Building America SM
U.S. Department of Energy

Research that Works

Habitat Metro Denver—

Perfecting Award-Winning Affordable Homes Using Building America's Integrated Design Approach

Habitat for Humanity's goal is to supply quality housing to poor families while reducing their energy cost burden, especially in light of ever-increasing energy prices. Habitat Metro Denver partnered with the U.S. Department of Energy's Building America Project and the National Renewable Energy Laboratory (NREL) to improve their construction and design process to create an affordable home that is not only cost-effective and volunteer friendly to build but highly energy efficient and a comfortable place to live.

Habitat Metro Denver streamlined its building process by working with NREL researchers to create a series of Energy Demonstration Homes that are responsive to climatic conditions. These homes were used to try out a wide variety of energy-efficient techniques and technologies using Building America's integrated systems-engineering design approach. Habitat used the experience gained from this process to choose which features could be easily and affordably replicated in their future homes. Today, every house built by Habitat Metro Denver is tight, well insulated, and energy efficient and typically receives a Colorado E-Star™ rating of 88 or higher. (Homes rated by Colorado E-Star™ typically rate a 77.) Habitat Metro Denver has become recognized nationally as a leader in energy-efficient building by partnering with Building America.

Paul Norton, NREL/PIX13618

The Colorado E-Star™ program rated this Habitat Metro Denver home at 95, making it one of the most efficient homes ever rated by the program.

Habitat Metro Denver includes the energy efficiency features listed below in all their homes because the group found them to be practical and effective. But these features could be adopted as a package by any cold-climate Habitat affiliate.

Energy-Efficient Features

Well-insulated building shell:

- 2-in. x 6-in. walls 24-in. on center with R-19 insulation
- Raised heel trusses and R-38 attic insulation
- Low-e vinyl windows
- Header space designed for 2-in. foam insulation
- 2-in. extruded polystyrene foam (XPS or "blue board") on the interior face of crawlspace walls
- ½-in. XPS foam over one layer of ½-in. OSB sheathing on exterior walls

Well-sealed building shell:

- Edges of OSB exterior sheathing caulked before being nailed onto walls
- Exterior sheathing seams taped with building tape
- All building envelope penetrations sealed with sill seal, caulk, or spray foam

Good solar control:

- Site and building design to allow maximum solar gain
- 2-ft eave overhangs for shading in the summer

Appliances and lighting:

- Front-loading washing machine
- Direct power vent, high-efficiency gas water heater
- Programmable thermostat
- 90% efficient closed-combustion furnace
- Compact fluorescent lights
- All HVAC duct work sealed internally and tested
- Continuous ridge and soffit vents

The Habitat/NREL Energy Demonstration House


Paul Norton, NREL/PIX13530

Photovoltaic panels

In 2002, Habitat Metro Denver partnered with NREL to design and build a 1,100-ft^2 demonstration home. The house features a well-sealed and insulated shell, high-performance windows, zoned radiant wall heating, high-efficiency appliances, solar water heating, and a photovoltaic (PV) system that produces electricity from sunlight. The PV system is grid-connected with no battery backup. The PV system feeds electricity into the utility grid when it produces more electricity than the home needs, and it consumes electricity from the utility grid when the home needs more electricity than the PV system is producing. At times, the electric meter on the home actually runs backward. This arrangement, called "net metering," is now available in most states. The home was evaluated by an independent energy rater and given a Colorado E-Star™ score of 95, making it one of the most efficient homes ever rated by the program. As a result, Habitat Metro Denver was honored by the U.S. Environmental Protection Agency with the 2003 New Millennium Builder Award.

The building design that received the award began with Habitat's standard energy-efficient features. NREL building researchers then reviewed the design and suggested a series of energy upgrades. The Habitat construction team and energy committee evaluated the list based on the "volunteer friendliness" of each idea and the availability of materials and expertise. Final design changes were as follows:

- Replace fiberglass batts with spray foam insulation in the walls, ceiling, and floor to improve insulation consistency and air tightness
- Reduce east and west windows and increase south windows to provide solar tempering
- Install a 1.8-kW, net-metered PV system and a solar water heating system
- Replace furnace with a high-efficiency boiler and zoned radiant wall system
- Make ADA[1] compliant by hanging the floors in the foundation to reduce step-up into house and design the bathroom for wheelchair use
- Reduce attic overheating with light-colored roofing shingles and increased attic ventilation
- Reduce lighting loads with compact fluorescent lighting in the home and a tubular skylight in the garage.


