Environmental Showcase Home Greens the Desert and Saves "Green" with a $30/Month Energy Bill

Project: Environmental Showcase Home

Contact: Arizona Public Service (APS), Phoenix, Arizona

Location: 60th Street and Greenway Road in Northeast Phoenix

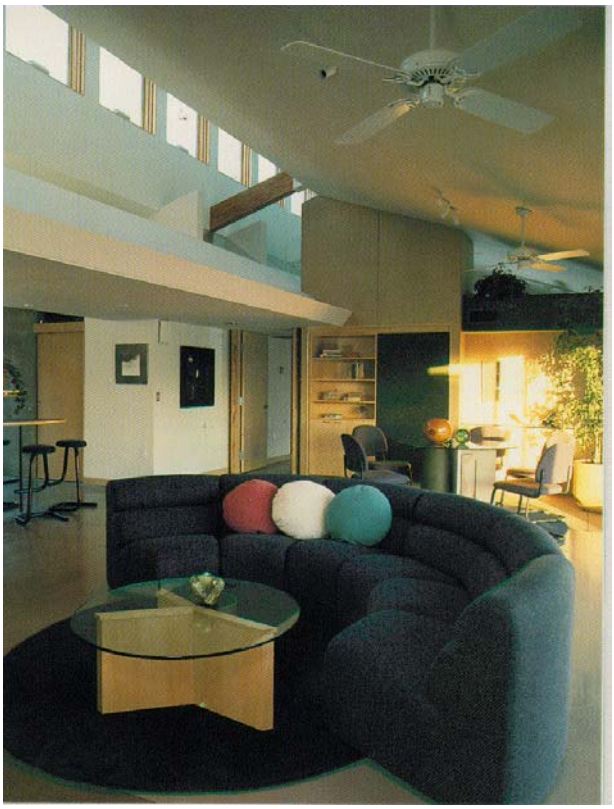
Demonstration

Energy efficiency, water conservation and sustainable design.

Project Description

The Arizona Public Service (APS) is a utility concerned about future levels of energy consumption, water use, and waste in its service area. The Environmental Showcase Home (ESH) was born from this concern and completed in February 1995. The 2,640 square-foot home features four bedrooms, three baths, a triple garage with electric vehicle charging station, a swimming pool, and four outdoor living areas. Its average energy bill is about $30 per month using the home's 2.7-kilowatt photovoltaic system.

The ESH was intended as a supermarket of ideas and new building practices, not as a model home. It contains over 150 technologies, strategies, concepts and materials, many of which are redundant. For example, the ESH has three different water heating systems. This approach increases the potential to demonstrate the wide range of choices available today. The home features mostly off-the-shelf technology and housing concepts that are appropriate for the desert climate. In a rapidly growing and competitive housing market which is often too price-sensitive to incorporate a lot of environmental features, there



The light and airy interior of the Environmental Showcase Home in Phoenix, Arizona.

is evidence that the ESH has had some positive influence on local builders. Nearly every local builder has toured the home and several developers are incorporating some of the ESH's building concepts and technologies in newer developments. The home would cost an estimated $170,000 in the current housing market. However, cost comparisons to a similar conventional homes are not possible because cost and quality vary widely.

Energy and Water Saving Strategies

Active Energy Systems Feature Three Heat Pumps and Cool Appliances

The ESH demonstrates three different heat pump applications for heating, cooling, and water heating. A stand-alone heat pump used in the home—the most efficient water heater ever made—can reduce water heating costs by up to 60 percent. Another high-efficiency, low-maintenance heat pump for

space heating and cooling uses a single-speed compressor with a variable speed fan to reduce noise levels. Finally, a triple-function heat pump combines space heating, cooling, and water heating. This system is capable of using warm interior air during the hot summer months to heat water, providing low-cost hot water during the air conditioning season (usually April–September).

The ESH also features multiple zone control (four zones) using a single heat pump. Home appliances are designed to minimize radiant heat. For instance, the kitchen cooktop uses a high-frequency, electronically controlled induction coil under smooth glass to create a safe electromagnetic field for heating iron cookware. Since the cooktop itself never gets hot, the appliance does not warm up the kitchen.

