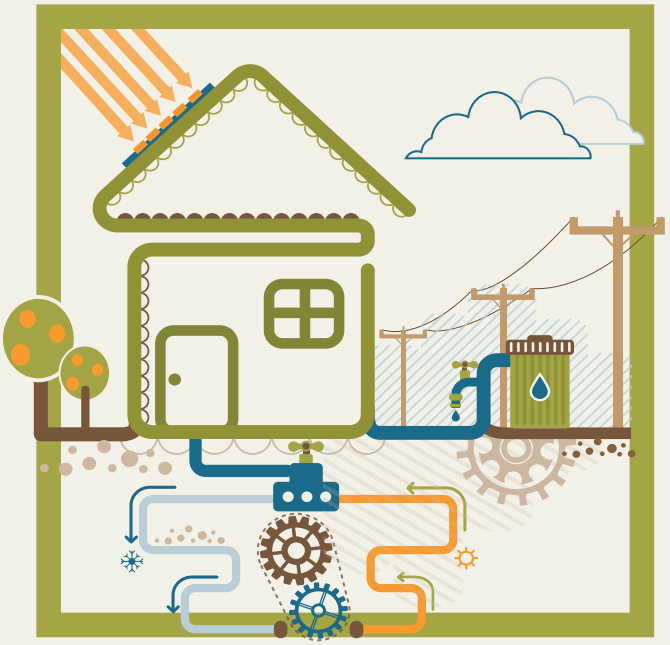
CREATING THE CLEAN ENERGY ECONOMY

Analysis of the Net Zero Energy Home Industry



INTERNATIONAL ECONOMIC DEVELOPMENT COUNCIL

The Power of Knowledge and Leadership

Creating the Clean Energy Economy

Analysis of the Net-Zero Energy Home Industry

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INTRODUCTION TO NET-ZERO ENERGY HOMES

In 2008, the most recent year for which data is available, the United States was the highest consumer of energy in the world. Buildings are a major consumer of energy in the U.S., and their share of consumption is growing. In 2008, building energy consumption was 50 percent higher than in 1980. Taken together, industrial and residential buildings currently account for approximately 40 percent of primary energy use in the U.S. The residential sector alone accounts for approximately 20 percent of total energy consumption in the U.S.[1]

Interestingly, while absolute levels of consumption have risen in recent years, residential buildings have actually become more energy efficient over time. For example, homes built between 2000 and 2005 used 14 percent less energy per square foot than homes built in the 1980s. They also utilized 40 percent less energy per square foot than homes built before 1950.[2] While current energy efficiency techniques such as weatherization, high-efficiency appliances, and HVAC systems—and widespread adoption of compact fluorescent lighting (CFL)—is helping to reduce energy use in homes, these measures are not keeping up with increases in total U.S. energy consumption. This disparity creates an opportunity for further implementation of energy efficiency and energy generation systems in U.S. homes as well as the further development of associated energy efficiency and generation industries. These development opportunities can maximized by encouraging development of highly efficient homes known as net-zero energy homes (NZEH).

Net-zero energy homes (NZEH) produce as much or more energy than they consume over the course of a year. This type of housing represents a growing segment of the housing construction and retrofit market in the U.S.; consumer demand for energy efficiency as well as public policy have fueled this growth. For example, a National Association of Home Builders Research Center consumer study of over 400 homeowners in Dallas, Texas found that 88 percent of respondents were interested in a zero-energy home if utility savings were sufficient to offset an increase in

[1] U.S. Department of Energy. (2011a, July 29). Building America: Program Goals. Retrieved March 2, 2012, from http://www1.eere.energy.gov/buildings/building_america/program_goals.html
[2] Ibid.

monthly mortgage payments. In addition, the U.S. Department of Energy's (DOE) Building Technologies Program, which promotes increased building efficiency in the commercial and residential sectors, has set a target date of 2020 for the availability of marketable net-zero energy homes.[3]

Achieving the DOE's goal will require changes and greater levels of efficiency in existing building technology, use, and design. Achieving these changes will require additional investment in research, design, and installation to make NZEH affordable to the general market. Currently, homeowners who install commercially available energy efficiency features in a home can typically expect a 60-70 percent reduction in energy use (sometimes as high as 80 percent) over conventional homes. While this is a significant step toward achieving the net-zero energy (NZE) goal, it still leaves a deficit of energy consumed. Energy efficiency alone, therefore, is not enough to achieve NZE; achieving net-zero requires the deficit in energy consumption to be balanced with clean energy generation. [4]

Developing NZEH is often discussed in the context of new construction, and while the retrofit market is not the most cost-effective strategy for achieving NZE, it does present a significant opportunity for job creation and investment in energy efficiency industries related to the net-zero market. More of the current housing stock consists of retrofit opportunities than new construction. In March 2012, there were an estimated 48.4 million units of single-family housing, of which 61% were built before 1980. These units are associated with higher energy use and, therefore, a greater opportunity for retrofitting.[5] The potential economic impact of increasing energy efficiency in these homes is significant. Achieving an energy efficiency improvement of just 30% in this pre-1980 housing stock could create an estimated investment opportunity of $144 billion and is associated with an estimated 1,700 job-years (where one job-year is equivalent to one job for one year.)[6] Architecture 2030, an independent nonprofit organization, has developed employment and revenue projections for several proposed NZEH and high efficiency incentive

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[3] U.S. Department of Energy. (2010). *Building Technologies Program: Better Buildings, Brighter Future*. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/btp_fs.pdf.
[4] Ed Mazria. (14 August 2012) Phone interview.
[5] Rockefeller Foundation and DB Climate Change Advisors (2012, May). *United States Building Energy Efficiency Retrofits, p.* 18. Retrieved from http://www.rockefellerfoundation.org/news/publications/united-states-building-energy-efficiency
[6] Ibid, 14

programs.[7] The organization's 2009 analysis of a proposed nation-wide $30 billion mortgage buy-down for homes that meet specific energy efficiency criteria can create 4.5 million new jobs, $280 billion in direct, non-federal investment spending, and will open a $5.7 billion renovation market that could increase to nearly $1 trillion by 2030.[8]

The market for new homes is smaller than in the past but still presents a future growth opportunity for NZEH as the market share of energy efficient homes increases. The new green homes market grew to 17 percent in 2011 from eight percent in 2008, and it is expected to comprise 29-38 percent of market share by 2016.[9] Although this statistic is in reference to the green home market, which consists of a broader and less energy efficient housing type than NZEH, energy efficiency is one of the most important aspects of a green home and therefore hints at the growth potential of the NZEH market.[10] In addition, experts from the housing firm KB Home, as well as nonprofit Architecture 2030, believe that new construction represents the most cost-effective opportunity for achieving net-zero energy.

While the technology necessary for NZEH already exists, the NZEH market is still in the early stages of development and in need of policies supportive of the development of marketable net-zero energy homes. To this end, the Federal Government has established goals to encourage greater adoption of energy efficiency and net-zero energy technologies. The Department of Energy's Building Technologies program, for example, set a goal for 20-30 percent reduction in energy use in existing homes by 2020 and a 50 percent reduction by 2030.[11] Such programs, in combination with other leadership efforts such as Executive Order 13514, which directs federal agencies to achieve net-zero energy use in new construction and renovations by 2030, and the

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[7] Architecture 2030. (2011). About Us. Retrieved from http://architecture2030.org/about/about_us
[8] Architecture 2030. (2009, October 1). *The One-Year, 4.5-Million-Jobs Investment Plan*. Retrieved from http://architecture2030.org/hot_topics/one_year_4_point_5_million_jobs_plan.
[9] McGraw-Hill Construction. (2012). *New and Remodeled Green Homes: Transforming the Residential Marketplace*. Bedford: McGraw-Hill. p.1
[10] Ibid, p. 40
[11] U.S. Department of Energy. (2011b, July 29). Building Technologies Program: About the Program. Retrieved March 2, 2012, from http://www1.eere.energy.gov/buildings/about.html

U.S. Army's initiative to establish five net-zero installations by 2020 with 25 installations by 2030, represent a federal-level commitment to developing net-zero energy homes and buildings.[12, 13]

Many states have proposed or approved regulations that support development of the NZEH market. In May of 2013, Colorado passed the Colorado Energy Saving Mortgage Program, which makes homebuyers purchasing a new or renovated NZEH (HERS 0[14]) eligible for $8,000 in savings off the home mortgage. In addition, a new or renovated home with a HERS rating of 0-50 is also eligible for a mortgage reduction. Through this program, each $1 million in incentives is expected to generate $16.22 million in direct spending, $16.49 million in indirect and induced spending, and $1.92 million in state and local government tax revenue.[15] New York's Assembly considered a similar program under which a homebuyer would receive a $5,000 tax credit for purchasing a HERS 50 home, a $7,500 tax credit for a HERS 25 home, or $10,000 for a NZEH.[16]

California is emerging as the leader in state-level support for NZEH. The California Building Energy Efficiency Standards (Title 24, Part 6), set a goal of reaching NZEH in new residential buildings by 2020 (the goal for new commercial construction is 2030). While the original energy efficiency standards required residential construction to adhere to a California-specific HERS 100 rating, subsequent years have brought enhanced requirements. The 2012 code, which goes into effect this year, offers builders two tiers of compliance: achieving either 15 or 30 percent additional energy efficiency over 2008 requirements. The 2016 code, which is expected to go into effect in 2017, will require a baseline energy efficiency of HERS 30. With the addition of energy generating systems, a HERS 30 home can easily achieve net-zero energy.[17]

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[12] The White House, Office of the Press Secretary. (2009). Executive Order: Federal Leadership in Environmental, Energy, and Economic Performance. p. 4 [Press release]. Retrieved from http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf

[13] Army Energy Program. (26 June 2012) *Army Vision for Net Zero*. Retrieved from http://army-energy.hqda.pentagon.mil/netzero/

[14] The Home Energy Rating System (HERS), is a nationally accepted method for measuring a home's energy performance relative to standard new construction. Standard new construction homes are rated 100; a HERS 70 home is 30 percent more efficient than standard construction.

[15] Architecture 2030. (2013). *Colorado's ZNE Good Lays Golden Eggs*. Retrieved from http://architecture2030.org/enews/news_061313.html.

[16] WBNG News. (17 May 2013). *Lifton introduces "Green" tax credit bill for homebuyers*. Retrieved from http://www.wbng.com/news/local/Lifton-introduces-Green-tax-credit-bill-for-homebuyers-207930421.html.

[17] Ed Mazria. (7 July 2013). Phone interview.

Since California is an exceptionally large market, the state's policies have the ability to become a driver for the adoption of NZEH in other areas. By setting a goal of NZEH for all new homes by 2020, California is incentivizing home builders, NZEH component manufacturers, and energy companies to find ways of incorporating NZEH into existing structures.[18] The lessons learned and efficiencies gained during this process can make achieving NZEH a less expensive and logistically challenging proposition for homebuyers, builders, developers, and utilities in the future.

Benefits of Net-Zero Energy Homes

When compared with conventional homes, NZEH have a variety of economic and environmental benefits at the individual, community, and societal levels.

Benefits for the Building and Construction Industry

Net-zero homes can increase profits for builders and developers since they often sell faster and at a higher price than conventional homes. By integrating net-zero energy technology into home construction, builders also have the opportunity to capitalize on their role as early adopters and get a head start on building relationships with other energy efficiency and clean energy businesses. It would appear that some builders are already taking advantage of this opportunity to enter a growing industry. A 2011 survey of 416 residential homebuilders, developers, and remodelers found that construction firms expect to carry out an increasing number of green construction projects in the future. This survey found that in five years half of respondent builders expect more than 60 percent of their new home projects to be green, which is nearly double the number currently building such projects. In addition, the percentage of remodelers expecting to have more than 60 percent of their projects be green is 34 percent, which is more than double the 13 percent currently working on such a large share of green projects.[19] This increase in the expected number of green projects is accompanied by an increase in market share for residential green building. In 2011, the share of new green homes increased to 17 percent of the market,

[18] Ibid.

[19] McGraw-Hill Construction. (2012). *New and Remodeled Green Homes: Transforming the Residential Marketplace*. Bedford: McGraw-Hill. p.4.

which is more than double the share found in 2008. Further, the share of new green homes is expected to increase to 22-25 percent by 2013, representing a $32-$36 billion opportunity.[20]

Benefits for Communities

An increased reliance on clean energy, especially when coupled with lower demand for energy from non-clean sources, can lead to lower emission levels, a cleaner environment, and a less vulnerable energy infrastructure. There is also a cost advantage for homeowners and communities that adopt NZEH. Since these homes are less dependent on the local electricity grid, communities can serve more people with existing energy generation resources. In addition, if homeowners are spending less money on energy costs, there is more disposable income to spend in the community.

Developing more NZEH will require a workforce trained in energy efficiency and energy generating systems, and many of these industries are already growing in consumer demand and employment. In 2010, for example, residential solar installations increased by 64 percent, with growth rates over each of the past five years of 33 to 103 percent.[21] Employment in this sector is also growing. In 2011, The Solar Foundation, a nonprofit that promotes the solar industry through research and education, sampled solar employers throughout the U.S. as part of their National Solar Jobs Census 2011. They found that, as of August 2011, there were 100,237 solar workers (workers who spent at least 50 percent of their time on solar projects) in the U.S., an increase from 93,000 the previous year. This represents an overall growth rate of 6.8 percent, significantly higher than the national average employment growth rate of 1.7 percent for the same time period. The Solar Foundation anticipates continued growth in the solar industry with a 12-month employment growth projection of 24 percent or approximately 24,000 jobs.[22] This number accounts for all solar workers, but the growth trend has implications for future opportunity and growth in solar jobs for NZEH projects.

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[20] Ibid, p.8.
[21] Sherwood, L. (2011). *U.S. Solar Market Trends 2010*. Interstate Renewable Energy Council. p. 6. Retrieved from http://irecusa.org/wp-content/uploads/2011/06/IREC-Solar-Market-Trends-Report-June-2011-web.pdf
[22] The Solar Foundation. (2011, October). *National Solar Jobs Census 2011*. p. 4. Retrieved from http://www.thesolarfoundation.org/sites/thesolarfoundation.org/files/TSF_JobsCensus2011_Final_Compressed.pdf

Benefits for Homeowners

When compared with conventional homes, net-zero homes tend to have comparatively lower, more predictable energy bills and reduced energy demand due to energy efficiency measures. This creates extra monthly income that can be put toward a larger mortgage payment or other spending needs. Many net-zero homes have appreciated faster and sold for a higher price than comparable traditional construction, so homeowners may benefit from greater appreciation on the home's original sales price during the resale process. Net-zero homes also feature increased availability of energy use information through net metering as well as advanced HVAC systems, which can empower homeowners to use energy more strategically, resulting in lower energy bills.

Benefits for Utility Companies

Utility companies have a dynamic role in the net-zero home market. Since net-zero homes consume less energy from the utility, investment in this type of construction could allow utility companies to serve more homes with existing plant capacity. In addition, net-zero homes can help with peak load management since they do not have the same energy profiles as conventional homes, thereby decreasing the need for expensive, inefficient "peaker plants." In order to take advantage of the benefits of net-zero energy homes, utility companies need the infrastructure required to receive and monitor the clean energy generated from individual homes as well as a pricing structure that will allow the utility to pay homeowners for the energy they generate.

The benefits of net-zero homes are clear, but the net-zero industry is still developing and faces challenges in technology development, identifying clear cost/benefit structures, and market acceptance by builders, developers, and homebuyers. Despite the challenges, continued federal investment though tax incentives, research and development initiatives such as the Department of Energy's Builders Challenge program, and ambitious goals such as the Department of Defense's recent commitment to net-zero energy at five installations by 2020, indicate that the share of net-zero homes is well-positioned for future growth.

Net Zero Energy Definitions

As discussed, there are several national-level goals pertaining to net-zero energy homes. However, there is not a straightforward or standard process for determining whether a home actually is NZE. This has important implications for measuring the effectiveness of NZE programs.

A variety of methods can be used to measure whether a home has achieved NZE, but the methodologies differ based on factors such as the metric used to measure energy use as well as where and how energy use is measured. For example, most strategies for calculating NZE only measure electric energy consumption rather than considering both gas and electric energy use. The four definitions most commonly applied to net-zero energy homes are: net-zero site energy, net-zero source energy, net-zero energy costs, and net-zero energy emissions. A detailed look at each of the definitions is below.[23]

Net-Zero Site Energy: A net-zero site energy home produces at least as much clean energy on-site as it uses in a year.

Net-Zero Source Energy: A net-zero source energy home produces at least as much clean energy as it uses in a year, as accounted for at the energy source. The "energy source" refers to the primary energy used to extract, process, generate, and deliver the energy to the homeowner's site. In this scenario, imported and exported energy are multiplied by the appropriate site-to-source multipliers.

Net-Zero Energy Costs: In a net-zero energy cost home, the amount of money the energy utility pays the building owner for the energy the building contributes to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

Net-Zero Energy Emissions: A net-zero energy emissions home produces or purchases at least as much emissions-free clean energy as it uses from emissions-producing energy sources. The most commonly measured emissions are carbon, nitrogen oxides, and sulfur oxides.

This report will focus on the net-zero site energy method in which a home produces at least as much clean energy on-site as it uses in a year, since this is the approach used most often by businesses and institutions to measure net-zero energy buildings. Net-zero site energy is also the

[23] Crawley, D., Pless, S., & Torcellini, P. (2009). Getting to Net Zero. p. 3 *ASHRAE Journal*. Retrieved from http://www.nrel.gov/docs/fy09osti/46382.pdf; P. Torcellini, S. Pless, M. Deru, & D. Crawley, 2006, p. 5

metric used by the Department of Energy and Department of Defense's net-zero efforts. There are several benefits associated with the net-zero site energy metric.[24]

- Industry familiarity: Many in the NZE industry already using net-zero site energy, including the Federal Government.
- Data reliability: Existing technology allows for easy and accurate measurements of energy use and generation within a single home.
- Owner impact: Measuring energy generation and consumption on-site gives a homeowner the opportunity to proactively impact a home's energy performance.

The shortcomings of using the net-zero site energy definition include: [25]

- An incomplete energy use profile. Many net-zero site energy calculations only measure the amount of electricity generated and consumed rather than including additional sources of energy consumption such as natural gas.
- External environmental costs. Net-zero site energy also does not account for any pollution incurred during the acquisition of non-clean energy.

Potential of Net-Zero Energy Homes

Net-zero energy homes are technically feasible today. If the cost of energy continues to rise as anticipated, net-zero energy homes are poised to become competitive with conventional construction. This is especially likely when utility costs are included in the cost of homeownership.[26] However, the timeline for market competitiveness is long-term. As with other building sector technologies and practices, the market for net-zero homes is expected to require 20-30 years to reach maturity. The National Association of Home Builders Research Center estimates that zero-energy homes will require a decade-long initial growth period, followed by a period of rapidly

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[24] P. Torcellini, S. Pless, M. Deru, & D. Crawley. (2006). Zero Energy Buildings: A Critical Look at the Definition. p. 11 Presented at the ACEEE Summer Study, Pacific Grove, CA: National Renewable Energy Laboratory. Retrieved from http://www.nrel.gov/docs/fy06osti/39833.pdf

[25] Ibid.

[26] NAHB Research Center. (2006). *The Potential Impact of Zero Energy Homes* (No. EG5049_020606_01). p. 1 National Renewable Energy Laboratory. Retrieved from http://www.toolbase.org/pdf/casestudies/zehpotentialimpact.pdf

accelerating growth for another decade, before reaching a stable market level of saturation, estimated at 70 percent of all housing stock.[27]

Although it will take decades for the net-zero energy homes market to reach its full market potential, a study by the National Association of Home Builders (NAHB) Research Center and the National Renewable Energy Laboratory (NREL) has shown that short-term actions can have a dramatic effect on the future of the net-zero home industry. The study looks at three scenarios to analyze the impact of net-zero homes on the single-family home market as well as the effect of each scenario on residential energy consumption through 2050. The baseline scenario assumes current residential energy consumption levels continue into the future without any major change in energy efficiency or consumption cost. This is compared with three reference cases:

1) The first reference case assumes that photovoltaic (PV) costs decrease and PV systems are therefore included in new homes.
2) In the second case, new homes are zero-energy and rely on a combination of energy efficiency, solar water heating, and PV technologies.
3) In the third case, new homes are offered with the same zero-energy combination as in case two, but come with a solar tax credit of 30 percent.

An analysis of the third case scenario shows that net-zero energy homes will begin to penetrate the market 33-35 years earlier than the first reference case (PV only) with market saturation by 2050. This is coupled with a 17 percent reduction in energy use among all single-family homes. In addition, net-zero energy homes could represent 67 percent of the new housing starts (construction) should case three be implemented. That rate decreases to 20 percent in case two, and net-zero energy homes are an insignificant portion of new homes in the reference case.[28]

As these scenarios show, the speed at which net-zero energy homes enter the marketplace, as well as their level of representation in the housing stock, is highly dependent on the way in which zero-energy homes are sold and financed. Bundling net-zero energy strategies with a 30 percent tax credit will expedite the entry and dominance of net-zero energy homes. As the degree of

[27] NAHB Research Center, 2006, p. 15
[28] Kenney, T., & Wiehagen, P. E. J. (2007). Zero Energy Homes—The Potential of Large-Scale Implementation. p. 6

coordination between net-zero energy strategies and tax incentives declines, so does the speed and degree of market integration.

Strategies for Achieving Net-Zero Energy

Achieving net-zero energy is a customizable process that involves a balance between energy efficiency strategies and on-site energy generation from clean energy sources. The precise level of investment in energy efficiency and clean energy generation needed to achieve net-zero energy depends on factors such as a particular home's external environment, budgetary constraints of the developer or buyer, and the requirements of a home's design or the local building code. A home in the southwest United States, for example, will be able to generate more power from solar photovoltaic (PV) panels than a home located in the Northeast, and both of these homes would require more investment in insulation against energy loss than a home located in a more temperate climate. Every home or development must be considered individually when identifying the proper strategies to reach net-zero energy in a cost-effective way that fits with the needs and expectations of the local market regarding factors such as overall quality, design, and energy use.

On average, a net-zero energy home must be 50-60 percent more energy efficient than a traditional home and have a photovoltaic (PV) capacity of at least 4.8-7.6 kW in order to achieve net-zero energy.[29] When designing a net-zero home, builders will often seek to maximize energy efficiency before examining options and needed capacity for energy generation. Examples of typical zero-energy strategies (summarized in Table 1) can be applied to new home construction as well as home retrofits. While these strategies are generally applicable, as mentioned previously, the precise combination used in a particular home or development will differ by region according to place-based factors such as the cost of materials and energy as well as the climate.[30]

[29] Kenney & Wiehagen, 2007, p. 2
[30] Ibid

Table 1: Strategies for Achieving Net-Zero Energy in Homes

Strategy	Energy Efficiency	Energy Generation
Building Design		
Strategic Siting	✓	
Interior Layout (open layout, takes siting into consideration)	✓	
Building Envelope (proper insulation, high-efficiency windows, climate-appropriate foundation, roof, doors)	✓	
Systems		
Lighting (CFLs, on/off timers or sensors)	✓	
Appliances (Energy Star rated)	✓	
HVAC/Climate Control (Programmable thermostat, real-time feedback)	✓	
Photovoltaics		✓
Solar heating		✓
Other (small-scale wind or hydro, biofuel, etc)		✓

Hurdles

The benefits of net-zero energy homes are far-reaching, but several major obstacles need be addressed for this industry to move forward.

Education

Many builders and homeowners are unaware of the benefits of net-zero homes. With a greater understanding of the benefits of this type of construction and how net-zero homes work, however, there might be higher customer demand as well as willingness on the part of builders to develop NZEH. As awareness of NZEH benefits develops, builder and developer sales staff will become more confident marketing the net-zero features, and buyers might be more comfortable purchasing a house with new technology. In addition, if policy makers and utilities were more aware of the economic and community benefits of net-zero energy homes, they might be more willing to support these projects.

Cost

Cost is another factor hampering the growth of the net-zero home market. When constructing a net-zero home, builders must account for higher up-front costs, which means higher carrying costs and increased pressure to sell net-zero homes quickly. Obtaining the financing necessary to compensate for the additional cost of a net-zero home may be difficult, as energy efficiency features are not often reflected in a home appraisal, and estimations of energy savings, which might allow for a higher loan approval amount, can be imprecise.

Uncertain Regulatory Environment

An uncertain regulatory environment further complicates investment in net-zero technology. Builders and homeowners do not have the assurance of an ongoing incentive or rebate program for the purchase of PV panels, and not all utility companies offer a net metering program for homeowners with on-site clean energy generation. A detailed description of the hurdles facing the net-zero energy industry, and potential solutions to address many of those hurdles, is included in chapter two of this report.

JOB CREATION POTENTIAL OF NET-ZERO ENERGY HOMES

Current Job Market

Like the larger clean economy, the net-zero energy homes industry is comprised of a conglomeration of existing sectors in the construction and real estate industries. While data from the Bureau of Labor Statistics does not differentiate between net-zero or nearly-zero-energy homes and conventional homes, it is useful to look at the occupations associated with the construction of NZEH to get a feel for the size and earning potential of occupations that could be applied to NZEH projects (Table 2 below). These occupations were chosen based on job classifications identified in the Brookings-Battelle Clean Economy Database, which is part of the Brookings Institution's 2011 Sizing the Green Economy Study, as well as conclusions drawn from IEDC research on the requirements of net-zero energy homes.

Table 2: Current Employment in the NZEH Sector by Occupation (potential sources, 2011)

Occupation	Number Employed	Mean Hourly Salary	Mean Annual Salary
All Occupations	127,097,160	$21.35	$44,410
Appraisers and Assessors of Real Estate	62,560	$26.07	$54,230
Architects, Except Landscape and Naval	87,700	$37.75	$78,530
Architectural and Engineering Managers	174,720	$60.53	$125,900
Carpenters	620,410	$21.10	$43,890
Construction and Building Inspectors	89,270	$26.11	$54,320
Construction Laborers	777,700	$16.15	$33,590
Construction Managers	191,430	$45.31	$94,240
Electrical and Electronic Equipment Assemblers	180,440	$14.96	$31,110
Electricians	514,760	$24.91	$51,810
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	224,320	$21.57	$44,860
Helpers- Carpenters	46,910	$12.93	$26,890
Helpers- Electricians	72,390	$13.61	$28,300
Helpers- Roofers	12,310	$11.75	$24,450
Helpers, Construction Trades- All Other	19,570	$13.29	$27,650
Insulation Workers, Floor, Ceiling, and Wall	23,380	$17.37	$36,120
Insulation Workers, Mechanical	28,100	$20.49	$42,620
Interior Designers	40,120	$25.05	$52,100
Operating Engineers and Other Construction Equipment Operators	334,730	$21.55	$44,830
Real Estate Agents	153,740	$25.24	$52,490
Real Estate Brokers	41,210	$36.57	$76,060
Roofers	99,280	$18.21	$37,880

Source: United States Department of Labor, Bureau of Labor Statistics, 2011

The current job market for the NZEH sector can also be explored by industry segment. Segments of the green economy applicable to the net-zero home industry include employment opportunities for both college-educated workers as well as those with just a high school diploma. An analysis of sectors by the share of jobs that are green collar (middle wage and skill level), as well as the share of jobs that require educational attainment at the high school diploma level or less, is

below. In this instance, green collar jobs are defined as those with a wage within 20 percentage points of the national median wage of $33,190 (i.e. $26,553-$39,828).[31]

Table 3: Potential Sources of NZEH Employment by Industry Segment

Segment	Share of Jobs That Are Green Collar (percent)	Share of Jobs That Require a Diploma or Less (percent)
Green Building Materials	85.3	61.1
Energy-saving Building Materials	81.6	58.7
Green Consumer Products	78.9	55.4
Appliances	77.8	54.0
Water Efficient Products	72.9	50.2
Lighting	71.4	49.6
Energy-saving Consumer Products	71.4	49.2
Solar Thermal	70.8	53.3
Solar Photovoltaic	66.7	45.0
HVAC and Building Control Systems	65.2	45.0
Renewable Energy Services	63.6	40.5
Regulation and Compliance	59.1	29.0
Training	50.3	40.2
Smart Grid	48.2	33.4
Green Architecture and Construction Services	32.9	26.0
Professional Energy Services	26.2	20.5

Projected Job Market

NZEH is a mostly disaggregated market with no complete and systematic estimate of the industry's future job creation potential. However, there is quantitative and qualitative information that can shed light on job prospects. Quantitatively, employment impacts can be inferred by several proxies:

- Employment projection for entire green construction market,

[31] Muro et al., 2011, pp. 23–24

- Employment projections for BLS occupations tied to NZEH construction,
- Employment projections across individual NZEH component industries, and
- Employment projections contingent on incentive programs.

While these proxies each have their drawbacks, they provide useful information on the job creation potential of NZEH.

Employment Projection for Green Construction Market

Green construction encompasses many types of technologies and building designs, including LEED building, NZEH, and other green standards. Thus, this proxy is broader than the current scope of study. However, as green building continues to "raise the bar" in terms of stricter, greener standards, employment in the larger green construction industry will become increasingly relevant for NZEH. In 2009, the U.S. Green Building Council commissioned a study by Booz Allen Hamilton of the job creation potential for the green construction market. Booz Allen used McGraw Hill's definition of green building:

> *"We define green building as one built to LEED standards, an equivalent green building certification program, or one that incorporates numerous green building elements across five category areas: energy efficiency, water efficiency, resource efficiency, responsible site management, and improved indoor air quality. Projects that only feature a few green building products (e.g., HVAC systems, waterless urinals) or that only address one aspect of a green building, such as energy efficiency, are not included in this calculation."*[32]

This study expects that green construction will create a total of 7.9 million jobs (direct, indirect, and induced) from 2009-2013. This is a leap from the estimated job creation during the previous eight years, which saw a growth of 2.4 million jobs. Booz Allen's projection includes not only single and multi-family residential construction, but also commercial, manufacturing, and other non-residential construction as well. For all these sectors, they examine new construction as well as retrofits.

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[32] Booz Allen Hamilton. (2009). U.S. Green Building Council Green Jobs Study. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=6435

Booz Allen employs an IMPLAN model under a few critical assumptions. First, they use McGraw Hill's estimates of the value of the green construction market for 2005, 2008, and 2013. They also assume that savings generated from green building (i.e. lower electricity bills) will result in reduced economic activity in some sectors. These savings are calculated according to detailed data on LEED buildings from the USGBC (which Booz Allen extrapolates to all green buildings). The net impact of green construction less savings represents the final economic impact of the green building industry.

As an analysis of the green construction market and green building, Booz Allen's projection can only be tangentially applied to the NZEH industry. This study is likely to overstate the employment impacts of NZEH, since: 1) It includes projects built according to LEED and other green building standards; 2) It includes non-residential construction; and 3) It assumes cost savings equivalent to that by LEED buildings, which is typically less than NZEH cost savings.

Employment Projection in BLS Occupations Tied to NZEH Construction

Every two years, BLS updates its projections for occupational growth for the next ten years. The most recent projections cover the 2010-2020 period. Table 4 lists BLS's projected growth for occupations that operate within the NZEH industry (as identified by IEDC). Employment in these occupations reflect jobs in the construction industry overall including NZEH construction, other green construction, and conventional construction.

Table 4: Employment Projection, BLS

Occupation	2010 Employment (in thousands)	2020 Employment (in thousands)	Number (thousands)	Percent
Total, All Occupations	143,068.20	163,537.10	20,468.90	14.3
Carpenters	1,001.70	1,197.60	196	19.6
Construction Laborers	998.8	1,211.20	212.4	21.3
Electricians	577	710.6	133.7	23.2
Construction Managers	523.1	609.6	86.6	16.6
Real Estate Sales Agents	367.5	412.5	45	12.2
Operating Engineers and Other Construction Equipment Operators	349.1	431	81.9	23.5
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	267.8	358.1	90.3	33.7
Electrical and Electronic Equipment Assemblers	182.9	172.4	-10.4	-5.7
Architectural and Engineering Managers	176.8	192	15.2	8.6
Roofers	136.7	161.1	24.4	17.8
Architects, Except Landscape and Naval	113.7	141.6	27.9	24.5
Construction and Building Inspectors	102.4	120.8	18.4	17.9
Real Estate Brokers	98.6	106.2	7.5	7.6
Appraisers and Assessors of Real Estate	77.8	83.5	5.8	7.4
Helpers-Electricians	73.5	96	22.5	30.6
Interior Designers	56.5	67.4	10.9	19.3
Helpers-Carpenters	46.5	72.4	25.9	55.7
Insulation Workers, Mechanical	28.3	37.3	9	31.8
Helpers, Construction Trades, All Other	19.6	25.2	5.6	28.7
Helpers-Roofers	12.7	13.9	1.2	9.6

Source: United States Department of Labor, Bureau of Labor Statistics, 2011

While the number of jobs in the overall economy is expected to grow 14.3 percent, many NZEH occupations are expected to grow faster than this. Several occupations, such as Helpers – Carpenters and Heating, Air Conditioning, and Refrigeration Mechanics and Installers, are projected to grow substantially faster. Only one occupation, Electrical and Electronic Equipment Assemblers, is expected to decline in employment.

