

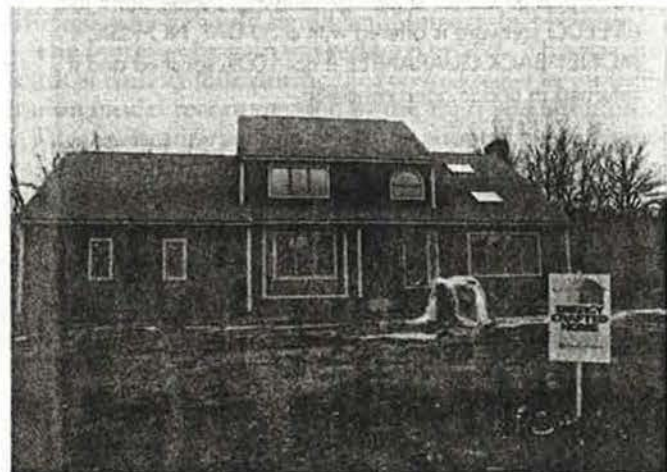
## NEW CONSTRUCTION

# New Construction in New England: The Energy Crafted Home Program

by Nancy A. Schalch and Lynn R. Fryer

*The comprehensive design of the Energy Crafted Home program includes regional utility collaboration, builder involvement, and a multi-media marketing approach.*

Several electric utilities in New England developed the Energy Crafted Home program to encourage the construction of single-family and multifamily homes that are substantially more energy efficient than those built to code. New construction energy efficiency programs tend to be cost-effective for utilities because it's less expensive to build a home right the first time than to retrofit it later.



Lynn Fryer

Field inspections (note blower door) and cash incentives are only a part of the Energy Crafted Home program. Marketing support is even more important to builders.

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**Table 1: Building Shell Performance Requirements**

<b>Heating:</b>	≤ 1.4 Btu/ft <sup>2</sup> of shell/heating degree-day
<b>Cooling:</b>	≤ 2.7–3.7* Btu/ft <sup>2</sup> of shell/cooling degree-day (*depending on cooling load of utility region)
<b>Infiltration:</b>	≤ 1.0 in <sup>2</sup> of opening/100 ft <sup>2</sup> of shell (at 4 Pascals of pressure difference)
<b>Moisture control:</b>	Continuous vapor barrier (on walls, ceiling and floors, around insulated ducts, and under slabs)
<b>Indoor air quality:</b>	Pollutant source reduction and continuous ventilation (60 cfm in small homes and 100 cfm in larger homes)
<b>Fossil-fuel appliances:</b>	Sealed or closed combustion on heaters and water heaters (fireplaces/stoves must have airtight doors and fresh air supply)
<b>Lighting:</b>	Hard-wired fluorescent fixtures are encouraged (also, bare-bulb fixtures must have compact fluorescents)

In some respects, the Energy Crafted Home program is similar to the Canadian R2000 and the Bonneville Power Administration Super Good Cents programs. It is performance-based and provides builders with training and technical assistance in getting their homes to achieve the program specifications. Field inspections of each home are also part of the program. Builders receive cash incentives for each qualifying home, but even more important to the builders is the program's marketing support.

In other respects, the program is unusual. It is open to all homes regardless of fuel type. (The financial incentives are significantly larger for electric heat homes.) Besides heating, other end-uses are targeted, including lighting and cooling. Blower-door tests verify air-tightness standards, and indoor air quality issues are addressed, in part by requiring mechanical ventilation.

Because of the program's thermal and ventilation standards, these homes should be less expensive to operate, healthier to occupy, and more comfortable to live in—significant advantages to both the builder and home-buyer.

## Program Design

The program helps builders improve their construction standards by providing training and technical assistance, an energy analysis of each home, and a series of quality assurance inspections during construction. Financial incentives defray some or all of the added costs of building a home. And marketing to homebuyers and promotion to real estate agents and lenders helps create demand.

### The Specs

The Energy Crafted Home program achieves energy savings in new construction by increasing thermal effi-

ciency. With performance-based energy standards, builders can maintain design flexibility and participate regardless of the size or complexity of the home. Every house must meet building shell energy performance budgets for heating, cooling, and infiltration (see Table 1).

