U.S. Department of Housing and Urban Development
Office of Policy Development and Research

PATH
Partnership for Advancing Technology in Housing

Factory Built Housing Roadmap (Including Recommendations for Energy Research)

PATH (Partnership for Advancing Technology in Housing) is a private/public effort to develop, demonstrate, and gain widespread market acceptance for the next generation of American housing. Through the use of new or innovative technologies the goal of PATH is to improve the quality, durability, environmental efficiency, and affordability of tomorrow's homes.

PATH is managed and supported by the U.S. Department of Housing and Urban Development (HUD). In addition, all federal agencies that engage in housing research and technology development are PATH partners including the Departments of Energy and Commerce, as well as the Environmental Protection Agency (EPA) and the Federal Emergency Management Agency (FEMA). State and local governments and other participants from the public sector are also partners in PATH. Product manufacturers, home builders, insurance companies, and lenders represent private industry in the PATH partnership.

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Factory Built Housing Roadmap

(Including Recommendations for Energy Research)

Prepared for:

U.S. Department of Housing and Urban Development
Affordable Housing Research and Technology Division
Washington, DC

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This Roadmap is the result of hours of discussions with and debates among business, industry and government leaders that share a stake in factory built housing. The 56 contributors to this document were all asked same question: where should factory built housing be headed and what research is required to reach that destination? The responses were wide ranging, thought provoking and challenged the industry to expand its horizons. The recommendations, culled from these discussions, underscore the enormous potential of the industry to continually innovate and fill the nation's need for homes that are high quality, high performance and offer excellent value.

The Manufactured Housing Research Alliance acknowledges the contributions to defining future industry research made by the following individuals:

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Disclaimer

PREFACE

This is one in a series of Roadmaps created to guide the housing industry in making decisions about research and development investments.

The Partnership for Advancing Technology in Housing (PATH), administered by the U.S. Department of Housing and Urban Development, is focused on improving the affordability and value of new and existing homes. Through public and private efforts, PATH is working to improve affordability, energy efficiency, environmental impact, quality, durability and maintenance, hazard mitigation and labor safety. To accomplish this, PATH has identified research and established priorities for technology development that will enable the homebuilding industry to work toward the PATH mission. This priority setting process, known as "Roadmapping," has brought together many industry stakeholders, including home manufacturers, retailers, builders, remodelers, community owners and managers, trade contractors, material and product suppliers, financial industry representatives, codes and standards officials, power suppliers and public agencies. To date, the group's work has led to the development of roadmaps in five areas*:* Energy Efficiency in Existing Homes, Whole House and Building Process Redesign, Manufactured Housing, Information Technology and Advanced Panelized Construction.

This document is the second on the topic of manufactured housing. The initial roadmap, ***Technology Roadmap for Manufactured Housing,***[1] released in March 2003, provided an overarching structure for thinking about and formulating research related to factory built homes. It offered a vision of how the factory built housing industry, the nation's primary supplier of affordable homes, will continue to create and apply new technologies that increase home value and performance.

This version expands on the original Roadmap by suggesting a broad array of research initiatives drawn from discussions with leaders in the factory building industry. Priorities were established by a committee consisting of a cross-section of industry representatives and government officials. The Roadmap contains 64 concepts for research culled from an original list of over 100 recommendations. From this list, six project ideas were selected that the committee agreed through consensus had highest priority for immediate funding consideration.

Working in parallel, a separate committee also comprised of industry and public sector representatives developed factory housing research ideas related to advancing energy efficiency. Improving energy performance has a special emphasis in the current environment of rapidly rising energy prices and is a major contributor to improving home affordability. The recommendations of the energy committee are more broad brush and this part of the Roadmap includes a comprehensive discussion of energy and its role in the future of factory built housing.

Backed by a robust program of research responsive to the nation's future housing needs, the factory homebuilding industry will continue to play a key role in providing affordable, durable housing for U.S. families.

[1] ***Technology Roadmap for Manufactured Housing,*** Manufactured Housing Research Alliance and the Partnership for Advancing Technology in Housing (2003).

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1 INTRODUCTION

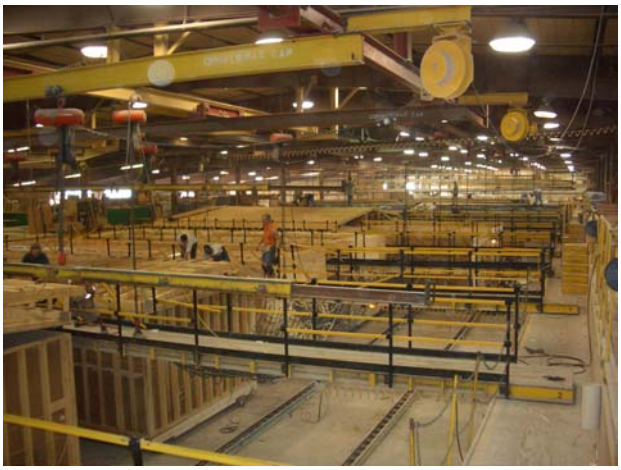
There is a well worn adage in the housing industry that factory building is simply site building under a roof. The comment has some basis in fact: most homes, regardless of building method, use similar framing techniques and the same materials, and in many instances it is difficult to tell from the finished product if a home was built from thousands of small parts assembled at the building site or was primarily fabricated in a factory and transported to the site as relatively few pre-finished modules.

Defining Factory Built—The Roadmap embraces all types of factory built homes, defined as residential structures that are built primarily away from the building site in a controlled production environment. Excluded from this definition of factory built are homes built of panel elements and components that employ pre-manufactured elements but are mainly assembled at the building site.

Factory building is generally divided into two types: modular homes that meet the provisions of the local building code and manufactured homes (also referred to as HUD-code homes) constructed in conformance with nationally-preemptive standards administered by the U.S. Department of Housing and Urban Development. Beyond the differences in the regulations, it is increasingly difficult to distinguish between modular and manufactured construction. For the most part, therefore, in formulating Roadmap research recommendations no distinction is made between the two building types (although manufactured homes tend to be more affordable than modular homes and more sensitive to price increases). Where appropriate, modular and manufactured are discussed separately.

However, viewed from the perspective of the total process, site building and factory building represent, in many fundamental respects, vastly different methods for providing housing. Most site builders, for example, are land developers and the home is one part of an overall package sold to the buyer. For factory home builders, the home is the product. Site built homes are generally sold by the building company; factory built homes are sold by a builder (modular) or retailer (manufactured), thereby insulating the customer from the company that actually does most of the building. In addition, site built homes are erected mainly at the building site, often by several independent subcontractors, working out in the elements, effectively customizing the home to the site as the work proceeds. Factory builders are product assemblers working with a closely coordinated and integrated team in a controlled and, from a production standpoint, highly controllable environment.

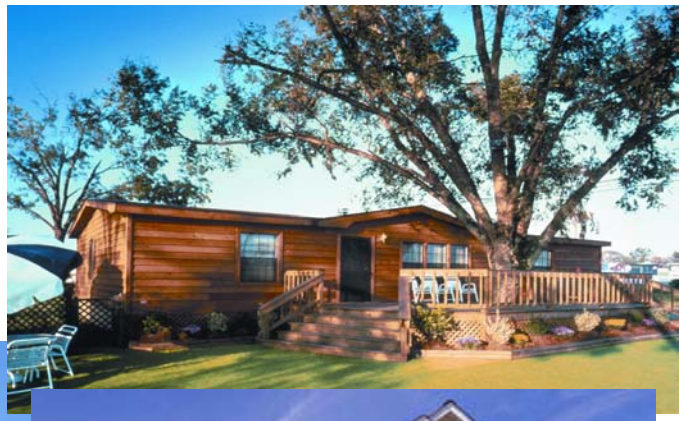
These are more than just anecdotal distinctions: they affect how information within the factory built housing industry flows, how innovation occurs and, importantly in the context of the Roadmap, the kinds of research needed to move the industry forward. Even a casual glance at the Roadmap directions suggest that, at least within the research context, many of the important developmental issues facing factory building and site building today are, on the whole, quite distinct. Even in areas of common research focus, such as moisture mitigation, the approach to research and techniques developed to abate the problem are likely to differ between housing types. Further, trends of site building and factory building are often divergent a result of the fact that they often respond to a unique set of external and internal forces. For example, the recent site built housing boom benefited modular construction but hurt sales of manufactured homes. Some of the major factors expected to impact factory building in the future are explored below in the section titled **Trends and Forces Shaping Factory Built Housing.**



Within this Roadmap, the factory built housing industry has attempted to capture and prioritize research needs that are broadly representative. While site building is often characterized as a highly fragmented industry involving the interests of tens of thousands of organizations, factory building is compact, consisting of less than three hundred building facilities and a few thousand other related firms. Therefore, within reasonable limits, it was possible to involve in the development of the Roadmap a representative cross section of industry people drawn from the major types of companies. The opinions and suggestions of about 100 people were solicited and, of this group, 56 provided suggestions, guidance and often detailed commentary on the Roadmap research directions. The group included representatives from modular and manufactured home builders, lenders, trade associations, consultants, product suppliers, academics, community developers and owners, engineers and architects, retailers and related businesses. These contributors were interviewed often in depth over the course of several one-on-one conversations in an attempt to capture and vet their ideas for industry research needs.