Paul Norton, NREL/PIX13528

Spray foam insulation

In February 2003, NREL monitored the home's energy performance by installing sensors to track energy consumption. The results showed that during the summer of 2003, the solar water heating system provided between 50% and 78% of the energy used for water heating. The solar electric system produced one-third of the home's electricity. When the energy efficiency features of the home are combined with solar water heating and solar electricity, the home saves about 60% of the total energy that would be used in an identical home built with standard features.

[1] Americans with Disabilities Act

ENERGY STAR® New Millennium Builder Award

In 2003, Habitat Metro Denver won this award, which recognizes builders that design, construct, and market the best high-performance homes.

Solar Electricity for Habitat Homes — Step-By-Step

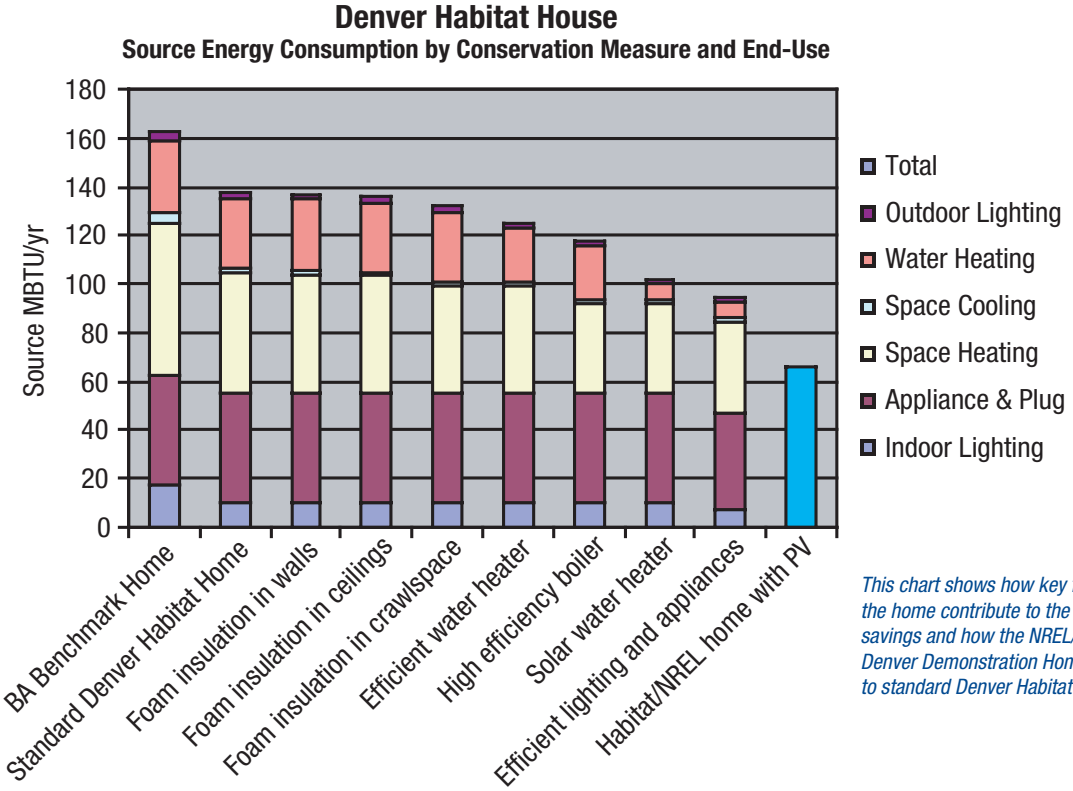
Despite the initial cost of solar electricity, there are countless reasons you may want to consider a PV system on your Energy Demonstration Home, including the environmental benefits, the demonstration of your commitment to clean energy, energy bill reductions for your homeowners, and press visibility for your local Habitat efforts that may lead to increased sponsorship.

