Building for a Clean Energy Future

How Texas Can Reduce Pollution, Save Energy and Cut Costs with Efficient Solar Homes

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Table of Contents

Executive Summary

Texas can reduce its dependence on dirty, dangerous and expensive fossil fuels by adopting new, high performance home designs. Using energy-efficient technology and small-scale solar energy systems, homes can be built to generate as much energy as they use, achieving "net-zero energy" performance.

Given anticipated population growth, Texas will likely build nearly 2.2 million additional single-family homes from 2010 to 2030. These homes represent an enormous energy opportunity. If all new homes are built for net-zero energy performance by 2020, then by 2030 the state would avoid the need to build seven new large power plants, reduce annual global warming pollution by an amount equivalent to eliminating emissions from more than 3 million Texas cars and trucks, and reduce homeowners' energy bills by more than $5 billion – benefiting all Texans. With incentive programs available now, a net-zero energy home could cost about $40 per month less to own than a standard home. In the future, potential homeowner savings are poised to grow.

The technology necessary to build net-zero energy homes is ready and available today. However, it is not yet in widespread use, because of a variety of market barriers, including lack of familiarity and up-front cost. To unlock the potential of high-performance homes, Texas and federal officials should work to overcome these market barriers and encourage the spread of efficient home designs and small-scale renewable energy technologies such as solar energy systems.

Net-zero energy homes can help Texas become less dependent on fossil fuels.

- If all new single-family homes in Texas achieved net-zero energy performance by the year 2020, Texas would save more than 15 billion kWh of electricity per year by 2030. At current consumption patterns, that amount of electricity could power all the residences in the greater metropolitan areas of San Antonio, Austin, and Corpus Christi combined (or 1.1 million Texas homes).

- At the same time, solar energy systems on those homes would generate another 10 billion kWh of electricity per year by 2030 – equivalent to nearly 3 percent of current statewide annual electricity consumption.
- In total, these homes would generate or save more than 25 billion kWh of electricity per year and 500 million therms of natural gas per year by 2030. That amount of electrical energy would eliminate the need to build 7 large (500 MW) coal-fired power plants, and that amount of gas could meet the annual needs of more than 1 million Texas homes.

Net-zero energy homes prevent pollution, protecting public health and Texas' environment.

- By displacing fossil fuels, in the year 2030 net-zero energy homes could annually prevent 18 million metric tons of global warming pollution, 7.5 million pounds of smog-forming nitrogen oxide emissions, and nearly 400 pounds of highly toxic mercury pollution.
- In terms of global warming pollution, this impact would be roughly equivalent to making one out of every six cars and trucks in the state pollution-free (more than 3 million vehicles).
- In addition, deploying net-zero energy homes could save nearly 10 billion gallons of water in 2030, water which would otherwise be used to generate steam in fossil-fired power plants. That much water could meet the domestic needs of a city of more than 400,000 people.

Net- zero energy homes can save society and individual homeowners money.

- Net-zero energy homes deliver many benefits which save all Texans money. Net-zero energy homes reduce the need for expensive power lines and power plants to meet peak demand for electricity. They reduce demand for – and thus the price of – electricity and natural gas. And net-zero energy homes prevent air pollution, reducing costs to public health and Texas' environment.
- To compensate builders and buyers of net-zero energy home technology for providing these benefits to society as a whole, federal and state government offers a variety of incentives and rebates to reduce the initial purchase price of a net-zero energy home. With currently available incentives, a net-zero energy home would save a homeowner $40 per month in total home ownership costs compared to a standard home.
- Because net-zero energy homes generate as much energy as they consume, they can greatly reduce monthly utility bills. For example, a Houston-area homeowner would pay $2,400 less per year for utility service in a net-zero energy home compared to a standard home. Savings on energy bills offset the initial price premium of a net-zero energy home of about $10 per square foot (after incentives).
- The potential for net-zero energy homes to deliver homeowner savings will grow over time. For example, by 2015, analysts at the U.S. Department of Energy predict that the installed cost of solar PV will decline by 50 percent. When this milestone is achieved, a net-zero energy home

This net-zero energy home near Dallas was built in 2004. *Photo: Chet Yeary*

will cost the same amount per month as a standard home, without incentives.

- If all new homes in Texas achieved net-zero energy performance by 2020, Texas homeowners would save an estimated $5.4 billion on utility bills in the year 2030. Over the entire 20 year period of analysis, net total home ownership savings would be in the range of $1.1 billion (2009 dollars).

Incorporating energy-efficient features during construction can allow homes to use two-thirds less energy than a typical home. For example:

- Improved insulation, tight construction, high-efficiency windows, and light colored "cool roofs" can drastically improve the thermal efficiency of a home and enable the use of smaller cooling and heating equipment. Together, these measures can cut the energy needed for cooling and heating by more than 75 percent.
- Efficient lighting and appliances can deliver the same convenience and comfort that homeowners are used to while using far less electricity. For example, using compact fluorescent or LED bulbs in place of traditional incandescent versions can reduce lighting energy use by more than 70 percent. Similarly, efficient clothes washers, dishwashers, dryers and refrigerators can cut electricity use by more than 50 percent compared to standard versions.

Solar energy systems can generate electricity and hot water to offset the remaining home energy use.

- A 5 kW home solar photovoltaic system could produce 5,800 kWh per year in a hot and humid location near the Gulf, such as Houston, and up to 7,000 kWh per year in a hot and dry climate like that of Midland or Odessa. In comparison, an energy-efficient home uses about 5,000 kWh of electricity per year.
- An efficient hot water heater, supplemented by a roof-mounted solar hot water system, could cut

Table ES-1: Energy and Utility Bill Savings in 2030 if All New Single-Family Homes Achieve Net-Zero Energy Performance by 2020*

Metropolitan Area	Electricity Savings (GWh)	Solar Power Generation (GWh)	Gas Savings (Million Therms)	Energy Bill Savings (Million 2009 Dollars)
Dallas-Fort Worth Metroplex	5,138	3,200	158	$1,797
Greater Houston	3,839	2,391	118	$1,343
Austin	1,471	916	45	$515
McAllen-Edinburg-Mission	908	566	28	$318
San Antonio	825	514	25	$288
El Paso	439	356	24	$187
Laredo	366	228	11	$128
Brownsville–Harlingen	353	220	11	$124
Killeen-Temple-Fort Hood	230	143	7	$80
Corpus Christi	209	130	6	$73
College Station-Bryan	91	57	3	$32
Amarillo	86	79	10	$48
Waco	74	46	2	$26
Beaumont-Port Arthur	69	43	2	$24
Tyler	66	41	2	$23
Longview	55	34	2	$19
Victoria	43	27	1	$15
Lubbock	38	31	2	$16
Odessa	38	31	2	$16
Midland	27	22	1	$12
Sherman–Denison	23	16	1	$9
Wichita Falls	20	14	1	$8
San Angelo	16	13	1	$7
Abilene	15	12	1	$7
Texas Statewide Total	*15,348*	*9,725*	*502*	*$5,452*

**See the Methodology section on page 34 for a description of how these estimates were derived. See page 31 for a list of how many homes are forecast to be built in each metropolitan area.*

the amount of natural gas needed to supply hot water for a typical home by about two-thirds.

- Other sources of renewable energy can deliver cooling, heating and electricity for Texas homes, including geothermal heat pumps and small-scale wind turbines.

Net-zero energy homes will be a key tool for breaking our dependence on fossil fuels. Texas, and the United States as a whole, should encourage energy-efficient home construction and the use of solar energy systems.

- President Obama has announced an ambitious but achievable goal for all new buildings to achieve net-zero energy performance by 2030. Texas should embrace this goal and lay out a plan to achieve this benchmark for new homes by 2020.
- As a first step, Texas should require local jurisdictions to strengthen building energy codes, ensuring that all new homes across the state meet or exceed the 2009 International Energy Conservation Code.
- Texas should provide financial incentives and technical assistance to encourage high performance new construction and the deployment of solar energy systems. For example:
  - Texas should establish a statewide solar rebate program so that all Texans are able to take advantage of solar incentives.
  - Cities should help residents install solar energy systems by offering loans that can be paid back via property taxes, as authorized by House Bill 1937.
  - Texas should require true "net metering," removing limits on the ability of homeowners to be fairly compensated by their utility for any excess electricity they feed into the power grid.
  - Texas utilities should add to and expand incentive programs to encourage the construction of net-zero energy homes.

Energy efficiency and renewable energy technologies can benefit all sectors of the Texas economy. To fully capture these resources,

- Texas should require electric utilities to increase their investment in energy efficiency programs, such as rebates for Energy Star homes, such that 1 percent of the state's electricity consumption is offset with efficiency annually by 2015 and 2 percent annually by 2020 and thereafter.
- Federal leaders should adopt national energy efficiency and renewable energy requirements, including:
  - A national energy efficiency resource standard, requiring that utilities reduce electricity consumption by at least 10 percent by 2020;
  - Enforceable national lighting and building energy efficiency codes for new residential and commercial buildings, requiring a 50 percent reduction over current practice by 2015 and a 75 percent reduction in energy use by 2030; and
  - A building retrofit program, to ensure existing buildings use energy efficiently.

Introduction: Building for a Clean Energy Future

Texas has always been a state that prides itself on independence. Today, Texas is continuing that tradition by leading a national transition toward clean energy sources that never run out.

While Texas' economy was once built around oil and gas, the state is now America's leading producer of wind power.[1] Clean electricity is helping Texas to prevent air pollution and make the air healthier to breathe.[2] At the same time, clean electricity is helping to reduce Texas' contribution to the serious problem of global warming.[3] Finally, clean electricity is proving a boon to the state's economy, providing stimulus for rural communities and reducing the cost of electricity and natural gas for everyone.[4]

However, many additional sources of clean energy remain underutilized. By capturing more of these resources, Texas can continue to make progress toward a healthier future.

One of the best places to start is with our homes. How future homes are built will have a large impact on the growth of energy use in the residential sector, and on Texas' future levels of air and global warming pollution. Homes account for more than one-third of all of Texas' electricity use.[5] And more than 86 percent of Texas' electricity comes from fossil fuels, the leading source of soot, smog and carbon dioxide emissions.[6]

The fossil fuel consumption of new homes can be greatly reduced – even eliminated – by designing new homes to achieve the highest energy performance. By designing a new home to be highly energy-efficient, and by incorporating small-scale renewable energy technology such as solar energy systems, new homes can produce as much energy as they use. Homes that achieve this level of performance are called "net-zero energy" homes. Any electricity or gas consumed by the home can be offset by the generation of electricity from Texas sunlight during daylight hours – or by the use of small-scale wind or geothermal energy systems.

Cities such as San Antonio and Austin are already leading the way forward. San Antonio has adopted the 2009 Interna-

Architects KRDB are constructing a neighborhood made up of 38 net-zero energy homes on the eastern side of Austin. The neighborhood, entitled Sol Austin, or "Solutions Oriented Living," features homes designed to produce as much energy as they use in the course of a year through efficient construction and integrated solar energy systems. Photo: KRDB

tional Energy Efficiency Code, which requires new homes to be 15 percent more efficient in 2010, on a trajectory to reach net-zero energy performance by 2030.[7] Austin has established building energy codes that will require new homes to use 65 percent less electricity and gas by 2015, a strong step toward making all homes achieve net-zero energy performance.[8] One of the first neighborhoods entirely composed of net-zero energy homes is now under construction on the eastern side of Austin.[9] (See photo above.)

This report compares the performance of a standard new home in Texas with a similar home upgraded to achieve net-zero energy performance. The report then examines the benefits of a scenario in which Texas builders construct an increasing number of net-zero energy homes, such that all new homes built in 2020 and after achieve this level of performance.

The technology necessary to build net-zero energy homes is ready and available today. In fact, Texas' first net-zero energy home was built near Dallas in 2004.[10] More will soon be on the way, particularly if the state of Texas acts to encourage residential energy efficiency measures and the use of solar energy systems. In so doing, Texas can take another major step toward energy independence.

