Cold Climate Housing NEWS

A Quarterly Newsletter For Building Professionals

Cold Climate Housing Center, Minnesota Extension Service
Minnesota Building Research Center, University of Minnesota

MnBRC Volume 4, Issue 2
Spring 1991

Planting Trees for Energy Conservation

Patrick Huelman, *Forest Products and* ***Margaret Sand,*** *Landscape Architecture*

Planting trees can help remove atmospheric carbon dioxide, a crucial greenhouse associated with global warming. This message has gotten through to many Americans as the popularity of tree planting has exploded in recent years. It is also well established that fossil-fuel consumption for heating and cooling buildings is a major contributor to atmospheric carbon dioxide. However, the public seems much less aware of this fact. Recent studies, including one completed by the authors and others from the University of Minnesota, have shown that trees planted to reduce energy consumption of buildings are potentially many times more valuable in reducing carbon dioxide than remotely planted trees. It was also shown that properly placed trees, especially in southern Minnesota, can return their initial investment in energy savings from just the shade they provide.

Background

The Minnesota environment plays a major role in the energy used for heating and cooling buildings, especially residential dwellings. While temperature is the primary climatic factor, sun and wind have a strong influence on energy use in homes as well. Because the sun and wind are both directional, they can be intercepted by trees before they reach the home. Secondly, trees can modify nearby temperatures by shading adjacent surfaces and, in the summer, trees can modify surrounding air temperatures through the process of *evapotranspiration* (defined as "the total water loss from the soil, including that by direct evaporation and that by transpiration from the surfaces of the plants" [*Webster's New World Dictionary*, second edition]).

For Minnesota, planting for energy conservation means achieving summer shade and winter wind protection while minimizing impact on winter solar gain and summer breezes. Even though this seems intuitive, there has been limited research which simultaneously evaluates the heating and cooling impacts of planting trees.

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CCHC Targeted for Shutdown

As summer draws near, the future of the Cold Climate Housing Center (CCHC) remains uncertain. On June 30 of this year, funding for this research-based Minnesota Extension Service program will be exhausted. Numerous proposals for funds have been submitted to various potential granting bodies throughout the state and nation, but the current fiscal situation in Minnesota and at the federal level combine to give a bleak outlook. With no yet-guaranteed funds to continue CCHC beyond this date, this technology-transfer arm of the Minnesota Building Research Center has begun to develop procedures for a systematic shutdown.

Since its establishment in 1986, CCHC has reached thousands of building professionals, housing educators, and housing consumers throughout Minnesota and the surrounding region. The Center's programs have focused on residential energy efficiency, indoor air quality, moisture-induced building deterioration, environmental impacts of residential energy consumption, and housing affordability.

Planting Trees

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Research Efforts

The recent research at the University of Minnesota was undertaken to determine the impact of tree shading on home heating and cooling and its association with carbon dioxide production. This first study of Minnesota conditions was limited to the impact of three shade on building windows. The planting configurations in the study concentrated on shading east and/or west orientations while minimizing shade on south windows. A prototype tree at three heights and one prototype single-family home with two insulation levels and two orientations at three latitudes were analyzed using CALPAS3, a computer energy simulation program. The tree shade data generated by a second computer program, SALADDS (see figure 1), was integrated with weather and building information to quantify the impacts on energy loads and costs.

Major conclusions include:

- Trees planted west and east of a building are most effective in reducing total energy demand.
- For all of the building and planting configurations evaluated, the trees reduced the net amount of carbon dioxide released.
- Strategic tree planting can reduce energy demand for both homes and communities. However, the effects of tree shading on energy conservation and utility costs are distinctly different between northern and southern Minnesota. When shading effects are the only factors considered, little savings are likely for northern regions. (A future study will include the wind-shielding value of trees for northern locations.) In the southern half of the state, however, annual utility costs can be consistently lower with proper planting, considering shading benefits alone.
- In southern Minnesota, tree planting for energy conservation is often a good economic investment especially for smaller, less expensive tree stock.

