**Southwest Energy Efficiency Project**

*Saving Money and Reducing Pollution Through Energy Conservation*

# High Performance Homes in the Southwest: Savings Potential, Cost Effectiveness and Policy Options

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# Executive Summary

## Introduction

The six-state Southwest region of the United States (Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming) is a fast-growing region that is experiencing a boom in population and new housing construction. Nearly 2 million homes are projected to be built in the Southwest between 2008 and 2020, equivalent to about 150,000 new homes per year. Growth rates are as much as triple the national average in parts of Arizona and Nevada, and electricity demand is growing at rates as high as 4% per year. Total peak electricity demand in just three of the Southwest States (AZ, NM, and NV) is expected to grow by 2,000 MW per year for the next 15 years. Two-thirds or more (as high as 89% in New Mexico and 95% in Utah) of the electricity generated in the Southwest comes from coal-fired power plants, which release emissions of air pollutants that harm public health and contribute to global warming.

**Benefits of High Performance Homes**

High performance homes are capable of achieving 40-60% energy savings by combining energy-efficient technologies and solar energy systems. These homes save homeowners an average of $1,600 annually on their energy bills, with positive monthly cash flow immediately.

**Homebuyers** benefit by having lower energy bills and a home that is more energy efficient, comfortable, durable, and environmentally friendly.

**Homebuilders** benefit by marketing a higher quality, higher value product, and one that costs less to own and operate.

**States and cities** benefit by having desirable communities that reduce demand for energy and natural resources.

## Purpose and Scope of the Report

The purpose of this report is to analyze the energy savings, cost and cost effectiveness of high performance homes for five Southwest states (AZ, CO, NV, NM and UT). Utilities, states, local governments and home builders can use the information in the report to develop new programs, policies and strategies for increasing the energy efficiency of new homes.

SWEEP analyzed the energy savings and net economic benefits to each state and the region of significantly increasing the energy efficiency of new homes, versus typical homes built to minimum requirements of currently adopted state or local energy codes. The report makes recommendations for utility, state and local government programs and incentives to accelerate the adoption of high performance building practices in the new homes industry, including a 3-tiered incentive structure for ENERGY STAR, Best Practice and Net Zero-Energy Homes.

The report includes several case studies and examples of high performance homes and communities in the Southwest – ranging from ENERGY STAR qualified homes to net-Zero Energy Homes – that document the energy and cost savings achieved from increasing the efficiency of new homes. It also addresses the technical, financial and institutional barriers to constructing high performance homes, and presents strategies and best practices for overcoming each barrier, based on lessons learned and successful programs that have been adopted by utilities, states and local governments.

**Recommendations for Utilities, States and Local Governments**

Utilities, states and local governments all play an important role in advancing high performance homes. This report identifies best practices, implementation strategies and incentive programs that can significantly improve the energy efficiency of new homes. Key recommendations from the report include the following actions for utilities, states and local governments:

***Utilities***

- Offer a 3-tiered incentive package for high performance homes, including incentives for best practice and net zero-energy homes.
- Support high performance building practices by providing technical assistance, training and marketing and outreach support to the building industry.
- Conduct evaluation and field monitoring studies to document home performance.

***State governments***

- Provide financial incentives for high performance homes, including tax credits and exemptions for high performing homes, energy efficient products and renewable energy systems.
- Adopt updated residential building codes that achieve at least 15% energy savings over model codes.
- Partner with utilities and local governments to offer technical assistance, training and outreach to builders and homebuyers.

***Local governments***

- Adopt a green building program with mandatory energy efficiency criteria for new homes.
- Offer incentives to builders for constructing high performance homes.
- Educate homeowners about the features and benefits of high performance homes.

For more information about these and other recommendations, see Chapter 8 of the report.

## Features and Benefits of High Performance Homes

Increasing the energy efficiency of new homes offers a cost-effective way to help homeowners save money and lower their energy use, while reducing the energy and environmental impacts of new homes. High performance homes – defined as homes that maximize energy efficiency, comfort, and durability – can be built cost-effectively while achieving energy savings of up to 50% through energy efficiency measures, and up to 65% savings by incorporating on-site renewable energy systems, such as solar PV and solar thermal systems. High performance homes are also designed to reduce the risk of indoor air quality problems, through programs such as the ENERGY STAR Indoor Air Package.

The energy, economic and environmental benefits of improving the efficiency of new homes in the Southwest region are significant.[1] Achieving the high performance home scenario analyzed in this report would result in the following energy and cost savings between 2008 and 2020:

- Over 2.7 million GWh of grid electricity savings – enough electricity to meet the annual electricity consumption of approximately 250,000 typical households.
- Reduction in residential natural gas consumption of 228 million therms (up to 50% reduction in natural gas use per household).
- Summertime peak electricity demand would be reduced by nearly 200 MW annually by 2020; average hourly summertime peak loads per home would be reduced between 50 and 67%.
- Southwest households would reap $500 million in reduced electricity and natural gas bills, with savings of $30 million in the first three years alone.
- Electricity from customer-sited solar PV systems would generate more than 500 GWhs of electricity from 2008 to 2020, worth $52 million to homeowners.
- Emissions of greenhouse gases from power plants would be reduced by 2.4 million tons of $CO_2$ between 2008 and 2020.

## Cost and Cost Effectiveness of High Performance Homes

### Energy Efficiency

There are many cost-effective opportunities to improve the energy efficiency of new homes through a combination of improvements to residential building design, construction practices, higher efficiency levels of installed equipment, and homeowner education about ways to save energy. Common energy efficiency design practices and measures that are used in high performance homes include:

- Proper site selection and building orientation, which can help reduce heating costs in the winter and cooling costs in the summer, and facilitate the use of on-site PV to generate electricity. Where

[1] States included in the analysis are Arizona, Colorado, Nevada, New Mexico and Utah.

feasible, choose sites with good southern exposure without significant shading from mountains, trees or buildings and orient subdivision parcels and homes to maximize southern exposure for buildings. Rooms and windows should be designed to maximize solar heat gain in the winter but with proper window shading to reduce heat gain in the summer.

- Higher levels of ceiling and wall insulation (R-40 or higher) coupled with advanced framing techniques to minimize thermal bypasses.
- Radiant barrier installed on the inside of the roof to reduce solar heat gain and help keep the attic cool, particularly in hot-dry climates.
- Use of thermal mass for improved heating and cooling performance, including additional insulation in ceilings and walls, and use of 5/8" drywall instead of ½" drywall in ceilings.
- Properly designed and installed heating and cooling systems that help keep energy costs low and improve indoor air quality.
- High-performance windows with spectrally selective glass, which reduces solar heat gain in summer and reduces heating costs in the wintertime.
- Highly-efficient heating and cooling systems, including:
    - Engineered HVAC (proper sizing and diagnostic testing of HVAC systems by mechanical engineers)
    - Advanced evaporative cooling systems such as direct-indirect evaporative cooling systems
    - Ducts placed inside conditioned space, with sealing and diagnostic testing
- Tankless or solar water heating.
- High-efficiency lighting (e.g., fluorescent lamps and fixtures), or a combination of fluorescent and incandescent lighting with lighting controls (e.g., dimmers and occupancy sensors).
- Energy-efficient appliances, including refrigerators, clothes washers, dryers, dishwashers and consumer electronics.
- Integration of controls to monitor home energy use, including switches and controls for turning off designated electrical outlets (to reduce losses from standby devices).
- Third-party verification (analysis of home design and onsite inspections and testing to verify and rate the energy performance of the home on the HERS scale).

The additional cost of using energy-efficient building designs and systems can be partially offset by reductions in the size of cooling and heating equipment (particularly if proper equipment sizing procedures are followed and adhered to during construction and equipment installation) and other building design changes (e.g., reducing framing materials used by going to 2' x 6' wall construction with studs spaced 24" apart). When done properly, this can represent a significant cost savings to the builder and homeowner, as the smaller systems and reduce material requirements reduce construction and operation costs.

Renewable Energy Systems and Design Features

Renewable energy systems and design features – such as incorporating passive solar thermal design strategies, solar PV electric systems and solar thermal hot water – can reduce the heating and cooling load of the home and generate a portion of a home's electricity and water heating needs. Passive solar thermal design strategies can often be implemented at little or no incremental cost through proper building orientation, daylighting, and use of thermal mass.

Typical residential solar PV systems are between 2 kW and 4 kW in size, and are capable of offsetting approximately 25-30% of total household electricity consumption. Although the initial cost of renewable energy systems remains high (approximately $15-20,000 for a 2 kW solar PV system), the system costs are expected to continue to decline, and are made more affordable to the builder and homeowner by a combination of federal, state and utility tax credits or rebates now available in most Southwest states.[2] Utilities can also utilize residential PV systems to satisfy state renewable portfolio standard requirements by offering renewable energy credits to homeowners that have installed grid-tied PV systems. Colorado, Nevada and New Mexico already offer homeowners a RECs purchase option for solar PV systems.

## Analytical Methodology

The analyses in this report were prepared using the BEopt building optimization software and its related components, developed by the National Renewable Energy Laboratory (NREL). BEopt analyzes a range of home energy designs, operating conditions and technologies to identify optimal combinations of energy efficiency and renewable energy measures that achieve maximum savings at the lowest cost. BEopt has been used to design and analyze many zero-energy homes, such as Habitat for Humanity's affordable zero energy home in Denver, Colorado.[3]

Using BEopt, SWEEP analyzed four levels of home performance for five Southwest states (AZ, CO, NV, NM and UT):

- A reference case home built to current state or local building energy code requirements (i.e., IECC 2003 or 2006), using standard home building industry construction practices and equipment.
- An ENERGY STAR qualified new home (20-30% savings).
- An energy-efficient 'Best Practice' home (30-50% savings).

[2] For a complete list of federal, state, and utility incentives for energy efficiency and renewable energy by state, see the Database of State Incentives for Renewables and Energy Efficiency (DSIRE) at: www.dsireusa.org.

[3] For more information, see: http://www.eere.energy.gov/buildings/building_america/affordable_housing.html.

- A so-called 'Zero Energy Home' incorporating renewable energy measures as well as being high energy efficient (50% or greater savings).

Separate market penetration scenarios were developed and analyzed for each state, based upon the current building code in effect, levels of ENERGY STAR market penetration, and housing styles and preferences (e.g., 1 versus 2 story, basement, slab on grade, etc.). The per home savings estimates for each city (or average of cities in cases where more than one city per state was analyzed) were scaled up to the state level using historical estimates of total and single-family housing units by state, and population projections from the U.S. Census Bureau for the 2008-2020 time period.

Each of the scenarios is designed to achieve a minimum of 50% market penetration for ENERGY STAR Homes by 2020, 20% market share for Best Practice homes and 20% zero energy homes. The Best Practice and Zero Energy Home levels set aggressive yet achievable near, mid and long-term goals for raising the overall performance of residential new home construction, using readily available efficiency measures and construction techniques (e.g., SEER 15 AC, 2x6 framing, etc.). The average annual market penetration rate for Best Practice and Zero Energy Homes increases in each state by 2% per year, allowing time to train additional builders and contractors as the programs expand. The Best Practice and Zero Energy Home performance levels will help make progress toward the DOE Building America Program goal of developing a marketable home that achieves net-zero energy use by 2020.[4]

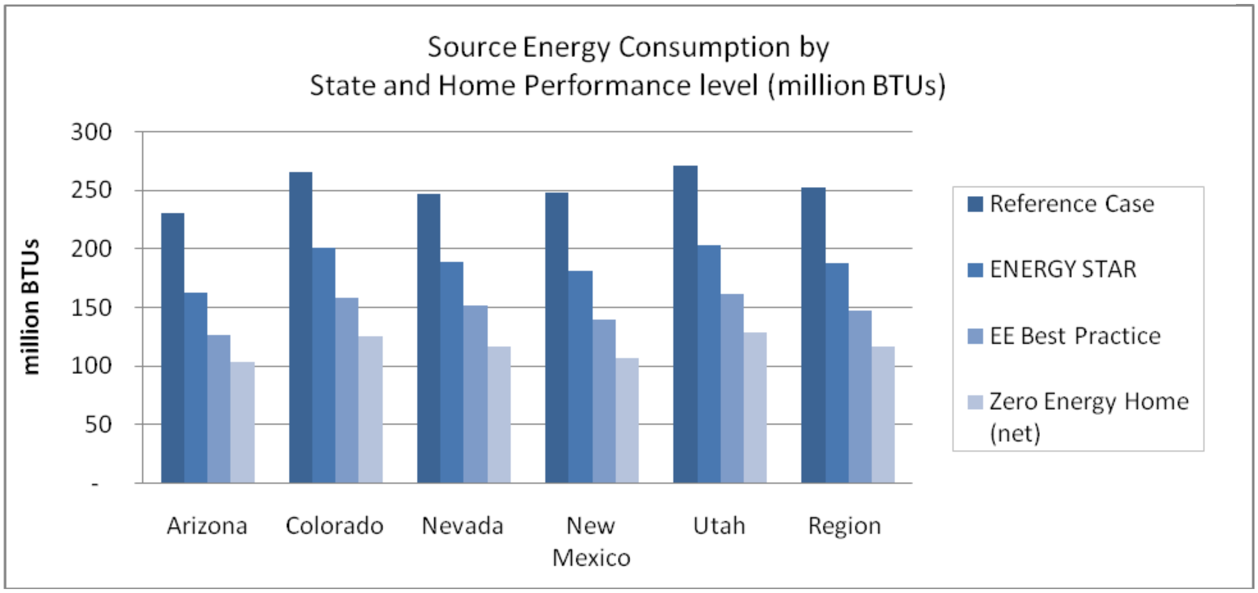
## Results

Home energy savings by performance level

The analysis of energy savings was conducted for each home performance level and main city in each state. The energy consumption and net cost savings for each home performance level are summarized in Tables ES-1 and ES-2. The average source energy savings across the region are 25% for the ENERGY STAR home, 42% for the Best Practice home, and 54% for the Zero Energy Home.

[4] For more information about the Building America program, see: http://www.eere.energy.gov/buildings/building_america/. The Building America residential goals are described in more detail at: http://www.eere.energy.gov/buildings/building_america/pdfs/35851_ba_puts_research.pdf

**Figure ES-1. Source energy consumption by state and home performance level**




Cost savings per household

High performance homes are cost-effective for homeowners, with net savings versus a code-built home when compared on the basis of the total cost of mortgage and utilities payments.[5] The incremental costs and net savings of each performance level are shown in Table ES-1. Energy efficiency measures reduce energy costs for single-family households by up to 50%, equivalent to a net cost savings of up to $1,085 per year. Averaged across the region, the annual energy savings per household is $743 for ENERGY STAR Homes, $1,172 for the Best Practice Home, and $1,523 for the Zero Energy Home. Combining energy efficiency and customer-sited renewable energy systems reduces net energy consumption by 60% or more, with net annual cost savings of up to $960 per household, before state or utility incentives are applied.[6]

**Table ES-1. Incremental costs and net savings per home**

| State | Incremental cost | | | Net savings, annual ($)** | | |
|---|---|---|---|---|---|---|
| | ENERGY STAR | Best Practice | Zero Energy Home* | ENERGY STAR | Best Practice | Zero Energy Home |
| Arizona (Phoenix) | $3,218 | $3,474 | $15,210 | $552 | $946 | $767 |
| Colorado | $2,917 | $6,588 | $19,895 | $432 | $616 | $271 |

[5] The homeowner cashflow analysis assumes a 30-year fixed rate mortgage with a 7% annual interest rate.

[6] Detailed descriptions of energy and cost savings are provided in Chapter 5, "Benefits of High Performance Homes to the Southwest Region," and Appendix A, Table A-3.

| | | | | | | |
|---|---|---|---|---|---|---|
| (Denver) | | | | | | |
| 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 |

*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).
** Net savings represents the savings to the homeowner in the annual cost of the mortgage plus utility bills versus a typical home.

### Avoided Peak Electricity Demand

Peak electricity demand in high growth states such as Arizona has doubled in the past 15 years, and is expected to double again in the next two decades.[7] Much of the growth in peak electricity demand is driven by increased air conditioning loads from new homes, and retrofits to existing homes that either had evaporative cooling or no cooling at all.

Energy efficiency design features that achieve peak savings include, but are not limited to:

- Proper orientation of the parcel and the home, with shading to reduce cooling loads,
- Improving the efficiency of AC systems through higher SEER levels, or use of evaporative cooling,
- Tightening the thermal envelope, and placing ducts inside conditioned space with proper sealing and diagnostic testing, and
- Reducing indoor loads from lighting, appliances and consumer electronics

The expected summertime peak savings by home performance level are shown in Table ES-2. Improving the energy efficiency of new homes can reduce the average daily peak electricity demand per home in the region by 55%. As a fraction of electricity demand in the region, the reductions in peak electricity demand achieved by high performances homes are much more significant than the total electricity savings.

The combination of a highly-efficient home with solar PV can achieve even greater peak reductions, eliminating 70 - 85% of the peak load throughout the afternoon and early evening hours on hot summer

[7] Presentation by Jeff Schlegel, SWEEP Arizona representative. Available online at: http://www.swenergy.org/pubs/Energy_Efficiency_and_Climate_Change-Jeff_Schlegel_03292007.pdf.

days. Maximum peak demand levels in zero energy homes are reduced by as much as 6 kW per home in hot climates, such as Las Vegas, Nevada and Phoenix, Arizona. In some cases, the net power draw from the utility grid drops to less than 1 kW at system peak (typically 4pm) on a hot summer day.

**Table ES-2. Average summertime peak electricity demand (kW) and % savings by home performance level.**

| State | Reference Case | ENERGY STAR | % Savings | Best Practice | % Savings | ZEH - Net | % Savings |
|---|---|---|---|---|---|---|---|
| AZ | 5.17 | 3.61 | 30% | 2.67 | 48% | 1.71 | 67% |
| CO | 2.32 | 1.28 | 45% | 1.06 | 54% | 0.38 | 84% |
| NV | 4.96 | 2.74 | 45% | 1.64 | 67% | 0.65 | 87% |
| NM | 2.70 | 1.94 | 28% | 1.18 | 56% | 0.35 | 87% |
| UT | 2.36 | 1.37 | 42% | 1.14 | 51% | 0.41 | 82% |
| **Region** | 3.50 | 2.19 | 38% | 1.54 | 55% | 0.70 | 81% |

## Statewide and regional savings potential, costs and cost effectiveness

The cumulative electricity, natural gas and peak demand savings from the high performance scenario for all new single-family homes expected to be built in each state and the Southwest region (1.8 million homes total) are shown in Table ES-3. The annual electricity savings in the region in 2020 are 427 GWh, and the annual reduction in peak electricity demand is 224 MW. The total annual electricity generation from PV systems installed on new homes is 81 GWh per year in 2020.

The high performance scenario achieves significant cost savings for Southwest households, with net economic benefits of $4.3 billion from efficiency measures between 2008 and 2020, and an additional $430,000 in net benefits from renewable energy measures (see Table ES-4). While on-site renewables are marginally cost-effective on a lifecycle basis (excluding utility and state incentives), many types of readily available energy efficiency measures are highly cost-effective.

Approximately 95% of the net economic benefits come from energy efficiency measures; the remainder comes from a combination of rooftop solar PV and solar thermal hot water systems. Each home performance level, however, has a positive benefit-cost ratio in every state and region of the Southwest. The highest savings ratios are in Arizona and Nevada, which are also the fastest-growing states in the region (see Table ES-4). The energy efficiency measures have a higher benefit-cost ratio than the combination of energy efficiency and renewable energy measures. Renewable energy measures, however, are capable of delivering significant reductions in peak electricity demand (up to 100% at system peak loads), and are expected to become more cost-effective in the future as the cost of PV systems continues to decline and additional federal, state and utility incentives for solar systems become available.

**Table ES-3. Summary of Analysis Results: Annual Savings in 2020 and Cumulative Energy Savings and Renewable Energy Generation, 2008-2020**

| State | Annual Savings, 2020 | | Cumulative electricity savings (GWh) | Avoided Peak Demand (MW) | Cumulative Natural gas savings (million therms) | Cumulative Primary Energy Savings (trillion Btus) |
|---|---|---|---|---|---|---|
| | Electric (GWhs) | Natural Gas (million therms) | | | | |
| Arizona | 183 | 5.4 | 1,159 | 592 | 34 | 21 |
| Colorado | 94 | 16.4 | 606 | 293 | 106 | 18 |
| Nevada | 69 | 2.1 | 425 | 309 | 13 | 8 |
| New Mexico | 25 | 3.0 | 166 | 68 | 20 | 4 |
| Utah | 56 | 8.7 | 354 | 153 | 55 | 10 |
| **Region** | **427** | **35.5** | **2,710** | **1,416** | **228** | **62** |

**Table ES-4. Summary of Incremental Costs and Savings: 2008-2020 (millions 2008 $)**

| State | Total investment, energy efficiency | Net economic benefit, energy efficiency | Benefit-cost ratio: energy efficiency measures | Total Investment, energy efficiency & renewables | Net economic benefit, energy efficiency & renewables | Benefit-cost ratio: energy efficiency & renewables |
|---|---|---|---|---|---|---|
| Arizona | 401 | 1,296 | 3.2 | 1,034 | 1,455 | 1.4 |
| Colorado | 443 | 1,409 | 3.2 | 974 | 1,493 | 1.5 |
| Nevada | 279 | 583 | 3.1 | 905 | 699 | 1.2 |
| New Mexico | 94 | 338 | 3.6 | 191 | 366 | 1.9 |
| Utah | 229 | 757 | 3.3 | 538 | 802 | 1.5 |
| **Region** | **1,446** | **4,383** | **3.3** | **3,642** | **4,815** | **1.5** |

Notes: EE measures include the incremental cost of all energy efficiency measures, excluding renewable energy system costs. Net present value assumptions: 20 year lifetime for energy efficiency and renewable energy measures and 5% real discount rate (capital recovery factor = 12.5). The benefit-cost ratios are based upon annual incremental costs and savings; RE incentives include federal tax credits only and exclude state and utility incentives.

## Case Studies: Observations and Lessons Learned from Field Monitored Homes

The following case studies provide real-world examples of high performance home projects that incorporate highly-efficient features and on-site renewable energy systems. The case studies also illustrate the role of utilities, government and home builders in developing successful high performance home projects.[8]

**The Sacramento Municipal Utility District (SMUD) SolarSmart New Homes Program**

Figure ES-1. Photo of zero energy homes at Premier Gardens, Sacramento, CO (Credit: SMUD)

Since 2001, the Sacramento Municipal Utility District (SMUD) has sponsored several ZEH projects within its service territory through partnerships with the DOE Building America program. In 2007, SMUD initiated the 'SolarSmart New Homes' program, in which SMUD is partnering with builders to achieve up to 60% savings in electricity costs, and peak electricity demand reductions of up to 65% in new homes (BIRA 2006 and US DOE 2006). The SMUD projects show how a public utility can help drive the market for new homes that offer energy efficiency and renewable energy as standard features.

Lessons learned include: 1) homebuyers find highly-efficient homes with solar PV attractive and cost-effective; 2) high performance homes offer potential for significant peak load reduction, and 3) solar PV systems and rooflines should be oriented to optimize afternoon peak savings.

**Pulte Homes, Las Vegas, Nevada**

Pulte provides a good example of how a large-scale production builder can cost-effectively achieve a highly-efficient home through a combination of advanced design and construction practices and use of highly-efficient products and equipment. Since 2002, Pulte has built nearly 15,000 ENERGY STAR qualified homes in the Las Vegas area. Innovative design features implemented by Pulte include use of unvented roofs, placement of ducts inside conditioned space, spectrally selective windows and integrated space heating, hot water and ventilation systems. The improvements resulted from a collaboration between Pulte Homes, the Nevada State Energy Office, and Building Science Industries as an initiative of the U.S. Department of Energy's Building America program.

Lessons learned: 1) the whole-house approach to the design and construction of homes achieves greater energy savings at lower cost than applying measures individually; 2) Design and construction teams must be properly trained and educated about high performance construction practices; and 3) public-private partnerships can help accelerate the development and adoption of advanced building design and construction practices.

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[8] For additional information on high performance home projects, see the U.S. DOE Building America research projects database at: http://www.eere.energy.gov/buildings/building_america/cfm/project_locations.cfm.

Aspen Homes of Colorado

Aspen Homes is a small production builder that constructs homes that will perform 40 percent better than a typical home built to code, yet are affordable to the average homebuyer. 100% of Aspen homes exceed the requirements of ENERGY STAR and Built Green Colorado. Each home also includes a 2-year heating consumption guarantee.[9] Since 2002, the company has built more than 500 ENERGY STAR qualified homes, and has received numerous local and national awards for its highly-efficient and affordable homes. Aspen Homes demonstrates how a production builder can construct highly efficient, affordable homes using advanced building design and construction techniques.

Lessons learned: 1) highly efficient affordable homes can be built cost-effectively in cold climates; 2) homeowner involvement is critical to achieving high savings levels; and 3) high performance homes can help improve sales, particularly during market downturns.

## Findings and Recommendations

Major findings and recommendations from this report are summarized below. For additional information see Chapter 8, Summary and Recommendations.

Energy performance and savings

- High performance homes are capable of achieving whole-house, source energy savings of up to 50% in both cooling-dominated and heating-dominated climate zones in the Southwest. These savings estimates are supported by ongoing monitoring studies conducted by the U.S. DOE Building America Team.
- Maximum energy savings are achieved when energy efficiency and renewable energy features are implemented together, in an optimized way beginning with highly cost-effective energy efficiency measures.
- High performance homes significantly reduce peak electricity demand – eliminating 80% or more of afternoon peak electric loads and cutting evening peak demand levels in half.
- Reducing household 'plug loads' (e.g., consumer electronics, large and small appliances, and plug-in lighting) and occupant behavior (e.g., using setback thermostats, turning off electronic and other devices when not in use) could achieve additional energy savings. Lighting, appliances, and miscellaneous electric loads now represent 60% or more of energy use in high performance homes (Brown et al 2007).

Cost and cost effectiveness

- High performance homes can be built cost-effectively, with annual net savings to the homebuyer when annual mortgage and utility costs are considered together.
- Energy efficiency measures are more cost-effective to implement than renewable energy measures. Combinations of efficiency and renewables, however, are also cost-effective to the homeowner, and deliver valuable peak electricity savings for utilities.

[9] A copy of the heating consumption guarantee is available at: http://www.aspenhomesco.com/index.php?pr=Heating_Guarantee.

Environmental benefits

- High performance homes can reduce the environmental impact of new home construction in the Southwest – the nation's fastest growing region. Cumulative greenhouse gas emission reductions from the SWEEP high performance homes scenario are 2.3 million tons of $CO_2$ in 2020.
- Emissions of air pollutants from coal-fired power plants that harm public health (i.e., sulfur dioxide, nitrogen dioxide, and mercury) would also be lowered because of reduced electricity demand.

Implementation issues and strategies

- Building design, construction practices and minimum code requirements vary considerably within the region, with some regions building the majority of homes at or above code (e.g., Las Vegas) and others that are using older, outdated building codes with varying levels of compliance and enforcement.
- The home building industry, including builders, contractors and trade allies need additional education and training on all aspects of high-performance home design and building practices.
- The design and construction process needs to be better supported by a robust QA/QC infrastructure, including visual inspections and performance testing at key stages of construction.
- Public-private partnerships involving federal, state, and local government, utilities and the home building industry play an important role in successfully implementing high performance home projects because builders continue to have concerns about recovering first costs in a highly competitive new homes marketplace. Utility incentives and marketing programs can help reduce this risk, and help builders differentiate high performance homes in the marketplace.
- The new homes industry – including builders, sales professionals, realtors and appraisers – needs better tools and guidelines for establishing and incorporating the value of high performance home features into home valuations.
- Production built high performance home projects are most successful when efficiency and renewable energy improvements are offered as standard home features, as opposed to optional upgrades for the homebuyer. Studies have shown that very few homebuyers select high performance features when offered as a builder option (Farhar and Coburn, 2006).

Recommendations for Utilities

- SWEEP recommends that utilities with low levels of market penetration for ENERGY STAR new homes (<10%) offer a 3-tiered incentive package to builders, beginning at ENERGY STAR ($350 - $500) and going up to a Net-Zero Energy Home level of performance ($750 - $1,000 for energy efficiency measures and $4,000 - $8,000 for renewable energy measures). A few Southwest utilities (e.g. Rocky Mountain Power, Arizona Public Service) are already offering incentives at the ENERGY STAR level that are achieving cost-effective savings.

- For utilities that already have high levels of market penetration for ENERGY STAR new homes (>35%), utility programs and incentives should focus on achieving the higher performance levels of Best Practice and Net-Zero Energy Homes, or include incentives for optional ENERGY STAR measures, such as the Advanced Lighting Package. Utilities should also consider offering additional incentives for measures that reduce miscellaneous electrical loads in the home, such as ENERGY STAR appliances.

- Improve coordination between energy efficiency and renewable energy incentive programs. In most cases, these programs are administered and marketed separately, and not always to the same groups (i.e., builders versus homeowners). All new homes that receive renewable energy incentives should be required to meet high performance efficiency criteria (i.e., 30-50% improvement in efficiency). Improving program coordination will also help maximize savings, reduce program administration costs, and promote improved technical assistance to builders, contractors and leverage marketing dollars.

- Conduct rigorous evaluations, measurement and verification of new home performance to assess the actual performance of new homes and the impacts of utility incentives and technical assistance programs. If feasible, the assessments should also include evaluations of traditional, code-built homes to provide a more accurate baseline for evaluating home performance.

### Recommendations for State Governments

States play an important role in advancing high performance homes by adopting a comprehensive and coordinated portfolio of policies designed to promote investment in energy-efficient building and renewable energy systems. States can implement the following incentives, programs and policies to support high performance homes:

- Adopting statewide residential building energy codes that exceed the requirements of the 2006 International Energy Conservation Code (IECC) by 15% or more.
- Offering targeted training and technical assistance to builders on energy-efficient construction practices and installation and maintenance of residential solar PV and thermal hot water systems.
- Expanding training, education and outreach activities to architects, builders, building contractors, real estate professionals and local building code officials on the features and benefits of high performance homes.
- Providing tax credits for energy-efficient home purchases, including income tax credits and reductions in property taxes for highly-efficient homes.
- Providing property tax exemptions for energy efficiency improvements and renewable energy systems.
- Require homes that are receiving incentives for renewable energy to also meet high performance efficiency criteria (i.e., 30-50% improvement in efficiency).
- Partnering with utilities and the home building industry to conduct homeowner education and outreach campaigns on the benefits of energy efficient homes.

### Recommendations for Local Governments

Local governments play an important role in high performance home projects through the siting, permitting and building inspection and approval process. Recommended actions that local governments can take to promote high performance homes include:

- Initiating a green building program that includes minimum energy efficiency standards that are well beyond minimum code requirements.
- Providing incentives to builders, including permit fee waivers or deferrals, density bonuses, per home incentives, and priority plan reviews and field inspection.

- Conducting educational programs, training and outreach to architects, designers, builders and trades on energy and resource efficient home building practices and their benefits.
- Promoting high performance homes through public recognition, including newspaper ads/articles, access to promotional packages, job site signs, and recognition by city officials.
- Develop a directory or network of participating architects, builders, suppliers, realtors and lenders that offer high performance home products or services.

# Chapter 1. Introduction

The six-state Southwest region of the United States (Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming) is a fast-growing region that is experiencing a boom in population and new housing construction. Growth rates in parts of Arizona and Nevada are as high as triple the national average.[10]

More than a million homes were built in the Southwest between 2000 – 2006, equivalent to approximately 150,000 new homes each year.[11] This growth trend is projected to continue, with nearly 2 million additional homes expected to be built between 2008 and 2020. Driven primarily by this growth in residential housing, electricity demand is also growing, at rates as high as 4% per year, with peak demand growing even faster. Total peak electricity demand in just three of the Southwest states (AZ, NM, NV) is expected to grow by 2,000 MW per year for the next 15 years.[12] Two-thirds or more (as high as 89% in New Mexico and 95% in Utah) of the electricity generated in the Southwest comes from coal-fired power plants, which release emissions of air pollutants and greenhouse gases that harm public health and contribute to global warming.[13]

A number of utilities, states, and local governments across the Southwest are beginning to implement financial incentives, training and education programs, demonstration projects, and other actions that are

**High Performance Homes Save Energy and Reduce GHGs**

High performance homes are built, operated and maintained to achieve superior energy efficiency performance over conventionally built homes. High performance homes are capable of achieving a 50% or greater improvement in energy performance (50% or greater reduction in conventional energy use) through a combination of energy efficiency improvements and use of on-site renewable energy systems, such as photovoltaic (PV) panels and solar thermal hot water systems.

Features of high performance homes include:

- highly energy-efficient building designs, appliances and equipment
- designs that perform well, are comfortable, require only standard maintenance, and look no different from an ordinary home.
- on-site renewable energy generation (which typically includes a solar hot water production system and a rooftop photovoltaic, or PV, system)

Source: Vang and Hammon, 2007

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[10] Table 3: Annual Percent Change of Housing Unit Estimates for the United States and States, and State Rankings: July 1, 2004 to July 1, 2005 (HU-EST2005-03). Source: Population Division, U.S. Census Bureau. Release Date: August 21, 2006

[11] U.S. Census, new residential housing permits, and American Community Survey. http://www.census.gov/const/C40/Table2/tb2u2005.txt and http://factfinder.census.gov.

[12] Arizona Solar Electric Roadmap Study. January 2007. Arizona Department of Commerce. Prepared by Navigant Consulting. http://www.azcommerce.com/doclib/energy/az_solar_electric_roadmap_study_executive_summary.pdf.

[13] EPA E-GRID version 2.1, state resource mix for electricity generation, 2004. http://www.epa.gov/cleanenergy/egrid/pdfs/eGRID2006V2_1_Summary_Tables.pdf.

demonstrating how high performance homes can be built feasibly and cost-effectively using existing technologies and building design practices.
These projects demonstrate how high performance homes have helped utilities, builders and homeowners achieve significant energy, economic and environmental benefits through cost-effective utility-sponsored programs, incentives from federal, state and local governments, and green building programs offered by the home building industry.

This report describes programs, incentives and policies that utilities, states and local governments in the Southwest U.S. can take to help overcome barriers to high performance homes. It describes the benefits, features and performance of high performance homes, presents best practices for building and operating high performance homes, and case studies of high performance home projects in the Southwest. The report makes recommendations for utilities, state and local government programs, incentives, and technical assistance activities that can help address the barriers to improving the energy efficiency of new homes.

**High Performance Homes Will Help Achieve the Western Governors' Clean Energy Goals**

In 2004, the Western Governors' Association adopted goals for developing an additional 30,000 megawatts of clean energy from renewable resources by 2015, and for a 20% improvement in energy efficiency by 2020. Subsequent analysis showed that achieving the energy efficiency goal would avoid the need for 100 typical baseload power plants and provide over $50 billion in net economic benefits for consumers and businesses. Several states in the Southwest, including AZ, CO, NM and UT, have adopted or are considering Executive Orders or legislation that commits their states to achieving or exceeding the WGA goals. High performance homes can play an important role in meeting these goals.

For more information visit the WGA Web site: http://www.westgov.org/wga/initiatives/cdeac/

Addition information on high performance home programs, design characteristics and construction practices, and utility, state and local programs is provided in the information resources section at the end of this report.

# Chapter 2. Benefits of High Performance Homes

High performance homes have a range of energy, economic and environmental benefits to states, utilities, local governments, and homeowners. Each of these benefits is summarized below, and described in more detail in the accompanying case studies.

## Energy and environment benefits

The energy benefits to states, utilities and local governments of high performance homes include:

- *Avoided energy costs*
  Through integrated design approaches, builders can reduce energy consumption through energy efficiency improvements by 50 percent or more relative to code requirements, and do so cost-effectively. As with energy efficiency, generating electricity from clean, on-site renewables (e.g., solar PV) reduces generation, transmission and distribution-related losses and helps offset peak electricity demand.

- *Reduced system load growth and peak electricity demand*
  The Southwest is a high-growth region, with electricity load growth increases as high as 4% per year, and with peak electricity demand expected to double within the next decade in some states in the absence of expanded utility demand-side management (DSM) programs (e.g., Arizona). High performance homes offer a cost-effective strategy for reducing system load growth and peak demand. For example, the Premier Gardens community of net zero energy homes located in Sacramento, CA reduce average peak demand load by as much as 60% relative to a typical Sacramento home (SMUD 2006).

**Box 1. Clarum Homes: Vista Montana High Performance Homes**

The Vista Montana development in Watsonville, California, features 257 solar-powered single family homes and townhomes, including 25% affordable homes that have reduced energy consumption by more than 50% and use almost zero net electricity on an annual basis. The combination of energy efficiency improvements and on-site renewables are designed to reduce homeowner electricity bills by up to 90%.

Source: DOE Building America Program http://www.eere.energy.gov/buildings/info/documents/pdfs/35305.pdf

Vista Montana Zero Energy Homes Community by Clarum Homes, Watsonville CA (Credit: U.S. DOE)

- *Reduced emissions, environmental impacts and compliance costs*
High performance homes reduce demand for electricity from power plants, which in the Southwest are primarily coal-fired. Generating electricity from coal-fired power plants releases emissions of air pollutants that are harmful to public health, as well as greenhouse gases that contribute to global warming. Lowering emissions can reduce the environmental impacts and costs of electricity generation. Between 2008 and 2020, greenhouse gas emissions from electricity generation in the region would be reduced by 2.4 million tons of $CO_2$. The cumulative avoided emissions of $CO_2$, $SO_2$ and $NO_x$ are summarized in Table 1.

- High performance homes can also serve as a core component of green building programs, which achieve energy and non-energy environmental benefits, such as water efficiency improvements, improved air quality, reduced solid waste from construction, and improved land use planning that can reduce transportation demand.

Table 1. Reduction in $CO_2$, $SO_2$ and $NO_x$ emissions from high performance homes: 2008-2020[14]

| | **Avoided Emissions (tons): 2008 – 2020, electricity generation only** | | |
|---|---|---|---|
| **State** | **$CO_2$ (tons)** | **$SO_2$ (tons)** | **$NO_x$ (tons)** |
| Arizona | 882,714 | 222 | 317 |
| Colorado | 457,382 | 108 | 236 |
| Nevada | 422,970 | 45 | 147 |
| New Mexico | 130,889 | 32 | 65 |
| Utah | 375,184 | 15 | 98 |
| **Region Total** | **2,409,164** | **410** | **985** |

[14] Source: SWEEP analysis using emission reduction estimates based upon emission factors developed for the SWEEP *New Mother Lode report*, Tables 3-7 and 3-12.

### Economic benefits

There are multiple economic benefits of high performance homes that go beyond the benefits achieved through energy cost savings.  Economic benefits include:

- Local governments benefit from having well-built communities that contribute to quality of life and higher property values.
- Improves the comfort and performance of the home, ensures more stable energy prices (from on-site PV and solar thermal water-heating systems) and higher property and resale values (Farhar and Coburn, 2006).
- Helps home builders achieve faster sales of new homes, improved customer satisfaction, and positive coverage in local media and trade publications (McGraw Hill, 2007).  Examples include John Wesley Miller homes in Tucson, Arizona, Pulte homes in Las Vegas, Nevada, Clarum Homes in Sacramento and Watsonville, California, and Shea Homes in San Diego, California (U.S. DOE 2006, Farhar and Coburn 2006).
- Energy efficiency helps promote economic development by making more household disposal income available for spending on non-energy goods and services.  Energy efficiency investments would reduce household energy costs by a total of $500 million in the Southwest between 2008 and 2020, equivalent to an average annual savings of more than $1,100 per household for the Best Practice scenario.
- Supports new jobs related to energy efficiency and renewable energy products and services, such as installing and servicing energy efficiency and renewable energy equipment, conducting energy audits and home diagnostic testing, and solar PV system installation and maintenance. The high performance scenario would cumulatively create more than 15,000 new direct or indirect jobs between 2008 and 2020.[15]
- Promotes energy efficiency improvements in retrofits and remodeling of existing homes by developing a high performance home building infrastructure, including trained and certified contractors, and lowering the cost and increasing the availability of energy efficient products at the wholesale and retail sales levels (see Box 2, next page for more detail).

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[15] Source: SWEEP analysis assuming a total investment in EE and RE of $3.3 billion (in discounted 2008 dollars), 60% labor-related costs, and $75,000 annual salary per employee.

**Box 2. Relationship between new homes and the existing homes market**

Utility, state and local policies and incentives for high performance homes are primarily targeted at the new homes market. Existing homes, however, offer significant opportunities for energy improvement as well, and many states and utilities offer programs targeted at improving the efficiency of existing homes which build on national programs, such as Home Performance with ENERGY STAR offered by US EPA and US DOE. As the cost of highly efficient products (e.g., tankless water heaters, windows), solar PV and solar thermal systems decline, retrofitting existing homes to achieve improved energy performance will also become a cost-effective energy savings strategy for utilities and homeowners.

High performance home programs for new construction can also help raise the energy performance of existing homes in several ways:

- Training builders, contractors and code officials in state-of-the art building practices. This knowledge and experience can transfer to the existing home renovation and remodeling activities. For example, additional HVAC contractors can be trained in the proper sizing and sealing of HVAC equipment and duct work when replacing or adding systems to existing homes.
- Establishing local markets for highly-efficient equipment, design materials, and installers. Highly-efficient equipment stocked and installed by building suppliers and contractors for the new homes market can also be used for retrofits or equipment replacements in existing homes
- Developing markets for solar products distributors and installers. Developing a local solar systems infrastructure through large-scale, new homes projects will help establish a marketplace for solar PV and solar thermal system installers. The existing homes market can help diversify the client base for solar equipment distributors and installers.
- Transfer of advanced technologies and efficiency practices. Certain types of advanced technologies implemented for high performance homes may be readily transferable to existing homes in 'plug-and-play' fashion. Examples include technologies for improving the building envelope, home energy monitoring systems, low-energy cooling technologies (e.g., advanced evaporative coolers), high-efficiency lighting systems, and energy management devices for consumer electronics. Educational materials, messages and delivery vehicles for new homes can be adapted and applied to the existing homes market as well.

For more information, see:

- *Home Performance with ENERGY STAR* Web site: http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_hpwes
- HUD's *Technology Roadmap for Existing Homes, Volume 3.* May 2004. http://www.huduser.org/publications/destech/tech_roadmap_EEEH.html

# Chapter 3. Barriers to High Performance Homes

High Performance homes face a number of barriers that are financial, technical, regulatory or institutional in nature. High performance homes experience similar barriers that other energy efficiency programs face, such as high first costs for capital, split incentives (i.e., someone who rents a home from a homeowner is less likely to invest in efficiency improvements), and lack of information about the costs and benefits of energy-efficient measures and practices. Barriers specific to achieving higher efficiency levels in the new homes market include:

- Lack of builder training and expertise in high performance construction design techniques and practices, such as advanced framing and insulation practices, and installing solar PV systems.
- Inconsistent compliance with code requirements, and wide variation in code compliance and enforcement from community to community. This makes it challenging to compare and evaluate the energy savings of high performance homes relative to baseline homes.
- Builder concern about ability to recover higher first-costs to construct high performance homes.
- Risk-avoiding behavior that deters interest and investment in new building technologies and design practices.
- Increased time and expense for plan reviews and obtaining building permits from city/county building permit authorities.
- Code and covenant restrictions (e.g., homeowners associations that restrict installation of roof-mounted solar systems).
- Lack of information and awareness about home EE/RE features and their benefits by homebuyers, sales professionals and realtors, appraisers and lenders.
- Increased use of 'plug loads', such as lighting, consumer electronics, and appliances, which represent 60% or more of electricity consumption in otherwise highly-efficient homes (Anderson et al 2004).
- Occupant behavior, including usage patterns for lighting, electronics and plug-in appliances, which can increase or decrease home energy consumption in otherwise similar homes by as much as 30% (Puttagunta, et al. 2006).

Each of the barriers is summarized in Table 2, along with descriptions of strategies for overcoming each barrier, who is involved, and examples of successful programs and implementation strategies.

Table 2. Barriers to High Performance Homes

| Barrier | Strategies for Overcoming Barrier | Who is Involved | Examples of Successful Programs / Strategies |
|---|---|---|---|
| • **Builders lack information or expertise in high performance home construction** | • Offer training, technical assistance, and education<br>• Apply Design Tools such as ENERGY STAR Target Finder, HERS Software, and PV Watts<br>• Conduct field performance testing | • Builders and designers<br>• Contractors, manufacturers and installers<br>• Home energy raters<br>• State energy offices | • APS High Performance Homes Program<br>• Built Green Colorado and New Mexico<br>• ENERGY STAR: Southern Nevada<br>• Environments for Living New Homes program<br>• Pulte Homes and Pardee Homes (AZ, CA and NV) |
| • **Higher first-costs for some energy efficient products and for renewable energy systems.** | • Offer a coordinated package of incentives that reduces risk associated with first-costs<br>• Develop networks of energy efficiency and renewable energy professionals to deliver whole-house services<br>• Achieve economies of scale through larger projects; analyze costs based on builder costs, not individual project costs<br>• Achieve lower implementation costs by integrating EE and RE measures and coordinating program delivery | • Utilities<br>• Builders and homebuilder associations<br>• Realtors and sales professionals<br>• Home Energy Raters<br>• Lenders<br>• Equipment manufacturers, contractors and installers<br>• Homebuyers | • New Homes Construction programs in Phoenix (APS, SRP), Utah (Rocky Mountain Power), and California (PG&E, SCE, SDG&E and SMUD)<br>• Guaranteed Energy Cost programs for heating & cooling (APS, TEP)<br>• Home Performance with ENERGY STAR - Northwest Energy Efficiency Alliance<br>• Sacramento, CA – Premier Gardens Zero Energy Home development<br>• Pulte Homes, Las Vegas, NV; Lennar Homes, Sacramento, CA; Shea Homes, San Diego, CA |

| Barrier | Strategies for Overcoming Barrier | Who is Involved | Examples of Successful Programs / Strategies |
|---|---|---|---|
| | | | |
| • **The appraisal process does not recognize the value of EE/RE improvements**[16] | • Establish guidelines for valuing efficiency and renewable energy improvements in the appraisal process<br>• Train and educate appraisers about methods for valuation of EE/RE technologies<br>• Incorporate estimates of the value of energy efficiency and renewable energy features in appraisals<br>• Conduct demonstration projects at multiple performance levels to help establish the market value of efficiency and renewable features<br>• Incorporate efficiency 'labeling in sales databases (e.g., flag 'ENERGY STAR' homes in MLS systems) | • Lenders<br>• Appraisers<br>• The Appraisal Institute<br>• National Association of Realtors<br>• Home Energy Raters<br>• ENERGY STAR | • Ensure energy savings / on-site generation estimates are accurate and reliable.<br>• The U.S. EPA / ENERGY STAR program offers seminars to train appraisers about the value and benefits of ENERGY STAR Homes.<br>• Demonstration projects include:<br>- Shea Homes, San Diego, CA<br>- Clarum Homes, Watsonville, CA<br>- Pulte Homes, Las Vegas, NV<br>- Lennar Homes, Sacramento, CA<br>- John Wesley Miller Homes, Tucson AZ<br>- Harvard Communities, Denver, CO<br>- Artistic Homes, Albuquerque, NM<br>- McStain Homes, Denver, CO |

[16] For more information, see NAHB Research Center report, "ZEH Preliminary Market Analysis", August 2005, at: http://www.toolbase.org/PDF/CaseStudies/ZEH_ApprReport.pdf.

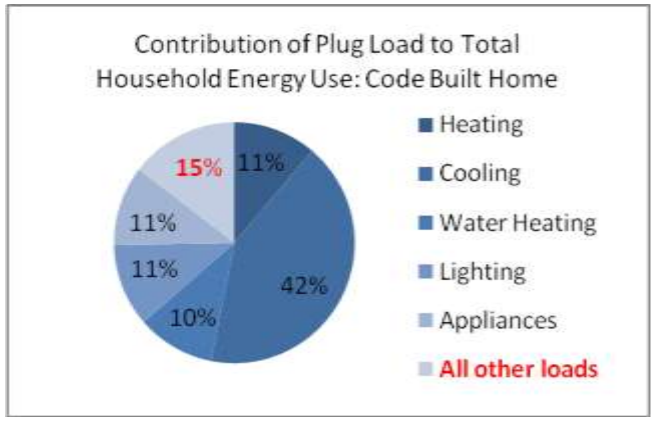
| Barrier | Strategies for Overcoming Barrier | Who is Involved | Examples of Successful Programs / Strategies |
|---|---|---|---|
| • **High performance homes are perceived as unaffordable to the average buyer or low-income households** | • Develop a homebuyer 'toolkit' that educates homebuyers about how energy demand affects the total cost of home ownership, and provides homebuyers with tools to make objective comparisons about the net monthly costs of a highly-efficient home versus a typical home<br>• Provide better access to lending products that facilitate efficiency improvements, such as energy efficient mortgages | • Lending industry<br>• HERS Raters<br>• State / local weatherization assistance programs<br>• Public and non-profit housing agencies | • Habitat for Humanity demonstration homes, Metro Denver, CO<br>• Energy efficient mortgages offered by Bank of America, J.P. Morgan Chase and Fannie Mae<br>• Arizona Department of Commerce, Energy Office, Affordable Housing Program<br>• Local and state low-interest loans for energy efficiency improvements (Fort Collins, CO; States of Kansas, Pennsylvania, and New York) |
| • **The growth of house size and 'plug loads' (e.g., computers, larger televisions / other consumer electronics, small appliances, fans and lighting, etc.) increases overall energy demand** | • Ensure energy efficient appliances and equipment are installed in the home<br>• Educate consumers about energy management and behavioral practices, such as turning off equipment when not in use<br>• Offer incentives for lowering energy use through behavior changes<br>• Install energy feedback systems in homes, and educate homeowners about ways to reduce energy use in their home | • ENERGY STAR<br>• Homeowners<br>• Utility DSM programs<br>• Educators and schools<br>• Appliance and consumer electronics manufacturers | • ENERGY STAR new homes, lighting and office products programs<br>• 80+ program for personal computers<br>• PG&E, SCE 20/20 savings programs |

## Box 3. Reducing Household Plug Loads

An important barrier to consider when developing high performance home programs is the growth of household 'plug loads,' such as consumer electronics and small appliances. Plug loads are steadily increasing, in part because of larger house size (i.e., larger homes require additional builder-installed ventilation fans, smoke alarms, and lighting), and the growth in number and size of appliances and equipment installed by the homeowner (e.g., televisions, computers and home office equipment, audio devices, small appliances, and portable light fixtures). A recent survey of 11 zero-energy home projects found that, on average, 'other' uses (besides water heating, cooling and heating) accounted for up to 65% of annual electricity use in highly efficient homes (Brown, Rittelman et al, 2007). The study concluded that electricity consumption by 'other' end uses is too large to allow cost-effective zero energy homes, because the cost of offsetting the electricity load with additional solar PV is very high.

Reducing plug loads will require additional measures beyond those aimed at improvements to the home envelope, heating and cooling systems, such as federal or state appliance standards for additional consumer electronic products, and energy monitoring and information systems to help homeowners understand and manage household energy usage.

**A Higher Share of Household Energy Use:**
**Plug Loads play a greater role in total household energy use in high performance homes**



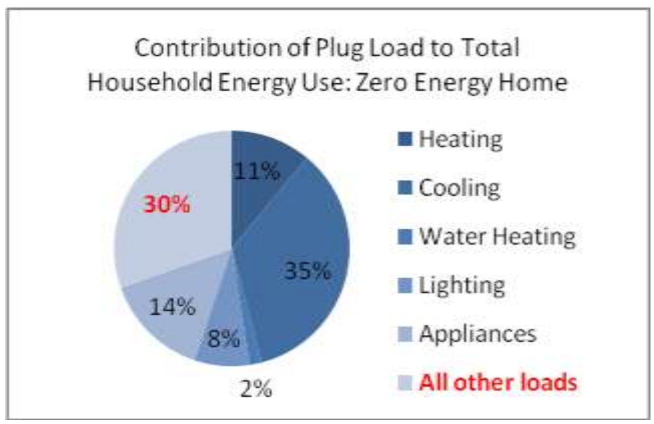




Figure notes: data is from analysis conducted by SWEEP using the NREL BEopt model of a code-built home versus a zero energy home in Phoenix, Arizona.

## Programs, tools and resources for overcoming barriers to high performance homes

Several programs offered at the national, state and local levels are available to help the new homes industry overcome the barriers to high performance homes. At the national level, they include the ENERGY STAR New Homes Program, co-sponsored by the U.S. EPA and U.S. DOE, and the U.S. DOE Building America Program. The U.S. Green Building Council has developed a voluntary rating system for homes ("LEED-H") that promotes the design and construction of high performance homes, including minimum energy efficiency criteria for new homes.

The **ENERGY STAR New Homes** program helps builders differentiate and is a useful resource for understanding and overcoming the multitude of barriers to energy efficiency in new homes. ENERGY STAR New Homes are designed to be 15-20% more efficient than a typical new home built to minimum code requirements, and include additional energy-saving features that typically make them 20–30% more efficient than standard homes. The program helps builders overcome barriers to achieving higher performance levels in new homes by providing an 'off-the-shelf' solution that offers technical specifications, marketing tools, sales training and technical support to the new homes industry and energy efficiency program sponsors, including well-established programs in Arizona, Nevada, Utah and Colorado. ENERGY STAR has prepared a Sponsor and Utility Partner Guide that identifies lessons learned and best practice recommendations for new ENERGY STAR program sponsors and existing sponsors looking to improve their programs. The Guide describes a number of strategies for overcoming barriers to improving energy efficiency in new homes, and provides examples of successful programs.[1]

Web site: www.energystar.gov/homes

**Building America** is a private/public partnership sponsored by the U.S. Department of Energy that conducts research to find energy-efficient solutions for new and existing housing that can be implemented on a production basis. The long-term goal of the Building America program is to develop cost-effective systems for homes that can produce as much energy as they use—a zero energy home. The program has worked with several production builders in the Southwest to improve the efficiency of new homes by using a systems engineering approach to home building (see the case study on Pulte Homes in Chapter 7 for an example of Building America program activities). The Building America Program has also developed a series of climate-specific Best Practices Guides, and a Guide to Solar Thermal and PV Systems.

Web site: www.buildingamerica.gov

**LEED for Homes** is a new initiative of the U.S. Green Building Council that is designed to actively promote the transformation of the mainstream home building industry toward more sustainable practices. The program was developed through a consensus process, with the goal of providing national consistency in defining the features and requirements of green building programs. The LEED for Homes rating system measures the overall performance of homes across eight separate resource categories, with four progressively stringent rating levels (Certified, Silver, Gold and Platinum). The program incorporates ENERGY STAR for New Homes as a mandatory energy efficiency measure, and includes points-based credits for additional energy efficiency and renewable energy measures. The average LEED Home (in USGBC's pilot program) achieves 40% savings versus a typical home. The USGBC provides training and technical assistance to participating builders through its national programs and its network of LEED for Homes Providers. In the

Southwest, there are currently providers serving the Metro Phoenix and Scottsdale, Arizona areas, and the State of Colorado.

Web site: www.usgbc.org/homes

A number of utility or industry-sponsored programs and services are also available to builders in the Southwest. In Colorado, **Built Green** offers technical assistance, training and education to participating builders and contractors, and the **Governors Energy Office** initiated an ENERGY STAR New Homes program in September 2007. Utah's primary electric and natural gas utilities, **Rocky Mountain Power** and **Questar Gas,** both offer an ENERGY STAR New Homes program that provides technical assistance, financial incentives, and sales and marketing support to builders constructing ENERGY STAR qualified homes. In New Mexico, builders can participate in **Build Green New Mexico**, sponsored by the Home Builders Association of Central New Mexico. New Mexico also has a very active **Chapter of the USGBC** that conducts training sessions, conducts community outreach and maintains a directory of Green Building Service Providers. In Nevada, several programs and partnerships are available to home builders, including the **Southern Nevada Green Building Partnership**, the **Nevada ENERGY STAR Homes Partnership,** and the **U.S. Green Building Council, Nevada Chapter**.

For more information about these and other technical assistance opportunities, see the information resources section at the end of the report.

# Chapter 4. Features of High Performance Homes

## Overview

This chapter describes the features, costs, and cost effectiveness of high performance homes. It describes the steps involved in designing and building high performance home, including:

- the role of site selection, building orientation and design in maximizing energy savings;
- the types of energy efficiency measures typically used in high performance homes, including technologies that are ideally suited to the Southwest climate, such as evaporative cooling; and
- renewable energy systems for homes, including passive and active solar energy systems.

The chapter also includes analyses of the incremental costs for all four home performance levels in a cooling-dominated climate (Phoenix, AZ) and a heating-dominated climate (Denver, CO). Incremental cost data and detailed information on individual measures analyzed is provided in Appendix A.

### Site Orientation and Building Design

Developing a high performance home begins with the site plan for the development and the house itself. Proper site selection and building orientation can help reduce heating costs in the winter and cooling costs in the summer, and facilitate the use of on-site PV to generate electricity. These measures are often overlooked in the site selection, subdivision plotting and home design process, but are very important factors to consider for high performance homes. Siting and building orientation considerations include the following:

**Site selection.** If possible, choose sites with good southern exposure without significant shading from mountains, trees or buildings.

**Subdivision plotting.** If possible, orient parcels to maximize southern exposure for buildings.

**Orientation.** Orient the house to provide maximum southern exposure for rooms and windows in order to maximize solar heat gain in the winter but with proper window shading to reduce heat gain in the summer.

**Solar access.** Ensure the solar collector area, roof, and window surfaces are unshaded during the morning and afternoon in colder months to maximize solar gain. If possible, place rooftop PV panels on the west-facing side of the roof to maximize on-site electricity generation during peak demand periods.

For more information on site orientation, passive solar and other building design, see DOE's 'Building Toolbox' collection of online resources:

- Building Configuration and Placement
  http://www.eere.energy.gov/buildings/info/design/integratedbuilding/buildingconfiguration.html

- Passive Solar Design
  http://www.eere.energy.gov/buildings/info/design/integratedbuilding/passive.html

- Active Solar Systems
  http://www.eere.energy.gov/buildings/info/design/integratedbuilding/activesolar/

### Energy Efficiency

There are many cost-effective opportunities to improve the energy efficiency of new homes through a combination of improvements to residential building design, construction practices, higher efficiency levels of installed equipment, and homeowner education about ways to save energy, including:[17]

- Higher levels of ceiling and wall insulation (R-40 or higher) coupled with advanced framing techniques to minimize thermal bypasses.
- Radiant barrier installed on the inside of the roof to reduce solar heat gain and help keep the attic cool.
- Low air infiltration rate to help reduce air flow into and out of the house, verified by a blower door test.
- High-performance windows with spectrally selective glass, which reduces solar heat gain in summer and reduces heating costs in the wintertime.
- Highly-efficient heating and cooling systems, including:
  - Engineered HVAC (proper sizing and diagnostic testing of HVAC systems by mechanical engineers)
  - Advanced evaporative cooling systems such as direct-indirect evaporative cooling systems
  - Sealed and tested ducts, installed either inside the conditioned space, or buried in the ceiling insulation.
- High-efficiency water heater (0.80 EF or greater) combined with a solar water-heating system.
- High efficacy lighting (e.g., fluorescent lamps and fixtures), or a combination of fluorescent and incandescent lighting with lighting controls (e.g., dimmers and occupancy sensors).
- Energy-efficient appliances, including refrigerators, clothes washers, dryers, dishwashers and consumer electronics.
- Third-party verification (analysis of home design and onsite inspections and testing to verify and rate the energy performance of the home on the HERS scale).

[17] The list of energy efficiency measures is adapted from Anderson et al., 2004 and Hammon, 2007.

Furthermore, many of the efficiency improvement opportunities in homes are more difficult and expensive to implement once construction is complete (e.g., adding wall insulation or sealing ductwork).

The additional cost of using energy-efficient building designs and systems may be partially offset by reductions in the size of cooling and heating equipment (particularly if proper equipment sizing procedures are followed and adhered to during construction and equipment installation) and other building design changes (e.g., reducing framing materials used by going to 2' x 6' wall construction with studs spaced 24" apart). When done properly, this can represent a significant cost savings to the builder and homeowner, as the smaller systems and reduced material requirements reduce construction and operation costs.

Fully achieving cost-effective energy efficiency improvements and cost savings in new homes can be challenging for several reasons, such as lack of builder awareness and training in advanced building techniques (see previous section on barriers). Many conventionally built homes do not perform well, as evidenced by prior field performance and evaluation studies of new homes. In some states, more than half of new homes do not fully meet minimum building energy code requirements (York and Kushler, 2003). Even homes that nominally meet the code requirements still may exhibit significant performance problems in areas such as comfort and combustion safety (City of Fort Collins, 2002). These problems result from many factors, including a focus on components rather than systems, ineffective design practices, improper construction and installation techniques, lack of code enforcement, and insufficient QA/QC procedures. This suggests that improved builder training and education, implementation of 'best practice' design and construction techniques, better code enforcement and compliance, and improved QA/QC procedures will all be needed in order to effectively capture these and other energy efficiency savings in new homes.

## Box 4. Modern evaporative cooling: a low-energy cooling strategy for the Southwest

Evaporative cooling systems are ideally suited to the hot dry climate that predominates in much of the Western U.S. When properly installed and maintained, evaporative coolers use about one-fourth (or less) the electricity of conventional central air conditioners and cost about one-third to operate. Modern evaporative coolers use less energy, less water, and require less maintenance than traditional evaporative cooling systems. Because of their superior energy performance, properly installed and maintained evaporative cooling systems can play an important role in utility DSM programs aimed at reducing both regular and peak electricity demand, particularly during the hot summer months when cooling is most needed.