### Workshops

All interested builders attend two-day training workshops. The utility sponsors these workshops frequently throughout the region, and at a very low cost. Builders learn to treat a house as a system, with special attention to moisture, indoor air quality, thermal integrity, isolation

### Typical Construction Detail

The performance-based approach of the Energy Crafted Home program results in a great deal of flexibility on the part of the builder. However, several basic construction details are typical of many Energy Crafted Homes.

**Walls:** Some house plans pass the thermal analysis with R-20 or -21 in the walls (2x6 studs with cellulose or high-density fiber glass) but most are 2x6 construction with an inch of rigid foam on either the inside or outside (R-24 to R-28 total). The foam, typically extruded polystyrene or foil-faced isocyanurate, helps reduce thermal bypasses through the studs, and in some cases can function as the air/vapor retarder.

**Ceilings:** Virtually every Energy Crafted Home has more than the R-30 ceiling insulation required by code. R-40 is typical, and builders use various techniques to minimize thermal bypasses.

**Windows:** Since windows can be a major source of heat loss and solar gain, most Energy Crafted Homes have either thermal low-E glazing or argon-filled glazing. The thermal analysis considers orientation, unit U-values, solar transmittance, and exterior shading in evaluating the effect of windows on heating and cooling loads.

**Heating Equipment:** Heating systems and fuels vary, but they are consistently smaller and more efficient than the traditional installation. Design loads are typically 25–50,000 Btu per hour instead of 50–150,000 Btu/hr. Many houses have integrated systems, where one heating unit provides both space heat and domestic hot water.

**Moisture Control:** Energy Crafted Homes must also comply with moisture control specifications. Vapor retarders reduce the potential for condensation of water vapor in walls and attics, which can lead to dry rot and structural damage. Although technically required by building codes, vapor retarders have often been no more than kraft paper, often improperly installed. In Energy Crafted Homes, a continuous vapor retarder must be installed on exterior walls, ceilings, and floors and around insulated air ducts. Moisture retarders are also installed under slab floors and on crawl space floors. These continuous vapor retarders also serve as air barriers, significantly reducing infiltration.

**Air Quality Control:** With the very low natural infiltration rate of an Energy Crafted Home, special precautions assure good indoor air quality. The best solution to indoor air pollutants is to eliminate the source, so builders avoid materials with high urea-formaldehyde content. Since radon is another potential concern, program homes are built with a sub-slab layer of stone which will permit the installation of a sub-slab ventilation system, should radon mitigation become necessary.

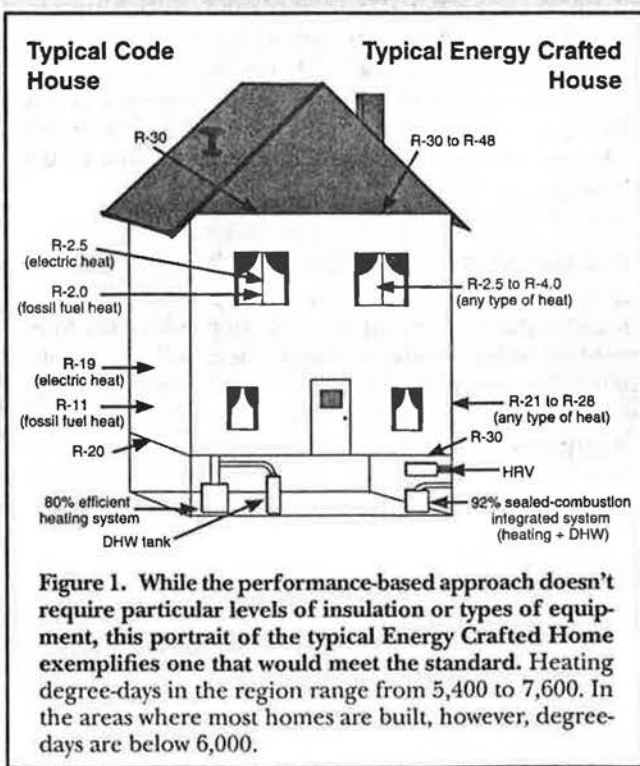
**Ventilation Equipment:** Most Energy Crafted Homes have heat recovery ventilators, sometimes fed directly into the heating system ductwork. The rest have exhaust-only ventilation, which