The ESH uses 50 percent of the energy needed to light a typical home with standard lighting technologies. Daylighting from the clerestory windows reduces the need for artificial light and a low-heat-gain skylight (Sola-tube) helps reduce the need for electrical lighting in the entryway. Conventional incandescent lights are virtually eliminated and fluorescent, compact fluorescent, and halogen light fixtures are strategically placed to light critical areas—not the entire room. The energy-efficient features of this home would prevent 540,000 pounds of air pollution over 30 years. The ESH uses forty-two 44- by 20-inch, roof-mounted photovoltaic modules to produce a total of 2.7 KW of electricity—about half the electrical energy requirements of the home.

Passive Solar Systems and Varied Shading Balance Natural Lighting

The ESH is oriented on an east-west axis to minimize heat gain where sun exposure is heaviest. Each window in the ESH is designed for its specific placement. Clerestory windows on the north side collect the less harsh sunlight from the exposure which provides natural light to the interior below. Fabric shade screens flanking each of these windows reflect light into the home for a more diffused, aesthetically pleasing result. Windows on the east, west, and south sides are shaded to protect from harsh sunlight. South-facing windows in the bedrooms are recessed and shaded by landscaping or overhangs. Large south-facing patio doors allow for a sweeping view of the pool area from the great room. Due to their size, the patio doors are shaded in a number of ways, including a trellis and a fabric awning system that automatically extends or retracts according to the requirement for more or less sunlight. All exterior windows are one inch thick, high-performance glass systems, with an overall R-4 insulation rating. The high-performance glass system consists of clear or tinted outer panes (depending on the exposure) and a clear inner pane with a low-emissivity coating to reflect heat.

Block Walls Allow Better Insulation

The eight-inch, recycled-content masonry wall unit (Integra Block) used for most of the exterior walls of the ESH was selected for the special design that minimizes "thermal bridging" and which also permits more cavity space for insulation compared to conventional cement block. The block walls are injected with foam insulation to provide an excellent thermal envelope which rates an R-factor of 24 (Superlite Block Company, Phoenix).

Appliances Conserve 70 Percent of Energy and 16,000 Gallons of Water

The appliances selected for the ESH are all energy-efficient (and in some cases water-efficient) compared to standard equipment. For instance, the Amana DU7500 dishwasher saves 70 percent of the energy of standard dishwashers and uses only eight gallons of water per load, conserving 1,000 gallons of water per year over standard models. The Westinghouse LT 350R clothes washer is 33 percent more energy-efficient than standard top-loading models because the horizontal axis design uses less water; and, therefore, requires less energy to heat. This appliance could save a family of four up to 15,000 gallons of water per year compared to standard models. When all of the ESH's energy-efficient appliances are used exclusively, 770 KWh are saved over standard, inefficient appliances.

Gray Water/Rain Water System Recycles Water

ESH features a gray water system to capture the portion of the home's waste water (about 65 percent) which does not contain organic matter. The gray water is collected in an underground storage tank and pumped to an above-ground tank, where it is then used as landscape irrigation water. Over a 30-year period, a family living in the ESH would use 2.3 million gallons less water than a family living in a conventional home.

In addition, the ESH demonstrates a rainwater harvesting system. The system captures rainwater at each corner of the house, feeds it along two gutters leading to four grated cement slabs. The rainwater then flows into a recycled plastic underground storage tank that is also used to hold the graywater.

Plumbing and Landscape Features Use Less than Half the Water of Other Homes

Indoor water systems in the ESH feature low-flow shower heads, bathroom fixtures, and low-water-use toilets. For instance, the master suite bathroom shower head (made by Resources Conservation, Inc. of Connecticut) uses only 2.25 gallons per minute compared to 3 gallons per minute used by a standard shower head. The Rialto Pressure Lite toilet by Kohler also used in the master suite bathroom uses 1.6 gallons or less per flush compared to 3.5 gallons per flush for a standard toilet.

Xeriscape landscaping used at the ESH will conserve about 33 percent of the water consumption used in typical turf landscaping. Even without using the gray water for irrigation, the ESH saves 52 percent of indoor and outdoor water use of a typical residence in the area.

