Introduction
Over the course of American history, houses have reflected concerns, or a lack thereof, regarding energy use. During colonial times, houses in the southern U.S. featured wide porches that shaded those houses from the sun; those in the north were small with little windows to retain heat in the winter; and prairie homes were built into the ground to protect them from harsh storms (Taylor, 2010). The availability of inexpensive energy eased concerns about efficiency until the Arab oil embargo of 1973-74. That event was followed by a relatively brief period of experimentation with active and passive solar homes and then with superinsulated homes (Nissen and Dutt, 1985). As energy prices dropped and stabilized, interest in energy efficiency waned because of a political environment that was hostile to the issue (Lutzenhiser, 2002). But difficult economic conditions of recent years, coupled with rising energy prices, have seen a resurgence in this interest.

The objective of this paper is to review programmatic efforts to advance energy efficiency in the residential sector of the U.S. Various approaches currently underway will be described and potential impacts will be reviewed.

Federal Initiatives
According to the U.S. Environmental Protection Agency, over one million ENERGY STAR homes have been constructed in the United States since 1995 (U.S. EPA, 2010a). This compares with 25, 344,100 total housing starts in the U.S. since that time, or 3.9% of all homes built in the U.S. between 1995 and 2009. Homes qualify for the ENERGY STAR designation if they are at least 20 percent more efficient than those built to the 2009 International Energy Conservation Code. This efficiency is achieved through an airtight building envelope, high-
efficiency heating and cooling systems, state-of-the-art measures to prevent water entry from the house exterior, efficient lighting and appliances, and third-party verification (U.S. EPA, 2010b). But ENERGY STAR is not the only program designed to promote residential energy efficiency. From 1998 – 2008, the U.S. Department of Housing and Urban Development administered the Partnership for Advancing Technology in Housing (PATH), which focused on energy efficiency in addition to other housing features including durability, disaster resistance, environmental performance, and affordability (PATH, 2009). PATH was funded through annual appropriations from Congress, and has not been funded since 2008. The U.S. Department of Energy administers the Building America program, which features the Builders Challenge (U.S. DOE, 2010). This effort uses the EnergySmart Home Scale, or E-Scale, which is shown in Figure 1 on page 3. The E-Scale is based on the Home Energy Rating System (HERS) index, and ranges from 0 – 150, with 70 representing the score that qualifies a home as meeting the Builders Challenge. A score of 0 qualifies a home as being a Net-Zero Energy Home, one that produces at least as much energy as it consumes. Interestingly, there is no reference to ENERGY STAR homes on the E-Scale. In addition to focusing on energy efficiency, builders participating in the Builders Challenge must document every phase of home construction, develop and implement a plan to minimize construction site waste, design and install state-of-the-art systems that prevent water entry from the exterior to the interior of a home, follow a construction plan that minimizes material cuts and waste, follow proper sizing procedures for space conditioning equipment, specify Energy Star windows, install low VOC-emitting cabinets, and more. In short, homes constructed to the Builders Challenge criteria would qualify for green building certification as described below.

Contractors can achieve the Builders Challenge designation directly, or by working with one of two partnering programs: the U.S. Green Building Council or the National Green Building Council. To date, 3,972 homes in the U.S. have met the Builders Challenge (U.S. DOE, 2010), which represents 0.003% of the U.S. housing stock (Rice, 2010).

Ongoing Programs
Other programs that promote residential energy efficiency are those with a green building focus. Four national green building standards are currently in use. The oldest is Leadership in Energy and Environmental Design (LEED), which is administered by the U.S. Green Building Council (USGBC). LEED is a program through which buildings are certified as meeting sustainability standards (USGBC, 2008). LEED focuses on specific areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality (USGBC, 2008). LEED criteria are performance-based, as opposed to prescription-based, which allow builders to meet program goals through a variety of ways. LEED is applicable to all buildings, including homes.

Since 2004, Enterprise Community Partners has administered the only national program to develop green homes for low-income families (Morley and Tohn, 2008). The Green Communities Criteria established under this initiative relate to design, neighborhood fabric, resource efficiency, environmental health, and maintenance. With input from several thousand stakeholders, the National Association of Home Builders (NAHB), the International Code Council (ICC), and the NAHB Research Center developed ICC-700, the National Green Building Standard. It was approved in 2009 as an American National Standard and is the only green standard that is consistent with ICC’s I-Codes. Green features covered by this standard are similar to those in use by LEED and Enterprise and include a provision for homeowner education on maintenance of green status. ICC Codes are used as the basis of building codes in use across the United States (Building Design and Construction, 2009).
The EPA Indoor airPlus program of the U.S. Environmental Protection Agency is an enhancement to the ENERGY STAR Home program. To be certified as an Indoor airPlus home, over 30 additional construction features are added to the home to provide for healthy levels of indoor air quality (U.S. EPA, 2009).