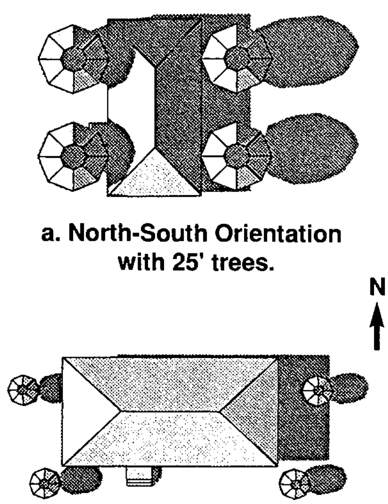

Figure 1. Computer simulation of tree shade on homes on July 21 at 4:00 p.m. in the Twin Cities.

Guidelines for Energy-Efficient Plantings

One of the most significant tree planting guidelines for Minnesota is to avoid shading south, southeast, and southwest windows in the winter. While it has always been recognized that evergreen trees should be avoided on the south side of buildings, this research has shown that the winter shade from deciduous trees can increase winter heating bills more than the reduction in summer cooling costs. Even trees used on east and west orientations should be "solar-friendly" trees. This type of tree has few branches in winter and more favorable foliation periods (develops leaves late and loses them early). Among the more solar-friendly trees in Minnesota are Kentucky coffeetree, walnut, butternut, and ash.

Summer shade can improve comfort and reduce both cooling demand and air-conditioning costs. Primary emphasis should be to shade southwest to northwest

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CCHC Takes Part in Model Home Remodeling Project

The Cold Climate Housing Center is once again involved in a model home project, but this time with a different twist: remodeling and renovation. This project includes a new approach to residential remodeling – using a building commission team. The team, headed by the general contractor, Danberry Companies, includes CCHC specialists as well as designers, subcontractors, and suppliers. In the initial stages of the project, the team developed an overall design strategy for the structural, energy, spatial layout, historic, and aesthetic concerns of the home. As a result, the home will feature many special cold climate building techniques and materials including airtight gasket construction; energy-efficient, condensation-resistant windows; a high-density insulation system; a high-efficiency heating and cooling system; and balanced ventilation with heat recovery.

Although the work on this home involved a major renovation, the concepts used are applicable to smaller-scale remodeling projects. Many of the approaches to airtightening, insulation, ventilation, and heating and cooling could be incorporated as well.

Located in the historic community of Excelsior, the finished home will be open to the public on June 15 and 16. For more information regarding this home, contact CCHC at the number listed on page 3. (Donations will be accepted for WCCO Iron Crib Kids and Minnesota Builders Association Homeless Shelter charities.)

Consumer Awareness Impacts Demand for Energy-Efficient Homes

You won't find many builders who argue the fact that energy-efficient construction practices are a good idea. Consumers are also becoming increasingly aware of energy efficiency, and many have come to expect it in their new homes. Last summer ***Cold Climate Housing News*** ran an article on energy-efficient model homes ["Spring Preview Reveals High Interest in Energy-Efficient Housing," Volume 3, Issue 3]. An increasing interest in energy efficiency and controlled ventilation was identified as an emerging consumer trend. But what do consumers actually know and understand about the details of energy-efficient construction?

During this year's County Extension Day at the University of Minnesota, many visitors to the Cold Climate Housing Center's (CCHC) display stopped to talk with staff members. Some asked questions regarding particular aspects of their homes; others indicated that they were planning to incorporate many cold climate housing techniques into homes they were currently building.

David Melberg, a Renville County Extension Committee member, enthusiastically told CCHC specialists how he incorporated cold climate building techniques into the construction of his new 1,650 square-foot, two-level home. His goal was to achieve a comfortable and pleasant home with economical construction and operation. "I wanted to raise my standard of living *and* save money, and I did both," he says. He also adds that, while his home is one-third *larger* than his old house, he actually pays *less* to operate it.

Melberg's first contact with CCHC was at the same event three years earlier. And when he began building his home, he remembered the Center's work. He reviewed various cold climate building techniques with CCHC specialists and obtained technical information through publications and other materials.

Ceiling Design

One of the construction details that Melberg incorporated into his home was the use of energy-heel trusses, which allowed for higher levels of insulation to be used at the edges of the ceiling. And despite some skepticism from others, he also installed a ceiling air/vapor barrier. According to Melberg, this technique was not commonly used in other homes in the area but has made a significant difference in controlling heat and humidity.

Ventilation Details

Melberg also received technical guidance from CCHC regarding proper ventilation of his new house. In his traditional bath and kitchen, he used systems which exhaust air down and out the side of the house, as opposed to the conventional route of up and out. Melberg also installed a combustion air supply for his furnace and water heater, along with make-up air for ventilation, practices which CCHC specialists advocate for this type of home and mechanical system.

A Liveable Basement

By using CCHC information as well as tips from the local utility, Melberg was also able to design his lower level (basement) into a "total living area." Insulated both inside and outside, the basement's temperature and humidity are both under control. Windows not only provide egress but also allow the sun to warm the space during cold weather.

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The Cold Climate Housing Center (CCHC)

is an interdisciplinary group that draws its technical expertise from three departments at the University of Minnesota: **Agricultural Engineering; Design, Housing, and Apparel;** and **Forest Products.** Throughout the year, the CCHC staff will be conducting educational programs in many subject areas related to cold climate housing. Questions regarding these programs and other information that is available through the Center can be directed to CCHC's central telephone number: **(612) 624-9219**. Technical questions will be forwarded to one of our specialists in the appropriate subject area.

If you have questions or comments regarding this newsletter, contact:

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The House Doctor

The intent of this column is to discuss issues or problems currently being encountered by contractors, builders and consumers in building and maintaining homes in cold climate regions.

Watch Out For Faulty Cathedral Ceiling Construction!

Timothy Larson, *Forest Products*

If you've seen one cathedral or vaulted ceiling, you may not have seen them all. While many builders often use this type of ceiling in their residential construction because their consumers like the feeling of openness it gives, moisture-related problems can develop when certain rules are not followed, resulting in costly call-backs from the consumer. Figure 1 shows a home that has severe moisture problems due to poor cathedral or vaulted ceiling design and construction.

The first distinction that may separate one vaulted ceiling from another is whether it is **vented** or **unvented**. While unvented roof systems are warranted in certain circumstances, such as in geographical areas with fine snow and high winds, great care must be taken to ensure a durably airtight ceiling in addition to design and construction that locates possible dewpoint planes in a low permeable, insulative material.

Current building practices in cold climates primarily use vented cathedral ceilings. What follows will be a brief discussion of the basic elements and construction details for a sound vented cathedral or vaulted ceiling.

There are six basic elements in the vented cathedral ceiling that are critical to successful construction. They include the following:

- Structural members
- Exterior moisture barrier
- Ventilation
- Insulation
- Air barrier
- Vapor retarder (barrier)

While all six elements are important, there is not room to discuss all of them here. Structural members and exterior moisture barriers will not be addressed in this article.

Figure 1. An exterior photo of a home with cathedral ceilings and bad moisture staining of siding due to an inadequate air barrier.

Ventilation

Ventilation of attics and ceilings is very effective in reducing summer heat gain through the ceiling. It also removes water vapor from the ceiling/roof system that may have diffused or leaked from the house. Ventilation can also aid in drying water that may have leaked into the cavity due to a failure of the exterior moisture barrier or condensed in the cavity during the winter. Another important benefit occurs during the winter when ventilation can help maintain a uniform roof deck temperature by removing escaping heat. This is critical in controlling ice dam development.

To ensure proper air movement, the ventilation space should have a depth of 2 to 3 inches. This air space, coupled with the necessary depth for insulation, can be obtained by using high-heeled scissors trusses, parallel chord trusses, wood I-beams, or furring-out 2x12s on the top or bottom. Screened openings to the vented space should provide 1 square foot (144 square inches) of free net area for every 300 square feet of ceiling area. Each rafter cavity should have ventilation. Half of the required vent opening should be near the ridge and half should be distributed at the eaves. Continuous ridge and soffit vents are preferred to periodic roof and soffit vent openings. Any vent system must be designed to resist the entry of snow and rain.