typically exhausts air continuously from bathrooms and kitchens directly outside, drawing in fresh air through inlets in living room and bedroom walls. Either method of controlled ventilation is acceptable; however, less energy is required to heat air that has passed through a heat recovery ventilator.

In addition, mechanical ventilation brings in fresh air and exhausts air which may contain pollutants and/or excess moisture. Systems must provide 60 cfm of continuous ventilation in small homes and 100 cfm in larger homes. These levels of ventilation are based on ASHRAE recommendations of 15 cfm per person above 0.35 ACH. An Energy Crafted Home-certified installer must install and balance the system.

**Heating and Domestic Hot Water:** All fossil-fuel heating appliances must have sealed or closed combustion, where outdoor air is provided directly to the combustion chamber and flue exhaust gases are vented directly outside. No interior house air is used for combustion, so there is no risk of backdrafting.

**Lighting:** Hard-wired fluorescent fixture are encouraged, and for each one installed, the builder receives an additional incentive. Compact fluorescent bulbs must be used in all bare bulb, non-decorative sockets inside an Energy Crafted Home.



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Lynn Fryer

The utility provides a minimum of three on-site inspections during construction. Inspectors examine the home before and after drywall installation, and do a final evaluation of air infiltration, heating, and ventilation systems when construction is complete.

of combustion equipment, and controlled ventilation (instead of uncontrolled infiltration). For example, they are shown various techniques for minimizing thermal bypasses and installing continuous vapor barriers in difficult areas (namely, around windows and in corners). They are also provided with a reference manual and computer software so they can perform their own building thermal performance simulations. The builder's manual includes program requirements, many examples of good construction detail, and explanations behind recommendations and requirements. A number of small builders in New England already use many of the state-of-the-art construction details recommended at the workshops, but the majority of the participants see these construction techniques for the first time at the workshops.

### *Plans Evaluation and Technical Support*

Builders submit plans for each Energy Crafted Home to the utility that will serve it. An evaluator reviews the blueprints and system details for compliance, and uses a computer simulation program to determine whether the design meets thermal efficiency standards. Modifications are generally required, so the plans evaluator analyzes the energy performance and thermal integrity of various changes and works with the builder to select upgrades to meet program specifications.

Even after the training workshop, most builders need additional technical assistance with such issues as continuous air/vapor retarders, state-of-the-art heating and ventilation equipment, and overall design for maximum thermal performance. Most builders feel the plans evaluation process is beneficial and depend on the evaluators' technical and construction expertise as they design and build their first Energy Crafted Homes.

### *Inspections and Quality Control*

The utility ensures that a home is constructed to specification by paying an inspector to make three site visits. The first inspection verifies that the insulation and air/vapor retarder are properly installed. The primary purpose of the second inspection is to confirm that the building meets the program's air-tightness standards. The inspector uses a blower door test to measure infiltration and to identify any air sealing still required to meet program guidelines. This inspection takes place after the drywall is in place, but before any trim has been installed. The third inspection is a final walk-through once the home is complete. While the heating, domestic hot water, ventilation, and distribution systems are generally examined at each stage, the final inspection confirms that these systems and their controls are functioning properly. Sealed combustion is critical, as is proper air flow and balancing of ventilation systems. The utility inspector checks lights, duct and pipe insulation, fireplaces, wood stoves, and exhaust hoods during a final inspection.

When the house is complete, the utility certifies it as an Energy Crafted Home and registers the builder as an Energy Crafted Home builder. An owner's manual, which details the advantages of owning an Energy Crafted Home and how to care for it, is then presented to the buyer.