While Roadmaps are by their nature works in progress and need to be refreshed to keep pace with changes in the building environment and advances in technology, the 64 concepts contained in this Roadmap are a rich source of ideas for future investigation. The list is long but by no means complete. The industry groups that assembled and critiqued the Roadmap noted gaps that future contributors will need to fill. For example, research related to industry financing and lending approaches, particularly as they relate to the effectiveness of public sector programs, was identified as an area for future consideration.

To provide guidance to public and private sector organizations that actively support research, a subgroup of the 56 contributors met, debated the merits of the Roadmap concepts, and produced a short list: six projects for immediate funding consideration. These six are described in this chapter under the heading: **Top Research Initiatives for the Near Term**.



The basic Roadmap document written in 2003 divided research topics into five broad areas—the Home, the Plant, the Site, the Market and the Consumer. Building on that overall structure, this work establishes research groups within each area and suggests specific research concepts intended to serve as the basis for future projects. The research areas are defined as follows:

The Home—Chapter 2 focuses on the factory built housing industry's core product: the single-family detached home. Research in The Home is grouped into four categories:

- System Optimization
- Durability and Performance
- Indoor Environmental Quality
- Moisture Control

The Plant— Chapter 3 focuses on the core engine of innovation in the factory built housing industry: the factory. Research in The Plant is grouped into four categories:

- Lean Factory Homebuilding
- The Design and Engineering Process
- New Models of Production
- Maintaining a Stable and Capable Work Force

The Site—Chapter 4 focuses on the factory built housing delivery and installation process. Research in The Site is grouped into five categories:

- Construction Management Tools
- Foundation Design
- Site Planning
- Transportation to the Site
- Installation

The Market—Chapter 5 focuses on the socioeconomic environment within which factory built homes are designed, constructed, sold and installed; in other words, it analyzes the factory built housing market. Research in The Market is grouped into three categories:

- Design for an Evolving Marketplace
- Regulatory Environment
- Influencing Practice and Measuring Research Benefits

The Consumer—Chapter 6 focuses on the people who underpin the ultimate success or failure of the factory built housing industry: the home-buying and home-owning public. Research in The Consumer is grouped into two categories;

- Creating Value
- Operation and Maintenance

Energy—Among the many factors that play into crafting a research agenda, energy performance stands apart. Energy is not easily pigeonholed into a single research area but rather is intertwined with all aspects of the building process. Future home energy use is impacted at every stage of construction. The decisions of the

companies that provide products, and build, sell and install homes intrinsically shape home energy efficiency and help buyers recognize the vital role energy costs play in home affordability. Over the life of a home—and this is particularly true for affordable housing—energy is likely to be the single largest component of total homeownership costs.

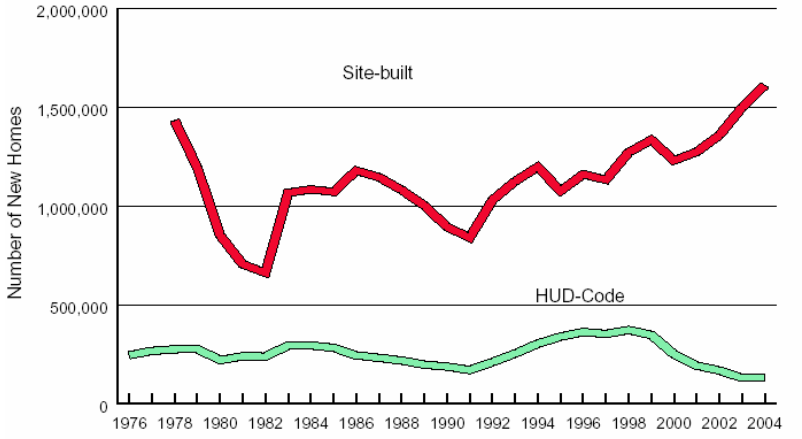
Given its overarching role in the development of the Roadmap, therefore, a separate section—Chapter 7—is devoted to the defining a strategy for improving energy efficiency in factory building.

Trends and Forces Shaping Factory Built Housing

Modular and HUD-code, convergence and emergence. As recently as a decade ago, factory builders fell into two relatively distinct groups: companies that built manufactured homes conforming to the HUD standards and those engaged in the construction of modular homes built under the prevailing local code. Modular homes were almost exclusively built and sold in the Northeast and North Central states. By contrast, manufactured housing has a national presence but the bulk of new home sales were, and continue to be, in the Southern tier states, particularly in the Southeast.

In recent years, the two factory building segments have become closely entwined. Many traditional manufactured home builders have diversified into modular construction, in part to participate in the dynamic growth in modular sales just as HUD-code home shipments have lagged (see Figure 1). Indicative of this trend, the fastest growing market for modular homes is the South and the largest HUD-code producer in the nation is now also one of the largest manufacturers of modular homes. As a result, the interests of the two segments have become more closely aligned. This integration of the factory building industry is expected to continue with the two segments increasingly sharing common research goals and agenda.

Figure 1 Housing Starts by Building Type



SOURCE: Data SourcesInstitute for Building Technology and Safty (shipments), US Depatment of Commerce, Census Bureau (housing starts and homes sold)

The merging of modular and HUD-code interests will shape future research by emphasizing initiatives that benefit all types of factory construction. Practices perfected in any area of factory building will be rapidly adopted by all parts of the industry. The two segments of factory building will increasingly share research goals and methods.

Emphasis on consumer perception and satisfaction will grow. Increasingly, the factory built housing industry and, in particular, manufactured housing, is focusing on creating a consistently positive purchase and ownership experience for buyers and helping the general public recognize the

value and high quality of factory built homes. The industry seeks to continually improve home performance through research and technological development, with the goal of enhancing home performance and value in ways that are readily recognized by homeowners and help the general public associate factory building with value, innovation and high quality.

Among the criteria applied in selecting and shaping future research will be its ability to enhance quality and durability while emphasizing the positive attributes of factory built homes.

Skilled labor shortages. The declining supply of skilled construction workers will continue to pressure the building industry to make changes that might include: exploring methods for reducing the amount of labor required for building homes; simplifying the construction process so as to reduce the skills and training needed to perform tasks; and/or, introducing low impact, ergonomic building practices that allow older workers to more fully participate in construction work.

Energy efficiency. Until relatively recently, absent real increases in energy costs, homebuyers and owners had little incentive to spend resources on making their homes more energy efficient. As described in Chapter 7, the energy landscape is changing rapidly. Homeowners now see energy costs escalating at a pace not seen for several decades and higher utility costs crimping disposable income. Families in affordable housing are hit the hardest. With the majority of affordable homes constructed by factory builders, improving energy efficiency is one of the top industry priorities.

The importance of energy efficiency is reflected in the detailed discussions contained in Chapter 7 of this Roadmap. Initial steps to apply market forces to improve energy performance were taken over six years ago when the factory built housing industry, in partnership with the U.S. Environmental Protection Agency, began a program to improve the Energy Star for Homes Program by developing a program tailored to the factory building methods. These initial steps are paying dividends as the industry, with the assistance of incentives and energy efficient mortgages, moves toward widespread adoption of Energy Star principles.

