11-17-2016

The Pathway to Net Zero Energy Buildings: A Practical Practitioner Guide

Celine Manoosingh
Georgia Southern University, cmanoosingh@georgiasouthern.edu

Bonnie McMakin
Georgia Southern University

Debalina Ghosh
Georgia Southern University

International Journal of Current Engineering and Technology

E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

The Pathway to Net Zero Energy Buildings: A Practical Practitioner Guide

Celine Manoosingh*, Bonnie McMakin and Debalina Ghosh

Georgia Southern University, Statesboro, Georgia, United States of America

Accepted 14 Nov 2016, Available online 17 Nov 2016, **Vol.6, No.6 (Dec 2016)**

Abstract

Net Zero Energy Buildings (NZEB) are being constructed throughout the United States, promoting construction practices that achieve more than the minimum energy performance required to meet current codes and demonstrating their financial feasibility. The practicality of these technologies have been proven, in many cases, to improve energy efficiencies, and to provide buildings with capabilities to produce the energy levels necessary to sustain the building operation systems while maintaining comfort and minimizing the financial payback period of the investment. Broadly, these strategies include changes in site selection, water efficiencies, reducing energy consumption, and utilizing environmentally benign materials. This paper presents a detailed review of existing and developing technologies and their effectiveness in replacing conventional design and building strategies at all levels of the design and construction process. In addition, this work provides a user-friendly road map to assist practitioners in planning and implementing the energy reduction strategies necessary to move toward achieving energy efficiency, improving the indoor air quality and constructing buildings zero energy ready. Strategies for implementing energy efficiency measures in low-cost, budget-restrained conditions are also described.

Keywords: *NZEB etc.*

Introduction

The energy consumption of buildings comprise of 41% of the energy produced in the United States, (U.S. Energy Information Administration, 2015). The average life of commercial buildings is 50 years or longer, depending on the building usage, and homes are designed to last even longer. The concept of designing a NZEB which by definition produces all the energy it consumes is nothing new and net zero energy technology strategies have been emergent in the built environment. As the population increases worldwide and finite resources become increasingly scarce, the need for methods to decrease the energy levels in the built environment is essential. The U.S. government has mandated that federal buildings must meet zero net energy by the year 2030. To move toward this goal the Department of Energy, (DOE), has established guidelines for participating in the DOE Zero Energy Ready Home Program, (Department of Energy, 2015). This resource is used to track construction of net-zero energy projects that meet the minimum mandatory requirements, as shown in Table 1. However, for small firms relying on traditional methods of construction, Net Zero Energy Building strategies remain abstract and a seemingly insurmountable design barrier. Thus, a fundamental and simplistic road-map describing this technology, its effectiveness, and strategies of implementation is much needed in the industry, as described in Figure 1.

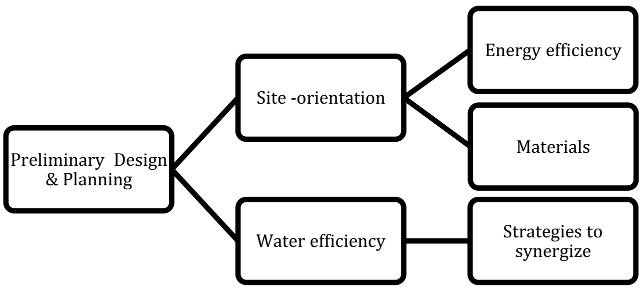

Figure 1 Fundamentals of the NZEB design process

Preliminary Design and Planning

Over the last 20 years, more than 200 projects claiming to be net zero have been constructed in various parts of the world. The technology is increasingly commercially available, and this field is a growing arena for the expansion of the design and construction technologies to move toward reducing energy needs. The planning and preliminary design is where the project begins, before the first pieces of equipment are

*Corresponding author: **Celine Manoosingh**

moved onto the site. This is arguably the most important phase of the entire project. Comprising of this phase are considerations including the site, water efficiency opportunities during and after construction, energy conservation of building and equipment, materials to be utilized and the strategies to be incorporated to comply with the building codes/standards. The paradigm shift toward NZEB thinking must begin with the preliminary design and planning discussions.

