Getting to Net Zero

The U.S. Department of Energy (DOE) recently released a common definition for a net zero energy building (NZEB), also referred to as a "zero net energy" or "energy net zero" building. The DOE definition states that an NZEB is "an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy."

Executive Order (E.O.) 13693 "Planning for Federal Sustainability in the Next Decade" mandates all new federal facilities to be designed as NZEBs:

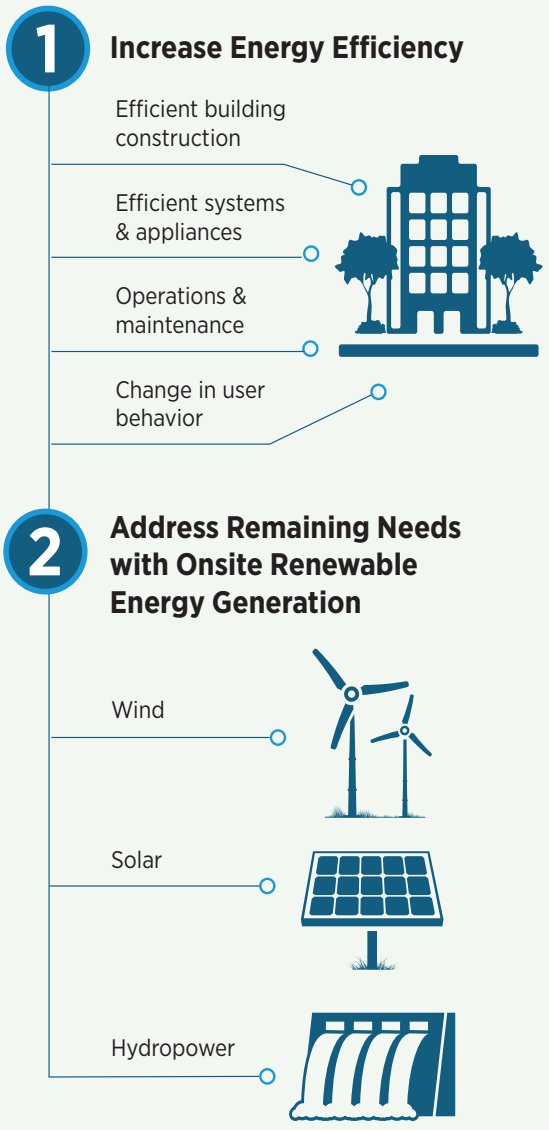
> "By fiscal year (FY) 2020 and thereafter, that all new construction of Federal buildings greater than 5,000 gross square feet that enters the planning process are designed to achieve energy net-zero and, where feasible, water or waste net-zero by FY 2030."

The technology necessary to build energy efficient buildings is ready and available today, however, building to net zero energy performance levels can be challenging. Energy efficiency measures, onsite energy generation resources, load matching and grid interaction, climatic factors, and local policies vary from location to location and require unique methods of constructing NZEBs. It is recommended that Components start looking into how to construct and operate NZEBs now as there is a learning curve to net zero construction and FY 2020 is just around the corner.

Benefitting the Environment and Mission Goals

Residential and commercial buildings account for almost 39% of total U.S. energy consumption and 38% percent of U.S. carbon dioxide (CO_2) emissions.[1] The zero net energy principle is a means to reduce carbon emissions and dependence on fossil fuels by reducing emissions and energy consumption through efficient building design. Federal buildings have long served as symbols of our country's ideals and priorities and given the tremendous impact buildings have on our environment, the net zero requirement of E.O. 13693 augments our nation's commitment to protecting the environment and combatting climate change.

To Create a Net Zero Energy Building...



Credit: Department of Energy

[1] U.S. Department of Energy, 2008 Buildings Energy Data Book. Prepared for the DOE Office of Energy Efficiency and Renewable Energy by D&R International, 2008.

For the Department of Homeland Security, energy efficiency and renewable energy is not just a policy objective. NZEBs incorporate energy savings measures that can save millions of dollars in energy costs. Addressing energy requirements can be a strategic advantage to the Department when the savings achieved from reducing energy use is redirected to increase operational effectiveness in its core mission—ensuring a homeland that is safe, secure, and resilient against terrorism and other hazards.

Guiding Principles

The Federal Energy Management Program provides guidance to help agencies comply with the 2016 Guiding Principles for Sustainable Federal Buildings, which were issued by the Council of Environmental Quality on February 26, 2016 and are required by E.O. 13693. These six principles apply to new construction and are used by the Office of Management and Budget to score federal agencies' progress and compliance within the "Green Buildings" category on annual agency scorecards:

1. Employ integrated design
2. Optimize energy performance
3. Protect and conserve water
4. Enhance indoor environmental quality
5. Reduce environmental impact of materials
6. Assess and consider climate change risks.

NZEB designers and owners should first employ all possible cost-effective energy strategies, and then use renewable sources and technologies that can be located on the building and at the site.

Energy Efficiency

Optimizing energy use through efficient building design should be the highest priority of all NZEB projects. Energy efficiency is generally the most cost-effective strategy with the highest return on investment.

Maximizing efficiency opportunities will not only reduce building energy consumption, but will also curb the emissions that are driving climate change. Aside from the net zero requirement, E.O. 13693 directs federal agencies to reduce energy use in federal buildings by 2.5% per year between 2015 and 2025 and water intensity by 2% per year through 2025. NZEBs can increase a Component's ability to comply with not only the NZEB requirements of E.O. 13693, but other requirements within the "Green Buildings" performance category as well.

A net zero energy goal requires a whole-building systems approach to energy efficiency. The whole-building approach works a lot like designing and manufacturing an automobile—all of the parts of the building are designed and built to work together as a complete system, instead of just as a collection of individual parts.

Some efficiency measures to consider include:

- Procuring an Energy Information System
- Best in class, robust energy efficiency for each climate zone and building type
- Efficiency lighting systems that optimize daylighting
- Aggressive plug and process load control
- High efficiency heating, ventilation, and air-conditioning (HVAC) systems
- Highly efficient data centers
- Occupant engagement and training.

Renewable Energy

In an NZEB, the energy demand from the operation of the building is met by renewable energy generated onsite. The most common onsite renewable energy source considered in the design of NZEBs is the sun. Other commonly considered renewable energy sources include geothermal, wind, and in some situations, biomass.

- **Solar** is the Latin word for sun—a powerful source of energy that can be used to heat, cool, and light homes and businesses. A variety of technologies convert sunlight to usable energy for buildings. The most commonly considered solar technologies for NZEBs are solar photovoltaics (PV) for electricity, passive solar design for space heating and cooling, and solar water heating.

As solar prices decrease and heat pump performance improves, the combination of rooftop solar PV and geothermal heat pumps present a noteworthy opportunity for net zero building performance.

- **Geothermal** heat pumps offer a unique and highly-efficient renewable energy technology for heating and cooling. Most work by circulating water in a closed system through a "loop field" of durable, high-density polyethylene pipe installed horizontally in the ground adjacent to, beside, or even vertically beneath a building. Heat is absorbed through the water that circulates in the underground loop and carried to the ground source heat

Researcher Otto VanGeet leads a DHS group at NREL for the MSE Data center Training on a rooftop PV tour at NREL's net zero Research Support Facility.

pumps where it's concentrated and then sent as warm, comfortable air throughout the buildings. Geothermal heat pumps can support space heating and cooling needs in almost any part of the country.

- **Wind** turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more above ground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades and a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.
- **Biomass** energy refers to the energy from plants and plant-derived materials, including food crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae, and the organic component of municipal and industrial wastes. These products can be burned onsite to provide space and water heating.

NZEBs can be a way to comply with the renewable energy requirements of E.O. 13693 that mandates 30% of total building electricity use in federal buildings is renewable electric energy by FY 2025.