Examples of Recycled-Content Building Products

- **Carpet:** The Enviro-Tech carpet in the ESH is 100 percent postconsumer plastic from old soda bottles (Image Industries, Inc., Armuchee, GA). The ESH uses a combination of smooth-surface floors made from integrally colored concrete and carpeting. The carpet uses no adhesives and a carpet pad made from jute fiber with a nontoxic binder.
- **Ceramic Bath and Shower Tile:** Bath tiles used are made from 70 percent recycled glass, primarily from automobile windshields. It should be noted, however, that the selection of recycled bath tiles may not be an entirely environmentally efficient choice when embodied energy is considered. The production of glass and ceramic tiles is a relatively energy-intensive process (Stoneware Tile Company, Richmond, IN).
- **Concrete Floor Slab, Sidewalks, Curbs, and Gutters:** Fly ash replaces about 25 percent of the concrete used in the ESH. The fly ash is a by-product of APS's coal-fired power plants. Replacing cement with fly ash conserves energy (portland cement is among the most energy-intensive of building materials) and strengthens the concrete. While there are heavy metals in fly ash, the cement binds these hazardous materials and prevents them from leaching (Phoenix Cement Company, Phoenix, AZ).
- **Countertops:** The guest bath countertops are Poly-Mar HD, a durable solid polymer panel made from 50 percent recycled-content plastic, 20 percent postconsumer and 30 percent postindustrial (Santana Products, Scranton, PA).
- **Drywall Support:** The nailer—a recycled plastic clip (25 percent postconsumer and 75 percent postindustrial) that supports drywall at the interior corners—is used wherever drywall finish is applied in the ESH. The plastic clip replaces wood backing for drywall (The Millennium Group, McHenry, IL).
- **Exterior Siding:** Trex composite lumber was used as siding on the exterior frame made of concrete block. Trex is 50 percent postindustrial wood fiber and 50 percent postconsumer plastic. Trex is resistant to rot and mold (Mobil Chemical Company, Norwalk, CT).
- **Frame Wall and House Roof Insulation:** Cellulose insulation for exterior walls and the roof of ESH is Nature Guard, made from 85 percent postconsumer newsprint (Louisiana Pacific Corp., Portland, OR).
- **Insulation Board:** Amofoam RCY insulation board, made from 25 percent postconsumer plastic and 25 percent postindustrial plastic, was used in the perimeter slab to minimize heat gain from the soil near the edge of the home, due to temperature differences between the slab and the soil. (Amoco Foam Products, Atlanta, GA).
- **Interior Accents:** Prefinished interior accent paneling in the office work areas are made from

100 percent postconsumer newsprint panels covered with natural jute fabric. (Homasote, W. Trenton, NJ).

- **Kitchen Floor Tile:** The Armstone Confetti kitchen tiles are made from 90 percent post industrial marble chips from Tennessee (PermaGrain Products, Inc., Newton Square, PA).
- **Patio Door:** The Norwood Series 3050 patio door used in the ESH is made from recycled aluminum. Since the production of aluminum from bauxite is very energy-intensive, a primary environmental benefit from recycling the of aluminum is energy conservation (Fleetwood Aluminum Products, Inc., Corona, CA).
- **Standing Seam Shingles:** The steel roof contains 60 percent postconsumer recycled content. Independent assessments by Scientific Certification Systems of California, which compared two roofing systems specified by APS, indicated that the steel roof of the ESH uses 56 percent less wood and 83 percent less ores and minerals than an alternative cement tile roof system. Since the material is very light weight (half as much as an asphalt shingle and only 15 percent of the weight of clay or cement tile), there is a savings in the materials needed for structural support of the ESH (ATAS Aluminum Corporation, San Diego, CA).
- **Steel Studs:** Steel studs used in the interior walls of the ESH are 60 percent recycled-content material. The use of steel studs helps conserve old growth forests. Steel studs also produce straighter walls, (there is less warping and twisting compared to wood studs), and are 100 percent recyclable. However, the amount of energy needed to manufacture a 2,000-square foot house is 28 percent greater for steel framing compared to wood framing. The conductivity of steel is 1,100 times greater than wood, therefore steel framing must incorporate design features to prevent heat loss. This is particularly true for exterior walls (American Studco, Phoenix, AZ).
- **Stucco:** The finish for the few exterior wall sections where block was not used (frame walls) is an integrally colored, three-coat, cementitious stucco with fly ash added to provide embodied energy reduction benefits (Phoenix Cement Company, Phoenix, AZ).
- **Wall Blocks:** Fly ash also replaces 25 percent of the cement used to make the concrete walls selected as the ESH's envelope, which results in stronger blocks that use less embodied energy to produce, compared to all cement blocks (Superlite Block Company, Phoenix).
- **Wall Board:** Wall board used as interior finish of painted walls is USG gypsum wall board. The face sheets are 100 percent recycled paper fiber and may contain recycled content in some areas of the country (United States Gypsum Company, Chicago, IL).