During this phase the project requirements are established and are agreed upon by the team. The team should consist of a minimum of the following: an Architectural Design Professional; Project Manager; Mechanical; Electrical; Plumbing; Civil, and Structural Engineer, Interior Designer; Commissioning Agent; building occupant representatives; maintenance department representative and management representatives capable of making financial decisions. Initially site considerations for the building location are necessary for reasons that affect the building and the community it will become a part of. The site must meet the environmental requirements of the Environmental Protection Division's (EPD) Clean Water Act, for Pollution Prevention practices (U.S. Environmental Protection Agency, 2015). It is essential to comply with local, state and federal government regulations. Environmental Protection requirements include the planning and initiation of a storm water design, as part of a storm water management plan it is to be designed in accordance with local protocol. In Georgia that is to meet the Georgia Soil & Water Conservation Commission Manual for Erosion & Sediment Control requirements. (U.S. EPA, 2015). Further site design criteria includes investigating options to use site materials such as open grid pavement systems, used to filter the water before it leaves the site, and prevent erosion of soils, a requirement of the EPD. Required considerations to maximize drainage and control the flow of water are necessary during and following construction. Practitioners should seek to evaluate the soil for the purpose of drainage and to ensure no remediation is necessary due to hazardous materials from previous land uses. Factor in financial considerations that may require additional financial commitments for the budget, for example, additional remediation expenses would result if site contamination is found on the building site.

Building Orientation

A key consideration during the design and planning phase is the orientation of the building.

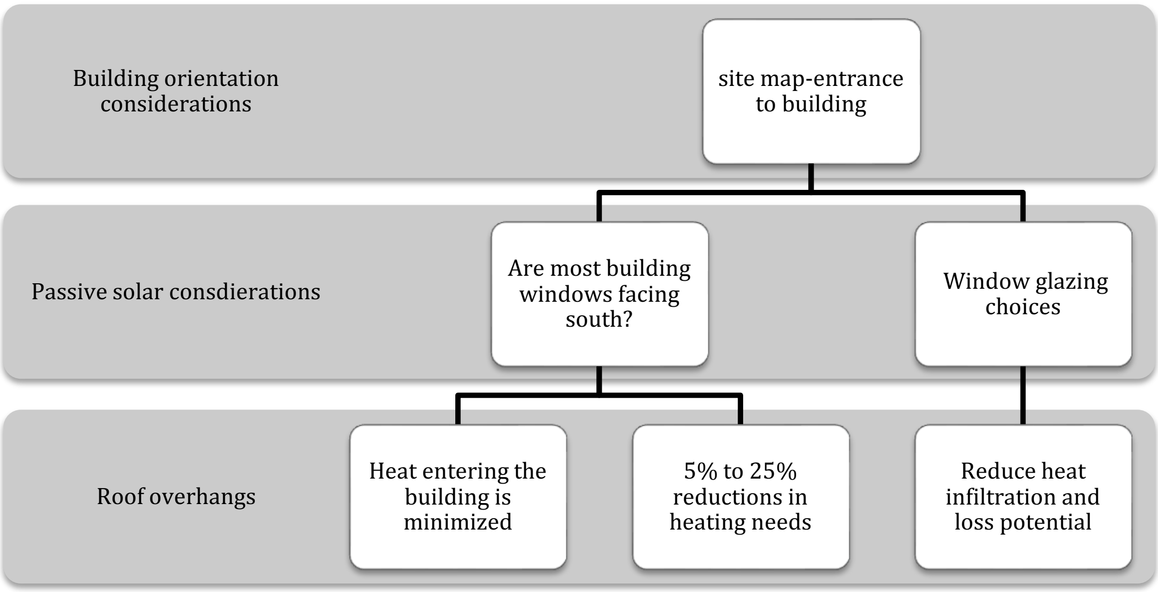

Figure 2 Simple practitioner guide to site selection decisions toward the construction of a net zero energy building

By use of a site map, the proposed building is located. The map may be adjusted in size and/or orientation as the project design progresses or further considerations dictate. In practice this is important for considerations of adjacent roadways, the entrance onto the site, and to maximize light entering interior spaces to ensure that heat entering the building is more during cooler months and less during the hotter months of the year (Fosdick, 2012). Future considerations of renewable energy use will mandate building positioning to maximize energy production (U.S. Green Building Council, 2009). By incorporating passive solar heating into the initial design, the context of the building envelope design for the windows, daylighting, heating and cooling systems provides opportunities to maximize views through well positioned windows.

Windows designed with glazing choices are critical to the effectiveness of passive solar heating. Modest implementations have shown 5 % to 25% reductions in auxiliary heating energy requirements, with little or no incremental first cost. The percentages vary depending upon the building project. By utilizing more aggressive passive solar heated buildings the energy usage can be reduced by 25% to 75% (Fosdick, 2012). Figure 2 provides a simple road map for practitioners in order to mitigate building orientation impacts.

Mitigation of the Heat Island Effect

The heat island effect components include site landscaping, and the components, described by Figure 3, should be considered. Of priority is the minimization of the disturbance by protecting the existing site and limiting land disturbance of any trees beyond 10' of the building perimeter, thus minimizing the heat effects of the building, while maximizes shading by natural vegetation. Landscaping, included in the project, should include plant species of trees that provide a natural canopy of shade within five years. Added benefits of the shade include the site being cooler thus lowering the building temperatures, resulting in less energy required to cool the building spaces.