Net-Zero Energy Homes Use Less Fossil Fuel than Standard Homes

New homes in Texas today deliver a great deal of comfort and convenience. However, nearly all new homes also use energy inefficiently. As a result, the buyer of a standard new home can expect to pay more than $2,500 per year for electricity and natural gas to maintain a comfortable climate and to power appliances. At the same time, this energy consumption results in the emission of pollutants that threaten public health and disrupt Texas' climate.

However, by incorporating energy-efficient design, quality construction, and efficient appliances, builders can create high performance homes that deliver equal or better comfort while using at least two-thirds less electricity and natural gas. And by including a rooftop solar energy system, or a small-scale wind energy system, new homes can actually produce as much energy as they consume, achieving "net-zero energy" performance.

Such high performance homes can help Texas become independent from fossil fuels and reduce the pollution associated with energy production. Moreover, these homes can reduce the monthly utility bill to almost zero. These savings can offset the up-front cost of the solar energy system and quality construction of the net-zero energy home. Initially, rebates and incentives are necessary to deliver net savings overall – but by 2015, experts predict that the cost of solar PV systems will decline to the point where net-zero energy homes cost less to own than standard homes.

This section of the report compares the energy consumption and cost characteristics of a "standard," or average, new single family home in Texas' hot and humid climate region with a high-performance "net-zero energy" version of the same home. (See Table 1 for a brief comparison of the features of each home. Energy consumption characteristics were modeled using Energy Gauge USA software by the Florida Solar Energy Center. See the Methodology section on page 34 for full details.)

Table 1: Comparing the Characteristics of the Modeled "Standard" Single-Family Home and the "Net-Zero Energy" Home

	"Standard" Home	**"Net-Zero Energy" Home**
Floor	R-0 Insulation	R-10 Insulation
Roof	Standard Shingles	"Cool Roof" with Low Solar Energy Absorbance
Ceiling	R-30 Insulation	R-50 Insulation
Walls	R-13 Insulation	R-30 Insulation, Low Solar Absorbance
Doors	Wood Doors, No Insulation	Insulated Doors
Windows	Double-Paned, Tinted, Basic Performance	Double-Glazed, Low-E, High Performance
Air Leakage	Normal	Tight Construction
Cooling System	Large Central Unit, SEER 13 Efficiency	Small Central Unit, SEER 15 Efficiency
Heating System	Large Natural Gas Furnace, 80 percent Efficient	Small Natural Gas Furnace, 97 percent Efficient
Programmable Thermostat?	None	Yes
Hot Water System	Natural Gas, 59 percent Efficient	Natural Gas, 80 percent Efficient
Ducts	Default Leakage, Supply from Attic	Leak Free, Supply and Return in Conditioned Space
Appliances	Default	Best Energy Star Models
Lighting	10% Fluorescent or LED	100% Fluorescent or LED
Solar Hot Water System	None	Roof-Mounted, Integrated Collector
Solar Photovoltaic System	None	Roof-Mounted, 5 kW Capacity

Standard New Homes in Texas Use Energy Inefficiently

Much of the energy used in Texas homes is wasted. Because of relatively light insulation, and inefficient lighting and appliances, homes use much more energy than necessary.

The average Texas residence uses more electricity than homes in other parts of the country.[11] High demand for air conditioning during hot summer months contributes to high demand for electricity in the residential sector.[12] Most Texans (87 percent) live in the state's hot and humid climate region – which includes major metropolitan areas such as Houston and Dallas – meaning that our air conditioning bills are unusually high.[13]

A standard home built in Texas' hot and humid climate region uses on the order of 14,700 kWh of electricity each year, and about 420 therms of natural gas. Figure 1 gives an approximate breakdown of the purposes that energy is used for.

Net-Zero Energy Homes Produce as Much Energy as They Consume

In contrast to a "standard" new Texas home, a high performance "net-zero energy" home produces as much energy as it consumes. By deploying technologies such as improved weatherization, cool roofs, higher-efficiency air conditioners, and higher-performance appliances, builders can reduce energy consumption in a typical new Texas home by two-thirds or more. And, by including a rooftop solar energy system, a new home can actually generate enough electricity to offset most or all of its remaining energy use. (See Figure 2.)

Net-Zero Energy Homes are Energy Efficient

Net-zero energy homes incorporate a wide variety of energy-saving design features.

Figure 1: Breakdown of Energy End-Uses in a Standard New Home in a Hot and Humid Climate (such as Houston)[14]

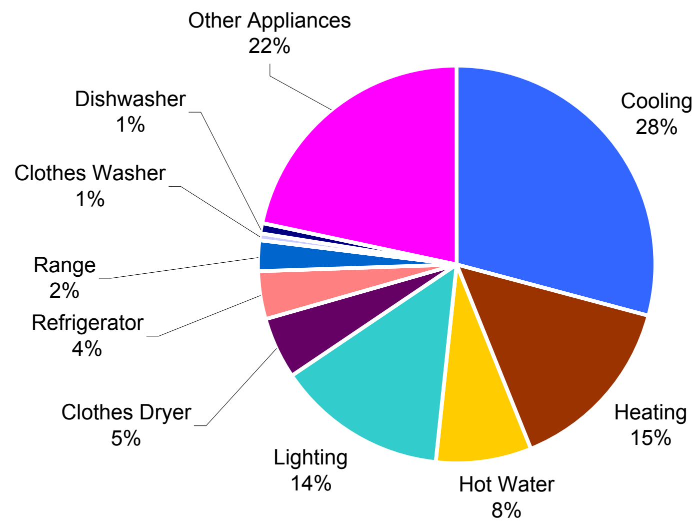
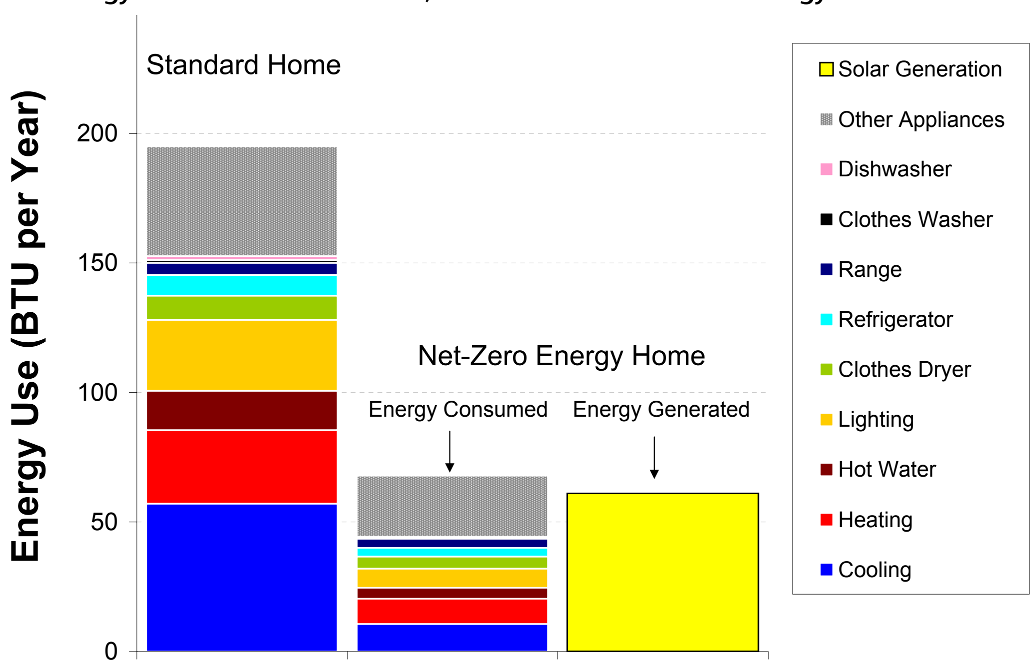


Figure 2: A Net-Zero Energy Home in Texas' Hot and Humid Climate Uses Two-Thirds Less Energy than a Standard Home, and Generates as Much Energy as it Consumes



- **Cooling and Heating**: Improved insulation, high-performance windows and tight construction of walls and ducts improves the thermal efficiency of a net-zero energy home, reducing the amount of energy required for cooling and heating by nearly 80 percent.
- **Lighting**: By replacing standard incandescent lighting fixtures with energy-efficient compact fluorescent or LED technology, the same or better light quality can be achieved, using at least 70 percent less electricity.
- **Hot Water**: Using a solar water heating system, which incorporates roof-mounted solar energy collectors to pre-heat water, coupled with an efficient hot water heater and appliances that require less hot water, would reduce electricity or fossil fuel use for water heating by about 70 percent.
- **Appliances**: Efficient clothes washers, dishwashers, dryers and refrigerators can cut electricity use by more than 50 percent compared to standard versions.

Implementation of these measures can reduce the annual electricity consumption of a new home in Texas' hot and humid climate region by two thirds, to 5,300 kWh per year, and natural gas consumption by a similar percentage, to around 130 therms per year. (See Figure 2.)

Net-Zero Energy Homes Generate Electricity from Sunlight

The remaining energy requirements of a net-zero energy home, after implementation of energy efficiency measures, can be offset by energy captured from sunlight through the use of solar photovoltaic (PV) panels.

The simplicity of photovoltaic panels makes them easy to install on rooftops. They are the only electric generators without moving parts, and they require no fuel supply. During bright and sunny daylight hours, a home PV system feeds surplus electricity into the larger electric-

Geothermal and Wind Energy Can Also Power Homes

Solar power is not the only limitless, local energy source that a net-zero energy home can tap. Although they are not included in this analysis, geothermal and wind energy can also contribute to home energy needs.

Across the state there is great potential to take advantage of the naturally consistent temperatures near the earth's surface using geothermal heat pumps. At a distance of 10 to 12 feet below the earth's surface, temperatures generally remain about 55 degrees.[15] Geothermal heat pumps use the disparity between the consistent temperature of the earth and hot or cold air temperatures to reduce the need for fossil fuels to provide space heat or cooling to buildings. More than 1 million geothermal heat pumps are currently in use in the United States, but much of the market remains untapped.[16]

Additionally, for properties with enough available space and a good wind resource, small-scale wind turbines can generate electricity.[17] Small wind turbines have been used for generations to pump water on farms. Modern wind turbines incorporate a small generator to turn the motion of the wind into electric power. To offset annual electricity consumption, a net-zero energy home would require a small wind system with a generation capacity of around 3 kW, and a good wind resource.[18]

ity grid. At night, and at other times when home energy demand exceeds available sunlight, the home draws electricity from the grid like a typical home. A properly sized solar PV system can produce as much electricity as an efficient home uses in a year, or more. Balancing on-site production with overall use is referred to as "net-zero" energy consumption.

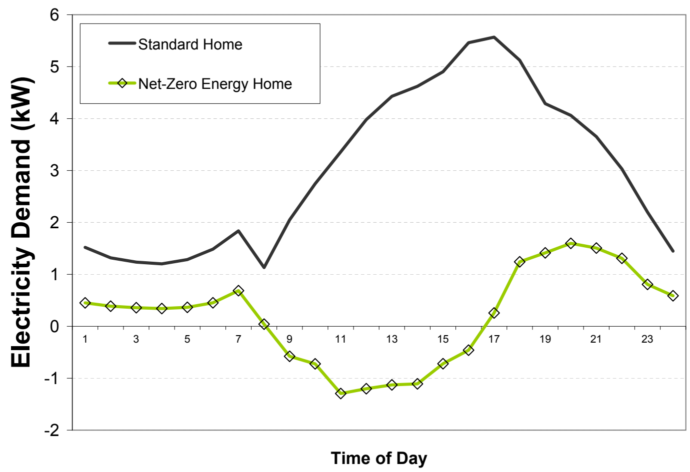
The energy productivity of a solar PV system depends on how intensely the sun shines on the panels over the course of a year. At a hot and humid location relatively close to the Gulf Coast, such as Houston, the net-zero energy home modeled in this report would need a solar PV system capable of generating about 5 kW of electricity at peak output. A system of this size in Houston would produce about 5,800 kWh per year. (See Figure 2.) In a hot and dry climate with fewer clouds and more intense sunlight, such as that of Midland or Odessa, such a PV system could generate up to 7,000 kWh per year.

