Zeroing In on Green Building

A Study of the Z6 House

by Joe Portelli

Context

World energy consumption and prices are rising and the demand for products and services that promote health, wellness, and environmental responsibility is arguably at an all time high. In a world where the construction and operation of buildings account for forty percent of the world's resources, forty percent of energy consumption, and sixty percent of pollution emissions,[1] design and real estate professionals should utilize all available technologies to design buildings that benefit surrounding ecosystems, conserve resources through bioclimatic design, and promote human health with improved lighting and indoor air quality.

In 2006, LivingHomes, LLC introduced this type of building to a quiet hillside street in Santa Monica, California. The Ray Kappe-designed Z6 House is the first residential project in the United States to attain a platinum rating from the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) for Homes program (Figure 1).[2] The Z6 house, which is constructed of factory-built modules and has 4 bedrooms and 2.5 baths, is a single-family residence whose architect and developer pursued the "six zeros of sustainability" concept as a way to achieve a sustainable design: zero energy, zero water, zero waste, zero emissions, zero carbon, and zero ignorance. This building philosophy has a close relationship with the categories found within the LEED for Homes certification. Although the Z6 House comes with a high price tag, it makes a valuable contribution to the green building movement because it has a holistic approach to design whose LEED certification increases the general awareness of the technologies that would be a part of a green building revolution.

[1] "About Us." http://www.greenable.net/about.php
[2] The Z6 House was a pilot project assessed under LEED for Homes v. 1.7.

Figure 1. View of Z6 House from Street. Source: www.livinghomes.net

Energy and Atmosphere

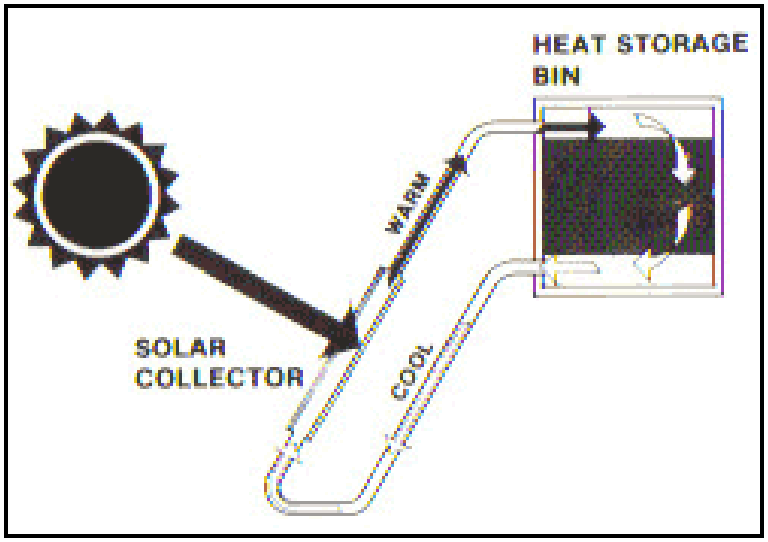
LEED's energy and atmosphere category describes features that promote the concept of zero energy. A zero energy home is one that produces all the energy it consumes. A design can achieve this by finding ways to reduce the demand for energy and installing technologies that produces the power to meet these demands. Based on the Home Energy Rating System (HERS), though, where a home built to code has a rating of 100 and a zero energy home has a rating of zero, Z6's rating of 93 seems rather unimpressive. However, this is a dramatic improvement from existing homes and achieves a low energy profile with site orientation, airflow, and appliance selection.