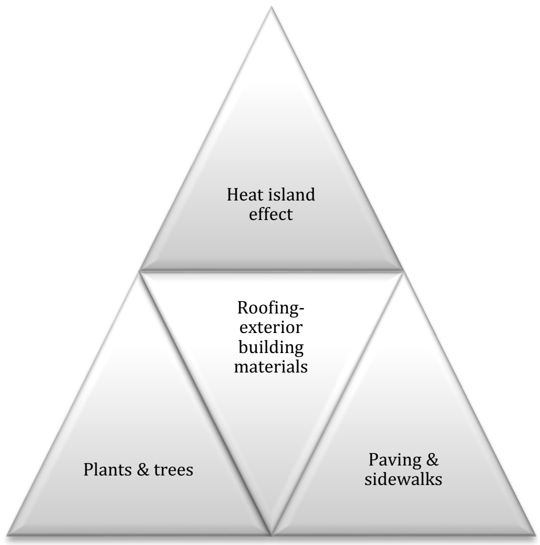

Figure 3 Components to consider when mitigating the Heat Island Effect

Further strategies of reducing the heat island effect include minimizing the number of parking spaces and pedestrian walkways needed to meet the building needs, while meeting local zoning requirements. By reducing the size of the pavement the temperatures and the heat island effects are less impacted. These strategies are recommended based on evidence from recent research related to this technology where an exponential increase in energy usage is related to heat island effect. Fifteen studies were examined to determine the impact of ambient temperature on the total electricity consumption. The potential electricity increase ranged from 0.5% to 8.5% for buildings not employing heat island mitigation strategies. The studies indicated that the ambient warming show peak electricity demand rises from 0.45% to 4.6% per degree of ambient temperature rise (Santamouris *et al*., 2014), (U.S. Green Building Council, (2009). Additional site considerations to reduce impact of the heat island effect include the use of materials with a solar reflectance index (SRI) of 29 or better. These materials absorb less heat from the sun. Traditional roofing materials and even vegetated roof possibilities should be considered. Through the development of roofing materials the energy needs are reduced, the stress on the building components to heat and cool is reduced and thus less energy is required. With less energy required the goal of NZEB is one step closer.

Water Efficiency

A number of studies demonstrate the critical issue of water consumption demands and its effect on energy consumption in a building (U.S. DOE, 2016). Designers should decrease the need for water by increasing efficiency to the maximum extent feasible. This can be accomplished with the use of strategies to use a minimum of 20% less water than calculated industry standards (Whole Building Design Guides, 2015); (U.S. Green Building Council, 2009). Once the efficiency strategies are maximized, further design considerations like onsite water collection and re- use water for irrigation should be prioritized. Conservation measures must remain a consideration throughout the life of the building. Once the high efficient fixtures are in place, practitioners should be diligent to eliminate leaks as they may occur over time. Decisions to be made in the preliminary phase affect the building throughout the entire span of the building use. Employing the use of water meters and water measurement and verification methods and specify Water-Sense labeled products for water-efficient products are also key strategies in this categories. The Federal Energy Management Program (FEMP) Best Management Practices (BMPs) has been found as one of the most effective techniques for water conservation. The Best Management Practices, BMPs, developed due to Executive Order, (EO), 1123, requires federal agencies to reduce water use through cost effective water efficiency improvements. Through this order, the BMP list evolved to include fourteen categories to be considered. Table 2, developed by the FEMP, is included for reference of the water efficiency measures to be developed. Of the items to be considered the use of water efficient fixtures for toilets and sinks; use refrigeration equipment that re-circulates water during the refrigeration process to maximize the reduction in water usage; water efficient clothes washers; dishwashers; refrigerators w/ice machines and so on. (Whole Building Design Guides, (2015), (U.S. DOE, 2016). Manufacturers are producing equipment that is more energy, water efficient and cost competitive, than in the past years.