### *Hard Cash*

The utility pays financial incentives for each home. For electrically heated homes, the incentives (\$1,650 for single-family and \$900 per multifamily unit) were designed to cover the average incremental cost to the builder of going from a code-built home to an Energy Crafted Home. Incentives for fossil-fuel-heated homes (\$150 for single family and \$75 for multifamily) are based on the electrical savings for lighting, water heating, and cooling. In addition, builders receive \$25 for each hard-wired fluorescent fixture they install. It turns out the primary incentive for most builders is not the money, but the program marketing—more about this later.

## Getting Everyone Involved

### *A Commonwealth of Utilities*

The Energy Crafted Home program was developed jointly by several electric utilities in Massachusetts, Rhode Island, and New Hampshire. (The participating utilities are Blackstone Valley Electric, Boston Edison, Eastern Edison, Granite State Electric, Massachusetts Electric, Narragansett Electric, Newport Electric, and Western Massachusetts Electric.) The program began in early 1989 when the utilities established the Joint Management Committee to oversee program development, builder training, marketing, and implementation. It includes representatives from each of the participating utilities, and involves builders, technical experts, and a consultant who helps coordinate it. The Joint Management Committee met biweekly for the first two years and continues to meet monthly.

Coordinating the effort of so many separate utilities presented many challenges; fortunately, the resulting regional program has many advantages. Most builders work across utility jurisdictions, so having one program means they need to learn only one set of program require-

## Measuring 40% Savings

Is it possible to measure the energy savings obtained through construction of new, efficient homes? The Pacific Northwest found that it was possible to determine the energy savings with surprising confidence. Moreover, the results were obtained with old-fashioned technology.

In 1985, Bonneville Power Administration (BPA) wanted to test the efficacy of the proposed insulation standards for new electrically heated houses in the Pacific Northwest. The standards required heavy insulation, triple-glazed windows, and mechanical ventilation. Like those in the Energy Crafted Homes program, participating builders received extensive training prior to construction (in addition to generous subsidies). The monitoring was surprisingly primitive: separate kilowatt-hour meters for the furnace and water heater. That, along with the normal meter on total use, provided submetered data for space heating, water heating, and other uses (including appliances, cooking, lighting, and miscellaneous uses). One other device recorded the average inside temperature. The occupants took readings from each meter every week and mailed them on postcards to BPA. More than 200 efficient homes, plus an equal number of control homes, were monitored for two years. (The energy and temperature data for a typical house are shown in Figure 1.) The houses were inspected for physical factors, such as infiltration rates and gen-

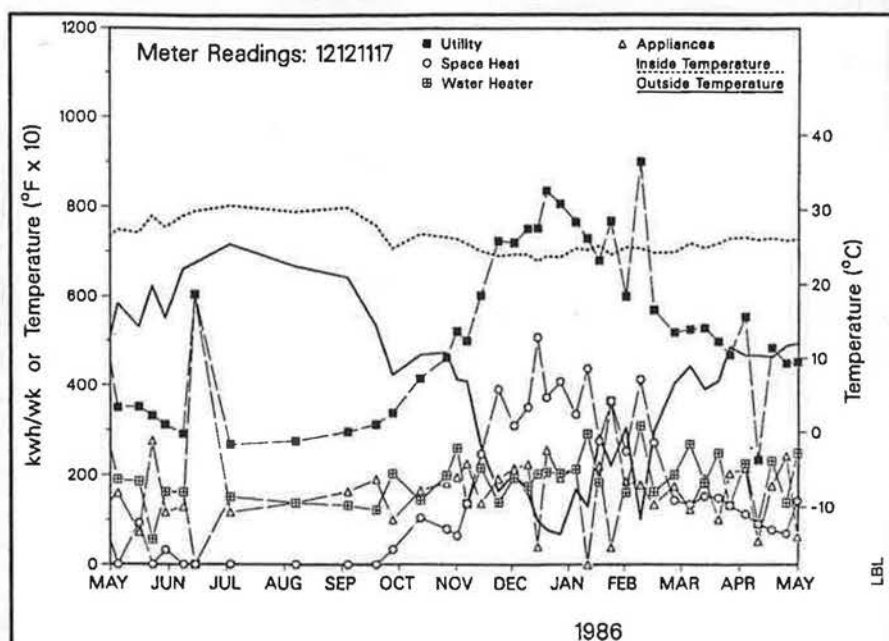


Figure 1. Raw data for one house in the Bonneville program. Over a year of energy and temperature data were collected for each house. In this low-tech system, the occupants served as the "data loggers" by reading three kilowatt-hour meters each week and mailing postcards to Bonneville. Data failures occurred frequently at first (one can be seen in mid-June) but became less common as the occupants learned to read the meters.

eral quality control. Finally, builders and occupants were surveyed to order to determine costs, appliances, demographics, and satisfaction.

These data were sufficient to determine that the homes built to the new standards used about 40% less space heating energy than those built to current practice. The actual metered difference was smaller—about 30%—but the efficient homes were also 25% larger than the control homes and were kept warmer. If the two groups of homes had been the same size and operated at the same temperature, then the savings would have been over 40%. The energy use of each house depends on the climate, insulation levels, appliances present, and occupants' behavior, but the average savings were unmistakable. (The range in performance and savings are shown in Figure 2.) The results of the study convinced the Northwest to adopt new, tighter building standards. (For more on the savings from the standards, see "Model Conservation Standards Prove Themselves During Cold Snap," *HE*, Sept/Oct '90, p. 11-12.)

—Alan Meier

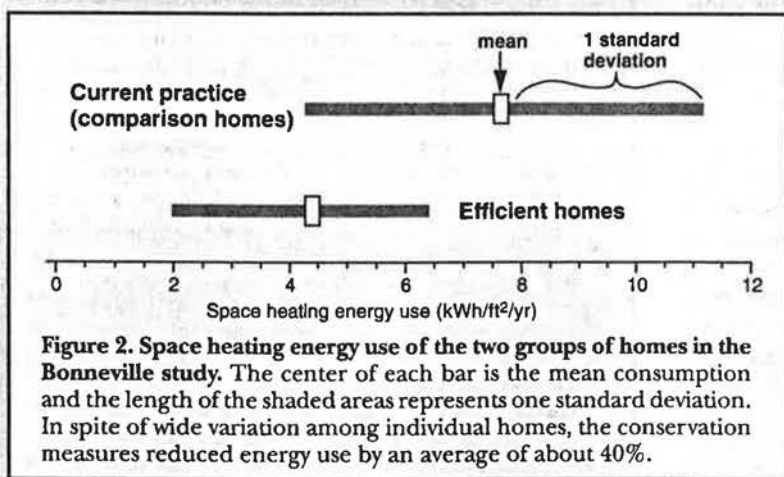


Figure 2. Space heating energy use of the two groups of homes in the Bonneville study. The center of each bar is the mean consumption and the length of the shaded areas represents one standard deviation. In spite of wide variation among individual homes, the conservation measures reduced energy use by an average of about 40%.

ments and attend just one training session. It is also more cost-effective to have one program and marketing plan to reach customers throughout the region.

### True Trade Allies

Using a regional design approach, the utilities were able to pool resources and retain the services of experienced energy-conscious builders, architects, and engineers. They

assembled more than a dozen teams to work on specific issues such as the building shell, cooling, lighting, appliances, construction details, ventilation, and passive solar design.

The utilities' Builders' Advisory Board was established to provide a forum for communication between the Joint Management Committee and builders. Through regular meetings of the Builders' Advisory Board, builders have been kept apprised of program status, and invited to provide input and feedback on documents and training sessions. Several

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marketing tools, including a video for prospective clients and a display booth for home shows, were developed based on suggestions from the Builders' Advisory Board.

The involvement of so many industry "gate-keepers" has been critical to the program's acceptance by the building community. These local professionals all feel some program ownership and hence are likely to build Energy Crafted Homes themselves and encourage their colleagues to do likewise. A measure of the program's success is its endorsement by such diverse groups as the Massachusetts Association of Home Builders and the Northeast Sustainable Energy Assoc. (formerly Northeast Solar Energy Assoc.). NESEA has also endorsed and helped to market the program, and its members have played key roles as program designers, workshop instructors, and inspectors.

### *Performance Standard Approach*

The utilities and building professionals selected performance-based standards for several reasons. Design flexibility is critical for most participants. Another advantage is that, as building technologies or building codes improve, it is simple to update the program by changing performance targets. Performance standards also "require" overall energy savings, so contractors aren't tempted to trade off sloppiness or inefficiency in some areas to meet prescription standards in others. Actual savings should therefore be higher for performance-based programs than prescriptive programs.

### **Marketing**

The program can only succeed if builders erect and people buy Energy Crafted Homes. Without widespread acceptance, a technically sound program will not save much energy. Thus, marketing targets both builders and buyers with the message that energy efficiency is an indispensable feature in a new home.

The core of the marketing strategy is to communicate that energy efficiency is not only an economic feature of a new home but part of a package of features as important as siting or kitchen design. These features include comfort, durability, and environmental safety. Reduced energy costs are assured through energy analysis and inspections during construction. Educational materials emphasize that features such as mechanical ventilation and sealed combustion appliances, which are not standard in new homes, can significantly reduce risk of unsafe air quality in homes. Energy-efficient homes have fewer drafts and temperature swings than do traditional homes. Moisture damage is prevented by extensive use of vapor retarders and proper exhaust systems.

### *Reaching Builders*

To get the program going, we sold it first to builders. The message to them combined two themes:

- the marketing competitive advantage—"looking for a hard edge in a soft market"—something to set the builder apart.
- the fear of being left behind in a changing market—"the market for inefficient homes is disappearing."

In both cases, the idea is that the Energy Crafted Home package of features will help give them a sales advantage over others that lack these features. Both small custom builders and large developers receive assistance with marketing.

### *Educating Homebuyers*

Utilities and builders are using creative strategies to enhance the marketing of certified homes. Feature articles in newspapers, lawn signs, homeowner manuals, cooperative advertising in real estate journals, home show booths staffed by Energy Crafted Home builders, videos, television advertising, brochures, educational booklets, and promotional items such as hats and pens are just a few

### **Good Cents' Measured Savings Fall Short of Prescription**

Just a bit to the north, Central Maine Power has been running a training and incentive program to encourage construction of new, efficient, electrically heated homes for several years. Central Maine Power's Good Cents program did not prescribe specific levels of insulation; instead, it required a level of performance under design conditions (an 80°F temperature difference). This allowed builders to trade off various features, such as extra glass area with thicker wall insulation. Builders prefer this kind of standard because it gives them much more flexibility to meet the demands of individual clients.

Based on a 1985 field study, the thermal performance of current-practice new homes was thought to be around 30 Btu/hr/ft<sup>2</sup>, so CMP required Good Cents homes to consume less than 16 Btu/hr/ft<sup>2</sup> for those smaller than 1,250 ft<sup>2</sup> (less than 15 Btu/hr/ft<sup>2</sup> for 1,250 ft<sup>2</sup> and larger). Good Cents promotional literature promises a 40% space heating savings compared to baseline homes. Over 4,500 houses and condominiums have been built to Central Maine Power's specifications.

The energy savings were recently estimated in a report by the consulting firm, RCG/Hagler, Bailly. It evaluated the savings based on utility bills, engineering estimates, and a small number of submetered homes.

The engineering surveys revealed one problem: the current practice houses (that is, the non-participants) were much better insulated than the utility had supposed: audits found that the average new electrically heated house's thermal performance was actually 18 Btu/hr/ft<sup>2</sup>. So, even though the Good Cents houses were also a little better than assumed, the expected savings were considerably reduced. The billing data confirmed the engineering estimates: actual energy savings were only a little more than 20% (about 3,000 kWh per single-family house).