Energy Performance Scores
In Oregon, the Energy Performance Score system is now in use for new homes on a voluntary basis. A pilot version of this system in being used for existing homes in Seattle and is under consideration in Chicago and Houston (DeFreitas, 2010). In addition, the state legislatures in Oregon and Washington have created task forces to explore the feasibility of making the program mandatory in their states; and the U.S. DOE at one point considered developing a voluntary national home rating standard, so that banks could use it as a basis for applying favorable financing for energy efficient homes (World-Wire, 2010).

Conclusion
A growing number of programs and approaches to promote residential energy efficiency exist at the federal and state levels in the U.S. These may be indicators of a movement toward routine inclusion of energy efficient features in homes. While long overdue, this movement is a necessary component of achieving energy independence in the U.S. and reducing carbon dioxide emissions in the residential sector. The number of programs, however, and the lack of coordination among them raise important policy issues that should be addressed. Which of the programs described is most suitable for a home builder or buyer? What criteria are most important for a builders and buyers to follow when choosing among the programs? Which program is appropriate for a small home builder? And,
finally, should these programs be combined into one or two efforts that address the needs for high quality housing and environmental sustainability and eliminate the confusing and overlapping array of options now available to home buyers and producers?

References


U.S. Census Bureau (2010). Housing units authorized by building permits. Table 1: United States and Four Regions. History Table. Available at: http://www.census.gov/const/www/C40/table1.html


An earlier version of this paper was presented by Professor Joseph Laquatra at the 2010 Annual Conference of the Housing Education and Research Association, November 3-6, 2010, Portland, OR.
Energy education took a new, exciting twist at the 2010 NYS fair. Have you ever generated your own electricity? It was your chance to step “off the grid”, shed some light on the matter and to try it for yourself! Located at the NYS fair, the Youth Building held some pretty amazing exhibits, demonstrations, and activities for all to experience. A demonstration that really took control, drawing in huge crowds was open to the public from August 30 to September 2 at the Genessee and Oneida County booths. 4-H Teen Leaders showed the importance of saving energy even if it meant changing your incandescent light bulbs to compact fluorescent bulbs, also called CFL’s. Genesee and Oneida County 4-H’ers showcased the “Cornell Energy Bike”, which was cabled to a board that displayed different electronic devices that are common in anyone’s daily use. The point of the “Energy Bike” was to show that each device consumed different amounts of energy, which made pedaling the bike easier or more difficult.

Genesee County 4-H Teen Leaders Lizzy Weber and Chris Defelice explained that it gets harder each time you pedal to light up the incandescent light bulbs because they consume more energy. The CFL’s were easier to light up because they consume less energy. The energy bike incandescent bulbs take 25.0 kilowatts (kWh) of energy and the CFL bulbs take only 7.5 kWh. This means that it takes about the same amount of energy to light up 4 compact fluorescents compared to one incandescent (on the display board). This demonstrated that you save money, energy, and become more eco-friendly by changing to compact fluorescents.

I tested the bike myself. Each time one of the incandescent bulbs was turned on using my pedaling power, the more energy I exerted to keep the light bulb on, without flickering. I found it much easier to pedal while the fluorescents were turned on and I noticed the difference a great deal! Also, 4-H’er and Teen Leader Camille Wrege from Oneida County helped out with explaining the Energy bike to fairgoers. She stated that she could actually “feel the difference” in how much she worked and how much of her energy it took to generate electricity in the form of light and heat. Generally, the more “heat” something produces, the more energy it takes to generate.

Along with the Energy Bike, another demonstration showed how much energy ordinary household appliances consumed. Different appliances were placed on a table which included a cell phone charger, an electric razor, a curling iron, a toaster, a hairdryer, and an electric water kettle. Fairgoers, youth and adults, were put to the challenge by having to arrange the appliances from those that consumed the least amount of energy to those that used the highest amount of energy (in the form of watts). To see if the appliances were in the correct order, a hand-held wattage tester was used. Measurements (in watts) ranged from 4 watts for the cell phone charger to 1450 watts for the electric water kettle. This demonstration made it apparent that there are more energy efficient and eco-friendly ways to live by.

Figure 1: Energy Bike at N. Y. State Fair
Chip Malone, CCE-Genesee County operates the lights while Camile Wrege, Oneida County 4-H pedals Sparks, the energy bike.
After experiencing this demonstration, it made me realize that there are alternatives to many of the things that we use in our homes. For example, you could start by checking the different appliances in your household to see if they are energy efficient or are approved by Energy Star. You could also make sure that you are using these items sparingly by turning the appliance off when you are not using it and in some cases, even unplugging them. This demonstration helped me think about the choices I’m making about energy and how to save money. I am sure that it would help you understand better as well.

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**What is the Thermal Stack Effect and Why Should You Care?**

By Mark Pierce
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The thermal stack effect is busy robbing heat from your home every winter. And in some cases it is also sucking nasty soil gasses such as radon into your home, which creates health risks for you and your family. The thermal stack effect is driven by a basic law of physics - hot air rises. If you have ever seen a hot-air balloon floating in the sky you have seen the physical evidence of this. The balloon pilot uses a torch to heat the air just below the opening at the bottom of the balloon. The hot air rises and is trapped within the balloon. Since the warmer air within the balloon is less dense than surrounding ambient air, it causes the balloon to rise up into the sky.