Insulation

Insulation levels in cathedral ceilings built here in Minnesota should range from R-40 to R-60. The R-value for this type of ceiling needs to be higher to reduce heat loss than that found in flat ceilings with attic spaces because of its reduced ventilation capacity. Insulation at the eaves must cover the double top plate of the wall and be protected from (yet not block) the ventilation

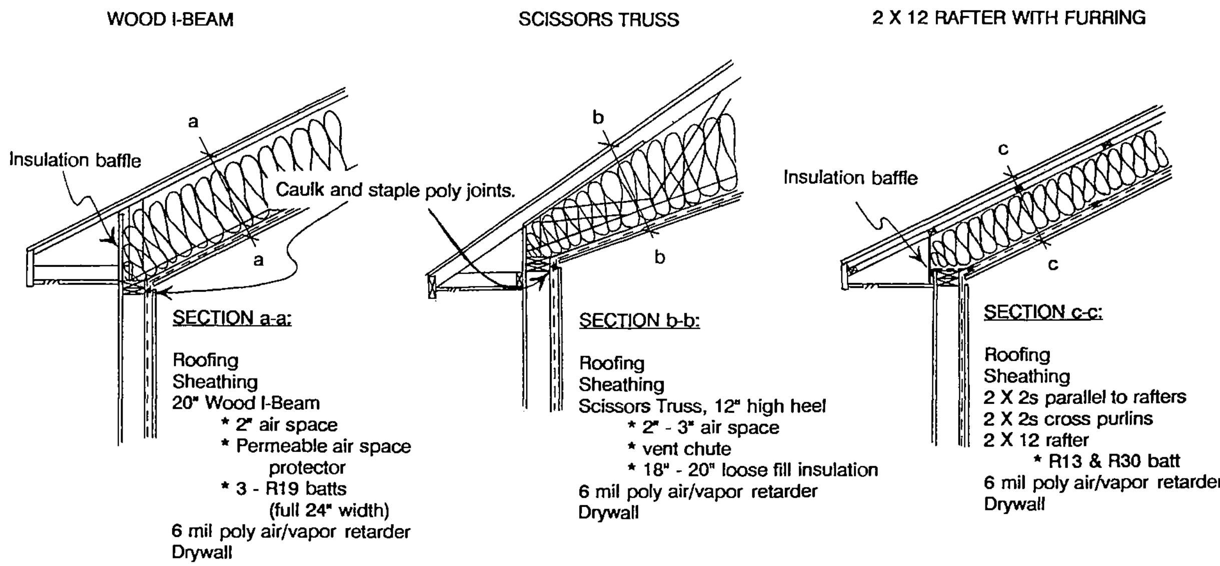

Figure 2. Options for the design and construction of vented cathedral ceilings in cold climates.

air stream. Figure 2 illustrates the proper placement of insulation and blocks for a vented cathedral ceiling.

Air Barrier

The most critical element in the cathedral ceiling is the AIR BARRIER! Three factors create pressure differences between the inside and outside of a house: wind; mechanical systems; and the buoyancy of warm, moist air. When the pressure inside the house is greater than that of the outside; warm, moist air will flow out and more than likely reach the dew point and condense (during the winter) in the ceiling/roof system. When dealing with moisture problems due to an internal moisture source in northern climates, it has been shown that air leakage transports much more water than diffusion. Because of this, it is imperative that an air barrier exist in the ceiling and that it be 100% continuous. Polyethylene or drywall can function as the air barrier <u>but they must be installed in a continuous manner</u>. For example, it polyethylene is used as the air barrier it must have durable and effective seals at the seams, electrical outlets, exposed beams, across interior partitions, and at intersections with exterior walls. Any penetration through the air barrier puts the performance of the cathedral or vaulted ceiling at risk. Skylights and recessed lights place the air barrier at risk and can significantly degrade the thermal performance of cathedral ceiling systems.

WARNING: It is imperative that exhausting or combustion devices have sufficient make-up air or combustion air in tightly constructed homes.

Vapor Retarder

All other things being equal, water molecules move from warm to cold regions or from areas of high concentration to areas of low concentration. Because of this type of water movement (which is called *diffusion*), vapor retarders are required on the warm sides of walls and ceilings to prevent moisture movement to potential sites of condensation. Most codes require a vapor retarder with a perm value below 1 on the warm side of a wall or ceiling.