Table 1: FEMP's 14 Best Management Practices for Water Efficiency (U.S. Department of Energy Federal Energy Management Program, 2016)

BMP Description	Existing	Reductions
1. Water Management Planning	Document Current Water Usage of project.	Improvement Goals specific to project.
2.Information/Education Programs	Establish communication methods to inform owners of ongoing programs of efficiencies and contact information.	Start an incentive program to recognize improvements and savings.
3. Distribution System Audits, Leak Detection and Repair	Establish regular distribution system leak detection surveys and repair programs	Record water reductions in water losses, operating costs, reduced property damage.
4. Water- Efficient Landscaping	Depending upon the climate-Investigate what are the native and appropriate plant materials	Use water-efficient landscaping plants and materials to reduce water required, thus less money and time to maintain.
5. Water-Efficient- Irrigation	Initial installation considerations for optimal performance, manage, and maintain system	Reduce overwatering landscaping, damage to plants, damage to streets, curbs, and building foundations.
6. Toilets and Urinals	Accounts for nearly one-third building's water consumption.	Efficient and properly maintained toilet and urinal fixtures can offer significant savings.
7. Faucets and Showerheads	Federal requirements for faucets are no more than 2.2 gallons per minute, (gpm)showers at 2.5gpm	High-efficiency faucets specified are at 1.5 gpm, or less, and showers of no more than 2 gpm, (approximately 32% reductions).
8. Steam Boiler Systems	Used in systems to generate large amounts of process steam, varying amounts depending on the size and amount of condensate returned to system.	Operation and maintenance programs check for leaks and losses in the system. Proper insulation, regular inspection, meter installations on make-up lines and consult with professionals for resources in this area.
9. Single-Pass Cooling Equipment	Specify single pass cooling systems vs. closed loop systems that require no additional water at each cycle.	Single-pass systems require 40 times more water so eliminate usage where possible or modify to a closed loop system. If necessary inspect and maintain.
10. Cooling Tower Management	Significant amounts of water usage for recirculation to cool chillers, ac units, or other process equipment.	Maximize water cycles of concentration to minimize blowdown water quantity and make-up water demand. Increasing cycles from three to six reduces cooling tower make-up water by 20%, blowdown by 50%.
11. Commercial Kitchen Equipment	Significant water usage in non-residential sector. Important due to high volume of hot water typically used.	Operations, maintenance, retrofit and replacement options for equipment to reduce water pressure. Typically if too high, require more water.
12. Laboratory and Medical Equipment	Equipment uses significant amounts of water.	Est. a method of reporting leaks, fix immediately, encourage cleaning, install auto shutoff feature for unnecessary usage periods, install pressure reducing devices, set at minimum flow rates, retrofit and replace with more water efficient equipment when possible.
13. Other Water- Intensive Processes	Identify and analyze all water-intensive processes for potential efficiency improvements.	Regularly check for leaks and repair broken or loose connections. Encourage proper usage, install an ozone system which can reduce water, other retrofits and replace with water efficient equipment as feasible.
14. Alternative Water Sources	Identify sources of alternative water for non-potable uses.	Reductions to potable water for landscaping, irrigation, ornamental pond and fountain filling, cooling tower make-up, and toilet and urinal flushing.

Thus it is easier to utilize better than the minimum requirements for building components. By making it standard practice to use the most water efficient equipment feasible the building project reductions must be maximized.

Energy Efficiency

The U.S. Energy Information Administration has indicated that building sectors use 76% of all electricity generated by U.S. power plants (Prowler, 2012). Energy efficiency factors illustrated in figure 5, through use of building commissioning energy systems minimize the need for energy consumption and ensure the synergy of equipment. Through building synergies a high performance building is not only energy efficient, but has limited environmental impact and operates with the lowest possible life-cycle costs.

The commissioning team should be directed to implement a Measurement and Verification plan (Richman, 2012), and (Vermont Energy Investment Corporation, 2014). It is essential to monitor the building energy consumption to narrow in on any areas that may need to be adjusted to ensure the energy goals meet local codes and ASHRAE standards (ASHRAE Advanced Energy Design Guide, 2007). A reduction of a minimum of 10% is required by USGBC requirements, however, with the efficiency of equipment available in recent markets, this minimum is quickly becoming a set point that is too low. The EPA's Target Finder rating tool is a source to assist with the determinations (EPA Target Rater Calculator, 2015). The commissioning team should inquire as to the design teams' design preferences of methods and prescriptive paths to be used, such as the DOE Zero Energy Ready Homes or other Performance Paths. The use of passive solar heating is one of several design approaches to reduce energy demand. When the design approaches are combined appropriately the strategies contribute to the reducing the heating and cooling load of most buildings. Well positioned windows and glazing selections for the windows are useful techniques to further decrease these loads. For passive solar design effectiveness the penetrations must be minimized. Practitioners must understand that openings, like doors and windows opportunities for energy loss and are a critical factor for the effectiveness of passive solar heating (Fosdick, 2012), (ASHRAE Advanced Energy Design Guide, (2007), (USGBC, 2015).

Should the economics of the project allow for the addition of on-site renewable energy, solar energy can be maximized with properly-oriented south facing windows which allow the storage of energy and through the use of building materials with a high heat capacity. Concrete slabs, brick walls or tile floors allow natural distribution of stored energy back to the living spaces. A passive solar system typically does not require the use of mechanical equipment for it uses heat flow from natural radiation, convection, conductance and through thermal storage in the building structure (Fosdick, 2012). Mechanical equipment and solar energy production equipment supplement the passive design approach when the costs are not feasible to construct a complete passive system.

Another key tactic for practitioners under this category is the establishment of the use of computer simulation for energy modeling of the building equipment systems (U.S. DOE, 2015). The use of computer simulation determines areas where the energy efficiency can be maximized for compliance with DOE Zero Energy Ready Home. This is an important tool to use whether pursuing certification through DOE or not. The whole building approach is crucial to ensure that all energy efficient tools are used to maximize the equipment and ensure the various components are the most energy efficient, as feasible, for the particular project specifications. A key use of energy in building is the mechanical equipment used within. It is necessary to heat, ventilate, and air-condition the building. The team must ensure that the requirements are discussed and the energy efficient requirements of ASHRAE are included. (U.S. Green Building Council, 2009) and (ASHRAE Advanced Energy Design Guide, 2007). Additionally, it is necessary to discuss the use of Chlorofluorocarbon, CFC, based refrigerants in HVAC & Refrigerant systems. Commissioning agents have proven valuable for the DOE Zero Energy ready homes for theses have been verified to be at least 40%-50% more energy efficient than those not verified by a third party inspector (U.S. DOE, 2015).

Practitioners must also verify the components meet the code requirements of US EPA Clean Air Act. (U.S EPA, 2015). Through the use of programmable equipment, such as motion activated sensors, the power usage of the space is minimized, when the space is not occupied by the building owners. As new technology becomes available it should be discussed to determine the feasibility, as it relates to the building project. Beyond the passive design features, the power source for a net zero energy building is the use of renewable onsite energy production to supply the energy for the building. By utilizing the Department of Energy's checklist the renewable energy components are understood as the ultimate power source for the electrical needs of the building project (DOE Zero Energy Ready/PV-Ready Checklist. (2015). Options include Geothermal heating, solar PV electrical systems, and other geographical specific renewable options for sources of renewable energy. Teams should also discuss the grid-source requirements of the renewable energy components of local utility services. Local requirements are important for requirements of excess renewable energy production purposes. Studies indicate that on sunny days it is not uncommon to produce more energy than a building requires (Norton, 2008).

Benign Construction Materials

Building materials used to construct and insulate are critical, whether it is a passive design or conventional design. Teams must discuss all proposed materials, beginning with the foundation type. It is important to ensure that additional insulation is included, beyond the minimum code requirements, as an efficient building envelope is key to a successful NZEB. Options include concrete slabs, at various thicknesses and concrete with a geothermal floor. The geothermal option includes openings in the floor, to allow water to circulate through the floor, controlling the temperature of the building. The pipes in the floor are connected to outside pipes and the water is circulated to maintain the temperature at a constant temperature. The heat or cooling, depending upon the season, radiates up through the walls and keeps the building at a constant temperature. In a USGBC study, the average internal temperature when utilizing this technique was 70 ^{0} F. (USGBC, 2015). Aesthetics for exterior siding, windows, doors and openings in the exterior of the building are important to the owner as they want to be appealing but, they are potential points of energy loss. So the R-factors of these components must be a consideration during the selection process (U.S. Department of Energy, (2014), (USGBC, 2015). Other energy efficient factors, described in Figure 4 for all components of the building work toward the ultimate goal of a net zero energy building. The use of efficient building components and renewable energy sources are the key to successful net zero energy building projects. (Norton, 2008), (USGBC, 2015).

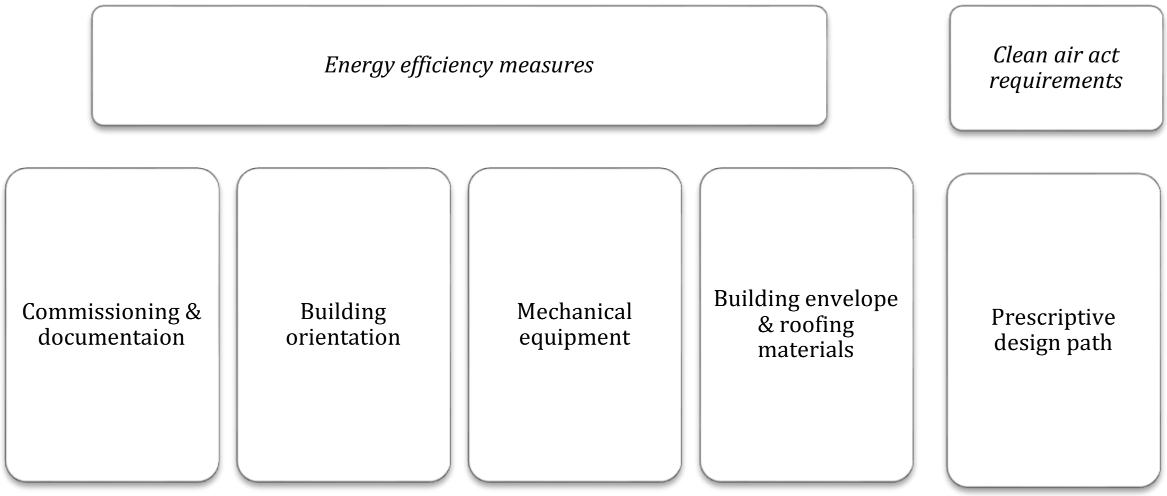

Figure 4 Energy Efficiency Factors for minimizing NZEB usage

Final Design Audit and Construction

It is critical that the multi-disciplinary team involved in the project come together for a final design audit before the project is executed. The purpose of the final design is to identify potential risks of the preliminary design strategies and opportunities with respect to the building's energy performance. A risk management exercise is essential to evaluate all performance risks and issues in the incorporation of preliminary design options. This process will continue to be evaluated throughout construction, as new technologies become available. It is imperative that the impact and feasibility of incorporating new opportunities always be evaluated. Through this risk management exercise each of the categories mentioned previously must be revisited and developed to maximize efficiency of the site, water, materials, equipment and energy for the building (Prowler, 2012), (WBDG, 2015), (Office of Energy Efficiency & Renewable Energy, 2016).

Communication among team members is crucial to the success of the project. The project manager must ensure that all team members are informed of the progress, through correspondence and scheduled meetings, to provide more information as the design is finalized. This process is continued throughout the construction of the building. An aspect that is rarely mentioned, but is critical to the ongoing support of a NZEB is the training of building occupants. This is necessary to ensure that the building systems run in an efficient manner for energy conservation and that the building users understand how to utilize the building components for maximum comfort, efficiency. It is important to monitor the building beyond construction, after occupancy, as it is important to make any adjustments necessary to ensure the final product is the most energy efficient, user friendly product, as feasibility allows (Whole Building Design Guide, 2015).

Budget Constrained Case Studies: Designing for Climate Variations

The process of the design and construction of a NZEB is dynamic and necessitates the consideration of the environment as a guide to driving design. Each unique climate often requires a different set of design considerations. In order to explore the varying design considerations by climate, two examples are discussed in this section: one NZEB constructed in a cold climate, and a NZEB constructed in a warmer, sub-tropical climate. Both examples have similar budget constraints, and make economics a design constraint as they are Habitat for Humanity homes. Habitat for Humanity home projects are restricted by conservative budgetary restrictions. Often donations finance the design and construction of these homes and any additional expenses are closely scrutinized. However, the goal is to provide a home for low income occupants that they can afford to maintain. The project data represented how net-zero design can still be achieved under stringent budge constraints.

Cold Climate Net Zero Energy Home Example

One of the first zero net-zero energy Habitat for Humanity homes was designed in 2004, and constructed in 2005 in Denver, Colorado (Norton, 2008). The project combined envelope efficiency, efficient equipment, appliances and lighting, and passive/active solar features to reach the ultimate goal of net-zero. This project utilized software such as BEOpt, DOE2 and TRNSYS for analysis of the building systems. As with most Habitat homes, volunteers did the construction work and thus, designers needed to keep the design simple. This opportunity opened up the path for simple designs, easily maintained mechanical systems and construction practices. To monitor the ongoing energy performance, a data collection system was installed to track the energy levels through the lifetime of the home. The project exceeded the goal of zero net energy, and was an energy producer for the first two years after construction; because, the home produced more energy than it consumed in the first two years of monitoring (Norton, 2008). The primary source of electricity generation was the Photovoltaic, PV, energy. The PV sizing for zero energy homes, ZEH's, is challenged by the occupant choices and behaviors toward energy usage and the economics of excess PV production which is dependent upon net metering agreements with local power suppliers.

Sub-Tropical Net Zero Energy Home Example

In the southern region of the United States there are different design considerations to consider. For instance, the heat and humidity must be factored into the equation and equipment to condition the space is different from the Northern regions and cooler climates. The Habitat for Humanity South Sarasota County, in Nokomis, Florida addresses these considerations. The project was certified by the U.S. Department of Energy Zero Energy Ready Home certification program. This certification states that the home meets ENERGY STAR Certified Homes Version 3.0 requirements; meets the U.S. Environmental Protection Agency's Indoor airPlus and WaterSense criteria, as well as DOE's strict energy efficiency and zero energy readiness requirements." (U.S. DOE, 2014). The Sarasota County project consisted of six homes in the new Laurel Gardens development; a 3-Bedroom/2 Bath floor plan on a single level construction; conditioned space of 1290 square feet; completed in May of 2014; climate zone was hot and humid; and the category is affordable housing.

