The term “green building” is in widespread use and is prominent in discussions about sustainability. Homeowners, home buyers, builders, and remodeling contractors are becoming more aware of green building issues through information available from the following sources:

- U.S. Green Building Council (www.usgbc.org)
- Green Builder College (www.greenbuildercollege.com)
- Green Builder magazine (www.greenbuildermag.com)
- and many other resources.

A green building, whether it is a house, a commercial structure, or institutional building, is energy and resource efficient and has healthy indoor air. But other issues are critical as well, such as choices made regarding building materials and heating systems.

What makes a home green? The *Green Builder* “Homeowner’s Handbook” (November 2011) illustrates the Green Building Pyramid, in which features that are easy to incorporate into your home are at the lower levels of the pyramid and those that are the most challenging to achieve are at the top. The pyramid’s lowest level includes siting, which should reflect the use of sunlight for daylighting and energy. Damage to plants and vegetation is minimized at this stage. This level of the pyramid also features the consideration of location, because automobile dependency is to be avoided in green design; and house size, because small and clever is preferable to big and boxy.

Progressing to higher levels on the pyramid leads to material specifications: from specifying re-used or salvaged materials to those with the highest recycled content and finally to sustainably harvested or mined materials. Products are chosen for their...
durability and contributions to energy efficiency. Water use is also a factor. In fact, a house without a lawn is considered to be greener than one that features native plants that are watered with recycled water.

Embodied energy – the energy used in producing and transporting materials to the construction site – is also examined in the pyramid, as is waste minimization during construction. Paints that do not emit volatile organic compounds (VOCs) are natural choices for green construction, because they do not contribute to indoor air quality problems.

At the pyramid’s highest levels are applying for green certification from one of various organizations that provide this service, including EarthCraft House (www.earthcraft.org), the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) program (www.usgbc.org/LEED), and the National Green Building Program of the National Association of Home Builders (http://www.nahbgreen.org/NGBS/default.aspx). Also in the higher pyramid levels is the use of alternative construction techniques that minimize the use of building materials and provide higher levels of energy efficiency than conventional techniques. Examples of this are Advanced Framing, which is also referred to as Optimum Value Engineering; and the use of Structural Insulated Panels (SIPs).

The pyramid’s peak, or the highest level of green building, is represented by a home that produces its own energy, through solar, wind, or geothermal energy, for example. This home also recycles water.

Green homes are not difficult to build and make contributions to energy independence and human health. As educational resources become increasingly available to help people understand issues related to green building, so do chances that building green homes will become routine. You can see the Green Building Pyramid here: http://www.greenbuildermag.com/Homeowner sHandbook

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The Energy Conservation Construction Code of New York State (NY ECCC) was updated in December of 2010. Significant changes have been made to the code in an attempt to improve the energy efficiency of new buildings. Since it is much less expensive to build efficiency into a building as it is being constructed than it is to retrofit an existing building, these code changes make sense and can have a significant impact on the energy consumption of buildings going forward.

While it certainly is not the responsibility of Extension Educators to know building codes, it is useful to be aware of the basic requirements and to make the information about code changes available to potential new home buyers and home builders. Changes to the energy code will reduce energy costs only if builders are aware of the changes, and code officials make certain those changes have been implemented. The ultimate check for ensuring this occurs is through informed consumers. This article provides an overview of residential energy code changes and the methods code officials are required to use to verify compliance. It also argues that building codes will probably not be successful in spurring builders to produce truly energy efficient homes.

In addition, the point is made that current government programs to increase the supply of highly efficient houses have largely failed because little to no attention has been paid to increasing demand for energy efficient housing.

The 2010 ECC, similar to previous code versions, provides two different paths that builders can follow to meet energy code
requirements. One is the prescriptive path. Meeting the prescriptive path is basically a “follow the recipe” approach. The builder simply determines what the R and U-value requirements are for building components as listed in the code book and then follows those minimum requirements (see Table 1 on page 2 for examples of prescriptive requirements).

The other option available to builders for meeting the energy code is to follow the performance path. The performance path allows the builder some flexibility in how the code requirements are met. For example, if a house is designed to have a cathedral ceiling, it is often difficult to install the amount of insulation required for a ceiling as listed under the prescriptive path. The performance path allows a builder to tradeoff lower insulation levels in one building component for higher levels in a different component.