BLS's methodology relies on forecasting six interrelated steps: labor force, aggregate economy, GDP, industry output, employment by industry, and employment by occupation.[33] Results from each step are fed into other steps, and the process is repeated to check for consistency. Employment projections according to this method are also likely to overstate job growth in NZEH, since these figures include jobs in other green construction and conventional construction.

Employment Projections Across NZEH Component Industries

While there is not a great deal of employment data available for many of the net-zero energy home component industries such as lighting, appliances, and HVAC/climate control, data is available for the solar industry. In 2011, The Solar Foundation published their National Solar Jobs Census, which provides insight into employment. While solar employment isn't a perfect proxy for the NZEH market, energy generation (which is often accomplished through PV panels) is essential to achieving net-zero energy. During the Solar Jobs Census, The Solar Foundation surveyed a statistically valid sampling of solar employers throughout the United States.

As of August 2011, there were 100,237 workers in the solar industry, which was an increase of 6.8 percent over the previous year. When compared with the national growth rate of 1.4 percent, this growth rate is quite significant, and it is expected to continue. Over the year following the 2011 census, the Solar Foundation expected solar job growth of nearly 24 percent, which translates to approximately 24,000 new jobs. In addition, almost 50 percent of solar firms are expected to add jobs in the coming year and only 2.6 percent are expected to cut workers.[34] Within the solar industry from 2011-2012:[35]

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[33] Bureau of Labor Statistics. (2012, March 29). Employment Projections. Retrieved from http://www.bls.gov/emp/noeted/empnumb.htm
[34] Solar Foundation, 2011, p. 4
[35] Ibid, pp.4-5

- Nearly half of installation firms expected to hire in the next year at a growth rate of 25 percent, or 13,068 jobs.
- Over 40 percent of manufacturing firms expected to add a total of 3,473 jobs at a growth rate of 35 percent.
- More than 45 percent of sales and distribution firms expected to add a total of 6,188 jobs at a growth rate of 35 percent.
- A quarter of utilities (who were included in the 2010 Solar Jobs Census but not the 2011 census) expected to add clean energy workers through 2012, with a growth rate of 10 to 19 percent.

In addition to asking employers about expected growth, the Solar Jobs Census asked employers about major obstacles to growth. While approximately 32 percent of employers cited the general economic conditions, just over 20 percent cited a lack of state incentives and 17.5 percent cited lack of consumer awareness of solar products and services. When asked to identify positive factors related to growth, employers' answers seem to support the identified barriers. Over 32 percent of employers cited an extension of federal tax incentives, 21.1 percent cited creation of state or local incentive programs, and just over 19 percent cited greater consumer awareness of solar products and services.[36] Therefore, from an industry perspective, continued support for solar incentives and consumer education are high priorities for continued employment growth.

Employment Projections Contingent on Incentive Programs

Architecture 2030, an independent nonprofit organization, has developed employment and revenue projections for several proposed NZEH and high efficiency incentive programs. Founded in 2002 by architect Edward Mazria, Architecture 2030 seeks to "to achieve a dramatic reduction in the climate-change-causing greenhouse gas (GHG) emissions of the Building Sector by changing the way buildings and developments are planned, designed and constructed."[37] The organization's 2009 analysis of a proposed nation-wide $30 billion mortgage buy-down for homes that meet specific energy efficiency criteria can create 4.5 million new jobs, $280 billion in direct, non-federal investment spending, and will open a $5.7 billion renovation market that could

[36] Ibid, 8
[37] Architecture 2030. (2011). About Us. Retrieved from http://architecture2030.org/about/about_us

increase to nearly $1 trillion by 2030. These benefits could be realized with participation from just 2.2 percent of the U.S. housing stock. [38]

Based in part on analysis conducted for a May 2009 proposal by Architecture 2030, ICLEI-Local Governments for Sustainability, RESNET, and Veterans Green Jobs, the October 2009 estimate is based on several assumptions: [39]

- Purchasers of new homes, those looking to refinance a mortgage, and purchasers of newly constructed homes that qualify for a location-efficient mortgage can reduce their qualifying mortgage rate by one percent or more by meeting specific energy targets, which are outlined in
- Table 5: ,
- And by investing a minimal amount in energy efficiency and/or renewable energy systems.[40] The energy efficiency targets are measured using the Home Energy Rating System (HERS), which is a nationally accepted method for measuring a home's energy performance relative to standard new construction. Standard new construction homes are rated 100; a HERS 70 home will be 30 percent more efficient than standard construction.

  Table 5: Mortgage Buy-Down and Energy Targets

Percent Below Qualifying Mortgage Rate	Minimum Energy Reduction Target
1.0%	HERS 70
1.5%	HERS 50
2.0%	HERS 25
2.5%	Net-zero

- A home buyer's qualifying mortgage rate discount can be tied to prevailing market rates, or it can be fixed. If the rate is fixed, a four percent discount would be correlated with HERS 70, three percent discount with HERS 25, and 2.5 percent with net-zero.
- The minimum amount invested is double the cost of each one percent buy-down. For a $150,000 mortgage, for example, a one percent by-down would require a $12,000 investment by the homeowner and a two percent buy-down would require a $24,000 investment.
- The program will cost $30 billion per year if the average mortgage buy-down of one percent is 4 points (or 4 percent of the mortgage amount). Seventy six percent of the

[38] Architecture 2030. (2009, October 1). *The One-Year, 4.5-Million-Jobs Investment Plan*. Retrieved from http://architecture2030.org/hot_topics/one_year_4_point_5_million_jobs_plan.
[39] Ibid.
[40] Ibid.

investment is allocated for renovation of existing homes, five percent for purchases with location-efficient mortgages, and 19 percent for new construction.

Given the conditions above, this plan would create 1.5 million jobs in the building sector and 3 million indirect and induced jobs for a total of 4.5 million new jobs. This estimate does not include an estimated 131,399 jobs that would be created by increased consumer spending resulting from mortgage and energy savings.[41]

In 2012, Architecture 2030 did a similar analysis for New Mexico, where the State Legislature was considering New Homebuyers Energy Savings Tax Credit Program (Plan) as a way to create jobs and revenue for the state. Under this plan, homebuyers could receive a:[42] [43]

- $4,000 State tax credit for purchasing a HERS 50 or equivalent home,
- $6,000 State tax credit for purchasing a HERS 25 or equivalent home, or a
- $8,000 State tax credit for purchasing a net-zero energy or HERS 0 home.

This plan, at a cost of $20 million, would generate an estimated $281.9 million in construction spending, $143.8 million in indirect and induced spending, $41.2 million in state and local government tax revenue and $2.1 million in annual property taxes, and could create 4,567 jobs (this includes an estimated 1,466 direct jobs). The jobs attributed to New Mexico's $20 million investment are based on multipliers for New Residential Construction Spending from the Political Economy Research Institute.[44] Unfortunately, while this plan was passed by the House on February 10, 2012, the State Senate postponed further action on the bill later that month.

Clean Tech and NZEH

An examination of trends in clean tech awareness, spending, and employment gives some insight on the state of the NZEH market. Greater awareness of clean energy will prompt interest in various cleantech industries, including NZEH. Thus, demand for NZEH is likely to be positively related to overall demand for cleantech. One measure of demand is corporate spending on

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[41] Ibid.

[42] New Mexico Green Chamber of Commerce, (9 February 2012). New Homebuyers Energy Savings Tax Credit Bill Passes House Tax and Revenue 13-0, On to House Floor. Press Release. Retrieved from http://nmgreenchamber.com/wp-content/uploads/2012/02/PR-New-Homebuyers-Energy-Savings-Tax-Credit-Bill-2.pdf

[43] Architecture 2030. New Mexico: New Homebuyers Energy Savings Tax Credit. Retrieved from http://library.constantcontact.com/download/get/file/1104335014834-188/New+Mexico+New+Homebuyers+Energy+Savings+Tax+Credit+FINAL.pdf.

[44] Ibid.

cleantech. Three-quarters of major global corporations plan to increase their cleantech budgets between 2012 and 2014; 40 percent of that spending is earmarked for research and development.[45] Growth in cleantech R&D will increase and richen the supply of clean energy technologies. Growth in corporate demand for cleantech, along with other factors, reflects a shift in the nation's zeitgeist toward greater environmental consciousness. These trends bode well for the future of NZEH.

Job growth can also be examined regionally. As will be noted later in the report, jobs in the clean economy (and net-zero energy home submarket) are not evenly spread throughout the United States. The South has the largest number of clean economy jobs, but the West has the largest share relative to its population. In addition to regional trends, clean economy jobs tend to cluster near cities, as 64 percent of all current clean economy jobs and 75 percent of jobs created from 2003-2010 are in the nation's largest metropolitan areas.

A closer look at clean economy industries in metro areas reveals the power of clusters. Clustered businesses located in counties containing a significant number of jobs from other establishments in the same sector grew 1.4 percent faster than more isolated establishments.[46] These industry clusters are made of individual companies, many of which are showing interest in investing in net-zero energy homes. For example, in 2009 GE announced their intent to develop a product portfolio that would allow homebuyers to purchase zero-energy homes by 2015. Their primary product development focus would be in three areas: energy efficient products, energy management products, and energy generation/storage products.[47]

In conclusion, job growth related to NZEH can only be roughly approximated by existing job studies in incentives, green building, construction, and the larger cleantech market. The outlook is positive in these markets, making NZEH a potential source of new jobs as the industry expands.

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[45] Muro et al., 2011, p. 10
[46] Ibid, p. 4
[47] Freeman, K, 2009

THE STATE OF THE U.S. NET-ZERO ENERGY HOMES MARKET

U.S. Housing Market

The recession and housing crisis have slowed residential construction in recent years, but analysts assert that the market is beginning to recover.[48] As more single-family homes are built, there will be more opportunities for designing them as net-zero energy houses. Retrofits will also be an important part of the net-zero energy home industry, especially in light of the recent slump in new residential construction.

According to the 2010 Census, there were over 130 million housing units in the U.S. Growth has slowed in the residential construction market since 2005 as a result of the housing crisis and recession, but recent data suggest the market is slowly recovering from its low point in 2009 (see Table 6).

Table 6: New Privately Owned Housing Units Started (Annual data)[49]

Year	New Housing Starts
2005	2,068,300
2006	1,800,900
2007	1,355,000
2008	905,500
2009	554,000
2010	586,900
2011	608,800
2012	780,000*

*seasonally adjusted annual rate for May 2012

[48] Glink, I. (2011, December 7). Housing Market Predictions for 2012. CBS News. Retrieved from http://www.cbsnews.com/8301-505145_162-57338565/housing-market-predictions-for-2012/;
Keely, L. & van Ark, B. & Levanon, G. & Burbank, J. (2012). *The Shifting Nature of U.S. Housing Demand*. New York. Demand Institute. Retrieved from http://www.demandinstitute.org/sites/default/files/blog-uploads/tdihousingdemand.pdf

[49] U.S.Census, 2011. New Privately Owned Housing Units Started, Annual Data 1959-2011. Retrieved from http://www.census.gov/construction/nrc/pdf/startsan.pdf
U.S.Census and U.S.Department of Housing and Urban Development. (2012, June 19). New Residential Construction in May 2012. Retrieved from: http://www.census.gov/construction/nrc/pdf/newresconst.pdf

The University of Central Florida's Institute for Economic Competitiveness also projects that the housing market will grow slowly (but steadily) over the next three years with regard to new housing starts and sales of existing homes. By 2015, the Institute estimates that new housing starts will number almost 2 million, and existing home sales will increase to over 5 million.[50]

Corroborating these projections of steady recovery is the Urban Land Institute's (ULI) most recent semiannual survey of leading real estate economists and analysts on their projections for the real estate market. This three-year forecast projects modest growth in single-family housing starts through 2014: in 2009, single-family starts are estimated at 445,100 with growth to 800,000 by 2014.[51] In addition, ULI expects to see an increase in average home price through 2014 – a new direction from the past three years of falling home prices.

The National Association of Realtors projects similar growth in housing starts, although the number of housing starts is still expected to be below the historical average of 1,500,000 per year.[52]

While the housing market seems to be recovering, existing homes will continue to make up a large portion of U.S. housing stock. According to 2009 estimates, "…by the year 2035, approximately 75 percent of the built environment will be either new or renovated," leaving 25 percent composed of un-renovated buildings.[53] The combination of new and existing housing stock presents opportunities for constructing new net-zero energy homes and retrofitting existing ones.

Not only is U.S. housing stock projected to increase, so too is the proportion of that stock considered to be green, energy-efficient homes. By 2016, green residential construction – either built to a recognized green building standard or energy/water efficient – is projected to account

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[50] Institute for Economic Competitiveness (2012). *Forecast for the Nation 2012-2015: March 2012* Report. Orlando: University of Central Florida. p. 22. Retrieved from: http://iec.ucf.edu/file.axd?file=2012%2F3%2Fusforecast_mar2012_sec.pdf.pdf

[51] U.S. Census, 2009-2011; ULI Consensus Forecast data, year-end 2012-2014. Retrieved from http://www.uli.org/~/media/ResearchAndPublications/CapitalMarkets/ULI-Real-Estate-Consensus-Forecast-General-032012.ashx

[52] National Association of Realtors. (2012, June 27). *NAR Economic Forecast*. Retrieved from http://www.realtor.org/sites/default/files/reports/2012/economic-forecast-2012-05-30.pdf

[53] Gupta, R. & Chandiwala, S. (2009). *A critical and comparative evaluation of approaches and policies to measure, benchmark, reduce and manage CO2 emissions from energy use in the existing building stock of developed and rapidly-developing countries - case studies of UK, USA, and India*. Paper presented at 5th Urban Research Symposium on Cities and Climate Change, Marseille, France. p. 18. Retrieved from http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1256566800920/6505269-1268260567624/Gupta.pdf

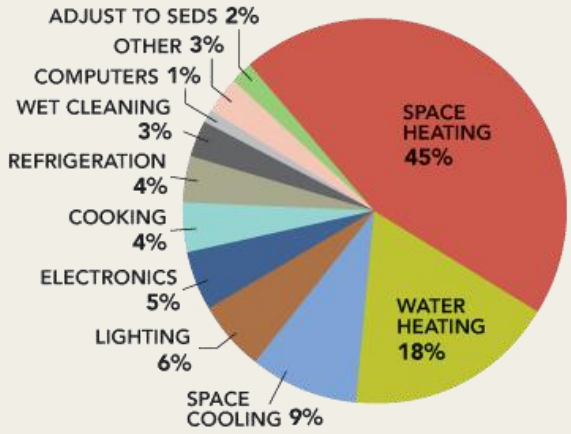
for at least a third of the residential market, or $87-114 billion.[54] Globally, the number of energy efficient homes (including retrofits) is expected to reach nearly 120 billion square feet by 2020. Most of this growth will occur in Asia and Europe rather than in North America.[55]

While improvements can be made to homes everywhere, metropolitan areas are of great significance in the net-zero energy homes market, since the largest 100 U.S. metropolitan areas contain 63 percent of the nation's residential structures.[56] The relative density of homes in the nation's metropolitan areas presents industry clustering opportunities as well as the potential for zero-energy communities rather than relying exclusively on individually constructed single-family home projects.

Residential Energy Use

The U.S. Department of Energy has analyzed energy use in residential buildings according to the following categories: space heating and water heating, which consume the highest proportion of residential site energy consumption, as well as space cooling, lighting, electronics, and other miscellaneous uses, which are a far smaller share of on-site energy consumption (see Figure 1):

Figure 1: Residential Site Energy Consumption by End Use



Source: U.S. Department of Energy, 2011a

[54] McGraw-Hill Construction. (2012). *New and Remodeled Green Homes*. p. 8.
[55] Clean Energy, Energy Efficient Homes on the Rise? (2012, May 15). *GreenTech Advocates*. Retrieved from http://greentechadvocates.com/2012/05/15/clean-energy-energy-efficient-homes-on-the-rise/
[56] Muro, M., Rothwell, J., & Saha, D. (2011). *Sizing the Green Economy: A National and Regional Green Jobs Assessment*. p. 10 Brookings Institution Metropolitan Policy Program.

Space heating and cooling, which account for 54 percent of site energy consumption and 42 percent of primary energy consumption, drive residential energy demand and represent the greatest area of opportunity in energy efficiency.[57] While the impact may be less significant in milder climates due to less reliance on heating and cooling systems, energy efficiency improvements in these categories can make a major difference in home energy consumption, especially when considering the increasing energy demands that accompany new home construction.

Homes built between 2000 and 2005 used 14 percent less energy per square foot than homes built in the 1980s and 40 percent less energy per square foot than homes built before 1950. However, larger home sizes have offset these efficiency improvements, as the average annual energy cost has increased since 1970. [58]

The average house size grew from 1,500 square feet to approximately 2,250 square feet between 1970 and 2000, creating an increased demand for cooling as well as energy supply for other needs such as appliances and miscellaneous plug loads.[59] More specifically, single-family homes built between 2000 and 2005 are 29 percent larger on average than those built in the 1980s and 38 percent larger than those built before 1950.[60]

From 1990 to 2008, residential energy consumption increased 27 percent. However, because of projected improvements in building and appliance energy efficiency, the rate of residential energy consumption is expected to slow. In fact, the Energy Information Administration's 2011 Annual Energy Outlook forecasts just a 4 percent increase in residential energy consumption from 2008 to 2030.[61]

Perhaps as part of a wider acceptance of energy efficiency measures in residential buildings, government programs such as ENERGY STAR are contributing to the energy consumption

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[57] Ibid.
[58] Ibid.
[59] Hammon, R. (2007, September/October). Building a Market for Solar Homes. *Solar Today*. Retrieved from http://www.bira.ws/files/Building_market_for_solar_homes.pdf
[60] U.S. Department of Energy. (2011a, July 29). Building America: Program Goals. Retrieved March 2, 2012, from http://www1.eere.energy.gov/buildings/building_america/program_goals.html
[61] Ibid

slowdown.[62] In 2009, for example, over 100,000 new homes qualified for the ENERGY STAR label - more than a fifth of all single-family homes permitted in the United States that year. In addition, approximately 25,000 homes were retrofitted in 2009 under the Home Performance with ENERGY STAR program, nearly twice the number retrofitted in 2008. As of 2011, more than 100,000 retrofits had been completed. This program growth occurred despite a $63 billion decrease in home improvement spending between 2007 and 2009, which was a consequence of declining home values and the recessionary economic climate.[63]

Global Perspective

In November 2008, the European Union (EU) set 2020 as the deadline for all new buildings to be "nearly zero energy."[64] While the EU has not set specific milestones, member states are required to develop national plans to increase the number of nearly zero energy buildings. A summary of each country's energy target for new buildings is below.

Table 7: European Union Members' Energy Targets for New Buildings

Country	Target
Denmark	75 percent by 2020 (base year 2006)
Finland	Passive house standards by 2015
France	By 2020 new buildings are energy-positive
Germany	By 2020 buildings should be operating without fossil fuel
Hungary	Zero emissions by 2020
Ireland	Net zero energy buildings by 2013
Netherlands	Energy-neutral by 2020
Norway	Passive house standards by 2017
UK (England & Wales)	Zero carbon as of 2016

Source: European Council for an Energy Efficient Economy, 2001, p.1

As mentioned, each member country is responsible for developing its own national plan for reaching the goal for all new buildings to be nearly zero energy by 2020. Germany, where

[62] Ibid
[63] Ibid
[64] European Council for an Energy Efficient Economy (2011). *Steering through the maze #2. Nearly zero energy buildings: achieving the EU 2020 target.*

feed-in tariffs have been in place since 1991, has been particularly successful in the PV market with approximately five times as many PV panels installed as the United States.[65] The feed-in-tariff program guarantees that any electricity produced from clean energy sources (hydropower, wind, solar PV, etc.) will receive an above-market rate of return for 20 years. As a result of this program, clean energy now accounts for 17 percent of the electricity produced in Germany, which is up from just five percent in the 1990s. This trend toward clean energy has also resulted in increased energy generation capacity, growth in the manufacturing industry, increased foreign investment in Germany's clean energy industry, and more jobs.[66] Ontario has seen similar benefits, as their program is credited for helping increase their clean energy capacity from 15 megawatts in 2003 to 1,950 megawatts in 2012 as well as creating 20,000 jobs, two thousand of which are in manufacturing.[67]

In the EU, 18 member states have feed-in tariffs or other similar systems by which clean power is incentivized. The European countries with the strongest feed-in-tariff systems, such as Germany, Spain, and Denmark, have seen much more growth in their clean energy sectors than have countries with renewable portfolio standards (RPS), which require energy suppliers to source a certain amount of power from clean energy sources.[68]

The popularity of feed-in-tariffs and other solar programs has sometimes proved problematic, however. Since the sponsors of feed-in-tariff programs have promised an above-market rate price for electricity contributed to the grid, countries and municipalities often cap the number of participants at a financially sustainable level. Spain, for example, has been forced to cap the number of solar installations it will subsidize, and Ontario, which has had a feed-in-tariff since 2006, temporarily suspended its program in 2008 due to issues regarding transmission capacity.[69]

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[65] Galbraith, K. (2009, March 12). Europe's Way of Encouraging Solar Power Arrives in the U.S. *New York Times*. Retrieved from http://www.nytimes.com/2009/03/13/business/energy-environment/13solar.html?_r=1
[66] Muro et al., 2011, p. 35
[67] Ontario Ministry of Energy (2012). *Ontario's Feed-in Tariff Program: Two Year Review Report*. 4-5.
[68] Berger, M. (2010, January 22). States Look to Feed-in Tariffs to Boost Renewable Energy. *Inside Climate News*. Retrieved from http://insideclimatenews.org/news/20100122/states-look-feed-tariffs-boost-renewable-energy
[69] Galbraith, K, 2009

Major Stakeholders and Partnerships

Homebuyers and owners

Homeowners and buyers are critical to the success of the NZEH market. Homebuyers who are equipped with the knowledge of NZEH benefits and a desire to purchase or own this type of home can increase market demand for NZEH, facilitating faster market share for NZEH. In addition, feedback from owners of NZEH is helpful to the assessment of NZEH components and subsequent development of effective and affordable strategies for achieving NZEH.

Builders: Design, construction, marketing

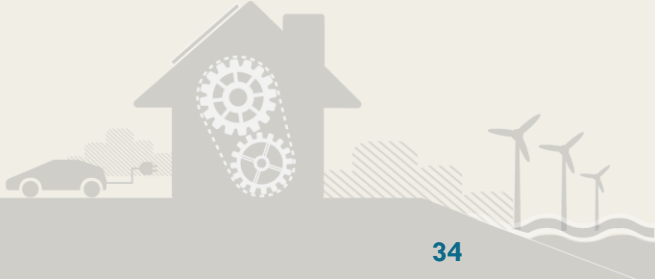
While homebuyers contribute to the demand for NZEH, builders contribute to the market supply of NZEH. Many builders have led NZEH market development by piloting net-zero energy home developments and individual demonstration projects throughout the country. Builders can be involved with some or all of the following steps in the NZEH development process: design, construction, and marketing.

Appraisers

Home appraisers are responsible for determining the value of a home, which has a significant impact on the ability of builders, developers, and homebuyers in the NZEH market to find financing. Since net-zero-energy homes have energy efficiency and energy generation systems that are not usually included in conventional construction, a comprehensive appraisal that takes these additional features into consideration is essential to the correct valuation of a net-zero home.

Government

The increased cost associated with NZEH components is a major cause for apprehension in potential NZEH buyers. Government policies and financing programs at the local, state, and federal level can help curb this apprehension and encourage industry growth. For example, the Department of Defense is implementing net-zero technology to reduce energy consumption in the Army, Navy, and Air Force. The Army has pledged to covert five installations to net-zero by 2020, and Navy is examining strategies for net-zero energy installations as well as energy



efficiency. The net-zero technologies used to achieve these goals will help to demonstrate the achievability of NZEH, and could help drive process improvements in NZEH parts.

Lenders/Banks

National lenders such as Freddie Mac and Fannie Mae, in addition to both national and local banks, are responsible for approving the mortgages of potential homebuyers. Proper understanding of the valuation of net-zero energy homes, in addition to NZEH-friendly programs such as energy efficiency mortgages, can facilitate the growth of the net-zero energy home market.

Manufacturers of Energy Efficiency Products

Energy efficiency is essential to achieving net-zero energy. Therefore, the technical and financial feasibility of energy efficiency products such as PV panels, energy efficient appliances, and solar water heating systems is important to the success of the NZEH industry. In addition to the technical benefits realized through effective energy efficiency products, placing a high priority on domestic manufacturing of these components can also help grow the local job base.

Utility Companies

The cooperation (or lack thereof) of utility companies can have a major impact on the net-zero energy home market. Part of the cost-benefit analysis of net-zero energy home feasibility often assumes that net metering will be available and some energy will be sold back to the grid; a utility company can choose to facilitate this process, which can sometimes involve complex price structures and new technical capabilities.

Economic Developers

Economic developers can help support policies that promote energy efficient building, help address financial gaps through the creation of incentives, and coordinate regional promotion of NZEHs. A thorough discussion of the role of economic developers is presented in the Hurdles and Solutions follow-up report.

Projected Growth of the NZEH Industry within the U.S.

Existing Domestic Manufacturing: A Cluster-Driven Industry

According to a 2012 report by Pike Research, the net-zero buildings market is expected to grow to $1.3 trillion by 2035, worldwide revenue is projected to reach $690 billion by 2020, and revenues are expected to nearly double by 2035.[70] While these estimates take into account the worldwide market, the rapid growth of this industry presents U.S.-based firms with an opportunity to take advantage of a growing domestic and international consumer base for net-zero energy homes. Manufacturers in a variety of industries associated with the construction of net-zero energy homes—such as solar PV, energy efficient appliances, insulation, smart meters, and energy efficient doors and windows—are located throughout the United States. These industries tend to develop in clusters in metropolitan areas, with the largest concentrations of jobs on the west and east coasts. Table 8 lists the top ten metro areas with the greatest number of green architecture and construction jobs in 2010.

Table 8: Top Ten Metro Areas for Green Architecture and Construction Jobs, 2003 vs. 2010

Metro Area	Jobs (2003)	Jobs (2010)
United States	36,512	56,190
New York-Northern New Jersey-Long Island	2,912	4,403
Chicago-Joliet-Naperville	3,226	3,332
Atlanta-Sandy Springs-Marietta	1,532	3,094
San Francisco-Oakland-Fremont	1,340	3,028
Kansas City	2,046	2,804
Las Vegas-Paradise	157	2,507
Seattle-Tacoma-Bellevue	1,373	2,269
Los Angeles-Long Beach-Santa Ana	1,227	2,063
Dallas-Fort Worth-Arlington	940	1,809
Boston-Cambridge-Quincy	1,566	1,787

Source: Sizing the Clean Economy Indicator Map - Brookings Institution, 2011

A clean economy report by the Brookings Institution found that industry clusters helped individual clean technology companies grow much faster than those in more isolated areas. The difference

[70] Zachary Shahan. (2012, February 6). Zero-Energy Building Market to Hit $1.3 Trillion by 2035. Retrieved from http://cleantechnica.com/2012/02/06/zero-energy-building-market-to-hit-1-3-trillion-by-2035/

between industries located near their peers and those that were not near clusters was equivalent to 5.5 percent in annual job growth over the seven-year study period.[71] Therefore, when seeking to build an industry associated with net-zero homes, it is important for economic developers to take into account associated industries and the potential benefits of clustering. Examples of cities with existing clusters where twenty percent or more of establishments are "clustered" into sectors related to net-zero energy home development include (but are not limited to):[72]

- Boston: HVAC and building control systems, solar PV, professional environmental services
- Chicago: Professional energy services, professional environmental services
- Raleigh: Green architecture and construction services, smart grid
- San Jose: Energy saving consumer products, solar PV
- Seattle: Green architecture and construction services, professional environmental services, smart grid

Construction Industry Expertise: First Mover Advantages

Several builders and developers have piloted net-zero energy homes and developments in the U.S. Builders and developers behind the first projects in a geographic area benefit from several advantages. As early adopters, these builders and developers receive media exposure beyond the levels associated with a conventional house or development. For example, the Premier Homes Development outside Sacramento, CA received a great deal of local and national media coverage, including a segment on CNBC that highlighted the energy savings of Premier homes. John Ralston, the Premier Homes VP of Marketing, characterized the development's media coverage as higher than expected and contributing to "remarkable" sales. [73]

The media exposure and willingness to go first can help net-zero builders and developers become the local go-to resource for net-zero projects, building partnerships, and relationships with local businesses, government entities, nonprofits, and utility companies that can give them a competitive edge on future NZEH projects. These partnerships can also provide builders and developers with

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[71] Muro et al., 2011, p. 30
[72] Muro et al., 2011, p. 31
[73] Kerr, R., Baccei, B., & Hammon, R. (n.d.). *Putting It all Together: Aggregating Benefits, Selling to Stakeholders The Benefits of Zero Energy Homes Reach Far Beyond Homeowners*. Building Industry Research Alliance. Retrieved from http://www.bira.ws/files/193MRyanKerr.pdf

a network of resources for best practices in NZEH construction, marketing, and financing.[74] For example, SheaHomes, the builder of several net-zero-energy housing developments in San Diego, had the opportunity to work with a variety of partners, including the U.S. Department of Energy, California Energy Commission, ConSol, and AstroPower during the course of their project. While the company was unable to put price tag on their project, they did describe an intangible benefits from developing a network of like-minded professionals.[75]

Department of Defense Installations

The U.S. Department of Defense (DOD) is looking to net-zero energy technology to reduce energy consumption across the Army, Navy, and Air Force. The department's strategic energy plan includes the goal of obtaining 25 percent of its electrical energy needs from clean energy sources by 2025, but the various branches of the military go even further in their pledges to decrease energy consumption.[1] The Navy hopes to obtain 50 percent of its energy for ships, aircraft, tanks, shore vehicles, and installations from clean energy sources by 2020 and the Army has pledged it will convert five installations to net-zero by 2020.[1] [1] The potential impact of these initiatives on the net-zero energy housing industry is significant, as entire installations are converted to net-zero rather than a merely few houses scattered throughout a neighborhood.

Solar Industry: Concentrated Along Coasts

The U.S. has a growing solar industry that employs thousands of people across the country. Solar PV is critical to the success of most net-zero energy home projects, as energy generation is required to help the home realize net-zero energy. The current concentration of jobs along the eastern and western coasts, as evidenced by the total number of jobs in the table below, provides a good foundation for regional clustering and business development. Those areas with smaller

[74] Farhar, Coburn, and Murphy (2004). *Large-Production Home Builder Experience with Zero Energy Homes.* p.6 Paper presented at the ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California.
[75] Farhar, Coburn, and Murphy, 2004

employment solar PV employment numbers during 2010 should examine their regional environment to determine if there is a viable opportunity to create a stronger cluster in the future.