Most importantly, the added cost over the ENERGY STAR 3:1 requirements was a mere $1,500. It is projected to have an annual energy cost savings of $613 based on a total annual utility cost of $862. The potential for annual PV production revenue is $1,284 with an annual energy production of 5,100 kWh.

As per the DOE's Zero energy Ready Home program's criteria the conduit and extra electrical panel space were installed so that the solar PV panels and solar water heating could be added in the future. Typical construction elements were utilized as well as additional insulation that would not be traditionally installed, like concrete forms that have a much higher R values than traditional insulation. In these structures, the concrete block open cells were filled with a two-part foam product that hardens as it dries to provide insulation and sound proofing within the wall. Next, on the inside of the wall a ¾ inch layer of rigid expanded polystyrene, (EPS) foam board was installed, followed by ¾ inch furring strips, a layer of corrugated-paper-backed perforated foil insulation with the foil facing toward the air space which resulted by the furring strips. Then, on top of that, the drywall was attached. The exterior wall surface was typically stucco cladding for this project.

The roof construction included a secondary barrier, for water penetration prevention. The designers used a peel and stick membrane which applied to the plywood roof decking, followed up with the ENERGY STAR-rated reflective shingles, in a light grey color, to absorb less heat. For the underside of the roof 5.5 inches, (R-20 rating), of open-cell foam was sprayed on the roof to insulate and air seal the attics. This provided a conditioned space for the HVAC equipment which minimizes the energy usage for the equipment, and it is protected from Florida's intense sun and humidity. The heating, venting, and air conditioning, (HVAC), systems used high efficiency model SEER 15 heat pumps and R-6 insulated flex products, located in the conditioned attics. The homes are air tight and fresh air is brought into the homes from the outside by mechanical dampers. The air flow rate is measured at 2.8 air changes per hour at 50 Pascals, (U. S. DOE, 2014). The energy performance of a building is dependent upon its design components which include the building envelope. The shell materials are only a part of the considerations important to the efficiency. The openings in the structure, primarily windows and doors, must be strategically placed to ensure the most benefit can be gained. In this particular project, the Habitat homes had 10 windows in each home. They were dual paned, vinyl-framed, thermally insulated windows that have impact-resistant glass, with a low emissivity coating and a U-factor of 0.32, and a solar heat gain coefficient of 0.22.

Additional features included high- efficiency lighting that was implemented with 25% LED and the other 75% was CFL. The ENERGY STAR appliances are standard for these homes, such as the refrigerators, ceiling fans, and dish washers. The design incorporated a hip roof design for the homes that is more resistant to hurricane wind loads than the standard gable roof design. An added bonus to the homeowners is that insurance companies offer a discount because of the roof design. Local code requirements caused borate treated lumber and hurricane strapping to be installed. (U. S. DOE, 2014). As an added precaution, homebuyers were required to participate in the construction and complete a homeowner training program that furnished information about the high-efficiency features in the home. This enabled the new homeowners to understand the ramifications of poor energy related decisions and to understand how to maintain a healthy environment that provides low cost energy bills and the ability to reduce them even more with a little effort on their part.

Conclusions

The methods and means of each component of the design phase is key to reaching the ultimate goal of net zero energy. Site selection strategies, to prevent heat island effects, incorporate techniques to reduce the internal temperature of the building. Thus the potential electricity decreases in the range of 0.5% to 8.5%, due to the ambient warming of the building, as studies indicate that electricity demand rises from 0.45% to 4.6% per degree of ambient temperature rise (Santamouris *et al*., 2014), (U.S. Green Building Council, (2009).

The use of passive solar features, such as additional south-facing windows, additional thermal mass; and roof overhangs have shown 5 % to 25% reductions in auxiliary heating energy requirements, with little or no incremental first cost. By utilizing more aggressive passive solar heated buildings the energy usage can be reduced by 25% to 75% (Fosdick, 2012). Water efficient strategies, like low flow fixtures, accomplished the use of 20% less water than calculated industry standards, and also reduced energy use. (Whole Building Design Guides, (2015), and (U.S. Green Building Council, (2009). Commissioning agents proved valuable for the DOE Zero Energy ready homes, verified to be at least 40%-50% more energy efficient than those not verified by a third party inspector (U.S. DOE, 2015). This work also examined building case studies which included solar voltaic panels were able to achieve 15% greater energy storage by the utilizing south-oriented windows. Concrete slabs, brick walls or tile floors allow natural distribution of stored energy back to the living spaces (Fosdick, 2012). The Habitat for Humanity case studies for both cold and warm climates, illustrate that paths to net zero energy buildings exist, even under very stringent budgetary constraints (Norton, 2008), (U.S. DOE, 2014).