Energy issues will continue to grow in importance and energy considerations will play a large role in the research agenda for the five core areas of factory built housing research.

Coordination among all stages of the building process. One of the factory built housing industry's greatest strengths, completing the vast majority of home assembly in a controlled environment, also suggests what has historically been its greatest challenge: maintaining the same high level of quality during home transport to the site and home installation. The dependence of final home quality and durability on installation will only increase as homes become more complex with greater design variation, more site attached components and more elaborate foundation systems. Coordination among all of the parties to the construction process, but particularly the home manufacturer, retailer and installer, is pivotal to the industry's drive to maintain a high level of quality from manufacturing through completion of the home at the building site. Despite the growing complexity and customization of home designs, the industry will find ways to provide a more seamless and

transparent home delivery experience for buyers, supported and backed by effective communication links between manufacturers, retailers and installers.

Top Research Initiatives for the Near Term

Over the course of several months in early 2005, the opinions and advice of industry members was solicited and 56 industry leaders responded with over 100 suggestions for needed research. Through a series of iterative committee reviews, these ideas were refined and reduced to a short list of the 64 research topics summarized in this report. A smaller committee consisting of representatives of the major areas of the factory built housing industry met and evaluated the full list of research, culling out the following six critical research projects for near term funding consideration:

1. Understand and maximize product performance (HOME: Durability and Performance, p. 12)

Context: Factory built homes, particularly homes built under the HUD standards, pass through several companies prior to occupancy, including the home manufacturer, the transporter, the retailer (HUD-code) and the installer/builder. Each step in the building and delivery process introduces opportunities to expose building materials and systems to damage and wear. When problems do occur, they are often documented through service records and warrantee claims.

Research direction: Understand the types of stresses to which materials and systems are subject during manufacturing, transportation and installation. Review and analyze information about material and product performance deficiencies from manufacturer service records, warranty claims, and consumer complaints. Establish relationships between service life and product characteristics, installation method, transportation circumstances, etc. Estimate the costs to industry and consumers of premature product and system degradation. Develop manufacturing, transportation and installation techniques and new component designs to minimize premature failures.

2. Manage moisture in hot, humid climates (Home: Moisture Control, p.14)

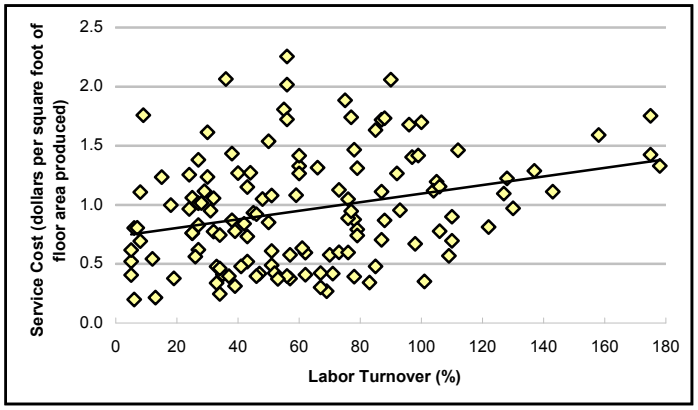
Context: Moisture problems have become a major source of concern for builders and occupants of residential and commercial structures of all types. Unique characteristics of factory built homes make some of the causes and solutions for moisture problems particular to these structures. Not surprisingly, all types of structures in hot, humid climates have been more prone to moisture problems. MHRA has initiated a multi-year research program to pinpoint likely causes of moisture problems in factory built homes in hot, humid climates and to develop, test and disseminate solutions.

Research direction: Complete moisture research for hot, humid climates by developing, through testing, recommendations for moisture mitigation practices for homes in hot, humid climates. Describe and rank the most important factory built home design, construction, installation and operation strategies that can avoid moisture problems in hot, humid climates. Consider mechanical dehumidification and smart vapor retarders among the strategies. Develop diagnosis and retrofit techniques for moisture problems of homes in hot, humid climates. Develop a guidebook for mitigation of moisture problems through design for manufacturers, installers and service technicians. The guidebook would consolidate previous applicable research into a set of guidelines on moisture problems in factory built homes. The publication would be written for industry practitioners and explain the basics of moisture science, how it impacts factory built homes, why certain home design and operation practices are beneficial and others are not, and how to design, construct and install factory built homes to avoid moisture problems.

3. Implement lean production (PLANT—Lean Factory Homebuilding, p.16)

Context: Lean production methods, developed in the auto industry but subsequently applied to many types of manufacturing and service industries, are new to most factory homebuilders. Lean production has shown promise for substantially improving production efficiency and reducing

waste in all forms, including time, materials and other resources, while improving quality. As a first step in helping plants evaluate the benefits of lean methods, MHRA conducted a nationwide benchmarking study that will serve as the foundation for future efforts to improve the efficiency of factory homebuilding.



Research Direction: Develop and implement a program to coordinate the application of lean tools in representative plants and overcome the main barriers to lean manufacturing practices. Activities may include: organizing rapid process improvement events (focused activities designed to make incremental improvements to existing processes); value stream mapping; DMAIC (define, measure, analyze, improve, control) problem solving. This effort might include assisting plants in implementing these tools and conducting training sessions to educate and train support personnel, plant managers, supervisors, team leaders, operators and factory hourly workers in lean concepts.

Specific areas of focus for lean production implementation may include developing and implementing more effective methods of warehousing, inventorying, and replenishing products and materials in the plant and methods to reduce waste. These methods might include: better planning; minimizing rework; altering manufacturing processes; challenging suppliers to modify products and/or packaging to reduce processing; and eliminating overage.

4. Innovations in foundation design: Insulated and conditioned crawlspaces and frost-free shallow foundations (SITE—Foundation Design, p.22)

Context: There are several common methods for securing manufactured homes to the ground. The most common techniques are piers that rest on surface-mounted footings, and to a lesser extent, floating slabs or in some areas concrete footings that extend down to the frost line. With most homes the crawl space between the home and the ground is unconditioned and generally enclosed by some type of vented skirting.

Other approaches to designing the supporting system for manufactured homes, which are not currently used by the industry, might prove to be more cost-effective and durable and result in improved thermal performance. For example, recent research by the site-building community has suggested that: (1) conditioned crawlspaces have energy and moisture performance advantages; and (2) frost-free shallow foundations, which eliminate the effects of frost heave without the excavation cost, have been used successfully in Scandinavia.

Research Direction: Investigate, evaluate and develop alternative foundation and support systems that provide superior performance yet maintain the cost-effectiveness essential to their use with affordable, factory built homes. The emphasis in this project is HUD-code manufactured homes, since modular homes are typically placed over the same types of foundations as site built homes and affordability is not as critical a design consideration.

Concepts such as conditioned crawl spaces and frost free shallow foundations will be considered along with other strategies that achieve the goals of improved overall home thermal performance, durability, low maintenance and high structural integrity. Tasks conducted as part of this effort would include: design development; prototyping and testing; facilitating commercialization; and, if required by the foundation design, advocating corresponding changes in regulations.

5. Improving installation quality (Site—Installation, p. 26)

Context: While the quality of the home delivered to the buyer is paramount, delivering that home on time and on budget requires a team of knowledgeable companies—manufacturer, transporter, retailer or builder and installer—capable of working together and effectively communicating.

Unfortunately, the home sales and delivery process is often too fragmented with incomplete information exchange among the partners involved in the process. In particular, the retailer, who generally coordinates the process on behalf of the buyer, must ensure that all steps are completed properly from the time the home leaves the plant through turnover to the buyer.

In order to do this effectively, the retailer depends on a number of things: knowledgeable, experienced installers; clear documentation of installation requirements; prompt and accurate information from plants; and most importantly, a management system to navigate the myriad details. When one or more of these items are lacking installation quality may suffer.

Research Direction: Two activities are underway to help improve the efficacy of factory homebuilding, including:

- The Manufactured Housing Educational Institute (MHEI) has an installer training program to improve the skill sets of installers.
- MHRA will soon begin development of a model manufacturer's installation manual to assist plants in providing clear, consistent guidance to installers (see Model manufacturer installation manual – page 28)

An effort is needed, that includes these elements, for creating an integrated home purchase, delivery and construction management system that facilitates clear and timely communication among all parties and assists the retailer in coordinating the entire process. Among the products of the research will be an electronic and/or paper-based information management system that facilitates timely and effective exchange of information between retailers, manufacturers and installers.