Paul Norton, NREL/PIX

Solar water-heating collectors

A grid-connected PV system is the most cost-effective. However, it can be relatively expensive compared to the total house cost. Costs can range from $10,000 to $20,000 for a 1- to 2-kW system. However, federal, state, or local rebates are available to help reduce system cost. A local net-metering program, where the local utility gives homeowners credit for or buys back excess power produced by the system, can help to offset system cost. Also, the homeowner needs to be aware that additional cost will be incurred when the roof needs replacing because the PV system must be removed and then reinstalled. The type of mounting system used during the initial installation will affect this cost.

For more detailed information, refer to "Get Your Power from the Sun," an online consumer's guide to purchasing PV. This publication is available at *www.nrel.gov/docs/fy04osti/35297.pdf.*



This chart shows how key features of the home contribute to the overall energy savings and how the NREL/Habitat Metro Denver Demonstration Home compares to standard Denver Habitat homes.

Systems-Engineering Approach

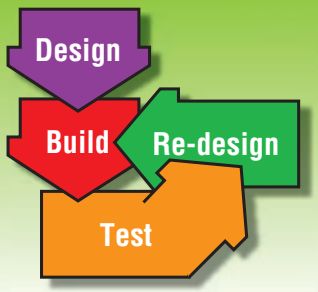
Building America's systems-engineering approach unites segments of the building industry that have traditionally worked independently of one another. Building America forms teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades.

The concept is simple: systems-engineering can make America's new homes cost effective to build and energy efficient to live in. Energy consumption of new houses can be reduced by as much as 50% with little or no impact on the cost of construction.

In order to reach this goal, Building America teams work to produce houses that incorporate energy- and material-saving strategies from design through construction.

First, teams analyze and select cost-effective strategies for improving home performance. Next, teams evaluate design, business, and construction practices within individual builder partnerships to identify cost savings.

Cost savings can then be reinvested to improve energy performance and product quality. For example, a design incorporating new techniques for tightening the building envelope may enable builders to install smaller, less expensive heating and cooling systems. The savings generated in this process can then be reinvested in high-performance windows to further reduce energy use and costs.



The "pilot" or "test" home is the field application of solution design. The team builds this prototype home according to their strategic design, tests each system for efficiency, and makes any necessary changes to increase efficiency and cost effectiveness. Before additional houses are built, these changes are incorporated into the design. This process of analysis, field implementation, re-analysis, and design alteration facilitates ultimate home performance once a design is ready for use in production or community-scale housing.

Understanding the interaction between each component in the home is paramount to the systems-engineering process. Throughout design and construction, the relationship between building site, envelope, mechanical systems, and other factors is carefully considered. Recognizing that features of one component can dramatically affect the performance of others enables Building America teams to engineer energy-saving strategies at little or no extra cost.

IBACOS, NREL / PIX12910

An energy-recovery ventilator ensures good indoor air quality.

IBACOS, NREL / PIX12937

Open web trusses provide space within the building enclosure to run electrical wires and ducts.

Achieving High Performance Using A Systems-Engineering Approach

IBACOS, NREL / PIX12935

This manifold piping distribution system is easier to install than traditional systems.

IBACOS, NREL / PIX12912

High-efficiency water heaters provide ample hot water using less energy.

IBACOS, NREL / PIX12906

Home airtightness is tested using a blower door.

	Annual Source Energy			Source Energy Savings of Energy Demonstration Home			
				Percent of End-Use		Percent of Total	
End-Use	Building America Benchmark MBTU/yr	Habitat Metro Denver Standard Home MBTU/yr	Habitat/NREL Energy Demonstration Home MBTU/yr	Compared to Building America Benchmark	Compared to Habitat Standard Home	Compared to Building America Benchmark	Compared to Habitat Standard Home
Space Heating	62	49	38	39%	23%	15%	8%
Space Cooling	5	2	2	68%	1%	2%	0%
DHW	29	29	7	77%	77%	14%	17%
Lighting	18	11	7	60%	33%	7%	3%
Appliances + Plug	45	45	39	11%	11%	3%	4%
OA Ventilation	0	0	0	0%	0%	0%	0%
Total Usage	159	135	93	41%	31%	41%	31%
PV System Generation	0	0	-29			18%	
Net Energy Use	159	135	64	59%		**59%**	

Notes: The "Percent of End-Use" columns show how effective the prototype building is at reducing energy use in each end-use category.
The "Percent of Total" columns show how the energy reductions in each end-use category contribute to the overall savings.