Net-Zero Energy Homes Reduce Peak Demand for Electricity

Demand for electricity varies widely over the course of the year and the course of any given day. Demand for power on a hot summer day when air conditioners are running can be two to three times as high as in the middle of the night during moderate temperatures. Even though periods of peak demand represent a tiny fraction of the time the electrical system must function, billions of dollars of infrastructure are in place to ensure reliable electric service during those times.

Compared to a standard home, a net-zero energy home requires less energy at all times of the day. Because of its greatly reduced cooling load and efficient features, and partially because of the contribution of the solar PV system, a net-zero energy home in Houston would require

Figure 3: A Net-Zero Energy Home Reduces Peak Demand for Electricity by More than 70 Percent Compared to a Standard Home



approximately 70 percent less electricity during a period of peak demand compared to a standard home. (See Figure 3.)

As a result, net-zero energy homes can reduce the amount of power needed to keep the lights on in Texas and make the electric system more reliable.

Net-Zero Energy Homes Save Society and Individual Homeowners Money

Net-zero energy homes deliver many benefits which save all Texans money. By reducing peak demand, net-zero energy homes reduce the need to build and operate expensive peaking power plants and new transmission lines, making electricity service cheaper. By reducing the demand for electricity and natural gas, net-zero energy homes can lower the price of these commodities for everyone. And by preventing pollution, net-zero energy homes can reduce the societal cost of public health and environmental damage from air pollution.

People who build or purchase net-zero energy homes receive very little compensation for the benefits that they provide to the rest of society. To correct this market failure, federal and state governments and utility companies offer a variety of incentives and rebates to reduce the initial purchase price of a net-zero energy home, which can be expected to cost more than a typical home.

Currently, these incentives, coupled with ongoing savings on energy bills, can save money for a net-zero energy homeowner. And as net-zero energy home technology becomes more widespread over time, the incremental cost of a net-zero energy home will fall, increasing potential savings. The cost of solar PV technology is already rapidly declining. According to analysts at the U.S. Department of Energy, the installed cost of a solar PV system is on track to fall 50 percent by 2015, making a net-zero energy home achievable at zero net cost for the homeowner even without incentives.[19]

Saving Money for All Texans

Net-zero energy homes provide benefits that save money for everyone who uses the electricity system, not just the individual homeowner.

Reducing the Need to Build and Operate Power Infrastructure

As discussed earlier, a net-zero energy home can reduce peak demand for power by about 70 percent compared to a standard Texas home. As a result, net-zero energy homes can reduce the need for expensive investments in electricity transmission and distribution infrastructure.

Moreover, a net-zero energy home actually generates electricity through solar panels during the peak hours of sunlight – often overlapping with periods of peak demand, when the cost to generate electricity is the highest. As a result, these homes reduce the need to build and operate expensive peaking power plants.

This benefits all Texans, not just owners of net-zero energy homes. For example, in 2006 the city utility of Austin estimated that solar power provided system-wide value of more than 10 cents per kWh when added to its system.[20]

Lowering the Price of Electricity and Gas

Net-zero energy homes reduce the demand for natural gas and electricity, putting downward pressure on prices for these commodities. As a result, net-zero energy homes cut energy bills for all Texans. These savings can then be reinvested in other parts of the economy, creating jobs.

Recent studies estimate that for every 1 percent reduction in national natural gas demand, natural gas prices fall by 0.8 percent to 2 percent below forecast levels.[21] Modeling the impacts of a hypothetical national renewable energy standard and energy efficiency effort in effect starting in 2003, the Lawrence Berkeley National Laboratory found natural gas bill savings with an estimated net present value as high as $73 billion through 2020.[22] And according to a 2005 analysis by the American Council for an Energy Efficient Economy, decreasing natural gas consumption by 1 percent per year for five years in eight Midwestern states would decrease wholesale natural gas prices by as much as 13 percent.[23]

Preventing Pollution, Protecting Public Health and the Environment

Net-zero energy homes can also prevent pollution, reducing the burden that pollution places on public health and the environment. By displacing dirtier power sources, these homes can help prevent emissions of pollutants that damage our lungs and cause asthma, bronchitis, lung cancer and heart attacks.[24] Net-zero energy homes also cut emissions of global warming pollution, helping to protect the state from effects of climate disruption. (See page 23 for a more detailed discussion of these benefits).

While the protection of public health and the environment is more difficult to quantify in strict dollar terms, these benefits remain a substantial and important way in which net-zero energy homes can contribute to the economic well-being of all Texans.

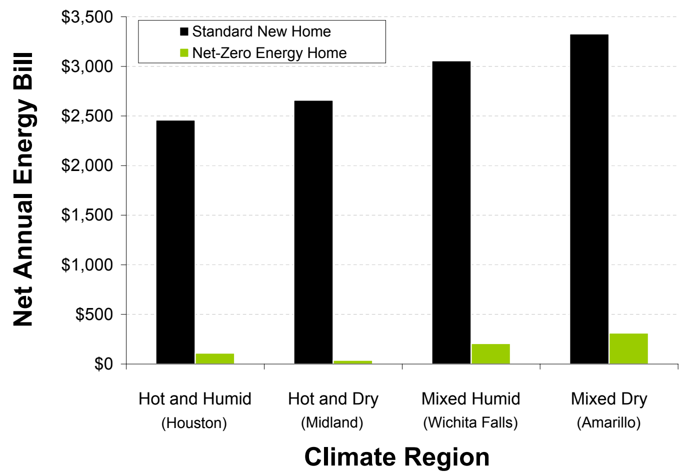
Saving Money for Individual Homeowners

With incentives, a net-zero energy home would save a homeowner $40 per month in total home ownership costs compared to a standard home. As the market for net-zero energy homes expands and costs decline, the potential for savings will become even larger.

Reducing Energy Bills

Net-zero energy homes reduce the need to purchase electricity and natural

Figure 4: Net Annual Energy Bill for a New Standard vs. a New Net-Zero Energy Home by Climate Region



gas from the utility company. Efficiency measures save energy, directly translating into lower electricity and gas bills. Additionally, through net metering, electricity produced by a solar photovoltaic system and fed into the electricity grid can be accounted for as credit on a utility bill.

Net Metering

This analysis assumes that Texas utilities will offer true net metering, which allows customers to be fairly compensated for any excess electricity generated by a home renewable energy system that is fed back into the power grid. Net metering policy recognizes that customer-owned renewable energy systems provide real value for the utility company.

Texas currently allows, but does not require, net metering. However, no utility in the state offers true net metering. Green Mountain Energy offers the closest policy, which allows customers to be compensated at the retail price of renewable power up to 500 kWh per month, and 50 percent of the retail price for any power generated thereafter.

For the homeowner to attain the full economic benefit of a net-zero energy home, more expansive net metering policies will be required. A feed-in tariff – a policy which would require utilities to purchase surplus renewable energy fed into the grid at a premium price – would have an even larger impact. Feed-in tariff policies in countries such as Germany have greatly advanced the deployment of renewable energy systems. They have also helped to attract clean energy manufacturing businesses and developed the local economy.[25]

Compared to a typical new home in Houston, a net-zero energy home would require two thirds less electricity and natural gas. A homeowner living in this net-zero energy home would pay $2,400 less per year for energy. In a cooler region of the state, like Amarillo, a net-zero energy homeowner could save $3,000 per year. (See Figure 4.)

Up-Front Costs of Net-Zero Energy Homes

Texans who build or purchase net-zero energy homes receive very little compensation for the benefits that they provide to the rest of society. This is one reason Texas has far fewer net-zero energy homes than would be optimal.

To correct this market failure, in part, federal and state government and utility companies offer a variety of incentives and rebates to reduce the initial purchase price of a net-zero energy home. These incentives also help to bring new technologies into the marketplace, increasing the number of companies with expertise in building net-zero energy homes and, over time, delivering better products that cost less.

Available Incentives and Rebates

The high-quality construction, efficient appliances – and especially the solar PV system – of a net-zero energy home currently have a greater up-front cost than a standard Texas home. However, currently available incentives can cut the incremental cost of a net-zero energy home in half.

High-quality and efficient design and construction can add in the range of 5 percent to the cost of a home.[26] Efficient appliances and lighting can cost hundreds of dollars more than standard versions. A solar hot-water system can cost several thousand dollars.[27] A 5 kW solar PV system at the price of $7.50 per Watt, installed, would cost $37,500. Altogether, these features could add $15-$20 per square foot to the price of a net-zero energy home.[28]

Many federal, state, utility, and manufacturer incentives and rebates are currently (mid-2009) on offer, compensating builders and buyers of net-zero energy homes for the value they provide to society by making net-zero energy homes more economically attractive. These incentives include:

- A federal tax credit of $2,000 for builders of homes that save at least 50 percent of the heating and cooling energy of a home built to 2004 IECC standards (set to expire at the end of 2009).[29]
- A federal tax credit of up to $1,500 for the purchase of high-efficiency home heating and cooling equipment (set to expire at the end of 2010).[30]
- A federal tax credit for 30 percent of the installed cost of residential solar PV or solar water heating systems (set to expire at the end of 2016).[31]
- Texas provides a property tax exemption for all renewable energy equipment, including solar PV and solar water heating systems.[32]
- Utilities and product manufacturers often offer incentives for the purchase of high efficiency equipment. For example, KitchenAid and GE are currently (mid-2009) offering rebates up to $500 on the purchase of select Energy Star-certified appliances.[33]
- Utilities also can offer rebates on the purchase of solar energy systems, or for efficiency measures that help to reduce peak demand. For example, Oncor offers a rebate of $2.46 per Watt for consumers who install solar PV systems (although the program's

budget is limited to $16 million over the next four years).[34] Many other major utility companies in Texas offer rebates for solar installation, including Austin Energy, CPS Energy, AEP and Bryan Texas Utilities.[35] Additionally, all utilities in competitive areas are required to offer rebates for energy efficiency measures under Texas' Energy Efficiency Resource Standard policy.

At $100 per square foot, the standard home modeled in this report would cost $272,000.[36] At $20 per square foot added, a net-zero energy home would cost 20 percent, or $55,000 more.[37] The exact combination of incentives and rebates will depend on where the net-zero energy home is located, and which utility company serves it. A representative package of incentives and rebates could reduce the incremental cost of a net-zero energy home in Texas by more than half, to $26,400. (See Table 2.)

Homeowner Monthly Cash Flow

For a homeowner, the measure of the affordability of a net-zero energy home comes down to monthly cash flow. If the higher cost of a net-zero energy home is wrapped into a home mortgage, the energy savings the home delivers can offset the increased mortgage payment. Available incentives and rebates tip the balance into net savings.

If a prospective homebuyer were financing a home purchase with a simple 30-year loan at 5.75 percent interest, with $50,000 down, a standard home would have a monthly mortgage payment of $1,295.53.[38] On top of that, the homeowner could expect to pay $205.60 on the average monthly energy bill, and $38.53 in property taxes.[39]

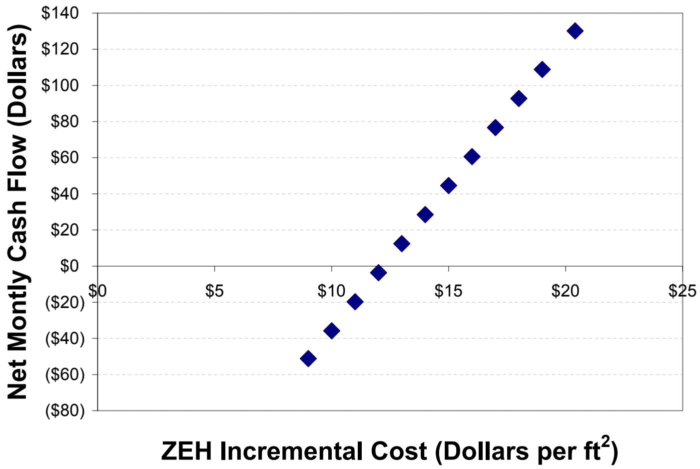
With the incentives listed in Table 2, a net-zero energy home would have an additional cost of about $10 per square foot. The monthly mortgage payment for this home would be $1,449.73, with an energy and tax bill under $50 per month. At this level, the net-zero energy home would save a homeowner $40 per month compared to a standard home.

In this example, when the incremental cost per square foot of the net-zero energy home falls to $12.23, either through incentives, design improvements, or through future economies of scale, the energy savings of the home will closely match the additional mortgage payment – making the net-zero energy home effectively cost the same as a standard home. (See Figure 5.)