Therefore, if the builder installs higher levels of insulation in the walls than required by the prescriptive path, then he/she is allowed to use less insulation in the cathedral ceiling area. Using the performance path approach requires the use of some type of computer energy modeling program to calculate trade-offs.

Probably the most commonly used program for determining allowable trade-offs under the code is one developed by the United States Department of Energy specifically for this purpose. The program, called Res-Check is available free and can be downloaded from http://www.energycodes.gov/rescheck/download.stm

Adoption of climate zones in specifying insulation levels and window U-factors is one of the significant changes in the 2010 International Energy Conservation Code compared to previous code versions. Under the 2010 ECCC, New York State is divided into 3 climates zones. The coldest counties are located in Climate Zone 6 and are illustrated as the blue counties on the map below (see Figure 1). Counties in climate zone 5, less cold than Zone 6, are illustrated in green on the map. Climate zone 4 has milder weather conditions and is designated in orange.

Blue = C.Z. 6
Green = C.Z. 5
Orange = C.Z. 4

Figure 1: Climate Zone Map of New York State by County
The Table below lists current R-Value and U-Value factors required under the prescriptive path according to New York State climate zones.

### Table 1: Required R and U-Values according to Prescriptive path*

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ceiling</th>
<th>Wood Frame walls</th>
<th>Foundation walls</th>
<th>Minimum Required U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.Z. 4</td>
<td>R-38</td>
<td>R-13</td>
<td>R-10(^{\text{continuous}}) or R-13(^{\text{cavity}})</td>
<td>U 0.35</td>
</tr>
<tr>
<td>C.Z. 5</td>
<td>R-38</td>
<td>R-20(^{\text{cavity}}) or R-13(^{\text{cavity}}) plus R-5(^{\text{continuous}})</td>
<td>R-10(^{\text{continuous}}) or R-13(^{\text{cavity}})</td>
<td>U 0.35</td>
</tr>
<tr>
<td>C.Z. 6</td>
<td>R-49</td>
<td>R-20(^{\text{cavity}}) or R-13(^{\text{cavity}}) plus R-5(^{\text{continuous}})</td>
<td>R-15(^{\text{continuous}}) or R-19(^{\text{cavity}})</td>
<td>U 0.35</td>
</tr>
</tbody>
</table>

*Go to [http://energycode.pnl.gov/EnergyCodeReqs/?state=New%20York](http://energycode.pnl.gov/EnergyCodeReqs/?state=New%20York) to see an interactive map of NY State where you can click on your individual county to obtain more detailed information.

There are several other changes to the 2010 ECCC, and these are mandatory requirements. That is, it makes no difference which compliance path a builder chooses, these requirements must be met. Below is a listing of the most significant changes.

Air sealing of the building enclosure to limit air infiltration/exfiltration is required. The code states: “the building thermal envelope shall be durably sealed to limit infiltration. The following shall be caulked, gasketed, weather-stripped or otherwise sealed with an air-barrier material”. Following is a list of some of the areas that must be sealed:

All joints, seams and penetrations (including)

- Openings between window and door assemblies and their respective jamb & framing
- Knee walls
- Behind tubs and showers on exterior walls
- Attic access openings
- Rim joist junction

Two different methods for verifying that these requirements have been met are allowed.

1. Testing Option: A blower door test that indicates air leakage through the building enclosure is less than 7 air changes per hour when the pressure difference between inside and out is 50 Pascal (7 ACH\(^{50}\)).

2. Visual inspection option: Code official verifies that items on air barrier and insulation inspection component criteria check list have been completed.

In houses with furnaces, all duct work must be sealed and pass a post construction duct leakage test that indicates duct leakage to the outside is less than 8 cubic feet per minute (CFM) per 100 square feet of conditioned floor area. Total duct leakage must be less than 12 CFM per 100 feet of floor area.\(^1\)

\(^1\) For example, if a house has 2,000 square feet of conditioned floor area, duct leakage to the outside must not be more than 160 CFM and total duct leakage must not be more than 240 CFM.
This requirement is waived if the furnace and all duct work are located within the conditioned space of the house.

- A programmable thermostat is required for homes with forced air furnaces.
- A minimum of 50% of lamps in permanently wired fixtures must be high efficacy (defined as producing 40 to 60 lumens per watt).

When the home is completed, and before the homeowner moves in, the builder or design professional is required to post a permanent certificate on the home’s electrical distribution panel that provides basic information about the components of the home that will affect its energy efficiency. The code states that this certificate must contain:

- R-values of insulation in:
  - Ceiling/roof
  - Walls
  - Foundation (slab and walls)
  - R-value on ducts outside conditioned space
- U-Value of windows
- Efficiencies of heating and cooling systems

This requirement is intended to provide information to increase awareness of the homeowner and future homeowners about the energy efficiency characteristics of the home. It is not a new requirement. It has been included in previous versions of the energy code. Unfortunately, many builders fail to do this and code officials seldom enforce it.

Few homebuyers and a large percentage of builders do not understand that a code requirement is an absolute minimum standard. Doing anything less than code is so substandard that it is illegal. A house can meet code requirements and yet be constructed without using high quality materials or best practices in construction methods and energy efficiency.

While advances in the energy code help increase efficiency of buildings, they do so at such a slow pace as to be nearly useless. For example, if you were to model a new home built in Climate Zone 6 to the 2010 ECCC with R-49 insulation in the attic, R-20 insulation in the walls, U factor of 0.35 for windows and a tested air leakage rate that met the code requirement of 7 ACH<sup>50</sup>, you would likely learn that infiltration is the leading cause of heat loss.

For less than $500 (labor and materials) this leakage rate could easily but cut in half. And for an additional $250 to $300, mechanical ventilation could be built into the house that would deliver the precise amount of fresh air for the home’s occupants. For less than $1,000 the homebuyer would obtain a much more efficient and comfortable home with good indoor air quality. This benefit lasts the life of the home and is likely paid for within two to three years in reduced energy costs. No savvy consumer would pass this up. Unfortunately few homebuyers are aware of this.

Why are new home buyers so poorly informed about simple, highly cost effective methods for making their new home less expensive to heat, more comfortable and healthier? Consider where most efforts and resources of government programs, both at the State and Federal level, have focused during the past two decades. Nearly all efforts have been
expended to educate and inform builders about available technologies for constructing highly efficient, yet affordable homes. Perhaps the most successful program is the U.S. Environmental Protection Agency’s ENERGY STAR labeled homes program. This program results in homes that are 15 to 30% more efficient than code compliant homes. Home buyers are assured that this is true because the additional efficiency requirements of ENERGY STAR labeled homes must be verified by a neutral third party. But this is a voluntary program. While some municipalities in the U.S. have mandated that new homes be ENERGY STAR labeled, for the most part, builders are not required to construct ENERGY STAR labeled homes. Yet nearly all State and Federal efforts to promote ENERGY STAR homes have been targeted to home builders. This strategy does not seem to be working. Consider that the ENERGY STAR homes program was developed in 1992, nearly 20 years ago. But in 2010, despite the high and rising costs of energy, only 25% of all newly built single family homes were ENERGY STAR labeled.

It is time to move away from a policy that focuses on increasing supply, and embrace a policy consistent with basic economics. The optimal method for increasing the supply of any good is to increase demand. Therefore we need a policy that focuses on educating potential new home buyers on the benefits and relative low costs of highly efficient houses. Do that and supply will take care of itself.

You can view a complete copy of the 2010 Energy Conservation Construction Code of New York State by going to: http://publiccodes.citation.com/st/ny/st/b1200v10/index.htm

Daylighting
By Yuriy Chernets
Cornell University

Daylighting is a technique that focuses on optimal fenestration design, solar shading, building orientation and room proportioning that maximizes the use of sunlight in order to reduce the need for artificial lighting. It takes into consideration climatic conditions, surroundings, and orientation. For example, south orientation with a deviation of 15 degrees east or west is desirable for the living areas [1], and based on photobiology the bedroom should be oriented in a way to receive the light approximately two hours before waking is anticipated [2].

Daylighting also utilizes technology available when great indirect illumination and reduced glare can be achieved by the use of tubular daylighting devices [3], sun louvers, skylight systems, light shelves [4] and other solutions widely available on the market. In addition to reducing the energy consumption associated with the use of lighting fixtures, daylighting also improves health of occupants and overall quality of the space [5]. Proper daylighting has a positive psychological effect by stimulating the human visual system and improving productivity [6]. All of these are important issues considering that Americans spend approximately 90% of the time indoors [7]. However, even though much research in the area of daylighting and fenestration has been done, it mostly deals with multistoried buildings and office spaces, while daylighting strategies seem to be neglected when it comes to the design of a typical single-family suburban house. This might partially be due
to the process of project development when the room layout and overall design is done before site selection, because the developer has to show some design to the potential investors. After the financing, if such occurs, the site is selected based on the land available for development and its cost. Another scenario might start with purchasing a lot and then picking a house from a catalog of projects where the main façade is parallel to the street. Primary consideration is given to the location of garage and main entrance, and all houses follow a straightforward grid. Efficient placement of plumbing walls is considered; even the location of a “TV wall” seems to receive more attention than the fenestration.