Z6 reduces the demand for energy to heat the house with passive solar heating. Large deck overhangs provide shading to prevent solar heat gain from the summer sun while window glazing, which covers 73% of the building envelope, allows direct solar gain to heat up the concrete floors on the first level.[3] Z6 also employs an isolated gain approach where a solar hot water collector powers a hydronic radiant floor heating system (Figure 2). Hydronic radiant heating systems are the most popular and cost-effective for climates like coastal California where mild heating in the winter is an important issue.[4] Radiant heating is more efficient than baseboard heating and forced

[3] American Institute of Architects. "Top Ten Green Projects." 2007. http://www.aia.org/SiteObject/files/Z6House_12pg.pdf. pg. 5.
[4] U.S. Department of Energy Efficiency and Renewable Energy. "EERE Consumer's Guide: Radiant Heating." http://apps1.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12590.

air heating because no energy is lost through ducts.[5] The passive solar heating works synergistically with the open plan and a whole-house fan drawing air up through the top of the home. Operable windows and doors on the southwest, southeast, and northeast facades provide natural ventilation and the fan helps draw hot air out of the building in a "chimney effect" (Figure 3). As a result, air moves in such a way that these two features are effective in cooling one hundred percent of the house, thereby reducing the demand for energy required to cool the house.[6] This seems reasonable and comfortable for a coastal California climate because it is dry with low humidity and ample breeze.

The architect of Z6 further reduces energy demand with Energy Star rated appliances and a low energy usage lighting system. One hundred percent of the building is daylit with natural light from skylights and floor-to-ceiling glass (Figure 4). An integrated home automation system controls this lighting system, which uses light emitting diode (LED) lights. LED lights use one tenth of the power of an incandescent bulb and can last up to 30,000 hours. A 2.4-kilowatt photovoltaic array power these lights by providing between sixty and seventy-five percent of the home's energy usage (Figure 5).[7] While research has highlighted how daylighting can significantly increase human health and performance,[8] floor-to-ceiling windows can be a source of discomfort when solar glare interferes with visibility. As a result, an individual is forced to turn on electric lights, thereby negating the energy-saving and health-promoting benefits of daylighting.



[5] Ibid.
[6] American Institute of Architects. pg. 5.
[7] Ibid.
[8] Ternoey, Steven E. "Daylight Every Building." http://www.daylighting.org/pubs/daylight_every.pdf

Figure 2. Illustration of Concept of Isolated Heat Gain in a Solar Collector. Source:www.azsolarcenter.com