6. Build asset value with manufactured homes (Consumer—Creating Value, p. 35)

Context: Wealth creation and the opportunity for property appreciation through home equity is often the key to long-term financial stability for many low and middle-income families. Manufactured housing provides one of the most affordable options for homeownership, and therefore wealth building through ownership of a manufactured home is a critical necessity for many Americans.

Research Direction: Characterize through the collection of empirical evidence the conditions required for homes—particularly manufactured homes—to contribute to long-term wealth creation. Explore ways to promote affordable housing and wealth building with

manufactured homes. An example of a program designed to assist homeowners create wealth is the ***I'm Home Program,*** an effort supported by the Ford Foundation and other promoters of affordable housing. This initiative provides resources to local non-profit community organizations to assist them in constructing developments of manufactured homes for sale to low-income residents.

2 THE HOME

This chapter focuses on the factory built housing industry's core product: the single-family detached home. Most homes consist of one or more factory built sections, with a two section home currently the most popular configuration. The entire industry—from factory home builders and suppliers to dealers and installers—is committed to continuously improving the quality and performance of this core product, primarily through the application of advanced technology.

System Optimization

Increasingly, as designs change, markets broaden, and building constraints and regulations evolve, other approaches to constructing the home's exterior membrane merit serious consideration and evaluation. The controlled environment of the plant affords factory builders the ability to develop, perfect and commercialize construction materials and methods that are alternatives to the traditional wood frame system of shell construction.

The U.S. home-building industry—factory built and site built—currently assembles finished homes from an incredibly wide range of individual materials, products and subassemblies. As many as 30 different categories of materials are used in a single, 2,000-square-foot home.

While many of these individual materials and subassemblies may be optimized for their specific functions, finished homes are not. These homes may meet, or even exceed, applicable building codes, but they do not attain the high levels of integrated performance associated with many of the products they contain, such as low-e windows, high efficiency dishwashers and programmable thermostats.

The key factor in obtaining these high levels of performance is systems integration. Many of the products and subassemblies in a home have been designed and engineered—from the outset —as integrated systems. The result is a product or subassembly that functions as an optimized, integrated whole, not simply an assembly of individual components. The need for systems engineering has also been recognized by the site built home industry in their ***Whole House and Building Process Redesign Roadmap.***[2]

To create the next generation of housing in the U.S., home builders will need to take the same approach: moving beyond their role as product assemblers to become true system integrators.

Compared with on-site construction, factory building also offers a more favorable setting for developing and implementing changes in building systems, notably electric, mechanical and plumbing. The factory advantages include: better integration and cross-optimization of systems with the envelope design (also referred to as concurrent engineering); greater opportunity to apply new and emerging systems technologies; and greater ability to subordinate systems design to the goal of maximizing production rates and overall economy of construction.

1. Stressed-skin panels

Context: Stressed-skin panels combine high strength and superior energy performance in a relatively narrow cross sectional area with an economy of structural material, all positive attributes in a production setting. High material cost has limited the use of these components in the past.

[2] U.S. Department of Housing and Urban Development, May 2004. "*Whole House and Building Process Redesign Roadmap."*

Research direction: Develop new structural insulated panel components or other stressed-skin panel systems (roof, wall and floor) that maximize shell performance and could be a part of a lean manufacturing approach. Concepts will be developed that are compatible with factory building methods, reducing production costs as a means for competing with traditional wood frame construction. Such research will create prototype designs that are cost-effective and improve production efficiencies. Studies will evaluate how stress skin elements can be integrated into manufacturing processes with minimal disruption to plant operations.

2. Steel framing

Context: Recent research focusing on leveraging the benefits of steel in home manufacturing has suggested limited benefit in the current environment when considered for single family detached homes. However, these efforts have suggested that for some applications steel could open markets formerly not tapped by factory builders.

Research direction: Continue to develop steel as an alternative to wood for home framing. Consider the application of steel for multistory homes and in niche markets such as inner cities where fire codes or current practice limits or restricts the use of wood framing. . Develop and demonstrate designs that combine attached, stacked configurations. Consideration needs to be given to how steel framed homes built on a chassis perform during transport.

3. Integrated chassis/floor systems

Context: Almost all manufactured homes are constructed on a wood framed deck placed over a steel frame. This configuration adds height to a home in a situation where due to transportation constraints; the vertical dimension has a premium (high ceiling heights and high-pitched roofs are desirable). A double floor system also and creates some structural redundancy. Integrated floors, where the floor and the transport support are in-line, have been around for many years but, due in part to higher cost, hold only a small market share.

Research direction: Develop an integrated chassis/floor system that reduces cost and improves performance and design flexibility. Integrated chassis/floor systems have the potential to simplify site installation; improve performance of the structure (adding rigidity to the structure thereby reducing cracking of wall and ceiling gypsum board); enhance flexibility for multiple installation types; reduce the thickness of the floor assembly thereby enabling lower-to-the-ground installations and higher roof pitches/wall heights; and cut costs and simplify manufacturing operations. Investigate and develop systems that capture these advantages at equal or lower costs compared to traditional systems. Methods for returning axle assemblies to the plant would need to be addressed through this effort as well.

4. Sound isolation

Context: The light construction of most factory built homes can create a challenge to acoustical control and sound attenuation, particularly in noisy environments, such as near airports and busy thoroughfares. Objectionable levels of noise can also be generated within the home by the operation of some home appliances.

Research direction: Identify situations and conditions that are associated with noise pollution and investigate the opportunities to reduce sound transmission both between rooms within factory built homes and from outside into the home. Develop cost-effective methods for building homes with improved sound attenuation properties.

5. Home electronics and communications technologies

Context: Although Smart Home technologies and new products for wiring homes have gained only a modest share of the site built market, the technology continues to evolve, improve and decrease in price.

Research direction: Identify and evaluate wiring and cabling systems that optimize whole-house performance and take advantage of communications and electronic technologies that are popular with buyers of site built homes. Assess the state-of-the art technology of wiring and cabling systems, including investigating the housing market's response to Smart Home technologies and their applicability to factory built homes.

Among the other technologies whose value in the factory building arena would be considered are the following: plug-and-play systems; WiFi; integrated cable systems/structured wiring; Z-Wave; wireless communication; and electrical raceways.

6. Plumbing systems

Context: Plumbing systems continue to improve with many of the developments initially marketed to high-end residential customers. Some of these systems may provide to factory builders benefits of particular value, such as faster assembly, reduced service costs and greater ease of installation.

Research direction: Review and evaluate the state-of-the art in plumbing systems technologies. Investigate their applicability to factory built homes. Include flexible (PEX or composite) piping systems; manifold plumbing systems; leak mitigation, detection and repair technologies; and corrugated stainless steel tubing for gas lines. Investigate the impact these systems have on home performance, manufacturing operations and marketing.

Durability and Performance

The material and component performance of factory built homes will become an increasingly important concern for the industry and its customers. Liability and warranty service issues will be important drivers, as will the overall relationship between the expected performance and the perceived value of the homes the industry produces. To meet these concerns, and turn them to its advantage, the industry must recognize early on those issues that have the potential to blossom into large problems and proactively address them. In addition, the industry must set continuous performance improvement as a central goal to remain competitive, innovative and progressive.

1. Understand and maximize product performance (Top Research Initiative)

Context: Factory built homes, particularly homes built under the HUD standards, pass through several companies prior to occupancy, including the home manufacturer, the transporter, the retailer (HUD-code) and the installer/builder. Each step in the building and delivery process introduces opportunities to expose building materials and systems to damage and wear. When problems do occur, they are often documented through service records and warrantee claims.

Research direction: Understand the types of stresses to which materials and systems are subject during manufacturing, transportation and installation. Review and analyze information about material and product performance deficiencies from manufacturer service records, warranty claims, and consumer complaints. Establish relationships between service life and product characteristics, installation method, transportation circumstances, etc. Estimate the costs to industry and consumers of premature product and system degradation. Develop manufacturing, transportation and installation techniques and new component designs to minimize premature failures.