	Site Energy		Source Energy		National Average Energy Cost		Builder Standard (Local Costs)			
							Energy Cost		Measure	Package
Increment	kWh	therms	MBTU	Savings %	$/yr	Savings %	$/yr	Savings %	value ($/yr)	savings $/yr
Building America Benchmark Home	5905	834	158.6		$ 481		$ 1,021			
Habitat Metro Denver Standard Practice Home	5014	713	135.3	15%	$ 408	15%	$ 870			
Habitat Standard Home + Foam Insulation in walls	5011	710	134.9	15%	$ 408	15%	$ 868	0%	$ 2	$ 2
Above features + Foam insulation in ceiling	4964	703	133.6	16%	$ 404	16%	$ 860	1%	$ 8	$ 11
Above features + Crawlspace Foam Insulation	5167	654	129.9	18%	$ 421	12%	$ 844	3%	$ 15	$ 26
Above features + High effiency water heating	5167	594	122.8	23%	$ 421	12%	$ 806	7%	$ 39	$ 65
Above features + High effiency boiler	4619	578	115.3	27%	$ 376	22%	$ 751	14%	$ 55	$ 120
Above features + Solar water heating	4619	447	99.9	37%	$ 376	22%	$ 666	24%	$ 85	$ 205
Above features + Efficient Lighting and appliances	3771	461	92.9	41%	$ 307	36%	$ 606	30%	$ 60	$ 264
Site Generation										
Above features + Photovoltiac system	981	461	64.3	**59%**	$ 80		$ 379	56%	$ 227	$ 492

Notes: "Source Energy Savings %" and "National Average Energy Cost Savings %" compared to the Building America base case, whereas the "Energy Cost Savings %" and the "Package savings $/yr" are compared to the Builder Standard Practice case.

Colorado Average Electric Cost : 0.08 $/kWh (Nov. 2003)
Colorado Average Gas Cost: 0.65 $/therm (Dec. 2003)

(Source: US Energy Information Agency)

Summary of Energy Performance

The tables above summarize the results of comparing the simulated performance of the NREL/Habitat home to homes that look identical but lack the energy-saving features of the NREL/Habitat home.

Future Projects

In 2005, NREL and Habitat Metro Denver will push the boundaries of energy efficiency even further by collaborating on the building of a Zero Energy Habitat Home. This home is being designed to produce as much energy as it consumes on an annual basis. The design will be based on the lessons learned from the 2002 Energy Demonstration Home. If you would like to follow the progress on this home, please send an email to Paul_Norton@nrel.gov.

Additional Resources

- The Building America Project: www.buildingamerica.gov
- Top Web sites for Energy-Efficient Homes: www.eere.energy.gov/buildings/building_america/for_builders_top25.html
- EPA's ENERGY STAR® Homes and appliances: www.energystar.gov
- Home Energy Magazine: www.homeenergy.org
- The Energy and Environmental Building Association: www.eeba.org
- ToolBase Green Building: www.toolbase.org/secondaryT.asp?CategoryID=1&TrackID=
- Building Science Corporation's Habitat house design for cold climates: www.buildingscience.com/about/habitat/default.htm
- NREL's Photovoltaics for Buildings (offers links to solar manufacturers): www.nrel.gov/buildings/pv

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

Research and Development of Buildings

Our nation's buildings consume more energy than any other sector of the U.S. economy, including transportation and industry. Fortunately, the opportunities to reduce building energy use—and the associated environmental impacts—are significant.

DOE's Building Technologies Program works to improve the energy efficiency of our nation's buildings through innovative new technologies and better building practices. The program focuses on two key areas:

- **Emerging Technologies**
  Research and development of the next generation of energy-efficient components, materials, and equipment
- **Technology Integration**
  Integration of new technologies with innovative building methods to optimize building performance and savings

For more information contact:
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

U.S. Department of Energy
Energy Efficiency and Renewable Energy

An electronic copy of this factsheet is available on the Building America Web site at **www.buildingamerica.gov**

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Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable