Electricity, Resources, & Building Systems Integration

Residential Research Leading to Net-Zero Energy Homes and Communities

The National Renewable Energy Laboratory's (NREL) Advanced Residential Buildings Research group develops the tools and systems required to design and build net-zero energy homes (NZEHs) and communities.

Buildings use 39% of the total energy consumed in the United States, more than any other sector. Residential buildings are the biggest energy users, with 21% of the total. Our work facilitates large reductions in energy use in new and existing homes, and supports the U.S. Department of Energy's (DOE) goal to develop cost effective, production-scale NZEHs by 2020.

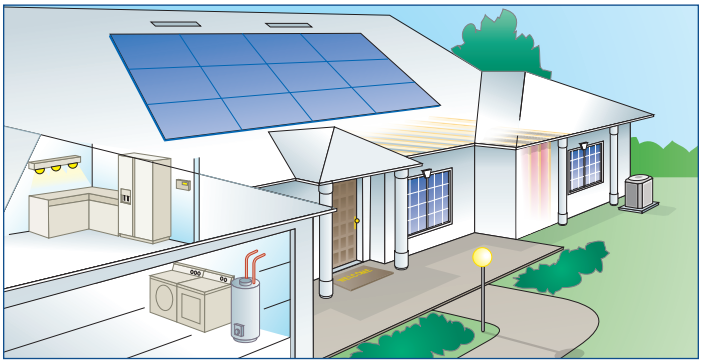
Optimizing Residential Energy Systems

Our research focuses on all energy uses in the home, including lighting, appliances, space conditioning, hot water, miscellaneous electric loads, and on-site renewable energy systems. Zero energy systems are tested and evaluated in the laboratory, prototype homes, and communities to determine the best cost and performance tradeoffs that lead to cost-effective NZEHs in all major U.S. climate regions.

Finding Least-Cost Approaches to Net-Zero Energy Homes

An essential step to maximizing the efficiency and cost-effectiveness of an NZEH is to model its energy use with computer simulation software. NREL has developed several energy analysis tools to determine the cost and performance tradeoffs that lead to NZEHs. We also conduct research in order to advance new energy systems for NZEHs. Our researchers have developed the following capabilities:

- **Building Energy Optimization (BEopt)**. BEopt allows users to navigate different building designs and provides an easy way to see the energy and cost impacts of alternative approaches to NZEHs. We have also developed a version of BEopt to use with California's Title 24 energy compliance software.
- **Residential Benchmark.** NREL has developed a research benchmark that sets a standard baseline for operating conditions and the basic characteristics of a home. Our researchers use this benchmark to determine the amount of energy savings in new homes. The DOE Building America (BA) program has adopted specific energy-saving targets relative to the benchmark that vary depending on the climate.
- **Building Energy Simulation Test (BESTEST).** NREL researchers created BESTEST to assess the simulation capabilities of other building energy simulation programs that measure the building enclosure. BESTEST evaluates the programs' ability to model the enclosure dynamics of buildings and has been adapted to certify tools for Home Energy Rating Systems.



Alfred Hicks, NREL

Critical components of an NZEH include a high R-value durable enclosure, efficient HVAC and appliances, grid-connected home energy management, and on-site renewable energy generation via photovoltaic and solar hot water systems.

Collaborating with the Building and Utility Industry

NREL's Advanced Residential Buildings Research group does extensive laboratory and field testing in collaboration with building and utility industry partners to ensure that emerging technologies meet minimum reliability and performance requirements for use in NZEHs and communities. We also partner with the BA Research Teams to evaluate homes built by the program's builder partners. Visit *www.buildingamerica.gov* and *www.buildingamerica.gov/challenge* for more information.