Table 2: Summary of the Incremental Cost of a Net-Zero Energy Home, Plus Potential Incentives and Rebates

	Incremental Cost	Federal Rebates	Utility or Manufacturer Rebates	Net Consumer Cost
Efficient Construction	$13,600	$3,500	$300	$9,800
Efficient Appliances	$1,000	$0	$500	$500
Solar Hot Water System	$3,200	$960	-	$2,240
5 kW Solar PV System	$37,691	$11,307	$12,500	$13,884
Total	**$55,491**	**$15,767**	**$13,300**	**$26,424**

Figure 5: Net Impact on Homeowner Cash Flow of the Modeled Net-Zero Energy Home at Different Incremental Costs



PV Price Trends and Expected Future Net-Zero Energy Home Costs

As the manufacturing of solar energy systems ramps up, and as energy-efficient building practices become more widespread, costs can be expected to decline.

The Florida Solar Energy Center, which built a net-zero energy home in Florida in 1998 that achieved an 82 percent electricity savings over a conventional home, believes that the average current incremental cost of a net-zero energy home is around $16 per square foot. However, the Center anticipates that, when the technology is mature, the additional cost will fall to $9 per square foot.[40]

At $16 per square foot, the net-zero energy home modeled in this report would cost about $60 more per month than a standard home, without incentives. However, at $9 per square foot, this home would deliver net savings of more than $50 per month. (See Figure 5.)

The solar PV system, which carries the highest individual price tag, has a large influence in the overall cost of a net-zero energy home. And as a relatively immature technology, the price of solar PV panels continues to decline as production ramps up. Prices have fallen by more than 80 percent since 1980.[41] And prices continue to decline as public policies encourage growth in capacity for solar panel manufacturing, distribution and installation, and as a result of policy changes reducing the market for solar panels in Spain.[42]

The net-zero energy home modeled in this report would begin to deliver net savings for the homeowner, even without incentives, if the installed cost of solar panels fell to about $3.50 per watt. This price benchmark is quickly approaching.

Analysts at the U.S. Department of Energy forecast that the installed cost of solar PV systems will fall below $3.00 per watt by 2015, a drop in installed costs of 50 percent or more.[43] Other market analysts tend to agree.[44] After this milestone is reached, net-zero energy homes are likely to become increasingly widespread. The number of such homes will no longer be limited by the availability of incentive or rebate funding.

Now is the time for Texas to prepare the way for the widespread adoption of net-zero energy home design.

Net-Zero Energy Homes are a Texas-Size Opportunity

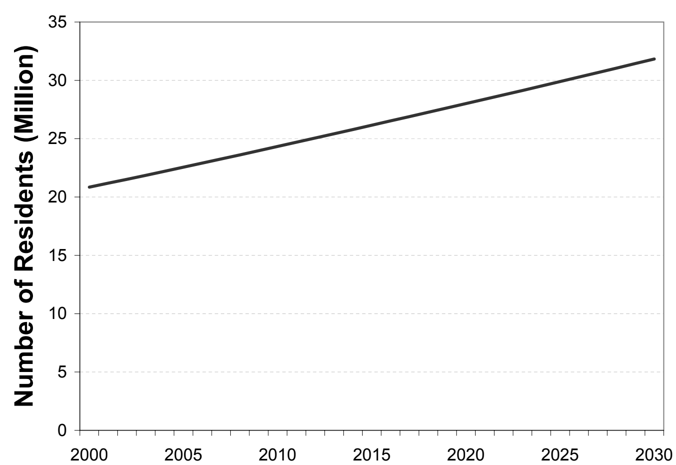
Given anticipated population growth, Texas will likely build 2.2 million additional single-family homes from 2010 to 2030. These homes represent an enormous energy opportunity. If Texas rapidly increases the use of energy-efficient construction and solar energy systems in new homes, such that by 2020 every new single-family home achieves net-zero energy performance, the state would avoid the need to build seven new large power plants.

All New Homes Can Achieve Net-Zero Energy Performance by 2020

Census officials predict that Texas' population will grow rapidly in the coming years. From 2010 through 2030, Texas will likely gain nearly 8 million new residents, increasing state population by 33 percent.[45] (See Figure 6.)

In order to accommodate these new residents, Texas builders will construct millions of new single-family homes. According to the most recent Census Bureau figures, 76 percent of Texans live in single-family homes, and each single-family home nationally houses 2.7 people, on average.[46] Assuming that these figures remain constant, the state will need approximately 2.2 million new single-family homes by 2030. That works out to more than 100,000 new homes per year.

Figure 6: Estimated Texas Population Growth through 2030[47]



If all of these new homes are built as the typical Texas home today (hereinafter referred to as the "business as usual scenario"), they will consume more than 35 billion kWh of electricity and 900 million therms of natural gas per year by 2030.

However, if Texas builders rapidly adopt a suite of strong energy efficiency measures and the state rapidly increases the use of solar energy systems on new homes, such that all new homes built in 2020 or later reach net-zero energy performance, millions of Texans will be able to help the state move towards independence from fossil fuels.

Under this scenario for net-zero energy home construction (hereinafter referred to as the "net-zero energy homes scenario"), builders will construct a declining number of homes with default energy performance, and an increasing number of net-zero energy homes. (See Figure 7.) By 2030, more than 560,000 homes with default energy performance will have been built, and more than 1.6 million new homes will have been built to achieve net-zero energy performance.

Building Net-Zero Energy Homes Would Yield Substantial Energy Savings

By 2030, the homes built under the net-zero energy home scenario would consume 17 billion kWh of electricity per year, almost 50 percent less than under the business as usual scenario. In other words, Texas would be saving 15 billion kWh of electricity per year through efficient home construction by 2030. (See the green dotted line in Figure 8.) That amount of electricity could provide for the current electricity demand of all the residences in the greater metropolitan areas of San Antonio, Austin and Corpus Christi combined (or 1.1 million Texas homes).[48]

Additionally, the solar energy systems placed on the roofs of many of these homes would be generating nearly 10 billion kWh of electricity per year by 2030. (See the solid orange line in Figure 8.) To put that in perspective, 10 billion kilowatt-hours of electricity is equivalent to nearly 3 percent of current statewide annual electricity consumption.[49]

In total, the homes built under the net-zero energy homes scenario would generate or save more than 25 billion kWh of electricity per year, reducing demand from new single-family homes for energy from traditional power plants by more than 75 percent compared to business as usual. (See Figure 8.)

The electrical energy impact of building 1.6 million net-zero energy homes would be the equivalent of building seven large (500 MW) coal-fired power plants.[50] By 2030, the homes would save or generate as much electricity per year as could be produced by more than 17 million tons of coal burned in Texas power plants.[51]

Additionally, the energy efficiency measures and solar hot water systems in these homes would save more than 500

Table 3: Energy Impact Summary of the Net-Zero Energy Home Scenario in the Year 2030

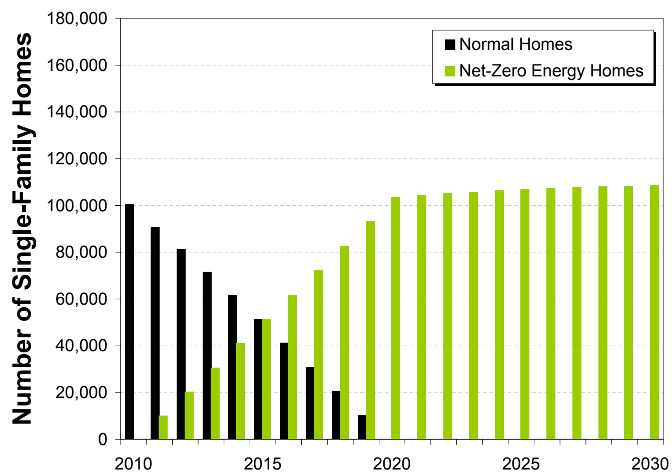
	Efficiency Savings	Solar Energy Production	Total Impact	Percent Below Business-as-Usual Scenario
Electricity (billion kWh)	15	10	25	78%
Natural Gas (million Therms)	400	100	500	51%

Table 4: Cumulative Energy Impact of the Net-Zero Energy Home Scenario from 2010 to 2030

	Efficiency Savings	Solar Energy Production	Total Impact	Percent Below Business-as-Usual Scenario
Electricity (billion kWh)	130	80	210	60%
Natural Gas (million Therms)	3,400	840	4,200	39%

million therms of natural gas. (See Figure 9.) At current consumption patterns, that amount of natural gas could meet the needs of more than 1 million Texas households.[52]

Figure 7: Estimated Number of Homes Built per Year in Texas under the Net-Zero Energy Homes Scenario



Net-Zero Energy Homes Protect Public Health and Texas' Environment

Investing in net-zero energy homes can reduce global warming pollution and help to create a cleaner, healthier future for Texas. By displacing electricity generated from fossil fuels, net-zero energy homes can cut emissions of carbon dioxide, the leading cause of global warming, as well as speed progress in reducing soot, smog and mercury pollution, which damage public health. At the same time, net-zero energy homes can help to conserve Texas' supplies of fresh water, reducing the amount of water that would otherwise be consumed in steam-driven power plants.

Preventing Global Warming Pollution

On average, each megawatt-hour of electricity generated in Texas produces 1,387 pounds of carbon dioxide, the leading pollutant driving global warming.[53] Additionally, every therm of natural gas burned produces 11.7 pounds of carbon dioxide.[54] In contrast, net-zero energy homes, which generate as much energy

Figure 8: Texas New Home Electricity Consumption under the Net-Zero Energy Homes Scenario

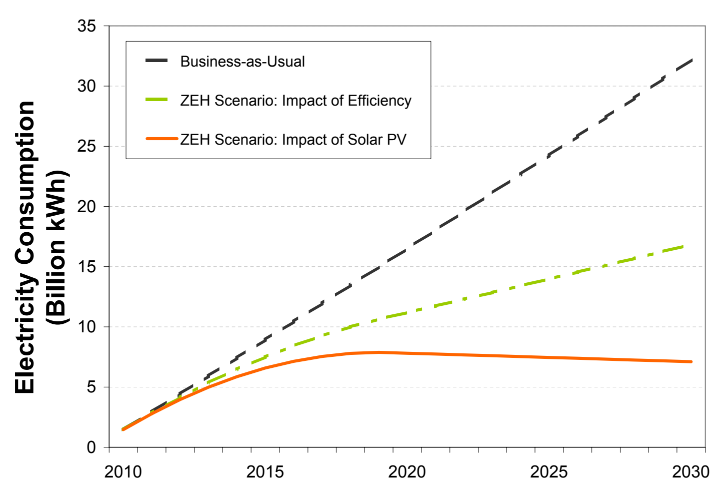


Figure 9: Natural Gas Consumption in New Texas Homes under the Net-Zero Energy Homes Scenario

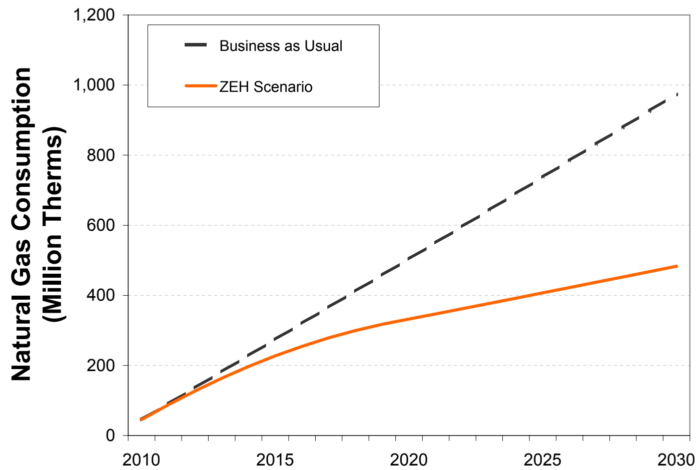
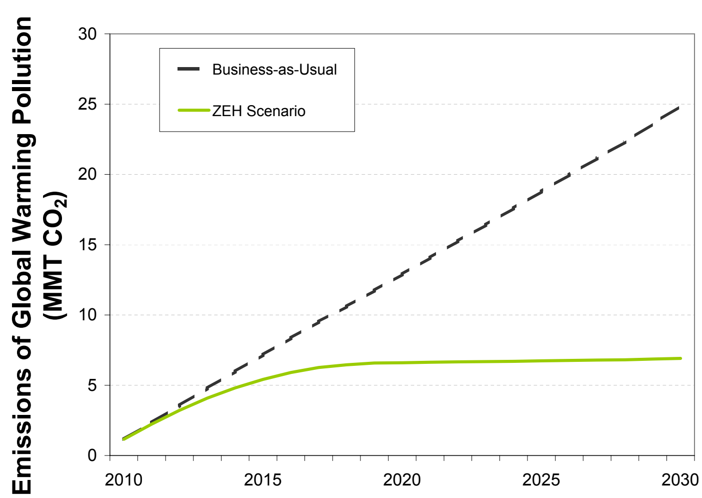


Table 5: Reduced Emissions of Air Pollution under the Net-Zero Energy Home Scenario

Pollution Impact	2030	2010-2030, Cumulative
Carbon Dioxide (MMT)	18	150
Nitrogen Oxides (Tons)	7,500	64,000
Mercury (Pounds)	390	3,800

Figure 10: Emissions of Global Warming Pollution from New Texas Homes under the Net-Zero Energy Homes Scenario



as they use through zero-emission solar photovoltaic systems, have little net emissions of global warming pollution.