Evaporative coolers also offer a number of other benefits to public health and the environment. They can help improve indoor air quality by frequently exchanging air from the outside and maintaining higher humidity levels than conventional air conditioning. Evaporative cooling systems do not use refrigerants (e.g., CFCs or HCFCs), which can damage the ozone layer or lead to increased concentrations of greenhouse gases in the atmosphere if released.

Recent advances in evaporative cooling technology have improved the energy efficiency and performance of evaporative cooling systems, which are now available for residential, commercial and industrial applications:

“Indirect” evaporative coolers take advantage of evaporative cooling effects, but cool without raising indoor humidity.

Indirect-direct evaporative coolers (IDEC) add a second stage of evaporative cooling before the conditioned air enters the dwelling to further lower the temperature of the incoming air.

Indirect/DX-compressor combinations are often used in larger commercial-scale applications, sometimes also coupled with a direct cooling phase.

Evaporative cooling systems are capable of being supplied (all or in part) by on-site PV systems, making them compatible with renewable energy applications, such as zero-energy homes.

Despite their significant energy cost savings and related benefits, advanced evaporative coolers have captured only a small share of the air conditioning market in the Southwest.

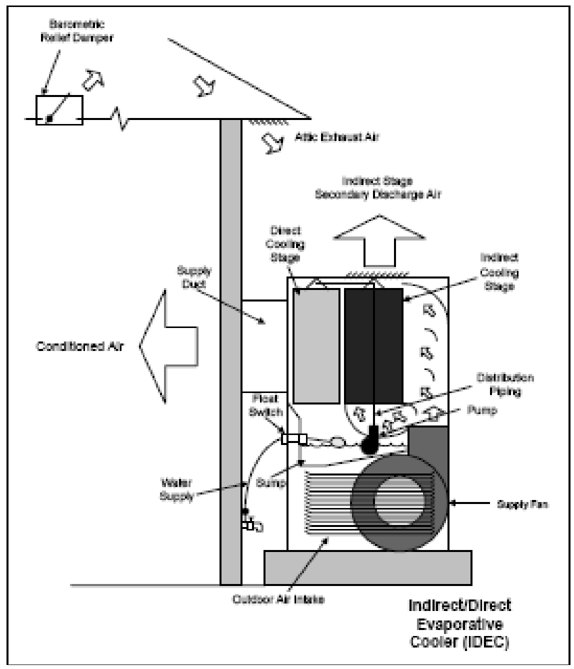



Diagram of an Indirect-Direct Evaporative Cooler
Source: CEC 2004.

Barriers to advanced evaporative cooling include builder and consumer preferences for conventional air conditioning systems, concerns about the capabilities of evaporative cooling to perform well under a variety of climate conditions, and lack of inclusion of evaporative cooling technology in energy efficiency programs, such as federal tax credits or utility incentives (which may only offer incentives to central A/C systems only).

States, local governments, utilities and builders can help advance modern evaporative cooling technologies through incentives, green building programs, and building design practices.
For more information, see SWEEP’s information resources on evaporative cooling, at:
www.swenergy.org/workshops/evaporative/

## Renewable Energy Systems

Renewable energy systems and design features can reduce the heating and cooling load of the home and generate a portion of a home's electricity and water heating needs. Passive solar thermal design strategies can often be implemented at little or no incremental cost through proper building orientation, daylighting, and use of thermal mass.

Common renewable energy systems include:

- Passive solar heating and cooling, which take advantage of siting, building orientation, daylighting and other passive features to reduce heating and cooling costs.
- Photovoltaic panels, including newer building-integrated photovoltaics that blend in with roof materials (see Figure 1).
- Solar thermal hot water heating systems, for supplying domestic hot water needs.
- Open and closed-loop ground source heat pumps, which can supply heating and cooling needs.

Figure 1. Example of a building-integrated rooftop solar PV system (shown on front roof) (Photo: BP Solar)

Typical residential solar PV systems are between 2 kW and 4 kW in size, and are capable of offsetting approximately 25-30% of total household electricity consumption. Table 3 shows the estimated annual electricity output for a 2 kW solar PV system across the Southwest region, by city and state.

Table 3. Annual electricity generation and energy value for a 2 kW residential PV system

| PV System Type / Size | Phoenix, AZ | Boulder, CO | Albuquerque, NM | Salt Lake City, UT | Las Vegas, NV | Reno, NV |
|---|---|---|---|---|---|---|
| Generation (2kw), kWh per year | 2,611 | 2,211 | 2,607 | 2,254 | 2,615 | 2,441 |
| Energy value, $ per year | $259 | $213 | $339 | $195 | $301 | $281 |

Source: NREL BEopt Model.

Notes: The PV system output for each city is based upon the total annual output of a 2kW, west-facing, roof-mounted (fixed tilt) system with an overall DC to AC derate factor of 0.85. Actual performance may vary based on several factors (e.g., PV system orientation, roof angle, and the amount of shading that may be present from adjacent buildings or vegetation).

Although the initial cost of renewable energy systems remains high (approximately $15-20,000 for a 2 kW solar PV system), the system costs are expected to continue to decline, and are made more affordable to the builder and homeowner by a combination of federal, state and utility rebates now available in many Southwest states (Navigant, 2004). There is also strong public support for installing solar PV on homes, with 78% of Westerners in favor of builders offering solar PV as an option on all new homes.[18]

New third party financing strategies, known as performance partnership agreements (PPAs), are being implemented that require no initial capital cost by the purchaser.[19] Although PPAs are being targeted at large scale PV projects (i.e., 30 kW or larger), they could evolve to also support residential systems involving multiple homes on a community scale, such as a 'green community' or a group of homes in a zero energy home subdivision. PPAs may also be a potential option where system ownership could be combined to benefit multiple households (e.g., a condominium complex, multi-family apartment buildings, and groups of homes with a common homeowners association).

There are several advantages of incorporating passive solar design, PV and other renewable energy systems in new home construction. An LBNL analysis of California's new solar homes program found that the cost of installing PV in a new home is $1.20 to $1.70 per watt lower than retrofitting an existing home to include a PV system.[20] Other advantages of installing solar systems at the time of construction include:[21]

- Ability to incorporate the cost of PV into the home mortgage (facilitating long term financing of the solar PV system at a moderate interest rate and with the tax advantages of a home mortgage).
- Potential for improved system performance and output (e.g., proper roof orientation, no shading).
- Better aesthetics, through use of products directly integrated into the roof, such as building-integrated photovoltaics (BIPV).
- Lower up-front costs (e.g., through bulk purchases, standardization of installations, and designing electrical connections to readily accommodate PV systems).

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[18] Renewable energy access.com. Majority of Americans favor solar on new homes. June 1, 2007. http://www.renewableenergyaccess.com/rea/news/story?id=48756

[19] Renewable energy access.com. Delivering a zero-day payback time for solar. April 9, 2007. http://www.renewableenergyaccess.com/rea/news/story?id=48034

[20] Source: Wiser et al., 2006, "Letting the sun shine on solar costs: an empirical investigation of photovoltaic cost trends in California." http://eetd.lbl.gov/ea/emp/reports/59282.pdf

[21] Source: Adapted from Barbose, Wiser, and Bolinger, 2006. Encouraging PV adoption in new, market-rate residential construction: a critical review of program experience to date. Solar 2006. http://www.solar2006.org/presentations/tech_sessions/t11-m181.pdf

- Ability to install PV as a standard feature in new housing developments, which lowers the cost to homebuyers and achieves greater system benefits for utilities.

Some builders are also designing energy-efficient homes that are 'solar-ready,' to more easily accommodate future installations of solar PV and/or solar thermal hot water systems. Solar ready home design features may include identifying a suitable location on the roof with unobstructed exposure to the sun, having wiring run from the panel location to the circuit breaker, and having conduits for solar hot water run from the attic to the basement or utility room, and providing extra space for a future solar hot water storage tank. An example of a program that offers solar ready homes is the Montana Solar ENERGY STAR Homes program, which provides guidelines to builders on designing and constructing solar ready homes.[22]

## Cost and Cost Effectiveness of High Performance Homes

One of the challenges to building high performance homes is the higher initial cost particularly when on-site renewable systems are included. Understanding the incremental costs of energy efficiency and renewable energy systems can help utilities, builders and homebuyers choose a package of measures that achieves the optimum level of energy savings and on-site renewable generation that is both profitable for the builder and generates positive monthly cash flow for the homebuyer. This section describes the range of incremental costs to build a high-performance home, and the resulting changes in homeowner's monthly cash flow under the Best Practice scenario. The analyses are based on modeling of a typical home in heating-dominated climates (e.g., Salt Lake City, Utah and Denver, Colorado) and cooling-dominated climates (e.g., Las Vegas, NV and Phoenix, AZ). The incremental costs analyzed include:

- A typical home built using current home building industry construction practices and equipment
- An ENERGY STAR qualified new home (15-30% source energy savings over a typical home)
- An energy efficient 'Best Practice' Home (35 - 50% savings)
- A so-called 'Zero Energy Home' incorporating renewable energy measures as well as being highly energy efficient (up to 65% savings)[23]

The analyses included in this report were developed using the BEopt software program, developed by the National Renewable Energy Laboratory (NREL), that analyzes a range of energy efficiency and renewable energy measures to identify combinations of energy efficiency and renewable energy measures that achieve maximum savings at the lowest cost (see Box 5). The energy efficiency and renewable energy features of each home performance level for a cooling-dominated climate (e.g., Phoenix, Arizona) are shown in Table 4.

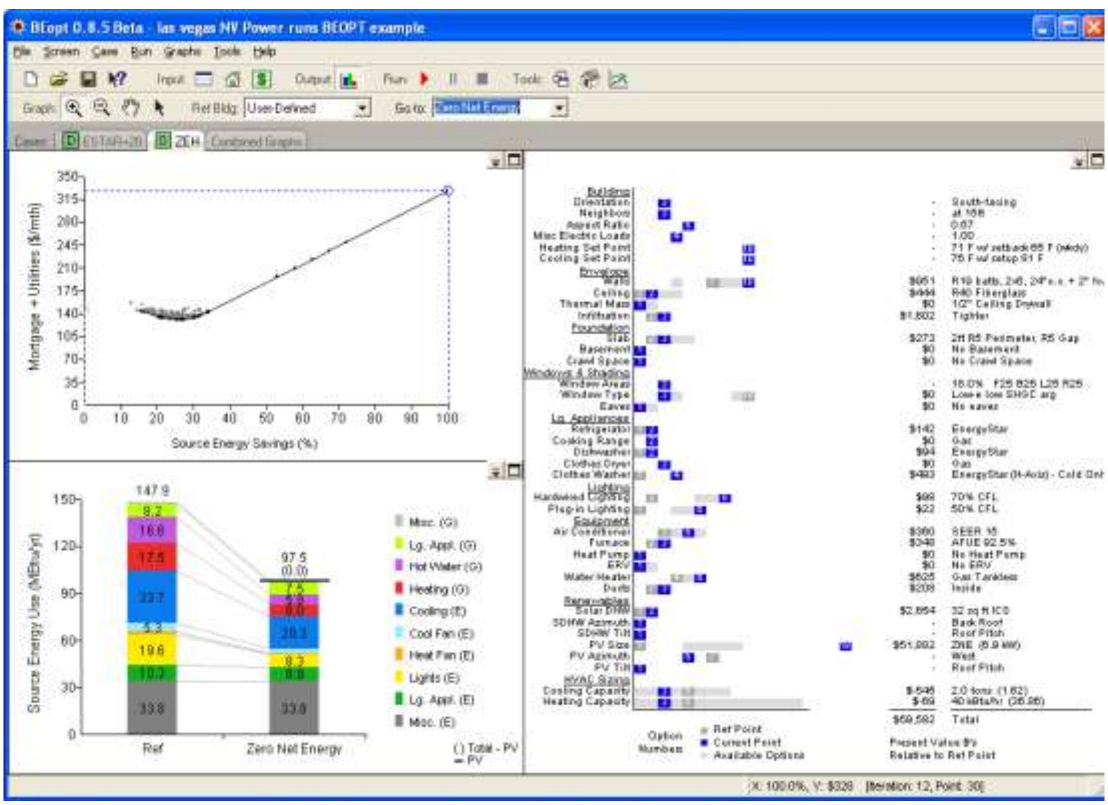
[22] Guidelines for builders and homeowners are available online at: http://www.montanagreenpower.com/solar/Builder%20Brochure.pdf (builders) and http://www.ncat.org/downloads/solar_owner.pdf (homeowners).

[23] The term 'zero energy home' is used to describe homes that generate as much energy as they consume on an annual basis.

**Box 5. Optimizing High Performance Homes: The NREL Building Energy Optimization Model (BEopt™)**

BEopt is a computer program developed by the National Renewable Energy Lab (NREL) that is designed to find optimal building designs along the path to net zero energy homes, and to facilitate analysis of the incremental cost and tradeoffs of high-performance building designs. The software allows the building designer to identify optimal combinations of pre-defined energy efficiency and renewable energy measures, as well as user-defined options. The BEopt software includes (1) a main input screen that allows the user to select, from many predefined options, those to be used in the optimization, (2) an output screen that allows the user to display detailed results for many optimal and near-optimal building designs, and (3) an options library that allows a user to review and modify detailed information on all available options. The BEopt software includes a results browser that allows the user to navigate among different design points and retrieve detailed results regarding energy end-use and option costs in different categories. Multiple cases, based on a selected parameter such as climate, can be included in a BEopt project file for comparative purposes.
An example of the BEopt output screen for a zero energy home in Las Vegas, Nevada is shown below.

**Illustrative BEopt results for Las Vegas, Nevada**




For more information, contact Dr. Ren Anderson, NREL. [Anderson.ren@nrel.gov](mailto:Anderson.ren@nrel.gov)

Additional design features included in heating-dominated climates, such as Denver, CO and Salt Lake City, UT include:

- Higher insulation levels (R-19 batts, 2x6, 24" O.C. with 1" foam, 4R-50 ceilings, 4ft, R10 exterior insulation basement)
- SEER 14 AC rather than SEER 15 (to partially offset higher incremental costs for heating system improvements)
- 92.5% AFUE gas furnace
- Use of closed loop solar thermal hot water systems instead of integral collector storage systems (to prevent freezing)

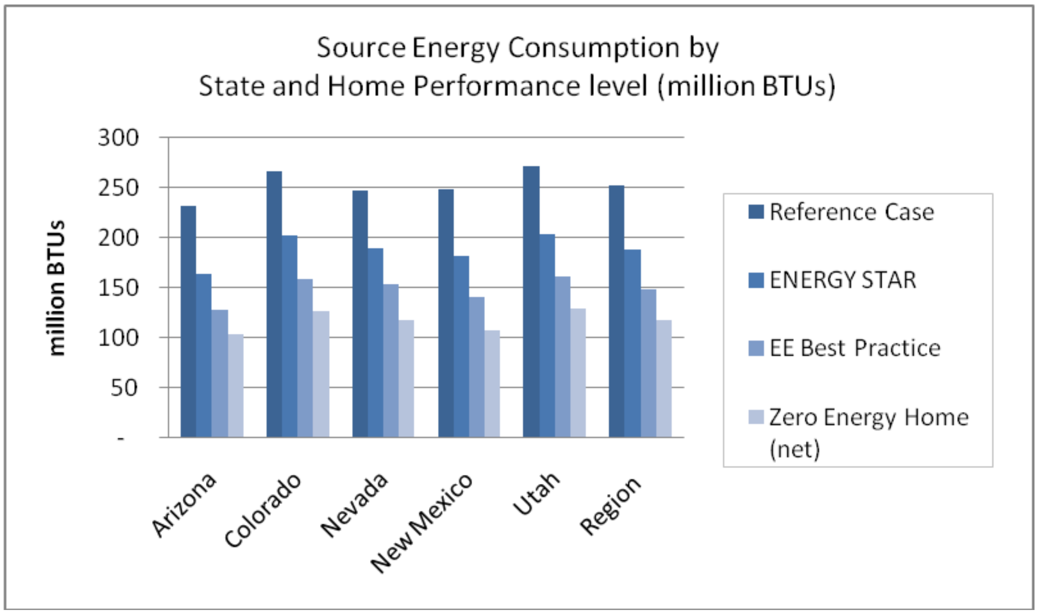
The analysis used relatively conservative assumptions about building orientation, electrical loads, and behavioral responses (e.g., use of setback thermostats for cooling). For example, plug loads are modeled as 25% higher than the Building America Benchmark home, to reflect the trend toward increased miscellaneous electric loads in homes (Brown et al, 2007). The building design assumes a typical 2-story new home with 2,400 square feet, 3 bedrooms, 2-car garage, and 9-foot ceilings. The Arizona home includes a small (2%) reduction in window area; otherwise, the home size, features and characteristics are the same as a typical home. The analysis assumes down-sizing of air conditioning and heating equipment is limited to 1-ton of cooling and 10 kBTU of heating capacity, because observations of actual home construction practices suggests that homebuyers and homebuilders are reluctant to accept more aggressive levels of downsizing for both heating and cooling systems. This estimate is consistent with other analyses and observed practices in high performance homes. On the other hand, modifying this practice to allow systems to be fully downsized to levels consistent with modeling estimates would help offset the cost of high performance homes to builders, and achieve greater levels of energy savings for homeowners.

Table 4. Energy Efficiency Features, Best Practice and Zero Energy Home: Phoenix, Arizona

| Category | Reference Case Home (IECC 2003) | Best Practice / Zero Energy Home |
|---|---|---|
| Building | • 2,400 sq. feet, east-facing<br>• Miscellaneous electric load factor 1.25 | • 2,400 sq. feet, east-facing<br>• Miscellaneous electric load factor 1.25 |
| Envelope | • Walls: R-13 batts, 2x4, 16" O.C.<br>• Ceiling: R-30 fiberglass<br>• Thermal mass: ½" ceiling drywall<br>• Infiltration: typical (specific leakage area = .0005) | • Walls: R-19 batts, 2x6, 24" O.C.<br>• Ceiling: R-30 fiberglass<br>• Thermal mass: ½" ceiling drywall<br>• Infiltration: tight (specific leakage area = .0003) |
| Foundation | • Slab on grade, uninsulated<br>• No basement | • No basement |
| Windows & Shading | • Window area: 18.0% F25 B25 L25 R25<br>• Window type: Double-pane, standard-SHGC (U = .65; SHGC = .41)<br>• No eaves | • Window area: 16.0% F20 B40 L20 R20<br>• Window type: Low-e, low-SHGC (U = .31; SHGC = .26)<br>• No eaves |
| HVAC Equipment | • SEER 13 AC; thermostat set at constant 74 degrees<br>• 80% AFUE furnace; thermostat set at 71 degrees with setback to 65 F<br>• Standard water heater (EF = .59) | • SEER 15 AC; constant 74 degrees<br>• 80% AFUE furnace; thermostat set at 71 degrees with setback to 65 F<br>• Gas tankless water heater (EF = .77) (Gas premium for zero energy home, EF = .62) |
| Appliances | • Standard (non-ENERGY STAR) dishwasher, refrigerator and clothes washer | • ENERGY STAR Dishwasher, refrigerator and clothes washer (cold water) |

| | | |
|---|---|---|
| Lighting | • 10% CFLs for hard-wired and plug-in lighting | • 50% CFLs for hard-wired and plug-in lighting |
| Renewables (Zero-Energy Home Only) | • No renewables | • 2 kW PV<br>• 32 square foot Integrated Collector Storage |

Figure 2. Source energy consumption by home performance level and state




The estimated incremental costs of building to each performance level are summarized in Table 5. Additional information on the incremental costs for each performance level by city and state is provided in Appendix A, Table A-3. The incremental costs (before incentives) range from a low of 1% (ENERGY STAR Home) to a high of 10% (net zero energy home). Factors that may increase or decrease the costs include the size and orientation of the home, the energy efficiency and renewable energy measures applied, local building costs and availability of trained contractors for specialized applications (e.g., solar installers), local permitting requirements (e.g., whether permitting fees are waived or reduced), and the size of the project (i.e., a custom home developer may have higher costs than a production builder that can procure equipment and services in large quantities), and the level and availability of incentives from utilities, state government, local governments .

Table 5. Incremental costs, annual energy savings, and net savings for each home performance level

| State | Incremental cost | | | Net savings, annual ($)** | | |
|---|---|---|---|---|---|---|
| | ENERGY STAR | Best Practice | Zero Energy Home* | 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 |
| New Mexico (Albuquerque) | $2,464 | $5,539 | $16,629 | $763 | $884 | $834 |
| Utah (Salt Lake City) | $2,946 | $6,588 | $19,331 | $434 | $636 | $253 |

*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).
** Net savings represents the savings to the homeowner in the annual cost of the mortgage plus utility bills versus a typical home.

Each of the home performance levels is cost-effective to the homeowner, when compared on the basis of monthly costs, including the home mortgage loan plus utility bills.  In all cases, the increased home mortgage amounts for investments in energy efficiency improvements and renewable energy systems are offset by a reduction in energy costs, resulting in a net savings to the homeowner.  Tables 5 and 6 provide a detailed breakdown of the energy consumption, incremental costs, and effect on homeowner cash flow of each performance level for a mixed-dry, heating-dominated climate zone (e.g., Denver, Colorado), and a hot-dry, cooling-dominated climate zone (e.g., Phoenix, Arizona).  The zero energy home level includes the value of net metered electricity from on-site solar PV.  The cash flow analyses shown in Tables 6 and 7 includes currently available federal incentives for energy efficiency and renewable energy.  The net savings would be even larger if utility and state incentives for energy efficiency and renewable energy are included.

A few mortgage lenders have begun to offer products and incentives for purchasing an energy-efficient home.  The energy-efficient mortgages capitalize the cost of energy efficiency improvements into the mortgage, which allows homeowners to pay for efficiency improvements over the life of the loan.  New products offered by Citigroup, Bank of America and J.P. Morgan Chase offer credits toward closing costs of up to $1,000 on energy efficient mortgages or ENERGY STAR-qualified homes.  A few states, including New

York, Kansas and Pennsylvania, are also beginning to offer low-interest loans for energy efficiency improvements.[24]

Although each of the performance levels are cost-effective to the homeowner without any incentives, utility, state and local incentives can also help lower the first-cost for builders, depending on the structure of the incentives and eligibility requirements. Chapter 8 of this report, Summary and Recommendations, includes a proposed utility incentive structure to encourage builders to construct high performance homes.

Table 6. Incremental Cost for High Performance Homes – Heating-Dominated Climates[25]

| | Typical Home | ENERGY STAR | Best Practice | Net Zero Energy |
|---|---|---|---|---|
| ***Annual Energy Consumption*** | | | | |
| Electricity (kWh) | 11305 | 8694 | 7758 | 5661 |
| Natural Gas (therms) | 1415 | 1062 | 744 | 639 |
| ***Annual energy savings*** | | | | |
| Electricity (kWh) | | 2,611 | 3,547 | 5644 |
| Natural gas (therms) | | 353 | 671 | 776 |
| Source energy, % savings[26] | | 24% | 40% | 53% |
| ***Annual on-site generation*** | | | | |
| • solar PV (kWh) | | - | - | 2,211 |
| ***Incremental Cost*** | | | | |
| Energy Efficiency | | $2,917 | $6,588 | $6,588 |
| Renewable energy (PV & solar thermal) | | - | - | $19,307 |
| Total incremental cost | | $2,917 | $6,588 | $25,895 |
| **Incentives** | | | | |
| Energy Efficiency[27] | | - | $2,000 | $2,000 |
| Renewable Energy | | - | - | $4,000 |

[24] Wall Street Journal. September 12, 2007. Going Green to Save Some Green, D1. http://online.wsj.com/public/article/SB118955748175824511.html

[25] Electricity and natural gas prices used in the cost analysis are $0.097 per kWh and $1.05 per therm. Loan assumptions are 30-year fixed mortgage at interest rate of 7 percent.

[26] Represents percent reduction in electricity from the power grid and natural gas supplied to the home, on a source energy basis.

[27] EE incentives include the $2,000 federal tax credit to builders for 50% or greater improvement in heating and cooling efficiency.

| | | | | |
|---|---|---|---|---|
| Net incremental cost after incentives | | $2,917 | $4,588 | $19,895 |
| **Homeowner Cash Flow Analysis** | | | | |
| Loan amount | $250,000 | $252,917 | $254,588 | $269,895 |
| Annual Mortgage payment (P&I) | $16,355 | $16,546 | $16,655 | $17,657 |
| Utility bill (annual) | $2,577 | $1,954 | $1,530 | $1,004 |
| Monthly Cost (mortgage + utilities) | $1,578 | $1,542 | $1,515 | $1,555 |
| Change in homeowner monthly cash flow | | **$36** | **$62** | **$23** |

Table 7. Incremental Cost for High Performance Homes – Cooling-Dominated Climates[28]

| | Typical Home | ENERGY STAR | Best Practice | Net Zero Energy |
|---|---|---|---|---|
| ***Annual Energy Consumption*** | | | | |
| Electricity (kWh) | 18507 | 14043 | 11293 | 11081 |
| Natural Gas (therms) | 491 | 296 | 212 | 182 |
| ***Annual energy savings*** | | | | |
| Electricity (kWh) | | 4464 | 7214 | 10,037 |
| Natural Gas (therms) | | 353 | 671 | 776 |
| Source energy, % savings | | 27% | 43% | 56% |
| ***Annual on-site generation*** | | | | |
| solar PV (kWh) | | - | - | 2,611 |
| ***Incremental Cost*** | | | | |
| Energy Efficiency | | $3,218 | $3,474 | $3,556 |
| Renewable energy (PV & solar thermal) | | - | - | $17,654 |
| Total incremental cost | | $3,218 | $3,474 | $21,210 |
| **Incentives** | | | | |
| Energy Efficiency | | - | $2,000 | $2,000 |
| Renewable Energy | | - | - | $4,000 |
| Net incremental cost after incentives | | $3,218 | $1,474 | $15,210 |
| **Homeowner Cash Flow Analysis** | | | | |
| Loan amount | $250,000 | $253,218 | $253,474 | $265,210 |
| Annual Mortgage payment (P&I) | $16,355 | $16,566 | $16,582 | $17,350 |
| Utility bill (annual) | $2,642 | $1,880 | $1,469 | $880 |
| Monthly Cost (mortgage + utilities) | $1,583 | $1,537 | $1,504 | $1,519 |
| Change in homeowner monthly cash flow – net savings | | **$46** | **$79** | **$64** |

[28] Electricity and natural gas prices used in the cost analysis show in Table 5 are $0.097 per kWh and $1.21 per therm. For additional assumptions, see footnotes to Table 4.

# Chapter 5. Savings Potential of High Performance Homes in the Southwest Region

This chapter of the report describes the analytical methods and results of SWEEP's analysis of the energy savings, cost and cost effectiveness of high performance homes for five Southwest states (AZ, CO, NV, NM and UT). SWEEP analyzed the energy savings and net economic benefits of significantly increasing the energy efficiency of new homes between 2008 and 2020, relative to current construction practices. Two scenarios were analyzed. They are:

- A **reference scenario**, in which most homes are built to current state or local building energy code requirements (typically IECC 2003 or IECC 2006), ENERGY STAR rates of market penetration remain constant, and only a few (< 1%) best practice or zero energy homes are built.
- A **high efficiency** scenario, in which, by 2020, 50% of new homes are ENERGY STAR qualified, 20% are 'Best Practice' homes that maximize cost-effective energy efficiency savings, 20% are Zero Energy Homes, which incorporate a combination of energy efficiency and onsite renewable energy measures. The percentage of code-built homes declines to 10% by 2020.

The results of the analysis are summarized below. Tables 8 and 9 summarize the cumulative energy savings and net economic benefits from the high performance homes scenario. The annual energy savings to the region in 2020 are 427 GWh – enough power for approximately 40,000 typical households.

Table 8. Summary of Analysis Results: Annual and Cumulative Energy Savings, 2008-2020.

| State | Annual Savings, 2020 | | Cumulative electricity savings (GWh) | Avoided Peak Demand (MW) | Cumulative Natural gas savings (million therms) | Cumulative Primary Energy Savings (trillion Btus) |
|---|---|---|---|---|---|---|
| | Electricity (GWhs) | Natural Gas (million therms) | | | | |
| Arizona | 183 | 5.4 | 1,159 | 592 | 34 | 21 |
| Colorado | 94 | 16.4 | 606 | 261 | 106 | 18 |
| Nevada | 69 | 2.1 | 425 | 261 | 13 | 8 |
| New Mexico | 25 | 3.0 | 166 | 68 | 20 | 4 |
| Utah | 56 | 8.7 | 354 | 133 | 55 | 10 |
| **Region** | **427** | **35.5** | **2,710** | **1,315** | **228** | **62** |

Table 9. Summary of Incremental Costs and Savings: 2008-2020 (millions 2008 $)

| State | Total investment, energy efficiency | Net economic benefit, energy efficiency | Benefit-cost ratio: energy efficiency measures | Total Investment, energy efficiency & renewables | Net economic benefit, energy efficiency & renewables | Benefit-cost ratio: energy efficiency & renewables |
|---|---|---|---|---|---|---|
| Arizona | 401 | 1,296 | 3.2 | 1,034 | 1,455 | 1.4 |
| Colorado | 443 | 1,409 | 3.2 | 974 | 1,493 | 1.5 |
| Nevada | 279 | 583 | 3.1 | 905 | 699 | 1.2 |
| New Mexico | 94 | 338 | 3.6 | 191 | 366 | 1.9 |
| Utah | 229 | 757 | 3.3 | 538 | 802 | 1.5 |
| **Region** | **1,446** | **4,383** | **3.3** | **3,642** | **4,815** | **1.5** |

Notes: EE measures include the incremental cost of all energy efficiency measures, excluding renewable energy system costs. Net present value assumptions: 20 year lifetime for energy efficiency and renewable energy measures and 5% real discount rate (capital recovery factor = 12.5). The benefit-cost ratios are based upon annual incremental costs and savings; RE incentives include federal tax credits only and exclude state and utility incentives.

The forecasted growth in new single family homes by state is shown in Table 10. The fastest-growing states in the region are Nevada and Arizona, which are forecasted to account for more than half of new housing growth within the region. The electricity and natural gas prices used in the analysis are shown in Table 11.