Without attempting to address the multitude of energy-saving issues, the scope of this article is to emphasize that energy savings in a typical single-family home can be achieved simply by a well thought-out layout of the rooms based on the building orientation, proper sizing of the windows and even an optimal design of the surrounding trees based on the solar angle and the length of horizontal shadow [8]. In addition, energy is saved if the artificial lights are turned off when there is no need for additional lighting.

Electric lighting represents between 20 to 40% of a building’s total energy consumption. Good daylighting design along with the responsive control system can lower the energy consumption by 15-30% [9]. Programmable time controls and use occupancy sensors can save 15-30% of energy [10]. Efficient floor plan zoning can save 10-15% in a house with good thermal insulation [11]. On a scale of one single-family home this might not seem impressive, but consider that end-use energy consumption of residential buildings sector is 23% [12].

According to these simple considerations, a well thought-out daylighting design of a single-family home would go a long way toward saving energy and money, not only for one house but on a far greater scale. Strategies to achieve this are fairly simple, but they should be considered at the initial stages of design as it would be harder to achieve through retrofits.

No matter how carefully you design or construct a building, it is how it is used that is key to building performance and efficiency. This is a principle that has been identified after much research on building design and performance, especially in the face of increasing focus on green building technology and energy efficiency.

The culture of empowering building occupants through education to be aware of and accountable for their own resource use and waste disposal habits is called occupant engagement. It is a planned, deliberate attempt to encourage behavioral change for people to transform from passive entities in a built space to active users who interact with their environment.

Traditionally when we speak of a high performance or high efficiency building, the focus has been on design & technology. It is, after all, obvious that the typical role of architects, engineers, planners and all those involved in the creation of a building are limited to the point in time when the keys are handed over to the owner.

Take the case of the Syracuse New York Center of Excellence LEED Platinum facility designed by Toshiko Mori. Along the daylit hallways are rows of red & green lights above eye level which are intended to function as indicators of when to open or close the windows. The signals are based on the readings of the HVAC system, as well as internal and external weather conditions. Green signals to open windows, red to close windows. This seems fairly simple. Unfortunately the building occupants - researchers of environmental quality - have the same behavior mechanism as the ordinary layperson. They open windows when it is hot outside and close them when it is cold. But when they open windows when it is hot, this shuts down the HVAC system and prevents proper cooling of the building. It took a planned intervention program of educating each and every building occupant about the features of the building before the desired performance goals were met. This allowed occupants to become positively engaged in the process.

So the performance gap between simulated energy calculations & observed building performance lies not just in design deficiencies but also in the usage of the building itself – specifically in the involvement of its occupants. Individual users and their choices – be it turning on and off lights, low water flushing, leaving appliances plugged in – can affect resource consumption and expenses related to that consumption. Plug loads alone account for up to 20% of energy consumption in both private homes and public facilities. Considering these
consequences, creating an occupant engagement culture becomes not just recommended but essential. Following are various pathways to achieve that.

One primary and easily implemented path is to increase occupant awareness of resource utilization. Accessible and legible systems, similar to dashboard readouts in some automobiles, can outline consumption characteristics of users in the spaces they occupy. This can promote an understanding of individual responsibility. And this type of smart system also provides for self-regulation of the building through sensor and alarm systems that measure thresholds of human movement, power consumption, etc. to automatically control and modify HVAC, lighting and other systems. These can also be built into a process of post-occupancy evaluation of building use to analyze design efficiency for future optimization and use.

Simplifying sustainability is key to engaging occupants to enable them to incorporate large scale changes into their daily routines. Simple sustainability information and concepts can be promoted through workshops, organizing communal activities that promote a sense of building ownership and belonging, and by enabling collaboration. One easy method to promote sustainable behavior is to make energy data more visible and visually and emotionally engaging. Constant reminders also help. In addition, social media can be leveraged in the cause of promoting awareness and discussion of “greenness.” This is further reinforced by creating incentives, either through competition, rewards or visibility among different user groups.

The bottom line is considering how we take sustainability beyond the world of elite experts to the general public, from the inexpressible to the achievable and tangible.

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