) in order to qualify for a low-interest mortgage. Like EGNH ratings, Energy Star ratings are based on a scale of 0 to 100, with homes scoring 86 or above receiving the maximum five stars.

Convinced that her home would receive five stars, Cheryl was not at all worried as an inspector set out to evaluate the home's heating-and-cooling system, insulation, windows and doors, hot water system, appliances, and air flow. To her surprise, however, the home only received a rating of 80, or four stars. Certain that there had to be some mistake, she met with an official from ERHC. After some discussion, they concluded that the software program used to evaluate the home needed some adjustment. It seems the software was designed to evaluate conventional houses with corners, not rounded edges. A home with no roof and a ceiling area that was different from the floor area threw everything for a loop.

After the appropriate adjustments were made, a second evaluation of Roberts's dome home resulted in a score of 87, enough to qualify for the maximum five stars. In a letter to MDI, ERHC explained that there were technical difficulties associated with "getting the round home to fit in a square box." Another factor that contributed to the low rating the first time was incomplete installation of the windows. "We resolved those difficulties, re-rated the home when it was completely finished, and the home did pass with flying colors," the official wrote.

Since most homeowners do not go through the evaluation process associated with the government rating systems, the anecdotal evidence on dome homes continues to be more plentiful than empirical data. But that's been enough to make a believer out of Ward Huffman, who recently retired as a financial specialist from DOE and is now a business professor at Mesa State College. He became intrigued by the energy savings associated with Monolithic Dome homes during his tenure at DOE and even traveled to Texas to speak at MDI's annual conference. Today he remains convinced that the round concrete homes are extremely energy efficient.

"There's been a lot of controversy about the energy efficiency of Monolithic Domes because they don't fit the standard building criteria, and inspectors sometimes won't pass them because they don't meet code," Huffman says. "The way I judge it is by the cost of the energy that's used in the home's operation. The average 2,500

dome homes

ft^2 existing home in Colorado will cost you probably $200 to $300 per month to heat in the winter and at least that to cool it in the summer. With a similar-size dome home, it will cost you $500 or $600 per year."

Skeptics also have questioned the use of the materials used to build the dome homes. But Norton points out that while the concrete used to construct domes has a relatively high embodied energy, it is much lower than the energy used over the life span of the building. "Over the life of an average home the energy efficiency is much more important than embodied energy, by over a factor of 10." Furthermore, Norton points out that there is very little waste in the construction of the dome, which serves to reduce the home's embodied energy.

South and his extended family have experienced the energy savings firsthand over more than three decades of living in dome homes in such diverse locations as Idaho, Texas, and Utah.

JAMES AMOS

Cheryl Roberts stands in front of her dome home in La Junta, Colorado. The home earned a five-star rating from Energy Rated Homes of Colorado.

It's that personal experience that makes him a zealot in spreading the energy-saving message to others. "The Monolithic Dome is the strongest, best-insulated structure that can be built for conventional prices, and it's also the most airtight of all structures," he says. "The concrete stores enormous amounts of heat and acts as a thermal battery, and because most dome homes are passive-solar structures, there's a significantly reduced need for HVAC equipment and daily energy usage."

Considering that the superstrong buildings also meet the Federal Emergency Management Agency's standards for near-absolute protection from tornadoes and hurricanes, South thinks it's only a matter of time before more people give up their aversion to change and decide to go round. "We live in a world of rectangles and squares, so we're trailblazers on an uphill trail," he says. "But even folks who say they don't like the way a Monolithic Dome looks—usually just because it's so different—can't deny that it has indisputable advantages." He

*Carol Lenham has worked as a journalist for the Associated Press, Reuters, **Newsweek**, and Vatican Radio. In 1991, she co-founded Business Writers Group and writes frequently on the topic of Monolithic Domes.*

For more information:

To learn more about the Monolithic Dome Institute, go to www.monolithic.com.