Table 10.Forecasted New Single-Family Housing Units, Annual: 2008 - 2020

| **State** | **Average Annual growth rate, housing units (%)** | **2008** | **2010** | **2020** | **Total New SF Housing Units, 2008 - 2020** | **Growth 2008 – 2020 (%)** |
|---|---|---|---|---|---|---|
| Arizona | 2.6% | 42,848 | 45,106 | 58,305 | 652,775 | 40% |
| Colorado | 2.1% | 28,458 | 29,666 | 36,518 | 420,353 | 31% |
| Nevada | 3.9% | 25,285 | 27,295 | 40,017 | 417,769 | 64% |
| New Mexico | 1.2% | 6,687 | 6,848 | 7,716 | 93,471 | 17% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Utah | 2.5% | 16,057 | 16,870 | 21,595 | 243,109 | 38% |
| **Region** | **2.5%** | **119,335** | **125,785** | **164,151** | **1,827,477** | **38%** |

Notes and sources:
Forecasts are based upon historical average annual growth rates in single-family housing units for each state (2000-2005), taken from the U.S. Census American Community Survey (2000 – 2005). Data is for single-family homes only and does not include multi-family housing units, such as condos, townhomes, and apartment complexes. http://quickfacts.census.gov/qfd/states/

Table 11. Electricity and Natural Gas Prices for Residential Customers, by State

| **City / State** | **Electricity ($ / kWh) (June 2007)** | **Natural Gas (therms) (2006, Annual)** |
|---|---|---|
| Arizona | $0.099 | $1.64 |
| Colorado | $0.097 | $1.05 |
| Nevada | $0.115 | $1.21 |
| New Mexico | $0.093 | $1.64 |
| Utah | $0.087 | $1.10 |

Sources:
Electricity prices: EIA Electric Power Monthly, June 2007.
http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html
Natural gas prices: EIA annual natural gas price data for the residential sector, 2006.
http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm

The annual electricity and natural gas savings by state are shown in Figures 2 and 3. Electricity consumption is highest in cooling-dominated states (e.g., Arizona and Southern Nevada), and natural gas consumption is highest in the heating-dominated states and regions (e.g., Colorado, Utah and northern Nevada). Source energy savings across the region average 25% for the ENERGY STAR home, 42% for the Best Practice home, and 54% for the zero energy home. The total source energy savings by home performance level and state are shown in Figure 4. For additional information on energy savings by category, fuel type and home performance level, see Appendix A.

Figure 3: Annual Electricity Savings, 2008-2020

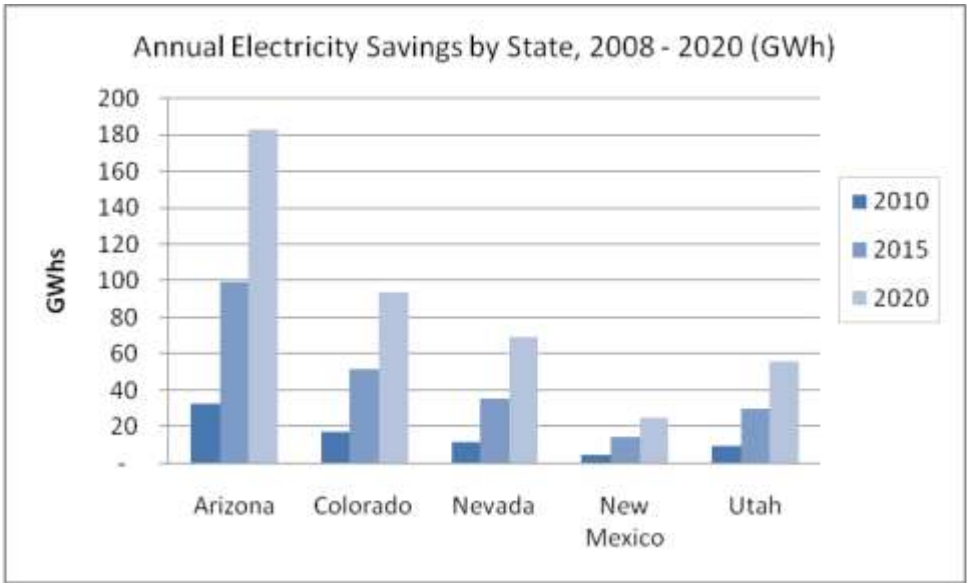
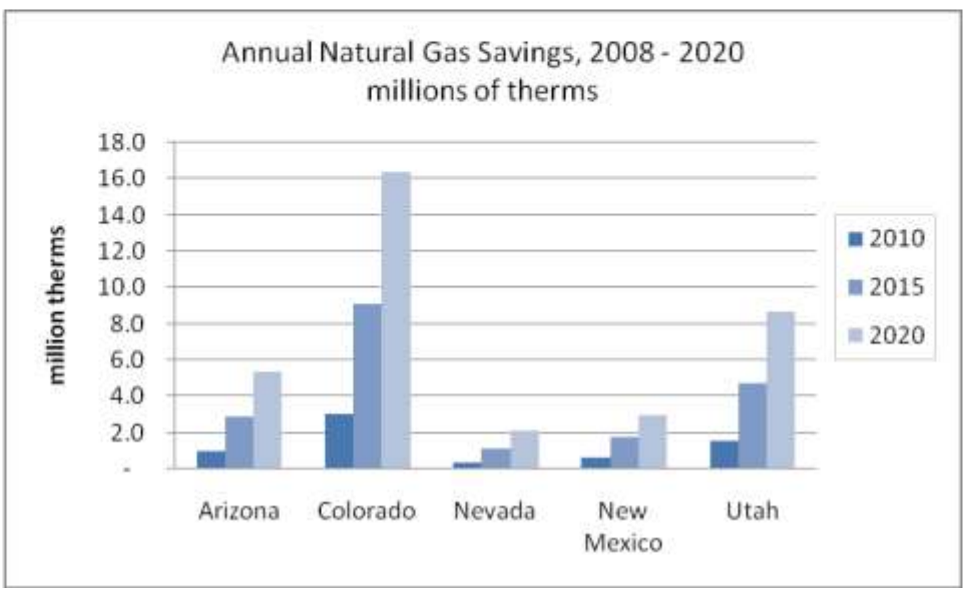



Figure 4: Annual Natural Gas Savings: 2008-2020



## Analysis of Energy Savings by State

Separate market penetration scenarios were developed and analyzed for each state, based upon the current building code in effect, levels of ENERGY STAR market penetration, and housing styles and preferences (e.g., 1-story versus 2- story, basement, slab on grade, etc.). The baseline and forecasted market penetration rates for code homes, ENERGY STAR homes, and beyond ENERGY STAR homes ("Best Practice" and zero energy homes) are shown in Table 12. Each of the scenarios is designed to achieve a minimum of 50% market penetration for ENERGY STAR Homes by 2020, 20% market share for Best Practice homes and 20% zero energy homes, with the remaining 10% of homes built to code. The total number of homes built by each performance level for the reference case and high performance homes scenario are shown in Table 13.

In the high performance homes scenario, the market penetration rate for ENERGY STAR homes increases 3% per year in Colorado, New Mexico and Utah, and 1% per year in Arizona. In Nevada, where the ENERGY STAR market share is already very high (currently 70%), the number of ENERGY STAR homes gradually declines as the market share of Best Practice and Zero Energy Homes increases. Achieving the 50% market share for ENERGY STAR homes will be more challenging in states with low rates of ENERGY STAR market penetration (Colorado, Utah and New Mexico), but experience in other states with utility and government programs actively promoting ENERGY STAR (e.g., Nevada, Texas and Arizona) suggest that these performance levels are achievable within a ten-year timeframe or less.[29]

The Best Practice and Zero Energy Home levels set aggressive yet achievable near, mid and long-term goals for raising the overall performance of residential new home construction. The average annual rate of increase for Best Practice and Zero Energy Homes in each state is 2% per year. The goals are consistent with the performance objectives established by the DOE Building America Program for achieving zero net energy use in the production-built homes marketplace by 2020.[30]

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[29] For example, the market penetration rate for ENERGY STAR qualified new homes in Texas increased from 1% in 2001 to 37% in 2006, equivalent to an average annual increase of 7 percent. Source: Sam Rashkin, ENERGY STAR New Homes program.

[30] For more information, see the Building America Web site at: http://www.eere.energy.gov/buildings/building_america/.

Table 12. Policy Scenarios for High Performance Homes by State: 2008-2020

| **State / Performance Level** | Distribution of New Homes by Performance Level (percent): Reference Case through 2020 | | | |
|---|---|---|---|---|
| | *Reference Case (2006)* | **2010** | **2015** | **2020** |
| **Arizona** | | | | |
| Code compliant | 65% | 50% | 35% | 10% |
| ENERGY STAR | 35% | 40% | 45% | 50% |
| Best Practice | <1% | 5% | 10% | 20% |
| Zero Energy Home | <1% | 5% | 10% | 20% |
| **Colorado and New Mexico** | | | | |
| Code compliant | 95% | 75% | 50% | 10% |
| ENERGY STAR | 5% | 15% | 30% | 50% |
| Best Practice | <1% | 5% | 10% | 20% |
| Zero Energy Home | <1% | 5% | 10% | 20% |
| **Nevada** | | | | |
| Code compliant | 29% | 20% | 15% | 10% |
| ENERGY STAR | 71% | 70% | 65% | 50% |
| Best Practice | <1% | 5% | 10% | 20% |
| Zero Energy Home | <1% | 5% | 10% | 20% |
| **Utah** | | | | |
| Code compliant | 84% | 65% | 45% | 10% |
| ENERGY STAR | 16% | 25% | 35% | 50% |
| Best Practice | <1% | 5% | 10% | 20% |
| Zero Energy Home | <1% | 5% | 10% | 20% |

Notes: The reference case for code built homes is based on the current statewide or predominant local building code in effect (2003 IECC or 2006 IECC). The State of Nevada (lead by the Las Vegas / Southern Nevada metro area) has the highest ENERGY STAR market penetration rate in the nation (71% as of 2006). The percentage of ENERGY STAR Homes in Nevada declines from 71% in 2008 to 50% in 2020, as more homes are built to the Best Practice and ZEH performance levels.

Table 13. New Single-Family Homes by Performance Level, 2008 - 2020

| New Single-Family Homes by Performance Level, 2008 - 2020 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Reference Case | | | High Performance Homes Scenario | | | | |
| **State** | **Code** | **ENERGY STAR** | **% ENERGY STAR** | **Code** | **ENERGY STAR** | **Best Practice** | **Zero Energy Home** | **Total** |
| Arizona | 424,000 | 228,000 | 35% | 221,000 | 284,000 | 74,000 | 74,000 | 653,000 |
| Colorado | 399,000 | 21,000 | 5% | 199,000 | 127,000 | 47,000 | 47,000 | 420,000 |
| Nevada | 121,000 | 297,000 | 71% | 73,000 | 248,000 | 48,000 | 48,000 | 417,000 |
| New Mexico | 89,000 | 5,000 | 5% | 45,000 | 28,000 | 10,000 | 10,000 | 93,000 |
| Utah | 204,000 | 39,000 | 16% | 103,000 | 86,000 | 27,000 | 27,000 | 243,000 |
| Region | 1,237,000 | 590,000 | 32% | 641,000 | 773,000 | 206,000 | 206,000 | 1,826,000 |

The annual and cumulative electricity, natural gas, and source energy savings for each state and the region are shown in Tables 14-16. The high performance homes scenario is expected to achieve the following energy savings and net economic benefits to the region between 2008 and 2020:

- Cumulative electricity savings of 2.7 million GWh, and a 1,400 MW reduction in peak demand.
- Source energy use per household is reduced by up to 48% by EE measures alone, and by up to 60% from EE and RE measures combined.
- Cumulative natural gas savings of 228 million therms (up to a 52% reduction in natural gas consumption per household).
- An additional 508 GWhs of electricity generated from PV systems installed in over 150,000 homes in the Southwest (equivalent to 20% of new construction in 2020) (see Table 17). Electricity generated by PV systems will reduce homeowner electricity bills by over $50 million (equivalent to approximately $225 per household, per year).[31]
- Cumulative energy cost savings (electricity and natural gas) of $528 million. The average energy bill savings (electric and natural gas) per household is $1,172 annually in the Best Practice scenario.
- Net economic savings over the lifetime of energy efficiency measures of $4.3 billion.

The energy efficiency measures are more cost-effective than renewable energy measures, with an average benefit-cost ratio of 3.3. The combined package of energy efficiency and renewable energy measures analyzed, however, is still cost-effective, with an average benefit-cost ratio of 1.5.

[31] The savings from PV are calculated as a credit for electricity generated by PV systems at the residential retail rate for electricity (except in New Mexico where PV is credited at the RECs rate, which is currently $.13/kWh). Revenues from net-metered electricity (i.e., the home generates more power than it uses) is not included in the estimate and could provide additional savings to homeowners.

Table 14. Annual and cumulative electricity savings (GWh)

| State | 2008 | 2010 | 2015 | 2020 | 2008 – 2020 (cumulative) |
|---|---|---|---|---|---|
| Arizona | 10 | 33 | 99 | 183 | 1,159 |
| Colorado | 6 | 18 | 52 | 94 | 606 |
| Nevada | 4.1 | 12 | 36 | 69 | 425 |
| New Mexico | 2 | 5 | 14 | 25 | 166 |
| Utah | 3.2 | 10 | 30 | 56 | 354 |
| **Region** | **24.9** | **77** | **231** | **427** | **2,710** |

Table 15. Annual and cumulative natural gas savings (million therms)

| State | 2008 | 2010 | 2015 | 2020 | 2008 – 2020 (cumulative) |
|---|---|---|---|---|---|
| Arizona | 0.3 | 1.0 | 2.9 | 5.4 | 34 |
| Colorado | 1.0 | 3.1 | 9.1 | 16.4 | 106 |
| Nevada | 0.2 | 0.4 | 1.1 | 2.1 | 13 |
| New Mexico | 0.2 | 0.6 | 1.7 | 3.0 | 20 |
| Utah | 0.5 | 1.6 | 4.7 | 8.7 | 55 |
| **Region** | **2.1** | **6.6** | **19.5** | **35.5** | **228** |

Table 16. Annual and cumulative source energy savings (trillion BTUs)

| State | 2008 | 2010 | 2015 | 2020 | 2008 – 2020 (cumulative) |
|---|---|---|---|---|---|
| Arizona | 0.2 | 0.6 | 1.8 | 3.3 | 21 |
| Colorado | 0.2 | 0.5 | 1.6 | 2.9 | 18 |
| Nevada | 0.1 | 0.2 | 0.7 | 1.4 | 8 |
| New Mexico | 0.0 | 0.1 | 0.4 | 0.6 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| Utah | 0.1 | 0.3 | 0.9 | 1.6 | 10 |
| **Region** | **0.6** | **1.8** | **5.3** | **9.7** | **62** |

Table 17. Electricity from PV (ZEH homes), GWhs, cumulative

| | 2008 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Arizona | 1.7 | 5.4 | 16.5 | 30.4 |
| Colorado | 1.0 | 3.0 | 9.0 | 16.1 |
| Nevada | 1.0 | 3.2 | 10.3 | 20.2 |
| New Mexico | 0.3 | 0.8 | 2.3 | 4.0 |
| Utah | 0.6 | 1.8 | 5.3 | 9.7 |
| **Region** | **4** | **14** | **43** | **81** |

### Peak Electricity Demand Savings

Improving the efficiency of new homes can reduce the average daily peak electricity demand per home by 50 to 60 percent. The average summertime peak electricity demand for each home performance level by state is shown in Figure 5. The combination of a highly-efficient home with solar PV can achieve even greater peak reductions, with the net power draw from the utility grid dropping to zero at 4pm on a hot summer day. Figure 6 gives an example of average peak savings for Phoenix, Arizona, where average household peak loads for the zero energy home are at approximately 2 kW at system peak (4pm), versus the code-built home which has a peak power draw of 7.5 kW. Additional peak savings data for each city and home performance level analyzed is provided in Appendix A. The annual and cumulative peak electricity savings by state and for the region are shown in Table 18.

Error! Reference source not found.Figure 5: Average electricity demand at summer peak, by state and home performance level

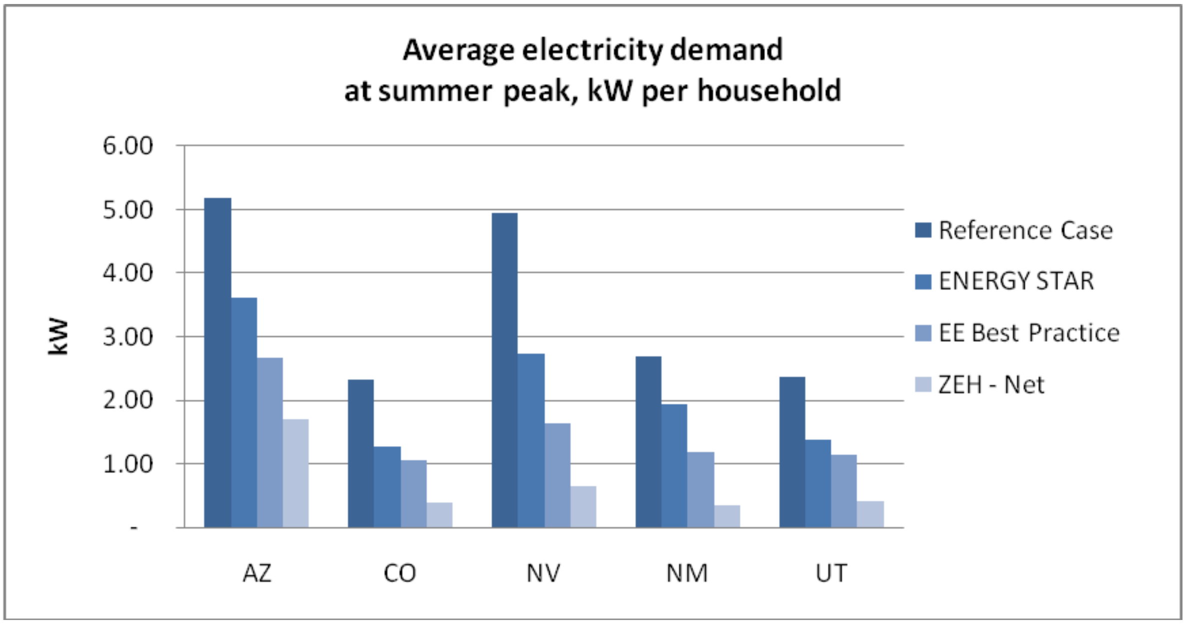


Figure 6. Comparison of hourly electricity demand for four home performance levels, Phoenix, AZ

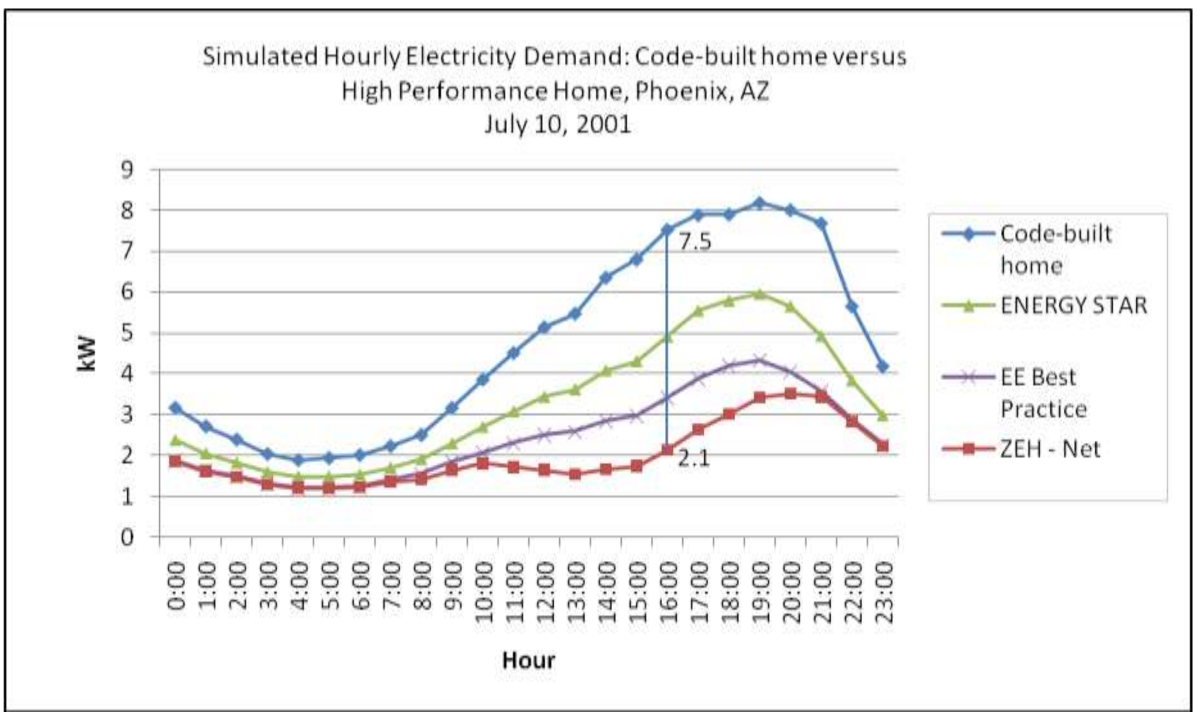

Table 18. Peak Electricity Savings by State (MW), 2008-2020

| State | 2008 | 2010 | 2015 | 2020 | 2008 - 2020 |
|---|---|---|---|---|---|
| Arizona | 5.3 | 17 | 51 | 93 | 592 |
| Colorado | 2.7 | 9 | 25 | 45 | 293 |
| Nevada | 2.5 | 8 | 26 | 51 | 309 |
| New Mexico | 0.7 | 2 | 6 | 10 | 68 |
| Utah | 1.4 | 4 | 13 | 24 | 153 |
| **Region** | **13** | **40** | **121** | **224** | **1,416** |

# Chapter 6. Policy options for utilities, states, and local governments

## Overview

This chapter of the report describes the types of incentives, technical assistance, training and education that utilities, states and local governments can provide to support high performance homes. It also provides information about federal incentives, which can be combined with incentives offered by utilities, states, and local governments. In some cases, a program or policy may be supported at multiple levels, such as builder training and education programs.

## State and Local Government Programs and Policies

States and local governments play an important role in overcoming the variety of market, institutional, technical, regulatory and financial barriers to high performance homes. Achieving the market penetration rates for the Best Practice and Zero Energy Home performance levels will require a coordinated and sustained effort by federal, state, and local government, utilities, builders, as well as energy efficiency and renewable energy equipment suppliers and installers (NAHB Research Center 2005). Policies and programs that states and local governments have used to support high performance homes are summarized in

Table 19 and Table 20. Federal, state and local government incentives, such as tax credits, buydowns for solar PV systems, and permitting fee credits or exemptions are summarized in Table 21.

Table 19. Energy efficiency policies and programs for high performance homes

| **Energy Efficiency Policies** | **Who Implements** | **Status of Adoption in Southwest States** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | AZ | CA | CO | NM | NV | UT | WY |
| State-wide energy efficiency savings goal (legislation or executive order) | Governor or Legislature | ● | ● | ● | IP | | ● | |
| Residential building codes updated to 2006 IECC or better | State agencies or local governments (in home rule states) | ● | ● | IP* | IP | ● | ● | |
| Residential new construction | State energy office; Public | ● | ● | IP | IP | ● | ● | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| program | and private utilities | | | | | | | |
| Utility incentives for builders – new residential homes | Public and private utilities | ● | ● | | ● | BC | ● | |
| Income tax credits for energy efficient homes | State legislature and energy office | ● | | | ● | | | |
| Property tax exemptions for energy efficient homes | State and Local Governments | | | | | BC | | |
| Home energy disclosure or rating at time of sale | State legislatures; local governments | | IP | | BC | ● | | |

*In 2007, Colorado adopted legislation (HB 1146) requiring municipalities that have already adopted a building energy code to update their local code to the 2003 IECC.
Key: IP = in progress; BC = being considered

Table 20. Renewable energy policies and programs for high performance homes

| **Renewable Energy Policies** | Who implements | Status of Adoption in Southwest States | | | | | |
|---|---|---|---|---|---|---|---|
| **Policy** | | AZ | CO | NM | NV | UT | WY |
| • PV buydown / incentives for on-site renewables | State or Public and private utilities | ● | ● | ● | ● | IP | ● |
| • Renewable portfolio standard with tariff rate for customer generation | State legislature and PUC | ● | ● | ● | ● | BC | |
| • Net metering for customer-sited renewable energy systems | State PUC | ● | ● | ● | ● | ● | ● |
| • State tax credits for residential renewable energy systems | State legislature and energy office | ● | | ● | ● | ● | |

Key: IP = in progress; BC = being considered

Notes: The Utah incentive program is a pilot program administered by Rocky Mountain Power, with an initial incentive level of $2.00 per watt for a maximum of 107 kW per program year.

Table 21. Federal, state and local government incentives for high performance homes

| Incentive Type | Builder Incentives | | Homeowner Incentives | | State and Local Examples |
|---|---|---|---|---|---|
| | Energy Efficiency | Renewable Energy | Energy Efficiency | Renewable Energy | |
| Federal tax credit –energy efficient new homes[32] | $1,000 - $2,000 | | | | n/a |
| Federal tax credits – solar PV[33] | | | | Up to $2,000 | n/a |
| Federal tax credits – solar water heating | | | | Up to $2,000 | n/a |
| Personal tax credits – energy efficient homes | $4.50 - $9,00 per square foot (NM) | | $5,000 (AZ) | | New Mexico, Arizona |
| Personal tax credits – renewable energy systems | | Up to $9,000 (NM) | | $2,000 (UT) | Arizona, Nevada, Utah |
| State property tax exemptions | | | | Up to 100% of value of renewable energy systems | Arizona, Colorado, Nevada, Utah |
| Local permit fee credits and incentives | | Up to $1,000 | | | Tucson, AZ and Scottsdale, AZ |

For more information on incentives by state, see the Database of State Incentives for Renewables and Efficiency (DSIRE), at: http://www.dsireusa.org.

[32] The federal energy efficiency tax credit is available for qualifying new homes 'substantially completed' between 1/1/06 and 12/31/2008. For information on the federal energy efficiency tax credit for new homes, see: http://www.energytaxincentives.org/builders/new_homes.php. The IRS Guidance is available at: http://www.irs.gov/newsroom/article/0,,id=154658,00.html.

[33] The solar PV and solar water heating tax credits are for systems placed in service between 1/1/06 and 12/31/08. For new homes, the 'placed in service' date is considered the date of occupancy by the homeowner. For more information about the federal renewable energy tax credits, see the DSIRE Web site at: http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US37F&State=federal&currentpageid=1&ee=1&re=1, and IRS Guidance at: http://www.irs.gov/pub/irs-pdf/f5695.pdf.

## Utility Programs

High performance homes can play an important role in meeting utility DSM programs goals in the fast-growing Southwest region. High performance homes can help utilities manage system load growth and peak demand, reduce system transmission and distribution costs, comply with renewable portfolio standards (i.e., by offering buydowns for customer-sited renewable energy systems, or through REC payments), and reduce emissions of air pollutants and greenhouse gases.

Program design options and strategies for developing a high performance home program include a combination of financial incentives, technical assistance, training and outreach to builders, homebuyers and real estate professionals, and education and marketing support. Utility incentive programs are often combined with builder training, field performance testing, education and marketing (to builders and homeowners), and related technical assistance. This section summarizes current utility programs and incentives that promote energy efficient new homes in the Southwest. Examples of the types of utility incentives provided to builders and homeowners are shown in Table 22. Additional information and links to individual utility program web sites are provided in the information resources section at the end of the report.

Table 22. Utility incentives for high performance homes.

| Incentive Type | Builder Incentives | | Homeowner Incentives | | State and Local Examples |
|---|---|---|---|---|---|
| | Energy Efficiency | Renewable Energy | Energy Efficiency | Renewable Energy | |
| Energy efficient new homes | $350 – $2000[34] | | | | CA IOUs; Rocky Mountain Power, UT; APS, AZ |
| Energy efficient appliances | $300 – $1,000 | | | | APS, AZ; CA IOUS; Rocky Mountain Power, UT |
| Buydowns – solar PV systems (2 KW, grid-tied residential system) | | $2.50 - $4.00/ Watt | | | APS, AZ; Xcel Energy, CO; Nevada Power, NV |
| Utility payments – renewable | | | | $0.13 per kWh, up to | PNM, NM |

[34] The $2,000 incentive level is offered by PG&E for homes that exceed Title 24 by 35%, demonstrate a 40% reduction in cooling load, have all ENERGY STAR appliances, and include solar generation as an option. For more information: http://www.pge.com/res/energy_tools_resources/efficient_new_homes/info_for_builders/rnc_nshp.html.

| | | | | | |
|---|---|---|---|---|---|
| energy credits (RECs) | | | | 10 kW (NM); Credit multiplier of 2.45 per kWh for solar PV (NV) | |
| Utility incentives – solar water heating systems | | | | $.50 per kWh, up to $10,000 | APS, AZ; SRP, AZ |
| Utility incentives – marketing and outreach campaigns[35] | $75 – $250 per home | | | | Rocky Mountain Power, UT |

For more information on incentives by state, see the Database of State Incentives for Renewables and Efficiency (DSIRE), at: http://www.dsireusa.org.

## Utility High Performance Home Programs and Incentives in the Southwest

Arizona

*Arizona Public Service (APS)*

APS offers an ENERGY STAR New Homes program for residential builders. Participating builders are required to meet the ENERGY STAR New Homes program requirements, as well as fresh air ventilation and room pressure balancing requirements specified by APS.[36] APS provides builders with a $400 cash incentive per home, along with advertising and sales support communicating the features and benefits of ENERGY STAR Homes. APS also offers a separate incentive for high efficiency air conditioner installations ($250 per home), and a buydown program for solar PV installations, known as the "Solar Partners® Incentive Program", and a net-metering rate (based upon retail electricity prices) for selling excess electricity generated by residential solar PV systems.

*Salt River Project (SRP)*

The Salt River Project PowerWise Homes program recognizes energy efficient subdivisions in the metropolitan Phoenix area that meet specific program requirements. SRP PowerWise homes are required to meet or exceed a HERS rating of 90 or lower, and to have high efficiency cooling and heating equipment. Each PowerWise home (or a sample of homes in a development) must be inspected and performance tested in the field to ensure that it meets program specifications. SRP

[35] Rocky Mountain Power will cover 1/3 of marketing and advertising costs, up to $10,000 maximum for 100+ homes. Web site: http://www.ecosconsulting.com/rockymtnpower/builders/documents/coop_overview.pdf.

[36] For more information, see: http://www.aps.com/aps/aps_services/construction/Construction_63.html.

provides coverage for the initial testing fees, along with plan review services, technical assistance and training to builders, and education and marketing to potential homebuyers. As of 2006, the program had 19 participating builders, with more than 12,000 new homes built. SRP also offers a solar PV buydown program, known as 'Earthwise.' The program provides buydown payments for PV systems of $3 per watt, up to a 10 kW system, and payments of $.50/kWh for residential solar hot water systems.