Figure 2 illustrates three good cathedral ceiling configurations for cold climates. Each incorporates good ventilation, adequate insulation, a continuous air barrier and a vapor retarder. ■

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Planting Trees

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windows from mid-afternoon to evening sun. The next priority should be to shade east windows from morning sun to reduce morning warm-up of the structure. Paved areas adjacent or near the home should be also shaded to reduce heat build-up. Lastly, air conditioning units can operate more efficiently if they are shaded by trees, provided that lower branches are pruned to permit necessary airflow around the unit. In urban areas, increasing the tree cover can also provide local temperature reductions in the summer due to shading of ground, paved, and building surfaces around the home. In addition, evapo-transpiration can again result in local temperature reductions. However, it is also critical to maintain access to summer breezes for natural cooling. Dense vegetation should be avoided near windows, especially on southern and southeastern orientations.

While the benefit of winter windbreaks is difficult to quantify and can be highly variable, it is desirable to protect homes from winter winds. This can be achieved with dense trees or a combination of trees to the north and west of the structure in rural or open areas. Typically, windbreaks are planted 50 feet or more, upwind, and extended slightly south and east of the building(s) being sheltered. Wind effects can also be reduced in urban areas by increasing general tree cover.

Planting trees can provide multiple benefits to you and your home (see figure 2) as well as contribute a small part in protecting our environment. In addition to increased tree planting, it is important to preserve existing trees and provide them with proper maintenance for improved growth and longer life. ■

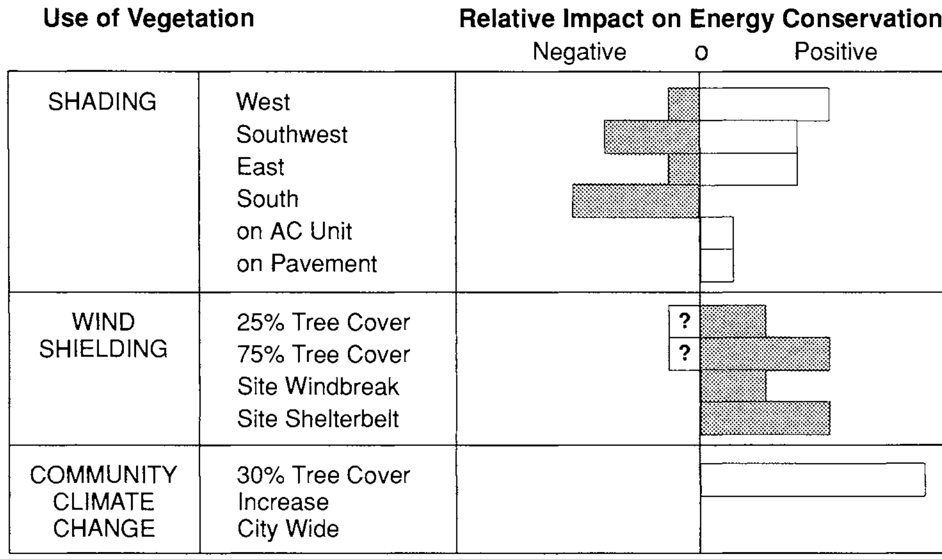

Figure 2. Relative Impacts of Vegetation on Heating and Cooling in Minnesota.

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American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. 1985. *ASHRAE Handbook of Fundamentals.* Atlanta, GA.

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Consumer Awareness

Continued from page 3.

Melberg now proudly boasts that, because his basement is comfortable in the summer due to controlled humidity, he is able to take advantage of the half-price electricity rate offered by the utility; he receives this rate in exchange for living with the potential that his air conditioner may be switched off during peak demand times. "When this happens we just go down to the basement where it's cool," he says.

Living with the Results

Melberg has been extremely pleased with the performance of his home. During the first two years, he experienced some window condensation, but now, in the third year, he has had no problems.

Because of the attention to good insulation and airtight construction, Melberg says that on mild, sunny days his home is heated by the sun, lights, and appliances alone. And last Christmas the guests that filled his house were enough to maintain a comfortable temperature without turning on the heater.

What Melberg has achieved is a dramatic reduction in the heating and cooling needs of his home. A good ventilation system also helps to maintain better air quality, control humidity, and check moisture problems. With his energy-efficient home, Melberg has not only lower utility bills, but also a healthier and more comfortable indoor environment. ■

Energy-Efficient Swedish Housing

Diane Herman, *Diane Herman and Associates and* **_Phil Steklenski,_** *Forest Products*

This is the third in a series of three articles on Swedish building practices. It provides a brief discussion of the future of Swedish building technology in Minnesota. The first article in this series provided an overview of the Swedish factory-building process and its development (Spring 1990). The second presented some of the elements that produce the high levels of energy efficiency in Swedish factory-built homes (Fall 1990).