Table 9: Top Ten Metro Areas for Solar PV Jobs, 2010[76]

Metro Area	Jobs (2010)	Percent Change in jobs (2003-2010)	Change in jobs (2003-2010)
United States	24,152	11%	12,286
San Jose-Sunnyvale-Santa Clara	1,988	11%	1,005
St. Louis	1,800	-3%	(470)
Los Angeles-Long Beach-Santa Ana	1,585	8%	658
San Francisco-Oakland-Fremont	1,438	39%	1,293
Boston-Cambridge-Quincy	1,359	9%	593
Toledo	1,174	28%	971
Memphis	1,000	5%	300
Detroit-Warren-Livonia	964	23%	743
Washington-Arlington-Alexandria	790	69%	770
New York-Northern New Jersey-Long Island	786	18%	534

Source: Brookings, *Sizing the Clean Economy, 2011*

Industries Ripe for Retooling

While the focus is often on new housing for net-zero energy, in any given year approximately 98 percent of all homes in the market are existing homes, rather than new construction built in that particular year. An analysis by the Rockefeller Foundation and DB Climate Change Advisors estimates that, should all pre-1980 housing stock receive energy efficient retrofits to increase overall efficiency by just 30 percent, an estimated 1,700 full-time employee job years would result.[77] This retrofit potential, when coupled with the increasing proportion of new homes that are green (17 percent of the market in 2011), creates a great opportunity to grow the net-zero industry by incorporating energy efficiency and clean energy measures in home renovation and

[76] Ibid.
[77] Rockefeller Foundation and DB Climate Change Advisors (2012, May). *United States Building Energy Efficiency Retrofits, p.* 14. Retrieved from http://www.rockefellerfoundation.org/news/publications/united-states-building-energy-efficiency.

construction.[78] [79] Jobs included in the net-zero home construction and retrofitting industry include lighting, weatherization, HVAC installers, electricians, carpenters, roofers, insulation workers, home inspectors, architects, designers, and energy auditors. These jobs already exist, and while some (such as energy auditors) are already focused on the net-zero and energy efficiency markets, most occupations are in traditional industries that, with a bit of extra training or product diversification, can also serve the net-zero market.

NZEH Components

Residential Solar Energy Market Concentrated in a Few States, but Poised for Future Growth

Energy generation is necessary to achieve net-zero energy. In residential buildings, solar energy is the most popular choice for on-site energy generation. There are three different types of solar energy technologies, each designed with a specific end use in mind. Two solar technologies, photovoltaics (PV) and concentrating solar power (CSP), produce electricity. Solar thermal collectors produce heat for water heating, space heating or cooling, pool heating, or they can process heat.[80] Solar PV and solar thermal are the two most commonly used systems in residential construction. Concentrating solar power is most often used in large-scale commercial projects.

In 2010, 124,000 new solar PV and heating systems were installed, a 22 percent increase over 2009. Growth is concentrated in states with supportive solar policies, but may become more widespread as larger international manufacturers move into the U.S. market.

Insulation: Increasing Market Share despite Residential Construction Slowdown

Net-zero energy homes require a tight building envelope that is sealed securely to prevent leakage of conditioned inside air to the outdoors or unconditioned outside air into the home. This tight thermal barrier works to reduce a home's heating and cooling costs and maximize energy

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[78] Larry Bernstein & Michele Russo. (2012). *New and Remodeled Green Homes: Transforming the Residential Marketplace*. p. 8. McGraw-Hill Construction. Retrieved from http://www.nahbgreen.org/Content/pdf/NewAndRemodeledGreenHomes.pdf.
[79] NAHB Research Center. (2006). *The Potential Impact of Zero Energy Homes* (No. EG5049_020606_01). p. 21. National Renewable Energy Laboratory. Retrieved from http://www.toolbase.org/pdf/casestudies/zehpotentialimpact.pdf
[80] Sherwood, L., 2011, p. 2

efficiency measures. Several types of insulation may be used to create this barrier. The more commonly used insulation types discussed in this section are discussed below.

Spray polyurethane foam (SPF): SPF is used in homes to keep out moisture. There are two types of SPF: open cell and closed cell. Open cell SPF will act as a barrier to moisture while allowing air to pass through it. Closed cell SPF keeps out both air and moisture.

Structural insulated panels (SIPs): SIPs consist of a foam core pressed between two structural panels, most often made of oriented strand board (a treated wood panel similar to plywood).[81]

Insulated concrete forms (ICFs): ICFs also utilize foam insulation, but as a form or mold into which concrete is poured. The foam forms remain part of the wall, acting as both thermal and sound barriers. ICFs can be constructed as interlocking blocks or panels held together with plastic ties.[82]

Despite the contraction of the housing construction industry, demand for spray foam insulation has increased since 2009, largely due to retrofits. While the number of housing starts decreased 8.5% from 2009-2011, SIP production only dropped by 4%.

Energy Efficient Doors and Windows: Gaining a Larger Share of the Fenestration Market

Just as they need a tight building envelope, net-zero-energy houses also require energy efficient doors and windows to prevent air seepage and reflect excess solar heat. To perform these functions, energy efficient windows may contain multiple panes of glass, often with inert gases like argon or krypton between each pane, to further reduce solar heat transfer. Glazes using low-emittance (low-E) coatings may also be used on glass to lower a window's U-factor, or the amount of non-solar heat loss or gain through a window. These low-E coatings are very thin and

[81] What Are SIPs? (2011). Structural Insulated Panel Association. Retrieved from http://www.sips.org/about/what-are-sips/
[82] Types of Insulating Concrete Forms. (2012). Insulating Concrete Form Association. Retrieved from http://www.forms.org/index.cfm/ICFtypes

transparent layers of metal or metallic oxide that reflect the longer wavelengths of infrared radiation while allowing shorter wavelengths of visible light to pass through.[83]

Energy efficient doors and windows comprised 34 percent of all purchases qualifying for the 2009 federal tax credit, amounting to $2.2 billion and $8.5 billion in sales respectively. Moreover, 60 percent of builders say they provide energy efficient windows as standard options.

Heating and Cooling Systems Market: Energy Efficient Options Will Become More Popular as Training, Awareness Increase

Energy efficiency strategies often used in net-zero-energy homes—such as creating a tight building envelope and installing tightly sealed doors and windows—require adequate levels of air filtration and ventilation. Several options are available for net-zero-energy homeowners beyond the customary HVAC systems. This section will discuss systems that use alternative sources of energy or use conventional sources in more efficient ways.

- **Geothermal heating and cooling:** Geothermal pumps use heat from the earth to heat and cool air, or to heat water, in a building. Using water or a fluid refrigerant, the pumps transfer heat from the ground to the home on colder days or from the home to the ground on warmer days. Geothermal systems may be horizontally oriented, with pipes shallowly laid over a large area, or vertically oriented, with pipes reaching deep underground. Pipes can be embedded into the earth or linked to a nearby body of water. Which system is installed depends on the amount of land or the size and quality of water bodies available.[84]
- **Evaporative cooling:** Evaporative cooling systems can serve as alternatives to traditional air conditioning systems. Evaporative coolers pull outside air through moist pads and circulate the cooled air through the building. Because they add moisture to the circulated air, they work best in less humid climates.[85]

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[83] Window Technologies: Glazing Types. (2012). Efficient Windows Collaborative. Retrieved from http://www.efficientwindows.org/gtypes.cfm
[84] Allen, L. (2010, December). A Guide to the Basics of Geothermal Heating and Cooling Systems. *Natural Home & Garden*. p. 2. Retrieved from http://www.naturalhomeandgarden.com/article.aspx?id=2147487098&page=2
[85] Consumer Energy Center. (2006). California Energy Commission. Retrieved from http://consumerenergycenter.org/home/heating_cooling/evaporative.html

- **Energy recovery ventilation (ERV):** ERVs supplement traditional HVAC systems by reducing the amount of energy needed to heat or cool air. They achieve this reduction in energy use by transferring heat from warm inside exhaust air to cold supply air in winter or from warm supply air to cooler inside exhaust air in summer.[86]

The geothermal pump industry can increase production quickly and easily, but more training for installers will be necessary. The evaporative cooling and ERV industries, however, will need to overcome unfavorable consumer perceptions to see real growth.

Solar Thermal Water Heaters: Cost is Biggest Market Barrier, but Supportive Policies can help

Net-zero-energy homes can use a variety of different systems for water heating and storage, including tankless water heaters and hybrid systems that are more energy efficient than traditional water heaters. This section will discuss solar thermal heating systems, which rely on alternative sources of energy to operate, that heat water without substantially contributing to a home's energy consumption.

There are two basic types of solar thermal water heating systems.

- **Active systems** that contain circulating pumps and controls. *Active indirect systems* use a solar collector to heat the refrigerant and pump it to a heat-transfer unit where it warms the water within a conventional storage tank. They are the most prevalent type used in the U.S., because, unlike other solar thermal models, they work well in both warm climates and climates prone to freezing temperatures.
- **Passive systems** that do not contain pumps. *Flat-plate collector systems* are most often used to heat swimming pools.

Both types of solar thermal systems will require backup conventional storage systems for cloudy days or times of high demand.

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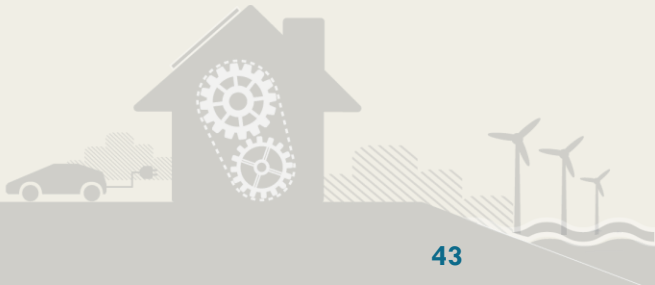
[86] Energy Recovery Ventilation Systems. (2011). U.S. Department of Energy. Retrieved from http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11900



The most pressing issue facing the solar thermal water heater industry is the high cost of purchasing a solar thermal system. The price needs to fall below $1,000 to compete with electric and natural gas water heaters. Huge growth is seen in installations when federal tax credits are put in place.

Energy Efficient Lighting Market: Huge Gains Projected with Passage of Federal Legislation, Decreasing Cost

Energy efficient lighting is another important component of net-zero energy housing: the less electricity a light requires, the more energy is available for other uses (such as heating and cooling). Both new types of light bulbs and lighting controls play a part in reducing a home's overall energy consumption. In this section, the following technologies will be discussed.

- **Compact Fluorescent Light Bulbs (CFLs):** Unlike incandescent bulbs, CFLs do not use heat to produce light. Instead, electricity interacts with argon and mercury inside the bulb to produce ultraviolet (UV) light. The UV rays excite the fluorescent coating on the inside of the bulb, generating visible light.[87] Because CFLs do not generate as much heat to produce light–heat that is mostly wasted–they are much more energy efficient than incandescent bulbs.
- **Light-Emitting Diodes (LEDs):** LEDs also use electricity more efficiently than incandescent bulbs, but rather than exciting electrons in argon gas and phosphor coatings, LEDs use diodes, which are electrical devices through which current flows in one direction.[88] When current runs through them, these diodes emit bright light. Different colors can be emitted using different types of semiconductors.
- **Lighting Controls (including dimmers, occupancy/motion sensors, timers, and daylight sensors):** Lighting controls can be installed on incandescent bulbs, CFLs, or LEDs to regulate how much energy the light uses. Dimmers to vary the brightness of a light, and motion detectors and timers to control when the light turns off and on, have been utilized in residential lighting fixtures for decades. Newer technologies, including daylight sensors

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[87] Learn about CFLs. (2012). Energy Star Program. Retrieved from http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about
[88] Holzer, D. (2012). What Does LED Stand For and How Does it Work? *National Geographic*. Retrieved from http://greenliving.nationalgeographic.com/led-stand-work-2682.html

and occupancy sensors, regulate the amount of light emitted by light fixtures according to the amount of natural light in the room or whether the room is occupied.

Perhaps the most crucial driver of this market is the Energy Independence and Security Act, which phases out incandescent bulbs by 2015. As incandescent bulbs stop being produced, consumers will replace them with CFLs and LEDs. Market penetration for CFLs is expected to be 30-43 percent by 2015. As prices drop, LEDs' CAGR is projected to rise to 200 percent through 2015.

Energy Efficient Appliances: Energy Star Products Continue to Gain Recognition and Market Share

Like lighting and HVAC systems, appliances must use energy efficiently to maintain the balance of energy consumption versus generation in a NZEH. If a home is built with energy efficient insulation, doors, windows, HVAC, and water heating systems but does not have energy efficient appliances, it will still consume more energy than it is able to generate. In the U.S., the Environmental Protection Agency (EPA) and DOE's Energy Star program sets the standard for energy efficiency requirements and ratings. To become Energy Star qualified, a product must meet certain criteria based on the guiding principles of the program.

- Product categories must contribute significant energy savings nationwide.
- Qualified products must deliver the features and performance demanded by consumers in addition to increased energy efficiency.
- If the qualified product costs more than a conventional, less-efficient counterpart, purchasers will recover their investment, within a reasonable period of time, in increased energy efficiency through utility bill savings.
- Energy efficiency can be achieved through broadly available and non-proprietary technologies offered by more than one manufacturer.
- Product energy consumption and performance can be measured and verified with testing.
- Labeling would effectively differentiate products and be visible for purchasers.

In 2010, over 1,600 manufacturers produced more than 40,000 Energy Star products in 60 categories. Since 2000, over four billion Energy Star qualified products have been sold. Rebate

programs for qualified appliances span the nation and spurred over $1.3 million in purchases from 2009 to 2011.

Smart Meters Market: Utility-Driven Growth in the Face of Privacy and Health Concerns

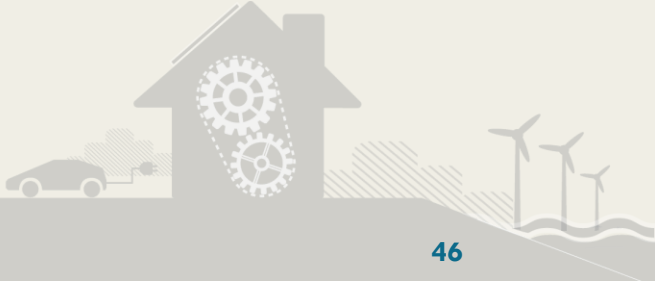
Once homeowners have purchased energy efficient appliances, ventilation, and water heating systems, they must also ensure the systems are being used efficiently. Net-zero energy and traditional homeowners alike can install smart meters to monitor their energy usage. Smart meters are the newest breed of electric, gas, or water meters that record energy usage in timed increments that allow residents to understand just how much energy is being used in their homes and on which applications. By comparing this data to past or desired usage rates, people can make informed decisions on regulating their energy consumption and use. Smart meters can also communicate with utility providers to more quickly identify outages and regulate supply during peak demand periods.

Smart meters' market penetration was 45 percent in 2011 and is expected to reach 75 percent in 2021. Concerns over privacy and radiation have led to opt-out programs in some states, but growth will continue as more utilities install them to lower costs and better monitor demand.

Home Automation Systems Market: As Prices Fall and Connectivity Spreads, More Homes Utilize Energy Management Systems

Although home automation systems have been used primarily for security in the past, producers are now focusing more on energy management and are offering a new line of products designed to help homeowners regulate their energy use. Once homeowners obtain and understand their households' energy use from a smart meter, they can use home automation systems to manage that usage–even from a different location. The system allows homeowners to turn off lights and appliances and program the HVAC system.

The increase in broadband and smartphone use and the transition to an affordable monthly payment model have contributed to the rise of home automation systems in the U.S. From 2009 to 2011, the percentage of new homes with energy management systems increased 133 percent. The global home automation market is expected to reach $11 billion in 2015, with energy management systems outpacing security automation.



HURDLES AND SOLUTIONS: NET-ZERO ENERGY HOME MARKET

Creating a net-zero energy home (NZEH) or community is a highly customizable process and should be reflective of the community in which a net-zero home is located. Factors such as climate, consumer and builder attitudes, and financing structures should be taken into account when deciding how to build the net-zero energy market at a local level. However, there are several hurdles confronting the industry as a whole and impacting the ability of builders, developers, utilities, and homeowners to effectively implement net-zero energy homes in their community. These hurdles, and potential solutions, are discussed in this section. Topics include the:

- Research and development of home energy systems to inform the efficient development of affordable net-zero energy homes;
- Uncertain regulatory environment surrounding net-zero technology and home construction;
- Higher up-front costs of net-zero energy homes relative to traditional homes; and
- Education of builders and homeowners about the benefits of net-zero homes.

Role of Economic Developers

Some industries—such as architecture, lighting, and energy efficient appliances—that provide products and services for NZEH are well-established; however, others—such as PV manufacturing and smart meters—are still developing. Many of these companies utilize new technology, may have heavy up-front capital requirements, and face unique regulatory and/or market settings.[89] There are several ways that economic developers can support NZEH (and associated industry) development in their communities. Potential action items are discussed below, with a more in-depth discussion in the Hurdles and Solutions section.

- **Support policies that promote energy efficient building and renewable energy systems** Municipalities and states can implement programs that support net-zero energy homes,

[89] Muro et al., 2011, p. 37

such as performance-based tax incentives for energy efficiency measures and renewable energy systems. They can also support training and outreach to architects, builders, building contractors, real estate professionals, and local building and permitting officials on the benefits of net-zero energy homes.[90] In addition, partnerships should be established between government planning and zoning officials, local utilities, and the home-building industry to identify opportunities, challenges, and strategies for future development. These partnerships can help stakeholders identify obstacles and solutions to the development of NZEH and associated businesses.

- **Address financial gaps**
  Financial incentives can help otherwise hesitant businesses, home buyers, and builders enter the NZEH market. State development authorities could supplement private lending by providing guarantees and/or loans to in-state companies with promising new technologies; or, they could provide the initial funding for revolving loan funds that target NZEH industries.[91] Other options include tax credits, like tax rebates for solar PV installation, for energy efficiency projects.

- **Maintain a regional focus**
  Businesses that could serve the net-zero energy home market tend to develop best and more quickly when located in an industry cluster, especially in metropolitan regions. Regions and regional industry clusters foster innovation, entrepreneurship, and job creation due to the proximity of existing and developing businesses, researchers, projects, workers, and suppliers.[92] Economic developers can facilitate the development of industry clusters by improving the quality of available information about the existing industry base, identifying obstacles to local industry development, and supporting existing regional cluster initiatives.[93]

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[90] Stephen V. Dunn, & Will Geller. (2008). High Performance Homes in the Southwest: Savings Potential, Cost Effectiveness and Policy Options. Presented at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.
[91] Muro, M., Rothwell, J., & Saha, D. (2011). *Sizing the Green Economy: A National and Regional Green Jobs Assessment*. p. 38-39. Brookings Institution Metropolitan Policy Program.
[92] Ibid. p. 41.
[93] Ibid, p. 43.

Research and Development

Funding for research and development is crucial to solving the data and technology hurdle. In order to achieve net-zero energy use, technologies and systems must increase home energy efficiency by 40 percent relative to current levels, which will require advances in the home energy systems available today. [94] This is a bridgeable gap, but several obstacles stand in the way, including:

- Developing a method for correctly projecting the energy demands and potential savings in a home,
- Understanding homebuyer preferences for net-zero energy versus traditional homes, and
- Helping utilities to address connectivity of residential solar energy to existing infrastructure and to manage peak demand.[95]

According to a 2008 report from the National Renewable Energy Laboratory, at least $12 million per year is needed for research on net-zero energy home systems to achieve the U.S. Department of Energy's zero-energy home performance goals, and some progress has been made toward this goal.[96] In 2010, for example, the U.S. Department of Energy (DOE) awarded $20.2 million to Oak Ridge National Laboratory and $15.9 million to Lawrence Berkeley National Laboratory to study net-zero energy buildings. This money was part of the $104.7 million in American Recovery and Reinvestment Act funds awarded to the DOE.[97]

Programs such as the Department of Energy's Builders Challenge, in addition to pilot developments throughout the country, will also address the research and development hurdle by adding to the existing net-zero energy home knowledgebase.

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[94] Anderson, R., & Roberts, D. (2008). *Maximizing Residential Energy Savings: Net Zero Energy Home Technology Pathways*. p. 1 National Renewable Energy Laboratory.
[95] Hammon, R. W., & Neugebauer, F. S. (2010). Applications for Large Residential Communities: What is Net-zero Energy? *Strategic Planning for Energy and the Environment*, *29*(3), 48-49.
[96] Anderson & Roberts, 2008, p. iii
[97] McKeough, Tim. (2010, March 9) *U.S. Directs $36 Million Toward Net-Zero Building Research*. Architectural Record. Retrieved from http://archrecord.construction.com/news/daily/archives/2010/100309net-zero.asp.

National Residential Efficiency Measures (NREM) Database

The NREM database was developed by the National Renewable Energy Laboratory (NREL) for the US Department of Energy. The purpose of this database is to provide retrofit measure and cost data so that software programs can more accurately evaluate the cost-effectiveness of various energy efficiency actions in a residential building. The database is publicly available in that anyone can submit and view data.

Several retrofit measures are covered by the database including: appliances, hot water, HVAC, lighting, and other miscellaneous measures such as ceiling fans and water coolers. Each measure includes before and after component information as well as cost information. The "before-component" analysis gives the current condition of the measure; the "after-component" data includes properties associated with the measure such as expected lifetime, energy use, and performance standard (ex: ENERGY STAR). Since the exact cost of a particular measure can differ by region, costs for each measure are given as a range as well as an average (NREL. *National Residential Efficiency Measures Database*. http://www.nrel.gov/ap/retrofits/about.cfm).

To illustrate the type of data available in the NREM database, a sample of retrofit measure data for replacing a type of incandescent light bulb with a CFL light bulb is below:

Table 10: Replacing a Light Bulb

Before-Component	After-Component	Cost
Light Bulb (100W Incandescent, 3-way 50/100/150) **Properties** • Function: 3-way 50/100/150 • Lamp Type: Incandescent • Lifetime: 800h • Luminous Efficacy: 16 lm/W • Wattage: 100W	**Light Bulb (20W CFL, 3-way 13/20/25)** **Properties** • Function: 3-way 13/20/25 • Lamp Type: CFL • Lifetime: 8300h • Luminous Efficacy: 65 lm/W • Wattage: 20W **Performance Standards** Exceeds Energy Star 2008	**Measure Cost** **Total** • Range: $9.7- $15 • Average: $13

Source: NREM Database, *Retrofit Measures for Light Bulb,* http://www.nrel.gov/ap/retrofits/measures.cfm?gId=5&ctId=30

As more homes are developed with the support of financial subsidies and organizational partnerships, builders, developers, utilities, nonprofits, researchers, and homeowners can share best practices and lessons learned. The National Renewable Energy Laboratory (NREL) is contributing to this effort with their National Residential Efficiency Measures Database, which provides cost and consumption information for things such as appliances, hot water use, types of building enclosures, HVAC, and lighting. The purpose of the project is to develop a national database that explains the impact of residential building retrofit measures.[98]

Predictability in Estimating Costs and Savings for Energy Use

Programs such as NREL's National Residential Efficiency Measures Database will be helpful for developers and prospective net-zero energy homebuyers. Homebuyers want to know which investments will yield the greatest returns over different timelines. While developers want to know for the same reasons, the limitations of existing technology to predict energy usage, savings, and generation rates can create a liability if advertised estimates are not closely aligned with a homeowner's actual experience. In addition, since some net-zero components are new (or made by young companies), developers may be hindered by worries over reliability and the potential cost of replacing dysfunctional equipment on a house under builder warranty.[99]

While net-zero energy is achieved through a combination of energy-efficiency measures and on-site renewable energy generation, a study sponsored by the U.S. Department of Energy predicts that the cost tradeoff between achieving greater levels of energy efficiency and increasing the amount of energy generation will result in a greater emphasis on energy efficiency. While the technologies required to increase energy efficiency in a cost-effective manner could be available within the next 10-15 years, the speed at which these technologies reach the market will depend on investments in research and development.[100]

Predictability: Potential Solutions

Builder's Challenge

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[98] NREL. *National Residential Efficiency Measures Database*. http://www.nrel.gov/ap/retrofits/about.cfm

[99] Larry Gotlieb. (2012 Aug. 30). Telephone Interview.
[100] JA Dirks, 2010, p. 4

Programs such as the Builders Challenge are making progress toward greater market adaptation of net-zero energy homes. The Department of Energy has sponsored net-zero energy home projects throughout the country to determine the resources and systems needed to achieve net-zero energy in different climates, and some developers have started their own projects independent of this initiative. DOE uses information from these projects to publish a best practices series as well as white papers describing the individual projects, lessons learned, and strategies for mitigating issues in the net-zero home industry.

NREM Database

Databases such as the National Residential Efficiency Measures (NREM) Database, developed for the U.S. Department of Energy, are another source of agglomerated data on NZEH measures. As the database grows, homebuyers and builders can consult the available data as part of a cost-benefit analysis for NZEH components.

While the individual projects completed thus far may not all be cost effective or fully achieve net-zero energy status, the lessons learned from these construction experiences can be applied to future NZEH developments. In particular, these projects have revealed the following needs: provide net-zero home design assistance to builders, monitor the performance of existing net-zero and nearly net-zero energy homes, understand buyer motivations and decision-making, and develop better whole-house energy monitoring and controlling mechanisms.

Understanding Homebuyer Preference

In addition to knowledge surrounding the technical needs of net-zero energy homes, more data is needed regarding homebuyers' preferences and what might entice individuals to buy a net-zero energy home. Some research to determine the preferences, priorities, and concerns of homebuyers has already been carried out. This information should be used when devising a strategy for efficiently building and marketing NZEH to a community.

A focus group survey from the National Association of Home Builders (NAHB) Research Center identified the following homebuyer preferences.

- Homeowners value comfort, energy efficiency, indoor air quality, and resale value.

- Homeowners believe the cost of selecting an environmentally responsible home will most likely be higher than any monetary return.
- Homeowners appear willing to pay for comfort, energy efficiency, and environmental responsibility. Over 80 percent of respondents to a NAHB online survey expressed a willingness to buy a home in which savings in utility bills offset an energy technology-caused increase in mortgage payments. Furthermore, over 70 percent of respondents expressed a willingness to pay a premium each month to eliminate utility price fluctuations and 42 percent of respondents expressed a willingness to pay an additional $100 per month or more for a net-zero energy home.
- Homeowners seem to be intrigued by the concept of zero-energy homes and want to learn more about financial incentives tied to zero-energy homes.[101]
- About 60 percent of respondents were willing to pay at least $10 per month more on their mortgage to avoid fluctuating energy costs and/or to use non-polluting sources of energy. Over 50 percent would pay $20 or more for the same benefits.
- Over two thirds of respondents were willing to pay at least $50 more per month for a zero-energy home, while over 50 percent would pay at least $100 more per month on their mortgage for a zero-energy home.
- While many people were willing to trade off a higher mortgage for a more energy efficient home, the following three things were identified as very important to the decision-making process:
    - Government tax incentives,
    - Reduced mortgage rates, and
    - Free 5-year annual maintenance on the house heating/cooling system.[102]

These findings were confirmed in a 2012 McGraw-Hill Construction survey of homebuilders. In this survey, despite the recession, 61 percent of builders and 66 percent of remodelers reported that their customers were willing to pay more for a green home or remodeling project, which was an increase over the 58 percent who gave that answer in 2008. Some of the most prominent reasons why builders and remodelers felt that customers wanted green projects were to achieve lower energy use, save money, experience better health, and do something that is better for the environment.[103]

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[101] NAHB Research Center, 2006, pp. 13–14
[102] NAHB Research Center, 2004a, pp. 1–2
[103] McGraw-Hill Construction. (2012). *New and Remodeled Green Homes: Transforming the Residential Marketplace*. Bedford: McGraw-Hill. p.19, 24.

Connectivity and Peak Demand for Utilities

Utility companies are central to the success of net-zero energy homes as they often purchase the solar energy generated by a home. In many communities, utilities are not required to purchase any of the energy generated by a private residence. Caps on the amount of renewable energy accepted by a utility, such as the California Public Energy Commission's 5 percent cap on net metering, also contribute to uncertainty regarding energy buyback in large-scale NZEH development.[104]

In contrast to the limitations discussed above, some utilities, such as the Sacramento Municipal Utility District (SMUD), have realized financial benefits from a proactive attitude toward the NZEH market. After several nearly-zero home developments were established in Sacramento, SMUD has worked with developers, the Building Industry Research Alliance (BIRA), and other partners such as Pacific Gas and Electric (PG&E) to analyze the efficiency of zero-energy homes for energy usage and cost patterns. Their study of approximately 200 homes in two different communities revealed an average peak period electricity savings of 70 percent when compared with traditional homes, which saved homeowners an average of $590.64 per year on utility bills.[105]

The peak energy savings of one of the developments, Premier Homes, was enough to convince SMUD to create a Zero Energy Homes Program to encourage the development of NZEH and further leverage their ability to take advantage of peak energy savings.[106] This zero energy homes program, now called "Home of the Future," offers homeowners resources such as premade home plans that meet building codes as well as energy efficient measures at two levels: 60 percent less and 85 percent less than a traditional home. In addition, the City of Sacramento and County of Sacramento help connect homeowners with available tax credits and incentive programs for building net-zero energy homes.[107] A higher number of NZEH will enable SMUD to serve a greater number of customers with existing infrastructure.

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[104] Jacob Atalla. (10 Sept. 2012). Phone interview.
[105] Kerr, Baccei, & Hammon, n.d., pp. 1–2
[106] Kerr et al., n.d., pp. 4–5
[107] Sacramento Municipal Utility District (2012). *Home of the Future*. https://www.smud.org/en/about-smud/environment/green-home-innovations/

Connectivity

Utility companies do not all have the ability or willingness to integrate homeowners' solar power systems with their existing infrastructure, and not all utilities have developed a cost structure to facilitate net metering.[108] In addition, there are concerns regarding profitability should utilities accept NZEH on a large scale, since NZEH consume less energy and contribute to the grid, which is a potential cost for the utility. As the net-zero market develops and more PV panels are installed, the value of energy will fall and, at a high enough NZEH concentration, both the profits of utility companies the cost-effectiveness of PV could decrease. Potentially, as PV installations become more common, utilities will be paying more homeowners for energy generation rather than energy use. In addition, as PV use grows homes will use less energy during midday, when demand is traditionally highest. This has the ability to decrease the value of the power generated that the utility is willing to pay a homeowner. This, in turn, could decrease the cost-effectiveness of PV panels.[109]

Connectivity: Potential Solutions

Transparent and Fair Rules

The establishment of consistent, easy-to-understand connectivity and net-metering rules that allow homeowners to receive credit for excess energy generation is an important next step. Utilities should be involved with the development of and allow for the connection between energy infrastructure and homeowners' solar systems.[110] Economic developers can facilitate the process by working with companies and regulatory agencies to ensure that utilities develop a technical capacity to allow for distributed energy generation as well as a revenue structure that ensures financial stability for utility companies that incorporate net-zero homes into their portfolios. The needs of homeowners should also be taken into account. If the cost of energy drops too low, the energy credit offered by utilities falls below market rate, or the expense of PV becomes too high,

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[108] NAHB Research Center. (2006). *The Potential Impact of Zero Energy Homes* (No. EG5049_020606_01). p. 22. National Renewable Energy Laboratory. Retrieved from http://www.toolbase.org/pdf/casestudies/zehpotentialimpact.pdf

[109] JA Dirks. (2010). *An Exploration of Impacts of Wide- Scale Implementation of Net Zero- Energy Homes on the Western Grid* (Technical Report). p. 24. Pacific Northwest National Laboratory for the U.S. Department of Energy. Retrieved from http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19693.pdf

[110] NAHB Research Center, 2006, p. 22

the number of homeowners and builders investing in net-zero energy will decrease. Therefore, pricing strategies should take into account both utility companies and homeowners.

Peak Demand

Peak demand management is a major concern for utility companies as flat loads are more cost-effective to manage than volatile loads. In order to continue producing enough energy to meet peak demand, some utility companies currently have "peaker plants" that are used to meet electricity demand that exceeds the generation capability of baseline plants. "Peaker plants" are usually run for just a few hours at a time and are not as efficient as plants that serve the baseline load, making peak period electricity more expensive to produce, buy, and distribute. Therefore, the ability to reduce peak demand to off-peak periods and flatten the demand for electricity is very attractive to utility companies as it can help reduce the capital investments and marginal costs of creating extra energy, thereby lowering prices for all consumers and allowing the company to potentially reach more customers with the same infrastructure.[111]

Since net-zero energy homes have lower grid-based energy demands, an increase in the number of net-zero homes could help reduce energy demands during peak load times. Utility companies are often hesitant to rely on net-zero energy homes as a resource for peak load management, however, due to the variability in energy demand and solar energy production.