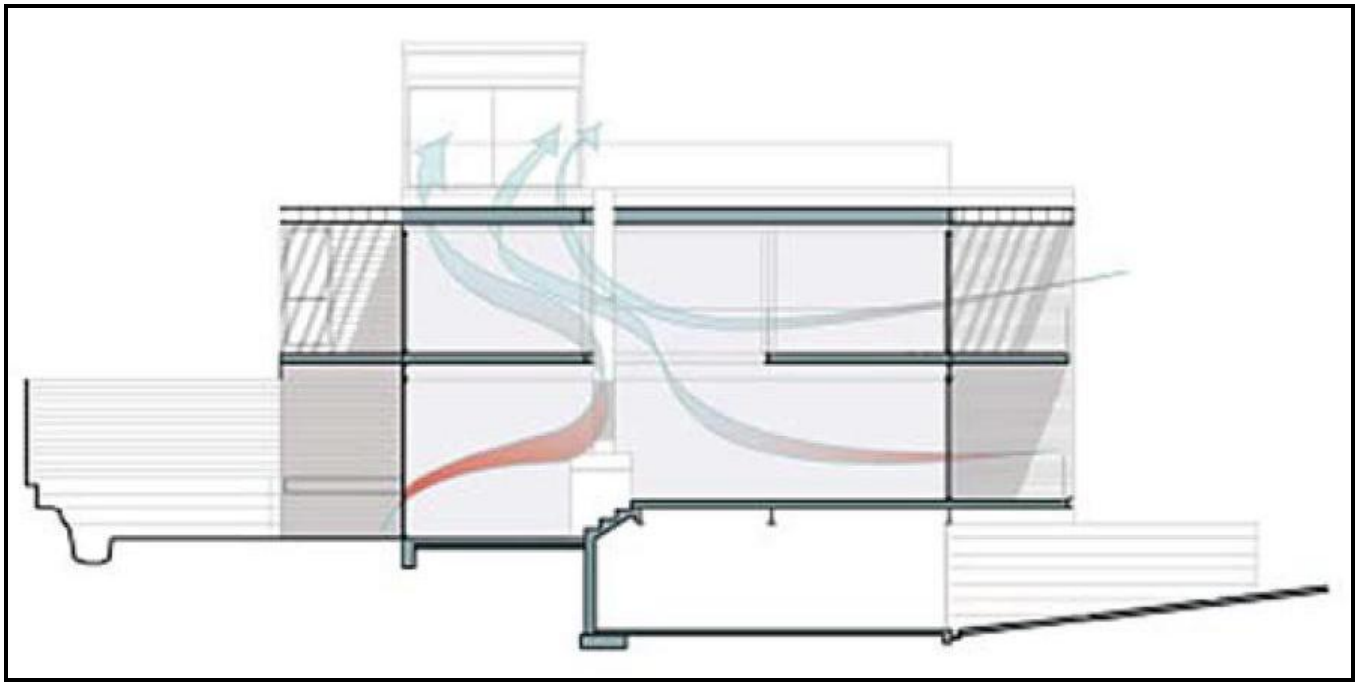


Figure 3. Natural Ventilation and Solar Shading Diagram. Source: American Institute of Architects

Figure 4. Floor-to-Ceiling Windows Emit Plentiful Daylight. Source: www.livinghomes.net

Figure 5. Photovoltaic Array at Z6. Source: www.livinghomes.net

Water Efficiency

Z6's maximum score in water efficiency is a direct result of the design's emphasis on reduction, reclamation, and reuse in an effort to achieve zero water. A design that focuses on this cycle is definitely sustainable because water is a critical component of all life on Earth and even the economy. This is an important consideration for Z6 because not only does landscaping consume fifteen percent of all water use, but also Santa Monica is part of a region where scarcity of water and water supply is a growing concern. In Z6, a 3,500-gallon cistern captures rainwater collected from the roof or stormwater diverted from site drains in swales.[9] This prevents pollutant-carrying runoff from flowing to nearby bodies of water. The cistern also collects the grey water from baths, sinks, and dishwashers for use in a subterranean irrigation system. This system efficiently pumps water to the green roof or to ground level landscaping where plants filter this

[9] American Institute of Architects pg. 4.

grey water. The irrigation system reduces demand for water because a device monitors humidity in the atmosphere to prevent irrigation when it is raining and water is pumped up through the roots of native, drought-resistant plants as opposed to the surface. Native plants are easier to maintain and require less care. The design further reduces demand with low-flow plumbing fixtures throughout the house.

Materials and Resources

Buildings affect the Earth directly through their use of resources. We live in a world of finite resources and of increasingly limited spaces available to which we can dispose of those resources. In pursuing the concept of zero waste, Z6 was more likely to eliminate waste from every stage of the building life cycle and this is why it actually exceeds the LEED requirements in this category. In addition to reusing materials left from site clearance, Z6's prefabricated components reduce waste and energy consumption because factory production is a more efficient process (Figure 6). In a conventional wood-framed home, between thirty and forty percent of the materials used end up in a landfill. Z6 generated only ten percent of that number in landfill-destined materials.[10] Furthermore, Z6 is comprised of modular components that are built to last. The fact that it is possible to disassemble and move the house would reduce waste, if it were necessary. The modular components in combination with an open floor plan allow the inhabitants of Z6 to easily reconfigure the floor plan without wasting new building materials. Since these components are also long lasting, Z6 requires less replacement materials and finishes, both of which would require more of Earth's limited resources.[11] The architect employed materials based on the level of environmental impact of their manufacture as well as recycled or renewable materials in countertops, tiles, and steel framework.