*Tucson Electric Power (TEP)*

TEP offers a 'Guarantee Home' program that works with new home builders to improve the heating and cooling efficiency of new homes, while maintaining indoor air quality. TEP specifies construction requirements that each builder must meet, and conducts a minimum of three verification field inspections of each guarantee home. The program guarantees the monthly heating and cooling costs for a period of three years (or five years with certain builders). The average electricity bill savings is 35% per home.

Colorado

In 2007, new DSM legislation was approved (HB 1037) that is expected to result in Xcel Energy (the main investor-owned utility in the state) promoting and providing financial incentives for highly-efficient new homes. In addition, other municipal and investor-owned utilities in Colorado offer ENERGY STAR New Homes programs, including Fort Collins Utilities, Colorado Springs Utilities, and Aquila.

Nevada

Nevada Power Company and Sierra Pacific Power Company are examining a number of potential DSM programs for their service territories, including a new homes incentive program. Nevada Power is proposing a new incentive program for highly efficient homes that are at least 15% more efficient than ENERGY STAR.

New Mexico

Although New Mexico has a very active green building community, there are currently no statewide utility incentive programs to support high performance home construction. In August 2007, however, the New Mexico Public Regulation Commission (PRC), approved 9 electricity DSM programs proposed by the state's primary investor-owned electric and natural gas utility, Public Service Company of New Mexico (PNM). The approved PNM programs have a total first year budget of $7.5 million, equivalent to about 1.3% of PNM's retail sales revenue.[37] The programs include residential lighting, new homes, AC load control, and refrigerator recycling programs; commercial lighting and load control programs, and promotion of energy-efficient evaporative cooling technology. The initial budget and participation rates for ENERGY STAR homes are relatively small ($295,000 and 400 homes), but experience in other states

[37] PNM press release, Aug. 29,2007: http://www.pnm.com/news/2007/0829_programs.htm.

(e.g., Texas, Nevada) have shown that utility program support can lead to significant increases in the level of market penetration of ENERGY STAR homes.

Utah

Utah's primary electric and gas utilities (Rocky Mountain Power and Questar Gas) both offer ENERGY STAR new homes programs for builders. In 2007, Rocky Mountain Power modified its ENERGY STAR New Homes program to include a higher incentive tier for homes that go beyond basic ENERGY STAR performance as well as additional incentives for new homes with special features such as evaporative cooling or ducts placed within the occupied space. Rocky Mountain Power also filed a five-year pilot PV buy-down program (April 2007 – December 2011) for approval by the Utah Public Service Commission. The PV program would provide $300,000 per year for up to a total of 107 kW of residential and nonresidential PV installations per program year. The pilot incentive level is $2.00 per watt for PV installations on grid-connected residential and nonresidential buildings.[38] The program is awaiting approval by the Utah PSC.

Questar Gas is implementing a pilot set of natural gas DSM programs and market transformation initiative. The programs include incentives for natural gas efficiency improvements in new homes, including a $500 incentive for ENERGY STAR whole house improvements, and a $300 incentive for tankless gas water heaters.[39] The program is designed to take advantage of synergies and coordination with Rocky Mountain Power's ENERGY STAR home builder program, including aligning the ENERGY STAR certification requirements for Builders and Home Energy Rating System (HERS) raters.

### Action Steps for Utilities

Actions that utilities can take to support high performance homes include the following:

- Establishing a comprehensive New Homes Construction program. Examples include the Rocky Mountain Power New Homes program, the California New Solar Homes Partnership, and ENERGY STAR New Homes programs offered by Texas utilities.
- Offering financial incentives such as utility rebates for high performance homes.
- Educating architects, builders, and contractors about high performance home design and construction.

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[38] For more information about the RMP pilot solar incentive program, see: www.psc.state.ut.us/elec/07docs/07035T14/52965PacifiCorp'sImplementationPlan.doc and http://www.rockymountainsolar.net/.

[39] For more information, see: http://www.thermwise.com/builder/BuilderRebates.html, and http://www.psc.utah.gov/gas/05docs/05057T01/Application%20for%20Expedited%20Approval%20of%20DSM12-5-06.doc.

- Developing targeted education, training and marketing programs for sales professionals, realtors, appraisers/lenders, and homebuyers.

- Supporting the development of energy efficient New Home and/or Green Building programs, and helping builders of high performance homes differentiate their product from that of other builders. Examples include the Rocky Mountain Power ENERGY STAR Homes program, and the City of Scottsdale, Arizona Green Building Program.

- Offer the option of tiered electric and natural rate structures that promote energy conservation by imposing a premium charge for excessive electricity and natural gas usage, and seasonal time-of-use rates that provide lower electric rates during off-peak periods and higher rates during on-peak times.

- Providing mechanisms for selling electricity from on-site renewables back to the utility at retail rates (e.g., net metering, time-of-use pricing), or transferring the value of renewable energy credits (RECs) to homeowners that have installed grid-connected PV systems.

## State Policies and Programs

States can play an important role in advancing high performance homes by adopting a comprehensive and coordinated portfolio of policies designed to promote investment in highly energy efficient homes and renewable energy systems. States can also provide support for high performance home activities through incentives, technical assistance and outreach to builders and buyers of high performance homes. These policies are summarized in Table 23. They can also help foster statewide coordination and partnerships between utilities, local governments and home builders.

State incentives, programs and activities may include the following:

- Adopting stringent residential building codes for new construction that exceed the 2006 International Energy Conservation Code (IECC) requirements by 15% or more.
- Offering training and technical assistance to builders on energy efficient construction practices and installation and maintenance of residential solar PV and thermal hot water systems.
- Providing income tax credits/subtractions for energy efficient home purchases, and property and sales tax exemptions for EE/RE equipment and services.
- Expanding training and technical assistance to architects, builders, building contractors, and local building code officials.
- Partnering with utilities and the home building industry to conduct education and outreach campaigns on the benefits of energy efficient homes.

Table 23. State policies supporting high performance homes

| ***State Policies Supporting Energy Efficiency and Renewable Energy Investments*** | ***Examples of State Programs Supporting High Performance Homes*** |
|---|---|
| Energy Efficiency<br>• Establish and regularly update building energy codes<br>• Establish a statewide energy efficiency standard or goal for public and private utilities<br>• Require electric and gas utilities to invest in energy efficiency, with mechanisms for cost recovery and positive incentives for exceeding goals<br>Renewable energy<br>• Establish an RPS with net metering<br>• Create a performance-based PV buydown incentive program<br>• Establish interconnection standards for customer-sited renewable generation | • Establish a new residential high performance homes program<br>• Provide tax credits to homebuyers for high performance homes<br>• Provide sales and property tax exemptions for renewable energy systems<br>• Educate and train builders, lenders, appraisers and local code officials about high performance home features, design, and code compliance<br>• Develop and maintain a list of certified solar installers and contractors |

Southwest states are implementing a range of incentives, programs and technical assistance to support high performance homes in the Southwest:

- The California Energy Commission's ***New Solar Homes Program*** provides rebates for residential solar PV systems. The PV incentives are combined with requirements to achieve higher energy efficiency levels in homes that receive incentives.[40]
- In **Colorado**, the Governor's Energy Office has supported the High Performance Homes-100 Consortium, an initiative lead by the City of Fort Collins to accelerate the building and sale of high performance homes in Colorado and the Rocky Mountain West. The Governor's Energy

[40] For more information, see: www.gosolarcalifornia.ca.gov/ .

Office is actively developing energy efficiency and renewable energy programs for new residential construction. GEO will be working closely with local jurisdictions and homebuilders throughout Colorado to encourage implementation of ENERGY STAR New Homes programs, including pilot programs for homebuilders interested in receiving home design assistance and modeling to improve energy performance, as well as financing options for the inclusion of renewable energy systems. The Governor's Energy Office is also administering the Colorado **Clean Energy Fund**, which provides incentives for energy efficiency and renewable energy projects.[41]

- **In Nevada,** the Nevada legislature adopted **a lamp standard** (AB 178) that imposes an effective ban on general service incandescent lamps (which are widely used in permanent hard-wired fixtures and plug-in lamps in homes). The legislature also adopted a modified version of legislation that would have require**d home energy ratings** at time of sale (SB 437). The enacted legislation requires the Nevada Energy Office to develop a home energy evaluation program, and contains an 'opt-out' provision.

- Since the mid-1990s, the **Arizona Energy Office** has been training builders and testing homes in the field using blower doors, duct blasters, and other performance testing equipment. The Arizona Energy Office provides support for The Southwest Building Science Training Center, which gives weatherization technicians and residential building tradesmen the opportunity to learn how to perform diagnostics and repairs on Arizona's houses.

- In 2007, **New Mexico** enacted a ***Green Building Tax Credit*** that will provide $5 million annually to homes that achieve a HERS rating of 60 or better, and meet either the LEED-Homes Silver rating or higher, or the Build Green New Mexico Gold rating.[42] The New Mexico tax credits extend federal tax credits, such as the $2,000 tax credit for building energy efficient new homes and solar tax credits for PV and solar thermal hot water systems totaling $4,000. The amount of the state tax credit is based on the qualified occupied square footage of the building (up to 3,000 square feet), the sustainable building rating achieved, and the energy efficiency of the building. The tax credit per home can be substantial. For example, a 2,000 square foot, LEED-Silver certified home that is 40% more efficient than a code-built home would be eligible for a $10,000 tax credit. The tax credit was adopted through the work of Governor Richardson's Green Building Task Force.

[41] For more information, see: http://www.colorado.gov/energy/ .

[42] For more information on the New Mexico green building tax credit, see the New Mexico Energy Conservation and Management Division Web site at: http://www.emnrd.state.nm.us/ecmd/NMSustainableBuildingTaxCredit.htm.

- **Utah's** Governor John Huntsman adopted a statewide goal of a 20% improvement in energy efficiency by 2015 on May 30, 2006.[43] A comprehensive energy efficiency strategy for meeting the 20% goal was released in September, 2007. The Governor's Blue Ribbon Advisory Council on climate change also issued a series of recommendations for reducing greenhouse gases that includes measures for the residential sector. The state recently updated the mandatory statewide building energy code to IECC 2006, and is co-funding training for builders and local code officials on techniques for meeting and exceeding the new code. Utah will also complete a baseline energy study for the residential and commercial building sectors to identify additional energy savings opportunities beyond code. The baseline study will repeated every three years in conjunction with the adoption of new energy codes.

## Local Government Policies and Programs

Local governments play an important role in facilitating high performance home projects. They are directly involved with all aspects of siting, permitting, and approving new residential construction. In addition, local governments in 'home rule' Southwest states (e.g., AZ, CO, NV) are responsible for developing and enforcing residential and commercial building energy codes. A few municipalities in the Southwest also operate their own municipal electric utilities, which can provide incentives and technical assistance for high performance homes. Thus, local governments need to be actively involved in the process of developing high performance home projects.

Local governments can initiate a green building program, which include minimum energy efficiency standards that are well beyond minimum code requirements. Examples include the City of Boulder, Colorado's 'Residential Green Points' program, the City of Scottsdale, Arizona's Green Building Program, and Albuquerque's proposed green building code.

Local Governments can also provide financial incentives, recognition, and priority in the development permitting, review and approval process. Examples of local government incentives include the Community Energy Efficiency Program (CEEP), a voluntary initiative in which developers can receive incentives for constructing new homes that are 15% more energy efficient than California's Title 24 building energy code requirements.[44] Another type of incentive that has become increasingly common is flexibility in zoning requirements, such as density bonuses, reduced setback and parking requirements, and increasing allocations for new lot permits.

The types of programs, incentives and assistance that local governments can provide to support high performance homes are summarized below.

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[43] Executive Order 2006/0004: http://energy.utah.gov/energy/docs/energy_executive_order.pdf

[44] For more information about CEEP, visit the Building Industry Institute Web site, at: http://www.thebii.org/lgp.asp

### Green Building and Other 'Beyond-Code' Programs

Local governments can establish a range of programs and provide technical assistance to builders and the construction industry on beyond-code approaches. Programs can range from comprehensive green building programs, such as the City of Boulder, Colorado's 'Green Points' program, to targeted improvements to current code requirements. Programs and technical assistance that local governments can implement to promote energy efficient construction practices include:

- Establishing a municipal green building program within minimum energy efficiency criteria that exceed ENERGY STAR requirements. Examples include the City of Boulder, Colorado 'Green Points' program and the City of Scottsdale, Arizona green building program.

- Incorporating 'beyond-code' components to residential building codes. Examples include Parker, Colorado, Albuquerque, New Mexico, and Austin, Texas.

- Establishing a net zero energy ordinance for large homes that exceed a square footage threshold, energy use threshold, or both. Example: City of Aspen / Pitkin County, Colorado Renewable Energy Mitigation Program(REMP).

- Providing technical assistance, training and guidelines to builders on energy efficient construction practices. Examples include Fort Collins Utilities, Colorado (a municipally-owned utility), which has developed a 'Builder's Guide to Energy Efficient Home Construction'[45], and the City of Scottsdale, Arizona 'Green Building Program'.[46]
- Work collaboratively with other local governments in your region, as well as state and federal agencies, HERS raters and NGOs to promote energy efficient building practices.

### Financial and procedural incentives

Financial and procedural incentives help encourage builders to construct highly efficient homes through financial incentives that reduce or defer project costs, and streamline the plan review, building permitting, and inspection process. The reductions in permitting fees are more than made up for by higher property tax revenues, as high performance homes have higher value than typical homes. For example, the City of Scottsdale, Arizona offers a 'fast track' plan review for builders that participate in its Green Building program (see Box 7). Financial and procedural incentives offered by local governments include:

- Giving priority to high performance homes for plan review, permitting, and inspections.

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[45] The Builder's Guide is available online at: www.fcgov.com/electric/builders-guide/index.htm.

[46] For more information, visit the City of Scottsdale Green Building Program Web site at: http://www.scottsdaleaz.gov/greenbuilding/.

- Waiving, deferring or reducing permitting fees for high performance homes. Fee deferrals or waivers for high performance homes provide an important incentive to builders with little or no fiscal impact to the local government.
- Providing flexibility in zoning code requirements, such as increased density, reduced setbacks, higher building heights, and increased lot coverage.

### Outreach, Education and Recognition

Local governments can educate builders and homeowners about the benefits of high performance homes through public meetings, web sites, fact sheets, advertising in local newspapers, and public events. Recognition provides a way to acknowledge the efforts of high performance building, while providing valuable media attention to builders and educating the public about the benefits of high performance homes. Outreach, education and recognition support may include:

- Developing education and outreach materials, checklists, and guidelines for architects, designers, builders and trade professionals and homebuyers on building and buying energy and resource-efficient homes. For example, the City of Fort Collins collaborated with E-Star Colorado and the Home Builders Association of Northern Colorado to develop a Web site, fact sheets, case studies and other information resources about features to look for in energy efficient new homes.[47]

- Provide public recognition to builders constructing energy efficient homes through awards, newspaper articles and press releases, and city council/mayoral events (e.g., City Council proclamation, Mayoral breakfasts) are a valuable tool for helping builders raise public awareness about their project and differentiating their product in the highly competitive new homes marketplace.

[47] The Buyer's Guide and supplemental materials are available online at: http://www.coloradonewhomechoices.org/buyersguide/default.htm

**Box 6. Local Government Incentives for High Performance Homes:**
**The City of Scottsdale, Arizona Green Building Program**

The City of Scottsdale, Arizona green building program has been very successful in promoting energy efficient construction practices in the Scottsdale new homes market. As of 2005, 33% of new homes in Scottsdale were built to the City's green building guidelines. The builder incentives offered by the City of Scottsdale are summarized below:

**Priority plan review** - All qualified green building projects receive fast track plan review service. This means green building projects receive building permits in half the time as regular projects depending on degree of complexity. Development process assistance is offered in the resolution of compliance issues.

**Job site signs** - City green building construction job site signs are available to distinguish projects involved in the program. This serves as a billboard that informs the general public of the builder's commitment to environmentally responsible building and the long-term health of the community.

**Directory of participating designers and builders** - Participating architects, designers and builders are listed and published in promotional materials. This material is on the city web site and is a part of the green building information packets which is distributed at public events and mailed out to the general public on request.

**Green building certification through inspections** - The City provides a series of green building inspections during the course of construction to ensure the project is following prescribed guidelines. From a homebuyer's perspective, this extra inspection process ensures a superior quality product as compared to typical building projects. Upon successful completion of the project, a green building certificate is awarded.

**Homeowner's manual** - A homeowner's manual is available which explains the features and benefits of green building, including indoor environmental health, energy, water, and resource efficiency. The manual is in layman's terms and helps to describe the uniqueness of each project.

**Promotional package for builders/developers** - Promotional packages include green building logo for ads, brochures, and abbreviated green building checklists. The Green Building Program provides additional media coverage in the form of press releases and articles in the local news media, including the City Cable Channel 11, Tribune, Arizona Republic, and Scottsdale Independent.

**Educational programs** - The City of Scottsdale sponsors green building lectures and seminars that serve as an introduction to energy/ resource efficient and environmentally responsible buildings. These programs feature information and resources in the areas of site use, energy, building materials, indoor air quality, water and solid waste reduction.

Source: City of Scottsdale, Green Building Program, http://www.scottsdaleaz.gov/Page2119.aspx

# Chapter 7. Case Studies

The following case studies provide examples of completed high performance homes and communities in the Southwest. Each of the case studies describes the building practices, incremental costs and savings achieved in the individual homes or communities. In each case, public-private partnerships involving utilities, state government, local government and the developer helped achieve a successful project.

## California

### Sacramento Municipal Utility District 'SolarSmart' New Homes Program

Since 2001, the Sacramento Municipal Utility District (SMUD) has sponsored several ZEH projects within its service territory in partnership with the DOE Building America program, including the Premier Gardens development (shown in photo). In 2007, SMUD launched the SolarSmart New Homes program, in which SMUD is working with several builders in its service territory to design and construct high performance homes that achieve significant energy cost savings for homeowners, and reduce summertime peak electricity demand and the need for new electric system capacity. The program is designed to work with large-scale production builders that are installing efficiency and solar PV as standard features in the home.

Premier Gardens Zero Energy Homes, Sacramento, CA
Photo credit: SMUD

The SolarSmart New Homes program integrates energy efficiency features with renewable energy systems to achieve up to 60% savings in electricity costs for SMUD's customers, and peak electricity demand reductions of up to 65%.[48] The homes achieve 35% energy savings through energy efficiency measures, and up to 60% energy savings with the PV system, as shown in Figure 7 (BIRA 2006 and US DOE 2006).

Features of SMUD SolarSmart Homes include:

- Solar electric system (Building-Integrated PV Panels, approximately 2 kw)

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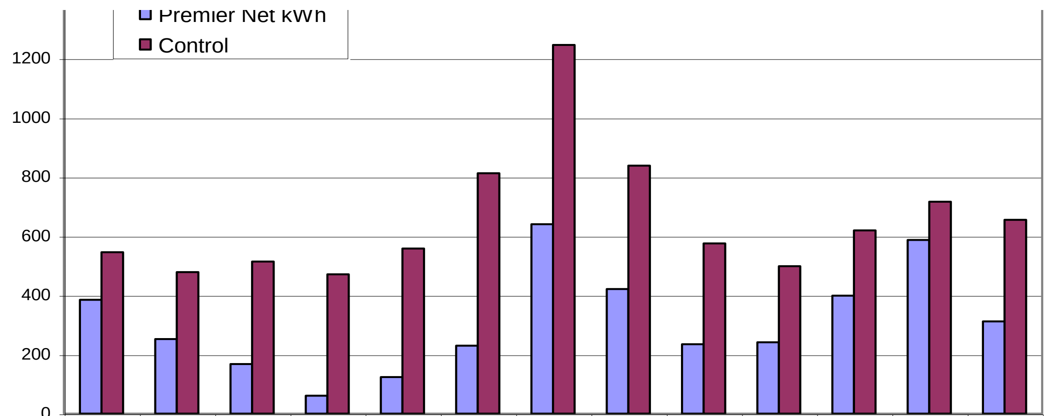
[48] Presentation by Steve Vang, Consol. California Solar Center. 2006 Solar Forum. http://www.californiasolarcenter.org/pdfs/forum/2006.8.25_SolarForum-SVang-ConSol_EE%2BREinNewHomes.pdf

- Radiant Barrier
- High Efficiency (90%) Furnace and Air Conditioner **(**14 SEER/ 12 EER)
- Compact Fluorescent Lighting
- ENERGY STAR windows
- Third Party Certification

Figure 7. Average monthly net electricity use: net zero energy home versus control home




| | Jan,05 | Feb, 05 | March, 05 | April, 05 | May, 05 | June, 05 | July, 05 | Aug, 05 | Sept, 05 | Oct, 05 | Nov, 05 | Dec, 05 | Monthly Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Premier Net kWh | 385 | 252 | 168 | 61 | 123 | 229 | 640 | 421 | 234 | 241 | 399 | 587 | 312 |
| Control | 545 | 478 | 514 | 471 | 558 | 812 | 1246 | 838 | 575 | 498 | 619 | 716 | 655 |

Source: SMUD

SMUD pays participating builders a per home incentive for solar PV systems on each qualifying SolarSmart home built, along with incentives for diagnostic testing and home energy ratings. The ncentive was initially set at $3.00 per watt, but has been reduced to $2.50 per watt because of the large number of program participants. The systems also qualify for federal tax credits for solar PV. SMUD works closely with participating builders, architects, contractors, and trades on the design and construction of energy-efficient homes. It also has worked with contractors to train and develop a qualified base of solar PV system installers. SMUD offers annualized net metering for electricity generated by customers, with payment at SMUD's retail electricity rates. SMUD also offers incentives for energy efficiency and solar PV installations in existing homes, through a pre-screened network of qualified solar installers.

In March 2007, SMUD signed an agreement with Lennar homes to build more than 1,200 SolarSmart homes, which represents the largest solar new homes partnership in the United States. Overall, the program has signed commitments with builders for 1,900 homes, which are expected to reduce SMUD's peak demand by nearly 3 MW per year.[49] SMUD estimates the total potential peak demand savings from SolarSmart Homes in its service territory is greater than 20 MW per year.[50]

**Lessons learned**

Lessons learned from the SMUD SolarSmart program include:

- Homebuyers find highly efficient homes with solar PV attractive and cost-effective (when system costs are incorporated into the mortgage), but more work needs to be done to raise awareness of the energy and environmental benefits of high performance homes.
- High performance homes offer potential for significant peak load reduction and distribution system benefits.
- Where feasible, solar PV systems and rooflines should be oriented to optimize afternoon peak savings (i.e., no east-facing panels, and roofs optimized for solar PV).

**For more information**

Contact: Mike Keesee, PV Project Manager, SMUD
e-mail: mkeesee@smud.org
Web site: www.smud.org

[49] SolarBuzz, August 3, 2007. SMUD Signs Solar Home Deals with Homebuilders Towne, Centex http://www.solarbuzz.com/News/NewsNAPR844.htm

[50] Mike Keesee, presentation at 2005 Solar Forum. http://www.californiasolarcenter.org/pdfs/forum/2005.9.13-SolarForum_MKeesee-SMUD.pdf

## Colorado

Aspen Homes of Colorado

Aspen Homes is a small production builder that constructs homes that will perform 40 percent better than a typical home built to code, yet are affordable to the average homebuyer. 100% of Aspen homes exceed the requirements of ENERGY STAR and Built Green Colorado. Each home also includes a 2-year heating consumption guarantee for the homeowner.[51]

**Aspen Homes, Loveland Colorado**
**Credit: NAHB**

The energy efficiency features of Aspen Homes include the following:[52]

- Enhanced wall, ceiling and slab insulation. External wall system features include blown-in insulation (R-15 blown-in fiberglass and one-inch extruded polystyrene foam. Ceilings use cellulose insulation (R-42). The exterior basement walls and the perimeter of at-grade slabs are insulated with R-10 (2" thick) extruded polystyrene rigid board. The basement wall and slab insulation helps keep the floor slab warm and minimize heat loss to the ground.

- Highly-efficient HVAC and ducts, including a sealed-combustion, properly-sized furnace, and ducts that are properly sealed, pressure balanced and tested (less than 10% leakage rate). Ducts are placed entirely inside the conditioned space. The furnace is centrally located in the basement to minimize duct runs.

- Extensive home sealing (e.g., foam sealing voids in the rim joist, foam sealing mechanical penetrations, caulking around window and door frames, weather stripping around the attic hatch and exterior doors, caulking top and bottom plates, and gluing the drywall to the top and bottom plate with subfloor adhesive, and exterior wall insulation around showers and baths).

- Installation of the ENERGY STAR "Indoor Air Package" to maintain indoor air quality. The system includes a mechanical ventilation system to exchange indoor and outside air.[53]

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[51] The guarantee specifies that annual heating costs will not exceed a specified amount, provided that the homeowner operates and maintains the heating system in a responsible manner. A copy of the heating consumption guarantee is available at: http://www.aspenhomesco.com/index.php?pr=Heating_Guarantee

[52] For a detailed description of building design features, see the U.S. DOE / Building America report "Performance Evaluations of Prototype House: 50%-60% Total Energy Savings Level" at:

- Gas tankless water heater.

- Diagnostic testing: HERS rating and duct diagnostic testing.

Since 2002, the company has built more than 500 ENERGY STAR homes. Aspen Homes received the Built Green Colorado 'Home of the Year' Award in 2006, the 2007 Energy Value Housing Award from the NAHB, and was named the 2006 ENERGY STAR Partner of the Year. Aspen Homes has also received recognition for building energy efficient affordable housing.[54]

Lessons learned

- Air sealing and insulation are highly cost-effective measures, but should be implemented as components of a whole-systems approach.
- Highly-efficient affordable homes can be built cost-effectively in cold climates.
- Aspen Homes recognizes that homeowner involvement is critical to achieving high levels of home energy performance. The company provides information about the energy efficiency features and benefits to each homeowner at a pre-construction meeting, and again during construction walk-throughs and post-closing walk-throughs. Simpler, straightforward messages about tangible energy savings are more effective than detailed information in conveying the benefits of energy efficient homes to homebuyers.
- High performance homes can help improve sales, particularly during market downturns.

**For more information**

Web site: www.aspenhomesco.com

Articles:

- Aspen Homes' system first to include guarantee. http://www.builtgreen.org/articles/0302_Aspen.htm
- NAHB Energy Value Housing Award: http://www.nahbrc.org/evha/2005-EVHA-book.pdf
- Fort Collins Coloradoan: http://www.aspenhomesco.com/media/2007%20March%20Coloradoan.pdf

Technical report:

- DOE Building America Research Report, Performance Evaluations of Prototype House: 50%-60% Total Energy Savings Level. Task Order KAAX-3-33410-06. Prepared by IBACOS. www.ibacos.com

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[53] Aspen Homes participated in the EPA Indoor Air Quality Pilot program. The current Indoor Air Package specifications are available online at: http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_iap

[54] See EVHA description at: http://www.aspenhomesco.com/media/2006_EVHA_Affordable.pdf

## Nevada

### Pulte Homes, Las Vegas

Pulte provides a good example of how a large-scale production builder can cost-effectively achieve a highly-efficient home through a combination of advanced design and construction practices and use of highly-efficient products and equipment. Innovative design features implemented by Pulte include use of unvented roofs, placement of ducts inside conditioned space, spectrally selective windows and integrated space heating, hot water and ventilation systems. The improvements resulted from collaboration between Pulte Homes, the Nevada State Energy Office, and Building Science Industries as an initiative of the U.S. Department of Energy's Building America program.

Pulte Corporation was one of the first builders in the Las Vegas area to commit to building all of its homes to ENERGY STAR levels. Since 2002, Pulte has built nearly 15,000 ENERGY STAR qualified homes in the Las Vegas area.[55] The energy efficiency improvements implemented by Pulte are highly cost-effective for the homeowner, which save $300 or more on their annual energy bill. The incremental cost to achieve Pulte's highest efficiency level, known as "Engineered for Life (EfL) Platinum was $760, including offsets for switching from 2x4 to 2x6 framing, and downsizing the HVAC system. The incremental costs and savings for each measure are shown in Table 24. The higher performance construction also reduced the number of call-backs and warranty costs for Pulte, which results in higher customer satisfaction.

Table 24. Incremental Cost to Achieve Pulte 'EfL Platinum Level' (1999 $)

| **Measure** | **Cost** |
|---|---|
| Building feature changes in a typical 1800 $ft^2$ home | -$250 |
| Moving insulation to roof deck, and insulating the gables | $1,000 |
| Advanced framing, including upgrading from 2x4 to 2x6 | -$200 |
| Spectrally selective glass (low-e glass with low solar heat gain coefficient) | $360 |
| Properly sized HVAC system | -$800 |
| Sealed ductwork + pressure relief | $300 |
| Controlled ventilation system | $150 |
| Sealed Combustion Furnace (90% AFUE) | $200 |
| **Total:** | $760 |

Source: Pulte Homes. http://www.builtgreen.org/articles/0104_pulte.htm

[55] Source: ENERGY STAR New Homes Partner database. http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showHomesResults&partner_type_id=SHB&s_code=NV

**Lessons learned**

- The whole-house approach to the design and construction of homes achieves greater energy savings at lower cost than applying measures individually. Whole-house design and construction practices are capable of reducing home heating and cooling costs by 50%, at minimal incremental cost to the builder. The unvented roof design allowed Pulte to effectively place the ducts inside conditioned space, which significantly reduces cooling-related electricity demand.
- Design and construction teams must be properly trained and educated about advanced building design and whole-house engineering practices.
- Public-private partnerships can help accelerate the development and adoption of advanced building design and construction practices.

For more information:

- Pulte Homes Corporation
  www.pulte.com

- Building America Case studies:
  http://www.nrel.gov/docs/fy02osti/31793.pdf and
  http://www.nrel.gov/docs/fy00osti/28322.pdf

- Article: Pulte Homes and Re-engineering
  http://www.builtgreen.org/articles/0104_pulte.htm

# Chapter 8. Summary and Recommendations

This report shows there are significant opportunities to cost-effectively reduce energy demand from new homes in the Southwest using readily available building technologies and innovative yet well established design practices.  By starting to implement high performance home programs now, states, utilities, and local governments – working in partnership with the home building industry – can reduce the energy demand of new homes while improving home performance with net benefits to homeowners.

Utilities, states and local governments all play an important role in advancing high performance homes. The policies, strategies and case studies described in this report provide examples of how to develop effective public-private partnerships that can help overcome the financial, regulatory, institutional, and technical barriers to high performance homes.

This chapter summarizes best practices for high performance home programs and makes recommendations for utility, state and local government policies and programs.

## Best Practices for High Performance Home programs

Summarized below are lessons learned and best practices for high performance homes, compiled from the combined experiences of builders, architects, utilities, and Building America's research teams.

SWEEP recommends adopting the following best practices for high performance home programs:

- Start with proven, 'off-the-shelf' technologies.  Use incentives and tax credits to reduce the risk of newer technologies or design practices.

- Promote whole-building approaches, rather than piecemeal improvements to individual systems. Whole building approaches achieve greater savings at less cost to the builder and homeowner.