Peak Demand: Potential Solutions

NREM Database

Research efforts such as NREL's National Residential Efficiency Measures Database are helping to create a standard method of evaluating energy efficiency measures used in net-zero energy homes, but more accurate methods of large-scale energy prediction are needed. As more NZEH homes and developments are established, utilities will be able to obtain more usage data to inform peak load management strategies. In addition, as net-zero energy systems are refined, an

[111] Kerr et al., n.d., p. 6

ideal system will result in a zero-peak load so that utilities do not have to account for large differences in energy use between normal and peak times.[112]

Uncertain Regulatory Environment

The regulatory environment surrounding net-zero homes is uncertain, which makes it more difficult to convince builders, developers, and homebuyers to invest in net-zero energy homes. Specifically, current financial incentives such as tax rebates are not guaranteed into the future (some, such as the federal personal tax credit for energy efficiency, have expired). Further, utility companies are not always required to accept and credit a homeowner for excess solar energy. Lastly, homeowners do not always have long-term guaranteed access to sunlight. For example, changes in area building codes may lead to construction that blocks sunlight access.

Uncertain Regulatory Environment: Potential Solutions

Educate Stakeholders on Successful Policies

Educating various stakeholders including politicians, builders, developers, buyers, and utilities can help develop a greater level of support for net-zero energy policies. Examples of successful policies include tax rebate programs, local building codes that allow for the installation of PV panels as well as continued access to sunlight, and utility pricing structures that ensure continued acceptance of excess energy at a market rate. For example, the Boulder, Colorado Solar Access Guide guarantees homes four hours of sunlight per day, and the Florida feed-in-tariff program that guarantees 19¢-24¢per kWh (the exact amount depends on the type and size of solar system installed) was fully subscribed for 2012 at the beginning of May, although new participants cannot join until 2013.[113] [114]

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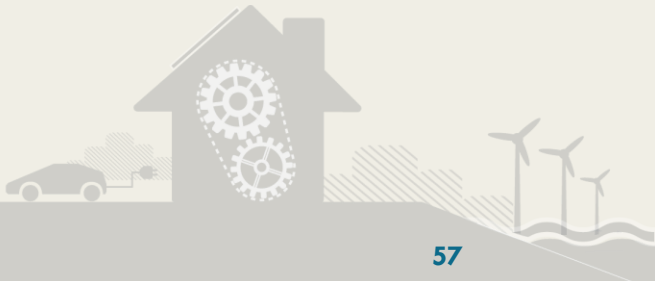
[112] NAHB Research Center, 2006, p. 22

[113] Building Design + Construction, 2011

[114] Database of State Incentives for Renewables & Efficiency, (2012, May 9), http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=FL77F



Financing

The additional cost of a NZEH can make it difficult for builders and homeowners to achieve net-zero energy in a cost-effective way. The hurdles discussed in this section include:

- Upfront costs and
- Home appraisal.

Upfront Costs

Increasing housing equipment and envelope efficiency to the highest available standards could decrease energy use in homes by 69 percent. The remaining 31 percent of energy reduction needed to achieve net-zero energy will need to come from renewable energy sources.[115] Currently, PV and solar thermal systems are the most popular ways to bridge this energy gap. While photovoltaic and solar thermal space and water heating can provide enough energy efficiency to make net-zero technology feasible in most U.S. climates, the current technology is often accompanied by large up-front installation costs and long-term cost recovery timelines.

In the United States, solar panels are sometimes perceived by homeowners and builders as prohibitively expensive. This may be a reason why solar panels account for less than 1 percent of total electricity generation in the U.S. This perception has been a hurdle for NZEH developers as well, according to Larry Gotlieb, Vice President of Government Affairs at KB Home. In his experience, while homebuyers are willing to purchase homes with standard energy-saving measures, they are not always as willing to pay more for the extra energy efficiency and generation features needed to achieve net-zero energy. This is especially true when buyers face a long-term (more than five to seven years) return on investment.[116]

Under current funding structures, generating power from the sun using rooftop panels can cost four times as much as coal, which is the largest and cheapest source of electricity in this country.[117] Installing solar panels can add between $25,000 and $50,000 to the up-front costs of a new home.[118] It is important to note that despite the high cost of solar energy when compared to coal-

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[115] NAHB Research Center (2006). The Potential Impact of Zero Energy Homes. 19.
[116] Larry Gotlieb. (2012 Aug. 30). Telephone interview.
[117] Kate Galbraith, 2009
[118] Department of Energy. (n.d.). Building America Puts Residential Research Results To Work.

based energy, the price of solar panels (excluding labor and taxes) is declining, going from $10 per watt in 1980 to $3 per watt in 2008.[119]

Solar energy can cost several times more than traditionally sourced electricity when accounted for at the time of installation, but solar energy generation saves homeowners money on energy expenses in the long term. One way to address the disconnect between upfront cost and long-term savings is to conduct an analysis of the average payback period of a solar installation. While cost/benefit analyses will differ by state due to different funding structures and climates (which affects the amount of energy generation), it is possible to estimate the average payback period of a solar PV system.

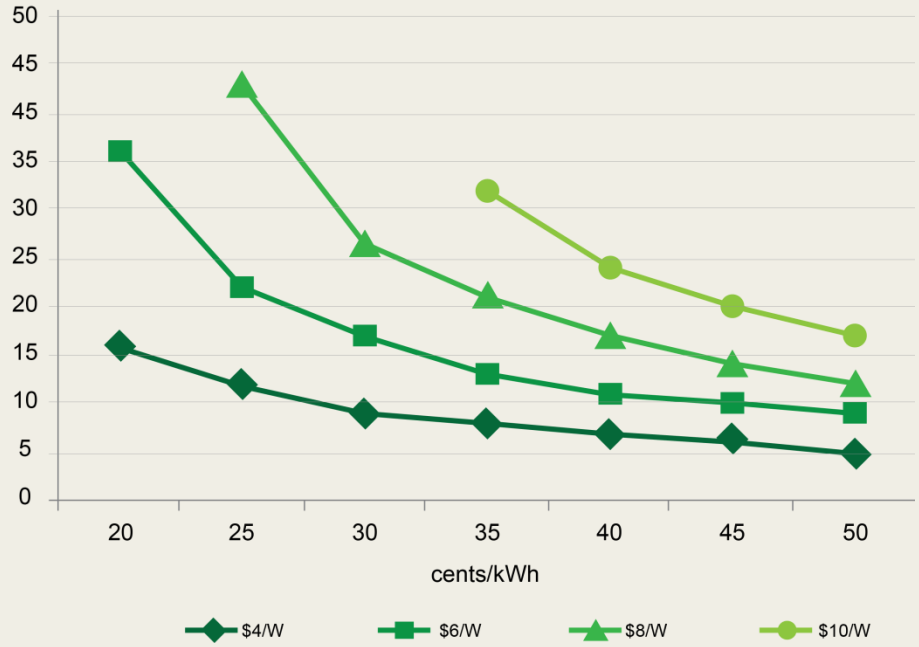
According to Solarbuzz, a solar market research and analysis company, the cost for a one kilowatt peak system is between $8,000 and $12,000 before tax, assuming no governmental financial assistance (tax rebates, credits, etc.). Installation costs for this type of system are between $1,000 and $2,000. Assuming a 20-year life for the system the purchase, financing, and installation can cost 30-40¢ per kilowatt hour (kWh) in sunny climates and 60-80¢/kWh in cloudy climates. Programs that subsidize the cost of PV systems can reduce the total cost by 10-60 percent, which decreases the cost per kWh by 15-20¢ in sunny climates and 30-40¢ in cloudy climates.[120] The graph below shows the payback period of PV systems for different electricity rates and installment costs. If, for example, the average electricity rate is 20¢ per kWh and the installed cost is $4.00 per watt, the payback time for a solar PV system would be just over 15 years. It is important to remember this graph only provides estimates. If the homeowner in this hypothetical situation has more or less sunlight than the assumed five hours per day, received peak pricing for electricity generated, or used tax incentives, the payback period would be different.

Eric Wolff. (2011, July 9). Housing: State may require "net zero" energy homes by 2020. North County Times. Retrieved from http://www.nctimes.com/business/article_df31cdef-fac9-5731-ba37-69fa901b4881.html

[119] Department of Energy, (n.d.)

[120] Solarbuzz (2012, May 10). *Economic Payback*. Retrieved from http://www.solarbuzz.com/going-solar/using/economic-payback

Figure 2: Payback Period of Installed Solar PV Systems (Assuming 5 sun-hours and 5% discount rate)



Source: Solarbuzz, *Economic Payback*, http://www.solarbuzz.com/going-solar/using/economic-payback

Table 11, from a report by the American Council for an Energy Efficient Economy (ACEEE), shows incremental costs and net savings per home in five western states for ENERGY STAR rated homes, best practice homes, and zero-energy homes. In this study, an ENERGY STAR rated home would have 15-30 percent energy savings over a traditional home, an energy-efficient best practice home would have 30-50 percent energy savings over a traditional home, and a zero-energy home would have 50 percent or greater energy savings over a traditional home in addition to the ability to produce as much energy as it consumes on an annual basis.[121]

[121] Stephen V. Dunn, & Will Geller. (2008). High Performance Homes in the Southwest: Savings Potential, Cost Effectiveness and Policy Options. p. 2-58. Presented at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

Table 11: Incremental Costs and Net Savings per Home

State/City	Incremental Cost			Net Savings, Annual[3]		
	ENERGY STAR[1]	Best Practice	Zero Energy Home[2]	ENERGY STAR	Best Practice	Zero Energy Home
Arizona (Phoenix)	$3,218	$3,474	$15,210	$552	$946	$767
Colorado (Denver)	$2,917	$6,588	$19,895	$432	$616	$271
Nevada (Las Vegas)	$3,236	$5,547	$16,231	$550	$961	$960
Nevada (Reno)	$3,653	$5,640	$18,491	$139	$262	$97
New Mexico (Albuquerque)	$2,464	$5,539	$16,629	$763	$884	$834
Utah (Salt Lake City)	$2,946	$6,588	$19,331	$434	$636	$247
Regional Average	$3,072	$5,563	$17,631	$478	$718	$529

Source: ACEEE (2008). *ACEEE Summer Study on Energy Efficiency in Buildings. 2-63.*

[1] Includes ENERGY STAR Appliance Package (dishwasher, refrigerator, clothes washer)

[2] Includes adjustment for federal tax credits for energy efficiency ($2,000) and renewable energy systems ($2,000) for solar hot water and $2,000 for solar PV

[3] Net savings represents the savings to the homeowner in the annual cost of the mortgage plus utility bills versus a typical home. The net savings is after federal tax credits to the homebuilder and homeowner for energy efficiency and renewable energy measures, and excludes utility rebates and state tax credits

As Table 11ble 11 indicates, net savings for different types of energy homes differs by region. Increased affordability is therefore critical to encourage greater market adoption of net-zero homes. Table 12 lists the technologies with the greatest potential for energy savings. The technologies are listed in decreasing order according to their potential for energy savings in all U.S. climate regions as well as the priority for cost reduction.

Table 12: High Priority Technologies for Zero Energy Homes

Technology	Desired Efficiency / Characteristic	Average Energy Savings Potential (MMBtu)
Photovoltaic System	1.8 - 4.8 kilowatts (depending on climate)	76.04
Solar Thermal Space/ Water Heating	42 - 100% load reduction (depending on climate)	45.66
Lighting	100 lumens/watt	37.84
Water Heating	>=2.0 energy factor (solar thermal)	33.19
Windows	0.10 U-value 0.18 - 0.38 solar heat gain coefficient	26.08
Space Heating	6.8 - >10.0 heating seasonal performance factor (depending on climate)	25.62
Appliances	50% reduction in small appliance loads	16.90
	400 - 500 kWh/yr refrigerator	10.52
	3.9 - 4.3 cycle/kWh clothes dryer	10.50
Walls	0.023 – 0.060 U-value	6.48
Ducts	5% leakage	5.82
Foundation	0.033 – 0.064 U-value	3.40
Roof	0.025 – 0.033 U-value	2.68
Space Cooling	12.0 – 16.8 seasonal energy efficiency ratio (depending on climate)	2.30

Source: NAHB Research Center (2006). *The Potential Impact of Zero Energy Homes*. 20.

In addition to the direct cost of installing energy efficient components, some builders, such as SheaHomes, have reported increased transactional costs associated with selling NZEH. If current suppliers do not offer energy-efficient products, builders will need to find new suppliers, which

may alter cost estimates and project timelines. In addition, both construction and sales staff must be trained on the benefits of net-zero energy homes.[122]

Upfront Cost: Potential Solutions

Rebates

Tax rebates can help offset the purchase and installation cost of PV panels, and further industry research and development could increase production efficiencies, making it more cost-effective to reach net-zero energy. The Federal Government currently offers a personal tax credit for renewable energy (the energy efficiency tax credit expired on December 31, 2011). This tax credit, which expires at the end of 2016, offers up to $2,000 for solar-electric systems, solar water heaters, and geothermal heat pumps. This tax credit also offers up to $4,000 for wind turbines and $500 per 0.5kW in fuel cells installed.[123] In addition to the federal programs, several states and municipalities offer tax rebates for solar technology. New York, for example, offers a maximum $5,000 tax credit for the installation of solar energy systems, and both California and Oregon have guaranteed prices per kWh for energy generated by residential solar PV systems. [124]

Consumer Education

Homebuyer concern over the additional upfront cost of PV panels can also be mitigated by emphasizing the long-term energy savings to a homebuyer, especially when accompanied by tax incentives, grants, and loans that help finance PV systems upfront. In addition to financial reasoning, effective marketing and education outreach to homebuyers about NZEH can help address concerns over the reliability and usability of technologies and systems used in NZEH. SheaHomes, an early NZEH developer, offered a "Shea University" to homebuyers to encourage the adoption of NZEH. Shea University consisted of Saturday morning sessions held in the garage of one of their homes, and covered many of the features of the home as well as the process for completing a home purchase, moving in, and addressing problems that may arise.[125]

Builder Education

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[122] Farhar, Coburn, and Murphy, 2004, p. 7-8.
[123] Database of State Incentives for Renewable & Efficiency (2011, December 20). *Residential Renewable Energy Tax Credit*. Retrieved from http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F&re=1&ee=1
[124] Ibid
[125] Farhar, Coburn, and Murphy, 2004, p. 9

Builders can benefit from the shared knowledge of available NZEH component suppliers as well as increased staff awareness of the benefits of net-zero energy homes. The National Renewable Energy Laboratory's National Residential Efficiency Measures Database is a one example of efforts to increase builder knowledge of net-zero energy homes. Builders can use this database to estimate how much an energy efficiency measure might cost as well as the potential energy savings that installation would bring. The Department of Energy's Builders Challenge also tries to engage builders by challenging them to get involved with building energy efficient homes. The DOE offers an orientation to interested builders as well as a free online resource library, and current builders are featured on the DOE Builders Challenge website.

Feed in Tariff

Feed-in-tariff programs guarantee a renewable energy generator an above-market price for energy contributed to the grid. These systems have been used very effectively in Europe, but have implemented to a much lesser extent in the United States. Feed-in-tariffs, in order to work the way they are intended, should have a standard set of characteristics including stable prices, long-term guarantees, and transparency in pricing and policies. Utilities often need to establish maximum energy generation limits per user as well as system-wide caps. In addition, most feed-in-tariff programs have a tiered system in which early adopters get a higher price for electricity than those who install later in the program since the price of equipment and installation is expected to decrease as more people install solar PV. Finally, the costs of feed-in-tariffs are borne by the utility companies, but those costs are often passed on to consumers. Once distributed among a utility company's customer base, the individual increase is usually negligible.[126]

In 2009, Gainesville, Florida became the first city in the United States to introduce a feed-in-tariff program after agreeing to pay energy-generating homeowners and businesses twice the standard electricity rate for a period of 20 years. City leaders, who controlled the local electric utility, approved the program after seeing the success of Germany's program. The policy was extremely popular, and generated such a notable increase in the number of solar panel installations that the city reached its two-year cap on solar panel energy buy-backs in just a few

[126] Matthew Berger, 2010

days.[127] Other states, such as California, Vermont, and Washington, have implemented feed-in-tariffs, as have cities such as Sacramento, California.[128]

Home Appraisal

Energy upgrades to a standard home add approximately 3-5 percent to the construction cost of a home, and photovoltaic and solar thermal systems alone can add $25,000 in additional costs to the base price of a home.[129] These expenses, while a significant upfront cost, are meant to save net-zero energy homeowners money in the long term. This long-term savings, however, is often ignored in home value calculations.

A home appraisal can be a way to recognize the added value of zero-energy technologies, but current appraisal structures are often inadequate for properly calculating the value of energy efficiency. In fact, in a 2012, 81 percent of large home builders and remodelers identified "lenders/appraisers don't understand long-term value" as a major obstacle to increased green building activity.[130]

Home appraisals are typically developed using one of three major approaches.[131]

1. **Cost approach -** The value of a home is based on the estimated cost to replace or reproduce the property improvements at the time of the appraisal, with a depreciation percentage factored into the final value. This amount is added to the value of the land.

2. **Comparison analysis -** The value of a home is derived from the estimated value of the land and improvements as compared with the recent sales price of other properties of similar size with similar features, quality, and location.

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[127] Kate Galbraith, 2009
[128] Ibid.
[129] NAHB Research Center. (2004a). *Zero Energy Home Preliminary Market Analysis: General Investigation of the Residential Appraisal Industry*. p. 2 Zero Energy Home Project. National Renewable Energy Laboratory.
[130] New and Remodeled Green Homes: Transforming the Residential Marketplace. McGraw-Hill Construction, p.29. 2012
[131] NAHB Research Center. (2004b). *Zero-Energy Home Project: ZEH Market Analysis for the Dallas, TX Area*. p.4 National Renewable Energy Laboratory. Retrieved from http://www.toolbase.org/pdf/casestudies/zehmarketres.pdf

3. **Income approach -** This value estimate is based on what a knowledgeable investor might pay for the property based on the net income that could be generated by the property. This approach is more often used for commercial properties and is rarely applied to single-family homes.

Local Partnerships

California Solar Initiative
The California Solar Initiative (CSI) is the solar rebate program for California consumers that are customers of Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). CSI offers solar customers different incentive levels based on the performance of their solar panels, including such factors as installation angle, tilt, and location rather than simply monitoring system capacity.

The CSI program has a total budget of $2.167 billion, extrapolated over the expected life of the program (2007-2016), with a goal of installing approximately 3,000 MW of new solar generation capacity by 2016. The CSI program is funded by electric ratepayers ("About the California Solar Initiative (CSI) - Go Solar California," n.d.).

New Solar Homes Partnership
The New Solar Homes Partnership (NSHP) provides financial incentives and other support for installing eligible solar energy systems on new residential buildings that receive electricity from specified investor-owned utilities. In addition to direct financial assistance, the NSHP offers builders and developers of qualifying homes access to an advisory committee made of stakeholders from the building, electric utility, and solar industries; expedited building permits and land entitlement; possible fee deferrals; and increased recognition (Robert W. Hammon, 2007, p. 29).

The California Energy Commission implements NSHP in coordination with the California Public Utilities Commission (CPUC) as part of the overall California Solar Initiative. Funding for the NSHP is provided through the Energy Commission's Renewables Resources Trust Fund (California Energy Commission, 2010, pp. 1–3).

None of these approaches perfectly captures the value of net-zero energy homes. While appraisers have the option of itemizing NZEH benefits under an "Additional Features" section, this is rarely done since there are few guidelines available for recognizing the value of energy

efficient features or renewable energy technologies added to homes.[132] Even when an appraiser includes the energy efficiency and generation features of a home, it can be difficult to value these technologies that are relatively untested in the market and that may not appear in the appraisers' Multiple Listing Service that is used to find similar properties that have recently sold. The result of these obstacles is that appraisers often ignore the features that add value to a net-zero energy home. These features are therefore not included in the home's appraisal value despite a higher construction cost.

Home Appraisal: Potential Solutions In response to the concern over appropriately appraising net-zero energy and energy efficient homes, the Appraisal Institute published a guide in 2010 to help appraisers estimate values for energy efficient features such as energy efficient appliances, highly efficient insulation, and green roofs. In addition, they offer a *Valuation of Sustainable Buildings* professional development program that teaches appraisers how to value green residential and commercial buildings.[133]

Once more net-zero energy homes come into the marketplace, it will be easier to accurately quantify the benefits of energy efficiency and energy generating technology and incorporate that into the estimated value of a home. Until this happens, there are several mechanisms for correcting the undervaluation of net-zero energy technology. Third-party subsidies, in the form of grants or incentives for net-zero technologies, are one way to keep the purchase price of a net-zero energy home more comparable with standard

Local Partnerships (Continued)

New Mexico Moving Toward Zero Energy Homes Program

New Mexico's Moving Toward Zero Energy Homes Program works with local governments to create incentives to build better-than-code homes. New Mexico, with help from a grant from the U.S. Department of Energy, incentivizes builders trying to build high performance homes, defined as those that reduce energy costs by 50-70 percent. These incentives can be monetary, such as fee deferrals, reductions, or waivers; promotional, such as news releases, mayoral breakfasts or ribbon cuttings; or entitlements, such as flexibility in zoning requirements, expedited plan reviews, or priority field inspections (New Mexico Energy, Minerals, and Natural Resources Department, n.d.).

[132] Ibid.
[133] Appraisal Institute. *Appraisal Institute Book Teaches How to Appraise 'Green' Homes*. Retrieved from http://www.appraisalinstitute.org/newsadvocacy/news/2010/060210_IntroGreenHomes.aspx.

construction. An appraiser can then add the value of this grant to the purchase price of the home, lowering the loan-to-value ratio.[134] Shea Homes pursued a different strategy in the Scripps Highlands development where solar hot water and photovoltaic systems added between $7,000 and $15,000 to the cost of a home. These features, and their dollar values, were included on the list of amenities given to an appraiser. According to their sales manager, this method did not result in any difficulties regarding the valuation of the individual amenities or the homes as a whole.[135]

Energy Efficient Mortgages and Energy Improvement Mortgages

As discussed previously, due to the additional cost of energy-saving and energy generating systems NZEH, can be more expensive to construct than standard homes, thereby creating a higher loan-to-value ratio when compared to conventional homes of similar size, construction material quality, and location. Energy efficient mortgages (EEMs) and energy improvement mortgages (EIMs), offered by large lenders such as Fannie Mae, the Veteran's Administration, and the Farmers' Home Administration, have emerged as a way to mitigate this problem in the U.S. Market. EEMs are suitable for new or existing homes, and are based on the total value of a home plus any energy efficiency upgrades. EIMs for existing homes take into account the total value of a home plus the projected value of energy efficiency upgrades.

With an EIM, borrowers can include the cost of energy efficiency improvements in a home mortgage without increasing a down payment. EIMs therefore allow a homeowner to use the money saved in utility bills to finance energy improvements. In contrast, with an EEM, a lender can increase the borrower's income by a dollar amount equal to the estimated energy savings. The mortgage loan amount for an EEM borrower can therefore be increased beyond the amount for which that person might otherwise qualify. The reasoning behind both EIMs and EEMs is that investments in energy efficiency will allow homeowners to save on utility costs, which then frees additional income that can be devoted to a monthly mortgage payment.[136]

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[134] NAHB Research Center, 2004a, p. 5
[135] Ibid., p. 7
[136] ENERGY STAR (n.d.). *Energy Efficient Mortgages*. U.S. Environmental Protection Agency. Retrieved from http://www.energystar.gov/index.cfm?c=mortgages.energy_efficient_mortgages

Although energy efficient mortgages can help with the gap between the loan a homebuyer is qualified for and the cost of a net-zero energy home, EEMs are not extensively used in the residential market due to the shortage of lenders with the knowledge to coordinate an EEM as well as home inspectors who can accurately estimate the value and cost savings of energy features.[137]

Rebates

The current federal investment tax credit for renewable energy installations is available through 2016. However, according to projections from the U.S. Energy Information Administration, solar PV capacity growth will slow from an average increase of 39 percent per year to less than 1 percent per year from 2016 to 2035 if the credit is allowed to expire. In addition, the number of homes with ground-source heat pumps will increase by more than 19 percent per year with the tax credit. That growth will slow to 3 percent per year if the credit expires in 2016.[138]

While federal programs are very important to the development of the NZEH industry, many states have their own rebate systems for energy efficient and NZE homes. For example, homebuilders who construct homes to the Oregon High Performance Home (HPH) standard are eligible for a Business Energy Tax Credit of up to $12,000. The amount of the tax credit varies depending on the renewable energy systems installed. While homes are not required to be net-zero energy, they must meet heat loss requirements, be verified by the ENERGY STAR® Homes Program, have a high performance HVAC system, have one additional energy efficiency measure installed (builder choice), and must have a renewable energy system. The maximum amount of the tax credit for homebuilder-installed renewable energy systems is $9,000, based on the system's performance rather than the costs of the system.[139]

An analysis by the nonprofit organization Architecture 2030 found that a homebuyer tax credit is a very powerful way to generate jobs and revenue. The idea of promoting NZEH (and energy efficiency generally) through a state-level tax credit is based on the success of the federal First Time Homebuyer Tax Credit, available from 2008 to June 2010, which temporarily slowed the nationwide decline in existing home sales. According to Ed Mazria, Founder and CEO of

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[137] NAHB Research Center, 2004a, p. 8
[138] U.S. Energy Information Administration. (2011). *Annual Energy Outlook 2011 with Projections to 2035*. p. 65
[139] Oregon Department of Energy (2011, February). Oregon High Performance Home Requirements. Retrieved from http://www.oregon.gov/ENERGY/CONS/BUS/docs/Renew/hph_requirements.pdf?ga=t

Architecture 2030, a homebuyer tax credit is a strategic way to spur a lagging housing market as well as to promote NZEH since net-zero energy is easiest to achieve with new construction. Architecture 2030 analyzed the New Homebuyers Energy Savings Tax Credit Bill, a $20 million New Mexico-based tax credit or rebate plan with a one-time and found several results:

- $4,000 state tax credit or rebate for purchasing a Home Energy Rating System (HERS) 50 new home or purchasing an existing home renovated to a 50% energy reduction.
- $6,000 state tax credit or rebate for purchasing a HERS 25 new home or purchasing an existing home renovated to a 75% energy reduction.
- $8,000 state tax credit or rebate for purchasing a zero-net energy or HERS 0 new home or purchasing an existing home renovated to ZNE.[140]

The financial benefits of the proposed tax credit, as applied in the state of New Mexico, would generate approximately (for each $1 of state incentive):

- $14.10 in construction spending and $14.68 in indirect induced spending.
- $1.44 in state and local government taxes from construction spending and $1.50 from indirect and induced spending.
- $.11 in property taxes.[141]

As a whole, the proposed $20 million plan would:

- Create 4,567 jobs.
- Generate $58.62 million in total state and local government tax revenue and $2.13 million in annual property taxes. Approximately $28.72 million of this would be generated before the proposed $20 million in incentives were given, thereby making the program tax-neutral.[142]

Although the New Homebuyers Energy Savings Tax Credit Bill did not pass the New Mexico House, Architecture 2030's analysis is a useful tool for examining the potential impact of tax credit programs on the net-zero housing market specifically as well as revenue and job creation more generally.

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[140] Architecture 2030. (2012). New Mexico Homebuyers Tax Credit or Rebate.
[141] Ibid.
[142] Ibid.

Non-Monetary Incentives

Location-specific non-financial incentives can also help to encourage the development of NZEH. These incentives include expedited entitlement and permitting, a dedicated point of contact within local government for builders, priority inspections, builder recognition, and deferred fees. Each of these would contribute to increased willingness on the part of builders and developers to invest in net-zero energy homes. While these incentives do not give direct financial assistance, they can help builders expedite the construction process, which can help to lower carrying costs incurred on loans for NZEH before they are sold.[143]

Partnerships

Partnerships between local governments, utilities, builders, developers, and industries associated with NZEH component products can facilitate quicker market adoption of net-zero energy homes. When these various players work together, they can share ideas, lessons learned, and solve problems more quickly than when each entity works independently. The programs described below have large-scale benefits beyond those realized by individual builders and homeowners. These programs will help stimulate the residential PV market by increasing demand for the panels as well as increasing competition among solar vendors, the combination of which will result in industry efficiencies and reduced costs.[144]

Scaling Up

It is difficult to achieve net-zero energy on a large, community-wide scale by relying solely on rooftop PV panels due to lack of space and house orientation, as not every home has enough space or the appropriate placement for PV panels. One strategy for increasing the amount of, and access to, solar energy is to create community-based sources of renewable energy. This could include placing PV systems on other community locations such as schools, commercial buildings, and parking lots in addition to drawing power from nearby wind farms or the use of biofuel from nearby agricultural or waste sites.[145] Large-scale PV systems provide a broader base for energy generation, and increasing the number of renewable energy generation options could result in

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[143] Kerr et al., n.d.

[144] Robert W. Hammon, Ph.D., 2007, p. 32

[145] Hammon & Neugebauer, 2010, p. 28

energy cost savings for homeowners if the expense for building and maintaining community sources of energy is amortized over multiple homes.[146]

Business Incubators

Business incubators can offer emerging domestic companies producing goods and services for the NZEH market guidance, access to financing, and technical assistance. Since the market for energy efficiency in the U.S. is still in the development phase, business incubators can help entrepreneurs and small businesses enter the marketplace. While most energy efficiency incubator programs are not specifically directed at NZEH, they still foster businesses that create products beneficial to net-

Business Incubator Case Study

The New York State Energy Research and Development Agency (NYSERDA) Clean Energy Business Incubator Program

The NYSERDA has worked with early-stage cleantech companies and regional incubators that provide guidance and technical assistance with the goal of helping the companies develop and commercialize clean energy technologies. Some of their clients include ThermoLift, Inc., which is developing a heating pump that will use natural gas to heat and cool homes at a significant energy savings over existing heat pumps; Priority Cool Refrigerants, Inc., which manufactures nontoxic energy efficient refrigerants; and Vision Quest Lighting, which manufactures a variety of indoor and outdoor energy efficient lighting (Clean Energy Business Incubator Program, www.cebip.org).

Since 2009, NYSERDA has invested nearly $9 million into six cleantech incubator programs. By the end of 2010, after just 18 months of operation and $2.5 million in program expenditures, the Clean Energy Business Incubator Program has helped net several hundred new jobs at client startup companies and has introduced 26 new products to serve the clean energy market. In addition, through this program client companies have raised $16 million in private capital and have attracted $11 million in federal funding, thereby leveraging state expenditures by more than 10 to 1 (Muro et al., 2011, p. 40).

[146] Hammon & Neugebauer, 2010, p. 53

zero energy homes.

Lack of Builder, Developer, and Homeowner Awareness

Builders and homebuyers are often unaware of the benefits of net-zero energy homes, how to achieve net-zero energy, or are skeptical of their ability to recoup the additional costs incurred when incorporating net-zero energy into their plans. In a 2012 survey of homebuilders and remodelers, over half of respondents identified lack of consumer education as a top obstacle to green building and remodeling.[147] Before agreeing to pay more upfront, builders need assurance that homebuyers are willing to pay more for the energy efficiency and energy generating systems that are part of a net-zero home.[148]

This lack of awareness on the part of many players in the home building and buying sectors, in addition to the question of cost reimbursement, presents a challenge to the acceptance and development of net-zero energy homes. Expenses come from a variety of sources including the upfront cost builders incur when learning how to build and market net-zero homes as well as the cost of energy efficiency and energy generation systems. In addition to the upfront cost of a system, homeowners are often unaware of utility payments, such as gas bills, that may remain after achieving net-zero energy.

Builder concern regarding buyer perception and lack of knowledge about net-zero energy homes is not unfounded. A survey of homebuyers in the high performance home development called Scripps Highlands in San Diego revealed that energy features were not one of the most important decision factors when selecting a new home. In fact, energy efficiency was less important than other factors such as location, the safety and security of the area, the quality of the neighborhood, and cost. However, after purchasing a high performance home, most homebuyers reported being satisfied with their new homes, and those who had high performance homes were more satisfied with their purchase than those who bought conventional homes. In fact, 77 percent of high performance homebuyers said they would purchase their same house if they had to do it

[147] New and Remodeled Green Homes: Transforming the Residential Marketplace. McGraw-Hill Construction, p.28. 2012
[148] NAHB Research Center, 2006, p. 21

over again while only 67 percent of people who purchased conventional homes answered the same way.[149]

Since net-zero energy homes rely on recently developed technologies and systems, many homeowners do not understand how a net-zero energy home works, or how this type of home might benefit them. Another challenge lies in the aesthetics of a zero-energy home. Homeowners may worry that photovoltaic panels will be unsightly, and sometimes prefer to invest money in tangible upgrades rather than zero-energy features, which may not be as visually prominent.