[10] American Institute of Architects pg. 9.
[11] http://www.livinghomes.net/zeroWaste.html

Figure 6. On-Site Assembly of Prefabricated Components. Source: www.livinghomes.net

Indoor Air Quality

Indoor air quality corresponds with Z6's mission to achieve zero emissions. This means designing to eliminate the sources of harmful gases and compounds through off-gassing, the process by which volatile organic compounds (VOCs) evaporate into the spaces in which we work, sleep, cook, and play. This leads to poor indoor air quality, which, according to the EPA, costs Americans $1.5 billion in medical bills and tens of billions in lost productivity.[12] Z6 protects occupant health with low- or no-VOC paints, millwork, and other finishes. The floor plan also has an indoor garden, which supposedly emits oxygen and filters the air. To some, this may seem like an innovative feature to help reduce your ecological footprint. To me, it is more of a "greenwashing" technique that helps market the building.

Location and Linkages and Sustainable Sites

Where you site a home and how you go on to manage the resources on site is critical from an environmental persepctive. Z6 used zero carbon as a guiding concept to earn a maximum score in both location and linkages and sustainable sites. Public transportation stops within a quarter-mile of the house and grocery stores, schools, parks, and other services are available within

[12] Spiegel, Ross and Dru Meadows. *Green Building Materials: A Guide to Product Selection and Specification*. New York: Wiley, 1999. pg. 22

walking distance.[13] It earns points for being an infill site with native plants and lack of grass, but it is a 3,500 square-foot single family home built on a lot zoned for a multi-family use. While this does not detract from its high level of sustainability, it would have been more sustainable if the site had been developed to accommodate a higher density.

Homeowner Awareness

While this category is only worth 1 out of 109 points on the LEED for Homes scale, this is arguably the most important category because it empowers the occupants of any home to live out the values of sustainability that their home represents (Figure 7). Besides an integrated home automation system and an owner's manual to educate the owner how to optimize the performance of the building, there is also a comprehensive real-time monitoring system that tracks total usage of all water as well as total energy consumption and production.[14] As a result, Z6 has fully implemented its zero ignorance concept. In an effort to promote awareness of the possibilities for green design in homes, those responsible for the development of LEED ratings might improve this category by introducing a credit for a comprehensive but voluntary neighborhood education about the building.

Figure 7. Photo of Home Automation System to Control Lighting and Other Features. Source: www.livinghomes.net

[13] American Institute of Architects pg. 3.
[14] American Institute of Architects pg. 11

Evaluating LEED as a Rating System

Since its conception in 2000, LEED has certainly lived up to its original mission of transforming the real estate market place to allow green architecture to become a reality. As of September 2007, three were over 1,1000 LEED-certified commercial projects and 6,000 projects registered for future LEED certification, with a 60% increase in the number of certified projects in 2007 alone.[15] It is easy to see how LEED has become so widespread. LEED has an intuitive category system that is relatively easy to understand, appeals to the competitive nature of America with its varying levels of certification among project types, and has created the presence of a brand as a means of comparison in a highly competitive marketplace.[16] LEED's comprehensive categories and the LEED brand are the two biggest contributors to its success (Figure 8).

[15] Judelson, Jerry. "LEED-ing the Way." October 24, 2007. United States Green Building Council. http://www.usbgc.org/News

[16] Building Design and Construction. "White Paper on Sustainability: A Report on the Green Building Movement." November 2003. pg. 4.