By displacing the need for electricity from traditional power plants in Texas, and by reducing consumption of natural gas, in the year 2030 net-zero energy homes could annually prevent 18 million metric tons of global warming carbon dioxide pollution from entering the atmosphere.[55] This impact is roughly equivalent to eliminating the tailpipe emissions of more than one out of every six cars and trucks in the state (more than 3.1 million vehicles).[56]

Under this net-zero energy home scenario, emissions of global warming pollution from new homes in Texas built in 2010 and after will be 72 percent lower than under business-as-usual conditions. (See Figure 10.) The 560,000 homes with business-as-usual energy performance built before 2020 would increase Texas' emissions of global warming pollution by about 6 MMTCO$_2$ per year. Emissions would remain at about that level beyond 2020, because the hundreds of thousands of additional homes built would have effectively no global warming impact.

These emission cuts would help Texas do its fair share to mitigate the worst effects of global warming. According to climate scientists, the world as a whole must reduce carbon dioxide pollution 50 percent or more by 2050. The United States must shoulder a larger burden, as one of the leading emitters of global warming pollution – cutting pollution by at least 80 percent by mid-century.[57] Net-zero energy homes are one important tool to make reaching this target possible.

Preventing Soot and Smog Pollution

For every megawatt-hour of electricity generated, the average Texas power plant emits 1.3 pounds of smog-forming nitrogen oxides.[67] Partially because of this pollution, 20 counties in the major metropolitan areas of Houston, Dallas-Fort Worth, and Beaumont-Port Arthur do not meet federal health standards for air quality.[68] Moreover, the San Antonio, Austin and Longview/Tyler metropolitan areas are expected to fail to meet new, more stringent standards.[69]

By displacing the need for electricity from traditional power plants in Texas, in the year 2030 net-zero energy homes could annually prevent 7,500 tons of smog-forming nitrogen oxide emissions from entering the atmosphere. To put that in perspective, 7,500 tons is equal to more than four days worth of pollution from every factory or power plant in Texas (at 2005 emission rates).[70] Under this net-zero energy home scenario, emissions of these pollutants due to new homes would be nearly 80 percent lower than under business-as-usual conditions.

Preventing Mercury Pollution

Mercury emissions from coal-fired power plants and other industrial sources are making the fish in Texas' lakes, rivers and streams unsafe to eat. Burning coal releases mercury into the air that eventually contaminates rivers and lakes, where bacteria convert it to a highly toxic form that bioaccumulates in fish.[71]

Mercury is a neurotoxin that is particularly damaging to the developing brain. In early 2004, EPA scientists estimated that one in six women of childbearing age in the U.S. has levels of mercury in her blood that are sufficiently high to put her baby at risk of learning disabilities, developmental delays and problems with fine motor coordination, among other health impacts.[72]

In 2005, Texas' coal-fired power plants emitted 9,750 pounds of mercury.[73] As a result, Texas has issued fish consumption advisories for all coastal waters and many inland lakes.[74]

By displacing coal-fired power, net-zero energy homes help to prevent mercury contamination. In the year 2030, zero energy homes could annually prevent the emission of 390 pounds of highly toxic mercury pollution. This amount is significant – just 1/70th of a teaspoon of mercury can make the fish in a 25 acre lake unsafe to eat.[75]

Global Warming Threatens the Well-Being of All Texans

Dependence on fossil fuels threatens the future of all Texans by contributing to global warming.[58] Were Texas its own country, it would rank eighth in the world for emissions of global warming pollution, ahead of such nations as Great Britain, Spain and Canada.[59]

Because of these emissions, Texas' climate is changing. Texas is becoming a hotter place.[60] Storms with heavy rainfall are now 28 percent more frequent in Texas than they were 60 years ago.[61] Hurricanes have become more intense.[62]

Should emissions of global warming pollutants continue to increase, global average temperatures could increase by another 2° to 11.5° F by the year 2100 (depending on the pace of the emissions increase).[63] As a result, sea levels could rise by as much as 6.5 feet, causing extensive coastal flooding.[64] The number of severe hurricanes (category 4 and 5) could increase from 13 to 17 worldwide per year by 2050.[65] The state could experience extended periods of hot weather and drought, punctuated by heavy downpours, interfering with water supplies and agriculture.[66]

Reduced Water Usage

Net-zero energy homes have the additional benefit of conserving water.

Traditional power plants depend heavily on a constant supply of water to produce steam and provide cooling.[76] Texas' thermoelectric power plants consume more than 150 trillion gallons of fresh water every year.[77] That's enough to supply 3 million people with 140 gallons of water every day throughout the year.[78] On average, every megawatt-hour of electricity generated in Texas consumes about 390 gallons of water.[79]

In contrast, net-zero energy homes save electricity and generate power using very little water. For example, a homeowner might periodically wash dust off of his or her solar panels. Additionally, energy-efficient appliances, such as high-efficiency washing machines and dishwashers, actually save water while saving energy, as opposed to consuming it.

If all new Texas homes were built to achieve net-zero energy performance by 2020, by 2030 the state would be saving nearly 10 billion gallons of water per year, in addition to the impact of water-efficient appliances (which we have not attempted to estimate). That much water could meet the domestic needs of nearly 400,000 people.[80]

Table 6: Net Energy Bill Impact Summary (Million Dollars)

	2030	2010-2030, Cumulative
Business as Usual	$7,607	$75,185
Net-Zero Energy Homes Scenario	$2,155	$32,523
Net Savings	$5,452	$42,663

Net-zero energy homes, like this one in the SolAustin neighborhood, prevent pollution, protecting public health and Texas' environment. Photo: KRDB

Net Homeowner Savings

The energy-efficient features of a net-zero energy home save consumers money on their electricity and gas bills. If all new homes are built for net-zero energy performance by 2020, the state would reduce energy costs for new homeowners by $5.4 billion in the year 2030. (See Figure 11.) From 2010 through 2030, the total amount spent on energy at new Texas homes would be 57 percent less, a savings of nearly $43 billion.

To get some sense of the overall scale of possible net savings, assume that the incremental cost of the modeled net-zero energy home falls from around $20 per square foot today, to $13 per square foot in 2015, to a mature cost of $9 per square foot in 2023. Further, assume that Texas retail electricity and gas costs will increase according to the Energy Information Administration's *Annual Energy Outlook 2009*.

Under these assumptions, by 2030, owners of single-family homes built since 2010 would be saving on the order of $200 million per year, in total home ownership costs, due to the net-zero energy home scenario. (See Figure 12.) Over the entire 20 year period of analysis, net savings to homeowners would be in the range of $1.1 billion.

However, to unlock these savings – and to unlock the widespread benefits to society that these net-zero energy homes represent – Texas will have to take proactive steps. In this example, costs for the net-zero energy homes built between 2010 and 2014 would exceed savings by $35 million through 2030 (without incentives). While this cost is far less than the potential savings from the entire scenario, it poses an initial obstacle. Texas can overcome this barrier by encouraging the deployment of energy-efficient building practices and small-scale renewable energy systems.

Figure 11: Total Annual Energy Expenditure for New Texas Homes Built in or after 2010: the Impact of the Net-Zero Energy Homes Scenario

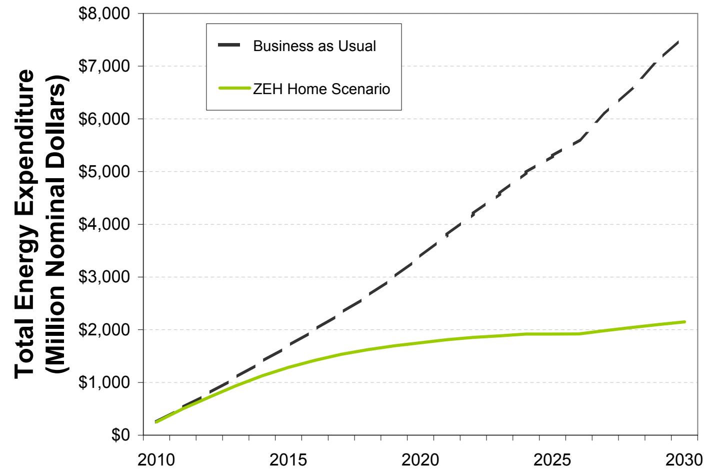
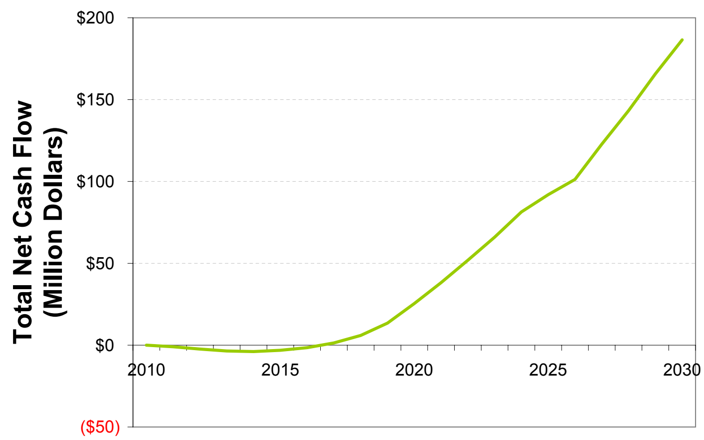


Figure 12: Total Net Cash Flow of New Homeowners (Homes Built in 2010 or Later) under the Net-Zero Energy Home Scenario



Policy Recommendations

The technology necessary to build net-zero energy homes is ready and available today. However, it is not yet in widespread use because of a variety of market barriers – including higher up-front cost, split incentives between builders and buyers, and the fact that home buyers do not always take into account the long-term savings available through higher energy performance. (See *Market Barriers to Net-Zero Energy Homes* on page 29 for further discussion.)

With the right mix of incentives and policies, Texas can give net-zero energy homes – and the efficiency and solar markets – the kick-start they need to get up and running. A small investment now could bring billions in investment to the state over the next decade. With growth in demand, economies of scale will help make all new homes energy efficient, make solar energy affordable for everybody, and deliver widespread benefits to all of Texas society – cleaner air, less global warming, savings on energy, and less vulnerability to fossil fuel price spikes.

To unlock the potential of high-performance net-zero energy homes, Texas and federal policy should work to overcome market barriers and encourage the spread of solar power systems and efficient home design.

Net-zero energy homes will be a key tool for breaking our dependence on fossil fuels. Texas, and the United States as a whole, should encourage energy-efficient home construction and the use of solar energy systems.