Lack of Awareness: Potential Solutions

Include Net-Zero Equipment as Standard

A solution to the lack of homebuyer education about NZEH is to include zero-energy components as standard features in home models so that homebuyers do not have to choose between something tangible and highly visible, such as granite countertops, and a less tangible upgrade that achieves net-zero energy.[150] Based on sales at Scripps Highlands as well as other developments, it appears that homebuyers prefer to purchase homes with net-zero technologies included as standard equipment rather than as add-on options. Including net-zero technology as standard equipment also lowers the number of housing prototypes, thereby simplifying the construction process for the builder while lowering costs. This simplifies the purchasing process for the homebuyer, decreasing the amount of staff time required to explain the functionality and value of energy efficiency and generation features.[151]

Builder Education

Another potential solution to the problem of builder, developer, and buyer awareness is to proactively educate the parties involved in a net-zero projects. This includes making sure construction crews and subcontractors are aware of the differences between traditional and net-zero energy homes as well as the additional inspections that may be required and benefits received by the future homeowner. An enthusiastic and adequately trained sales staff will be

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[149] B.C. Farhar, & T.C. Coburn. (2006). *A New Market Paradigm for Zero-Energy Homes: December 2006 The Comparative San Diego Case Study* (Technical Report No. NREL/TP-550-38304-01). p. 26 National Renewable Energy Laboratory.

[150] NAHB Research Center, 2006, p. 22

[151] Willard Dakin, David Springer, & Bill Kelly. (n.d.). Case Study: The Effectiveness of Zero Energy Home Strategies in the Marketplace. Presented at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings. p. 6-42. Retrieved from http://eec.ucdavis.edu/ACEEE/2008/data/papers/6_616.pdf

able to answer homeowner questions, while sales displays and easily accessible literature will help educate potential buyers. A study by ACEEE reports that the most successful builders have built showrooms to explain the features and benefits of NZEH.[152]

[152] Ibid. p. 6-43

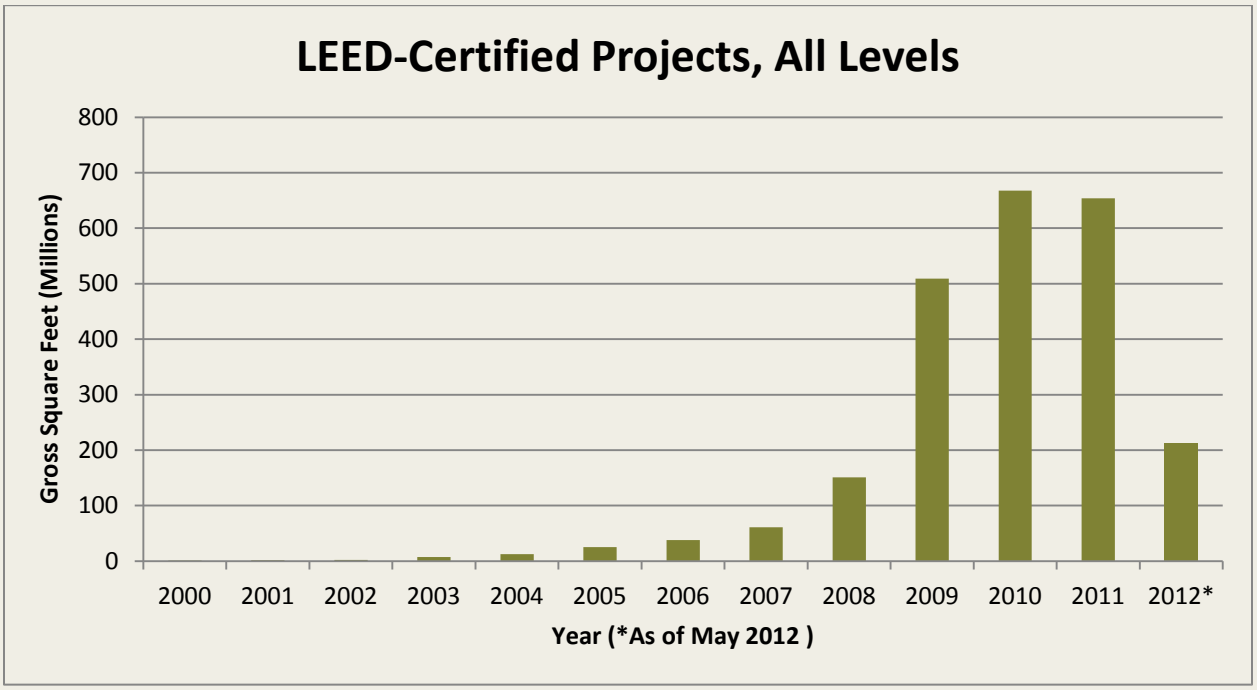
LEED BUILDING: APPLYING LESSONS LEARNED TO THE NZEH HOME INDUSTRY

Although the green and low-energy building industry is relatively young, the Leadership in Energy and Environmental Design (LEED) system is one of its great achievements thus far. LEED was developed by the U.S. Green Building Council (USGBC) in 2000 to be the foremost standard for green building in the U.S. It has since spread to projects in all 50 states and to over 120 countries worldwide.[153] Although NZEH building involves more stringent requirements than does LEED, both standards target sustainable design and construction and thus face similar hurdles. There is a cost associated with building green, but the marketability of LEED has proven to be a major asset that has prompted universities, government agencies, and private firms alike to invest in the premium price. Creating policies that capture real social and environmental benefits can be tricky. To ensure a thorough and fair rating system, USGBC engages experts across a variety of fields and reaches out to its entire membership when updating LEED policies. To encourage education and awareness of LEED, USGBC provides what has become one of the most sought after accreditation program by industry professionals and offers several lessons from which the NZEH industry can learn.

LEED has gained tremendous momentum in its short lifetime and grew even during periods of recession. Figure 3 tracks the total square footage of property that becomes LEED certified each year (across all LEED rating systems). In 2008, USGBC streamlined the process for existing buildings to become LEED certified, which resulted in a huge jump in certification.

[153] U.S. Green Building Council. (2011). Who Uses LEED. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2492

Figure 3: LEED-Certified Projects in Gross Square Feet[154] [155]



A Brief Early History

When the USGBC was formed in 1993, one of its first priorities was to create a new standard for green building. It reviewed existing systems and was particularly inspired by the United Kingdom's BREEAM sustainability standard. USGBC formed a dedicated committee including architects, realtors, a building owner, lawyers, an environmentalist, and industry representatives.[156] The committee also received significant technical support from the Natural Resources Defense Council, and $500,000 in funding from the U.S. Department of Energy.[157] The

[154] Does not include some confidential projects
[155] U.S. Green Building Council. (2011). LEED Projects & Case Studies Directory. Retrieved from http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx
[156] AccessPoint Business Continuity and Recovery. (n.d.) History of LEED. Retrieved from http://www.businessrecovery.ws/leed-certification/history-of-leed
[157] U.S. Green Building Council. (2008, July 25). Federal Support for Green Building Grows [Newsletter]. Retrieved from http://communicate.usgbc.org/newsletters/USGBC_Update/0724_full.html

LEED pilot program was introduced in 1998, and USGBC launched the full rating system in 2000.[158]

The general LEED rating system is based on a 100 point scale with points awarded by categories. For the construction of new buildings, these categories are: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.[159] USGBC launched a LEED rating system for the operation and maintenance of existing buildings in 2004. LEED accreditation of existing buildings has grown over the years and surpassed new construction (in square footage of building space) in 2011.[160] LEED rating systems continue to be expanded and refined, with the latest revision undergoing membership review in mid-2012.[161]

Hurdles and Solutions

LEED certification shares many of the same hurdles as NZEH building, including a:

- Cost premium over traditional construction;
- Complex technical development process;
- Need to educate industry stakeholders; and
- Lack of leadership.

Perhaps the most difficult hurdle currently facing the NZEH industry is a lack of leadership. Whereas USGBC developed LEED and was the driving force behind its momentum, NZEH has a number of customers (including the U.S. Department of Energy and Department of Defense) but no champion in the United States. The primary industry association is the Net-Zero Energy Home Coalition, which is most active in Canada. A key step to overcoming other hurdles will be to increase the coalition's U.S. activity or to form a separate NZEH association in the U.S.

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[158] AccessPoint Business Continuity and Recovery. (n.d.) History of LEED. Retrieved from http://www.businessrecovery.ws/leed-certification/history-of-leed
[159] U.S. Green Building Council. (2011). How to Achieve Certification. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1991
[160] U.S. Green Building Council. (2011, December 7). Square Footage of LEED-Certified Existing Buildings Surpasses New Construction [Press release]. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=10712
[161] U.S. Green Building Council. (2011). Dive into LEED v4. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2360

Hurdle

Obtaining LEED certification can involve a variety of costs both in terms of construction and manpower.

Solutions

Engaged industry representatives to develop value of the brand

Although estimates vary, studies find that the construction cost of basic LEED certification ranges from zero to 2.5 percent above the conventional construction cost.[162] In addition, documenting and administering the certification process can cost up to $150,000.[163] These upfront costs can deter builders from using LEED even with future energy savings and environmental considerations. In this case, the LEED brand must provide other benefits that justify the cost premium.

The key to the LEED brand is its marketability. In fact, USGBC got its start when David Gottfried, a real estate developer, joined forces with Rob Watson, a senior scientist at Natural Resources Defense Council.[164] The two, along with others, worked to incorporate sustainable practices while keeping in mind the business point of view. They invited industry representatives to join the steering committee from the very start. Later on, USGBC President and CEO Richard Fedrizzi also honed in on the marketability of LEED. A former marketing executive, Fedrizzi presented the business case of LEED to firms along the entire construction supply chain: realtors can capture high-end clients and government agencies that value sustainability, architectural firms can attract free publicity by building LEED, and component suppliers can meet new demand for greener building materials.[165] By developing the LEED brand with the help of industry, USGBC had a willing partner once it launched. The value of the brand helped justify the cost premium associated with building LEED.

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[162] Nicolow, J. (2008, November). Measuring The Cost To Become LEED Certified. FacilitiesNet. Retrieved from http://www.facilitiesnet.com/green/article/Measuring-The-Cost-To-Become-LEED-Certified--10057#

[163] Ibid.

[164] Kamenetz, A. (2007, October 1). The Green Standard? *Fast Company*. Retrieved from http://www.fastcompany.com/magazine/119/the-green-standard.html?page=0%2C0

[165] Ibid.

NZEH could be developed as its own marketable brand or possibly as another tier within the LEED rating system. The latter would allow NZEH to piggyback on LEED's momentum, which includes an existing network of industry partners, government contracts, and brand recognition.

Developed flexible point system to keep costs down

Sustainable design and construction can be achieved through a number of building technologies, and the LEED rating system is designed to recognize this. Points are awarded on a per-category basis, but only the final point total determines eligibility for LEED certification. The point threshold ranges from a minimum of 40 points (out of a possible 100 points) for basic LEED certification to an 80 point minimum for Platinum status.[166] Further, bonus points can be awarded for addressing specific regional priorities, which are determined by each local USGBC chapter. The flexible point system means that builders can utilize the existing strengths of a site to achieve points at the lowest cost. For example, sites located close to public transportation gain points in the Sustainable Sites category, while sites that reuse existing buildings gain points in the Materials and Resources category.[167] The point system helps keep total project costs down while recognizing all aspects of sustainability across the site. NZEH would involve more stringent point requirements, but it can also adopt aspects of the LEED point system that apply to energy use.

Hurdle

LEED standards must address a host of site considerations and building technologies, which can make consensus on the standards difficult. Even once standards are finalized, the task of overseeing LEED projects can be daunting.

Solutions

Engaged steering committees through three-tiered system

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[166] U.S. Green Building Council. (2011). How to Achieve Certification. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1991

[167] U.S. Green Building Council. (2011, November). LEED 2009 for New Construction and Major Renovations Rating System. Retrieved from. http://www.usgbc.org/ShowFile.aspx?DocumentID=8868

The LEED development process began with a small but diverse committee of building professionals. Today, there are over 200 volunteers who form over 20 core committees as well as 150 professional staff members to help guide the future direction of LEED.[168] LEED committees and technical advisory groups recommend policies which are voted upon by the body of USGBC members.[169] The membership body is comprised of 16,000 companies and organizations and represents the expertise of professors, planners, architects, federal/local government, and firms along the entire construction supply chain. Steering committees co-develop the updates to LEED with the help of the membership body through a series of public comments and revisions. Thus, the appended revisions to LEED represent the expertise of a wide body of professionals.

LEED committees operate through a three-tiered system to maximize productivity.[170]

1. *LEED Steering Committee (LSC):* LSC is a standing committee of the USGBC Board of Directors.
2. *Subcommittees*: These are on-going committees appointed by LSC to focus on subject areas such as technical development, market transformation, and administration.
3. *Working groups*: Subcommittees can appoint a working group to accomplish a specific task. Each task has a defined scope and a set deadline.

Through this tiered system, the LSC is able to engage and manage the expertise of its large membership base. Likewise, NZEH standards vary from region to region, and bringing stakeholders together to reach a national consensus is critical to creating a unified brand.

Established separate body to oversee certification

According to the American National Standards Institute, credentialing and certification programs are best administered separately from the body that develops the standards themselves. The separation allows for balanced and objective implementation of the standards and helps program developers maintain impartiality in the development process. Along this vein, USGBC established a separate organization to maintain oversight of LEED certification projects. The

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[168] The Lundy Group. (2009). LEED History. Retrieved from http://www.lundygroup.com/about/historical-projects/green-projects-leed-certified/leed-history/
[169] U.S. Green Building Council. (2011). Dive into LEED v4. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2360
[170] U.S. Green Building Council. (2009, July 17). Foundations of LEED. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=9217

Green Building Certification Institute (GBCI) ensures that LEED standards are adopted with consistency on the project-level.[171] GBCI received accreditation from the American National Standards Institute. Once a project registers for LEED rating, GBCI performs third-party reviews at the project site to confirm that standards are indeed being met. With nine billion square feet of building space registering for LEED rating and 1.6 million square feet certified each day around the world, GBCI keeps pace with the volume of demand for LEED certification. In addition to its project certification duties, GBCI implements USGBC's LEED professional certification program (discussed here later). Once NZEH standards are unified, the brand can gain significant credibility by partnering with GBCI or by establishing another third-party body to certify projects.

Hurdle

The success of LEED depends on raising awareness and educating stakeholders about the certification process. Misperceptions about LEED's benefits and costs can undermine its credibility.

Solutions

Engaged industry representatives, who became natural marketers

As aforementioned, LEED was originally developed by industry representatives including architects, realtors, a building owner, lawyers, an environmentalist and construction industry representatives. Not only did practitioners lend invaluable expertise in the development process, but they also became LEED's pioneering advocates in the field. Architects instrumental in the development of LEED brought back those practices to their design firms. Industry associations also became involved and raised the recognition of LEED among their members. The first USGBC conference was held in conjunction with the International Union of Architects/American Institute of Architects convention, which provided a strong foundation for an initial audience.[172] Federal agencies were also pulled into conversations on LEED development, including the Department of Energy, the National Institute of Standards & Technology, and the Naval Facilities Engineering

[171] Green Building Certification Institute. (2011). Home Page. Retrieved from http://www.gbci.org/Homepage.aspx
[172] Building Design and Construction. (2003, November). White Paper on Sustainability: A Report on the Green Building Movement [White paper]. Retrieved from http://www.usgbc.org/Docs/Resources/BDCWhitePaperR2.pdf

Command.[173] Federal input early on opened the way for LEED to become the preferred green building standard by federal agencies across the board. The General Services Administration now requires all new GSA construction to apply for silver LEED status. By including critical stakeholders in the development process, LEED planted the seeds of its own success.

Offers accreditation program in LEED certification

As demand for LEED grew, USGBC created a professional LEED accreditation program for building professionals to gain and market their knowledge of LEED principles and standards. The accreditation program offers three levels of certification: the non-technical LEED Green Associate, the LEED AP with a specialty in one of the LEED rating systems, and the LEED Fellow for seasoned veterans in green building.[174] LEED-registered projects can gain points by hiring a LEED accredited professional in the building process. In 2008, GBCI took over administration of the LEED accreditation program, which now has accredited over 170,000 LEED professionals.[175] LEED accreditation has far surpassed membership in the other leading industry organization: the American Institute of Architects (which counts 80,000 members). Increased recognition of the LEED brand has prompted more and more building professionals to apply for LEED credentials. NZEH can piggyback on LEED's programs (as aforementioned), or it can also serve as the basis for a separate accreditation program.

Hold annual conference on latest green building technologies and issues

In 2002, USGBC hosted the first Greenbuild conference and expo to present the latest green building technologies and to foster networking between industry professionals. The conference brings together active stakeholders in USGBC, LEED, and green building for special industry updates, research sharing, and an expansive green building expo hall. LEED accredited professionals can satisfy continuing education requirements by participating in the conference's education sessions. Sessions range from half-day workshops on the basics of LEED to more advanced sessions on implementing technical aspects of specific LEED rating systems. The Greenbuild conference helps to both raise awareness of LEED among the larger green building community and to grow the number and expertise of LEED accredited professionals. NZEH has

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[173] Ibid.
[174] Green Building Certification Institute. (2011). LEED Professional Credentials. Retrieved from http://www.gbci.org/main-nav/professional-credentials/credentials.aspx
[175] U.S. Green Building Council. (2011). LEED Professional Directory. Retrieved from http://www.usgbc.org/LEED/AP/LEEDProfessionalDirectory.aspx

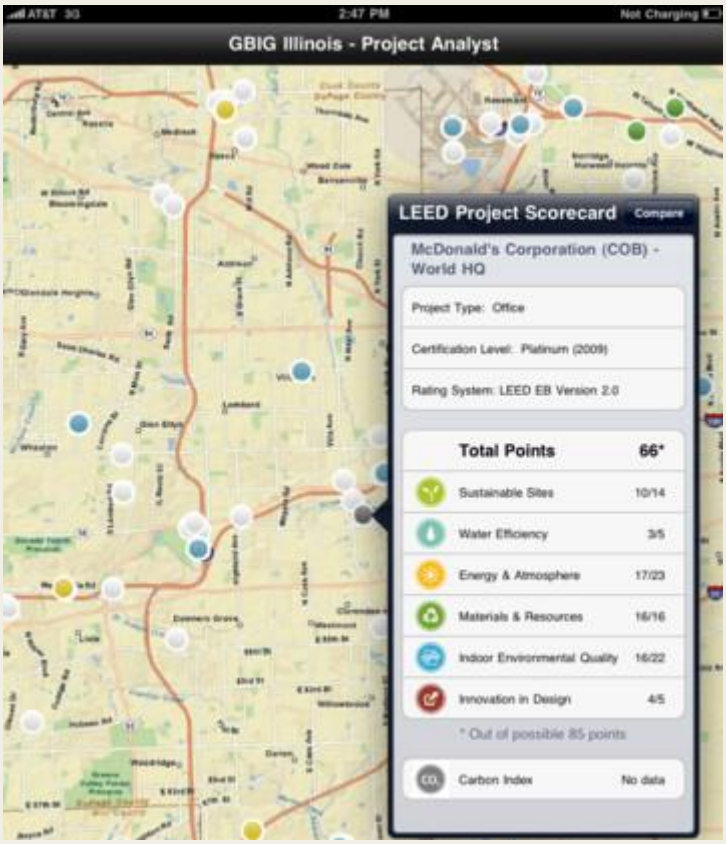
already made strides into Greenbuild's education sessions, and it continues to grow as a conference theme in recent years.

Set up portal for access to building data

A more recent development is the USGBC's information technology portal, which is called the Green Building Information Gateway.[176] The Gateway is a user-friendly interface that presents data on green building and includes information on the location of LEED-certified projects, their credit achievement, Carbon Index values, and year certified. The Gateway is also available on two mobile applications for the iPod and iPad (see Figure 4). The project is currently in the pilot phase. As it expands, the Gateway will allow for a much more systematic method to track and analyze the universe of LEED projects. Since the concept of NZEH is still relatively new, developing user-friendly applications can help provide a frame of reference for NZEH alongside other green building standards.

[176] U.S. Green Building Council. (2011). Green Building Information Gateway. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2367

Figure 4: GBIG iPad Application



APPENDIX

Resources for NZEH Market Development

Department of Defense Installations

The U.S. Department of Defense (DOD) is looking to net-zero energy technology to reduce energy consumption across the Army, Navy, and Air Force. The department's strategic energy plan includes the goal of obtaining 25 percent of its electrical energy needs from clean energy sources by 2025, but the various branches of the military go even further in their pledges to decrease energy consumption.[177] The Navy hopes to obtain 50 percent of its energy for ships, aircraft, tanks, shore vehicles, and installations from clean energy sources by 2020 and the Army has pledged it will convert five installations to net-zero by 2020.[178] [179] The potential impact of these initiatives on the net-zero energy housing industry is significant, as entire installations are converted to net-zero rather than a merely few houses scattered throughout a neighborhood.

The Navy's Efforts at Marine Corps Air Station Miramar

DOD is by far the largest energy consumer in the Federal Government, accounting for approximately 80 percent of the government's energy consumption.[180] In 2010, 26 percent of this energy was used by buildings and non-tactical fleet vehicles.[181] With 507 permanent installations comprising over 2.2 billion square feet of facility space, there is significant opportunity for reducing DOD's energy demand by regulating its facilities' energy use. Recognizing this, a joint DOD-DOE task force selected a Marine Corps Air Station in Miramar, California as a pilot for net-zero-energy installations. For this project, a net-zero-energy installation (NZEI) is defined as a

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[177] Booth, S. & Barnett, J. & Burman, K. & Hambrick, J. & Westby, R. (2010a). *Net Zero Energy Military Installations: A Guide to Assessment and Planning*. (Technical Report NREL/TP-7A2-48876). National Renewable Energy Laboratory. Washington, DC:US Department of Energy. p. 4

[178] Mabus, R. (2009, October 14). Remarks by the Honorable Ray Mabus, Secretary of the Navy given at the Naval Energy Forum, McLean, VA. Retrieved from http://osiris.usnwc.edu/pipermail/nwc_onlinediscussion/attachments/20091119/9d999c42/attachment.obj

[179] Environmental and Energy Study Institute. (2011, July). Fact Sheet: DoD's Energy Efficiency and Renewable Energy Initiatives. p. 1. Retrieved from http://files.eesi.org/dod_eere_factsheet_072711.pdf

[180] Department of Defense. (2011). *Department of Defense Annual Energy Management Report: Fiscal Year 2010*. Washington, DC: Office of the Deputy Under Secretary of Defense. p. 9. Retrieved from http://www.acq.osd.mil/ie/energy/DoD_AEMR_FY2010__July_2011%5B1%5D%5B1%5D.pdf

[181] Booth, 2010a, p. 3

"military installation that produces as much energy on-site from clean energy generation, or through the onsite use of clean fuels, as it consumes in its buildings, facilities, and fleet vehicles."[182]

The National Renewable Energy Laboratory (NREL) did an assessment of the Miramar base and its potential to become a NZEI. NREL's recommendations include incorporating daylighting controls and timers, solar panels, and solar water and pool heaters into the base's infrastructure. NREL also suggested adding fuel cells or microturbines to effectively create a microgrid for the base, whereby it can generate its own power.[183] The report quantified the energy savings to privatized housing on the base as well. By installing energy efficient air conditioners, appliances, and lighting—along with programmable thermostats and low-flow showerheads and faucets—the base could save 13 percent on residential energy costs.[184] To date, Miramar has incorporated some of NREL's recommendations and undertaken a few of its own efforts as well. The base purchases electricity from a nearby landfill gas generation plant, has installed several hundred solar panels, and installed a diesel generator. These improvements enable Miramar to maintain its own microgrid and resulted in a 51 percent reduction in fossil fuel use.[185]

The Army's Net Zero Installation Strategy

The Army has begun its own NZEI campaign, selecting 16 installations in the U.S. and one in Germany to obtain net-zero status by 2020. The Army is focusing on achieving net-zero from three different perspectives: energy, water, and waste. Six installations were selected in each category and two were selected to be net-zero across all three categories. The Army has set the additional goals of achieving 25 net-zero installations in each category by 2030 and net-zero energy at all installations by 2050. The installations selected in the net-zero-energy category for 2020 are:

- Fort Detrick, Maryland,
- Fort Hunter-Liggett, California,
- Kwajalein Atoll, Marshall Islands,

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[182] Booth, S. & Barnet, J. & Burman, K. & Hambrick, J. & Helwig, M. & Westby, R. (2010b). *Targeting Net Zero Energy at Marine Corps Air Station Miramar: Assessment and Recommendations* (Technical Report NREL/TP-7A40-47991). National Renewable Energy Laboratory. Washington, DC: U.S. Department of Energy. p. vii.
[183] Ibid, p. xiv
[184] Ibid, p. 26-27
[185] Disalvo, E. (2012, March 3). Marines take lead on green ideas. Defense Video and Imagery Distribution System. Retrieved from http://www.dvidshub.net/news/85099/marines-take-lead-green-ideas#.UARh0dk6_ct

- Parks Reserve Forces Training Area, California,
- Sierra Army Depot, California, and
- West Point, New York.

The two bases selected to be net-zero across all three categories by 2020 are:

- Fort Bliss, Texas and
- Fort Carson, Nevada.

Slightly larger than Rhode Island, Fort Bliss is the largest Army base and will host roughly 30,000 people by 2018, when the First Armored Division returns from Germany. Located outside El Paso, Texas, the base is relying heavily on solar power in its efforts to meet net-zero-energy requirements. A recently completed solar project is expected to generate one percent of the electricity needed by the base, with a new project slated to begin in 2013. Wind turbines and geothermal pumps are also being considered, but no definitive proposal has been advanced.[186] On the housing side, Fort Bliss partnered with a private firm in 2010 to convert four homes on base to solar power with the intent of monitoring their performance for a year.[187] These pilot homes could represent the beginning of a base-wide conversion to solar-powered homes in the future. While Fort Bliss's efforts are laudable, little headway has actually been made and it seems unlikely–given budgetary constraints and the looming influx of returning troops–that the installation will achieve net-zero status in the next eight years.

Fort Carson is also employing solar panels, especially on the installation's homes.[188] Indeed, energy efficient construction and the installation of solar panels have helped reduce the base's energy use per square foot by 13 percent since 2003.[189] Like Miramar, Fort Carson is also purchasing energy from clean energy sources, such as wind and biomass. Like Fort Bliss, Fort Carson is expecting an influx of soldiers returning from service overseas. This increase in

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[186] Galbraith, K. (2012, April 26). Despite Budget Cuts and Base Expansion, Trying to Save Energy. *Texas Tribune*. Retrieved from http://www.nytimes.com/2012/04/27/us/at-fort-bliss-and-fort-hood-going-solar-for-net-zero-energy-production.html?pagewanted=all.
[187] Lopez, C.T. (2010, July 8). Fort Bliss moving toward 'net-zero' energy compliance. U.S. Army. Retrieved from http://www.army.mil/article/42005/
[188] Fort Carson Public Affairs. (2011, April 21). Fort Carson achieves Net Zero status. U.S. Army. Retrieved from http://www.army.mil/article/55328
[189] Ft. Carson on the way to becoming 'net zero' energy user. (2012, February 5). Defense Communities 360. Retrieved from http://www.defensecommunities.org/headlines/ft-carson-on-the-way-to-becoming-net-zero-energy-user/

population will create a need for new housing and facilities, which the base is hoping to meet with energy efficient construction.[190] New non-residential buildings on the base already incorporate energy efficient lighting and HVAC systems and solar water heaters. To achieve base-wide net-zero energy status, these features will need to be incorporated into housing as well. At the moment, Fort Carson's focus is on the waste aspect of the NZEI initiative: the base has launched aggressive composting and recycling initiatives and is considering construction of a waste-to-energy facility.[191] [192]

Other Residential Net-Zero Initiatives

While they were not selected for the Army's Net Zero Installation Strategy, a few bases have begun implementing residential net-zero energy strategies. Campbell Crossing, a public-private partnership between the Army and Actus Lend Lease, completed two net-zero energy homes at Fort Campbell, Kentucky in 2010. The first net-zero-energy houses on a military base, these homes use roof-mounted PV panels for energy generation and consume approximately 54 percent less energy than their conventional counterparts. Residents can monitor their energy use via the homes' smart metering systems and may be asked to participate in a monthly usage review. The net-zero energy homes are estimated to save $1,041 annually, and the money saved will be returned to Campbell Crossing to help fund future projects. The performance of these two net-zero homes will be compared to two conventional homes to measure their energy efficiency. An eventual extension of the net-zero program is planned that will encompass over 4,000 other homes at Fort Campbell. If cost savings estimates are accurate, annual savings could reach $4.6 million.[193]

Marine Corps base Camp Lejeune, North Carolina is moving toward net-zero energy with the installation of solar water heaters in on-base homes. Beginning in 2010, the base contracted with

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[190] Guthrie, V. (2012, February 21). *Ft. Carson Net Zero Initiative: The Way Forward.* [presentation]. Fort Carson: Department of Public Works. Retrieved from http://posts.same.org/pikespeak/PDFs/Fort%20Carson%20Net%20Zero%20and%20CAB%20MILCON%20Update%20%20%20%20%2021%20FEB%2012.pdf.

[191] Alguire, H. (2011, May 5). Interview by A. Panoka [podcast]. Fort Carson hopes to reach 'net-zero' on energy, water, waste. Colorado Public Radio. Retrieved from http://www.cpr.org/article/Fort_Carson_hopes_to_reach_net_zero_on_energy_water_waste

[192] Galentine, S. (2012, July 12). DPW pilots in-house initiative at Fort Carson. U.S. Army. Retrieved from http://www.army.mil/article/83475/Zero_waste__DPW_pilots_in_house_initiative_at_Fort_Carson/

[193] Building Design + Construction. (2011). *Zero and Net-Zero Energy Buildings and Homes.* Arlington Heights: Building Design + Construction. p. 51.

FLS Energy to install solar water heaters on the roofs of 900 homes, with the ultimate goal of providing 2,200 homes with solar water heating systems.[194] In 2011, PV panels were installed on barracks and other buildings on the installation.[195]

DOD, and other federal departments, are ideal laboratories for experimenting with large scale net-zero-energy implementation not only because of the sheer number of homes on U.S. military bases, but also because these departments have access to the resources and scope to provide an educational platform to homeowners and the industry on best practices for net-zero-energy residential development.[196]

DOE Builder's Challenge and Building America Program

Begun in 2008, the Department of Energy's Builders Challenge "works to improve the efficiency of buildings and the equipment, components, and systems within them. The program supports research and development (R&D) activities and provides tools, guidelines, training, and access to technical and financial resources."[197] Specific program goals include:

- Providing Building America research results and marketing tools to builders who are trying to build high performance and net-zero-energy homes.
- Driving consumer demand through national outreach.
- Partnering with programs, nonprofits, real estate organizations, lenders, utilities, and state and local governments to leverage and expand green building infrastructure.
- Establishing a design competition to increase the supply of high-performance home plans.
- Recognizing and rewarding participants.

The goal of this program is that, by 2030, a consumer will be able to buy a cost-neutral, net-zero energy home anywhere in the United States. In this case, cost-neutral homes are those where the added initial cost of energy efficient upgrades are equal to the monthly energy cost savings that result from the upgrades, when amortized over a 30-year period.[198]

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[194] Barrera, V. (2011, February 10). 2,200 homes to be equipped with solar hot-water heaters. *The Globe*. Retrieved from http://www.camplejeuneglobe.com/news/inside_lejeune/article_84543e80-3484-11e0-b082-001cc4c002e0.html
[195] Environmental and Energy Study Institute. (2011, July). p. 4.
[196] Building + Construction. (2011), p. 50.
[197] U.S. Department of Energy, 2011b
[198] Ibid.

Net-Zero Home Pilot Developments

Carsten Crossing (Rocklin, CA)[199]

The Grupe Company was one of the first builders in Stockton to offer energy efficiency and PV panels as standard features in all of their homes. Before building their development, Carsten Crossing, the Grupe Company spent time educating their sales staff and construction crews about energy efficiency and PV panels. When construction began in January 2006, the housing market was beginning to slow. Despite the higher cost of homes in Carsten Crossing compared with conventional homes, the Grupe Company decided to offer the houses at market rates, hoping the energy features would give the homes a boost in the market and assist with quicker sales.