References

ASHRAE Advanced Energy Design Guide, (2007). ANSI/ASHRAE Standard 90.2-2007, Retrieved from: http://www.ashrae.org on 2/29/2016

Department of Energy, (2015). DOE Zero Energy Ready Home National Program Requirements (Rev. 05), Retrieved November 24, 2015, Retrieved from: http://energy.gov/eere/buildings/downloads/ doe-zero-energy-ready- home-national-program-requirements - rev-05.

EPA's Target Finder calculator. (2015). Retrieved from: http://www.energystar.gov/buildings/service providers/ design/ step-step- process/ evaluate target/epa%E2%80%99s-target-finder-calculator

Fosdick, J. updated by U.S. Department of Energy Federal Energy Management Program, (FEMP), (2012). Passive Solar Heating, 1-6, Retrieved from: http://www.wbdg.org/ resources/psheating.php

Norton, P. and Christensen, C. (2008). The NREL/Habitat for Humanity Zero Energy Home: A Cold Climate Case Study for Affordable Zero Energy Homes, 1-41.

Office of Energy Efficiency & Renewable Energy, (2016). Water Efficiency Case Studies, Retrieved from:http://energy.gov/eere/femp/water-efficiency-case-studies

Prowler, Don. (2012). The Role of Buildings And The Case For Whole Building Design, 1-3. Retrieved from https://www.wbdg.org/wbdg_approach.php

Stafford, Steve. (2005). Revit OpEd, Retrieved from: http://revitoped.blogspot.com/ 2005/10/ property boundaries- and-setbacks.html

Richman, EE. (2012). Standard Measurement and Verification Plan for Lighting Retrofit Projects for Buildings and Building Sites, Retrieved from: http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/lighting_measurement_evaluation_protocol.pdf

Santamouris ,M., Cartalis,C., Synnefa, A., and Kolokotsa,D. (2014). On the impact of urban heat island and global warming on the power demand and electricity consumption of buildings—A review, 119-124

U.S. Department of Energy, DOE, (2014). Habitat for South Sarasota County, Laurel Gardens Nokomis, FL, Retrieved from: http://www.energy.gov/ sites/prod/files/2014/ 09/f18/DOE_ZEH_Sarasota_Habitat09- 20-14_0.pdf

U.S. Department of Energy, DOE, (2015). Guidelines for Participating In The DOE Zero Energy Ready Home, Retrieved November 24, 2015, from: http://energy.gov/eere/buildings/guidelines-participating-doe-zero-energy-ready-home

U.S. Department of Energy Federal Energy Management Program, DOE (2016). Bes Management Practices for Water Efficiency. Retrieved from http://energy.gov/ eere/femp/best-management-practices-water-efficiency

U.S. Energy Information Administration, (2015). How much energy is consumed in residential and commercial buildings in the United States? (Rev. 2015), Retrieved from: http://www.eia.gov/tools/faqs/faq.cfm?id=86t=1

U.S Environmental Protection Agency, EPA, (2015). Stormwater Homepage. Retrieved from: http://water.epa.gov/polwaste/npdes/stormwater/index. cfm , Pages 1-2.

U.S Environmental Protection Agency, (2015). Summary of the Clean Water Act. Retrieved from: http://www2.epa.gov/laws-regulations/summary-clean-water-act

U.S. Green Building Council, USGBC, (2015). From Start to Finish-A LEED Platinum near zero energy passive house documentary, GBCI: 0920004098, Retrieved from:http:/ /www.usgbc.org/ education/sessions/start-finish-%E2%80%93-leed-platinum-near-zero- energy-passive-house-documentary-6159230

U.S. Green Building Council, (2009). Publication Manual of U.S. Green Building Council, LEED Reference Guide for Green Building Design & Construction, (2009). Washington, DC: Author. DOI: 978-1-932444-33-9

Vermont Energy Investment Corporation. (2014). Measurement and Verification. Retrieved from: http://www.ppescohowto.org/measurement-and-verification

Whole Building Design Guide, WBDG, (2015). Building Commissioning, 1-4, Retrieved from: http://www.wbdg. org/ project/buildingcomm.ph

Whole Building Design Guides, (2015). Protect an Conserve Water, 1-4, Retrieved from https://www.wbdg.org/design/conserve_water.php