Now think about your house on a winter night when the outdoor temperature is very cold. While a house is not a hot-air balloon, it is a warm-air filled container surrounded by much colder outdoor air. And your furnace or boiler is working very hard to keep you and your family comfortable by keeping the air within this container, your home, at 65 to 70 degrees. The warm air within the house rises up through the building toward the ceiling. Once it hits the ceiling it gets pushed out into the unheated attic through any cracks and holes in the ceiling plane. House ceilings are full of cracks and holes around electrical boxes, attic access doors, plumbing vent pipes and wires inside partitions, etc.

Along with pushing warm air out of the house at the ceiling plane, the stack effect is also responsible for actively sucking cold outdoor air into the house through cracks and holes in lower parts of the building. Much of this cold air infiltration occurs where the wood part of the house rests on the concrete foundation walls (see Figure 2 for a more detailed explanation of the stack effect).

Air leakage driven by the thermal stack effect can account for 40% of the annual heating costs of a typical home. This air leakage is also responsible for several other negative impacts on the building, including:

- Leakage of warm air into unheated attics driven by the thermal stack effect is the primary cause of ice buildup and ice damming at roof edges (see Figure 1)
dozens of holes, cracks, and breaks in gypsum or plaster wall and ceiling surfaces. Cracks around electrical boxes, light fixtures, access doors into attics, and openings around plumbing vent pipes provide just a few examples (see Figure 3).

How can the thermal stack effect be controlled?

We cannot stop hot air from rising. But it is possible to reduce the warm air from quickly escaping out of the upper parts of the house and cold air from being sucked into lower parts. In existing homes, this is done by finding and sealing the many small holes and cracks. This is most important to do at the ceiling plane and at lower levels of the house. Gypsum board or plaster finish on ceilings and walls is relatively impervious to the passage of air. But a typical house has

Figure 2: The Thermal Stack Effect

- Air flowing through most insulation products degrades the manufacturer’s stated R-value by as much as 60%. Most insulation products do not block the flow of air. That means insulating an attic will have little effect on reducing heat loss from your home unless air leaks are first found and sealed. (Note: R-value is a measure of an insulation material’s ability to resist heat flow through solid materials. The higher the R-value, the better the material is at resisting heat flow.)
At lower levels of a house cold air gets drawn in at cracks where wood parts of the house rest on relatively uneven concrete foundation walls (See Figure 4). Air is also drawn in at lower levels where holes have been drilled in the lower wall or floor structure to allow for pipes and wires to be installed (see Figure 5).

You as a homeowner can take some fairly simple steps that will reduce air leakage related to the thermal stack effect. For example, weather stripping around attic doors and hatches and around doors and windows is easy to do and will help increase comfort levels and lower annual heating costs. However, special diagnostic equipment and the knowledge of a skilled professional are needed to significantly reduce the negative effects of air leakage driven by the thermal stack effect. Unfortunately many home builders and home improvement contractors do not know about basic building science issues such as the thermal stack effect and the negative effect it has on our homes. Yes, there are very proficient homebuilders and home improvement contractors that do, but if you, as the consumer of a building contractor’s services, don’t know the basics of what the thermal stack effect is, and how it is controlled, then you don’t have enough information to identify a qualified building professional to hire.

If you are considering having a new home built, it is important for you to know that the best time to take steps to reduce the thermal stack effect is when a house is being constructed. Sealing the areas where heated air can escape from a home is a primary requirement of the ENERGY STAR® labeled homes program, and this is a primary reason why ENERGY STAR® homes are significantly more energy efficient than non-ENERGY STAR® homes. ENERGY STAR® homebuilders also hire a neutral third-party firm to perform diagnostic tests on the new home to be certain air sealing efforts have attained minimum requirements set by the ENERGY STAR® homes program. ENERGY STAR® homes also have ventilation systems designed to deliver the precise amount of fresh air to maintain good indoor air quality for the occupants of the home.
To obtain a list of homebuilders in your area that build ENERGY STAR® homes go to the NY Energy Smart Resource Locator Map at http://www.getenergysmart.org/Resources/FindPartner.aspx?t=4. In the “resource to find” box select “ENERGY STAR® Builders”, then click on your county.

As the owner of an existing home you need to be aware that many home improvement contractors are not well informed about building science issues and do not know about the thermal stack effect and how it affects your home. Therefore, you must be very careful in hiring a contractor to improve your home. If a contractor cannot describe what the thermal stack effect is, how it affects heating costs, indoor air quality and roof ice buildup, then you should find a more knowledgeable person to hire.

Contractors accredited by the Building Performance Institute (BPI) have demonstrated that they have the necessary knowledge, qualifications and diagnostic equipment to work on and retrofit existing houses to make them energy efficient, durable, safe and healthy. To obtain a list of BPI-accredited contractors in your area, go to the NY Energy Smart Resource Locator Map at http://www.getenergysmart.org/Resources/FindPartner.aspx?t=4. In the “resource to find” box select “home performance contractors,” then click on your county.

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