- President Obama has announced an ambitious but achievable goal for all new buildings to achieve net-zero energy performance by 2030. Texas should embrace this goal and lay out a plan to achieve this benchmark for new homes by 2020.
- As a first step, Texas should require local jurisdictions to strengthen

Market Barriers to Net-Zero Energy Homes

- **Bad incentives** – Utilities have commonly made more money through increasing sales of energy. For example, a 5 percent reduction in energy sales for an electricity generation, transmission and distribution utility could reduce its overall earnings by up to 25 percent. For a utility focused only on electricity distribution, such a reduction in sales could reduce its overall earnings by as much as half.[81] This sends a perverse signal that undercuts energy efficiency.
- **Split incentives** – Often, the person who is the most logical candidate to install energy efficiency improvements is least likely to benefit from them. Consider builders, who (in the absence of good consumer benchmarks), face pressure to minimize construction costs rather than make buildings as energy efficient as possible.
- **Missing incentives** – Every consumer who saves energy reduces demand, which lowers the cost of energy for everyone. A homeowner who installs efficient lighting or a solar PV system reduces the need for a new power plant or transmission wire, thus saving other ratepayers money. However, individuals who pursue clean energy changes are rarely compensated for the benefits they deliver to the rest of society.
- **"Sticker shock"** – Consumers often value lower purchase prices for homes, even when they can save money in the long run by paying a small premium for energy-efficient or net-zero energy models.
- **Lack of knowledge** – Even consumers who want to buy more energy efficient products sometimes find it difficult to tell which products are truly energy savers. While the Energy Star® program helps consumers make good choices for appliances and new homes, many products – including most homes – are not "labeled" for their energy efficiency performance. In addition, consumers might not even be aware of new technologies that can tap renewable energy resources.
- **The "crystal ball" problem** – Energy prices are notoriously volatile, making it hard for consumers and businesses to make educated decisions about future investments. Investing in a fuel-efficient vehicle, for example, appears a lot more attractive when gasoline prices are at $3 per gallon than when they are $1.50 a gallon. Yet, there is no guarantee that gasoline prices will remain high over any given period of time, thereby justifying the investment.
- **The "chicken and egg" problem** – Billions of dollars have been invested over the years in building up Texas' energy infrastructure. These historical investments can make it difficult for new technologies to compete. For example, few people will demand a net- zero energy home if builders are not producing and marketing them. But builders won't produce them unless they perceive adequate demand.

building energy codes, ensuring that all new homes across the state meet or exceed the 2009 International Energy Conservation Code.

- Texas should provide financial incentives and technical assistance to encourage high performance new construction and the deployment of solar energy systems. For example:
  - Texas should establish a statewide solar rebate program so that all Texans are able to take advantage of solar incentives.
  - Cities should set up clean energy districts to help residents install solar energy systems by offering loans that can be paid back via property taxes, as authorized by House Bill 1937.
- Texas should require true "net metering," removing limits on the ability of homeowners to be fairly compensated by their utility for any excess electricity they feed into the power grid.
- Texas utilities should add to and expand incentive programs to encourage the construction of net-zero energy homes – much like they already offer incentives for Energy Star appliances.

Energy Efficiency and Solar Power Are Not Just for New Homes

The same technologies that enable a new net-zero energy home to generate as much energy as it consumes can be used to make existing Texas homes achieve higher energy performance. By making every Texas home and business more energy-efficient, and by taking full advantage of the state's many and vast renewable energy resources, Texas can become independent of fossil fuels – yielding great benefits in terms of cleaner air, less global warming, and greater control over its own energy destiny. Toward this purpose:

- Texas should require electric utilities to increase their investment in energy efficiency programs, such as rebates for Energy Star homes, such that 1 percent of the state's electricity consumption is offset with efficiency annually by 2015 and 2 percent annually by 2020 and thereafter. According to an analysis commissioned by the Public Utility Commission of Texas, an aggressive energy efficiency program could reduce electric usage by 23 percent, saving Texans as much $11.9 billion on their electric bills.[82]
- Federal leaders should adopt national energy efficiency and renewable energy requirements, including:
  - A national energy efficiency resource standard, requiring that utilities reduce electricity consumption by at least 10 percent from today's levels by 2020;
  - Enforceable national lighting and building energy efficiency codes for new residential and commercial buildings, requiring a 50 percent reduction over current practice by 2015 and a 75 percent reduction in energy use by 2030; and
  - A building retrofit program, to ensure all existing buildings use energy efficiently.

Appendix: Net-Zero Energy Home Potential by Metropolitan Area

Table 7: Forecast Number of Homes Built by Municipality between 2010 and 2030

Metropolitan Area	Projected Number of Additional Homes
Dallas-Fort Worth Metroplex	715,795
Greater Houston	542,947
Austin	206,796
McAllen-Edinburg-Mission	126,979
San Antonio	122,992
El Paso	70,505
Laredo	50,762
Brownsville–Harlingen	50,385
Killeen-Temple-Fort Hood	33,275
Corpus Christi	31,171
Amarillo	15,863
College Station-Bryan	13,543
Waco	10,917
Beaumont-Port Arthur	10,352
Tyler	9,348
Longview	8,093
Lubbock	6,770
Victoria	6,454
Odessa	6,240
Midland	4,625
Sherman–Denison	3,501
Wichita Falls	3,217
Abilene	3,139
San Angelo	2,971
Texas Statewide Total	2,198,756

Table 8: Energy Savings and Solar Power Generation in 2030 by Metropolitan Area under the Net-Zero Energy Home Scenario*

Metropolitan Area	Electricity Savings (GWh)	Solar Power Generation (GWh)	Number of Current Texas Homes that Could Power	Gas Savings (Million Therms)	Number of Current Texas Homes that Could Supply
Dallas-Fort Worth Metroplex	5,138	3,200	611,845	158	319,848
Greater Houston	3,839	2,391	457,145	118	238,977
Austin	1,471	916	175,220	45	91,598
McAllen-Edinburg-Mission	908	566	108,176	28	56,550
San Antonio	825	514	98,220	25	51,345
El Paso	439	356	58,340	24	48,320
Laredo	366	228	43,565	11	22,774
Brownsville–Harlingen	353	220	42,049	11	21,981
Killeen-Temple-Fort Hood	230	143	27,333	7	14,289
Corpus Christi	209	130	24,834	6	12,982
College Station-Bryan	91	57	10,821	3	5,657
Amarillo	86	79	12,152	10	20,625
Waco	74	46	8,753	2	4,576
Beaumont-Port Arthur	69	43	8,201	2	4,287
Tyler	66	41	7,865	2	4,111
Longview	55	34	6,562	2	3,430
Victoria	43	27	5,073	1	2,652
Lubbock	38	31	5,111	2	4,233
Odessa	38	31	5,066	2	4,196
Midland	27	22	3,598	1	2,980
Sherman–Denison	23	16	2,806	1	2,757
Wichita Falls	20	14	2,518	1	2,474
San Angelo	16	13	2,163	1	1,791
Abilene	15	12	2,044	1	1,693
Texas Statewide Total	*15,348*	*9,725*	*1,839,827*	*502*	*1,016,726*

* *The column "Number of Current Texas Homes That Could Power" shows, for comparison purposes, the number of average current Texas residences, which use about 13,600 kWh per year, that could be powered by the energy efficiency and solar power output of the homes in the net-zero energy home scenario. Similarly, the column "The Number of Texas Homes that Could Supply" refers to the number of homes that could be supplied by the gas saved by net-zero energy homes, at an average current annual consumption of 490 therms per year. See the Methodology section on page 34 for a description of how these estimates were derived.*

Table 9: Utility Bill Savings in 2030 by Metropolitan Area under the Net-Zero Energy Homes Scenario*

Metropolitan Area	Energy Bill Savings (Million 2009 Dollars)
Dallas-Fort Worth Metroplex	$1,797
Greater Houston	$1,343
Austin	$515
Other	$326
McAllen-Edinburg-Mission	$318
San Antonio	$288
El Paso	$187
Laredo	$128
Brownsville–Harlingen	$124
Killeen-Temple-Fort Hood	$80
Corpus Christi	$73
College Station-Bryan	$32
Amarillo	$48
Waco	$26
Beaumont-Port Arthur	$24
Tyler	$23
Longview	$19
Victoria	$15
Lubbock	$16
Odessa	$16
Midland	$12
Sherman–Denison	$9
Wichita Falls	$8
San Angelo	$7
Abilene	$7
Texas Statewide Total	*$5,452*

**See the Methodology section on page 34 for a description of how these estimates were derived.*

Methodology

To generate the results of this report, we used Energy Gauge USA software, produced by the Florida Solar Energy Center, to model the annual energy consumption characteristics of a "standard" single family home and a "net-zero energy" version of the same home.[83] We then developed a scenario for single-family home construction in Texas from 2010 through 2030, and analyzed the impact of phasing in net-zero energy homes such that all new single-family homes built in 2020 and later achieve this high level of performance. Full technical details follow.

Standard Home Characteristics

A typical new single-family home in Texas has three bedrooms and bathrooms, two stories, and an air-conditioned floor area of 2,720 square feet. It is built on an un-insulated slab foundation. It has moderate attic insulation, light wall insulation, wooden doors, tinted double-pane windows, and moderately tight construction. The roof of the home, made up of darkly colored composite shingles, heats up quickly when exposed to strong sunlight. The home is equipped with a large, relatively inefficient air conditioning system and a relatively inefficient natural gas furnace for heat. Air ducts within the home are very lightly insulated, and tend to leak a little.

The home includes a relatively large air conditioning unit and a natural gas furnace for cooling and heating. A 40-gallon natural gas boiler produces hot water. The home includes a range of standard appliances, including:

- Ceiling fans,
- A dishwasher,
- A clothes washer and dryer,
- A cooking range and oven,
- A refrigerator and freezer, and
- Other appliances, including televisions, computers, and other electronic devices.

Table 10 and Table 11 present the characteristics, features, and equipment of the "standard" home.

The characteristics of the standard Texas home were determined using public use microdata sets from the U.S. Energy Information Administration's 2005 Residential Energy Consumption Survey (RECS). Only survey responses for single-family detached homes built in Texas from 2000 to 2005 were used in determining the characteristics for the typical Texas home. The characteristics selected for the home were based on the mode (highest individual value) of weighted results from the RECS microdata set, where the weight represents the estimated prevalence of this type of home across the state. For example, if options were given for no garage, a one-car garage or a two-car garage, the response with the highest weighted value in the survey was used. As there were only 27 homes built between 2000 and 2005 in the RECS data set, it is likely that use of the microdata set in this way did not produce statistically valid results. However, there were very few "close calls" in the data. As a result, while the home selected for this analysis does not represent every Texas home, it is typical of single-family homes built in the state over the past decade.

In one case, we did adjust the results of the RECS microdata analysis. The mode of the responses for the number of "other rooms" (i.e., not bedrooms or bathrooms) in the RECS database was three. However, the median value of the responses, and the median value of the responses for the total number of rooms in the house, indicated that the value was closer to four, and we chose to use four other rooms in this analysis. One other point of deviation is that we used the weighted average square footage of the homes in RECS, rather than the mode, to determine the square footage of the home.