- Consider partnering with or building upon existing green building programs and initiatives within your state or region.

- Develop education and marketing materials targeted at builders and contractors, homebuyers, and real estate professionals that communicate the energy, environmental and performance benefits that high performance homes offer.  An NREL study of a zero energy homes development in San Diego, CA found that most homebuyers were unaware of the energy efficiency and renewable energy features of their new homes (Farhar and Coburn, 2006).

- Work with appraisers, lenders, and realtors to educate them about the energy savings achieved by high performance homes, and how that translates to housing price and affordability for the homeowner.

- Ensure contractors, installers, and sales professionals receive proper training and/or technical assistance on high performance home technologies.

- Reduce transaction costs by offering 'turnkey' solutions that provide one single point-of-contact for all phases of energy efficiency and renewable energy system design, installation, maintenance, utility connection, and rebate processing.

- Involve local governments and consider providing expedited permitting and code approvals for high performance homes.

- Address plug load and occupant behavior through efficiency measures and homeowner education about good energy management and maintenance practices.

- Reduce the size of heating and cooling systems in response to improvements in the building envelope and insulation levels.

- Require builders or homeowners to implement high levels of energy efficiency in order to be eligible for incentives for installing on-site PV or solar thermal equipment.

- Offer time-of-use rates to allow homeowners to fully capture the value of efficiency measures that reduce cooling load and/or photovoltaic systems.

- Offer builders incentives for constructing all high performance homes at the community or sub-division level, rather than as an option if selected by a prospective home buyer. Experience from existing new solar home programs has shown that few homebuyers will purchase solar PV when offered as a builder option, and that the cost and time required for builders to install solar PV as a customer option are both higher than when solar PV is installed standard on every home (Farhar and Coburn 2006).

- Measure, document and evaluate actual home performance to identify where improvements or adjustments to programs and incentives may be needed.

## Recommendations for Utilities, States, and Local Governments

Utilities, states and local governments can take the following action steps to advance high performance homes in the Southwest region.

### Utility Programs

SWEEP recommends that utilities offer a 3-tiered incentives package to builders, beginning at ENERGY STAR and going up to a Net-Zero Energy Home level of performance. The recommended incentive levels are shown in Table 25. For utilities that already have high levels of market penetration for ENERGY STAR new homes (>50%), utility programs and incentives should focus on achieving the higher performance levels of Best Practice and Net-Zero Energy Homes, or include incentives for optional ENERGY STAR measures, such as the Advanced Lighting Package.

Table 25. Recommended Utility Incentive Levels and Source Energy Savings Levels

| Performance Level | Energy Efficiency Incentive | Renewable Energy Incentive | Source Energy Savings (%) |
|---|---|---|---|
| ENERGY STAR Homes: | $350 - $500 | - | 15-30% |
| Energy Efficiency – Best Practice | $750 - $1,000 | - | 30-50% |
| Net-Zero Energy Home | $750 - $1,000 | $4,000 - $8,000 | 50-60% |

In addition to new homes programs, utilities can also develop programs to reduce plug loads through rebates for energy-efficient appliances and consumer products, development of education and outreach material targeted at occupant behavior (e.g., turning off consumer electronics, appliances, and lighting when not in use). Examples include the 80+ program for desktop computer and server power supplies, and SCE's 20/20 summer savings program.[56]

Other recommended action steps for utilities include:

- Expand design assistance, financial incentives, demonstration and promotion programs, and guaranteed savings programs.
- Educate and train builders and contractors about high performance construction practices.
- Provide assistance with energy audits, conduct field performance tests, and document actual performance of EE and RE technologies and practices.
- Develop and provide education, outreach and marketing materials to builders and homebuyers.
- Develop a structured package of financial incentives for high performance homes.
- Educate homeowners about behavioral practices, proper equipment operation and maintenance, and energy-saving strategies.
- Conduct rigorous evaluations, measurement and verification of new home performance to assess the actual performance of new homes and the impacts of utility incentives and technical assistance programs. If feasible, the assessments should also include evaluations of homes built

[56] For more information about the 80+ program, see: www.80plus.org. For more information about SCE's summer savings program, see: www.sce.com/RebatesandSavings/2020/

using typical construction practices to provide a more accurate baseline for evaluating home performance.

### State Governments

State government plays an important role in raising the energy performance of new homes. States can establish aggressive energy efficiency and renewable energy goals that all utilities are required to meet, including investor-owned, municipal and electric cooperatives. States can provide tax credits and other incentives (e.g., property tax exemptions, buydowns for PV systems) for building more energy efficient homes, and provide high level recognition (e.g., Governor or director of the state energy or environment office head) to builders and organizations that are building or supporting high performance homes.

Recommendations and action steps for states include:

- Support high performance homes through a combination of effective 'foundation' policies for energy efficiency and renewable energy (see
- Table **19.** and Table 20) and targeted incentives for high performance homes, such as green building tax credits for builders.

- Develop a targeted package of technical assistance, training and education focused on energy efficiency and renewable energy opportunities in new homes, and renovations to existing homes. Programs should be coordinated with utility programs and local government efforts to the extent feasible.

- Coordinate statewide and regional program support, such as building code and green building design training.

- Work in partnership with utilities and builders to quantify, evaluate and publicize the benefits of high performance homes.

- Establish programs requiring energy ratings and labels at the time of sale of new homes.

- Develop education and outreach materials targeted at builders, the real estate industry, and homebuyers/homeowners.

## Local Governments

Local governments play an important role in facilitating the adoption of high performance homes in the marketplace. Local governments can offer technical assistance to builders, building code officials, and educate real estate professionals (realtors, appraisers, lenders) about the benefits and features of highly efficient homes. Local governments also can adopt cutting edge energy efficiency or green building requirements, such as the City of Albuquerque, NM Green Building Ordinance. Examples of the types of programs and policies that local governments have adopted to support high performance homes are described in the previous section of this report.

Recommended actions that local governments can take to promote high performance homes include:

- Initiating a green building program that includes minimum energy efficiency standards that are well beyond minimum code requirements.

- Providing incentives to builders, including permit fee waivers or deferrals, density bonuses, per home incentives, and priority plan reviews and field inspection.

- Conducting educational programs, training and outreach to architects, designers, builders and trades on energy and resource efficient home building practices and their benefits.

- Promoting high performance homes through public recognition, including newspaper ads/articles, access to promotional packages, job site signs, and recognition by city officials.

- Develop a directory or network of participating architects, builders, suppliers, realtors and lenders that offer high performance home products or services.

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http://www.construction.com/AboutUs/2007/GreenHomescustomersurveyApril2007.pdf (report summary)

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# Information Resources

The following Web sites, presentations, reports, and case studies provide additional information to help utilities, states and local governments develop and implement programs and policies to support high performance homes.

## National Programs

ENERGY STAR New Homes (U.S. EPA and U.S. DOE)

- www.energystar.gov/newhomes/
  The ENERGY STAR for New Homes program works with builders, home energy raters, rating providers, utilities, state and regional sponsors, and lenders to promote the benefits of energy-efficient homes. The program offers technical assistance, guidelines and specifications, and marketing and outreach support to energy efficiency program sponsors, the home building industry and new homebuyers.

Building America (U.S. DOE)

- www.buildingamerica.gov
  Building America is a private/public partnership sponsored by the U.S. Department of Energy that conducts research to find energy-efficient solutions for new and existing housing that can be implemented on a production basis.

U.S. Green Building Council, LEED for Homes

- www.usgbc.org/homes/
  LEED for Homes is a voluntary rating system that promotes the design and construction of high performance "green" homes. The LEED for Homes rating system measures the environmental performance of new homes across eight separate resource categories, including energy efficiency. LEED certification recognizes and rewards builders for meeting the highest performance standards, and gives homeowners confidence that their home is durable, healthy, and environmentally friendly.

National Association of Homebuilders (NAHB) National Green Building Standard

- http://www.nahbrc.org/GBstandard/
  The National Association of Home Builders (NAHB), the International Code Council (ICC) and the NAHB Research Center have initiated a process for the development of an ANSI standard for green home building construction practices. The NAHB standards, expected to be finalized by the end of 2008, will provide a voluntary green home building standard that can be adopted by local green home building programs or local building departments.

## Utility Programs

### Arizona

Arizona Public Service

- www.aps.com
  ENERGY STAR Homes: http://www.aps.com/main/green/choice/choice_8.html?source=hme
  High efficiency AC rebate program: http://www.aps.com/main/green/choice/choice_3.html
  Solar programs: http://www.aps.com/my_community/Solar/Solar_4.html

Salt River Project

- www.srp.net
  New Homes Programs: SRP Powerwise Homes:
  http://www.srpnet.com/energy/powerwise/homes.aspx
  Solar programs : SRP Earthwise Solar Energy
  http://www.srpnet.com/environment/earthwise/solar/default.aspx

Southwest Gas

- Energy Advantage Plus and ENERGY STAR New Homes programs
  http://www.swgas.com/natgasbuild/energyfaq.php

Tucson Electric Power

- www.tep.com
  New homes program: Guarantee home program: http://www.tep.com/Home/guaranteehome/

- Solar programs: SunShare: http://greenwatts.com/pages/sunshare.html

Unisource Energy Services

- Solar programs (SunShare):
  http://www.uesaz.com/Community/Environment/greenwatts/sunshare.asp

### California

- California New Solar Homes Partnership
  http://www.gosolarcalifornia.ca.gov/nshp/index.html

- California New Homes Program
  http://www.californiaenergyefficiency.com/sce/2505.pdf

- Sacramento Municipal Utility District
  http://www.smud.org/residential/saving/zeroenergyhomes.html

## Colorado

- Aquila
  http://www.aquila.com/
  PV rebate program: http://pv.aquilaprograms.com/

- Xcel Energy
  www.xcelenergy.com
  Solar rewards program:
  http://www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-2_39014_40262-23075-2_77_158-0,00.html

  Residential rebates and incentive programs:
  Overview: http://www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-2_738-316-2_77_158-0,00.html
  Home cooling: http://www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-2_738_36614-33562-2_77_158-0,00.html

- Colorado Springs Utilities
  ENERGY STAR New Homes Incentive
  http://www.csu.org/environment/conservation_bus/energy/page11899.html

- City of Fort Collins Utilities (municipal)
  www.fcgov.org, and Colorado New Home Choices: http://www.coloradonewhomechoices.org/

## Nevada

- Nevada Power and Sierra Pacific Power
  www.nevadapower.com and www.sierrapacific.com
  Residential solar PV Incentives:
  (applications open while 2007 program revisions are being made)
  http://www.solargenerations.com/

- Nevada ENERGY STAR Homes
  http://www.nevadaenergystarhomes.com/

## New Mexico

- Public Service Company of New Mexico (PNM)
  www.pnm.com

  Residential solar PV program
  http://www.pnm.com/customers/pv/program.htm

### Utah

- Rocky Mountain Power – ENERGY STAR New Homes Program
  http://www.utahenergystar.com/

- Questar Gas – Thermwise Program for New Homes
  http://www.thermwise.com

## State Government

### Arizona

- Arizona Department of Commerce. State Energy Office. Residential Building Science Program.
  http://www.azcommerce.com/Energy/Residential+Building+Science.htm

### California

- California Energy Commission.  New Solar Homes Program
  http://www.gosolarcalifornia.ca.gov/nshp/index.html

- California Public Utilities Commission, Energy Efficiency Programs
  Energy Efficiency goals, programs and utility requirements:
  http://www.cpuc.ca.gov/static/energy/electric/energy+efficiency/index.htm
  Utility rebates for new homes:
  http://www.cpuc.ca.gov/static/energy/electric/energy+efficiency/programs.htm

### Colorado

- Governor's Energy Office, Residential New Construction Programs
  http://www.colorado.gov/energy/residential/new.asp

- Building Professionals Energy Resource
  http://www.buildingenergyinfo.org/

### Nevada

- Nevada Energy Office
  New homes programs: http://energy.state.nv.us/efficiency/residential/newconstruction.htm

### New Mexico

- Energy, Minerals and Natural Resource Division (State Energy Office)
  http://www.emnrd.state.nm.us/main/index.htm

- Green building programs:
  http://www.emnrd.state.nm.us/ecmd/GreenBuildingTaskForce/GreenBuildingTaskForce.htm

- Sustainable building tax credit, new homes
  http://www.emnrd.state.nm.us/ecmd/index.htm, and
  http://www.emnrd.state.nm.us/ecmd/NMSustainableBuildingTaxCredit.htm

- Solar tax credits:
  http://www.emnrd.state.nm.us/ecmd/SolarTaxCredits/SolarTaxCredits.htm

**Utah**

- Utah Energy Office
  http://energy.utah.gov/energy/

## Local Government Programs

Albuquerque, NM
http://www.cabq.gov/sustainability/green-goals/green-building/green-building-page

Austin, Texas
The City of Austin Texas adopted the nation's first 'zero energy homes' building ordinance on October 18, 2007.
http://www.ci.austin.tx.us/news/2007/zech_release.htm

Boulder, CO
Greenpoints program
http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=208&Itemid=489

Fort Collins, CO, High Performance Homes Project
http://www.eere.energy.gov/state_energy_program/feature_detail_info.cfm/fid=55?print
and http://www.fcgov.com/utilities/powertosave/performancestudy.php

Saint George, Utah
http://www.dsireusa.org/library/includes/GenericIncentive.cfm?Incentive_Code=UT16F&currentpageid=3&EE=1&RE=1

Scottsdale, Arizona
Green building program
http://www.scottsdaleaz.gov/greenbuilding/

## High Performance Demonstration Homes and Communities

### Arizona

- Civano
  http://www.civanoneighbors.com

- Armory Park Del Sol, John Wesley Miller Homes
  www.armoryparkdelsol.com

### California

- Clarum Homes
  - Borrego Springs, CA
    - Project information: http://www.clarumzeroenergy.com
    - Background Presentation: http://www.csuchico.edu/sustainablefuture/events/2006conference/presentations/BorregoSprings.pdf
    - Case studies: http://www.bira.ws/projects/files/Clarum_BorregoSprings.pdf
    - Monitoring data and performance evaluations: http://www.bira.ws/projects/borregosprings.php
  - Vista Montana, Watsonville, California
    - fact sheet: http://www.eere.energy.gov/buildings/info/documents/pdfs/35305.pdf
    - Case study: http://www.bira.ws/files/BA_Clarum_CS.pdf
- The Grupe Company. GrupeGreen Homes at Carsten Crossings, Sacramento, CA.
  http://www.grupe.com/communities/carsten/index.cfm
- Premier Homes. Premier Gardens, Sacramento, California
    - Case studies: http://www.bira.ws/projects/premiergardens.php
    - Peak demand analysis (presentation): http://www.aceee.org/conf/mt06/con1b-ceniceros.pdf
- Shea Homes, San Diego, CA
  - www.sheahomes.com

- Large-Production Home Builder Experience with Zero Energy Homes (article): http://www.toolbase.org/PDF/CaseStudies/ZEH_NRELfarhar1.pdf
- A New Market Paradigm for Zero-Energy Homes: the Comparative San Diego Case Study (research report): http://www.nrel.gov/docs/fy07osti/38304-01.pdf

- Treasure Homes, Fallen Leaf at Riverbend, Sacramento, C A
  http://www.treasurehomes.com/leaf.html

### Colorado

- Aspen Homes, Loveland, CO
    - performance evaluations: http://www.ibacos.com/pubs/Reports/KAAX-3-33410-06.A.4-performance%20Evaluations%2050%20to%2060_BA.pdf, and http://www.ibacos.com/pubs/Systems%20for%2030%25%20Whole%20House%20Energy%20Savings.pdf

- Harvard Communities, Stapleton, CO
  www.harvardcommunities.com

- McStain Neighborhoods
  http://www.mcstain.com/VFSK/Files43847.id?ResponseForwardingTechnique=close

- Solar Village Homes
  http://www.solarvillagelife.com/

- For additional builders, see: the Built Green Colorado Web site:
  http://www.builtgreen.org/

### Nevada

- Pinnacle Homes, The Vinings
  Overview: http://www.consol.ws/zeh_pdfs/PinnacleHomes_TheVinings.pdf
  Design and construction: http://www.bira.ws/projects/files/7th_bimonthly_report_05-31-05.pdf
  Performance evaluation: http://www.bira.ws/projects/files/12D3_Pinnacle_Research_Paper.pdf
  Real-time monitoring data: http://www.zeh.unlv.edu/energy_saving.html

- Pulte Homes
  Case study: http://www.eere.energy.gov/buildings/building_america/pdfs/hot-dry_mixed-dry_bpg/38360_casestudyc_vol2_sept05.pdf

## New Mexico

- Artistic Homes, Albuquerque, NM
  www.artistichomes.com
  - Case study: http://www.eere.energy.gov/buildings/building_america/pdfs/hot-dry_mixed-dry_bpg/38360_casestudyb_vol2_sept05.pdf
- Oshara Village Homes, Santa Fe
  http://osharavillage.com/
- For additional builders, see the Build Green New Mexico Web site, at:
  www.buildgreennm.org

## Utah

- Watt Homes (acquired by Richmond American Homes in 2002)
  http://www.swenergy.org/casestudies/utah/watthomes.htm, and
  http://www.toolbase.org/Home-Building-Topics/Energy-Efficiency/Watt-Homes-Utah

  Ence Homes
  http://www.encehomes.com/epanational_builder
- Aaron Needham Homes
  www.needhamhomesinc.com
- For additional Utah builders, see the Utah ENERGY STAR Web site, at:
  http://www.utahenergystar.org/builders_list.html

# APPENDIX A

## HOME ENERGY AND ECONOMIC ANALYSIS SUMMARY TABLES

Table A-1. Annual Energy Consumption, Energy Cost and % Savings by State and Home Performance Level

**Arizona**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 14,881 | 373 | 225 | | | $ 2,484 | |
| ENERGY STAR | 11,456 | 304 | 167 | 27% | | $ 1,868 | 25% |
| EE Best Practice | 9,480 | 335 | 129 | 43% | | $ 1,377 | 45% |
| Zero Energy Home | 9,480 | 275 | 97 | 46% | | $ 1,281 | 48% |
| Zero Energy Home - Net | (801) | | 109 | 56% | 2,611 | $ 1,022 | 59% |

**Colorado**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 11,305 | 1415 | 266 | | | $ 2,577 | |
| ENERGY STAR | 8,694 | 1062 | 202 | 24% | | $ 1,954 | 24% |
| EE Best Practice | 7,758 | 744 | 159 | 40% | | $ 1,530 | 41% |
| Zero Energy Home | 7,872 | 639 | 150 | 44% | | $ 1,217 | 53% |
| Zero Energy Home - Net | 5,661 | 639.2 | 126 | 50% | 2,211 | $ 1,004 | 61% |

**Nevada (Las Vegas)**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 19,862 | 659 | 281 | | | $ 2,742 | |
| ENERGY STAR | 15,192 | 288 | 198 | 30% | | $ 1,980 | 28% |
| EE Best Practice | 10,586 | 709 | 147 | 48% | | $ 1,418 | 48% |
| Zero Energy Home | 10,375 | 288 | 141 | 50% | | $ 1,020 | 63% |
| Zero Energy Home - Net | 7,760 | 288 | 113 | 60% | 2,528 | $ 719 | 74% |

**Nevada (Reno)**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 10,085 | 1030 | 214 | | | $ 2,405 | |
| ENERGY STAR | 8,746 | 844 | 180 | 36% | | 2027 | 16% |
| EE Best Practice | 7,892 | 717 | 158 | 44% | | $ 1,775 | 12% |
| Zero Energy Home | 8,009 | 611 | 149 | 47% | | $ 1,380 | 22% |
| Zero Energy Home - Net | 5,568 | 611 | 122 | 56% | 2,441 | $ 1,099 | 20% |

**New Mexico**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 12,534 | 1108 | 248 | | | $ 2,665 | |
| ENERGY STAR | 9,400 | 786 | 182 | 27% | | $ 1,741 | 35% |
| EE Best Practice | 7,986 | 527 | 140 | 44% | | $ 1,418 | 47% |
| Zero Energy Home | 11,081 | 481 | 135 | 46% | | $ 1,325 | 50% |
| Zero Energy Home - Net | 8,470 | 481.3 | 107 | 57% | 2,607.00 | $ 986 | 63% |

**Utah**

| Home Performance Level | Electricity (kWh) | Natural Gas (therms) | Source energy (MBTUs) | % Energy Savings | PV Output (kWh) | Annual Energy Cost | % Energy Cost Savings |
|---|---|---|---|---|---|---|---|
| Code | 12,310 | 1362 | 272 | | | $ 2,563 | |
| ENERGY STAR | 9,420 | 1003 | 204 | 25% | | $ 1,918 | 25% |
| EE Best Practice | 8,271 | 709 | 162 | 41% | | $ 1,495 | 42% |
| Zero Energy Home | 8,384 | 617 | 153 | 44% | | $ 1,404 | 45% |
| Zero Energy Home - Net | 6,130 | 616.7 | 129 | 53% | 2,254.00 | $ 1,209 | 53% |

Table A-2. Electricity, natural gas and total source energy savings (MBTU) (% savings), by state and home performance level

| **State** | ***Electricity savings (%)*** | | | ***Natural Gas savings (%)*** | | | ***MBTU savings (%)*** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **ENERGY STAR** | **Best Practice** | **ZEH - Net** | **ENERGY STAR** | **Best Practice** | **ZEH - Net** | **ENERGY STAR** | **Best Practice** | **ZEH - Net** |
| Arizona | 24% | 38% | 54% | 31% | 37% | 47% | 24% | 40% | 53% |
| Colorado | 23% | 31% | 50% | 25% | 47% | 55% | 25% | 41% | 51% |
| Nevada | 20% | 38% | 55% | 33% | 16% | 45% | 16% | 26% | 41% |
| New Mexico | 25% | 36% | 57% | 29% | 52% | 57% | 27% | 44% | 57% |
| Utah | 23% | 33% | 50% | 26% | 48% | 53% | 27% | 43% | 56% |
| Region | 23% | 36% | 54% | 28% | 43% | 52% | 26% | 43% | 57% |

Notes: Electricity savings for the zero energy home are shown as net (grid electricity consumption minus on-site electricity generated from solar PV). MBTU savings shows the % savings in energy consumption for electricity and natural gas, and includes electricity generated by on-site solar PV.

Table A-3. Homeowner cash flow analysis by city and home performance level

**SWEEP High Performance Homes: Incremental cost - cash flow analysis by city and state**

| Phoenix, AZ | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2642 | | 18,998 | 1,583 | | |
| ESTAR | 3,218 | $ 253,218 | 16,566 | 1880 | 762 | 18,446 | 1,537 | $552 | $ 46 |
| Best Practice | 3,474 | $ 253,474 | 16,582 | 1469 | 1173 | 18,051 | 1,504 | $946 | $ 79 |
| ZEH | 15,210 | $ 265,210 | 17,350 | 880 | 1763 | 18,230 | 1,519 | $767 | $ 64 |

| Denver, CO | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2577 | | 18,932 | 1,578 | | |
| ESTAR | 2,917 | $ 252,917 | 16,546 | 1954 | 623 | 18,500 | 1,542 | $432 | $ 36 |
| Best Practice | 6,588 | $ 256,588 | 16,786 | 1530 | 1047 | 18,316 | 1,526 | $616 | $ 51 |
| ZEH | 19,895 | $ 269,895 | 17,657 | 1004 | 1573 | 18,661 | 1,555 | $271 | $ 23 |

| Las Vegas, NV | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2742 | | 19,097 | 1,591 | | |
| ESTAR | 3,236 | $ 253,236 | 16,567 | 1980 | 762 | 18,547 | 1,546 | $550 | $ 46 |
| Best Practice | 5,547 | $ 255,547 | 16,718 | 1418 | 1324 | 18,136 | 1,511 | $961 | $ 80 |
| ZEH | 16,231 | $ 266,231 | 17,417 | 719 | 2022 | 18,136 | 1,511 | $960 | $ 80 |

| Reno, NV | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2405 | | 18,761 | 1,563 | | |
| ESTAR | 3,653 | $ 253,653 | 16,594 | 2027 | 378 | 18,621 | 1,552 | $139 | $ 12 |
| Best Practice | 5,640 | $ 255,640 | 16,724 | 1775 | 631 | 18,499 | 1,542 | $262 | $ 22 |
| ZEH | 18,491 | $ 268,491 | 17,565 | 1099 | 1307 | 18,664 | 1,555 | $97 | $ 8 |

| Albuquerque, NM | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2665 | | 19,020 | 1,585 | | |
| ESTAR | 2,464 | $ 252,464 | 16,516 | 1741 | 924 | 18,257 | 1,521 | $763 | $ 64 |
| Best Practice | 5,539 | $ 255,539 | 16,718 | 1418 | 1247 | 18,136 | 1,511 | $884 | $ 74 |
| ZEH | 16,629 | $ 266,629 | 17,443 | 743 | 1922 | 18,186 | 1,515 | $834 | $ 70 |

| Salt Lake, UT | Incremental Cost | Mortgage + EE cost | Mortgage Payment | Energy Bill | Bill Savings | Mortgage + Energy Bill | Monthly | Net Savings, Annual | Net Savings, Monthly |
|---|---|---|---|---|---|---|---|---|---|
| Ref Case | 0 | $ 250,000 | 16,355 | 2563 | | 18,918 | 1,576 | | |
| ESTAR | 3,218 | $ 253,218 | 16,566 | 1918 | 644 | 18,484 | 1,540 | $434 | $ 36 |
| Best Practice | 6,588 | $ 256,588 | 16,786 | 1495 | 1067 | 18,281 | 1,523 | $636 | $ 53 |
| ZEH | 19,895 | $ 269,895 | 17,657 | 1014 | 1549 | 18,670 | 1,556 | $247 | $ 21 |

## Table A-4. Arizona results: Measures and Incremental Costs

**BEopt Measures and Incremental Costs: Salt Lake City, Utah**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | Measure | Measure | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. + 1" foam | R13 batts 2x4 16"o.c. + 1" foam | $0 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 |
| | Ceiling | R40 Fiberglass | R40 Fiberglass | $0 | R50 Fiberglass | $468 | R50 Fiberglass | $468 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $52 | 5/8" Ceiling Drywall | $52 |
| | Infiltration | Typical | Tight | $1,890 | Tight | $1,890 | Tight | $1,890 |
| Foundation | | | | | | | | |
| | Slab | No Slab | No Slab | $0 | No Slab | $0 | No Slab | $0 |
| | Basement | 4ft R10 Exterior | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas | 18.0% F20 B40 L20 R20 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e v. high SHGC | Low-e std. SHGC | $0 | Low-e low SHGC arg | $0 | Low-e low SHGC arg | $0 |
| | Eaves | No eaves | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard (V-Axis) | Standard (V-Axis) | $0 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 0% CFL | 30% CFL | $53 | 50% CFL | $88 | 50% CFL | $88 |
| | Plug-in Lighting | 0% CFL | 10% CFL | $4 | 50% CFL | $18 | 50% CFL | $18 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 13 | $0 | SEER 14 | $152 | SEER 14 | $152 |
| | Furnace | AFUE 80% | AFUE 92.5% | $294 | AFUE 92.5% | $294 | AFUE 92.5% | $294 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Gas Standard | Gas Standard | $175 | Gas Tankless | $739 | Gas Premium | $175 |
| | Ducts | Typical | Improved | $840 | Inside | $1,120 | Inside | $1,120 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 40 sq ft closed loop | $4,307 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | South | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | West | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 3.5 tons (3.28 tons) | 2.5 tons (2.28 tons) | ($400) | 2.0 tons (1.79 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) |
| | Heating Capacity | 90 kBtu/hr (82.21 kBtu/hr) | 60 kBtu/hr (57.34 kBtu/hr) | ($100) | 50 kBtu/hr (46.47 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $2,946 | Best Practice | $6,588 | Zero Energy Home | $25,331 |

Notes:
(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.
This credit for system downsizing is consistent with other Building America estimates of system downsizing credits.
(2) The ZEH level includes a small (2%) reduction in window area, which lowers cooling gains, and overall costs.

