EMERGING TECHNOLOGIES AND ACCELERATED COMMERCIALIZATION PROGRAM (ETAC)

Technology Update: Net-zero and Ultra-low Energy Buildings

Architects take a new approach to design that makes buildings become more energy-efficient, comfortable, and productive places.

Net-zero and ultra-low energy buildings are making waves in the high-performance building sector. By targeting aggressively low energy consumption goals, architects and builders have taken a new approach to energy efficiency. With these concepts in mind, they have begun designing and building or renovating structures that are better places to work and live, use little energy, and do not have to cost more to build than a standard alternative.

While there are several definitions for a **net-zero energy (NZE)** building, one of the simplest ways to define it is a building that, over the course of a year, consumes no more energy than it generates. This is accomplished with on-site renewable energy technologies such as solar electric systems. NZE is not feasible for all locations due to, for example, a lack of space on a multi-story building for installing a sufficient number of rooftop solar panels. But all developers can use the same integrated design process to achieve ultra-low energy consumption levels.

An **ultra-low energy** building is a very efficient building that does not have renewable energy sources on-site. These buildings may also be called NZE-capable buildings. An average office building has an energy use intensity (EUI) of about 100 kBtu/square foot/year, whereas an ultra-low energy building will consume about one-third of that amount.

The New Buildings Institute, which is considered an authority on high-performance design, defines ultra-low energy buildings as comparable to NZE buildings based on energy use, design strategies, and efficiency technologies, but without the stated goal of achieving NZE with on-site renewable energy generation. While a standard metric for “ultra-low” has not been defined, a good rule of thumb would be that an ultra-low energy building uses no more than half the energy of a building that meets current energy code.

The National Renewable Energy Lab’s Research Support Facility in Golden, Colorado is the world’s largest net-zero energy building at 360,000 square feet. It consumes approximately 35 kBtu/sf/year, which is offset by on-site solar electric panels

Image credit: Dennis Schroeder/NREL

Learn more about new energy-saving technologies and approaches.

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Redefining Form and Function

Ultra-low energy buildings use dramatically less energy and don't have to cost more than traditional buildings because they are different. Transitioning away from common architectural paradigms is going to make some architects and developers understandably uncomfortable. For example, glass curtain walls are a "proven-to-sell" feature, but they perform poorly from an insulating standpoint. Similarly, wider temperature bands may require an adjustment in thinking from facility staff. Allowing the temperature to float just a few degrees can yield substantial reductions in energy use by enabling natural ventilation. Not all strategies will work in all climates for all use cases, groups, and cultures, but the most successful ultra-low energy buildings balance energy use, space functionality, and aesthetic qualities.

Why Do It?

Ultra-low energy and NZE buildings have several benefits beyond energy bill savings, including:

- Happy, more productive workers.
- Bolstered corporate image. NZE buildings highlight their owners' commitment to sustainable practices and showcase their technical capabilities and progressive business thinking.
- Lower turnover and vacancy in green buildings, which puts more money in an owner's pocket, over and above all the energy savings.
- Recognition for environmental responsibility.

Using Integrated Design to Maximize Efficiency

Integrated design represents a departure from the traditional design process. Standard design is linear: an architect produces a concept sketch and then the specialist disciplines (electrical, mechanical, plumbing, etc.) each take a turn adding their piece to the puzzle. Decisions that affect energy-consuming systems are made independent of one another and with little to no consideration for how the building's structure and systems will interact.

With integrated design, the disciplines work together from the outset to meet the energy goals and functional requirements. An energy use target is determined up-front, and the design is conceived iteratively. It is imperative that the project team choose this approach at the very beginning of the project so that efficient principles can be built into the fundamental aesthetic and structural aspects of the building, such as site orientation and window size, shape, and location. The integrated design process relies heavily on these kinds of passive design features, which are often simple, low-tech, and elegant solutions.
Examples include:

- Narrow footprints (for instance, I- or H-shaped buildings) to accommodate daylighting and natural ventilation.
- Building orientation that maximizes daylighting potential and winter exposures, while minimizing direct summer sunlight.
- Light shelves, light louvers, or light-reflecting film that channels light deep into the space while reducing solar glare.
- Windows that are operable to accommodate natural ventilation and thoughtfully shaded to reduce solar heat gain in summer.

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While cutting edge technologies like LEDs or ground-source heat pumps have a role to play, they are not the main drivers in the transition to ultra-low energy. Instead, the success of these buildings is driven by a change in the way we think about, design, and construct buildings.