Table 10: Basic Characteristics of the Modeled Home, Both Versions

Type	New Single-Family
Bedrooms/Bathrooms	3 Bed / 3 Bath
Surroundings	Modeled without shade trees or adjacent buildings
Conditioned Area	2720 square feet
Total Stories	Two
Floor	1360 square feet, Slab-on-Grade, Edge Insulation
Roof	1473 square feet of roof, 284 square feet of gable, 22.6 degree pitch
Attic	Full Attic, Vented
Outside Doors	Two
Window Area	480 square feet
Garage	Attached on the east side
Thermostat Schedule	HERS 2006 Reference
Appliances	1 Clothes Washer, 1 Dryer, 1 Dishwasher, 25 Light Fixtures, 1 Range, 1 Refrigerator/Freezer, and Miscellaneous Appliances, Operated on HERS 2006 Reference Schedule

Table 11: Comparing the Characteristics of the Modeled "Standard" Single-Family Home and the "Net-Zero Energy" Home

	"Standard" Home	**"Net-Zero Energy" Home**
Floor	R-0 Insulation	R-10 Insulation
Roof	Standard Shingles, Solar Absorbance 0.85	"Cool Roof," Solar Absorbance 0.1
Ceiling	R-30 Insulation	R-50 Insulation
Walls	R-13 Insulation, Face Brick - Wood, Solar Absorbance 0.75	R-30 Insulation Assembly, 0.1 Solar Absorbance
Doors	Wood Doors, No Insulation	Insulated Doors
Windows	Double-Paned, Tinted, 0.55 U-Factor, 0.4 Solar Heat Gain Coefficient, Interior Drapes	Double-Glazed, Low-E, 0.2 U-factor, 0.14 Solar Heat Gain Coefficient
Infiltration	Effective Leakage Area: 196	Effective Leakage Area: 59
Cooling System	Central Unit, SEER 13, 46.6 kBtu/hr capacity	Central Unit, SEER 15, 20.7 kBtu/hr capacity
Heating System	Natural Gas Furnace, AFUE 0.80, 50 kBtu/hr capacity	Natural Gas Furnace, AFUE 0.97, 18.7 kBtu/hr
Programmable Thermostat?	None	Yes
Hot Water System	Natural Gas, EF 0.59, 40 gallon capacity, 120 degree set point	Natural Gas, EF 0.8, 40 gallon capacity, 120 degree set point
Ducts	Supply and Return to Attic, Handler in Garage, Default Leakage	Supply, Return and Handler in Conditioned Space, Leak Free
Appliances	Default	Best Energy Star Models
Lighting	10% Fluorescent or LED	100% Fluorescent or LED
Solar Hot Water System	None	Integrated Collector Storage, 29 degree collector tilt, 180 degree azimuth, 18.4 Tank Loss Coefficient
Solar Photovoltaic System	None	5 kW Shell SR100, 29 degree collector tilt, 180 degree azimuth, 0.0043 efficiency coefficient

Net-Zero Energy Home Characteristics

Starting with the same basic characteristics as the standard Texas home, we added the following upgrades to create the net-zero energy home:

- R-30 wall assembly
- R-50 ceiling, plus a radiant barrier and a cool roof
- Tight construction (0.00015 SLA)
- Triple glazed low-e windows (0.25 U-value, 0.25 SHGC)
- 100 percent CFL or LED lighting
- Evaporative condensing cooling system with 15 EER
- Solar assisted hot water with an 80 percent efficient gas water heater
- A 97 percent efficient gas furnace for heating
- Insulated, leak-free ducts, all within conditioned space
- Energy Star appliances
- Slab-on-grade edge insulation (R-10 floor)
- 5 kW solar photovoltaic system

Table 11 presents the upgrades in further detail, compared to the features of the standard home.

Modeling Home Energy Usage and Cost

We used Energy Gauge USA software, produced by the Florida Solar Energy Center, to model the annual energy consumption characteristics of the two homes.[84] Energy Gauge incorporates the U.S. Department of Energy's DOE 2.1-E hourly building energy simulation software. The software performs a simulation of an entire year, based on local weather data, producing an hourly estimate of energy demand, and a summary of annual energy consumption. The software complies with all national accreditation procedures for the Home Energy Rating System (HERS).

To estimate the cost of the energy consumed, we used Texas 2008 statewide average electricity and gas costs from the Energy Information Administration.[85]

The estimated range of the incremental cost for a net-zero energy home over a standard home is described on page 18. In calculating mortgage payments and monthly cash flow, we used the following assumptions:

- 30 year mortgage
- $50,000 down
- 5.75 percent interest

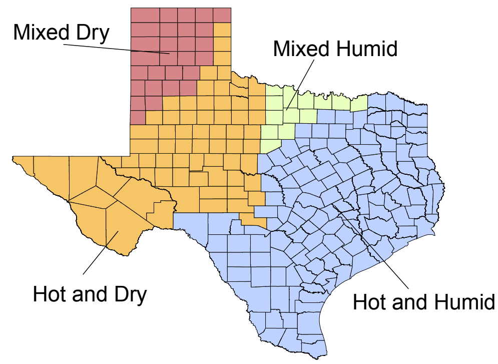
Climate Zones

Texas has four major climate zones, defined by the U.S. Department of Energy's Building America Program. These climate zones include the hot and humid region, with temperatures higher than 67 degrees F for 3,000 hours or more during the warmest 6 months of the year; the hot and dry region, with monthly average temperatures greater than 45 degrees F and less than 20 inches of annual precipitation; the mixed-humid region, with more than 20 inches of annual precipitation and where the average monthly temperature drops below 45 degrees F during the winter months; and the mixed-dry region, with less than 20 inches of annual precipitation and where the average monthly temperature drops below 45 degrees F during the winter months.[86] (See Figure 13.)

We modeled the energy performance of the standard home and the net-zero energy home in each of these climate regions, using weather data from the following cities as representative:

- Hot and humid: Houston
- Mixed humid: Wichita Falls
- Hot and dry: Midland
- Mixed dry: Amarillo

Figure 13: Texas Climate Regions[87]



Calculating Statewide Impacts of Adopting Net-Zero Energy Home Construction

We then developed a scenario for single-family home construction in Texas from 2010 through 2030, analyzing the impact of phasing in net-zero energy homes such that all new single-family homes built in 2020 and later achieve this high level of performance.

Housing Construction Scenario

We estimated the number of homes that would be built in Texas from 2010 through 2030 using state estimates of population growth by county. The state compiles four different population projections, based on different rates of immigration.[88] We used the growth scenario in which future immigration is estimated to be half the rate of 1990-2000. This is the scenario that the Population Estimates and Projections Program believes is most reasonable for long-term planning purposes.

Assuming, per the U.S. Census Bureau, that 75.8 percent of all housing units were single-family homes (with the rest in multi-unit structures, which were not considered in this report), and assuming 2.71 residents per single-family home, we translated population forecasts into a housing construction estimate by county.[89]

We translated the county housing construction estimate into an estimate of the number of homes that would be built within each climate zone, and the number of homes that would be built within each of Texas' 25 Metropolitan Statistical Areas, as defined by the Census Bureau.

Based on county-level population growth estimates, 93 percent of these new homes will be built in Texas' hot and humid climate region, which includes major population centers such as the Dallas, Houston, and San Antonio metropolitan areas. 5 percent of these new homes will be built in Texas' hot and dry climate region, which includes the towns of Midland and Odessa. The remaining 2 percent will be built in the mixed-humid and mixed-dry regions of the state.

Business-as-Usual vs. Net-Zero Energy Scenarios

For the business-as-usual scenario, we assumed that all of the homes built in the housing construction scenario from 2010 to 2030 would have characteristics and energy consumption performance equal to the modeled "standard" home.

For the Net-Zero Energy home scenario, we assumed that Texas would increase the fraction of new homes built each year that achieved net-zero energy performance, from 0 percent in 2010 to 100 percent in 2020. (See Figure 7 on page 23.) Under this scenario, by 2030, more than 560,000 homes with default energy performance will have been built, and more than 1.6 million new homes will have been built to achieve net-zero energy performance.

Extrapolating Modeling Results for Individual Homes to the Statewide Level

For the business-as-usual scenario and the net-zero energy homes scenario, we calculated the energy consumption of all homes built in 2010 and after in each climate zone using the modeled energy performance characteristics of each type of home in each of the four climate zones, combined with the forecast of how many homes of each type would be built within each zone from 2010 to 2030.

To calculate the homeowner's cost of energy consumption in each year through 2030, we applied modeled energy consumption data to a forecast of electricity and gas prices. We derived the price forecast by starting with average 2008 Texas electricity and gas prices and applied year-by-year rates of change from the Energy Information Administration's *Annual Energy Outlook 2009* (Updated Reference Case).[90]

To calculate total net costs of home ownership, we assumed that the incremental cost of the modeled net-zero energy home falls from around $20 per square foot today, to $13 per square foot in 2015, to a mature cost of $9 per square foot in 2023, without incentives. We also assumed that Texas retail electricity and gas costs will increase according to the Energy Information Administration's *Annual Energy Outlook 2009*.

To calculate electric sector emissions of carbon dioxide, oxides of nitrogen, and mercury due to new home electricity use through 2030, we used forecast emissions rates from the Energy Information Administration's *Annual Energy Outlook 2009* (Updated Reference Case) for the Texas region.[91]

All savings figures were calculated by subtracting consumption, spending, and emissions totals for the net-zero energy home scenario from the business as usual scenario.

Notes

1. Clifford Krauss, "Move Over Oil, There's Money in Texas Wind," *New York Times*, 23 February 2008.

2. Fossil fuel combustion makes the air in many of Texas' largest metropolitan areas – Dallas-Fort Worth, Houston, and Beaumont-Port Arthur – unhealthy to breathe. Additionally, Austin, San Antonio and Northeast Texas are near non-attainment for air quality. Texas Commission on Environmental Quality, *Texas Attainment Status by Region*, 10 March 2009.

3. Richard Alley et al., Intergovernmental Panel on Climate Change, "Summary for Policymakers," In: *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, [S. Solomon et al., (eds.)], Cambridge University Press, Cambridge and New York, 2007. Were Texas its own country, it would rank eighth in the world for emissions of global warming pollution, ahead of such nations as Great Britain, Spain and Canada. Environmental Defense, *Fair Warning: Global Warming and the Lone Star State*, May 2006. See also: U.S. Department of Energy, Energy Information Administration, *International Energy Annual 2006: Table H.1co2* and *State Carbon Dioxide Emissions Summary*, December 2008, available at www.eia.doe.gov/environment.html.

4. See note 1; Keith Johnson, "Blown Away: Wind Power Makes Electricity Cheaper in Texas" *Wall Street Journal*, 10 August 2009.

5. U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2007: 1990 - 2007 Retail Sales of Electricity by State by Sector by Provider (EIA-861)*, 26 January 2009.

6. U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2007: 1990 - 2007 Net Generation by State by Type of Producer by Energy Source (EIA-906)*, 26 January 2009.

7. Anton Caputo, "San Antonio Adopts Green Building Code," *San Antonio Express-News*, 13 March 2009.

8. 65 percent: Kate Alexander, "Austin Leads Way in Energy Efficiency: By 2015, Code Changes Will Reduce Energy Use by 65 Percent in New Homes," *Austin American-Statesman*, 17 October 2007; City of Austin, Office of the Mayor, *Mayor Wynn Announces Action on Zero Energy Homes* (press release), 18 October 2007.

9. Shonda Novak, "East Austin Subdivision Sets New Bar for Green Design," *Austin American-Statesman*, 14 June 2009.

10. U.S. Department of Energy, Building America Program, *Northern Texas Builds Its First Zero Energy Home*, October 2004.

11. U.S. Department of Energy, Energy Information Administration, *State Energy Profiles: Texas*, 9 July 2009.

12. Ibid.

13. "Most Texans": Population Estimates and Projections Program, Texas State Data Center, Office of the State Demographer, Institute for Demographic and Socioeconomic Research, The University of Texas at San Antonio, *2008 Population Projections*, February 2009; and U.S. Department of Energy, Building America Program, *Climate Zones* (map), downloaded from www.baihp.org/partners/ on 1 June 2009.

14. Compared in terms of BTU consumed, including estimated energy losses during the generation and transmission of electricity. In 2006, Texas electricity generators consumed 3,565.3 trillion BTU, and utilities sold 343 billion kWh to consumers, consuming 10,400 BTU per kWh. (BTU consumption: U.S. Department of Energy, Energy Information Administration, *State Energy Data System*, 28 November 2008; Retail electricity sales: U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2007: 1990 - 2007 Retail Sales of Electricity by State by*

Sector by Provider (EIA-861), 26 January 2009.) Also assuming 100,000 BTU per therm of natural gas.

15. U.S. Department of Energy, Energy Information Administration, *Geothermal Heat Pumps*, downloaded from www.eia.doe.gov/cneaf/solar.renewables/page/heatpumps/heatpumps.html, 5 October 2006.

16. Geothermal Heat Pump Consortium, *GeoExchange Heating and Cooling Systems: Fascinating Facts*, January 2006.

17. U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Small Wind Electric Systems*, March 2005.

18. Assuming a capacity factor of 0.2 – 0.25.

19. PV costs: Thomas P. Kimbis, U.S. Department of Energy, Solar Energy Technologies Program , *Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory* (presentation), 27 May 2008.

20. Clean Power Research and Austin Energy, *The Value of Distributed Photovoltaics to Austin Energy and the City of Austin*, 16 March 2006.