2. **Long-term durability**
   Context: Most materials and components that make up a home deteriorate over time and will at some point require maintenance to prolong service life. When maintenance is neglected it can lead to other problems, increased operating costs and eventually in some instances result in the deterioration of collateral systems. More durable structures, finishes and equipment are often more expensive initially but can reduce long-term maintenance and replacement costs.

   Research direction: Investigate how materials perform in service, including patterns of degradation and related maintenance and replacement costs. Review the literature relating to housing durability; examine a sample of existing factory built homes in the field and record conditions of materials and components of known origin and age; interview repair and remodeling contractors and weatherization contractors who specialize in factory built homes to find out what they most commonly encounter when they work on older homes; and examine state weatherization program archives for records of repair work and existing conditions found in factory built homes.

   Determine and quantify the causes of long-term material and component degradation. Candidates include moisture, vibration, thermal flexing, impact, abrasion, sunlight, creep, dry rot, insects, oxidation, settlement and wind. Suggest improvements to products or assemblies that make them better able to withstand these forces over longer periods of time.

Indoor Environmental Quality

Indoor environmental quality—and its impact on health and well being—is a topic of growing interest and concern among homeowners across the country. Looking forward, American consumers will increasingly expect and demand superior indoor environments in their homes.

1. **Healthy factory built homes initiative**
   Context: In the last several years, there has been an emphasis in the homebuilding industry on indoor environments and their impact on occupant health. Programs such as HUD's Healthy Homes Initiative, EPA's Indoor Air Package labeling program and the American Lung Association's Health House program have increased consumer awareness and set standards for indoor air quality and other healthy home issues.

   Research direction: Consider how factory built housing is affected by and might participate in healthy home programs. Determine the implications for the materials, design and construction of factory built homes and develop prototype specifications for factory built homes that would comply with the leading healthy house programs.

2. **Understand ventilation performance**
   Context: Home ventilation rates impact indoor air quality, comfort and moisture movement. Nearly all home ventilation systems operate on an intermittent basis determined by the operation of a furnace blower or through occupant control. How home ventilation systems moderate fresh air ventilation is not well understood nor is there consensus on effective strategies for achieving desired air change rates.

Research direction: Determine the relative amounts of fresh air brought into the home under fixed operating conditions for commonly used and proposed ventilation systems (positive pressure (POS) ventilation systems and exhaust fans in particular); determine which ventilation system control methods (occupant operated switch, timer, furnace fan controlled, humidistat, etc.) most reliably lead to operating frequencies adequate to achieve fresh air ventilation targets; and measure the impacts of these ventilation systems on house air pressures and thereby determine their climate suitability.

3. **Control the acoustic environment**
   Context: Almost all manufactured homes and most modular homes have the furnace and other noise producing equipment located adjacent to the main living spaces of the home. In order to achieve higher heating efficiencies, furnace manufacturers have increased blower output, resulting in increased sound levels.

   Research direction: A joint program with the equipment manufacturers is needed to develop cost-effective heating/cooling products and enclosure systems that dampen vibrations and noise generated by the furnaces.

Moisture Control

Water, in the form of condensation, wind-driven rain penetration of the envelope and bulk water plumbing leaks is perhaps the single greatest source of material damage, homeowner complaints and industry service issues. Condensation, in particular, is a challenge to control and requires design and construction approaches that differ by climate and involve the building envelope, equipment and ventilation systems.

1. **Managing moisture in hot, humid climates (Top Research Initiative)**
   Context: Moisture problems have become a major source of concern for builders and occupants of residential and commercial structures of all types. Unique characteristics of factory built homes make some of the causes and solutions for moisture problems particular to these structures. Not surprisingly, all types of structures in hot, humid climates have been more prone to moisture problems. MHRA has initiated a multi-year research program to pinpoint likely causes of moisture problems in factory built homes in hot, humid climates and to develop, test and disseminate solutions.

   Research direction: Complete moisture research for hot, humid climates by developing, through testing, recommendations for moisture mitigation practices for homes in hot, humid climates. Describe and rank the most important factory built home design, construction, installation and operation strategies that can avoid moisture problems in hot, humid climates. Consider mechanical dehumidification and smart vapor retarders among the strategies. Develop diagnosis and retrofit techniques for moisture problems of homes in hot, humid climates. Develop a guidebook for mitigation of moisture problems through design for manufacturers, installers and service technicians. The guidebook would consolidate previous applicable research into a set of guidelines on moisture problems in factory built homes. The publication would be written for industry practitioners and explain the basics of moisture science, how it impacts factory built homes, why certain home design and operation practices are beneficial and others are not, and how to design, construct and install factory built homes to avoid moisture problems.

2. **Bulk water intrusion**
   Context: Condensation-related moisture problems receive the most of the attention surrounding moisture issues. However, bulk water intrusion is also a known cause of moisture problems in homes. Far less research has been conducted on diagnosing and preventing these types of moisture problems. Bulk water problems arise from several sources, including wind driven rain, plumbing leaks and ice damming. The latter, in particular, is a problem in northern climates. Systems exist to prevent water intrusion caused by ice damming, but these are expensive and difficult to construct in the plant.

Research Direction: Investigate the significance of, and develop solutions to, ice damming, rain water intrusion and plumbing leaks as a cause of moisture problems in factory built homes. In particular, assess the efficacy of commonly specified flashing systems and pipe sealing materials and techniques. Develop cost-effective and practical solutions to ice damming.

3 THE PLANT

This chapter focuses on the core engine of innovation in the factory built housing industry: the factory. Factory production provides unique opportunities to improve performance and reduce the costs of housing. First, the factory process provides quality control and inspection levels that cannot be easily matched at the site. Construction accuracy is enhanced while inventory is controlled, resulting in added value without added cost. At the same time, the factory setting provides opportunities to utilize new materials and fabrication techniques that are simply not feasible in site building.

The factory built housing industry recognizes these inherent advantages and is committed to exploiting them by continuously improving its factory production processes. The objective is to foster incremental improvement in existing processes, and to investigate, through a sustained research and development program, completely new ways of creating housing inside a factory.

Lean Factory Homebuilding

Lean production is a revolutionary way of thinking about organizing a manufacturing operation that was pioneered by Toyota in the second half of the twentieth century. The fundamental tenet of lean is the reduction and elimination of waste in all forms. Lean production and lean thinking, in general, dramatically improve safety, quality and efficiency, and better align products with market needs. Lean is also a tool for helping manufacturers deliver a wider variety of products that are more responsive to buyer preferences in a shorter time with lower cost. Various forms of lean have begun to diffuse into industries other than automotive in such forms as lean manufacturing, lean office, lean logistics and lean accounting.

While construction techniques utilized in factory built housing today have evolved over the past fifty years, many of the core techniques used in the plant vary only slightly from those employed in traditional site built housing. Opportunities abound for applying production efficiency strategies in the plant that cannot be replicated at the building site, thereby expanding the already substantial advantage of factory building over site assembly.

1. Lean production protocol

Context: Lean production is an approach to reengineer operations with value stream mapping and rapid process improvement events that utilizes a collection of tools, such as the 5S's; pull production and kanban, standardized work; quick changeovers (SMED); total productive maintenance (TPM); mistake proofing (zero defects); cellular design; and design for manufacturing or design for assembly. All of these tools are used in an effort to eliminate waste in all forms (from scrap, damaged goods and offal to excess non-value added operations, surplus inventory, rework, etc.) and improve operating efficiencies. The factory built housing industry has not fully exploited the potential to utilize these methods to become lean.

Research Direction: Evaluate ways to improve plant output through the application of lean principles, drawing on models from other industries. Develop and package a set of tools and a library of lean manufacturing techniques (changes to plant operations) for factory homebuilders. The development process would include testing the tools and techniques at a variety of factory homebuilding plants.

2. Implement lean production (Top Research Initiative)

Context: Lean production methods, developed in the auto industry but subsequently applied to many types of manufacturing and service industries, are new to most factory homebuilders. Lean production has shown promise for substantially improving production efficiency and reducing waste in all forms, including time, materials and other resources, while improving quality. As a first step in helping plants evaluate the benefits of lean methods, MHRA conducted a nationwide benchmarking study that will serve as the foundation for future efforts to improve the efficiency of factory homebuilding.