Each of the Carsten Crossing homes cost approximately $18,350 more than conventional construction in the rest of the Whitney Ranch development even after taking into account available incentives. The additional cost for Carsten Crossing's 144 high performance homes was over $2 million; in order to break even, the Grupe Company needed to minimize their carrying costs and reduce the sale term by 8.5 months.

Between 2006 and 2007, the homes in Carsten Crossing sold at twice the average rate of the other communities, 1.5 times the next highest community, and twice the rate necessary to cover the cost of the energy efficiency and generation features.

A survey of homeowners in the Carsten Crossing community revealed that the energy efficiency features were not a primary reason for initially choosing homes in the community. Most homeowners were not even aware of the features of their high-performance home before looking in the Whitney Ranch development. Rather, they were focused on location and appearance of the home. It was not until homeowners interacted with Grupe sales staff that they learned about the energy efficiency and PV features, which were appealing to most people due to the financial and environmental benefits. Everyone surveyed said that they were satisfied with their purchase, and that when they purchase another home in the future, it will have energy and PV features.

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[199] Willard Dakin, David Springer, & Bill Kelly. (n.d.). Case Study: The Effectiveness of Zero Energy Home Strategies in the Marketplace. Presented at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings. p. 45. Retrieved from http://eec.ucdavis.edu/ACEEE/2008/data/papers/6_616.pdf

KB Home[200]

KB Home was recognized in the 2012 DOE Builders Challenge Awards, which pays tribute to builders who achieve significant benchmarks under the DOE Builders Challenge Program. This recognition came in response to KB Home's efforts to develop marketable net-zero energy homes.

In January of 2011, KB Home introduced their first net-zero energy home, called KB Home Greenhouse, at the International Builders Show. Based on the popularity of this model, KB Home introduced ZeroHouse 2.0 in September of 2011. This home, available in select communities in Tampa, San Antonio, Austin, Las Vegas, Denver, Houston, and Southern California, will give homebuyers the option to make almost any home net-zero. KB Home plans to continue the rollout of net-zero homes in the future, working with existing suppliers to make the houses even more affordable.

Scripps Highlands (outside San Diego, CA)[201]

This development, constructed in 2001 by Shea Homes, was the result of a partnership between the builder, state and federal agencies, and equipment manufacturers. It was one of the first developments to connect high-performance homes to the energy grid (many previous efforts focused on off-grid technology) and was also the first new development in the country to use net metering. As one of the first near-zero projects in the country, this development has become the focus of numerous studies.

The Scripps Highlands homes were designed to offer homeowners utility bills that were 30-50 percent lower than conventionally built homes and featured a combination of energy-efficiency features such as tightly sealed ducts, solar water heating systems, and solar radiant barriers as well as efficient heating, ventilating and air conditioning systems. While not all homes were eligible for PV systems, those homes that came with solar PV systems also included in-house digital electricity generation and use monitors. Homeowners were also able to choose their own appliances. San Diego Gas and Electric (SDG&E) offered homeowners a rebate for the purchase

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[200] KB Home, 2011, retrieved from www.kbhome.com/Documents/Energy %20Performance/2011_Sustainability%20Reportpdf p 10
[201] (Barbara Farhar & Timothy Coburn, 2008, p. 25).

of ENERGY STAR® appliances, and the California Energy Commission provided incentives for PV and solar heating systems.

A comparison between the Scripps Highlands homes and conventional homes by the same builder nearby revealed a strong market preference and builder benefit for the high performance homes. The Scripps Highlands high performance homes sold for 9.2 percent less per square foot than comparison homes, despite the addition of PV systems to many of the high performance homes. Shea Homes did not lose money on the project. The combination of bulk-purchasing and subsidies for the energy efficiency upgrades helped to offset the additional cost of installing photovoltaic panels.

Of those offered PV homes, 44 percent of people accepted while only 12 percent with PV-eligible homes chose to install the panels. This disparity indicates that had more buyers been made aware of the PV options, more people may have chosen to install them. By February 2005, four years after the development began, the high performance homes saw an average property value increase of 55.4 percent while the comparison homes increased an average of 44.7 percent.

Premier Gardens (Sacramento, CA)

Sacramento's first near-zero-energy home community is a result of a partnership between the Sacramento Municipal Utility District (SMUD), ConSol, the U.S. Department of Energy Building America Program, and Premier Homes. The near zero-energy development started later than a comparable non-zero-energy development in the same area, but homes in Premier Gardens sold before the conventional development, indicating a strong market for zero-energy homes.

Residential Solar Energy Market Concentrated in a Few States, but Poised for Future Growth

In 2010, 124,000 new solar PV and heating systems were installed, a 22 percent increase over 2009. Growth is concentrated in states with supportive solar policies, but may become more widespread as larger international manufacturers move into the U.S. market.

Overview

Energy generation is necessary to achieve net-zero energy. In residential buildings, solar energy is the most popular choice for on-site energy generation. There are three different types of solar energy technologies, each designed with a specific end use in mind. Two solar technologies, photovoltaics (PV) and concentrating solar power (CSP), produce electricity. Solar thermal collectors produce heat for water heating, space heating or cooling, pool heating, or they can process heat.[202] Solar PV and solar thermal are the two most commonly used systems in residential construction. Concentrating solar power is most often used in large-scale commercial projects.

Manufacturers

While most major solar manufacturers are located outside the United States, there are a few large companies in the U.S., including First Solar and SunPower. The top ten solar PV manufacturers in 2011 are listed below.[203]

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[202] Sherwood, L., 2011, p. 2

[203] Hessman, T. *Top Ten Solar Manufacturers of 2011*. Industry Week. Retrieved from http://www.industryweek.com/articles/top_ten_solar_manufacturers_of_2011_26881.aspx?Page=2.

Table 13: Top Ten Solar PV Manufacturers, 2011

Company	Headquarters	MW produced
First Solar	USA	2,001
Suntech	China	1,866
Yingli Green Enegy	China	1,554
Trina Solar	China	1,395
Canadian Solar	Canada	1,363
Sharp	Japan	1,155
Hanwha Solar One	China	825
Jinko Solar	China	782
LDK Solar	China	744
SolarWorld	Germany	767

Source: Industry Week, 2011

Although the U.S. is not home to the largest PV manufacturers, it does host many smaller firms. According to the Solar Energy Industries Association, there are at least 51 active facilities in 21 states manufacturing PV components including: polysilicon, wafers, cells, modules, and inverters. Most of the plants are located in California, due to the state's support for clean energy, as well as Oregon and Arizona, which have strong policy support for PV manufacturers and a skilled labor force.[204]

Sales and Market Size

Solar installations are becoming increasingly common in the United States. In 2010, over 124,000 new solar heating, cooling, and solar electric installations were completed in the U.S. This was 22 percent more than the number of installations in 2009.[205] These 124,000 installations comprised 887 megawatts of capacity, 104 percent more than what was installed in 2009.[206] In 2011, of all solar installations in the U.S., the non-residential sector was the largest at 50 percent while residential installations were approximately 30 percent.[207]

While the U.S. PV market has increased on the whole, growth is concentrated in a few states. The amount of PV capacity installed in Arizona, Colorado, Massachusetts, Nevada, New Jersey, New

[204] GTM Research. (2011a). U.S. *Solar Market Insight: 2nd Quarter 2011, Executive Summary*. Solar Energy Industries Association. p.13. Retrieved from http://www.seia.org/galleries/pdf/SMI-Q2-2011-ES.pdf
[205] Sherwood, L., 2011, p. 2
[206] GTM Research. (2011a). p.2.
[207] Sherwood. (2011). p. 6.

Mexico, Pennsylvania, and Texas in 2010 was at least double the capacity installed in each of those states in 2009. California is home to the largest solar market in the U.S. with about 28 percent of U.S.-installed capacity in 2010. This is a drop from the 49 percent market share held by California in 2009.[208]

On a larger scale, the U.S. market share of global solar installations has been steady at 5-7 percent since 2005, but this share is expected to increase in the future as PV manufacturers and developers seek opportunities in the U.S. market.[209] The Solar Energy Industries Association has predicted that the residential share of installations will grow in the future due to an increase in third-party financing programs.[210] This opinion is echoed by the Interstate Renewable Energy Council, which credits stable federal incentives with growth in the residential solar installation market. Growth in this market has been somewhat dramatic, as annual growth rates over the past five years have ranged from 33-103 percent. Most of the new installations occur in states with incentives at the state or local level in addition to federal incentives.[211]

Insulation: Increasing Market Share despite Residential Construction Slowdown

Despite the contraction of the housing construction industry, demand for spray foam insulation has increased since 2009, largely due to retrofits. While the number of housing starts decreased 8.5% from 2009-2011, SIP production only dropped by 4%.

Overview

Net-zero energy homes require a tight building envelope that is sealed securely to prevent leakage of conditioned inside air to the outdoors or unconditioned outside air into the home. This tight thermal barrier works to reduce a home's heating and cooling costs and maximize energy efficiency measures. Several types of insulation may be used to create this barrier. The more commonly used insulation types discussed in this section are discussed below.

- **Spray polyurethane foam (SPF):** SPF is used in homes to keep out moisture. There are two types of SPF: open cell and closed cell. Open cell SPF will act as a barrier to moisture while allowing air to pass through it. Closed cell SPF keeps out both air and moisture.

208 GTM Research, 2011a, p.2
209 Ibid
210 Ibid, p. 7
211 Sherwood, 2011, p. 6

- **Structural insulated panels (SIPs):** SIPs consist of a foam core pressed between two structural panels, most often made of oriented strand board (a treated wood panel similar to plywood).[212]
- **Insulated concrete forms (ICFs):** ICFs also utilize foam insulation, but as a form or mold into which concrete is poured. The foam forms remain part of the wall, acting as both thermal and sound barriers. ICFs can be constructed as interlocking blocks or panels held together with plastic ties.[213]

Manufacturers

Several large manufacturers produce spray foam insulation products. Companies like Owens Corning, CertainTeed, and Johns Manville offer a few spray foam options in addition to their more traditional product lines.

As recently as 2006, SIPs tended to be manufactured by small firms that dealt directly with customers.[214] However, as the panels' popularity grew, so too did the number of large manufacturers using distribution channels. By 2011, the 20 manufacturing members of the Structural Insulated Panel Association (SIPA) produced 69 percent of the total supply of SIPs. Currently, 59 firms manufacture SIPs in the U.S. and Canada.[215]

As in the SIP market, the number of ICF manufacturers has decreased as firms have consolidated over the past few years. Whereas in 2005 there were over 70 ICF manufacturers serving the U.S. market,[216] in 2011 the top five or six companies represented 70 percent of the market. While producers have consolidated, the high cost of transporting finished ICFs has not changed. Because of these high shipping costs, firms with in-house manufacturing operations are more profitable than those without. Further, more manufacturers are utilizing distributors; those that do not instead

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[212] What Are SIPs? (2011). Structural Insulated Panel Association. Retrieved from http://www.sips.org/about/what-are-sips/
[213] Types of Insulating Concrete Forms. (2012). Insulating Concrete Form Association. Retrieved from http://www.forms.org/index.cfm/ICFtypes
[214] Miller, S. Take a SIP? (2006, April 7). *Pro Sales Magazine*. Retrieved from http://www.prosalesmagazine.com/panels/product-monitor--take-a-sip-.aspx
[215] SIP Industry Remains Strong in Uncertain Housing Market. (2012, May 31). Structural Insulated Panel Association. Retrieved from http://www.sips.org/2011-production-survey/
[216] Industry Size. (2012). GreenBlock Insulated Concrete Forms. Retrieved from http://greenblock.com/industry-size.php

have several manufacturing plants dispersed across the country.[217] Table 14 14 lists some of the larger manufacturers in each insulation industry.

Table 14: Selected Top Insulation Manufacturers

Manufacturer - Spray Foam	Headquarters	Distribution	Total Employees
Owens Corning	U.S.	Global	15,000
CertainTeed Corporation (subsidiary of Compagnie de Saint-Gobain)	U.S.	Global	9,700
Johns Manville Corporation (subsidiary of Berkshire Hathaway)	U.S.	Global	8,000
Manufacturer - SIPs			
Insulspan Corporation	Canada	North America	90
Insulfoam, LLC	U.S.	North America	578
Manufacturer - ICFs			
GreenBlock - Insulated Concrete Walls, Inc.	U.S.	North America, Western Europe	70
Phil-Insul Corporation	Canada	North America, Europe	11-50

Source: Hoovers.com

Sales and Market Size

Residential sales of any type of insulation are directly affected by the health of the housing market. Due to the recent economic recession, the number of new housing starts and housing renovations has fallen over the past several years, with the result being a decrease in insulation sales. However, spray foam, SIPs, and ICFs have all seen increases in market share despite such slow overall growth in the housing market.

U.S. demand for spray foam insulation has increased steadily since 2009 and has been driven largely by retrofits of existing buildings rather than by new housing starts.[218] The vast majority of SIP production is for residential use and comprises approximately one percent of the residential insulation market. Though the SIP market caters mostly to residential development, it has remained

[217] 2010 Market Report & 2011 Forecast. (2010). *ICF Builder Magazine*. Retrieved from http://www.icfmag.com/articles/features/2010Overview-2011Forecast.html
[218] Verlag, G. (2011, December). Update on the global TPU market. *Polyurethane Magazine International, 8(6),* 376. Retrieved from http://www.sprayfoam.com/leps/letitem.cfm?letid=49

more resilient than the housing market as a whole. In 2011, single-family housing starts decreased by 8.5 percent, but SIP production only decreased by 4 percent. And even while production decreased, the volume produced by SIPA member manufacturers actually increased 6.3 percent that year.[219] ICFs have also seen steady growth. In 1993 only three percent of U.S. and Canadian homes used ICF construction; by 2009 that number had risen to 18 percent.[220]

Regional Distribution

According to a 2011 survey of SIP manufacturers, the highest ranking regions for SIP use in the U.S. were the:

- East North Central Region (Great Lakes),
- West North Central Region (Midwest), and
- Mountain Region (Rocky Mountains).[221]

Historically, ICF sales have been concentrated in the Midwest, but the recent recession has checked the market there. Instead, the Mountain and Pacific Northwest regions, which weathered the recession and are choosing ICFs as the preferred building method, are seeing steady growth in the ICF market. Some growth continues in the Gulf states, fueled by the rebuilding of hurricane-damaged areas. The state poised for the largest increase in ICF construction is New York, as a result of green building legislation passed in 2011.[222]

Challenges

The technology has been gaining market share as more companies produce SIPs and more homeowners purchase them. However, some challenges remain.

- For producers, in-house production is vital to keeping costs down, and beginning the production process requires substantial capital investment and floor space.

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[219] SIP Industry Remains Strong, 2012
[220] Kustermann, H.M. (2009, March). Solid, Energy Efficient Solutions. *Quad-Lock E-Connection, 21*. Retrieved from http://www.quadlock.com/insulated-concrete-forms/news/090311_solid_energy_efficient_construction.htm
[221] SIP Industry Remains Strong, 2012
[222] 2010 Market Report & 2011 Forecast, 201.

- Because SIPs fit together so tightly, the components must be cut precisely to prevent construction delays on site.[223]
- Impediments caused by building codes and permitting systems are being addressed as well. For example, recent changes to the International Energy Conservation Code (IECC) that raise insulation requirements for some climates may make energy efficient insulation systems more appealing to regulatory agencies, builders, and homeowners alike.[224]
- However, training of installers and builders in how to properly install these systems is still a concern, especially in the ICF industry.[225]

Market Drivers

Several factors are currently driving these energy efficient insulation industries. As is the case with the net-zero energy homes industry, the energy efficient insulation sector will expand as the energy efficiency and green building movements gain momentum, reinforced by climate change concerns and rising energy prices and demand. These industries will also build on themselves, as customer satisfaction with, and awareness of, ICFs have contributed in part to the recent rapid growth of ICF construction in North America.[226]

Projections of Growth

Forecasts suggest more growth ahead for energy efficient insulation. The demand for insulation in general is expected to grow 7.8 percent per year through 2016, with residential demand increasing most rapidly.[227] If spray foam and SIPs continue to post gains in market share as they have in recent years, it is likely that production in these sectors will also rise. Additionally, residential ICF construction is expected to grow 25 percent to 30 percent over the next several years.[228]

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[223] Levy, E. & Mullens, M. & Tompos, E. & Rath, P. (2012). *Expert Meeting Report: Advanced Envelope Research for Factory Built Housing*. p. 4. Retrieved from www.nrel.gov/docs/fy12osti/54439.pdf
[224] Technical Bulletin No. 5: SIPs and the 2012 IECC. (2012, Feb 2). Structural Insulated Panel Association. Retrieved from http://www.sips.org/wp-content/uploads/2012/04/SIPA_005_2012_IECC2-212.pdf
[225] 2010 Market Report & 2011 Forecast, 2010
[226] The ICF market in North America. (2012). Hirsch Servo Group. Retrieved from http://www.hirsch-gruppe.com/homepage/com/geschaeftsfelder/maschinen_anlagenbau/mold-shop/ICF.php
[227] Freedonia Group. (2012). *Insulation to 2016 - Market Research, Market Share, Market Size, Sales, Demand Forecast, Market Leaders, Company Profiles, Industry Trends*. Retrieved from http://www.freedoniagroup.com/Insulation.html
[228] Industry Size, 2012

Energy Efficient Doors and Windows: Gaining a Larger Share of the Fenestration Market

Energy efficient doors and windows comprised 34 percent of all purchases qualifying for the 2009 federal tax credit, amounting to $2.2 billion and $8.5 billion in sales respectively. Moreover, 60 percent of builders say they provide energy efficient windows as standard options.

Overview

Just as they need a tight building envelope, net-zero-energy houses also require energy efficient doors and windows to prevent air seepage and reflect excess solar heat. To perform these functions, energy efficient windows may contain multiple panes of glass, often with inert gases like argon or krypton between each pane, to further reduce solar heat transfer. Glazes using low-emittance (low-E) coatings may also be used on glass to lower a window's U-factor, or the amount of non-solar heat loss or gain through a window. These low-E coatings are very thin and transparent layers of metal or metallic oxide that reflect the longer wavelengths of infrared radiation while allowing shorter wavelengths of visible light to pass through.[229]

Energy efficient doors are sealed tightly to prevent leakage, and when they contain glass, are treated in much the same way as windows. The National Fenestration Rating Council (NFRC) has created a rating system for energy efficient doors and windows that is used by the Energy Star program to set performance levels and standards.

Manufacturers

Several large companies manufacture multiple product lines of Energy Star-rated doors and windows. Table 15 lists the top U.S. manufacturers by gross revenue. These companies manufacture both standard and energy efficient fenestration products.

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[229] Window Technologies: Glazing Types. (2012). Efficient Windows Collaborative. Retrieved from http://www.efficientwindows.org/gtypes.cfm

Table 15: Top U.S. Window and Door Manufacturers by Gross Revenue

Manufacturer	Headquarters	Distribution	Total Employees
JELD-WEN Inc.	U.S.	Global	20,000
Andersen Corporation	U.S.	Global	12,050
Masonite Inc.	U.S.	Global	8,500
Pella Corporation	U.S.	Global	7,100

Source: Hoovers.com, Pella Corporation (2012) About Us. Retrieved from http://www.pella.com/about-us/default.aspx

Sales and Market Size

Sales of energy efficient doors and windows received a boost from a 2009 federal tax credit program for certain energy efficient products. Windows and skylights accounted for 34 percent of all purchases qualifying for this credit, and energy efficient doors for 9 percent, amounting to $8.5 billion and $2.2 billion in purchases respectively.[230] Builders also recognize the trend toward energy efficient fenestration. A 2012 survey of *Professional Builder* subscribers reports that 60 percent of builders surveyed provide energy efficient windows as standard options in their new homes.[231] Energy efficient windows are being incorporated into existing homes as well. As of 2009, roughly 13 percent of U.S. homeowners had replaced their windows with Energy Star-rated models.[232]

Challenges

Barriers to greater market penetration for energy efficient doors and windows include:

- Increased upfront cost compared to standard products,
- Lack of consumer awareness or understanding of these products' benefits, and
- Costs associated with testing required for ratings systems.

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[230] Window, Door, Skylight Tax Credit Report Indicates Importance of Energy Efficiency. (2011, Oct 31). American Architectural Manufacturers Association. Retrieved from http://www.aamanet.org/news/1/10/0/all/654/window-door-skylight-tax-credit-report-indicates-importance-of-energy-efficiency

[231] Barista, D. (2012, May 26). Energy efficiency, quality top considerations when specifying windows, say builders. *Professional Builder*. Retrieved from http://www.housingzone.com/windowsskylights/energy-efficiency-quality-top-considerations-when-specifying-windows-say-builders

[232] U.S. Department of Energy. (2009). *Energy Star Qualified Windows: 2010 Partner Resource Guide*. p. 7. Retrieved from http://www.energystar.gov/ia/partners/manuf_res/downloads/PartnerResourceGuide-LowRes.pdf

The creation of the NFRC's rating standards and Energy Star's labeling process did much to increase consumer confidence in and awareness of energy efficient fenestration products. However, Energy Star-rated doors and windows are still more expensive than their traditional counterparts. When making the decision of which windows or doors to buy consumers often do not consider the future energy cost savings they will enjoy by purchasing energy efficient products, especially when that decision is only one component of a larger decision regarding the building of a new home. Further, though many builders now offer energy efficient windows as standard practice, the issue of "split incentives"–wherein the builder incurs the higher cost of energy efficient windows without receiving the energy saving benefits–may make purchasing non-energy efficient windows or doors more cost-effective for home builders.[233]

Finally, the cost of the testing and labeling required to certify products as "energy efficient" may be prohibitive for small manufacturers.[234] The majority of U.S. manufacturers of wood and metal doors and windows employ fewer than five people.[235] With so many small firms comprising the U.S. market, the cost of testing may prove a barrier to greater market penetration among a significant segment of manufacturers.

Market Drivers

Federal rebate programs or tax credits, such as the 2009-2011 credit, can make energy efficient doors and windows more cost-competitive with traditional products, thereby incentivizing consumers and builders alike to incorporate them into their homes. As with building insulation, a growing preference among consumers for energy efficient fenestration products is currently driving the market and projections for growth are positive.

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[233]Northwest Energy Efficiency Alliance. (2002). *Market Progress Evaluation Report: Energy Star Windows No. 5*.p. I-9, I-10. Retrieved from http://www.cee1.org/eval/db_pdf/207.pdf

[234] Tribble, A. & Offringa, K. & Prindle, B. & Arasteh, D., et. al. (2002). Energy Efficient Windows in the Southern Residential Windows Market. *Residential Buildings: Program Design and Implementation*. Davis: UC Davis. p. 2.232. Retrieved from http://eec.ucdavis.edu/ACEEE/2002/pdfs/panel02/20_46.pdf

[235] U.S. Census. (2009). Number of Firms, Number of Establishments, Employment, and Annual Payroll by Enterprise Employment Size for the United States, All Industries. Retrieved from http://www.census.gov//econ/susb/data/susb2009.html

Projections of Growth

Consumer demand, government support, and more stringent building codes point to future growth in the market for energy efficient doors and windows. An analysis of the global market forecasts a faster rate of growth for energy efficient doors and windows relative to that of the overall fenestration market through 2015 due to growing consumer awareness and government support.[236] The 2012 updates to the International Residential, Building, and Energy Conservation Codes–used in nearly half the states in the U.S.–will require greater energy efficiency in doors and windows once adopted, thereby spurring additional demand for energy efficient products.[237]

Heating and Cooling Systems Market: Energy Efficient Options Will Become More Popular as Training, Awareness Increase

The geothermal pump industry can increase production quickly and easily, but more training for installers will be necessary. The evaporative cooling and ERV industries, however, will need to overcome unfavorable consumer perceptions to see real growth.

Overview

Energy efficiency strategies often used in net-zero-energy homes—such as creating a tight building envelope and installing tightly sealed doors and windows—require adequate levels of air filtration and ventilation. Several options are available for net-zero-energy homeowners beyond the customary HVAC systems. This section will discuss systems that use alternative sources of energy or use conventional sources in more efficient ways.

Geothermal heating and cooling: Geothermal pumps use heat from the earth to heat and cool air, or to heat water, in a building. Using water or a fluid refrigerant, the pumps transfer heat from the ground to the home on colder days or from the home to the ground on warmer days. Geothermal systems may be horizontally oriented, with pipes shallowly laid over a large area, or vertically oriented, with pipes reaching deep underground. Pipes can be

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[236] Global Window & Door Demand to Grow 6.8% Annually Through 2015. (2011, Oct 4). *Window & Door*. Retrieved from http:// www.windowanddoor.com/news-item/markets/global-window-door-demand-grow-68-annually-through-2015

[237] Ruth, J. (2011). International Code Requirements for Windows and Doors. *Window & Door*. Retrieved from http://www.windowanddoor.com/article/codes-standards/international-code-requirements-windows-doors

embedded into the earth or linked to a nearby body of water. Which system is installed depends on the amount of land or the size and quality of water bodies available.[238]

Evaporative cooling: Evaporative cooling systems can serve as alternatives to traditional air conditioning systems. Evaporative coolers pull outside air through moist pads and circulate the cooled air through the building. Because they add moisture to the circulated air, they work best in less humid climates.[239]

Energy recovery ventilation (ERV): ERVs supplement traditional HVAC systems by reducing the amount of energy needed to heat or cool air. They achieve this reduction in energy use by transferring heat from warm inside exhaust air to cold supply air in winter or from warm supply air to cooler inside exhaust air in summer.[240]

Manufacturers

As of 2008, there were at least 16 manufacturers of geothermal heat pumps serving U.S. markets. Many manufacturers have also long produced water source heat pumps and thus have stable supply and distribution chains.[241] The Midwest and South possess the most geothermal pump manufacturers, installers, and maintenance personnel of any U.S. region.[242] Table 16 lists some of the top companies specializing in geothermal systems manufacturing. Large corporations that produce traditional HVAC systems, like Carrier and Trane, also offer geothermal pumps.

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[238] Allen, L. (2010, December). A Guide to the Basics of Geothermal Heating and Cooling Systems. *Natural Home & Garden*. p. 2. Retrieved from http://www.naturalhomeandgarden.com/article.aspx?id=2147487098&page=2

[239] Consumer Energy Center. (2006). California Energy Commission. Retrieved from http://consumerenergycenter.org/home/heating_cooling/evaporative.html

[240] Energy Recovery Ventilation Systems. (2011). U.S. Department of Energy. Retrieved from http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11900

[241] Hughes, P. (2008). *Geothermal (Ground Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers*. Washington DC: U.S. Dept of Energy. p. 17. Retrieved from http://info.ornl.gov/sites/publications/files/Pub13831.pdf

[242] Goetzler, W. & Zogg, R. & Lisle, H. & Burgos, J. (2009). *Ground Source Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers*. Washington DC: U.S. Dept of Energy. p. 27-28. Retrieved from http://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf

Table 16: Selected Geothermal Pump Manufacturers

Manufacturer - Geothermal Pumps	Headquarters	Distribution	Total Employees
ClimateMaster (subsidiary of LSB Industries, Inc.)	U.S.	Global	550
WaterFurnace International (subsidiary of WaterFurnace Renewable Energy, Inc.)	U.S.	Global	299
Geothermal International	UK	U.S., Europe, South Africa	91
Enertech Global, LLC	U.S.	North America	49
Manufacturer - Traditional HVAC with Geothermal Line			
Carrier	U.S.	Global	44,545
Trane	U.S.	Global	29,000

Source: Hoovers.com

Over 40 companies manufacture evaporative cooling systems in the U.S., but only a small fraction serve residential markets.[243] Of these, large producers include Energy Labs, Evapco, and Essick Air Products (see Table 17).

The North American ERV market contains only a few participants, many of which obtain their products from original equipment manufacturers (OEMs).[244] Some companies based in North America manufacture ERV and filtration systems under their own brand names. Of those companies listed in Table 17, only RenewAire manufactures ERV systems exclusively. The other firms have integrated ERVs into their existing product lines.

[243] Davis Energy Group. (2004). *Advanced Evaporative Cooling White Paper*. California Energy Commission. p. 11. Retrieved from http://www.energy.ca.gov/reports/2004-04-07_500-04-016_AT1.PDF
[244] Frost & Sullivan Research Service. (2007). *North American Energy Recovery Ventilation Markets Brochure*. Retrieved from http://www.frost.com/prod/servlet/report-brochure.pag?id=F720-01-00-00-00

Table 17: Selected Manufacturers of Evaporative Cooling and ERV Systems by Gross Revenue, 2011

Manufacturer - Evaporative Cooling	Headquarters	Distribution	Total Employees
Evapco Inc.	U.S.	Global	1,092
Essick Air Products	U.S.	U.S.	400
Energy Labs Inc.	U.S.	U.S.	600
Manufacturer – ERV			
Honeywell International Inc.	U.S.	Global	132,000
Broan-NuTone, LLC (subsidiary of Nortek)	U.S.	Global	3,200
Greenheck Fan Corporation	U.S.	Global	2,400
RenewAire, LLC (subsidiary of Soler & Palau Ventilation Group)	U.S.	North America, South America	60

Source: Hoovers.com

Sales and Market Size

The U.S. is the world leader in both the number of geothermal pumps installed and in overall geothermal pump capacity. In 2006, the U.S. market accounted for 65 percent of all ground-source heat pumps installed, and 53 percent of these were residential installations.[245] In 2009, the U.S. geothermal heat pump market was estimated to be $3.7 billion.[246] Annual U.S. sales of ground-source heat pumps are estimated to be approximately 60,000 units.[247]

Due to their inability to effectively cool in humid climates, traditional evaporative coolers are less widely used than geothermal heat pumps, with the 2006 national market totaling between $100 and $200 million in residential and commercial sales combined.[248] The ERV market in North America was slightly larger with revenues of $324.6 million.[249]

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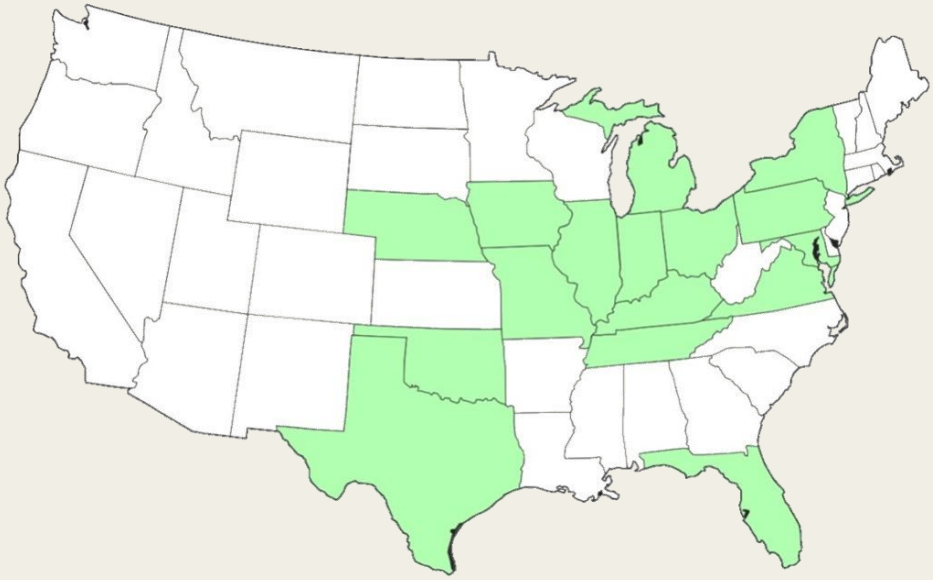
[245] Goetzler et. al. (2009). p. vii, 27-28.
[246] Williams, C. (2011, Jun 21). A Guide to Geothermal Heat Pump Investing Part I. ALT Energy Stocks. Retrieved from http://www.altenergystocks.com/archives/2011/06/a_guide_to_geothermal_heat_pump_ghp_investing_part_i.html
[247] Goetzler et. al., 2009, p. 26.
[248] Friedmann, R. & Bran, I. (2006). *Evaporative Cooling Market Assessment*. (Application Assessment Report 0510). San Francisco: Pacific Gas & Electric Co. p. 9. http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_368.pdf
[249] Frost & Sullivan Research Service. (2007). Going Green: Energy Recovery Ventilation Systems Reap Benefits. *Newswire Today*. Retrieved from http://www.newswiretoday.com/news/26037/

Regional Distribution

Geothermal heat pumps can be found throughout the country, but the distribution of pumps has traditionally been concentrated in the Midwest and South.[250] States containing pockets of extensive geothermal pump installations are highlighted in Figure 5.[251] While states with warmer climates have tended to dominate the geothermal pump market, the technology is especially well-suited for colder climates–where heating comprises a larger portion of a home's energy consumption–as geothermal systems are especially efficient in heating mode.[252]

Figure 5: States with Extensive Geothermal Pump Installations



Source: Hughes, P. (2008). Geothermal (Ground Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers. Washington DC: U.S. Dept of Energy. p. 24. Retrieved from http://info.ornl.gov/sites/publications/files/Pub13831.pdf

Made using "Your Visited States Map" template. (2012). Defocus Blog. Retrieved from http://www.defocus.net/visitedstates/generate.html

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[250] Goetzler et. al. (2009). p. 27
[251] Hughes, P., 2008, p. 19
[252] Kresge, J. (2012, May). Solar vs. Geothermal. [Web log post]. Retrieved from http://www.geothermalgenius.org/blog/solar-vs-geothermal

Because they add moisture to the inside air, evaporative coolers work best in climates where the humidity is usually below 50 percent.[253] Not surprisingly, evaporative coolers are most widely used in the arid southwestern U.S.