21. Ryan Wiser, Mark Bolinger and Matt St. Clair, U.S. Department of Energy, Lawrence Berkeley National Laboratory, *Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*, LBNL-56756, January 2005.

22. Ibid.

23. R. Neal Elliot and Ann Monis Shipley, American Council for an Energy Efficient Economy, *Impacts of Energy Efficiency and Renewable Energy On Natural Gas Markets: Updated and Expanded Analysis*, 2005.

24. C. Pope et al., "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution," *Journal of the American Medical Association* 287: 1132-1141, 2002; A. Peters et al., "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction," *Circulation* 103: 2810-2815, 2001; J. Samet et al., The United States Health Effects Institute, *The National Morbidity, Mortality, and Air Pollution Study, Part II: Morbidity and Mortality from Air Pollution in the United States,* Research Report Number 94, June 2000; Joel Schwartz, "Particulate Air Pollution and Chronic Respiratory Disease," *Environmental Research* 62: 7-13, 1993; D. Abbey et al., "Long-term Ambient Concentrations of Total Suspended Particles, Ozone, and Sulfur Dioxide and Respiratory Symptoms in a Nonsmoking Population," *Archives of Environmental Health* 48: 33-46, 1993; Joel Schwartz et al., "Particulate Air Pollution and Hospital Emergency Room Visits for Asthma in Seattle," *American Review of Respiratory Disease* 147: 826-831, 1993; J. Schwartz et al., "Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children," *American Journal of Respiratory Critical Care Medicine* 150: 1234-1242, 1994; W. McDonnell et al., "Pulmonary Effects of Ozone Exposure During Exercise: Dose-Response Characteristics," *Journal of Applied Physiology* 5: 1345-1352, 1983; R. McConnell et al., "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *The Lancet* 359: 386-391, 2002; M. Lippman, "Health Effects of Ozone: A Critical Review," *Journal of the Air Pollution Control Association* 39: 672-695, 1989; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine* 21: 1-48, 2000.

25. Mark Landler, "Germany Debates Subsidies for Solar Industry," *New York Times*, 16 May 2008.

26. Steve Dunn, Southwest Energy Efficiency Project, *Incentives for High-Performance Homes in New Mexico*, Presentation at the SWEEP Workshop on High-Performance / Net-Zero Energy Homes, Albuquerque, New Mexico, 20 June 2008.

27. Bernadette Del Chiaro and Timothy Telleen-Lawton, Environment California Research & Policy Center and Frontier Group, *Solar Water Heating: How California Can Reduce Its Dependence on Natural Gas*, April 2007.

28. Eric Martin et al., Florida Solar Energy Center, *Preliminary Performance Evaluation of a near Zero Energy Home in Callaway, Florida*, FSEC-CR-1793-09, February 2009;

Mike Keesee, Sacramento Municipal Utility District, *SMUD's Zero Energy Home Experience: Presentation to 2009-2030 Residential Strategic Planning Meeting*, 11 December 2007.

29. The Tax Incentives Assistance Project, *Builders & Manufacturers Incentives*, downloaded from energytaxincentives.org on 2 June 2009.

30. The Tax Incentives Assistance Project, *Consumer Tax Incentives*, downloaded from energytaxincentives.org on 2 June 2009.

31. Ibid.

32. N.C. State University, Database of State Incentives for Renewables and Efficiency, *Texas Incentives/Policies for Renewables & Efficiency: Renewable Energy Systems Property Tax Exemption*, 23 March 2009.

33. US Environmental Protection Agency, Energy Star Program, *Special Offers and Rebates Search Engine*, available at www.energystar.gov/index.cfm?fuseaction=rebate.rebate_locator.

34. Elizabeth Souder, "Oncor Offers Rebate for Solar Panel Installation," *The Dallas Morning News*, 16 February 2009.

35. N.C. State University, Database of State Incentives for Renewables and Efficiency, *Texas Incentives/Policies for Renewables & Efficiency*, 23 June 2009.

36. Average prices per square foot for all real estate sales range from $38 in San Antonio, $50 in Houston and Dallas, and up to $90 in Austin. (See www.trulia.com/city/TX/ for further examples.) We chose $100 as a reasonable estimate for a new home in Texas. Actual prices would depend on many factors, including the location of the home.

37. It should be noted that additional costs could turn out to be far less. For example, the U.S. Department of Energy's Building America program is working to develop integrated design approaches in which the additional cost of high-quality components is offset by savings from better design and faster construction.

38. Calculated using the simple loan payment calculator at www.mortgage-calc.com.

39. At the Texas average property tax rate of 0.34 percent, per: Texas Comptroller of Public Accounts, *2007 Property Tax Rates and Taxes*, downloaded from www.window.state.tx.us on 12 June 2009.

40. See note 28, Eric Martin et al.

41. Charles F. Kutscher, ed., American Solar Energy Society, *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030*, January 2007, estimate in constant 2004 dollars.

42. Kate Galbraith, "More Sun for Less: Solar Panels Drop in Price," *New York Times*, 26 August 2009.

43. See note 19.

44. Shyam Mehta, Greentech Media and Travis Bradford, the Prometheus Institute, "PV Technology, Production and Cost, 2009 Forecast," *GreentechMedia.com*, 27 January 2009.

45. See note 13, Population Estimates and Projections Program.

46. 76 percent: U.S. Census Bureau, Texas Quickfacts, Housing units in multi-unit structures, percent, 2000, downloaded from quickfacts.census.gov on 2 June 2009; 2.7: U.S. Census Bureau, *American Housing Survey 2005, Table 2-25. Units in Structure by Selected Characteristics-Occupied Units*, 2005.

47. See note 13, Population Estimates and Projections Program.

48. Housing units: U.S. Census Bureau, American Housing Survey, *Households and Housing Units by Metropolitan Area, Texas*, 2007.

49. Statewide annual electricity consumption in 2007 was 344 billion kWh: Energy Information Administration, U.S. Department of Energy, *Texas Electricity Profile 2007 Edition*, DOE/EIA-0348, April 2009.

50. Assuming that a coal-fired power plant operates with a capacity factor of 80 percent.

51. Based on a comparison of the amount of fuel necessary to generate an equivalent amount of electricity in Texas power plants, per: U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2007: 1990 - 2007 Fossil Fuel*

Consumption for Electricity Generation by Year, Industry Type and State (EIA-906) and *1990 - 2007 Net Generation by State by Type of Producer by Energy Source (EIA-906),* 26 January 2009.

52. Texas residential customers used 494 therms per customer in 2007, per U.S. Department of Energy, Energy Information Administration, *Natural Gas Consumption by End Use* and *Number of Natural Gas Consumers, Texas*, 29 June 2009.

53. See note 49.

54. U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2005. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types*. USEPA #430-R-07-002, 2007.

55. Calculated using statewide average electric sector emissions rates for the Texas region in: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2009 (Updated Reference Case)*, March 2009; and estimating direct emissions of carbon dioxide from the combustion of natural gas, using EPA emissions factors cited in note 54.

56. Calculated assuming 19.654 pounds of carbon dioxide per gallon of gasoline, per U.S. Department of Energy, Energy Information Administration, *Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source codes and Emission coefficients*, downloaded from www.eia.doe.gov, 10 January 2006. The projected fleet-wide average fuel economy in 2008 was 20.8 miles per gallon, per U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2008*, EPA420-S-08-003, September 2008. In 2006, around 18 million cars and trucks were registered in Texas, logging 243 billion vehicle miles traveled (Federal Highway Administration, *Highway Statistics 2006*, December 2007).

57. For example, see: Malte Meinshausen, "What Does a 2° C Target Mean for Greenhouse Gas Concentrations? A Brief Analysis Based on Multi-Gas Emission Pathways and Several Climate Sensitivity Uncertainty Estimates," in Hans Joachim Schnellnhuber, ed., *Avoiding Dangerous Climate Change*, Cambridge University Press, 2006; and note 3, Intergovernmental Panel on Climate Change.

58. See note 3, Intergovernmental Panel on Climate Change.

59. Environmental Defense, *Fair Warning: Global Warming and the Lone Star State*, May 2006. See also: U.S. Department of Energy, Energy Information Administration, *International Energy Annual 2006: Table H.1co2* and *State Carbon Dioxide Emissions Summary*, December 2008, available at www.eia.doe.gov/environment.html.

60. Environment Texas Research & Policy Center, *Feeling the Heat*, October 2008.

61. Environment Texas Research & Policy Center, *When it Rains, It Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States,* December 2007.

62. James Elsner et al., "The Increasing Intensity of the Strongest Tropical Cyclones," *Nature* 455, 92-95, 4 September 2008.

63. See note 3, Intergovernmental Panel on Climate Change.

64. W.T. Pfeffer et al., Institute of Arctic and Alpine Research, University of Colorado, Boulder, "Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise," *Science* 321: 1340-1343, September 2008.

65. Researchers at Florida State University calculate that for every 1 °C increase in sea-surface temperatures, the frequency of severe hurricanes (category 4 and 5) increases by nearly one-third. See note 62.

66. See notes 59 and 61.

67. See note 49.

68. See note 2.

69. Liz Carmack, Texas Commission on Environmental Quality, "Non-Attainment Counties Could Increase to 27," *Natural Outlook* (TCEQ Newsletter), Spring/Summer 2009.

70. Texas Commission on Environmental

Quality, *Revisions to the State Implementation Plan (SIP) concerning Ozone (O3) and Fine Particulate Matter (PM2.5) Transport Emissions*, Appendix B, 16 April 2008.

71. Charles Driscoll, David Evers and Thomas Holsen, for the Hubbard Brook Research Foundation, *New Scientific Studies Identify Causes of Mercury Pollution Hotspots* (Press Release), 9 January 2007.

72. Kathryn R. Mahaffey, Robert P. Clickner, and Catherine C. Bodurow, "Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000," *Environmental Health Perspectives* 112 (5), 562-570, April 2004; Kathryn R. Mahaffey, U.S. EPA, *Methylmercury: Epidemiology Update*, presentation before the Fish Forum, San Diego, January 2004.

73. U.S. Environmental Protection Agency, *E-Grid2007 Database*, Version 1.1, 28 January 2009.

74. Texas Parks and Wildlife, *Fish Consumption Bans and Advisories*, 22 January 2009.

75. Clean Air Network, *The Problem with Mercury* (factsheet), August 1999.

76. Ellen Baum, et al. Clean Air Task Force and the Land and Water Fund of the Rockies, *The Last Straw: Water Use by Power Plants in the Arid West,* April 2003; Ole von Uexküll, Rocky Mountain Institute, "Exploring The Relationship Between Energy and Water," *RMI Newsletter*, Spring 2005; based on PH Gleick, "Water and Energy" *Annual Review of Energy and Environment* 19:267–299, 1994; Stirling: Clean Energy Partnership, *Edison Signs Huge Solar Thermal Contract in California*, 26 August 2005, viewed at www.cleanenergypartnership.org.

77. Ashlynn Stillwell et al., University of Texas at Austin and Environmental Defense Fund, *Energy-Water Nexus in Texas*, April 2009.

78. Ibid.

79. Ibid.

80. Assuming 70 gallons of water per person per day for domestic uses.

81. Wayne Shirley, Regulatory Assistance Project, *Barriers to Energy Efficiency* (presentation), undated, downloaded from www.raponline.org/Slides/MACRUCEnergyEfficiencyBarriersWS.pdf on 8 February 2008.

82. Itron, Inc. for the Texas Public Utilities Commission, *Assessment of the Feasible and Achievable Levels of Electricity Savings from Investor Owned Utilities in Texas: 2009-2018*, 10 December 2008.

83. Florida Solar Energy Center, *Energy Gauge USA, Version 2.80.2*, available at www.energygauge.com.

84. Ibid.

85. U.S. Department of Energy, Energy Information Administration, *Electric Power Monthly with data for March 2009*, 15 July 2009; and U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator: Natural Gas Prices: Texas*, 29 June 2009.

86. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program, *Bulding America Climate Regions*, 11 September 2008.

87. Ibid.

88. See note 13, Population Estimates and Projections Program.

89. See note 46.

90. See note 85; forecast into the future using U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2009 (Updated Reference Case),* March 2009.

91. Ibid.

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