Research Direction: Develop and implement a program to coordinate the application of lean tools in representative plants and overcome the main barriers to lean manufacturing practices. Activities may include: organizing rapid process improvement events (focused activities designed to make incremental improvements to existing processes); value stream mapping; DMAIC (define, measure, analyze, improve, control) problem solving. This effort might include assisting plants in implementing these tools and conducting training sessions to educate and train support personnel, plant managers, supervisors, team leaders, operators and factory hourly workers in lean concepts. Specific areas of focus for lean production implementation may include developing and implementing more effective methods of warehousing, inventorying, and replenishing products and materials in the plant and methods to reduce waste. These methods might include: better planning; minimizing rework; altering manufacturing processes; challenging suppliers to modify products and/or packaging to reduce processing; and eliminating overage.

3. Lean production evaluation

Context: A key ingredient in lean is the receipt of continuous and immediate feedback. Each plant implementing lean processes will establish its own feedback system to measure productivity; cycle time reductions; work in process (WIP) inventory improvements; floor space reductions;, standard work definitions; and quality and safety improvements. However, there is also a need to gauge the success of the lean production program described above at the industry level.

Research Direction: Measure and evaluate the results of the application of lean production techniques in factory homebuilding plants. This includes determining the impact of lean methods on plant culture; business metrics; production efficiency; profitability; and quality and safety. Assess individual plant commitments to lean thinking and report on the impact of lean production activities to the industry at large. Develop correlations between embracing lean principles and increased customer satisfaction.

4. Technology transfer

Context: A number of industries and industrial organizations have established networks of companies and individuals that work together to institute lean practices and educate managers on lean techniques.

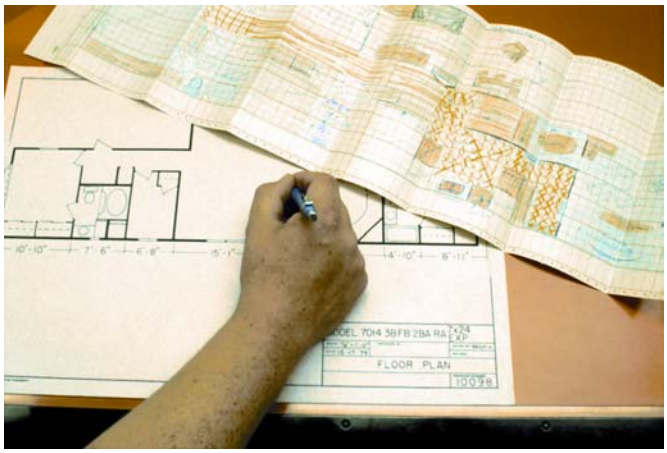
Research Direction: Organize a program to transfer lessons learned from the lean manufacturing research to housing plants nationwide. Possible mechanisms include creating and managing a peer-to-peer network among plants to facilitate the transfer of lean knowledge and sharing of experience; writing a series of case studies on how factory homebuilders are benefiting from lean production techniques; and managing a resource center on information related to lean for factory homebuilders.

The Design and Engineering Process

The “soft” side of the production process is often overlooked when considering manufacturing efficiency improvement. However production problems and opportunities for improvements can often be traced to design documentation and/or internal communication issues. In addition, industry growth into new markets and a wider customer base will exert pressures to expand the range of designs offered by factory home builders.

The process of designing and engineering factory built homes has advanced only marginally over the last several decades. As a result, HUD-code housing has not taken full advantage of the preemptive, performance-type building standard under which it operates. In addition, the limitations of some of the existing system designs, developed in an era when decisions were principally cost driven (particularly for HUD-code housing), are becoming a drag on innovation. In response, the factory built housing industry will need to rethink, redesign and reengineer its products from the ground up.

1. The design process



Context: One of the advantages of the factory homebuilding industry over site building is the speed at which homes can be produced and installed. However, customizing an existing home model and creating all the engineering and specification documents can often require significantly more time than actually producing the home, reducing or eliminating the time advantage.

Research Direction: Analyze the design and engineering process and look for opportunities to save time, reduce cost and improve the capability for design variation without adversely impacting production rates. Among the methods to be considered are emerging techniques of mass customization and modular coordination and the development and implementation of advanced drafting and design software tools that provide increased speed and flexibility in the preparation of construction and fabrication drawings.

2. Communication between engineering and the plant floor

Context: Communication between engineering and the plant floor in factory homebuilding, as in many industries, is essential to achieving a smooth flow of defect-free product. The degree to which communication problems lead to increased costs and/or other inefficiencies in factory homebuilding is unknown, but may be significant. Lean thinking often seeks to place engineering (as well as other professional staff) adjacent to and communicating directly with production. This may not be feasible in all homebuilding factories, but other techniques may exist to achieve the goal of seamless internal information flow.

Direction: Develop techniques for improving the quality and speed of information exchange between engineering, construction and sales. Determine the most common communication processes between engineering and production in factory homebuilding. Identify and quantify methods of conveying information between design and construction and quantify the opportunity for improvements (efficiency improvements, cost savings, quality improvements, increased design flexibility, etc.) possible with improved communication methods. Researchers would investigate existing technologies and systems in use in other industries such as auto and heavy equipment manufacturing and site construction, and evaluate their potential for adaptation and adoption by factory homebuilders.

3. Factory-retailer communication

Context: In most cases communication between the factory and the retailer (and by extension the final customer) depends on intermittent correspondence between individuals via phone, fax or email. Delays and/or errors in information transfer can result, leading to mismatches between the home and site and unmet homebuyer expectations. Further, designs are continually evolving along with related options and pricing information. Keeping retailers and builders current with manufacturer offerings continues to be a challenge in the factory built housing industry.

Direction: Develop a process that can establish an efficient communication link between manufacturers and retailers that allows manufacturers to check on the status of the sales process and permits retailers to place orders; select options and check on the status of the manufacturing process; and keep current on designs offered by the manufacturer. This may be an electronic system that not only permits access to information about the home but, when linked to a mass-customization production capability, permits customization of the home with a minimum of involvement from engineering. This value added service would be a dramatic marketing benefit for manufacturers and retailers, while at the same time providing real-time market intelligence to the manufacturer.

New Models of Production

Most research ideas in The Factory chapter focus on improvements to current production processes within the plant that merit attention. Some of the ideas in this sub-section are far-reaching concepts that explore radical new manufacturing paradigms without the encumbrance of considering an existing manufacturing infrastructure. These long-term concepts can lead to opening up of new markets and new forms of factory built housing.

1. Factory building practices in other countries

Context: Factory homebuilding technologies have developed in a variety of ways in other countries. MHRA missions in 2004 to Japan and Sweden revealed a number of opportunities of interest to U.S. industry with respect to production technologies and methods.

Research Direction: Become a conduit for technology exchange by cultivating relationships with factory builders in other countries; monitoring new developments; and documenting innovative building techniques. Evaluate specific manufacturing processes, equipment or materials used in other industries or countries that may offer advantages to factory built housing. Define any required changes to current industry practices that would be necessary to implement the new processes, equipment or materials.

2. The ideal homebuilding factory

Context: Factory building operations evolved from site building and in many respects the construction methods, design approaches, materials handling and other aspects of plant operations are still rooted in processes developed for on-site building. However, off-site home fabrication, like other types of manufacturing, offer an environment for applying methods of production uniquely suited to a factory environment and not possible or feasible with site building.

Research Direction: Develop a conceptual model of how homebuilding factories might operate if the building process was optimized for the plant setting. This model of an "ideal" factory would encompass systemization of the construction process, the appropriate application of automation techniques, design for manufacture, mass customization and other approaches that leverage the potential benefits of off-site homebuilding.

3. Specialty plants

Context: Most homebuilding factories are large facilities that serve the large and broad single family detached market. These homes are intended for individual sites and are structurally self-supporting and independent of other buildings.

Research Direction: Markets exist for home designs specific to more limited markets with unique needs and design constraints, examples of which include inner city housing, stacked housing and assisted living housing. Explore how production would change to serve these markets by developing a model production system design, marketing strategy, economic analysis and product design. The effort would also explore required code modifications that would be necessary to make these specialty unit designs feasible.