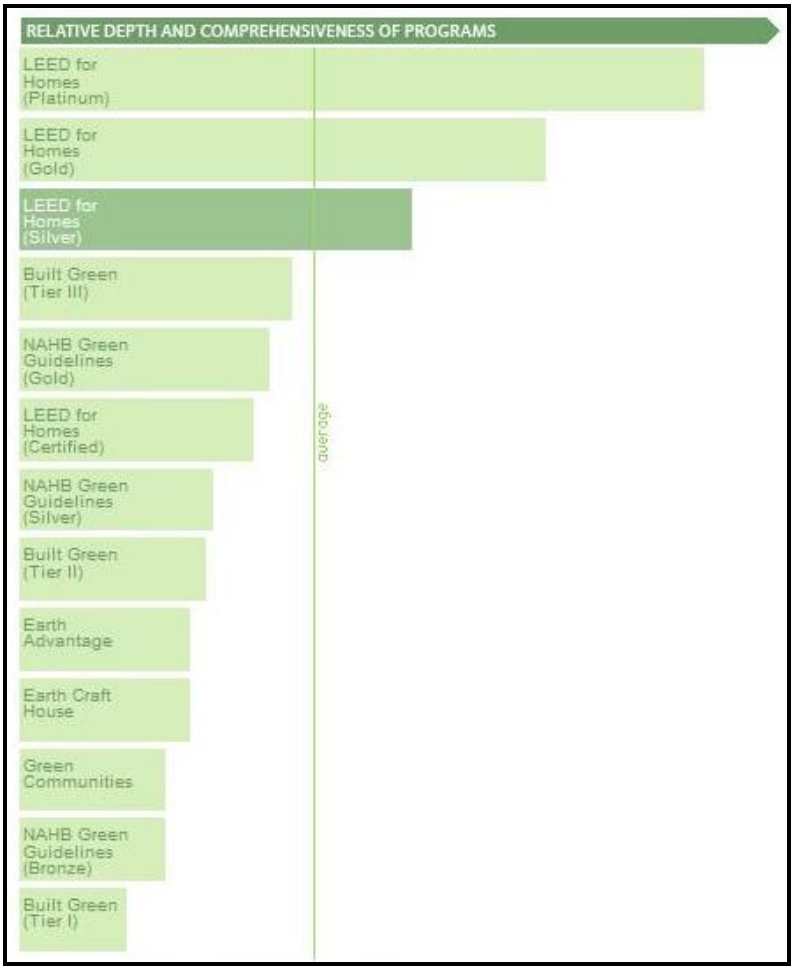


Figure 8. Comparison of Green Building Rating Systems. Source: The Brendle Group, Inc.

LEED is not without its flaws, however. The two most fundamental criticisms of the current LEED framework are its bioregional insensitivity and a weak connection to life-cycle analysis (LCA).[17] A major tenet of sustainable design is that design strategies must be local. A consequence of a points-focused system is that less environmentally conscious design teams may choose the least expensive strategies recognized by LEED to simply earn a credit, even if the strategies are not the most appropriate for addressing local conditions.[18] Furthermore, the point mongering does not encourage a sophisticated LCA to measure material resources and energy consumed throughout the life of a building. For example, in a renovation project, "developers can save more material resources by reusing 75% of an existing structure and shell…than by incorporating at least 5% of salvaged or reused building materials, but both strategies earn one

[17] Solomon, Nancy B. "How is LEED Faring After Five Years in Use?" *Architectural Record*, June 2005.
[18] Ibid.

point in the LEED rating."[19] Frustrations with bureaucracy-imposed costs of certification, time, and paperwork as well as confusion with energy modeling add to the list of complaints.[20]

Conclusion

The LEED rating system will likely remain a driving force of the transformation of real estate markets and design practices. According to one professional, "no other tool has been as powerful in encouraging designers and builders to look at the environmental performance of buildings."[21] Hopefully, the benefits from the values and strategies that LEED-certified buildings like Z6 espouse will continue to encourage designers, builders, researchers, and product manufacturers to focus on creating economies of scale in the green building industry. Economies of scale in green building will help address issues of affordability that arise in high performing buildings like Z6. Furthermore, government at all levels should work together to encourage and possibly even require LEED certification as a way to spur a green building revolution. Whatever the system may eventually be chosen, it must promote actions that consider the finite, cyclical matter of nature. At this point, LEED certification is only option. Green buildings, on the other hand, are essential and inevitable.

[19] Quoted in Solomon.
[20] Udall, Randy and Auden Schendler. "LEED is Broken- Let's Fix It." *iGreenBuild.com*, 9 August 2005.
[21] Solomon.

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