ZERO-NET-ENERGY AT NO EXTRA COST

OVERVIEW
The zero-net-energy remodel of a Dairy Queen restaurant in Davis, California into one of the most energy-efficient offices in the United States demonstrates how design-with-climate measures work and that even existing buildings can be made zero-net-energy. This has great importance, since most of the energy-consuming building stock in California is existing buildings. Features:
- Remodel and addition to 59-year old Dairy Queen.
- Ultra-low energy consumption, EUI 3.7 kWh/year, $0 monthly energy bills.
- About 29% of the energy used by conventional code-compliant buildings.
- Cost at $160/sq ft is same as or less than conventional construction.
- High-quality naturally lit and ventilated workplace.
- Demonstrates passive heating and cooling, coupled with thermal mass.
- Nighttime ventilation cuts down thermal mass for use next summer day.
- Superinsulation of walls using straw bale construction.
- Showcase for local energy harvest, only uses 11 kW photovoltaics.
- Produces enough energy surplus to charge 3 cars.
- USGBC Northern California Innovation Award, 2015.

WHAT IS ZNE & EUI?
Zero-net-energy, or ZNE, results where total energy use for the year is offset by on-site energy production returned to the electric grid, plus a contingency. Most often, on-site energy production is provided by photovoltaics. For zero-net-energy at no extra cost, the following conditions must exist:
- Cost of conventional building = Cost of building modified for ZNE + Cost of photovoltaics
- Energy Utilization Intensity factor, or EUI, is used to measure how efficient buildings are and is useful to compare with other buildings. It is determined by dividing total energy use for the year by the building area in square feet, resulting in a unit of kWh/sq/ft.

EU = total yearly energy use in kW / gross building area in #

HOW DOES DESIGN WITH CLIMATE WORK?
As the Dairy Queen remodel aptly demonstrates, designing for the specifics of climate is the most powerful and efficient way to reduce energy consumption and achieve zero-net-energy buildings. By harvesting energy local to the site and designing with natural systems instead of trying to override them, low-cost or even no-cost energy reduction gains are made. In simple terms, the approach is to reduce loads, passively harvest on-site energy and then buy enough photovoltaic collectors to offset the remaining energy demand. Passive solar, thermal mass storage, natural lighting and ventilation, and other low-cost sensible techniques are first employed. Once the basic building envelope has been optimized for a particular climate zone, efficient mechanical and electrical systems are then applied to support at facility uses such as offices, lobby, and training space. Total yearly energy demand is then calculated and converted to photovoltaic capacity in kW to offset this demand. These design measures pave the way to zero-net-energy buildings which are built at no extra cost. Specific design measures used:
- Site design / layout. Maximize solar potential with east-west orientation, take advantage of prevailing breezes, shelter against winter storms.
- Building & window orientation. Orient building east-west to minimize solar heat gain in summer.
- Window shading. Provide solar shading devices on north-facing and south-facing windows - overhangs on the south, vertical fins on the north to prevent heat gain.
- Daylighting. Locate windows high on the north-facing and south-facing sides of the building, avoidthem on the east and west where they would cause overheating. Use distributed skylights at interior spaces.
- Thermal mass. Create a high-thermal-mass building with stone, masonry, concrete, or contained water exposed to the occupants to ensure a passive radiant thermal effect.
- Superinsulation. Use R-50 roofs and R-30 walls. Place insulation on exterior of any concrete or masonry walls in order to gain the “thermos bottle” effect around thermal mass.
- Nighttime flushing. Operate window and skylight vents automatically to flush heat out of building and cool its thermal mass, especially summer nights.
- Natural ventilation. Provide cross-ventilation served by windows and skylights that open automatically to let in outside air when indoor conditions are optimal.

3 STEP ZNE METHOD

STEP #1 ESTABLISH ZNE GOAL
- Determine the goal for zero-net-energy, based on type of use, site location, and building envelope needs.

STEP #2 DESIGN WITH CLIMATE
- Optimize building design to maximize potential to generate and use energy from the site.

STEP #3 MINIMAL PHOTOVOLTAIC OFFSET
- Based on energy reduction from steps #1 and #2, install the basic amount of roof-mounted photovoltaics to offset usage, keeping costs to a minimum.