It's Not about the Savings: Achieving Energy Efficiency in Systems-Built Homes

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ABSTRACT

Systems-built housing represents a relatively untapped market for residential energy efficiency program efforts. Typical energy efficient new home construction programs may overlook the systems-built housing market because programs do not recognize and address the needs of these manufacturers. In Wisconsin, Focus on Energy's Wisconsin ENERGY STAR® Homes program has identified ways to make efforts valuable for homebuyers, builders, and manufacturers without significant costs. The program has achieved energy savings, developed valuable relationships with manufacturers and builders, and begun to influence process and technological change in the systems-built housing industry.

Introduction: Systems-Built Housing

"Systems-built" housing refers to home construction where certain components of the home are manufactured and assembled in a factory before arriving at the home site. Systems-built housing is potentially less expensive for both the builder and homeowner by reducing onsite construction time and the associated labor costs. In an effort to distance itself from lingering negative associations with terminology including "prefabricated" and "mobile home," the industry has adopted the term "systems-built" as an umbrella expression to refer to both modular and panelized home products. (Some groups also use the term "Industrialized Housing.")

The systems-built homes market has grown steadily over the last decade, establishing itself as an important element of the new housing market in Wisconsin and the nation. In 2002, according to the U.S. Census Bureau, homes built entirely with building systems technology accounted for 6% of all single-family homes built in the US and 9% of those constructed in the Midwest. Thirteen percent of new single family homes built outside metropolitan areas employed systems-built construction. While market share for systems-built housing has generally remained constant, overall modular housing production increased 27% over the last decade and 11% in 2002 alone. Furthermore, industry experts assert that elements of the systems-built approach are becoming more prevalent across the new construction industry; Automated Builder Magazine estimates that as many as 50% of all new homes incorporate some aspect of systems-built housing (NAHB 2004).

The systems-built housing industry has made quality building a priority. In recent years manufacturers have worked with other entities to form associations and research initiatives to explore quality improvements. These efforts include the "Quality Modular Building Task Force," which was convened by the Hickory Consortium in 1999 with funding support from the U.S. Department of Energy's Building America program and the "System Builders Council" organized by the National Association of Home Builders. As part of the Building America initiative, the Hickory Consortium worked with multiple systems-built homes manufacturers and

produced *ENERGY STAR Homes: Guide for Modular Housing*. The Department of Energy also has ongoing efforts in this area as part of Building America's Industrialized Housing Partnership.

Despite these various initiatives, the Wisconsin ENERGY STAR Homes program faced substantial challenges when a participating builder asked the program to certify a systems-built home as a Wisconsin ENERGY STAR Home. Because the Wisconsin program standards are more comprehensive than the national ENERGY STAR program and because the national initiatives were not geared toward verifying the performance of every house certified, the builder's certification request represented a unique program challenge.

New Homes and Opportunities in Wisconsin

Wisconsin ENERGY STAR Homes

The Wisconsin ENERGY STAR Homes program works with builders to increase building performance in Wisconsin's residential new construction market. The program accomplishes this objective by performance-testing and certifying new homes that meet rigorous program standards for comfort, safety, durability and energy efficiency. Since its inception four years ago, Wisconsin ENERGY STAR Homes has had a growing impact on Wisconsin's new construction market. In 2002-03 the program certified 883 homes. The program is currently funded by the statewide energy efficiency program, Wisconsin's Focus on Energy, as well as various municipal and cooperative electric utilities across the state.

The Wisconsin ENERGY STAR Homes program is delivered to builders through a network of independent consultants qualified and trained by the Wisconsin Energy Conservation Corporation (WECC) and their subcontractors. These consultants—typically individual proprietorships where the owner/proprietor has a strong building or construction background—cultivate consulting relationships with builders in their geographic area. The consultant is paid for their time and expertise by the builder, with partial assistance from the program. The program encourages consultants to see their builders—rather than the program—as their primary customers, really helping consultants become the building science expert for their builders. Atypical of most of the ENERGY STAR Homes programs around the country, the Wisconsin program conducts performance tests on every home that is certified and requires that each home meets minimum performance standards. Prior to the final certification test, program consultants visit each in-process home being built by a new program builder on two separate occasions—at framing and after insulation—to verify specific details of construction before those details are hidden from view. (As builders gain experience in the program, the number of site visits is reduced, based in part on the performance of that builder's homes.) The final certification testing, which occurs on every certified home, includes a blower door test to verify the home's tightness, performance testing of all ventilation equipment to verify airflow requirements, and various other performance tests.

Motivations for Systems-Built Manufacturers and Builders

Wisconsin ENERGY STAR Homes program staff have long recognized that one of the primary appeals of the program for builders is the potential to reduce builder callbacks. Responding to callbacks can be tremendously expensive for builders in terms of time, money, and reputation. Builders typically absorb all costs associated with these customer complaints but

in many cases, a customer's frustration over the issue remains high and can damage the builder's reputation. In addition, as consumers become more aware of and concerned about mold and other moisture issues, the builder's liability risks associated with callbacks rise substantially.

The Wisconsin ENERGY STAR Homes program attempts to reduce the potential for callbacks through the certification process. By providing another set of eyes to review the critical details of construction and test the installed equipment, the program seeks to increase the odds that the details will be done right. Additionally, when a home is certified and the homeowner does have a concern, the builder knows that he/she can turn to program staff and consultants to help diagnose and solve the problem.

In a typical stick-built home the liability associated with callbacks rests with the builder. This dynamic is altered in systems-built homes because the manufacturer is responsible for the components that are assembled by builder during the construction process. (In many cases the home might include some modular components from a manufacturer and some pieces—like the basement—that the builder constructs on site. Furthermore, the builder is typically responsible for heating and cooling equipment, plumbing, lighting, air sealing of components, etc.) This means that the builder and manufacturer effectively share liability for the home. From a practical perspective this shared liability means that manufacturers have added incentive for partnering with high-quality builders because—in addition to the general benefits of better customer satisfaction—the manufacturer faces reduced liability when working with builders who have fewer callbacks. Similarly, manufacturers would benefit from a program that improved the quality of homes produced by that manufacturer's builders.

The manufacturer-builder relationship is complicated by basic economics. While the consumer purchasing the home is the builder's customer, the manufacturer's customer is the builder, not the home buyer. Manufacturers invest considerable effort in recruiting and retaining builders; like any supplier, the manufacturer benefits from repeat business from its established clientele. Although it is in the manufacturer's interest to improve the building techniques of its builders to reduce the manufacturer's liability, as a supplier, the manufacturer has limited ability to suggest (much less enforce) increased standards for aspects of the home that are typically the builder's purview. Ideally, the manufacturer would like to focus on producing modules and be assured that someone else is educating their builder-customers. Furthermore, as liability issues arise and any questions of responsibility begin to circulate, both the manufacturer and the builder could benefit from an unbiased expert investigating the situation. Once program staff understood this dynamic they recognized that the Wisconsin ENERGY STAR Homes program could provide significant value to systems-built manufacturers.

Challenges in Working with Systems-Built Housing

Programmatic Challenges: Fitting the Certification Model to Systems-Built Housing

Initiated as a program serving stick-built housing, the Wisconsin ENERGY STAR Homes certification model required significant adjustment to accommodate the differences in the building process (i.e., modules are produced and sealed at a factory rather than at the home site, making it impossible to verify certain details of framing and insulation on- site) for systems-built homes. The program also wanted to maintain its rigorous performance standards. While it was relatively easy for staff to identify what needed to happen to certify systems-built housing, developing a cost-effective process associated with those requirements was much more difficult.

In order to certify a systems-built home, certain features would need to be verified at the factory during the manufacturing process. Once these features were verified, the modules were essentially "certification ready." Utilizing "certification ready" modules, a builder—who followed other program standards on site—could deliver a certified Wisconsin ENERGY STAR Home to his/her customer. Factory-level verification was, however, complicated by both the program and the manufacturers' preference to offer Wisconsin ENERGY STAR Homes certification as an option rather than as a standard feature. In working with stick-built builders the program has always accommodated builders who want to certify some, but not all of their homes and we believed we needed a similar approach here. Had manufacturers adopted changes system-wide, the program could have verified up front and conducted a periodic recheck to assure that the modifications were still in place. Nonetheless, manufacturers insisted that their priority was retaining the flexibility to produce a 'certification ready' module as an alternative, not a replacement, to their standard product. Program staff recognized that accommodating manufacturers on this point was vital.

Having manufacturers produce certification ready homes on an intermittent basis was more complicated than a stick-built builder building non-program homes. For stick-built construction the program consultant is involved in the homes that the builder identifies to the consultant as candidates for certification. For systems-built construction, though, this would necessitate having a consultant standing by to inspect modules at intermittent and irregular schedules. It was readily apparent that this model would quickly become time and cost intensive, effectively making the costs associated with certification unreasonable.

The solution to this obstacle was a partnership with PFS Corporation, a State of Wisconsin-approved housing code-compliance firm based in Madison. PFS works with systems-built manufacturers and their in-house quality control staff to provide in-factory code compliance. The PFS process involves detailed review of quality control documentation recorded on the factory floor, as well as random sampling of home products as they are completed. If compliance is not met PFS has the authority to shut down production lines until the problem is corrected systemically. Already in the factory, PFS provided the critical link to Wisconsin ENERGY STAR Homes certification during the manufacturing process. PFS recognized the value of Wisconsin ENERGY STAR Homes' certification to their clients (the manufacturers) and the benefit of working with the program to provide that certification. Accordingly, PFS volunteered to supplement their existing evaluation by verifying additional features of the modules intended to be "certification ready." With PFS offering to perform these verification services at no additional cost to the program or the manufacturer, the program could devote its energies to identifying technical measures each manufacturer needed to incorporate, and then working with PFS to ensure those measures were verifiable in the factory.

The partnership with PFS had significant implications for the program's cost effectiveness. By agreeing to provide the supplemental review at no cost, PFS enabled Wisconsin ENERGY STAR Homes to certify systems-built homes at a lower cost (because two site visits are effectively eliminated). The program has some new short-term costs associated with providing training to PFS personnel, but these training expenses are relatively minor compared to the eliminated site visit costs, especially as the number of systems-built homes enrolled in the program increases over time.

The benefits of the program's partnership with PFS extend well beyond the program's financial savings on site visits. This partnership enables the Wisconsin ENERGY STAR Homes certification to be fully integrated into a manufacturer's process; as an example, a builder is able

to verify that components are "certification ready" based on information PFS has added to the standard code compliance plates that are affixed to each component before shipping. In addition, as this effort evolves and PFS staff comes to appreciate the benefits the program delivers to manufacturers and builders, the PFS staff is starting to refer additional manufacturers to the program.

Technical Challenges: Taking Verification, Testing, and Standards to the Market

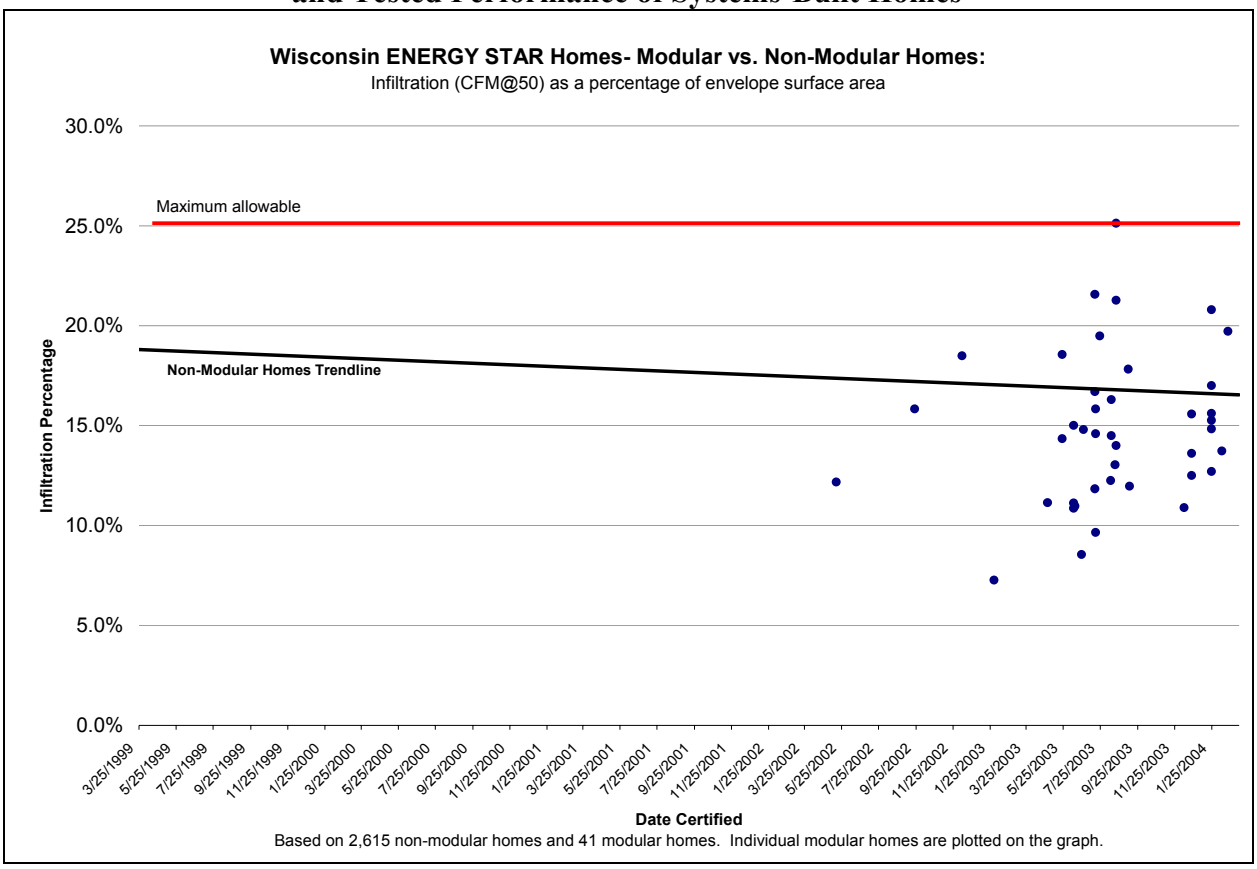
Wisconsin ENERGY STAR Homes built trust and rapport with systems-built manufacturers through participation in a special effort with Building America. Building America is a Department of Energy initiative that helps builders access and implement new energy efficient technologies and practices. In Wisconsin, a Building America grant, through the Wisconsin Division of Energy, enabled us to create a forum where we could meet Wisconsin-based modular manufacturers to identify and discuss their energy efficiency and building science issues.

From a technical standpoint, the first critical step was understanding the technology and process in place at the manufacturer's facilities. For each of the four manufacturers participating in the initiative, a base-case building practice model and material selection model was developed. Each model was based on in-factory visits, an on-site set and performance testing of a representative home, and an understanding of the quality control process. To produce improved performance, program staff, working with Building America consultants, identified opportunities that could be exploited inside the manufacturing facility. These opportunities fell in three categories:

- **Air Tightness -** Overall air tightness of the modules was not a particular concern as these modules tested as meeting program standards and, indeed, as being tighter than typical stick-built Wisconsin ENERGY STAR Homes in many cases. Figure 1 illustrates this phenomenon. Wisconsin ENERGY STAR Homes are allowed a maximum infiltration rate of 25% (measured as percentage of envelop surface area). The modular homes the program tested (represented by the dots in the graph below) tested well within this requirement and, indeed, clustered around the current infiltration level of all stick-built certified homes (as represented by the trend line).

  The one area of concern we did identify regarding air tightness had to do with potential damage to the factory applied mating seals during the on-site sets. In relatively tight homes, larger holes could cause point moisture problems, such as a ceiling marriage wall beam that is trimmed rather than air sealed with drywall.

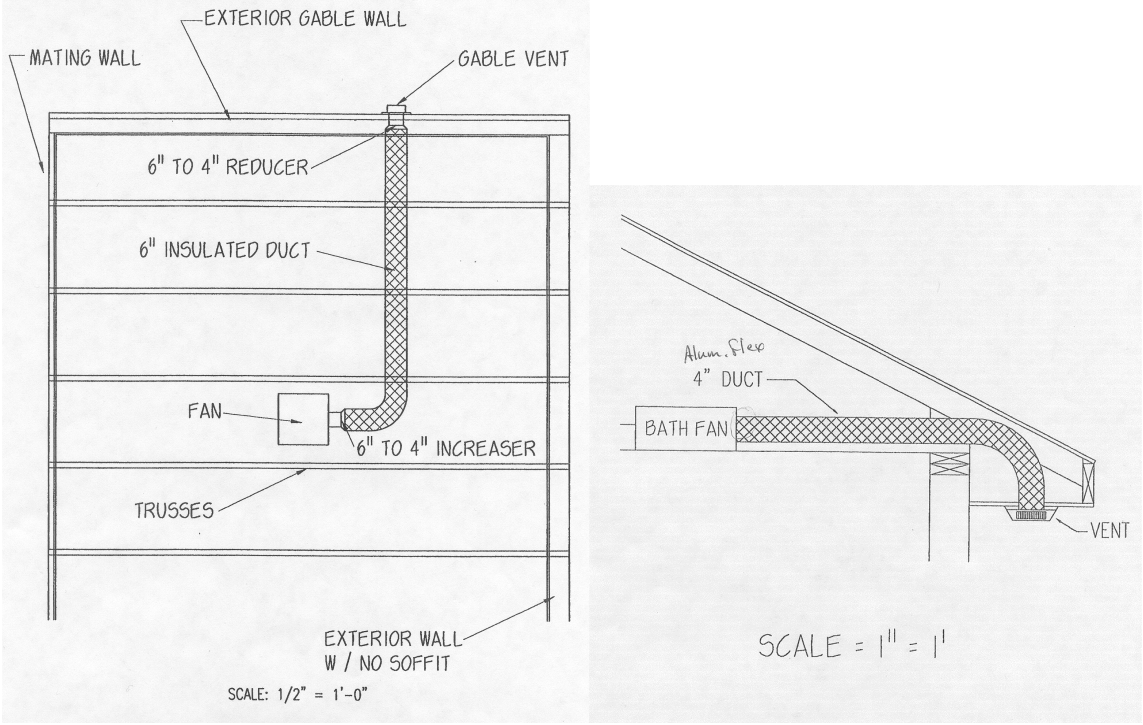
Figure 1. Wisconsin ENERGY STAR Homes Infiltration Rate Standard, Normalized Trend Line of Program-Certified Stick-Built Homes Over Time and Tested Performance of Systems-Built Homes



Source: Wisconsin ENERGY STAR Homes database

- **Ventilation –** Ventilation flows in the tested systems-built homes were generally about 55% of rated capacity for the mechanical ventilation equipment. This finding was consistent with what the program found when we first began testing such equipment for stick builders. In systems-built homes the ventilation system installation required three different trades people inside the factory. Once we identified our concerns each of the four manufacturers chose a different method of correction. Figure 2 illustrates the solution that one manufacturer applied; in this case the manufacturer set standards for the installation of ventilation equipment for the first time, even going so far as to set different specifications for different circumstances. This manufacturer is also adding a requirement for air flow testing to the other code-related tests they perform on modules.

Figure 2. One Manufacturer's Technical Specifications for Fan Installations



Source: Technical document from a Wisconsin systems-built manufacturer

- **Insulation –** The manufacturers employing blown cellulose insulation had a product and practice that met or exceeded program standards. Wisconsin ENERGY STAR Homes recommended that cellulose sent out to the job site to cover the mating walls was 'blown cellulose' rather than 'bagged cellulose,' which represented a cost-effective upgrade. For the manufacturer employing fiberglass batt attic insulation, the program recommended a switch to cellulose that, when tested in the facility, was demonstrated to save costs and improve performance. The manufacturer adopted this change system-wide.

As is the case with stick-built builders, the program emphasized flexibility when discussing these issues with manufacturers. In every case we identified the opportunities to increase performance, talked about multiple strategies for achieving that performance, and then let the manufacturer choose which strategies to implement in order to achieve the program's performance standards.

Measuring Success

Successful energy efficiency programs are ones that benefit all stakeholders. WECC believes that the best models are those that enable private industry to realize real benefits from delivering energy efficient goods and services while simultaneously delivering the public benefits associated with energy efficiency (ideally in an increasingly cost-effective manner). Considered in this context, the Wisconsin ENERGY STAR Homes partnership with the systems-built housing industry looks very promising.

Benefits for Manufacturers and Builders

Wisconsin ENERGY STAR Homes provides critical quality assurance services to both manufacturers and builders in the systems-built marketplace. On the factory floor, the certification requirements are an assurance for the builder that the product the builder requested is the product delivered. Thanks to the PFS verification process, the builder and his/her customer can be more confident that they are receiving product that, correctly assembled, will perform to some of the highest building standards in the nation. Similarly, at the home site, certification standards are an assurance for the manufacturer that the assembly of the systems-built home components was performed in a manner consistent with the manufacturer's intent, building science principles and construction best practices.

Furthermore, both the builder and manufacturer benefit from the program's commitment to provide homeowners with comfortable, safe, durable, and energy efficient homes. The most obvious benefit for both builders and manufacturers is the reduction in potential callbacks that typically results from the added attention to the details of construction required by the program's certification process. In addition, there is a significant potential for increased customer satisfaction associated with the certification process. As part of the program's communication strategy, the new owner of every Wisconsin ENERGY STAR Home receives a homeowner's manual and a report that describes the tested performance of their home; survey data associated with this mailing indicates that homeowners are very pleased with their homes and that they value the Wisconsin ENERGY STAR Homes designation.

The certification itself benefits this industry because it is an objective assessment of home quality. For the systems-built industry, communicating the quality of their products to homebuyers is paramount. Given the industry's history, they are very attuned to finding and exploiting opportunities to compare their current line of products to stick-built alternatives. Wisconsin ENERGY STAR Homes certification has come to represent quality and performance in the Wisconsin home market, and some manufacturers see tremendous benefit in having this label apply to their products.

Finally, manufacturers who participate in the program have more access to innovation than their peers. In many ways Wisconsin ENERGY STAR Homes functions as a kind of research and development service for these manufacturers, helping them to identify possible innovations that merit further analysis. This point is illustrated by the findings of a recent evaluation effort where interviewers talked with the participating manufacturers and identified the practices that manufacturers had changed as a result of program participation. Table 1 summarizes the changes that one manufacturer made as part of this process; we believe that it is significant that each of the four manufacturers that are currently participating in the program implemented program recommendations that were not required for certification (Talerico 2004).

It is worthy of note here that the program's list of benefits for manufacturers and builders does not include energy savings for the homeowners. Consumers typically assume (and often with good justification) that their newly constructed home will be more energy efficient than their previous dwelling. In Wisconsin the difference between the new home and the old home is usually much greater than the difference between the average new home and a higher performance new home. Further, staff acknowledge, based on past research as well as discussions with builders, that energy savings is simply not a big customer motivator. There is no good reason for staff to assert otherwise with builders and manufacturers.

Table 1. Summary of One Manufacturer's Practices, Before and After Program Participation

Practice	Used Practice Before Involvement with Wisconsin ENERGY STAR Homes		How Currently Uses Practice in Modular Homes	
	Yes	No	Only Certification-Ready Models	Plant-wide
Wisconsin ENERGY STAR Homes Requirement				
Install no wood fireplaces until factory makes an approved selection		X	X	
Install no B-vent chimneys		X	X	
Install bath exhaust fans that are rated 70 CFM or better	X			X
Vent kitchen range hood or other appliance to outside	X			X
Install gas fireplaces with Novus direct vent or equivalent	X			X
Wisconsin ENERGY STAR Homes Recommendation (Not Required)				
Provide a house wrap over OSB sheathing		X		X
Shorten length of bath exhaust run to increase CFM performance		X		X
Provide builders foam for vertical mating walls		X		X
Provide builders loose cellulose for attic fill		X		X
Cut fiberglass to fit in wall cavities greater than 2 inches		X		X
Install windows (at the factory) with U-values less than 0.35		X		X
Split fiberglass wall insulation to surround electrical boxes and plumbing		X		X
Frame and back vertical walls between changing ceiling heights so that the wall has the same thermal characteristics as all other exterior vertical walls		X		X
Flash window rough openings		X		X
Install CO detectors		X	X	

Source: Talerico 2004

Program Benefits

From the program's perspective, developing a partnership with systems-built manufacturers gives the program access to an important piece of the new construction market. One Wisconsin manufacturer, Wausau Homes, has decided to implement some recommendations associated with insulation and window installation in all new homes produced in both their Wisconsin facility and some of their facilities in other parts of the country, even though the company has no "program" incentive to do so in other areas. This broad adoption of Wisconsin ENERGY STAR Homes' recommendations indicates that Wausau Homes does truly see the program as a trusted and valuable technical resource.

The final metric of success from the program's perspective is, of course, energy savings. Wisconsin has strong building codes and most new homes are built sufficiently above code that they would meet the national ENERGY STAR Homes standards, which is what prompted more rigorous state-level standards initially. Past evaluations indicate that a certified home saves 100 therms annually over a typical new home. The 30 systems-built homes certified so far, then, account for 3,000 therms of savings annually. While this number is relatively small, staff is optimistic that it will grow substantially over time.

Conclusions: It's Not About the Energy Savings

This partnership with the systems-built housing industry works because the Wisconsin ENERGY STAR Homes program staff remains committed to two fundamental premises. First, they ensure that the program is responsive to the needs of the marketplace; this effort began, after all, with a request from a participating builder. And the partnership model evolved as staff recognized the needs and motivations of the systems-built manufacturers. Program staff was prepared to be flexible on various issues of implementation while also protecting overall program effectiveness. The commitment to responsiveness enabled a flexibility that yielded a creative new approach.

Equally significant was staff's recognition that, for our private industry partners, it is not about the energy savings. Energy issues are a minor consideration in the new home construction process. Significant and sustainable opportunities for energy savings are seized most cost-effectively when programs address issues more central to the concerns of the other stakeholders. In this case, the manufacturer and builder concerns about liability and the reputation of their industry provided an opportunity to build a partnership that does, in the end, generate energy savings for the program. Being responsive to the needs and priorities of the marketplace ensured that the program was relevant and, ultimately, that partnership opportunities could be realized.

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