Electricity, Resources, & Building Systems Integration

Advancing Net-Zero Energy Commercial Buildings

In the United States, buildings account for almost 40% of primary energy use and greenhouse gas emissions. Reducing this energy use will help address climate change and extend the life of our national resources. The U.S. Department of Energy (DOE) has set a goal to achieve cost-effective, net-zero energy commercial buildings in all U.S. climate zones by 2025. DOE's National Renewable Energy Laboratory (NREL) leads the way in net-zero energy building (NZEB) innovation.

Strategies to Reach Net-Zero Energy Buildings

An NZEB has two key energy features: (1) proven, highly energy-efficient technologies that significantly reduce energy demand; and (2) renewable sources that supply as much energy as—or more than—the building needs over the course of a year. An NZEB can deliver electricity to the grid during times of surplus production, and draw from the grid when necessary. An NZEB can also be grid independent.

Only a handful of NZEBs have been successfully built and operated. To make them more prevalent and meet DOE's goal of marketable NZEBs by 2025, NREL is developing and testing:

- **Energy modeling and optimization tools** that integrate on-site renewable energy technologies with advanced energy efficiency features. These tools help assess the energy impacts of design and maximize energy efficiency based on a cost model.
- **Technologies for low-energy buildings** including heating, ventilating, and air conditioning (HVAC), daylighting, windows, and controls.
- **Whole-building design processes** that address the building as an integrated system—improving energy efficiency and minimizing costs.
- **Systematic performance metrics and monitoring** to ensure buildings are measured consistently and actual performance can be accurately evaluated.

NREL's key strength lies in combining all these tools to help industry design well-integrated buildings that reach the goal of cost-effective NZEBs.

Defining Net-Zero Energy Buildings

NREL works with national and international groups to more precisely characterize NZEBs and net-zero energy performance. DOE and NREL identified four ways to define NZEBs:

- **Site NZEB**—produces at least as much renewable energy as it uses in a year, when accounted for at the site.

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The Aldo Leopold Legacy Center in Baraboo, Wisconsin, meets site, source, and emissions net-zero energy definitions. The Legacy Center requires very little energy and can produce more than 110% of its annual energy needs.

- **Source NZEB**—produces or purchases at least as much renewable energy as it uses in a year, when accounted for at the source. "Source energy" refers to the primary energy required to generate and deliver the energy to the site. To calculate source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers.
- **Cost NZEB**—incurs zero energy costs. The amount of money the utility pays the building's owner for the renewable energy exported to the grid is at least equal to the amount the owner pays the utility for the energy used during a year.
- **Net-Zero Energy Emissions Building**—produces or purchases at least as much emissions-free renewable energy to offset emissions from all energy used in the building annually. Carbon, nitrogen oxides, and sulfur oxides are common emissions that NZEBs offset.

These distinctions are important because achieving the various definitions requires very different strategies.

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
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Refining the Definition

For any type of NZEB, renewable energy technologies must be incorporated once cost-effective energy efficiency strategies are used to reduce demand. NZEBs can be classified based on their renewable energy sources.

- **NZEB:A**—uses renewable sources available within the building footprint.
- **NZEB:B**—uses renewable sources available at the building site.
- **NZEB:C**—uses renewable sources available off-site to generate energy on-site.
- **NZEB:D**—purchases recently added off-site renewable energy sources. These sources must be certified through a renewable energy certification program.

An NZEB must use energy sources described in NZEB:A and/or NZEB:B for much of its energy needs. The balance can then be supplied by sources categorized as NZEB:C and/or NZEB:D. The NREL report titled *Zero Energy Buildings: A Classification System Based on Renewable Energy Supply Options* provides detailed information about these supply options and how they relate to the definitions.

Setting Zero Energy Goals Is Critical to Success

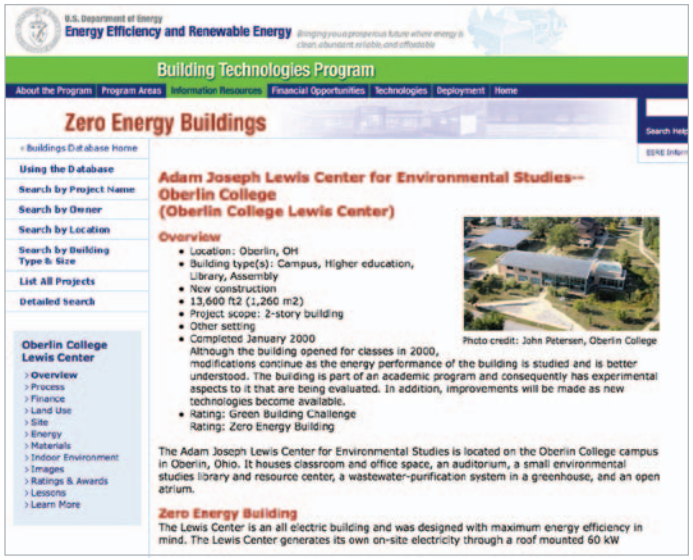
To successfully build an NZEB, the design team must:

❶ Decide which NZEB definition(s) to meet.
❷ Identify the building's energy use goal and how much energy can be generated through on-site renewable energy sources.
❸ Develop a design to balance supply and demand by optimizing efficiency in areas such as program, architecture, and plug and process loads, and incorporating renewable energy technologies.

The team must make these key decisions about NZEB goals, energy use, and renewable energy generation at the beginning of the process to drive design, construction, and operation of the building. Once the building is complete, the team and owner should regularly measure performance to verify the goals are still being met.

Reaching Toward Zero Energy Communities

The NZEB definitions and energy supply options focus on individual buildings, which may be part of a larger community. NREL is also exploring net-zero energy communities such as campuses, towns, or military bases that function in an analogous way. Community-scale systems can be cost effective and efficient by generating renewable energy in a central location and having a single point for all maintenance.



The Oberlin College Lewis Center in Oberlin, Ohio, was designed to be a site, source, and emissions NZEB. The database entry contains details about the design process, building site, energy measures, and more.

Sharing Successes—the NZEB Database

NREL, with DOE funding and support, developed the Net-Zero Energy Buildings Database to showcase examples of NZEB design and performance.

The database profiles a variety of buildings from around the world, such as offices, schools, and retail facilities. Entries include information about energy efficiency strategies, renewable energy technologies, costs, and more. Over time, this knowledge base will improve energy modeling, refine design approaches, and spur investment in NZEBs.

We encourage you to add NZEB projects to the database. Buildings can be entered after conceptual design, with energy simulations to verify the project will reach the NZEB goal. Measured data can be added upon project completion. NZEBs should be evaluated annually to verify performance. To see the database, click on "Net-Zero Energy Buildings Database" at www.buildings.energy.gov/zero_energy_commercial.

For more information:

- Learn about NZEB research and access the database at www.buildings.energy.gov/zero_energy_commercial
- Read *Zero Energy Buildings: A Critical Look at the Definition* at www.nrel.gov/docs/fy06osti/39833.pdf
- Contact Shanti Pless at shanti.pless@nrel.gov.

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