Table A-5. Energy and economic analysis, Arizona

| Arizona Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of homes by type | **2008 - 2020, cumulative** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| *Reference case* | | | | | | | | | | | | | | |
| Code (2003 IECC) | **424,304** | 27,851 | 28,576 | 29,319 | 30,081 | 30,863 | 31,665 | 32,489 | 33,333 | 34,200 | 35,089 | 36,002 | 36,938 | 37,898 |
| ENERGY STAR | **228,471** | 14,997 | 15,387 | 15,787 | 16,197 | 16,619 | 17,051 | 17,494 | 17,949 | 18,415 | 18,894 | 19,385 | 19,890 | 20,407 |
| *High performance homes scenario* | | | | | | | | | | | | | | |
| Code | **221,076** | 26,039 | 24,856 | 23,594 | 22,249 | 20,819 | 19,299 | 17,686 | 15,976 | 14,166 | 12,250 | 10,225 | 8,087 | 5,830 |
| ENERGY STAR | **283,897** | 15,491 | 16,401 | 17,348 | 18,333 | 19,358 | 20,423 | 21,531 | 22,683 | 23,879 | 25,123 | 26,415 | 27,758 | 29,152 |
| EE Best Practice | **73,901** | 659 | 1,353 | 2,082 | 2,848 | 3,652 | 4,497 | 5,383 | 6,312 | 7,285 | 8,305 | 9,373 | 10,491 | 11,661 |
| Zero Energy Home | **73,901** | 659 | 1,353 | 2,082 | 2,848 | 3,652 | 4,497 | 5,383 | 6,312 | 7,285 | 8,305 | 9,373 | 10,491 | 11,661 |
| Total | 652,775 | 42,848 | 43,963 | 45,106 | 46,278 | 47,482 | 48,716 | 49,983 | 51,282 | 52,616 | 53,984 | 55,387 | 56,827 | 58,305 |

| ***Energy analysis*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Electricity (GWh)** | | | | | | | | | | | | | | |
| Reference case | **9,996** | 656 | 673 | 691 | 709 | 727 | 746 | 765 | 785 | 806 | 827 | 848 | 870 | 893 |
| High performance scenario | **8,838** | 646 | 652 | 658 | 664 | 670 | 676 | 681 | 686 | 691 | 696 | 701 | 706 | 710 |
| annual savings, GWh | **1,159** | 10 | 21 | 33 | 45 | 57 | 71 | 84 | 99 | 114 | 130 | 147 | 164 | 183 |
| electricity generated by PV (GWh) | **193** | 2 | 4 | 5 | 7 | 10 | 12 | 14 | 16 | 19 | 22 | 24 | 27 | 30 |
| peak electric demand, annual savings, MW | **592** | 5.3 | 10.8 | 16.7 | 22.8 | 29.2 | 36.0 | 43.1 | 50.5 | 58.3 | 66.5 | 75.1 | 84.0 | 93.4 |
| | | | | | | | | | | | | | | |
| **Natural Gas (therms, millions)** | | | | | | | | | | | | | | |
| Reference case | **252** | 16.5 | 17.0 | 17.4 | 17.9 | 18.3 | 18.8 | 19.3 | 19.8 | 20.3 | 20.8 | 21.4 | 21.9 | 22.5 |
| High performance scenario | **218** | 16.2 | 16.3 | 16.4 | 16.5 | 16.6 | 16.7 | 16.8 | 16.9 | 16.9 | 17.0 | 17.0 | 17.1 | 17.1 |
| annual savings | **34** | 0.3 | 0.6 | 1.0 | 1.3 | 1.7 | 2.1 | 2.5 | 2.9 | 3.4 | 3.8 | 4.3 | 4.8 | 5.4 |
| | | | | | | | | | | | | | | |
| **Total source energy (MMBTUs)** | | | | | | | | | | | | | | |
| Reference case | **136** | 8.9 | 9.1 | 9.4 | 9.6 | 9.9 | 10.1 | 10.4 | 10.6 | 10.9 | 11.2 | 11.5 | 11.8 | 12.1 |
| High performance scenario | **115** | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 8.8 | 8.9 | 8.9 | 8.9 | 8.9 | 8.8 | 8.8 | 8.8 |
| annual savings, | **21** | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.3 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 |
| % savings | 15% | 2% | 4% | 6% | 8% | 11% | 13% | 15% | 17% | 19% | 21% | 23% | 25% | 27% |

| ***Economic analysis*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity cost savings, annual (million $) | **115** | 1.0 | 2.1 | 3.2 | 4.4 | 5.7 | 7.0 | 8.4 | 9.8 | 11.3 | 12.9 | 14.6 | 16.3 | 18.2 |
| Natural gas cost savings, annual (million $) | **41** | 0.4 | 0.8 | 1.2 | 1.6 | 2.0 | 2.5 | 3.0 | 3.5 | 4.1 | 4.6 | 5.2 | 5.9 | 6.5 |
| Total energy cost savings, annual (million $) | **156** | 1.4 | 2.9 | 4.4 | 6.0 | 7.7 | 9.5 | 11.4 | 13.3 | 15.4 | 17.6 | 19.8 | 22.2 | 24.7 |
| | | | | | | | | | | | | | | |
| Total EE investment w/ discounting (million 2008 $) | **401** | 5 | 10 | 15 | 20 | 24 | 28 | 32 | 36 | 39 | 43 | 46 | 49 | 51 |
| Total EE and PV investment w/ discounting (million 2008 $) | **1,034** | 14 | 27 | 40 | 52 | 63 | 73 | 83 | 93 | 102 | 110 | 118 | 126 | 133 |
| | | | | | | | | | | | | | | |
| Net present value, EE measures (millions 2008 $) | **1,296** | 17 | 34 | 50 | 65 | 79 | 92 | 105 | 117 | 128 | 138 | 148 | 158 | 167 |
| Net present value, all measures (millions 2008 $) | **1,455** | 20 | 38 | 56 | 72 | 88 | 103 | 117 | 131 | 143 | 155 | 167 | 177 | 187 |
| | | | | | | | | | | | | | | |
| Benefit-cost ratio: EE measures | | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| Benefit-cost ratio: all measures | | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |

## Table A-6. Measures and incremental costs, Colorado

**BEopt Measures and Incremental Costs: Denver, Colorado**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | | Measure | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. | R13 batts 2x4 16"o.c. | $0 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 |
| | Ceiling | R40 Fiberglass | R40 Fiberglass | $0 | R50 Fiberglass | $468 | R50 Fiberglass | $468 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $52 | 5/8" Ceiling Drywall | $52 |
| | Infiltration | Typical | Tight | $1,890 | Tight | $1,890 | Tight | $1,890 |
| Foundation | | | | | | | | |
| | Slab | No Slab | No Slab | $0 | No Slab | $0 | No Slab | $0 |
| | Basement | 4ft R10 Exterior | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas | 18.0% F20 B40 L20 R20 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e v. high SHGC (U=.35, SHGC=.51) | Low-e std. SHGC (U=.31, SHGC=.302) | $0 | Low-e low SHGC argon (U=.285, SHGC = .26) | $0 | Low-e low SHGC argon (U=.285, SHGC = .26) | $0 |
| | Eaves | No eaves | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard (V-Axis) | Standard (V-Axis) | $0 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 0% CFL | 30% CFL | $53 | 50% CFL | $88 | 50% CFL | $88 |
| | Plug-in Lighting | 0% CFL | 10% CFL | $4 | 50% CFL | $18 | 50% CFL | $18 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 13 | $0 | SEER 14 | $152 | SEER 14 | $152 |
| | Furnace | AFUE 80% | AFUE 92.5% | $294 | AFUE 92.5% | $294 | AFUE 92.5% | $294 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Gas Standard | Gas Standard | $0 | Gas Tankless | $739 | Gas Premium | $175 |
| | Ducts | Typical | Improved | $840 | Inside | $1,120 | Inside | $1,120 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 40 sq ft closed loop | $4,307 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 3.5 tons (3.29 tons) | 2.5 tons (2.20 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) |
| | Heating Capacity | 90 kBtu/hr (86.62 kBtu/hr) | 60 kBtu/hr (58.99 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $2,771 | Best Practice | $6,588 | Zero Energy Home | $25,331 |

Notes:

(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.

The estimated downsizing generated by the model is provided for comparison of the effects of each performance level on system size. This credit for system downsizing is consistent with other Building America estimates of system downsizing.

(2) The ZEH level includes a small (2%) reduction in window area, which lowers cooling gains, and overall costs.

## Table A-7. Energy and economic analysis, Colorado

| Colorado Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of homes by type | 2008 - 2020, cumulative | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| *Reference case* | | | | | | | | | | | | | | |
| Code (2003 IECC) | 399,335 | 27,035 | 27,603 | 28,182 | 28,774 | 29,379 | 29,995 | 30,625 | 31,269 | 31,925 | 32,596 | 33,280 | 33,979 | 34,693 |
| ENERGY STAR | 21,018 | 1,423 | 1,453 | 1,483 | 1,514 | 1,546 | 1,579 | 1,612 | 1,646 | 1,680 | 1,716 | 1,752 | 1,788 | 1,826 |
| *High performance homes scenario* | | | | | | | | | | | | | | |
| Code | 198,956 | 25,174 | 23,803 | 22,363 | 20,853 | 19,269 | 17,609 | 15,871 | 14,052 | 12,150 | 10,161 | 8,084 | 5,915 | 3,652 |
| ENERGY STAR | 127,101 | 2,408 | 3,464 | 4,564 | 5,708 | 6,899 | 8,136 | 9,423 | 10,760 | 12,150 | 13,592 | 15,091 | 16,646 | 18,259 |
| EE Best Practice | 47,148 | 438 | 894 | 1,369 | 1,864 | 2,379 | 2,915 | 3,472 | 4,051 | 4,653 | 5,279 | 5,928 | 6,603 | 7,304 |
| Zero Energy Home | 47,148 | 438 | 894 | 1,369 | 1,864 | 2,379 | 2,915 | 3,472 | 4,051 | 4,653 | 5,279 | 5,928 | 6,603 | 7,304 |
| Total | 420,353 | 28,458 | 29,056 | 29,666 | 30,289 | 30,925 | 31,574 | 32,237 | 32,914 | 33,605 | 34,311 | 35,032 | 35,767 | 36,518 |
| | | | | | | | | | | | | | | |
| ***Energy analysis*** | | | | | | | | | | | | | | |
| **Electricity (GWh)** | | | | | | | | | | | | | | |
| Reference case | 4,697 | 318 | 325 | 331 | 338 | 346 | 353 | 360 | 368 | 376 | 383 | 391 | 400 | 408 |
| High performance scenario | 4,091 | 312 | 313 | 314 | 314 | 315 | 315 | 316 | 316 | 316 | 316 | 315 | 315 | 314 |
| annual savings, GWh | 606 | 6 | 11 | 18 | 24 | 31 | 37 | 45 | 52 | 60 | 68 | 76 | 85 | 94 |
| electricity generated by PV (GWh) | 104 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 12 | 13 | 15 | 16 |
| peak electric demand, annual savings, MW | 261 | 2.4 | 5.0 | 7.6 | 10.3 | 13.2 | 16.1 | 19.2 | 22.4 | 25.8 | 29.2 | 32.8 | 36.6 | 40.5 |
| | | | | | | | | | | | | | | |
| **Natural Gas (therms, millions)** | | | | | | | | | | | | | | |
| Reference case | 587 | 39.8 | 40.6 | 41.5 | 42.3 | 43.2 | 44.1 | 45.0 | 46.0 | 47.0 | 47.9 | 49.0 | 50.0 | 51.0 |
| High performance scenario | 482 | 38.8 | 38.6 | 38.4 | 38.1 | 37.9 | 37.6 | 37.3 | 36.9 | 36.5 | 36.1 | 35.7 | 35.2 | 34.7 |
| annual savings | 106 | 1.0 | 2.0 | 3.1 | 4.2 | 5.3 | 6.5 | 7.8 | 9.1 | 10.4 | 11.8 | 13.3 | 14.8 | 16.4 |
| | | | | | | | | | | | | | | |
| **Total source energy (MMBTUs)** | | | | | | | | | | | | | | |
| Reference case | 110 | 7.5 | 7.6 | 7.8 | 8.0 | 8.1 | 8.3 | 8.5 | 8.6 | 8.8 | 9.0 | 9.2 | 9.4 | 9.6 |
| High performance scenario | 92 | 7.3 | 7.3 | 7.3 | 7.2 | 7.2 | 7.2 | 7.1 | 7.1 | 7.0 | 7.0 | 6.9 | 6.8 | 6.7 |
| annual savings, | 18 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.6 | 1.8 | 2.1 | 2.3 | 2.6 | 2.9 |
| % savings | 17% | 2% | 5% | 7% | 9% | 11% | 14% | 16% | 18% | 21% | 23% | 25% | 27% | 30% |
| | | | | | | | | | | | | | | |
| ***Economic analysis*** | | | | | | | | | | | | | | |
| Electricity cost savings, annual (million $) | 58 | 0.5 | 1.1 | 1.7 | 2.3 | 3.0 | 3.6 | 4.3 | 5.0 | 5.8 | 6.5 | 7.4 | 8.2 | 9.1 |
| Natural gas cost savings, annual (million $) | 111 | 1.0 | 2.1 | 3.2 | 4.4 | 5.6 | 6.9 | 8.2 | 9.5 | 11.0 | 12.4 | 14.0 | 15.5 | 17.2 |
| Total energy cost savings, annual (million $) | 169 | 1.6 | 3.2 | 4.9 | 6.7 | 8.6 | 10.5 | 12.5 | 14.6 | 16.7 | 19.0 | 21.3 | 23.7 | 26.3 |
| | | | | | | | | | | | | | | |
| Total EE investment w/ discounting (million 2008 $) | 443 | 6 | 12 | 17 | 23 | 27 | 32 | 36 | 40 | 44 | 47 | 50 | 53 | 56 |
| Total EE and PV investment w/ discounting (million 2008 $) | 974 | 14 | 26 | 38 | 50 | 60 | 70 | 79 | 88 | 96 | 103 | 110 | 117 | 123 |
| | | | | | | | | | | | | | | |
| Net present value, EE measures (millions 2008 $) | 1,409 | 20 | 38 | 56 | 72 | 87 | 101 | 115 | 127 | 139 | 149 | 159 | 169 | 177 |
| Net present value, all measures (millions 2008 $) | 1,493 | 21 | 40 | 59 | 76 | 92 | 107 | 121 | 135 | 147 | 158 | 169 | 179 | 188 |
| | | | | | | | | | | | | | | |
| Benefit-cost ratio: EE measures | | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| Benefit-cost ratio: all measures | | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |

# Table A-8. Measures and incremental costs, Las Vegas, Nevada

**BEopt Measures and Incremental Costs: Las Vegas, Nevada**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | | Measure | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. | R13 batts 2x4 16"o.c. | $0 | R19 batts 2x6 24"o.c. + 1" foam | $1,006 | R19 batts 2x6 24"o.c. | $1,368 |
| | Ceiling | R30 Fiberglass | R30 Fiberglass | $0 | R30 Fiberglass | $0 | R30 Fiberglass | $0 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $48 | 5/8" Ceiling Drywall | $48 |
| | Infiltration | Typical | Tight | $1,296 | Tight | $1,296 | Tight | $1,296 |
| Foundation | | | | | | | | |
| | Slab | Uninsulated | Uninsulated | $0 | Uninsulated | $0 | Uninsulated | $0 |
| | Basement | No Basement | No Basement | $0 | No Basement | $0 | No Basement | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas (2) | 18.0% F25 B25 L25 R25 | 18.0% F25 B25 L25 R25 | $0 | 18.0% F20 B40 L20 R20 | $0 | 16.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e std. SHGC | Low-e std. SHGC | $1,089 | Low-e std. SHGC | $1,089 | Low-e std. SHGC | $321 |
| | Eaves | No eaves | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Electric | Electric | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard (V-Axis) | EnergyStar (H-Axis) | $380 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 0% CFL | 30% CFL | $53 | 50% CFL | $88 | 50% CFL | $88 |
| | Plug-in Lighting | 10% CFL | 10% CFL | $0 | 50% CFL | $14 | 50% CFL | $14 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 14 | $152 | SEER 15 | $304 | SEER 15 | $304 |
| | Furnace | AFUE 80% | AFUE 80% | $0 | AFUE 80% | $0 | AFUE 80% | $0 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Electric Standard | Electric Standard | $0 | Gas Tankless | $864 | Gas Premium | $300 |
| | Ducts | Typical | Improved | $576 | Inside | $768 | Inside | $768 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 32 sq ft ICS | $2,654 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 5.0 tons (5.37 tons) | 4.0 tons (3.94 tons) | ($400) | 2.5 tons (2.47 tons) | ($400) | 2.5 tons (2.37 tons) | ($400) |
| | Heating Capacity | 120 kBtu/hr (117.33 kBtu/hr) | 80 kBtu/hr (78.80 kBtu/hr) | ($100) | 60 kBtu/hr (56.08 kBtu/hr) | ($100) | 60 kBtu/hr (53.93 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $3,236 | Best Practice | $5,547 | Zero Energy Home | $22,231 |

Notes:

(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.
This credit for system downsizing is consistent with other Building America estimates of system downsizing credits.

(2) The ZEH level includes a small (2%) reduction in window area, which lowers cooling gains, and overall costs.

## Table A-9. Measures and incremental costs, Reno, Nevada

**BEopt Measures and Incremental Costs: Reno, Nevada**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F w/ setback 65 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. + 1" foam | R13 batts 2x4 16"o.c. + 1" foam | $0 | R19 batts 2x6 24"o.c. + 1" foam | $95 | R19 batts 2x6 24"o.c. + 1" foam | $95 |
| | Ceiling | R40 Fiberglass | R40 Fiberglass | $0 | R40 Fiberglass | $0 | R40 Fiberglass | $0 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $52 | 5/8" Ceiling Drywall | $52 |
| | Infiltration | Typical | Tight | $1,890 | Tight | $1,890 | Tight | $1,890 |
| Foundation | | | | | | | | |
| | Slab | No Slab | No Slab | $0 | No Slab | $0 | No Slab | $0 |
| | Basement | 4ft R10 Exterior | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas | 18.0% F20 B40 L20 R20 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e v. high SHGC | Low-e std. SHGC | $0 | Low-e low SHGC | $0 | Low-e low SHGC | $0 |
| | Eaves | No eaves | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard (V-Axis) | Standard (V-Axis) | $0 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 10% CFL | 20% CFL | $18 | 50% CFL | $71 | 50% CFL | $71 |
| | Plug-in Lighting | 10% CFL | 10% CFL | $0 | 50% CFL | $14 | 50% CFL | $14 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 13 | $0 | SEER 14 | $152 | SEER 14 | $152 |
| | Furnace | AFUE 80% | AFUE 92.5% | $294 | AFUE 92.5% | $294 | AFUE 92.5% | $294 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Gas Standard | Gas Standard | $0 | Gas Tankless | $739 | Gas Premium | $175 |
| | Ducts | Typical | Improved | $840 | Inside | $1,120 | Inside | $1,120 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 40 sq ft closed loop | $4,307 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 3.5 tons (3.42 tons) | 2.5 tons (2.33 tons) | ($400) | 2.0 tons (1.91 tons) | ($400) | 2.0 tons (1.91 tons) | ($400) |
| | Heating Capacity | 90 kBtu/hr (84.95 kBtu/hr) | 60 kBtu/hr (59.34 kBtu/hr) | ($100) | 50 kBtu/hr (49.54 kBtu/hr) | ($100) | 50 kBtu/hr (49.54 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $2,732 | Best Practice | $4,497 | Zero Energy Home | $23,240 |

Notes:
(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.
This credit for system downsizing is consistent with other Building America estimates of system downsizing credits.
(2) The ZEH level includes a small (2%) reduction in window area, which lowers cooling gains, and overall costs.

Table A-10. Energy and economic analysis, Nevada

| Nevada Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of homes by type | 2008 - 2020, cumulative | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| *Reference case* | | | | | | | | | | | | | | |
| Code (2003 IECC) | **121,153** | 7,333 | 7,619 | 7,916 | 8,224 | 8,545 | 8,878 | 9,225 | 9,584 | 9,958 | 10,347 | 10,750 | 11,169 | 11,605 |
| ENERGY STAR | **296,616** | 17,952 | 18,652 | 19,380 | 20,136 | 20,921 | 21,737 | 22,585 | 23,465 | 24,380 | 25,331 | 26,319 | 27,346 | 28,412 |
| *High performance homes scenario* | | | | | | | | | | | | | | |
| Code | **72,734** | 6,944 | 6,810 | 6,656 | 6,479 | 6,279 | 6,052 | 5,799 | 5,517 | 5,204 | 4,858 | 4,477 | 4,059 | 3,602 |
| ENERGY STAR | **248,197** | 17,563 | 17,844 | 18,120 | 18,390 | 18,654 | 18,911 | 19,159 | 19,398 | 19,626 | 19,842 | 20,046 | 20,235 | 20,409 |
| EE Best Practice | **48,419** | 389 | 808 | 1,260 | 1,745 | 2,267 | 2,826 | 3,426 | 4,068 | 4,755 | 5,489 | 6,273 | 7,110 | 8,003 |
| Zero Energy Home | **48,419** | 389 | 808 | 1,260 | 1,745 | 2,267 | 2,826 | 3,426 | 4,068 | 4,755 | 5,489 | 6,273 | 7,110 | 8,003 |
| Total | 417,769 | 25,285 | 26,271 | 27,295 | 28,360 | 29,466 | 30,615 | 31,809 | 33,050 | 34,339 | 35,678 | 37,069 | 38,515 | 40,017 |
| ***Energy analysis*** | | | | | | | | | | | | | | |
| **Electricity (GWh)** | | | | | | | | | | | | | | |
| Reference case | **5,377** | 325 | 338 | 351 | 365 | 379 | 394 | 409 | 425 | 442 | 459 | 477 | 496 | 515 |
| High performance scenario | **4,952** | 321 | 330 | 340 | 349 | 359 | 369 | 379 | 390 | 400 | 411 | 423 | 434 | 446 |
| annual savings, GWh | **425** | 4 | 8 | 12 | 16 | 20 | 25 | 30 | 36 | 42 | 48 | 55 | 62 | 69 |
| electricity generated by PV (GWh) | **122** | 1 | 2 | 3 | 4 | 6 | 7 | 9 | 10 | 12 | 14 | 16 | 18 | 20 |
| peak electric demand, annual savings, MW | **261** | 2.1 | 4.4 | 6.8 | 9.4 | 12.2 | 15.2 | 18.5 | 21.9 | 25.7 | 29.6 | 33.9 | 38.4 | 43.2 |
| **Natural Gas (therms, millions)** | | | | | | | | | | | | | | |
| Reference case | **271** | 16.4 | 17.1 | 17.7 | 18.4 | 19.1 | 19.9 | 20.7 | 21.5 | 22.3 | 23.2 | 24.1 | 25.0 | 26.0 |
| High performance scenario | **258** | 16.3 | 16.8 | 17.3 | 17.9 | 18.5 | 19.1 | 19.7 | 20.4 | 21.0 | 21.7 | 22.4 | 23.1 | 23.9 |
| annual savings | **13** | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 |
| **Total source energy (MMBTUs)** | | | | | | | | | | | | | | |
| Reference case | **86** | 5.2 | 5.4 | 5.6 | 5.9 | 6.1 | 6.3 | 6.6 | 6.8 | 7.1 | 7.4 | 7.7 | 8.0 | 8.3 |
| High performance scenario | **78** | 5.1 | 5.3 | 5.4 | 5.6 | 5.7 | 5.8 | 6.0 | 6.1 | 6.3 | 6.4 | 6.6 | 6.8 | 6.9 |
| annual savings, | **8** | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 | 1.2 | 1.4 |
| % savings | 10% | 2% | 3% | 4% | 5% | 6% | 8% | 9% | 10% | 11% | 13% | 14% | 15% | 16% |
| ***Economic analysis*** | | | | | | | | | | | | | | |
| Electricity cost savings, annual (million $) | **49** | 0.5 | 0.9 | 1.3 | 1.8 | 2.3 | 2.9 | 3.5 | 4.1 | 4.8 | 5.5 | 6.3 | 7.1 | 8.0 |
| Natural gas cost savings, annual (million $) | **22** | 0.3 | 0.4 | 0.6 | 0.8 | 1.1 | 1.3 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.1 | 3.4 |
| Total energy cost savings, annual (million $) | **70** | 0.7 | 1.3 | 2.0 | 2.6 | 3.4 | 4.2 | 5.0 | 5.9 | 6.9 | 7.9 | 9.0 | 10.2 | 11.4 |
| | | | | | | | | | | | | | | |
| Total EE investment w/ discounting (million 2008 $) | **184** | 2 | 4 | 7 | 9 | 11 | 13 | 14 | 16 | 18 | 20 | 22 | 23 | 25 |
| Total EE and PV investment w/ discounting (million 2008 $) | **597** | 8 | 14 | 21 | 28 | 34 | 41 | 47 | 53 | 59 | 65 | 70 | 76 | 81 |
| | | | | | | | | | | | | | | |
| Net present value, EE measures (millions 2008 $) | **583** | 9 | 16 | 22 | 28 | 34 | 40 | 46 | 52 | 57 | 62 | 67 | 72 | 77 |
| Net present value, all measures (millions 2008 $) | **699** | 11 | 19 | 26 | 34 | 41 | 48 | 55 | 62 | 68 | 75 | 81 | 87 | 93 |
| | | | | | | | | | | | | | | |
| Benefit-cost ratio: EE measures | | 4.0 | 3.6 | 3.4 | 3.3 | 3.2 | 3.2 | 3.2 | 3.2 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 |
| Benefit-cost ratio: all measures | | 1.4 | 1.3 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 |

Notes: The Nevada analysis is based on electricity and natural gas consumption averaged between the Las Vegas and Reno datasets, shown in Table A-1.

## Table A-11. Measures and incremental costs, New Mexico

**BEopt Measures and Incremental Costs: Albuquerque, New Mexico**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | | Measure | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. | R13 batts 2x4 16"o.c. | $0 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 |
| | Ceiling | R40 Fiberglass | R40 Fiberglass | $0 | R40 Fiberglass | $0 | R50 Fiberglass | $0 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $52 | 5/8" Ceiling Drywall | $52 |
| | Infiltration | Typical | Tight | $1,296 | Tight | $1,296 | Tight | $1,296 |
| Foundation | | | | | | | | |
| | Slab | 2ft R5 Perimeter R5 Gap | 2ft R5 Perimeter R5 Gap | $0 | 4ft R5 Perimeter R5 Gap | $217 | No Slab | $217 |
| | Basement | No Basement | No Basement | $0 | No Basement | $0 | 4ft R10 Exterior | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas | 18.0% F25 B25 L25 R25 | 18.0% F25 B25 L25 R25 | $0 | 18.0% F25 B25 L25 R25 | $0 | 18.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e v. high SHGC (U=.352, SHGC=.511) | Low-e low SHGC (U=.318, SHGC= .266) | $0 | Low-e low SHGC (U=.318, SHGC= .266) | $0 | Low-e low SHGC (U=.318, SHGC= .266) | $0 |
| | Eaves | | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard | EnergyStar (H-Axis) | $380 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 0% CFL | 30% CFL | $53 | 50% CFL | $88 | 50% CFL | $88 |
| | Plug-in Lighting | 0% CFL | 10% CFL | $0 | 50% CFL | $14 | 50% CFL | $14 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 13 | $0 | SEER 15 | $304 | SEER 14 | $304 |
| | Furnace | AFUE 80% | AFUE 92.5% | $294 | AFUE 92.5% | $294 | AFUE 92.5% | $294 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Gas Standard | Gas Premium | $175 | Gas Tankless | $739 | Gas Premium | $175 |
| | Ducts | Typical | Improved | $576 | Inside | $768 | Inside | $768 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 40 sq ft closed loop | $2,654 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | Back Roof | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 3.5 tons (3.29 tons) | 2.5 tons (2.26 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) |
| | Heating Capacity | 90 kBtu/hr (86.62 kBtu/hr) | 60 kBtu/hr (56.71 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $2,464 | Best Practice | $5,539 | Zero Energy Home | $22,629 |

Notes:

(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.
This credit for system downsizing is consistent with other Building America estimates of system downsizing credits.

(2) The ZEH level includes a small (2%) reduction in window area, which lowers cooling gains, and overall costs.

Table A-12. Energy and economic analysis, New Mexico

| New Mexico Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of homes by type | **2008 - 2020, cumulative** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| *Reference case* | | | | | | | | | | | | | | |
| Code (2003 IECC) | **88,798** | 6,352 | 6,429 | 6,506 | 6,584 | 6,663 | 6,743 | 6,824 | 6,906 | 6,989 | 7,072 | 7,157 | 7,243 | 7,330 |
| ENERGY STAR | **4,674** | 334 | 338 | 342 | 347 | 351 | 355 | 359 | 363 | 368 | 372 | 377 | 381 | 386 |
| *High performance homes scenario* | | | | | | | | | | | | | | |
| Code | **44,996** | 5,915 | 5,544 | 5,163 | 4,771 | 4,370 | 3,958 | 3,536 | 3,103 | 2,660 | 2,205 | 1,739 | 1,261 | 772 |
| ENERGY STAR | **27,862** | 566 | 807 | 1,054 | 1,306 | 1,565 | 1,829 | 2,100 | 2,376 | 2,660 | 2,949 | 3,245 | 3,548 | 3,858 |
| EE Best Practice | **10,306** | 103 | 208 | 316 | 426 | 540 | 655 | 774 | 895 | 1,019 | 1,145 | 1,275 | 1,408 | 1,543 |
| Zero Energy Home | **10,306** | 103 | 208 | 316 | 426 | 540 | 655 | 774 | 895 | 1,019 | 1,145 | 1,275 | 1,408 | 1,543 |
| Total | 93,471 | 6,687 | 6,767 | 6,848 | 6,930 | 7,014 | 7,098 | 7,183 | 7,269 | 7,356 | 7,445 | 7,534 | 7,624 | 7,716 |
| ***Energy analysis*** | | | | | | | | | | | | | | |
| **Electricity (GWh)** | | | | | | | | | | | | | | |
| Reference case | **1,157** | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 96 |
| High performance scenario | **991** | 81 | 80 | 80 | 79 | 78 | 77 | 76 | 76 | 75 | 74 | 73 | 72 | 71 |
| annual savings, GWh | **166** | 2 | 3 | 5 | 7 | 9 | 11 | 12 | 14 | 16 | 18 | 21 | 23 | 25 |
| electricity generated by PV (GWh) | **27** | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 |
| peak electric demand, annual savings, MW | **68** | 0.7 | 1.4 | 2.1 | 2.8 | 3.6 | 4.4 | 5.1 | 5.9 | 6.8 | 7.6 | 8.5 | 9.3 | 10.2 |
| **Natural Gas (therms, millions)** | | | | | | | | | | | | | | |
| Reference case | **102** | 7.3 | 7.4 | 7.5 | 7.6 | 7.7 | 7.7 | 7.8 | 7.9 | 8.0 | 8.1 | 8.2 | 8.3 | 8.4 |
| High performance scenario | **82** | 7.1 | 7.0 | 6.9 | 6.7 | 6.6 | 6.5 | 6.3 | 6.2 | 6.1 | 5.9 | 5.8 | 5.6 | 5.4 |
| annual savings | **20** | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.3 | 1.5 | 1.7 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 |
| **Total source energy (MMBTUs)** | | | | | | | | | | | | | | |
| Reference case | **23** | 1.6 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.9 | 1.9 |
| High performance scenario | **19** | 1.6 | 1.6 | 1.6 | 1.5 | 1.5 | 1.5 | 1.4 | 1.4 | 1.4 | 1.4 | 1.3 | 1.3 | 1.3 |
| annual savings, | **4** | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 |
| % savings | 18% | 3% | 5% | 8% | 10% | 13% | 15% | 18% | 20% | 23% | 25% | 28% | 30% | 33% |
| ***ENMnomic analysis*** | | | | | | | | | | | | | | |
| Electricity cost savings, annual (million $) | **16** | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 |
| Natural gas cost savings, annual (million $) | **25** | 0.2 | 0.5 | 0.8 | 1.0 | 1.3 | 1.6 | 1.9 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.7 |
| Total energy cost savings, annual (million $) | **40** | 0.4 | 0.8 | 1.2 | 1.7 | 2.1 | 2.6 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 |
| | | | | | | | | | | | | | | |
| Total EE investment w/ discounting (million 2008 $) | **94** | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 11 |
| Total EE and PV investment w/ discounting (million 2008 $) | **191** | 3 | 5 | 8 | 10 | 12 | 14 | 16 | 17 | 19 | 20 | 21 | 22 | 23 |
| | | | | | | | | | | | | | | |
| Net present value, EE measures (millions 2008 $) | **338** | 5 | 10 | 14 | 18 | 22 | 25 | 28 | 31 | 33 | 35 | 37 | 39 | 41 |
| Net present value, all measures (millions 2008 $) | **366** | 5 | 11 | 15 | 19 | 23 | 27 | 30 | 33 | 36 | 38 | 41 | 43 | 43 |
| | | | | | | | | | | | | | | |
| Benefit-cost ratio: EE measures | | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| Benefit-cost ratio: all measures | | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |

## Table A-13. Measures and incremental costs, Utah

**BEopt Measures and Incremental Costs: Salt Lake City, Utah**

| Group Name | Category Name | Reference Case | ENERGY STAR | | Best Practice | | Zero Energy Home | |
|---|---|---|---|---|---|---|---|---|
| Building | Measure | Measure | Measure | Incremental Cost | Measure | Incremental Cost | Measure | Incremental Cost |
| | Orientation | East-facing | East-facing | $0 | East-facing | $0 | East-facing | $0 |
| | Neighbors | at 15ft | at 15ft | $0 | at 15ft | $0 | at 15ft | $0 |
| | Aspect Ratio | 0.67 | 0.67 | $0 | 0.67 | $0 | 0.67 | $0 |
| | Misc Electric Loads | 1.25 | 1.25 | $0 | 1.25 | $0 | 1.25 | $0 |
| | Heating Set Point | 71 F | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 | 71 F w/ setback 65 F | $0 |
| | Cooling Set Point | 74 F | 74 F | $0 | 74 F | $0 | 74 F | $0 |
| Envelope | | | | | | | | |
| | Walls | R13 batts 2x4 16"o.c. + 1" foam | R13 batts 2x4 16"o.c. + 1" foam | $0 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 | R19 batts 2x6 24"o.c. + 1" foam | $1,697 |
| | Ceiling | R40 Fiberglass | R40 Fiberglass | $0 | R50 Fiberglass | $468 | R50 Fiberglass | $468 |
| | Thermal Mass | 1/2" Ceiling Drywall | 1/2" Ceiling Drywall | $0 | 5/8" Ceiling Drywall | $52 | 5/8" Ceiling Drywall | $52 |
| | Infiltration | Typical | Tight | $1,890 | Tight | $1,890 | Tight | $1,890 |
| Foundation | | | | | | | | |
| | Slab | No Slab | No Slab | $0 | No Slab | $0 | No Slab | $0 |
| | Basement | 4ft R10 Exterior | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 | 4ft R10 Exterior | $0 |
| | Crawl Space | No Crawl Space | No Crawl Space | $0 | No Crawl Space | $0 | No Crawl Space | $0 |
| Windows & Shading | | | | | | | | |
| | Window Areas | 18.0% F20 B40 L20 R20 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 | 18.0% F20 B40 L20 R20 | $0 |
| | Window Type | Low-e v. high SHGC | Low-e std. SHGC | $0 | Low-e low SHGC arg | $0 | Low-e low SHGC arg | $0 |
| | Eaves | No eaves | No eaves | $0 | No eaves | $0 | No eaves | $0 |
| Lg. Appliances | | | | | | | | |
| | Refrigerator | Standard | EnergyStar | $120 | EnergyStar | $120 | EnergyStar | $120 |
| | Cooking Range | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Dishwasher | Standard | EnergyStar | $70 | EnergyStar | $70 | EnergyStar | $70 |
| | Clothes Dryer | Gas | Gas | $0 | Gas | $0 | Gas | $0 |
| | Clothes Washer | Standard (V-Axis) | Standard (V-Axis) | $0 | EnergyStar (H-Axis) - Cold Only | $380 | EnergyStar (H-Axis) - Cold Only | $380 |
| Lighting | | | | | | | | |
| | Hardwired Lighting | 0% CFL | 30% CFL | $53 | 50% CFL | $88 | 50% CFL | $88 |
| | Plug-in Lighting | 0% CFL | 10% CFL | $4 | 50% CFL | $18 | 50% CFL | $18 |
| Equipment | | | | | | | | |
| | Air Conditioner | SEER 13 | SEER 13 | $0 | SEER 14 | $152 | SEER 14 | $152 |
| | Furnace | AFUE 80% | AFUE 92.5% | $294 | AFUE 92.5% | $294 | AFUE 92.5% | $294 |
| | Heat Pump | No Heat Pump | No Heat Pump | $0 | No Heat Pump | $0 | No Heat Pump | $0 |
| | ERV | No ERV | No ERV | $0 | No ERV | $0 | No ERV | $0 |
| | Water Heater | Gas Standard | Gas Standard | $175 | Gas Tankless | $739 | Gas Premium | $175 |
| | Ducts | Typical | Improved | $840 | Inside | $1,120 | Inside | $1,120 |
| Renewables | | | | | | | | |
| | Solar DHW | No Solar DHW | No Solar DHW | $0 | No Solar DHW | $0 | 40 sq ft closed loop | $4,307 |
| | SDHW Azimuth | Back Roof | Back Roof | $0 | South | $0 | South | $0 |
| | SDHW Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| | PV Size | 0 kW | 0 kW | $0 | 0 kW | $0 | 2.0 kW | $15,000 |
| | PV Azimuth | Back Roof | Back Roof | $0 | West | $0 | West | $0 |
| | PV Tilt | Roof Pitch | Roof Pitch | $0 | Roof Pitch | $0 | Roof Pitch | $0 |
| HVAC Sizing (1) | | | | | | | | |
| | Cooling Capacity | 3.5 tons (3.28 tons) | 2.5 tons (2.28 tons) | ($400) | 2.0 tons (1.79 tons) | ($400) | 2.0 tons (1.76 tons) | ($400) |
| | Heating Capacity | 90 kBtu/hr (82.21 kBtu/hr) | 60 kBtu/hr (57.34 kBtu/hr) | ($100) | 50 kBtu/hr (46.47 kBtu/hr) | ($100) | 50 kBtu/hr (47.86 kBtu/hr) | ($100) |
| Total Incremental Cost | | | ENERGY STAR | $2,946 | Best Practice | $6,588 | Zero Energy Home | $25,331 |

Notes:

(1) SWEEP's cost-effectiveness analysis assumes HVAC system downsizing in all cases will be limited to 1/2 - 1 ton of cooling and 10 kBtu/hr of heating capacity, for a total credit of $500.

This credit for system downsizing is consistent with other Building America estimates of system downsizing credits.

## Table A-14, Energy and economic analysis, Utah

| Utah Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of homes by type | 2008 - 2020, cumulative | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| *Reference case* | | | | | | | | | | | | | | |
| Code (2003 IECC) | **204,212** | 13,488 | 13,825 | 14,171 | 14,525 | 14,888 | 15,260 | 15,642 | 16,033 | 16,434 | 16,844 | 17,266 | 17,697 | 18,140 |
| ENERGY STAR | **38,897** | 2,569 | 2,633 | 2,699 | 2,767 | 2,836 | 2,907 | 2,979 | 3,054 | 3,130 | 3,208 | 3,289 | 3,371 | 3,455 |
| *High performance homes scenario* | | | | | | | | | | | | | | |
| Code | **102,566** | 12,574 | 11,951 | 11,290 | 10,588 | 9,844 | 9,056 | 8,222 | 7,341 | 6,411 | 5,430 | 4,395 | 3,306 | 2,159 |
| ENERGY STAR | **85,599** | 2,989 | 3,494 | 4,023 | 4,576 | 5,154 | 5,758 | 6,388 | 7,047 | 7,735 | 8,453 | 9,202 | 9,983 | 10,797 |
| EE Best Practice | **27,472** | 247 | 506 | 779 | 1,064 | 1,363 | 1,677 | 2,005 | 2,349 | 2,709 | 3,085 | 3,478 | 3,889 | 4,319 |
| Zero Energy Home | **27,472** | 247 | 506 | 779 | 1,064 | 1,363 | 1,677 | 2,005 | 2,349 | 2,709 | 3,085 | 3,478 | 3,889 | 4,319 |
| Total | 243,109 | 16,057 | 16,458 | 16,870 | 17,292 | 17,724 | 18,167 | 18,621 | 19,087 | 19,564 | 20,053 | 20,554 | 21,068 | 21,595 |
| | | | | | | | | | | | | | | |
| ***Energy analysis*** | | | | | | | | | | | | | | |
| **Electricity (GWh)** | | | | | | | | | | | | | | |
| Reference case | **2,880** | 190 | 195 | 200 | 205 | 210 | 215 | 221 | 226 | 232 | 238 | 244 | 250 | 256 |
| High performance scenario | **2,526** | 187 | 188 | 190 | 191 | 192 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 200 |
| annual savings, GWh | **354** | 3 | 7 | 10 | 14 | 18 | 22 | 26 | 30 | 35 | 40 | 45 | 50 | 56 |
| electricity generated by PV (GWh) | **62** | 1 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 | 10 |
| peak electric demand, annual savings, MW | **133** | 1.2 | 2.4 | 3.8 | 5.1 | 6.6 | 8.1 | 9.7 | 11.4 | 13.1 | 14.9 | 16.8 | 18.8 | 20.9 |
| | | | | | | | | | | | | | | |
| **Natural Gas (therms, millions)** | | | | | | | | | | | | | | |
| Reference case | **317** | 20.9 | 21.5 | 22.0 | 22.6 | 23.1 | 23.7 | 24.3 | 24.9 | 25.5 | 26.2 | 26.8 | 27.5 | 28.2 |
| High performance scenario | **262** | 20.4 | 20.5 | 20.4 | 20.4 | 20.4 | 20.3 | 20.3 | 20.2 | 20.1 | 20.0 | 19.8 | 19.7 | 19.5 |
| annual savings | **55** | 0.5 | 1.0 | 1.6 | 2.1 | 2.7 | 3.4 | 4.0 | 4.7 | 5.4 | 6.2 | 7.0 | 7.8 | 8.7 |
| | | | | | | | | | | | | | | |
| **Total source energy (MMBTUs)** | | | | | | | | | | | | | | |
| Reference case | **63** | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.9 | 5.0 | 5.1 | 5.2 | 5.4 | 5.5 | 5.6 |
| High performance scenario | **53** | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.0 |
| annual savings, | **10** | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 | 1.6 |
| % savings | 16% | 2% | 4% | 7% | 9% | 11% | 13% | 15% | 17% | 20% | 22% | 24% | 26% | 28% |
| | | | | | | | | | | | | | | |
| ***Economic analysis*** | | | | | | | | | | | | | | |
| Electricity cost savings, annual (million $) | **31** | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.9 | 2.2 | 2.6 | 3.0 | 3.4 | 3.9 | 4.3 | 4.8 |
| Natural gas cost savings, annual (million $) | **61** | 0.5 | 1.1 | 1.7 | 2.3 | 3.0 | 3.7 | 4.4 | 5.2 | 6.0 | 6.8 | 7.7 | 8.6 | 9.5 |
| Total energy cost savings, annual (million $) | **91** | 0.8 | 1.7 | 2.6 | 3.5 | 4.5 | 5.6 | 6.7 | 7.8 | 9.0 | 10.2 | 11.6 | 12.9 | 14.3 |
| | | | | | | | | | | | | | | |
| Total EE investment w/ discounting (million 2008 $) | **229** | 3 | 6 | 9 | 11 | 14 | 16 | 19 | 21 | 23 | 24 | 26 | 28 | 29 |
| Total EE and PV investment w/ discounting (million 2008 $) | **538** | 7 | 14 | 21 | 27 | 33 | 38 | 43 | 48 | 53 | 57 | 61 | 65 | 69 |
| | | | | | | | | | | | | | | |
| Net present value, EE measures (millions 2008 $) | **757** | 10 | 20 | 29 | 38 | 46 | 54 | 61 | 68 | 75 | 81 | 86 | 92 | 97 |
| Net present value, all measures (millions 2008 $) | **802** | 11 | 21 | 31 | 40 | 49 | 57 | 65 | 72 | 79 | 85 | 92 | 97 | 103 |
| | | | | | | | | | | | | | | |
| Benefit-cost ratio: EE measures | | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| Benefit-cost ratio: all measures | | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |

## Peak electricity savings data and graphs

Table A-15. Average peak reduction by state and home performance level.

| State | Reference Case | ENERGY STAR | % Savings | EE Best Practice | % Savings | ZEH - Net | % Savings |
|---|---|---|---|---|---|---|---|
| AZ | 5.17 | 3.61 | 30% | 2.67 | 48% | 1.71 | 67% |
| CO | 2.32 | 1.28 | 45% | 1.06 | 54% | 0.38 | 84% |
| NV | 4.96 | 2.74 | 45% | 1.64 | 67% | 0.65 | 87% |
| NM | 2.70 | 1.94 | 28% | 1.18 | 56% | 0.35 | 87% |
| UT | 2.36 | 1.37 | 42% | 1.14 | 51% | 0.41 | 82% |
| Region | 3.50 | 2.19 | 38% | 1.54 | 55% | 0.70 | 81% |

Figure A-1. Average electricity demand at summer peak, kW per home.

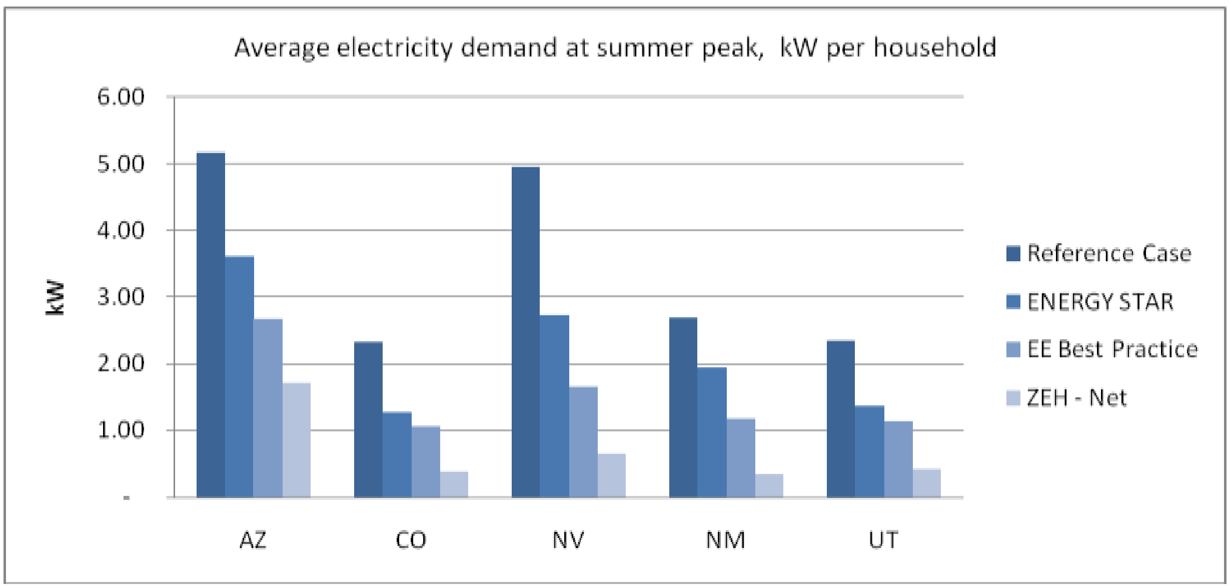



Table A-16. Reduction at system peak (4pm)

| State | Reference Case | ENERGY STAR | % Savings | EE Best Practice | % Savings | ZEH - Net | % Savings |
|---|---|---|---|---|---|---|---|
| AZ | 5.39 | 3.66 | 32% | 2.65 | 51% | 1.43 | 74% |
| CO | 2.61 | 1.80 | 31% | 1.40 | 46% | 0.59 | 77% |
| NV | 5.68 | 4.01 | 29% | 2.77 | 51% | 1.61 | 72% |
| NM | 3.24 | 2.22 | 31% | 1.58 | 51% | 0.54 | 83% |
| UT | 2.70 | 1.90 | 30% | 1.48 | 45% | 0.49 | 82% |
| Region | 3.92 | 2.72 | 31% | 1.98 | 49% | 0.93 | 78% |

Figure A-2. Average electricity load at system peak (4pm), kW

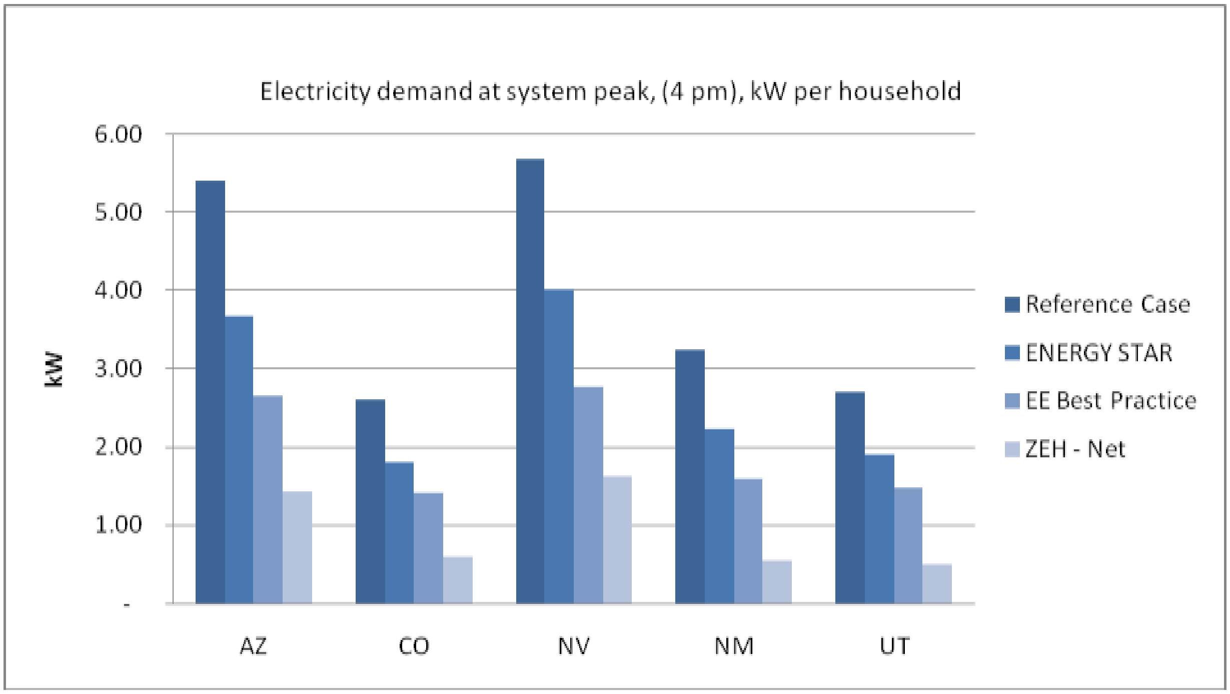
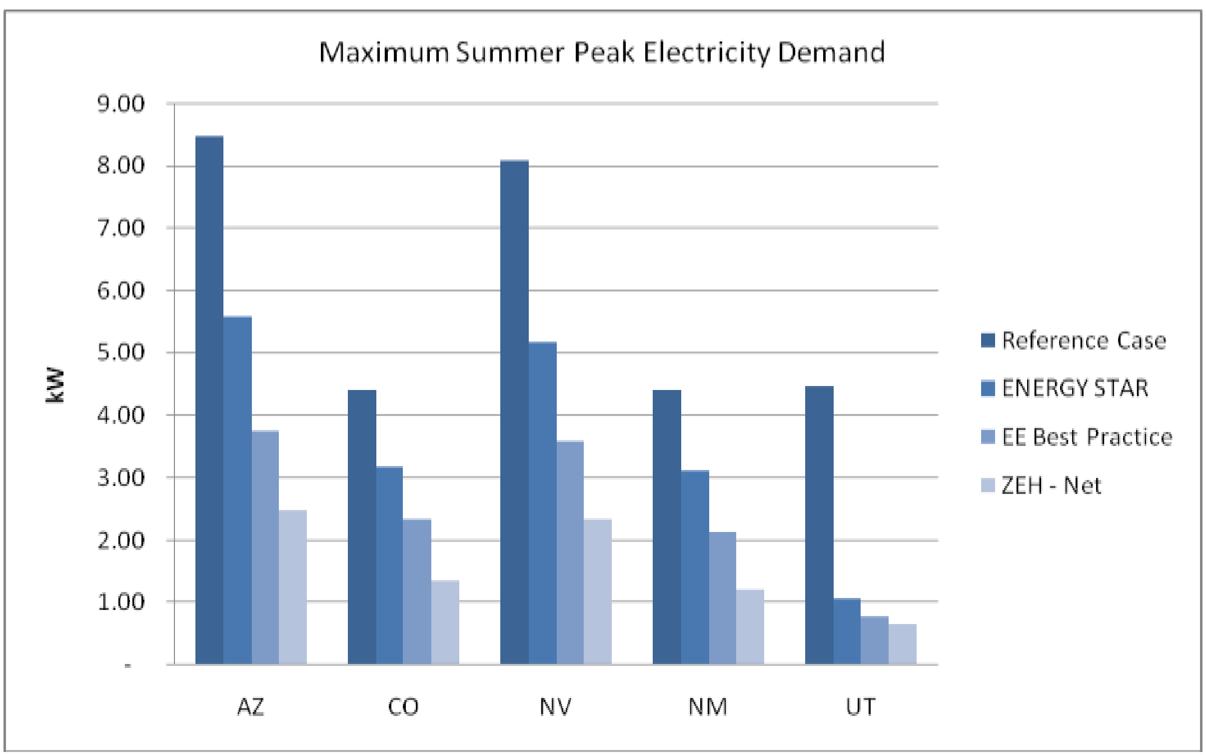
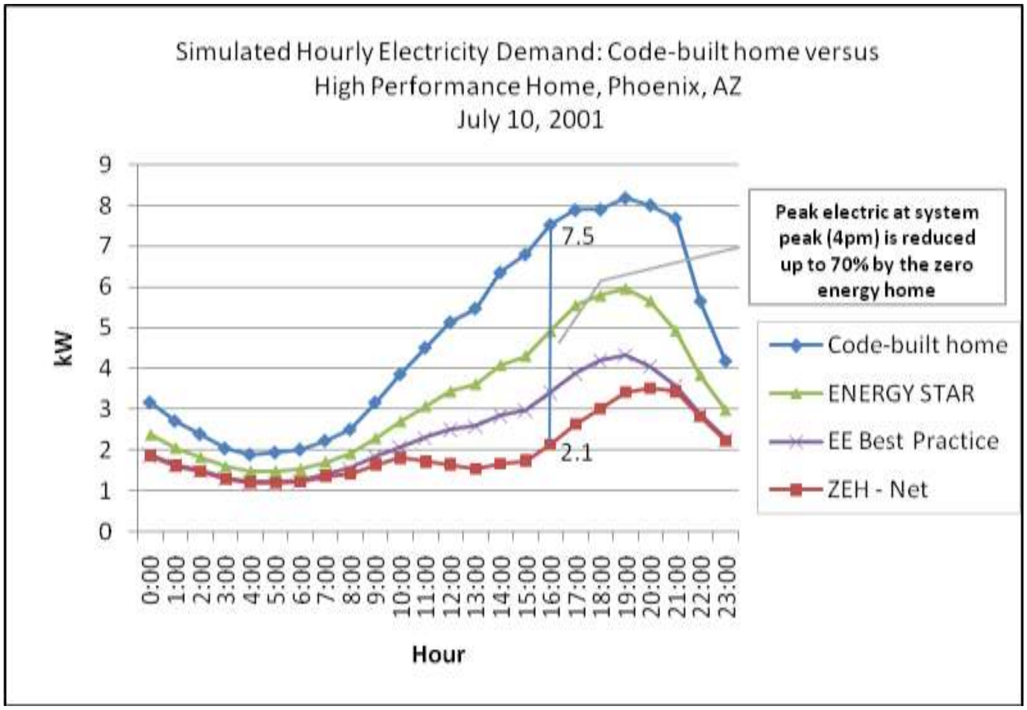



Figure A-3. Maximum summertime peak electricity load, kW



## Peak reduction graphs by city and state

### Figure A-4. Arizona




### Figure A-5. Colorado

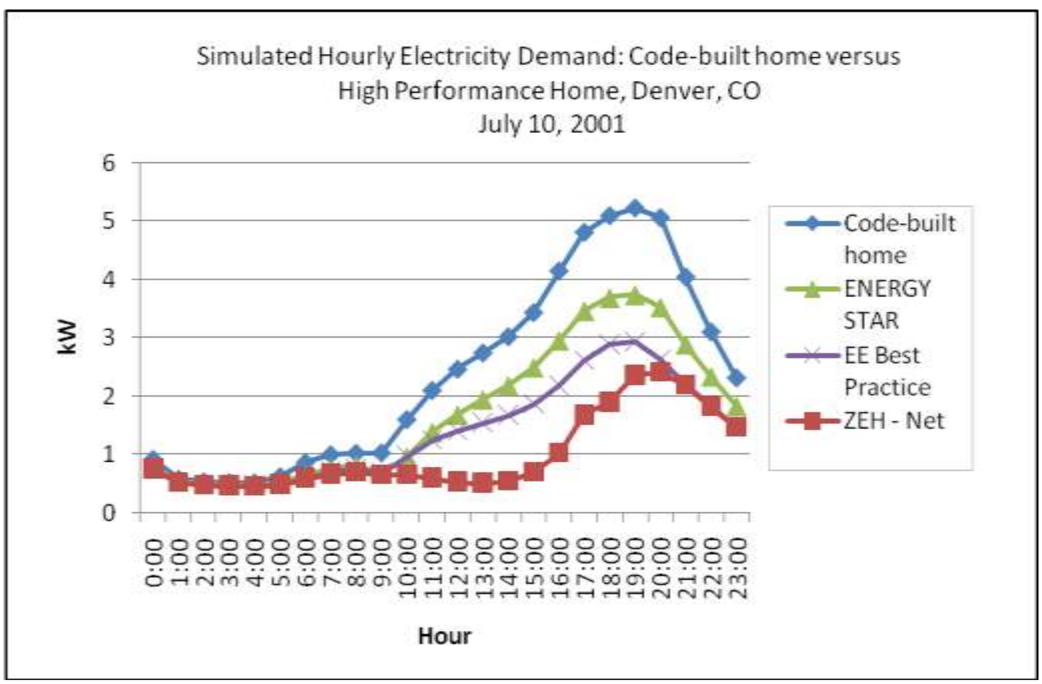


**Figure A-6. Nevada**

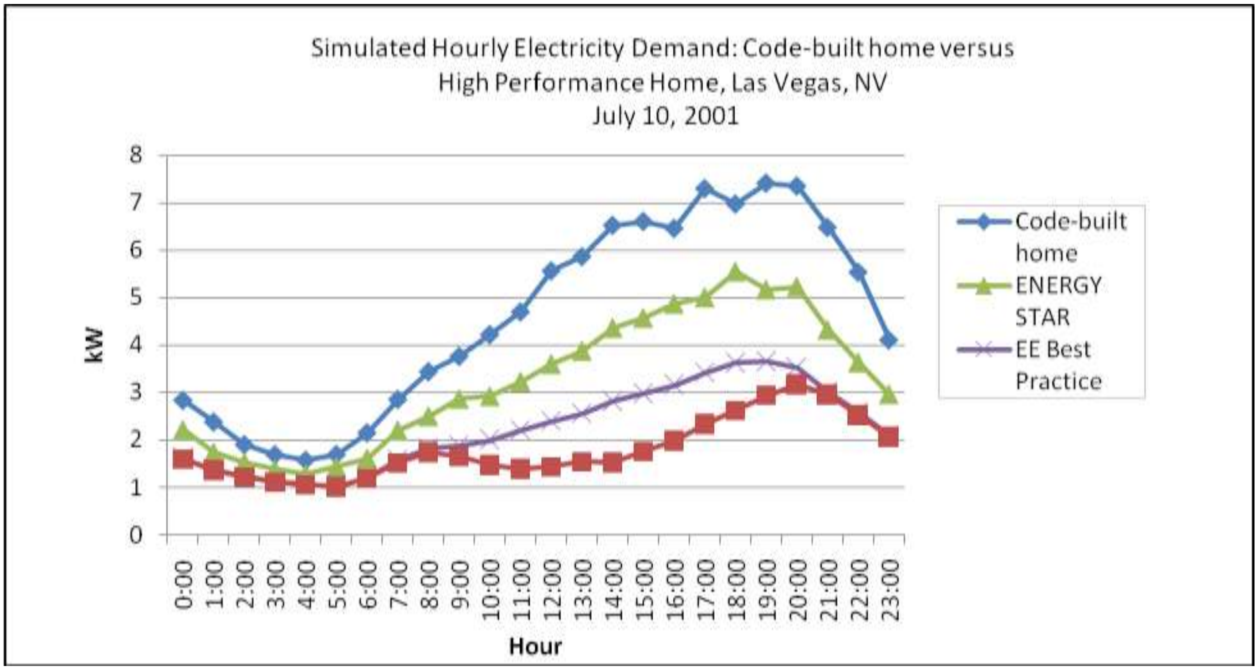



**Figure A-7. New Mexico**

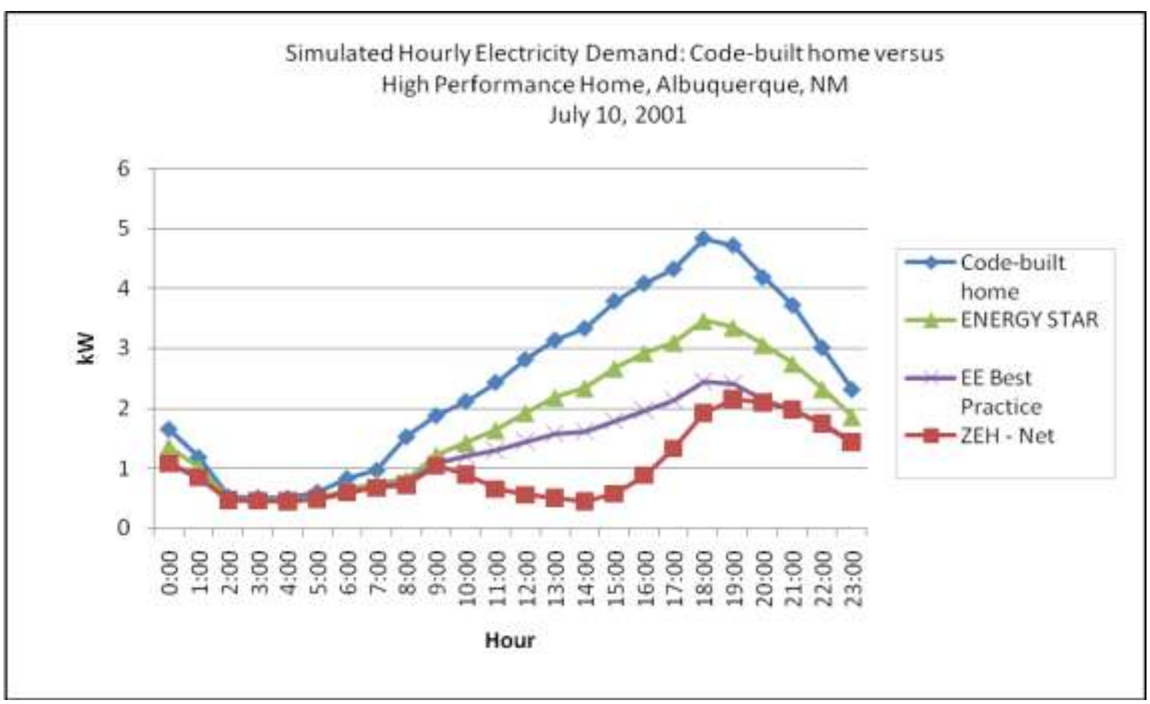


**Figure A-8. Utah**