4. Subassemblies

Context: Presently, a wide variety of components are delivered to factory homebuilding plants pre-assembled. These include windows, cabinets, HVAC components and appliances. While factory builders typically procure these types of components from outside suppliers, it may also be economical to outsource or remotely produce for several plants other pre-finished subassemblies.

Research Direction: Assess opportunities for building more subassemblies off the main production assembly line. Analyze the typical home production operation and identify candidate sub-assemblies. Candidates might include wet cores (bath assemblies), kitchen modules, stair/railing sections, complete roof systems, interlocking window/wall assemblies, electrical raceways, extruded floor/panel systems, finished exterior/interior panels, acceptable homogeneous interior wall coatings, etc. Develop a model of a home manufacturing plant using these sub-assemblies while defining the necessary tooling, equipment and work cells required. Ongoing partnerships between manufacturers and suppliers will become important as sub-assemblies become more complex.

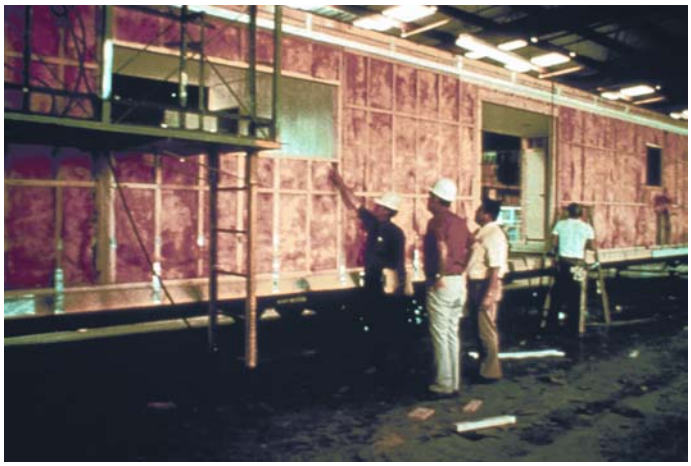
5. Eliminating waste in manufacturing

Context: Home manufacturing plants generate large amounts of waste materials including lumber, wallboard and discarded packaging. Lean manufacturing research is one way to reduce the volume of material discarded in the construction process; however a more direct effort targeting material waste in the plant may lead to quicker results.

Research Direction: Explore strategies to totally eliminate waste from the production process. Analyze the content, quantity and quality of the typical homebuilding factory waste stream. Explore ways to reduce the generation of waste and opportunities to re-use scrap materials in the construction process. Determine other potential markets for "required-scrap" and develop means of bundling scrap for use in other recycled products.

6. Controlling quality in the plant

Context: While home quality can be impacted at each step along the construction and installation chain, quality starts with the order writing process and continues through every phase of plant operations. Research and practice has demonstrated that effective quality management, including eliminating defects through product design and oversight, can increase customer satisfaction and reduce manufacturing and service-related costs. Where manufacturers have taken steps to advance quality management in the plant they have reaped the benefits of improved customer satisfaction and reduced service costs.



Research Direction: Research the link between production quality control and post-installation service costs. Identify the areas where improvements in plant quality can have the greatest impact on service costs and permanently eliminate the possibility of field failures. Quantify the magnitude of the potential costs and savings. Showcase how individual manufacturers have derived tangible benefits from quality management programs. (Note: This concept overlaps with the Home and Site. Some of the sources for service cost information will be the same as those for research investigating premature failures.)

Maintaining a Stable and Capable Work Force

The dwindling supply of construction trades labor is a major concern for the site building industry and enhances the appeal of factory built homes. Increasingly, however, factory builders are facing similar issues. Future research will focus on using the factory environment as a lever to attract construction trades. Research in this area includes the following:

1. Ergonomics

Context: The typical tenure of a plant production worker is relatively short. Annual turnover among plant workers can easily exceed 100%. The continual hiring and training of new workers represents a cost and the loss of experienced hands has an adverse effect on quality and morale. One reason for the loss of experienced workers is the physical demands put on them by their tasks in the plant. Techniques and equipment to ease this burden are available and in common use in other industries and in factory homebuilding in other nations where the workface is much older.

Research Direction: Investigate and develop methods to improve ergonomics for production workers. Applying production methods observed in homebuilding factories in Sweden and Japan, determine the impact of improving ergonomics on production and on worker retention and longevity. Develop recommendations for equipment and techniques to adapt to U.S. homebuilding factories.

2. Labor incentives

Context: Many different types of labor incentive programs are used across the factory homebuilding industry, yet labor retention, productivity and performance remain problems. Developing the ideal mix of incentives for a given plant remains more of an art than a science and success is hard to measure, often fleeting and modest at best.

Research Direction: Research and report on the variety of labor incentive programs in use in the industry, their success and shortcomings. Determine what systems work best and why, as well as what types of programs do not work as intended.

4 THE SITE

This chapter focuses on the factory built housing delivery and installation process. Considerable opportunities exist to add value to the factory built home once it leaves the factory. Opportunities exist for improving strength and durability through enhanced installation procedures and implementing a variety of site built amenities that expand the quality and functionality of the home. The factory built housing industry is committed to exploiting these opportunities as a means to enhance the overall performance of its core products and increase customer satisfaction. The Manufactured Housing Improvement Act of 2000 is a major step towards providing clear and consistent guidance for work performed at HUD-code home installation sites.

Construction Management Tools

One of the least structured aspects of the factory building process is the flow of information between the manufacturer, the retailer or builder and the home buyer. When the buyer's understanding of the building process, home design or total costs is not fully aligned with that of the builder, retailer and manufacturer, problems can occur that increase costs, delay construction and result in a less satisfying buying experience.

1. Construction management system

Context: Manufactured home retailers have traditionally sold homes to consumers from retail centers. The homes are then transported to and installed on either private land or in manufactured home communities. Historically, these transactions have been relatively straightforward, with the purchase consisting of a home with relatively few options.

A number of factors are pushing the traditional manufactured home retailer to become more akin to a builder or general contractor, a role they are often ill-equipped to handle. These factors include greater home complexity, increasing average home prices, more modular homes and more land-home deals. This new role demands that the retailer effectively communicate specifications and expectations to the customer, and perform construction management tasks such as accurate cost estimating, scheduling, subcontractor management and site inspection.

Research Direction: Develop a system that improves the home sales transaction process, including communication through the sales and delivery chain to the customer, and construction management, thereby eliminating common causes of customer dissatisfaction and cost overruns. The process should be applicable to the majority of the manufactured and modular home industry for the increasingly complex homes sold today, including land-home transactions.

Foundation Design

Developments in home design, mainly under the control of the manufacturer, continue to outpace other parts of the construction process such as the foundation. This research would focus on creating a more robust menu of foundation systems that are high performance and low cost.

1. Real property foundations

Context: Financing terms, as well as home re-sale value, are often tied to the type of a manufactured home foundation. In many cases, lenders and communities require foundations that are classified as suitable for real property.

Research Direction: Develop a greater array of foundation systems that qualify for real property financing and are less costly than traditional crawlspace, slab and/or basement systems. One example of an innovative new foundation type that may be considered is the helical footing foundation system sometimes used for retrofit applications in site built construction.

2. Alternative marriage line/perimeter support methods

Context: Manufactured homes are typically supported on piers spaced at fixed intervals under each chassis rail and at specified points under the marriage line and perimeter walls. This results in a necessary but duplicative forest of piers under the home. In addition, small movements in the structure as a result of live loads, temperature fluctuations, vibrations caused by occupants and equipment and wind pressures can take their toll on this type of foundation system.

Research Direction: Develop alternative structural schemes for the support of marriage line and perimeter loads that consider factory and site costs and long-term performance of the home. (Note: This issue may also be addressed through the integrated floor project in The Home section). In addition, assess how different types of foundation systems (perimeter supported versus piers under the I-beams) perform over time.

3. Insulated and conditioned crawlspace and frost-free shallow foundations (Top Research Initiative)

Context: There are several common methods for securing manufactured homes to the ground. The most common techniques are piers that rest on surface-mounted footings, and to a lesser extent, floating slabs or in some areas concrete footings that extend down to the frost line. With most homes the crawl space between the home and the ground is unconditioned and generally enclosed by some type of vented skirting.