NZEBs vs Traditional Building Costs

Recent research has demonstrated that NZEBs can be cost-effective when planned, managed, and verified using innovative, performance-based procurement approach and integrated design. For example, the National Renewable Energy Laboratory's (NREL) 360,000-square-foot-net-zero energy Research Support Facility, cost $259 per square foot to build in 2013, compared with $250-$350 per square foot for a traditional building. There is evidence that NZEBs can, in many cases, be constructed at traditional federal building costs, and incentives may be available that could significantly reduce the initial capital cost.

The lower bound of initial capital cost premium is possible when a project team:

- Selects energy efficiency as a project priority
- Integrates simple and passive efficiency strategies
- Downsizes or eliminates HVAC equipment based on passive envelope design
- Specifies readily available and tested technology
- Implements experimental strategies only when necessary
- Maximizes the use of modular and repeatable design strategies.

Retrofitting to Net Zero

Federal agencies are also required to establish a percentage of the agency's existing buildings (greater than 5,000 gross square feet) that will achieve energy, waste, or water net zero by FY 2025. Unlike with new construction buildings, federal agencies are permitted to purchase renewable energy from offsite renewable energy projects or purchase renewable energy certificates for existing building retrofit projects. Renewable energy purchases do not require project financing and can help Components meet their renewable energy goals.

Additional Resources

- DHS Mission Sustainable Energy: Technical Assistance Body of Knowledge
- Implementing Instructions for Executive Order 13693 Planning for Federal Sustainability in the Next Decade
- Cost Control Strategies for Zero Energy Buildings: High-Performance Design and Construction on a Budget
- Status and Trends in the U.S. Voluntary Green Power Market

Case Study: DHS's Only Net Zero Energy Building

Civil Engineering Unit (CEU) Oakland recently completed the design and construction of a new support building at the Corona Del Mar Mooring for the USCGC NARWHAL. The existing building at the site was demolished by the Port in order to facilitate repairs to the sea wall. The original building had not been designed or upgraded to include any energy saving features. In planning for the new building, CEU Oakland took the opportunity to create a new structure that was not only energy efficient but also would generate more energy than it consumes.

The "net-zero" plan was incorporated into the design of the 1,400 square foot single story building that houses office space as well as a shop space, toilet rooms, storage, and laundry facilities. Challenging the design, the new building had to architecturally blend with adjacent buildings at the site and with the neighborhood of custom beachfront homes. The new building is a steel frame structure with an Exterior Insulation and Finish System siding and brick wainscot. The flat roof has a prefinished standing seam metal fascia that hides a photovoltaic system and matches adjacent buildings. The open floor plan and large south-facing windows and tubular skylights allow plenty of natural daylight throughout the interior.

The HVAC system is a split unit system with a seasonal energy efficiency ratio (SEER) rating of 20. It was anticipated to provide a 50% reduction in energy use from the baseline. The low-flow, sensor-activated plumbing fixtures were anticipated to provide a 36% reduction in water consumption from the baseline.

Additional sustainable design elements incorporated into the building include insulated, operable windows, recycled glass tiles in the toilet rooms, and the use of low volatile organic compound materials throughout. These design features alone would be enough to qualify this building for LEED certification. But the addition of the solar PV system on the roof, designed to generate more energy than the building will consume, makes this the first NZEB for CEU Oakland.

Construction was completed in April of 2013 at a cost of approximately $800,000. Through a combination of sustainable design elements and onsite renewable energy, the facility produces more energy than it consumes and marks the first, and to this date, only new construction NZEB for the Department of Homeland Security.

The Narwhal Building is a replacement structure for a United States Coast Guard (USCG) facility constructed on the same site and recently demolished. The net-zero energy building is designed to achieve an annual energy savings of $4k and reduction of 60MBtu.

Homeland Security

For more information

Steve White, Energy Program Manager
Department of Homeland Security
steven.white@hq.dhs.gov

U.S. General Services Administration
Office of Federal High-Performance Green Buildings
www.gsa.gov/greenbuilding

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL prints on paper that contains recycled content.

NREL/FS-7A40-67081 • September 2016