Examples of Environmentally-Friendly Building Products

- **Cabinets:** The accent door fronts of the ESH's kitchen cabinets are Environ Biocomposite fiberbond, a monolithic resin product made from soy flour and recycled paper. Environ Biocomposite is nontoxic, looks like granite, and works like hardwood (Phoenix Biocomposites, Inc., Mankato, MN).
- **Driveway Surface:** Stabilized decomposed granite was selected for the driveway surface rather than concrete, to allow for infiltration of water and to reduce runoff. The selection of stabilized decomposed granite for this application is environmentally friendly compared to concrete, based on embodied energy. Concrete is among the most energy-intensive of building materials since production involves not only mining, but also the calcination process. The production of stabilized decomposed granite, on the other hand, does not involve energy-intensive production processes after the material is mined (Stabilizer, Phoenix, AZ).
- **Engineered Wood Products:** Roof framing used in the ESH is a single continuous parallel strand lumber beam (Parallam ridge beam) with Microlam I-joists spanning up to it from the outside walls. In addition, the facia and subfacia are laminated strand lumber and laminated veneer lumber, both engineered wood products. These engineered wood

products (EWP) usually cost up to 15 percent more than solid-sawn lumber, based on the cost per linear foot. However, EWPs have several advantages over dimensional lumber, which often make EWPs more economical, allowing for labor and waste considerations. EWPs are made from second- and third-growth trees, rather than old-growth trees. They allow more of the tree to be used, can accommodate longer spans, and can be prefabricated to exact lengths to prevent waste. Some EWPs, such as I-joists, are half the weight of solid-sawn joists, which can significantly reduce labor costs. (Trus Joist MacMillan, Boise, ID). Oriented strand board, another engineered wood product, was used as roof sheathing, exterior wall framing, and garage roof sheathing in the ESH (Potlatch Corporation, Spokane, WA).

- **Integrally Colored Concrete:** Adding color and texture to the concrete floor slab created an attractive finished floor. In some cases, the finish floor eliminated the need for energy and resource-intensive floor finishes such as vinyl tile and wall-to-wall carpeting (Bowman Concrete, Mesa, AZ).
- **Kitchen and Bathroom Cabinets:** Medite II fiberboard was used as substructure for cabinets and interior wall board, interior door frames and selected interior trim. This product is made from sawdust particles bonded together with a formaldehyde-free binder. It is a safe, resource-efficient product that is strong and long lasting for these applications (Medite Corporation, Medford, OR).
- **Polyurethane Foam Insulation:** Supergreen Foam was used for insulation, a polyurethane foam that does not depend on a blowing agent with hydrochloro-fluorocarbons (HCFC), the likely cause of atmospheric ozone depletion. This medium was used to insulate the blocks in most of the exterior walls (see "wall blocks" above) (H.C. Fennell, Inc., North Thetford, VT).

Comments

Every aspect of the ESH embodies the concepts of energy-, water-, and resource-efficiency without sacrificing comfort and aesthetics. The result is a home that uses 60 percent less energy and 60 percent less water than a typical energy-efficient home. In addition, resource-efficient and/or recycled products were selected whenever possible for use in the ESH. In particular, APS claims that recycled materials used in the home were readily available and often were as strong or stronger than their original counterparts.

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