Over the past 22 years, Swedish factory-built home producers have developed a systems approach to building healthy, economical, and energy-efficient homes. Swedish factory home-builders begin with stringent quality control in the fabrication and assembly process and benefit from well-trained workers; a controlled workplace environment; horizontal assembly; and automated, computer-controlled machinery.

Will Swedish Factory Building Gain Acceptance in Minnesota?

While forecasting the future of the Swedish factory-crafted home (FCH) building techniques in Minnesota is difficult, results of a research project conducted through the Minnesota Building Research Center at the University of Minnesota do offer some insights. As part of this study interviews with Minnesota builders, focus groups of new home sales professionals, and a consumer acceptance survey were conducted to evaluate the potential barriers and factors leading to the acceptance of the Swedish FCH system.

This article identifies some of the key issues critical to the acceptance of a home-building system based on the methods that are currently used in Sweden. While none of the barriers discussed in the following section present insurmountable difficulties, they must be addressed by a potential entrant into the market in order to avoid failure.

Consumer Acceptance Issues

Design Concerns: Minnesota homebuyers generally reject the Swedish FCH designs, which seem quaint and strange compared with typical Minnesota designs. In addition, a strongly held stereotype of U.S. factory-made houses as small, box-like, and of low quality makes home buyers leery of any housing associated with a factory.

Quality Concerns: Buyers in Minnesota have access to some of the highest quality stick-built housing in the country. This makes the claims of the extremely high quality of Swedish FCH less attractive than in other regions of the U.S. In addition, the stereotype associated with a factory-built house adds to consumer concerns despite the claims about the superior quality of Swedish FCH.

Homebuyer Conservatism: Minnesota homebuyers are conservative in their choices of home design, building materials, and construction methods. They are driven by concerns about resale and peer pressure to make a "good" housing purchase. Very few Minnesota homebuyers are interested in innovation.

Builder Acceptance Issues

Lack of Consumer Demand: Builders interviewed believed that Minnesota homebuyers are predisposed to reject FCH due to the negative perceptions of factory-built housing and that buyers are not interested in higher quality, extremely energy-efficient construction alternatives.

Regarding quality of construction, builders believe that buyers are satisfied with current quality levels in stick-built housing and that buyers are unable to discern quality behind the wall's surface. They believe that finishing details such as carpet, wallpaper, and lighting are perceived as the indicators of quality by consumers.

With respect to energy conservation, builders believe that buyers accept the state energy code as sufficient and are reluctant to pay for energy-conserving features beyond those required by code. They believe that most homebuyers are already financially stretched and making tradeoffs in their purchase choices. In that context, energy improvements rank lower than other variables such as the number of bathrooms, a screened porch, etc.

Labor: Shortages of skilled labor have been a significant influence in the use of factory-building methods in both Sweden and in some parts of the U.S. However, Minnesota builders are not experiencing the kind of shortages of skilled labor that have affected other parts of the country, such as the northeast. Some builders believe that, as in the past, any temporary labor shortages will be quickly filled by qualified workers from other states.

Competitive Retaliation: Assuming the FCH methods did find some acceptance in Minnesota, there is significant potential for competitive retaliation from traditional builders as they try to maintain market share in the face of increasing acceptance of an alternate building technology. It is unclear how well FCH could continue to maintain consumer interest if such a situation arose.

Failure of Earlier Attempts: Several prior attempts to develop this type of industry in Minnesota have failed, and the anecdotal history is widely known among builders. Several builders provided detailed examples of their own attempts or the attempts of others to establish a market for factory-built and/or energy-efficient housing. These experiences have increased the fear of failure of builders and bankers contemplating the use or financing of innovative building methods such as FCH.

In summary, it is difficult to determine the future of Swedish FCH technology in Minnesota. However, overcoming the potential barriers discussed here will prove critical to the acceptance of this alternate home-building system. It is clear from interviews conducted during this project that innovative solutions exist for eliminating each of these barriers. A report offering a complete assessment of barriers and methods of negating these barriers, as well as a complete analysis of the potential of Swedish FCH in Minnesota is currently being completed at the University of Minnesota and will be available this summer. ■

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