The analysis was complicated because the Good Cents homes were larger than the comparison homes, the occupants wealthier, and many used wood heat. Furthermore, only whole-house billing data were available for most homes, so space heating consumption could only be inferred through Princeton Scorekeeping Method (PRISM) analysis. Logistical problems prevented full use of the submetering phase of the project. Nevertheless, the small sample of submetered homes proved to be very reliable indicators of the savings. RCG/Hagler, Bailly recommended that future studies should submeter the heating system because data from that portion of the study were particularly reliable. The Bonneville results (discussed in the box, "Measuring 40% Savings") reinforce that advice.

—Alan Meier

of the marketing approaches currently in place. The single program logo and name reinforced the message.

The newest marketing piece is a video, created as a result of builders' requests. The video, made for builders to distribute to prospective clients, features Energy Crafted Homes in various layouts and architectural styles. Builders explain the quality of construction and satisfied customers talk about lower fuel bills, increased comfort, and environmental responsibility. An abbreviated version is currently running as an ad on cable television.

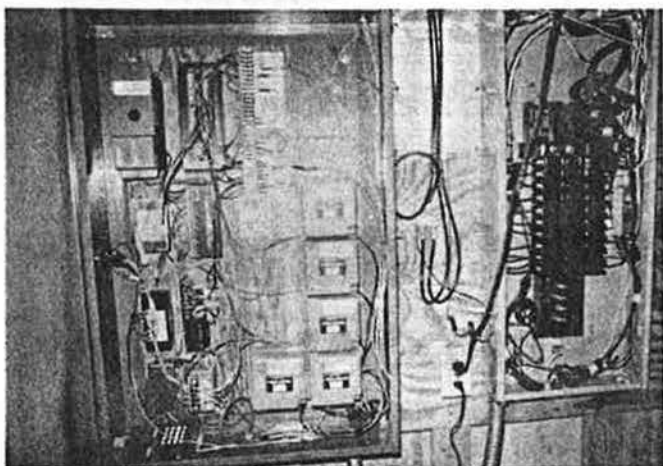
## Evaluation and Future Direction

The utilities are evaluating the program by way of interviews and focus groups with program designers, utility staff, plan evaluators, field inspectors, trainers, participating builders, non-participating builders, and recent and prospective homebuyers. The biggest barriers to builders are the slow market and the relatively low priority most buyers place on energy efficiency. Preliminary results indicate that most builders are aware of the program. Potential homebuyers, however, remain largely unaware of the program, indicating a need for marketing to target them.

A small, two-year end-use metering project began in January 1992. Sample program and control homes with similar floor plans and occupancy patterns were built by the same developer. The study is monitoring many end-uses. In addition, the whole building load and indoor and outdoor temperatures will be measured. Computer analyses for these homes predict a reduction of 30-40% in space heating for electric heat homes as compared to code, and a 40-50% reduction for fossil heat homes. (The difference in savings is due to the stricter code for electric heat.) The measured data will be used to modify the results of the computer simulations. While the measured results are not yet available, a preliminary analysis was presented at the American Council for an Energy-Efficient Economy Summer Study in August.

### Converting the Building Industry

Builders routinely depend on subcontractors for insulation, vapor retarders, heating systems, plumbing, and



Rob Willis, Solar Design Associates

On-site end-use metering of five Energy Crafted Homes is underway to estimate actual savings for heating, cooling, ventilation, water heating, and many other functions. The final measurements are stored in an on-site data logger, then periodically uploaded to a central computer.

electrical work. One of their biggest challenges has been finding installers willing to comply with program standards. One way to expand builders' choices of qualified subcontractors would be to offer focused training sessions and "Energy Crafted Home Installer Certification." A ventilation workshop and certification program already exists.

NESEA's annual Quality Building Conference and workshops are another avenue for providing more education to program builders. Other options include an information hotline or a panel of experts who could be available to answer questions and provide advice. Currently, evaluators and inspectors still provide most of the technical support.

In the first full year of implementation, the program trained over 400 builders who built nearly 150 Energy Crafted Homes. Most of the 1992 workshops are already booked to capacity. The regional goal for 1992 is to begin construction of another 400 to 600 single- and multifamily units (an ambitious goal in New England's slow market). Ultimately, the utilities plan to include 30% of the new, electric heat homes in the program. ■

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