Invest in First-Cost Savings

The goal of passive design is to reduce the loads met by energy-consuming systems – lighting, heating, and cooling. Reducing the loads saves money in the long run by reducing energy costs. It also reduces up-front costs by enabling owners to buy smaller capacity equipment or potentially avoid buying some equipment altogether. In general, the extra investment in design team services and better building envelope efficiency, such as daylighting features and insulation, is offset by the reduction in costs realized by installing smaller and fewer lighting, heating, and cooling systems.

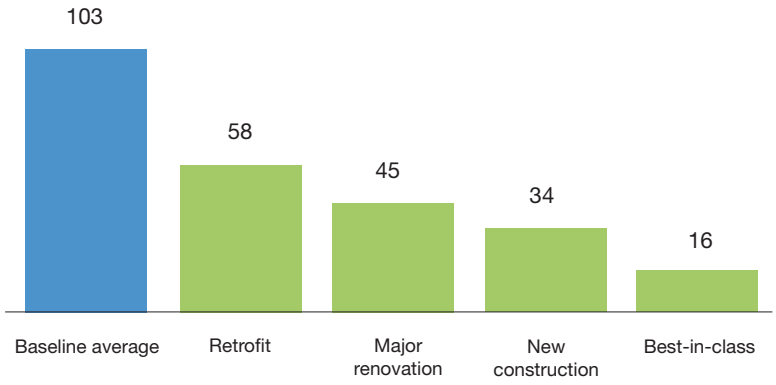
Numerous studies have shown that NZE and ultra-low energy buildings do not need to cost more than traditional buildings. Comprehensive studies by the New Buildings Institute have shown 3% premiums, on average, for NZE and ultra-low energy buildings, with dozens of examples being constructed for less than average costs. NYSERDA commissioned its own study of these buildings in New York and similar climates and found a nearly identical result.

Added Incentive to Save

The benefits of net-zero and ultra-low energy buildings go beyond savings and conservation. NYSERDA's Commercial New Construction Program offers support to applicants and their design teams to maximize energy efficiency in new buildings, and provides additional support for deep energy savings and zero net energy projects. (See contact info under "Additional Resources")

Energy use intensity (EUI) is a standard measure of energy use for a building. It is comparable to the miles-per-gallon rating on a car. EUI will vary by building type because different buildings carry different loads. EUIs for ultra-low energy buildings are a fraction of typical buildings. EUIs for NZE buildings are by definition zero, but the building still consumes an amount of energy similar to an ultra-low energy building; the difference is that an NZE building generates energy, too.

Commercial EUIs by Project Type: Buildings in New York and Similar Climates



The figure shows average EUIs for commercial office buildings in New York and similar climates. It compares a typical building EUI, shown on the left by the blue bar, to the average EUIs, indicated by the green bars, of those projects that have leveraged integrated design principles. The best-in-class value represents the lowest known EUI for this type of building in this type of climate. These values are sourced from the DOE's High Performance Buildings database and the New Buildings Institute's Building Registry.

Applying integrated design principles reduced cooling loads at the Empire State Building. Chillers were then renovated rather than replaced, which saved $17.3 million.

Image credit: iStock

The Empire State Building (ESB) used integrated design principles in their recent renovations, and their example illustrates how much money can be saved through passive design. While maintaining the historic facade, ESB has invested in materials, controls, and strategies to reduce their cooling loads. These include demand-controlled ventilation, better insulated windows, improved system controls, and daylighting. As a result, ESB reduced the chiller load by 1,600 tons. When it came time to replace the chillers, the team was able to renovate them instead of replacing and expanding them. This saved $17.3 million on avoided equipment costs as a result of their upfront investment in load reduction. Integrated design takes these load-reducing principles one step further by building them into the construction of the building itself, thus magnifying the potential savings – even if on a smaller scale than the ESB.

Additional Resources:

- NBI Getting to Zero Update: *http://newbuildings.org/sites/default/files/2014_Getting_to_Zero_Update.pdf* and associated resources: *http://newbuildings.org/2014-zne-update*
- NBI case study repository: *http://newbuildings.org/case-studies-zne-projects*
- US Department of Energy Zero Energy, Buildings Database: *http://zeb.buildinggreen.com/index.cfm* and High Performance Buildings Database: *http://eere.buildinggreen.com/index.cfm*
- Living Building Challenge: *http://living-future.org/lbc*
- Commercial Buildings Consortium ZNE resources: *http://zeroenergycbc.org/resources/cbc-reports*
- California Public Utilities Commission (CPUC) ZNE cost study: *http://newbuildings.org/sites/default/files/PGE_CA_ZNE_CostStudy_121912.pdf* and additional CPUC ZNE resources: *http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Zero+Net+Energy+Buildings.htm*
- NYSERDA's Commercial New Construction Program: *nyserda.ny.gov/ncp*

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The ETAC program supports multi-site demonstrations, provides indepth performance validation, and shares results through dedicated outreach.

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