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

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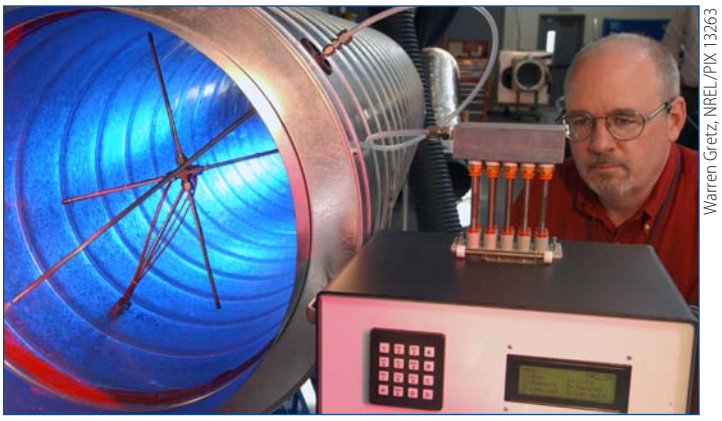
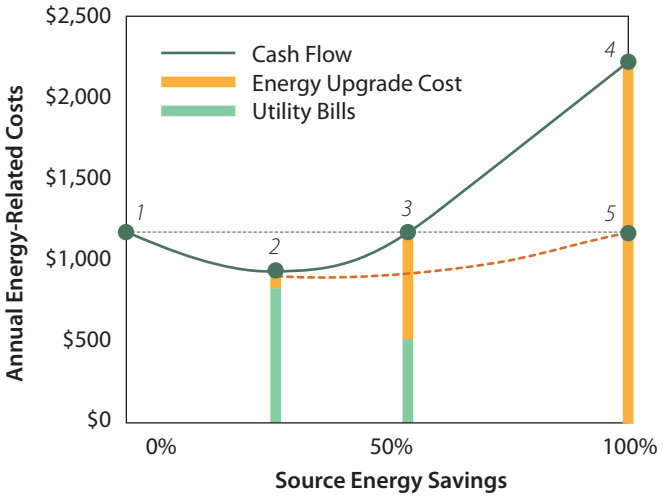
- **Subdivision Energy Analysis Tool (SEAT).** SEAT is being developed as a collaborative project with the California Energy Commission to optimize subdivision design in terms of house size, orientation, and design.
- **Advanced Space Conditioning Systems for Net-Zero Energy Homes.** We are evaluating high-performance cooling systems that are designed to meet the energy and moisture loads in NZEHs. New technology promises to use less energy, increase comfort, and alleviate indoor air quality problems. Our research focuses on developing integrated space conditioning systems that will cut the energy needed for cooling by more than 30% compared to current "best available" systems.
- **Solar Water Heating.** We work with the solar industry to lower the cost of solar water heating systems and to develop systems that work in mild and cold climates. The laboratory investigates new materials such as low-cost polymers to reduce system cost and improve performance. We also conduct technical evaluations of innovative system components and provide materials testing and modeling support.
- **Low-Cost Whole-House Energy Management Systems.** We are researching ways to automatically manage unnecessary energy uses from lighting, space conditioning, home offices, home entertainment systems, appliances, and other energy uses. In addition to reducing the energy used by NZEHs, these systems will reduce critical peak electric demand and take advantage of real-time variable pricing of electricity where available.
- **Retrofit Research.** The efficiency of existing homes needs to significantly improve to meet carbon emission reduction goals. NREL is developing cost-effective retrofit strategies that reduce energy use in existing homes by 50% through a combination of efficient equipment and enclosure redesign. We are also investigating how building energy simulation software predicts the energy savings from retrofitting existing homes and how the knowledge of previous energy use can be employed to improve these predictions.



Warren Gretz, NREL/PIX 13263

Advanced space conditioning test in NREL's Thermal Test Facility.

Financing Energy Upgrades with Utility Bill Savings



1. The home's baseline in terms of all annual energy-related costs.
2. The minimum cost point for the homeowner. The energy upgrade cost is lower, but achieves only 30% energy savings.
3. The cost is the same as the baseline home, but with 50% energy savings.
4. An NZEH with the best available systems and 100% energy savings.
5. NREL's research target: Reach 100% energy savings by financing energy upgrades with utility bill savings.

This chart indicates a homeowner's cost of ownership as energy efficiency improvements are made. The cash flow line represents the "least cost" curve. The dotted orange line represents NREL's research target: Reach 100% source energy savings by financing energy upgrades with utility bill savings.

Accelerating Development of Advanced Energy Systems

We partner with research teams, developers, builders, utilities, manufacturers, and nonprofit organizations. NREL's facilities are available for collaborative research, and the laboratory can provide experienced research staff to conduct testing and act as technical consultants.

For more information about working with us, visit *www.nrel.gov/technologytransfer/.*

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