ERV systems are gaining popularity in northern regions and areas with high humidity and high temperatures.[254] The distribution of ERVs in these areas most likely reflects the fact that residents here utilize their heating or cooling systems much more frequently than people living in more temperate climates, thus they can enjoy greater cost savings from an ERV system.

Challenges

Although geothermal heat pumps accounted for just one percent of the heating and cooling market in 2011, analysts believe the industry could easily accommodate significantly increased demand.[255] Manufacturers of many component parts already serve wider markets than the geothermal industry, so scaling up production could be accomplished easily. As manufacturers increase production, economies of scale could also drive down prices and therefore make the pumps more cost-competitive with traditional HVAC systems.[256] However, as in the case of insulation, training (especially of loop specialists and drillers) will need to become more widespread for any significant growth in geothermal's market share to occur.[257]

Evaporative cooling systems, on the other hand, face many hurdles to increased production, including a limited number of manufacturers and doubts about quality and performance. Until unfavorable perceptions of lower quality, more maintenance, and shorter lifespan associated with "swamp coolers" are altered, evaporative cooling systems will likely not expand beyond their current niche markets in southwestern states.[258]

The ERV market must also overcome awareness and credibility issues if it is to make any significant gains. Though technology has improved and the Air-Conditioning, Heating, and

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[253] Common Swamp Cooler Complaints - How to Troubleshoot Your Evaporative Cooler. (2012). Air & Water Portable Appliance Experts. Retrieved from http://www.air-n-water.com/common-swamp-mistakes.htm
[254] Frost & Sullivan Research Service. (2007). *Brochure.*
[255] Geothermal Heat Pump Shipments to Double in Volume to 326,000 Units Annually in the United States by 2017, Forecasts Pike Research. (2011, July 26). *Enhanced Online News.* Retrieved from http://eon.businesswire.com/news/eon/20110726005715/en
[256] Hughes, 2008, p. 18
[257] Ibid, 19
[258] Davis Energy Group, 2004, p. 11

Refrigeration Institute (AHRI) has created rating standards for ERV systems, both consumers and industry professionals still lack the understanding of the product needed to facilitate wider market adaptation. The perception among consumers that ERVs are merely additional costs on top of their current HVAC systems will also pose an obstacle to growth if left unaddressed.[259] See Table 18 for a summary of the strengths and weaknesses of these industries.

Table 18: Industry Strengths and Weaknesses of Heating and Cooling Systems

System Type	Strengths	Weaknesses
Geothermal	Component and system manufacturers can easily scale up production if demand for geothermal systems increases	More training for loop specialists and drillers will be necessary
Evaporative Cooling	Technological innovations, like the use of vapor-compression technology, could increase market penetration	Limited number of manufacturers Consumer perceptions of low quality and performance issues
ERV	AHRI ratings and standards increase confidence and quality	Consumers and industry professionals lack awareness Perception among consumers that ERVs are merely additional costs on top of HVAC system

Market Drivers and Projections of Growth

Recent technological innovations in the evaporative cooling industry could lead to growth in the product's market share. With indirect evaporative cooling systems, which utilize vapor-compression technology, moisture is not added to the air during the cooling process, keeping the

[259] Lin, H.S.W. (2010, Jul 19). Emerging Technology: Commercial Energy Recovery Ventilation Systems. Air Conditioning, Heating, Refrigeration. Retrieved from http://www.achrnews.com/articles/emerging-technology-commercial-energy-recovery-ventilation-systems

inside humidity much lower than with a typical evaporative cooling system.[260] Indirect evaporative cooling systems could thus be used effectively in a wider variety of climates.

Geothermal and ERV systems could both benefit from the increasing popularity of the energy efficiency and green building movements, while government policies and industry association standards are currently viewed as the primary drivers of the ERV market in North America.[261]

Solar Thermal Water Heaters: Cost is Biggest Market Barrier, but Supportive Policies can help

The most pressing issue facing the solar thermal water heater industry is the high cost of purchasing a solar thermal system. The price needs to fall below $1,000 to compete with electric and natural gas water heaters. Huge growth is seen in installations when federal tax credits are put in place.

Overview

Net-zero-energy homes can use a variety of different systems for water heating and storage, including tankless water heaters and hybrid systems that are more energy efficient than traditional water heaters. This section will discuss solar thermal heating systems, which rely on alternative sources of energy to operate, that heat water without substantially contributing to a home's energy consumption.

There are two basic types of solar thermal water heating systems.

- **Active systems** that contain circulating pumps and controls. *Active indirect systems* use a solar collector to heat the refrigerant and pump it to a heat-transfer unit where it warms the water within a conventional storage tank. They are the most prevalent type used in the U.S., because, unlike other solar thermal models, they work well in both warm climates and climates prone to freezing temperatures.
- **Passive systems** that do not contain pumps. *Flat-plate collector systems* are most often used to heat swimming pools.

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[260] Two-Stage Evaporative Cooler. (1997, August). *Energy Source Builder, 52*. Retrieved from http://oikos.com/esb/52/smartcool.html
[261] Frost & Sullivan Research Service. (2007). *Brochure*.

Both types of solar thermal systems will require backup conventional storage systems for cloudy days or times of high demand.

Manufacturers

The top producers of conventional water heaters in the U.S. have begun adding solar options to their product lines. A.O. Smith, Bradford White, and Rheem Manufacturing have integrated solar thermal systems into their lines, though their main focus remains on conventional systems. Other U.S.-based firms produce solar thermal options exclusively. Alternate Energy Technologies (AET), America's largest producer of flat-plate solar thermal collectors, serves 40 percent of the U.S. market. AET is the only cost-effective producer on the market; its products are cost-competitive with conventional heaters even without government subsidies.[262] The majority of solar thermal system components are sourced domestically with storage tanks–mostly imported from China–constituting the largest segment of components obtained from abroad.[263]

Table 19: Top U.S. Producers of Water Heaters

Manufacturer	Headquarters	Distribution	Total Employees
A.O. Smith Corporation	U.S.	Global	10,600
Rheem Manufacturing Company Inc.	U.S.	Global	5,500
Bradford White Corporation	U.S.	North America, India	1,219
Alternate Energy Technologies, LLC	U.S.	Global	65

Source: Hoovers.com, and Hall, C. (2011). AET's Cost Competitive Systems Lead the Industry. Business Review USA. Retrieved from http://www.businessreviewusa.com/reports/AET-Solar

Sales and Market Size

Federal tax credits strongly incentivize sales of solar thermal systems. The two years of greatest growth in the solar thermal system market during the last decade coincided with the enactment and expansion of residential federal investment tax credits on solar thermal water heaters. The number of installations in 2006, the year the residential tax credit was established, doubled from

[262] Hall, C. (2011). AET's Cost Competitive Systems Lead the Industry. Business Review USA. Retrieved from http://www.businessreviewusa.com/reports/AET-Solar
[263] GTM Research. (2011b). *U.S. Solar Energy Trade Assessment 2011*. Solar Energies Industry Association. p. 76. Retrieved from http://www.seia.org/research-resources/us-solar-energy-trade-assessment-2011

2005 rates. In 2008, the year the cap on the tax credit was removed, installations increased by 56 percent.[264] However, these years are outliers; the market's longer-term growth rate has tended to be more stable, with a 6 percent compounded annual growth rate (CAGR) since 1991.[265] From 1994 to 2010, 274,000 solar heating and cooling systems were installed in the U.S., with 35,500 of those installed in 2010 alone.[266] [267]

The vast majority of installations are for residential use: 79 percent in 2009 and 84 percent in 2010. In addition, the number of installed solar thermal systems for heating and cooling has remained relatively stable since 2008.[268]

Regional Distribution

While solar thermal systems have been incorporated into homes and businesses across the U.S., the states with the highest numbers of installations can be seen in Figure 6. States with supportive solar policies tend to have the highest amounts of solar installations.

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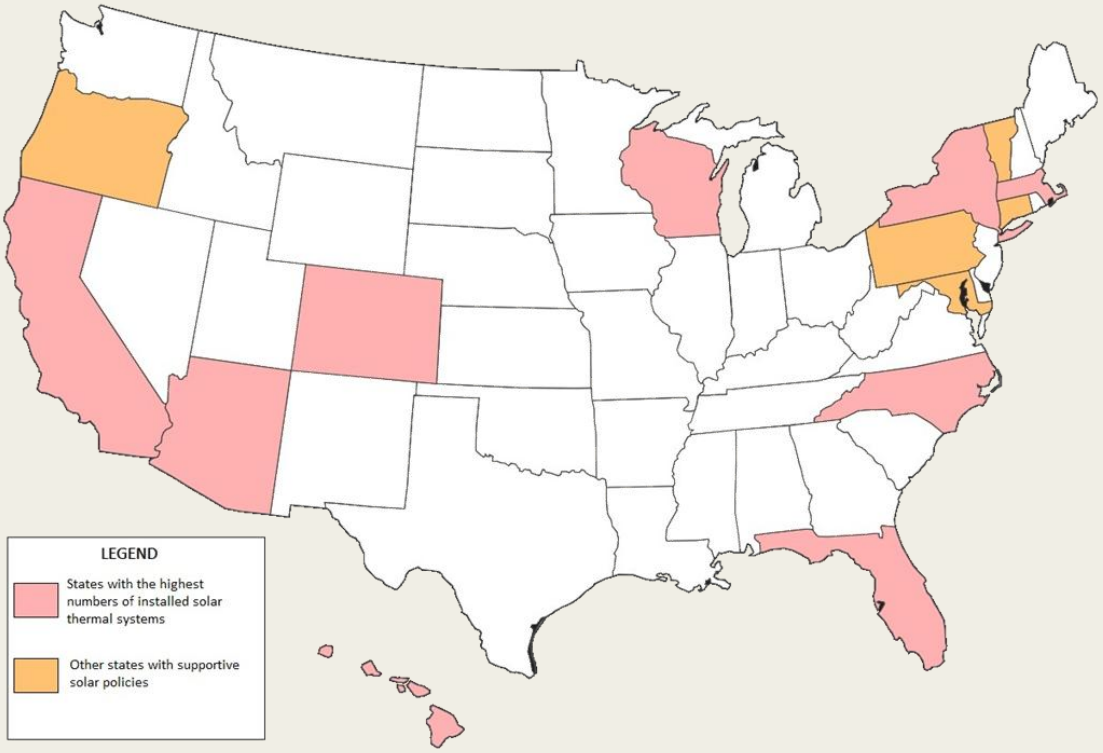
[264] Sherwood, 2010, p. 13
[265] Hudon, K. (2011, Jul 28). *Industry Review: Low-Cost Cold Climate Solar Water Heating Roadmap.* [webinar] National Renewable Energy Laboratory. p. 6. Retrieved from http://www.treia.org/assets/2011/Events/TR-2011/presentations/1.32b_mon_1030_ guiney_solar-thermal-industry_national-status-and-projections.pdf publications/pdfs/corporate/ns/webinar_lowcost_swh_roadmap_20110728.pdf
[266] Sherwood, 2010, p. 15
[267] Guiney, W. (2011, November 7). *Solar Thermal Industry: National Status and Projections*. [presentation]. p. 3. Retrieved from http://www.treia.org/assets/2011/Events/TR-2011/presentations/1.32b_mon_1030_guiney_solar-thermal-industry_national-status-and-projections.pdf
[268] Sherwood, 2010, p. 2, 13

Figure 6: States with Highest Numbers of Solar Thermal Installations



Source: GTM Research. (2011). U.S. Solar Market Insight 2010. Solar Energy Industries Association. Retrieved from http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf; Sherwood, L. (2010). U.S. Solar Market Trends. Interstate Renewable Energy Council. p. 13; Made using "Your Visited States Map" template. (2012). Defocus Blog. Retrieved from http://www.defocus.net/visitedstates/generate.html

Challenges

The most pressing issue facing expansion of the solar thermal water heater industry is the relatively high cost of purchasing a solar thermal system. Although solar technology could be effectively utilized in three fourths of U.S. homes, the systems are only currently cost-effective in the southwest, Alaska, and Hawaii.[269] According to the U.S. Department of Energy (DOE), the price of a solar thermal water heating system would need to fall below $2,500 to be cost-competitive

[269] Kanellos, M. (2010, January 22). After Six Decades of Slumber Solar Water Heaters Wake up in California. *GreenTechSolar*. Retrieved from http://www.greentechmedia.com/articles/read/ after-six-decades-of-slumber-solar-thermal-water-returns-to-california/

with natural gas water heaters, and to $1,000 to be cost-competitive with electric water heaters.[270]

While the majority of solar thermal water heater components are manufactured in the U.S., nearly half the systems produced in 2010 contained imported storage tanks. Solar collectors are also being sourced from abroad, with 22 percent of collectors coming from China, Europe, Mexico, and Israel.[271] If demand for solar water heaters increases dramatically in the coming years, heavy reliance on imports for two major system components could lead to bottlenecks or increased costs if these foreign industries are unable to quickly scale up production.

Finally, as in the case of ERV systems, solar thermal water heaters cannot completely replace traditional systems. The need for a conventional backup system for cloudy days or times of increased demand leaves open the possibility for consumers to view solar thermal systems as an unnecessary additional cost. Improvements in technology, increased consumer awareness and confidence, or higher energy prices may provide solutions to this market barrier in the future.

Market Drivers

Government incentives like the 2011 solar investment tax credit have been shown to boost sales, and extensions of these supports could increase solar thermal's market share. Strong state policies advocating solar, such as those passed in California and Wisconsin, can also contribute to solar thermal market penetration. However, the majority of states would need to enact such policies for significant growth to occur.[272]

Projections of Growth

Optimistic projections for the solar thermal market forecast a high CAGR of 32 percent for solar thermal water heaters, resulting in a nearly $4 billion market by 2017. More conservative estimates still project a relatively robust CAGR of 21 percent through 2017, culminating in a roughly $2 billion market in that year.[273] Assumptions of such high growth must be predicated on

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[270] Ong, S. (2011, July 28). *Break-even Cost for Residential Solar Water Heating in the United States.* [webinar] National Renewable Energy Laboratory. p. 5. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/ns/webinar_lowcost_swh_roadmap_ 20110728.pdf
[271] GTM Research, 2011b, p. 71
[272] Sherwood, 2010, p. 13
[273] Hudon, 2011, p. 4

extensions of government subsidies and tax incentives that make solar thermal systems cost-effective for U.S. consumers.

Energy Efficient Lighting Market: Huge Gains Projected with Passage of Federal Legislation, Decreasing Cost

Perhaps the most crucial driver of this market is the Energy Independence and Security Act, which phases out incandescent bulbs by 2015. As incandescent bulbs stop being produced, consumers will replace them with CFLs and LEDs. Market penetration for CFLs is expected to be 30-43 percent by 2015. As prices drop, LEDs' CAGR is projected to rise to 200 percent through 2015.

Overview

Energy efficient lighting is another important component of net-zero energy housing: the less electricity a light requires, the more energy is available for other uses (such as heating and cooling). Both new types of light bulbs and lighting controls play a part in reducing a home's overall energy consumption. In this section, the following technologies will be discussed.

- **Compact Fluorescent Light Bulbs (CFLs):** Unlike incandescent bulbs, CFLs do not use heat to produce light. Instead, electricity interacts with argon and mercury inside the bulb to produce ultraviolet (UV) light. The UV rays excite the fluorescent coating on the inside of the bulb, generating visible light.[274] Because CFLs do not generate as much heat to produce light–heat that is mostly wasted–they are much more energy efficient than incandescent bulbs.
- **Light-Emitting Diodes (LEDs):** LEDs also use electricity more efficiently than incandescent bulbs, but rather than exciting electrons in argon gas and phosphor coatings, LEDs use diodes, which are electrical devices through which current flows in one direction.[275] When current runs through them, these diodes emit bright light. Different colors can be emitted using different types of semiconductors.
- **Lighting Controls (including dimmers, occupancy/motion sensors, timers, and daylight sensors):** Lighting controls can be installed on incandescent bulbs, CFLs, or LEDs to

[274] Learn about CFLs. (2012). Energy Star Program. Retrieved from http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about
[275] Holzer, D. (2012). What Does LED Stand For and How Does it Work? *National Geographic*. Retrieved from http://greenliving.nationalgeographic.com/led-stand-work-2682.html

regulate how much energy the light uses. Dimmers to vary the brightness of a light, and motion detectors and timers to control when the light turns off and on, have been utilized in residential lighting fixtures for decades. Newer technologies, including daylight sensors and occupancy sensors, regulate the amount of light emitted by light fixtures according to the amount of natural light in the room or whether the room is occupied.

Manufacturers

The lighting market is dominated by the "big three" lighting manufacturers: GE, Sylvania, and Philips Lighting. While each of these companies provides traditional incandescent lighting, they also offer lines of energy efficient products. Other major players in the CFL market include U.S.-based Lithonia Lighting and TCP (Table 20). The number of firms producing CFL products has increased dramatically over the past decade. In 1999, only five manufacturers produced 22 Energy Star-rated CFLs. By 2009, 93 firms produced over 3,000 Energy Star-rated CFL products.[276]

LEDs, a newer technology, have also gained several large manufacturers, with 10 companies serving nearly 70 percent of the global LED market in 2011. These companies included such giants as Nichia, Samsung, Osram, and LG (seeTable 20).[277]

[276] Energy Star Program. (2009). *Big Results, Big Potential: CFL Market Profile 2009*. U.S. Department of Energy. p. 4. Retrieved from http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile.pdf

[277] LED market grew 10% to $12.5 billion in 2011. (2012, February 17). Optics.org. Retrieved from http://optics.org/news/3/2/24

Table 20: CFL and LED Manufacturers

Manufacturer	Headquarters	Distribution	Total Employees
GE	U.S.	Global	301,000
Sylvania (division of OSRAM AG)	U.S.	North America, Europe	7,400
Philips Lighting (U.S. division of Royal Philips Electronics)	U.S.	U.S.	470
Lithonia Lighting	U.S.	North America	900
TCP International Holdings LTD	U.S.	Global	6,111
Nichia Corporation	Japan	Global	6,808
Samsung Electronics Company, LTD	South Korea	Global	101,970
LG Corporation	South Korea	Global	210,000

Source: Hoovers.com

Just as the big three lighting manufacturers offer both traditional and energy efficient lights, the largest lighting controls manufacturers also produce traditional lighting products. The largest lighting controls manufacturers, listed by 2011 market share, can be found in Table 21.

Table 21: Largest Lighting Controls Manufacturers by Market Share

Manufacturer	Headquarters	Distribution	Total Employees
Lutron Electronics, Inc.	U.S.	Global	1,500
WattStopper (division of Legrand North America)	U.S.	Global	140
Leviton	U.S.	Global	6,035
Acuity Brands	U.S.	Global	6,000
Schneider Electric	France	Global	123,482
Encelium Technologies (division of OSRAM AG)	U.S.	North America, Europe	200

Source: Hoovers.com, and Encelium Technologies Inc (2012). Inside View. Retrieved from http://www.insideview.com/directory/encelium-technologies-inc

Sales and Market Size

To measure market penetration, Energy Star has coined the term "socket saturation," which is the ratio of installed CFLs to sockets in which a CFL could be installed.[278] However, the term can be applied to all types of lighting products. The socket saturation for CFLs, LEDs, and lighting controls in 2010 can be seen in Table 22. The size of the CFL market has increased steadily since 2001, experiencing a 52 percent CAGR from 2001 to 2010. Despite such strong growth, the CFL market still has a long way to go on its path to gaining market share. As of 2008, 30 percent of U.S. households did not have any CFLs installed and 75 percent had five or fewer.[279]

LEDs have also posted gains in market share over the past decade; however, they still represent a miniscule part of the U.S. residential lighting sector (Table 22). The global LED market is growing steadily, though: by 9.8 percent to $12.5 billion over the period 2010-2011 (Table 23).

Table 22: Socket Saturation by Lighting Type, 2010

Lighting Type	Socket Saturation
CFL	19.3%
LED	0.2%
Lighting Control	14.0%

Source: Ashe, M. & Chwastyk, D. & de Monasterio, C. & Gupta, M. & Pegors, M. (2012). 2010 U.S. Lighting Market Characterization. U.S. Dept of Energy. p. 23-24, 56, 58. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

Lighting controls have enjoyed an increase in popularity as well. The percentage of new homes that are built with lighting controls doubled between 2009 and 2011, resulting in some form of lighting controls in 12 percent of the 550,000 new homes built during 2011.[280] The size of the lighting controls market increased 8.6 percent from 2010 to 2011, largely as a result of government spending initiatives for energy conservation (Table 23).

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[278] Energy Star Program., 2009, p 5
[279] Ibid, 6
[280] Knott, J. (2012, May 30). Hottest Technologies among Builders. [Web log post]. Retrieved from http://www.kozimediadesign.com/blog/

Table 23: Value of Market for LEDs, Lighting Controls

Lighting Type	Market	Market Value (in billions of dollars)	
		2010	2011
LED	Global	$11.38	$12.5
Lighting Controls	European and North American	$1.8	$1.96

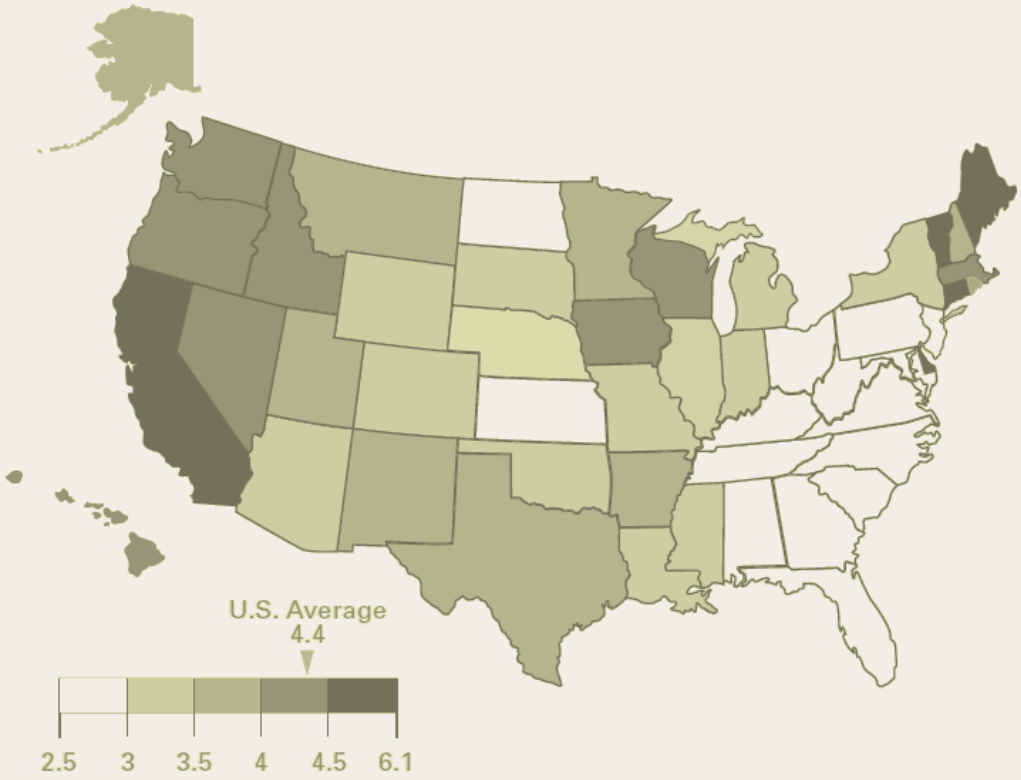
Source: LED market grew 10% to $12.5 billion in 2011. (2012, February 17). Optics.org. Retrieved from http://optics.org/news/3/2/24 and Lighting Controls Market Poised for Continued Growth. (2012, April 18). The Business Journals Digital Network. Retrieved from http://www.bizjournals.com/prnewswire/press_releases/2012/04/18/DA90332

Regional Distribution

The distribution of CFLs is similar to that of solar thermal water heaters in that the highest CFL socket saturation rates are found in states with strong CFL promotional programs. These areas tend to be located in California, the Pacific Northwest, Wisconsin, and New England.[281] Other states in which CFLs are heavily utilized include Delaware, Iowa, and Hawaii (Figure 7).

[281] Energy Star Program, 2009, p 6.

Figure 7: CFL Residential Saturation by State



Source: Energy Star Program. (2009). Big Results, Big Potential: CFL Market Profile 2009. U.S. Department of Energy. p. 6. Retrieved from http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile.pdf

Challenges

CFLs initially faced several serious hurdles to market penetration, including:

- Low light output,
- Inconsistent performance,
- Expense,
- Lack of coordination among industry players, and
- Lack of consumer education and awareness.[282]

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[282] Energy Star Program. (2012). *Energy Star Products: 20 Years of Helping America Save Energy, Save Money, and Save the Environment*. U.S. EPA. p. 26-28. Retrieved from http://www.energystar.gov/ia/products/downloads/ES_Anniv_Book_030712_508compliant_v2.pdf

Technology has improved since their market debut, and they now provide a better quality of light and product. Furthermore, the marketplace has grown more familiar with CFLs, thus promoting better coordination among utilities, manufacturers, and retailers. Energy Star standards and marketing programs increased consumer confidence in, and awareness of, CFL products as well. Technological improvements and government support have helped decrease the cost of CFLs somewhat. However, concerns about the mercury contained in CFLs are projected to pose a more intractable problem.[283]

LEDs, a few years behind CFLs in terms of technological advancement and market penetration, have only seen strong growth in niche markets like traffic signals and exit signs. According to DOE, continued technological research and marketing campaigns will be necessary to broaden the application of LEDs in the residential sector.[284] Technological barriers include:

- A complex fabrication process and
- The need for better systems design and integration.

The lack of consistency in creating LED systems must all be addressed before LEDs can become viable as a mass market lighting option. LEDs also share several barriers common to most nascent energy efficient technologies, such as:

- High prices,
- Lack of standards or a rating system,
- Low consumer awareness and education, and
- Relatively few manufacturers and distribution channels. [285]

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[283] U.S. Residential LED lamp installations projected to have a 200% CAGR through 2015. (2011, April 6). IMS Research. [Web log post]. Retrieved from http://www.ledmarketresearch.com/blog/US_Residential_LED_lamp_installations projected_to_have_a_200_ CAGR_through_2015

[284] Ashe, M. & Chwastyk, D. & de Monasterio, C. & Gupta, M. & Pegors, M. (2012). *2010 U.S. Lighting Market Characterization.* U.S. Dept of Energy. p. xii. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

[285]Ton, M. & Foster, S. & Caldwell, C. (2003). *LED Lighting Technologies and Potential for Near-Term Applications.* Northwest Energy Efficiency Alliance. p. 56. Retrieved from http://neea.org/docs/reports/EDLightingTechnologiesD8981309B83F.pdf?sfvrsn=6

Market Drivers

As previously discussed, the Energy Star program has helped to increase consumer confidence in and awareness of CFLs through its standards and ratings requirements and marketing programs. Rebates for CFLs have helped make the bulbs more cost-effective, thereby increasing their market share. Perhaps the most crucial driver of this market, though, is the Energy Independence and Security Act of 2007 (EISA). This act effectively mandates a complete phase-out of incandescent bulbs by 2015 by requiring increased efficiency standards for light bulbs. As incandescent bulbs that cannot meet the efficiency requirements cease to be produced, consumers will turn to CFL and LED bulbs to meet their lighting needs. LED market penetration will also be aided by the EISA, especially as technology improves and costs decrease.[286]

Like the insulation and energy efficient ventilation industries, the lighting controls market is also driven by the increased need for energy savings and reduction in peak energy demand. As in the case of CFLs and LEDs, government energy efficiency mandates also contribute to growth in this sector.[287]

Projections of Growth

In 2010, DOE developed three scenarios for EISA's impact on the CFL market.

1. EISA-compliant incandescent bulbs become available before all incandescent bulbs are phased out and CFL socket saturation does not grow substantially, with purchases merely going to replace burned-out CFLs. This scenario projects CFL socket saturation in 2015 to be 30 percent.
2. If EISA-compliant incandescents do not appear on the market in time, DOE anticipates a spike in CFL demand in 2014, when 40-60 watt incandescents are removed from the market, driving socket saturation in 2015 to 43 percent.

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[286] Lighting Controls Market Poised for Continued Growth. (2012, April 18). The Business Journals Digital Network. Retrieved from http://www.bizjournals.com/prnewswire/press_releases/2012/04/18/DA90332
[287] Ibid

3. A third scenario rests on the assumption that targeted marketing campaigns jumpstart CFL demand before 2014, with a 2015 socket saturation of 61 percent, followed by a subsequent decline in demand due to the long life of CFL bulbs.[288]

IMS Research, a market research and consulting firm specializing in the electronics industries, also projects the EISA legislation will have a dramatic impact on sales of LEDs over the next few years, resulting in a CAGR of roughly 200 percent through 2015. Substantial growth in LED use will begin in 2014 as their price falls below $10 and more rebate programs develop; 2015 will see the most growth in the LED market as the price continues to decrease and consumer concerns grow over CFLs' mercury content and relatively shorter life spans.[289] DOE estimates that the cost of LEDs will drop by 30 percent per year through 2015 and between 10 percent and 15 percent per year from 2015 to 2020.[290] These price decreases also suggest an increase in LED market share over the coming decade.

Figure 8 shows U.S. Energy Information Administration (EIA) projections of the amounts of CFLs and LEDs purchased relative to incandescent bulbs over the next few decades. Just as IMS Research predicts, EIA forecasts LEDs will gain a larger share of the market in the future.

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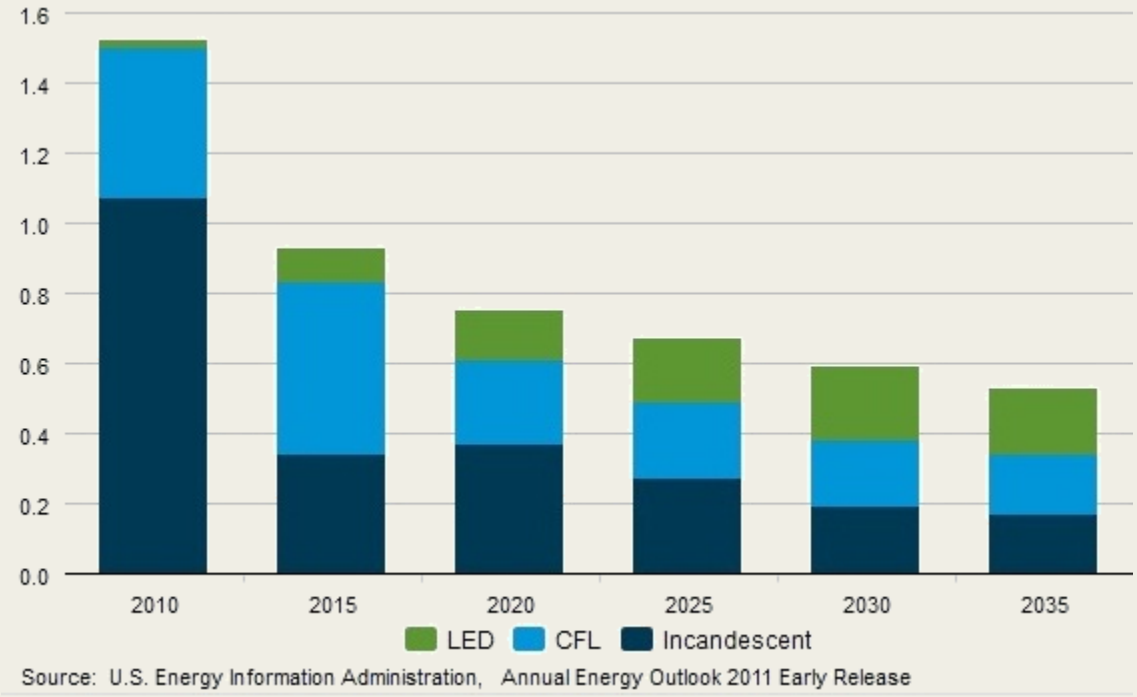
[288] D&R International. (2010). *Energy Star CFL Market Profile: Data Trends and Market Insights*. U.S. Department of Energy. p. 31-34. Retrieved from http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf

[289] US Residential LED lamp installations, 2011

[290] McKinsey & Company. (2011). *Lighting the way: Perspectives on the global lighting market*. p 19. Retrieved from: http://img.ledsmagazine.com/pdf/LightingtheWay.pdf

Figure 8: Residential sector general service light bulb purchases (in billions of bulbs)



Based on assumptions of continued government support and energy efficient mandates, and the need for energy savings and demand reduction, consulting firm Verify Markets anticipates the lighting controls market to grow at a CAGR of 4.2 percent and culminate in a $2.42 million market by 2016.[291]

Energy Efficient Appliances: Energy Star Products Continue to Gain Recognition and Market Share

In 2010, over 1,600 manufacturers produced more than 40,000 Energy Star products in 60 categories. Since 2000, over four billion Energy Star qualified products have been sold. Rebate programs for qualified appliances span the nation and spurred over $1.3 million in purchases from 2009 to 2011.

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[291] Verify Markets. (2011). In *Lighting Controls Market in North America Executive Summary*. Retrieved from http://verifymarkets.com/previews/ North%20America%20Lighting%20Controls%20Markets%20-%20Executive%20Summary.pdf

Overview

Like lighting and HVAC systems, appliances must use energy efficiently to maintain the balance of energy consumption versus generation in a NZEH. If a home is built with energy efficient insulation, doors, windows, HVAC, and water heating systems but does not have energy efficient appliances, it will still consume more energy than it is able to generate. In the U.S., the Environmental Protection Agency (EPA) and DOE's Energy Star program sets the standard for energy efficiency requirements and ratings. To become Energy Star qualified, a product must meet certain criteria based on the guiding principles of the program.

- Product categories must contribute significant energy savings nationwide.
- Qualified products must deliver the features and performance demanded by consumers in addition to increased energy efficiency.
- If the qualified product costs more than a conventional, less-efficient counterpart, purchasers will recover their investment, within a reasonable period of time, in increased energy efficiency through utility bill savings.
- Energy efficiency can be achieved through broadly available and non-proprietary technologies offered by more than one manufacturer.
- Product energy consumption and performance can be measured and verified with testing.
- Labeling would effectively differentiate products and be visible for purchasers.

The qualification criteria may be amended or strengthened for products with a 50 percent market share or greater. Other factors to be considered in the process include testing, quality or performance issues, difficulties in achieving energy savings, limited product availability, new technological innovations, and new minimum federal standards.[292]

With over 60 categories of qualified products, the Energy Star program provides ratings for virtually every component included in both net-zero and traditional homes: doors, windows, HVAC systems, heat pumps, water heaters, lighting, and insulation all have their own specifications and testing requirements to achieve Energy Star status. Most household appliances can also qualify for

[292] How a Product Earns the Energy Star Label. (2012). Energy Star Program. Retrieved from http://www.energystar.gov/index.cfm?c=products.pr_how_earn

Energy Star ratings, such as refrigerators, dishwashers, clothes washers and dryers, air filters or ventilators, and computers and electronics.

Because the Energy Star program provides consistent testing, labeling, and performance criteria for such a wide variety of energy efficient appliances, this section uses Energy Star-rated products as a measure of the overall energy efficient appliance market.

Manufacturers

In 2010, over 1,600 manufacturing partners produced more than 40,000 Energy Star-rated products. To sell an Energy Star-rated product in the U.S., a company must first become an Energy Star manufacturing partner by entering into a manufacturing partnership agreement with the EPA. Only producers that sell their products directly to consumers are eligible for partner status. Original equipment manufacturers that do not sell directly to consumers are ineligible.

As of 2012, 138 Energy Star partners produced appliances in the U.S., and 36 international manufacturing partners also produced qualified appliances for U.S. markets.[293] Large corporations including GE, Black & Decker, Hamilton Beach, Proctor & Gamble, Sunbeam, and Whirlpool top this list, while smaller, regional manufacturers also comprise a substantial portion.

Sales and Market Size

With over 40,000 Energy Star-rated products spanning 60 categories, it is no surprise that energy efficient appliances are being purchased in record numbers. In 2010, U.S. consumers bought over 200 million Energy Star qualified products across all categories. In 2011, consumers purchased 280 million qualified products. Cumulatively, over four billion Energy Star qualified products (including appliances, office equipment, and electronics) have been sold since 2000. Figure 9 provides a breakdown of the sales of Energy Star products by category from 1995. The share of appliances sold is increasing, but the category still comprises just a small part of overall Energy Star product purchases.

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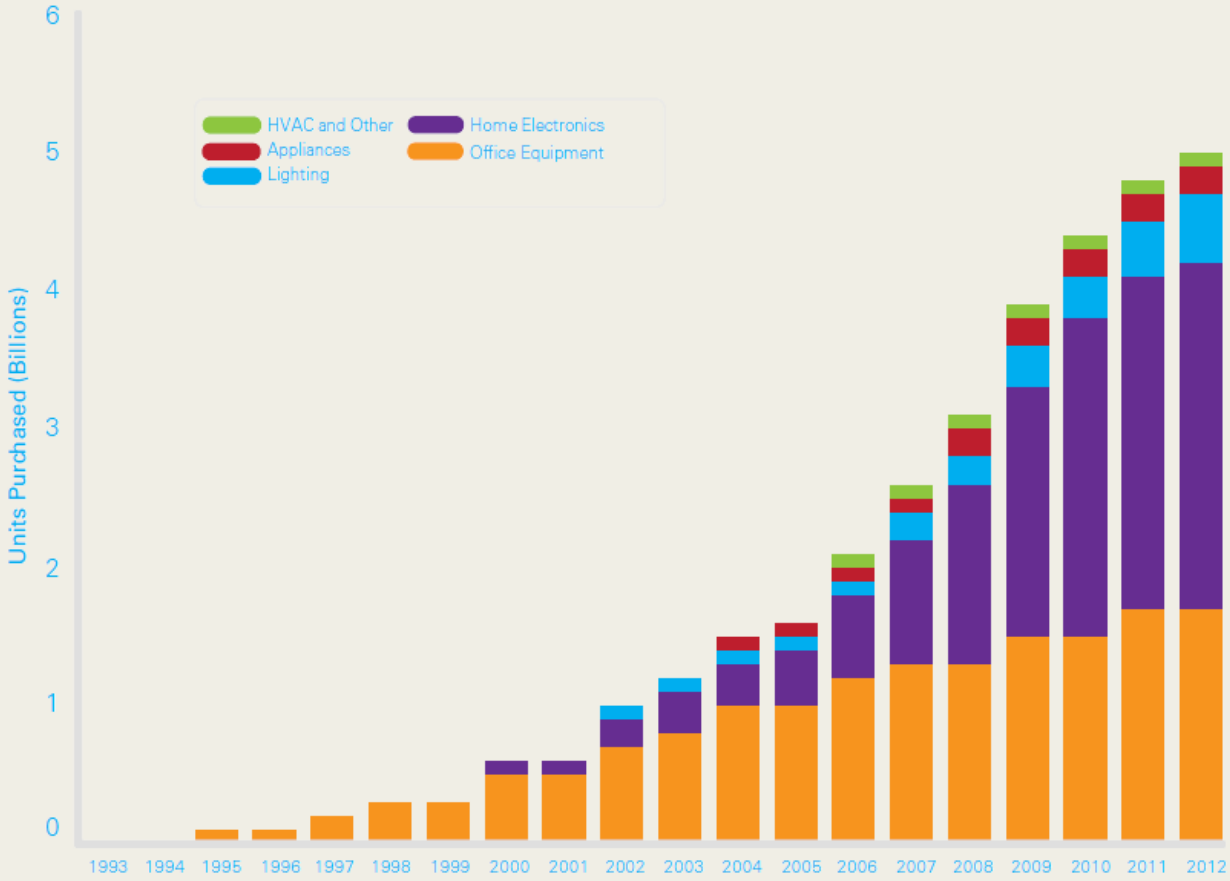
[293] Based on search of Energy Star partners database by product (all appliances) accessed June 26, 2012: Energy Star Partner List (2012) Energy Star Program. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=estar_partner_list.showProductSearch&s_code=ALL&partner_type_id=MANUFACTURER

Figure 9: Energy Star Products Sold (Cumulative)



Since the program's inception, thousands of individuals from more than 2,200 manufacturing companies, 1,600 retailers, 800 energy efficiency programs and the federal government have worked under the ENERGY STAR banner to define, build and create both supply and demand for energy-efficient products. Over the past 20 years, Americans have purchased a total of more than five billion ENERGY STAR products.

*The lighting data do not include CFL sales. Product sales may not appear in every year a category was included in the program due to scale.

Source: Energy Star Program. (2012). Energy Star Products: 20 Years of Helping America Save Energy, Save Money, and Save the Environment. U.S. EPA. p. 3. Retrieved from http://www.energystar.gov/ia/products/downloads/ES_Anniv_Book_030712_508compliant_v2.pdf

The market share for energy efficient appliances differs across products. Some appliances are experiencing highly successful market penetration, while others comprise only a small percentage of the market. Table 24 provides a cross section of products with high, medium, and low market penetrations.

Table 24: Market Penetration of Select Energy Star Appliances, 2011

Appliance	Rate of Penetration			Market Share
	High	Medium	Low	
Dishwashers	✓			100%
Dehumidifiers	✓			99%
Clothes Washers		✓		64%
Refrigerators		✓		50%
Room AC Units		✓		33%
Freezers			✓	25%
Room Air Purifiers			✓	21%

Source: Stephens-Booker, R. (2011, Nov 10). Marketing Energy Star Appliances: Opportunities and Resources. [presentation]. Energy Star Program. Retrieved from: http://www.energystar.gov/ia/partners/downloads/meetings/2011/Marketing%20ES%20Appliances.pdf

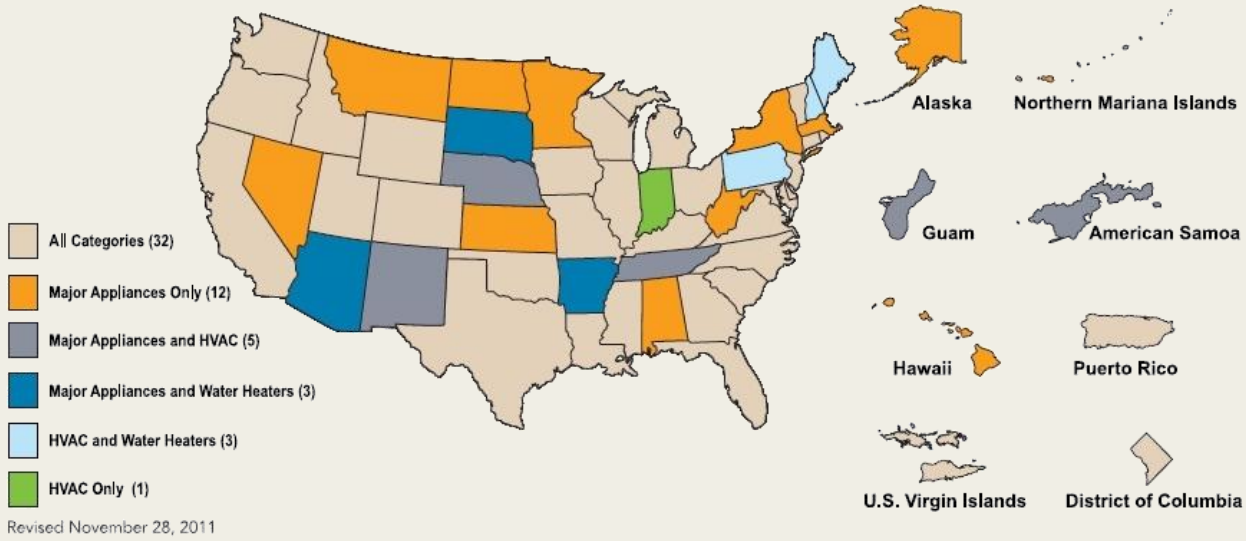
Clearly, certain energy efficient appliances do very well in the marketplace while others lag behind. The success of these high penetration products is due in part to the implementation of rebate programs both for purchasing and recycling. The rebate programs implemented from 2009 to 2011 covered appliances, HVAC systems, and water heaters, as 88 percent of rebates were used in the purchase of appliances. The rebates spurred over $1.3 million in spending on qualified appliances, with most consumers purchasing refrigerators, clothes washers, and dishwashers.[294]

Regional Distribution

Energy Star appliances can be found nationwide. Each state devised its own rebate programs in 2009 on major appliances, HVAC systems, and water heaters using American Recovery and Reinvestment Act (ARRA) funds. Figure 10 highlights rebate programs in all 50 states; all but four provided some sort of rebate for energy efficient appliances.

[294] U.S. Department of Energy. (2012). State Energy Efficient Appliance Rebate Program. p. 1. Retrieved from http://www.energysavers.gov/financial/rebates/pdfs/seearp.pdf

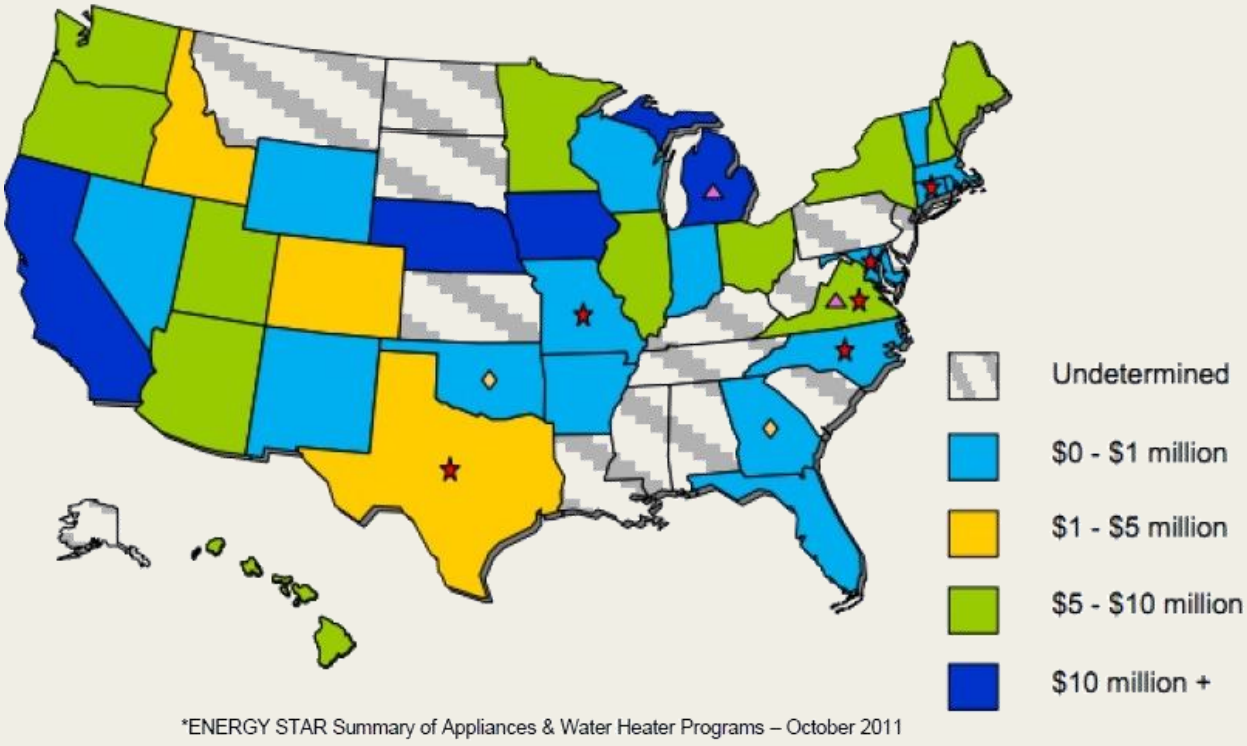
Figure 10: Products Rebated by State or Territory as of November 2011



Source: U.S. Department of Energy. (2012). State Energy Efficient Appliance Rebate Program. p. 2. Retrieved from http://www.energysavers.gov/financial/rebates/pdfs/seearp.pdf

Figure 11 shows state budgets for those rebate programs covering appliances. California and states in the Midwest had the highest appliance rebate budgets.

Figure 11: Appliance Rebate Program Budgets, 2011



Source: Stephens-Booker, R. (2011, Nov 10). Marketing Energy Star Appliances: Opportunities and Resources. [presentation]. Energy Star Program. p. 8. Retrieved from: http://www.energystar.gov/ia/partners/downloads/meetings/2011/Marketing%20ES%20Appliances.pdf

Challenges

Energy efficient appliances face many of the same challenges as other NZEH components. The higher upfront cost, lack of consumer awareness or consideration of longer term energy cost savings, and limited product availability are all impediments to greater market penetration of Energy Star-rated appliances. Additionally, from a marketing standpoint, fragmented consumer messaging and a lack of coordination among manufacturers, Energy Star staff, and retailers can lead to missed promotional opportunities.[295]

[295] Stephens-Booker, R. (2011, Nov 10). Marketing Energy Star Appliances: Opportunities and Resources. [presentation]. Energy Star Program. p. 31-32. Retrieved from: http://www.energystar.gov/ia/partners/downloads/meetings/2011/Marketing%20ES%20Appliances.pdf

Market Drivers

Energy Star's targeted marketing and consumer awareness campaigns have led to an increase in Energy Star label recognition and confidence among consumers. Ninety one percent of respondents surveyed in a Field Research marketing study reported that the Energy Star label influenced them to some degree in making their purchases. This makes the Energy Star label second only to the Good Housekeeping seal in terms of influencing purchasing decisions.[296] Partnerships with retail giants like Home Depot and Lowe's also increased Energy Star recognition and consumer understanding of qualified products' benefits.[297]

Rebate programs like the one begun in 2009 boost market share by lessening the high upfront cost of energy efficient appliances, thereby incentivizing more consumers to purchase them. Therefore, additional rebate or tax credit programs could spur further growth in the energy efficient appliance market.

Projections of Growth

If recent growth rates are any indication, Energy Star appliances will continue to grow as a market segment, especially as more products become qualified. As with other energy efficient products, Energy Star appliances will see increases in market share as energy prices rise and more emphasis is put on decreasing energy consumption.

Smart Meters Market: Utility-Driven Growth in the Face of Privacy and Health Concerns

Smart meters' market penetration was 45 percent in 2011 and is expected to reach 75 percent in 2021. Concerns over privacy and radiation have led to opt-out programs in some states, but growth will continue as more utilities install them to lower costs and better monitor demand.

Overview

Once homeowners have purchased energy efficient appliances, ventilation, and water heating systems, they must also ensure the systems are being used efficiently. Net-zero energy and traditional homeowners alike can install smart meters to monitor their energy usage. Smart meters are the newest breed of electric, gas, or water meters that record energy usage in timed increments that allow residents to understand just how much energy is being used in their homes

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[296] Ibid, 5
[297] Energy Star Program, 2012, p. 13-14

and on which applications. By comparing this data to past or desired usage rates, people can make informed decisions on regulating their energy consumption and use. Smart meters can also communicate with utility providers to more quickly identify outages and regulate supply during peak demand periods.

Manufacturers

The Smart Meter Manufacturers Association of America (SMMAA) asserts that its member manufacturers represent 99 percent of the installed base of U.S. smart meters.[298] Its members are comprised of large multinational corporations who have added smart meters to their existing product lines. Table 25 provides a comprehensive list of SMMAA members.

Table 25: SMMAA Manufacturers

Corporation	Headquarters	Number of Employees	Market Participation
GE	U.S.	301,000	No data provided
Echelon	U.S.	302	>35 million meters installed
Elster Group	Germany	6,985	200 million meters installed
Itron, Inc.	U.S.	9,600	8,000 utility customers
Landis + Gyr	Switzerland	5,139	300 million meters installed
Sensus	U.S.	1000-5000	No data provided

Source: Hoovers.com; SMMAA Manufacturers. (2012). SMMAA. Retrieved from SMMAA.org/about; Smart Metering (2012). Echelon. Retrieved from http://www.echelon.com/applications/smart-metering/; Elster Group (2012). Elster.com. Retrieved from www.elster.com/en/elster-group; About Itron. (2012). Itron. Retrieved from www.itron.com/about/Pages/default.aspx; Key Facts and Figures. (2010). Landis + Gyr. Retrieved from www.landisgyr.com/en/pub/our_company/key_facts_and_figures.cfm

Other key manufacturers in the supply chain include several startup companies that produce software and network programs to link smart meters with each other and with utilities. One such company is Silver Spring Network, a California-based firm that has connected over 11 million homes and businesses to utility providers with its software. Larger companies like Google, Inc. and Cisco Systems are also beginning to produce software for monitoring energy use.[299]

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[298] About the Smart Meter Manufacturers' Association. (2012). Smart Meter Manufacturers' Association of America. Retrieved from http://smmaa.org/about

[299] St. John, J. (2009, April 30). Top Ten Smart Grid. GreenTechGrid. p. 3. Retrieved from Greentechmedia.com/articles/read/top-ten-smart-grid-3605/N3

Sales and Market Size

Though it is still a relatively new industry, smart meters are gaining popularity. Market research firm Frost & Sullivan estimates sales of smart meters in 2010 were $1.01 billion.[300] That year, the smart meter industry's market share was 8.7 percent, which was up from 4.7 percent in 2008.[301] This growth continued: by 2011, 45 percent of the total number of installed meters were smart meters.[302]

Regional Distribution

Smart meters are available throughout the U.S., but are more readily adopted in areas where such meters are mandated by utility companies. Smart meters comprise over 15 percent of the market in seven states: Arizona, Oregon, Idaho, Pennsylvania, Wisconsin, California, and Missouri.[303] Forecasts predict growth will increase rapidly in the Northeast and Midwest, outpacing other regions of the country because these areas have made less progress in installing smart meters to date. Conversely, demand for smart meters in the West is expected to decline as several utility companies completed transitions to smart meter technology in 2011.[304]

Challenges

While any new technology must overcome certain barriers, the issues associated with smart meters have led to heated debates over privacy, security, and adverse health effects. Because smart meters collect data on how much energy is being used when, and for what purpose, concerns over the misuse of that information have proliferated. Worries about hacking have been cited in several communities, while apprehension over whether smart meter data could be obtained by law enforcement without a warrant in Hawaii led to policy amendments.[305] In response to privacy and security concerns, many utilities have been required to provide opt-out programs for customers.

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[300] Saeed, F. (2011, July). Smart Meter Market Thrives Despite Setbacks. *Electric Light & Power* 89(4). Retrieved from http://www.elp.com/index/display/article-display/5198014181/articles/electric-light-power/volume-89/issue-4/sections/smart-meter-market-thrives-despite-setbacks.html

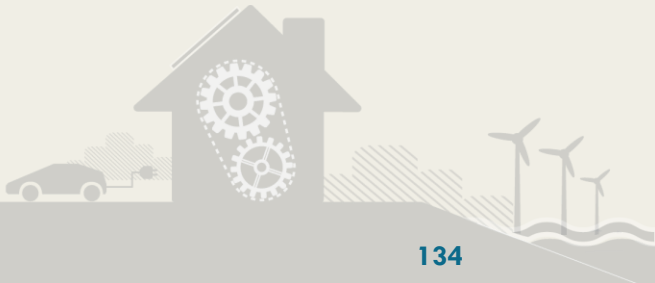
[301] Ibid.

[302] Freedonia Group. (2012). *Smart Meters: Industry Study with Forecasts for 2016 & 2021 Brochure*. p. 4. Retrieved from http://www.freedoniagroup.com/brochure/28xx/2844smwe.pdf

[303] Saeed, 2011, July

[304] Freedonia Group, 2012, *Smart Meters*. p. 4

[305] Van Voohis, V. (2012, March 28). KIUC Addresses Smart Meter Concerns with Policy Amendment. *The Garden Island*. Retrieved from http://thegardenisland.com/news/local/kiuc-addresses-smart-meter-privacy-concerns-with-policy-amendment/article_7c28a774-7983-11e1-b195-001a4bcf887a.html



In communicating wirelessly with utility providers, smart meters emit radio frequency (RF) radiation. As smart meters began to replace traditional electric and water meters, some people have become concerned about getting RF poisoning from their new meters. Public concern over this RF radiation contributed to the California and Maine Public Utilities Commissions' decisions to allow utilities to offer opt-out programs for customers. Research by the Edison Electric Institute and partners has shown, however, that RF exposure from smart meters is much lower than the FCC's limits, and the meter enclosure and the home's building envelope act as barriers for much of the radiation. Moreover, RF radiation from cell phones is significantly higher than from smart meters.[306] While worries over health hazards persist, opt-out programs and research are beginning to alleviate these concerns.

Market Drivers

The main driver in the smart meter market is the technology's growing acceptance among utility providers. Data collected by smart meters will allow utilities to improve service and lower the cost of labor, as detecting outages and connecting and disconnecting service remotely will save on the costs of sending workers to various sites to deal with these issues.[307] Additionally, as electricity demands intensify due to increased population and usage, more importance will be placed on regulating peak demand to prevent blackouts and the need for more capacity. Utility companies will undoubtedly look to smart meters in addressing these issues.

Projections of Growth

Market research firm Freedonia Group projects that the smart meter market will increase by over 11 percent per year to $4.4 billion by 2016. Growth will not stop there: by 2021 the research firm expects 285 million smart meters to be installed, which translates to a market penetration rate of 75 percent. The highest growth will be seen in electric meters, though gas and water will experience substantial increases as well.[308]

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[306] Queen, E. (2011). *A Discussion of Smart Meters and RF Exposure Issues*. Edison Electric Institute. Retrieved from http://www.aeic.org/meter_service/smartmetersandrf031511.pdf
[307] Saeed, 2011, July
[308] Freedonia Group, 2012, *Smart Meters*, p. 4

Home Automation Systems Market: As Prices Fall and Connectivity Spreads, More Homes Utilize Energy Management Systems

The increase in broadband and smartphone use and the transition to an affordable monthly payment model have contributed to the rise of home automation systems in the U.S. From 2009 to 2011, the percentage of new homes with energy management systems increased 133 percent. The global home automation market is expected to reach $11 billion in 2015, with energy management systems outpacing security automation.

Overview

Although home automation systems have been used primarily for security in the past, producers are now focusing more on energy management and are offering a new line of products designed to help homeowners regulate their energy use. Once homeowners obtain and understand their households' energy use from a smart meter, they can use home automation systems to manage that usage–even from a different location. The system allows homeowners to turn off lights and appliances and program the HVAC system.

Manufacturers

Table 26: Top Producers of Home Automation Systems in the U.S.

Manufacturer	Headquarters	Distribution	Total Employees
Johnson Controls	U.S.	Global	162,000
Honeywell International, Inc	U.S.	Global	132,000
Siemens	Germany	Global	360,000

Source: Hoovers.com

Johnson Controls is widely considered to be the top supplier of home automation systems in the U.S. by market share, with other top producers including Honeywell International and Siemens.[309] However, Johnson Controls currently only offers energy management systems for commercial buildings, and Siemens only for industrial ones. Honeywell has incorporated energy efficiency into its home automation systems, but its focus remains on security. Each of these companies has added

[309] St. John, 2009, April 30, p. 4

building automation to their product lines in recent years, so expansion into home energy management systems may be their next step.

Other corporations that are integrating residential energy management into their offerings are Time Warner Cable, Verizon, Leviton, Panasonic, and Lowe's. Time Warner Cable's IntelligentHome system incorporates security and energy management, as it provides security monitoring and live-feed cameras along with the ability to remotely control thermostats and lights. Verizon offers an automation system designed specifically for energy control. The package includes switches that act as smart meters: they can be placed on any appliance, allowing homeowners to monitor the appliance's energy consumption and cost.[310]

Sales and Market Size

In 2007, the U.S. market for home controls—including both security and energy management applications—was approximately $3.5 billion.[311] Since 2009, the percentage of homes built with energy management systems has increased steadily: from six percent to 14 percent of new homes built in 2011. This was a 133 percent increase in just two years. The number of homebuilders that offer these systems also grew from 40 percent to 59 percent during that time period.[312]

Challenges

The predominant obstacle that has historically impeded growth in the home automation market is the systems' high cost. As greater numbers of companies offer energy management systems with monthly billing cycles, however, costs will decrease to more affordable levels. Indeed, they already have: Time Warner Cable's IntelligentHome can be installed for $99 and monthly rates are as low as $35.[313]

Market Drivers

Several factors are prompting growth in the home automation sector. Chief among these is increasing connectivity. Most homes have broadband internet service, and more people are

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[310] Ray, T. & Berkman, L. (2012, February 3). 'Smart home' technology goes mainstream. *The Press-Enterprise*. Retrieved from http://www.pe.com/business/business-headlines/20120203-industry-smart-home-technology-goes-mainstream.ece

[311] Products & Technology. (2012). Threshold Smart Home. Retrieved from http://thresholdsmarthome.com/index.php?option=com_content&view=section&id=1&layout=blog&Itemid=2

[312] Knott, 2012, May 30

[313] Ray & Berkman, 2012, February 3

getting smartphones, which can be used to control the systems remotely. Secondly, a more affordable bundled monthly payment model is putting the systems within reach of more homeowners. Often, these systems are bundled together with existing services from telecoms, cable, security, and energy providers.[314]

Increasing consumer confidence is also an important part of the home automation market's success. Reasons for rising consumer confidence and demand include an increasing level of comfort with integrated technology systems as well as access to a growing number of trained engineers able to demonstrate and maintain systems for customers.[315]

Finally, Pike Research links projections of future growth to such drivers as government mandates, utility programs, rising energy prices, and the expanding popularity of energy efficient technology and green building.[316]

Projections for Growth

The research and consulting firm Markets & Markets anticipates the global smart homes market will grow at a CAGR of 15.6 percent to 2015, thereby bringing the size of the global market to $11 billion. Within this, the energy management component is expected to grow faster than security services at a CAGR of 23.7 percent.[317]

Pike Research projects growth for the global home energy management (HEM) market as well, with a CAGR of 38.3 percent through 2020. For networked-HEMs, much of this growth will be

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[314] Business Wire. (2012, May 16). 90 Million Homes Worldwide Will Employ Home Automation Systems by 2017, Finds ABI Research. *The Wall Street Journal*. Retrieved from http://www.marketwatch.com/story/90-million-homes-worldwide-will-employ-home-automation-systems-by-2017-finds-abi-research-2012-05-16

[315] Pragnell, M. & Spence, L. & Moore, R. (2000). *The market potential for Smart Homes*. York: Joseph Rowntree Foundation. p. 7. Retrieved from http://www.jrf.org.uk/sites/files/jrf/1859353789.pdf

[316] Home energy management market builds slowly but surely. (2012, May 16). Electric Light & Power. Retrieved from http://www.elp.com/index/display/article-display/5592335935/articles/electric-light-power/energy-efficiency/2012/May/Home_energy_management_market_builds_slowly_but_surely.html

[317] Markets & Markets. (2011). Global Smart Homes Market (2010-2015): Report Description. Retrieved from http://www.marketsandmarkets.com/Market-Reports/smart-homes-and-assisted-living-advanced-technologie-and-global-market-121.html

driven by utility companies working to manage peak demand and time-of-use pricing.[318]In the U.S., this market is expected to total $1.4 billion by 2016.[319]

[318] Home energy management market, 2012, May 16
[319] Ray & Berkman, 2012, February 3