Other approaches to designing the supporting system for manufactured homes, which are not currently used by the industry, might prove to be more cost-effective and durable and result in improved thermal performance. For example, recent research by the site-building community has suggested that: (1) conditioned crawlspaces have energy and moisture performance advantages; and (2) frost-free shallow foundations, which eliminate the effects of frost heave without the excavation cost, have been used successfully in Scandinavia.

Research Direction: Investigate, evaluate and develop alternative foundation and support systems that provide superior performance yet maintain the cost-effectiveness essential to their use with affordable, factory built homes. The emphasis in this project is HUD-code manufactured homes, since modular homes are typically placed over the same types of foundations as site built homes and affordability is not as critical a design consideration.

Concepts such as conditioned crawl spaces and frost free shallow foundations will be considered along with other strategies that achieve the goals of improved overall home thermal performance, durability, low maintenance and high structural integrity. Tasks conducted as part of this effort would include: design development; prototyping and testing; facilitating commercialization; and, if required by the foundation design, advocating corresponding changes in regulations

4. Multi-hazard foundations

Context: Recent natural disasters have pointed out the need for all types of homes to have robust foundation systems able to withstand the effects of severe wind, flooding and seismic events. FEMA has developed new foundation system recommendations for manufactured homes in flood zones that may significantly increase costs for these installations.

Research Direction: Prepare pre-engineered foundation design solutions to cope with simultaneous multiple natural hazards, such as wind and flooding, and ensure that these foundation designs meet the new recommended FEMA criteria. The prime objective of this research would be to develop low-cost structural solutions and materials that meet the new FEMA-85 Multi-Hazard Design Guidelines for Manufactured Homes Placed in Flood Hazard Areas[3] criteria. (See Design for hurricane resistance – page 29)

5. Test protocols

Context: A wide variety of foundation systems are available for manufactured homes and new foundation systems are continuously under development. However, the information necessary to comparatively evaluate these systems' performance under various conditions and for various home types is lacking. Universally-accepted methods for evaluating all types of foundation systems, including both proprietary and non-proprietary types, will help in developing optimized, cost-efficient designs.

Research Direction: Develop foundation element test protocols for evaluating and benchmarking proprietary and non-proprietary foundation elements including, but not limited to, anchor system components.

6. Long-term performance

Context: Many manufactured home foundation types require seasonal maintenance and/or adjustment after extreme events. As foundations age they are subject to day-to-day stresses such as wind buffeting of the home; vibrations due to equipment operation; thermal expansion and contraction; and unusual events, such as storms. The impact of these stresses on the durability of the foundation and its ability to withstand extreme events is difficult to estimate.

Research Direction: Evaluate the long-term performance of foundation systems and their need for routine maintenance. Evaluate and develop protocols for inspection and maintenance for various home types (single or multi section), foundation types (crawlspace, pier and anchor, frost line, etc.), age and climate. Determine the relative merits of perimeter foundations compared with pier and anchor systems as related to long-term performance.

Site Planning

Site planning and provisions for site activities can have far-reaching effects on the durability and long-term sustainability of the home and community. The following activities address this relationship.

Site preparation—from foundation systems for individual homes to essential infrastructure for land-lease communities and/or planned-unit developments—can have a major impact on the long-term performance of factory built homes. To create true value for consumers and continue to drive down the overall costs of home ownership, the factory built housing industry must begin to think differently and address site-related issues and opportunities. A holistic approach that optimizes not only the individual unit, but also the foundation on which it rests and the external infrastructure on which it depends, will be necessary if factory built housing is to continue to be a key source of high-value, low-cost housing in the U.S.

[3] FEMA-85 Multi-Hazard Design Guidelines for Manufactured Homes Placed in Flood Hazard Areas (1985).

1. Coordinate home design and site services layout

Context: The installation of site services is a significant cost item in home set-up. Additionally, the installation of site services has the potential to adversely impact the home if not done properly.

Research Direction: Evaluate the opportunity to simplify the home installation process and future service installations and repairs by making changes to the way the service connections such as water, sewer, power, communications and gas hook-ups are designed into the home.

2. Site planning guidelines

Context: Decisions made by community designers, such as home orientation, selection of materials, location of service connections and method of connecting auxiliary structures to the home can impact home performance, including energy usage and long-term durability. Additionally, advances in site design techniques that minimize long-term costs and environmental impact may require adoption for use by manufactured home communities.

Research Direction: Develop site planning guidelines that are sensitive to the specific characteristics of manufactured home communities. The guidelines would address community planning issues such as water treatment, sustainable/low-impact development, xeriscaping, septic technologies, etc. The guidelines would also help planners and designers recognize how their decisions impact the quality, durability, energy efficiency and overall performance of homes.

Transportation to the Site

Major structural stresses are imposed on the home during transport, potentially resulting in damage that can undermine some of the quality built in at the factory. This may require repairs at the site, contributing to a negative perception among consumers. Despite these concerns, transportation issues have received relatively little research attention in the past.

1. Securing modular homes for transport

Context: Rules governing the attachment of modular homes to carriers vary among states, creating difficulties in developing consistent transport methods. This subject is receiving some attention from the states and is a potential area of new regulation.

Research Direction: Develop and evaluate methods to transport modular homes that comply with most restrictive state regulations, but are cost-effective and simple to implement. Issues considered would include securement to carriers; carrier design; ship-loose materials; protection of the module; and ease of loading/unloading.

2. Impacts of transportation on the home

Context: The requirement that the mostly pre-finished home be transported to the building site is one of the factors that differentiate factory built homes from site built homes. Transport imparts additional stresses on the structure, particularly for factory built homes constructed on a chassis that is integral with the structure of the home.

Research Direction: Analyze how materials and systems withstand transport. Investigate transportation-related damage and determine the underlying causes and mitigation strategies.

3. Transportation resource manual

Context: Over the years, the factory building industry has accumulated a wealth of experience with regard to home transport, experience that has been assembled and presented as a best practices guide. The Manufactured Housing Institute has taken the first steps in assembling this information into a document that will require revision as technologies evolve and federal rules change.

Research Direction: Build on existing work done by MHI to continue to develop and maintain a transportation resource manual for manufacturers and transport companies. The manual would include guidance on the wide range of transportation-related issues and be a repository for new techniques for transporting homes.

Installation

Installation is one of the most fragmented segments of the factory built housing industry and one of the hardest to reach with new technical information. In 2006, HUD will implement minimum installation standards. This will have far-reaching impact on the installation segment of the industry. The R&D projects suggested below are intended to leverage the wealth of experience in home installation practices and the changes that will result from the new regulations.

While factory built homes arrive at the site nearly complete, siting and setting the home on its foundation play a major role in determining construction quality, performance and durability. Proper installation procedures will preserve the quality built in at the plant; poor installation quality can lead to a host of structural and other home performance failures.

Installation is potentially the weakest link in the manufacturing/construction process. Therefore, it is increasingly the focus of industry, government, homeowners and insurance companies intent on continually enhancing quality and safety, and further minimizing warranty and repair costs.

Unlike manufacturing, the installation industry is fragmented, and consists mainly of a large number of small companies. This makes it exceedingly difficult to introduce new methods and procedures into the installation process. In addition, because there is no nationally-accepted installation standard, practices vary widely. As a result, an industry that draws much of its competitiveness from uniformity and standardization of manufacturing methods across state and regional boundaries is severely limited in its ability to bring the same efficiencies to the methods of installing the home at the site.

Largely intended to establish more controls, oversight and standardization of installation practices, Congress enacted the Manufactured Housing Improvement Act of 2000. Steps taken in the implementation of the Act, particularly the recommendations of the HUD Manufactured Housing Consensus Committee, will be the major impetus for improving installation practices in the future.

1. Benchmark installation quality and performance

Context: Information on installation problems residing in state or national databases is limited, but, if properly analyzed and verified, can potentially be used by manufacturers to understand home performance and to improve home designs.

Research Direction: Investigate how the installation process, including site preparation; transportation; foundation construction; connection to the foundation; and connection of services affects factory built homes. Examine existing databases analyzing sources and types of installation problems.

2. Feedback process to identify and fix problems

Context: A wealth of information on the performance of factory built homes exists, but much of it is inaccessible to those who can benefit from it most – home manufacturers. Some information can be found in state or national databases, but much of the most important data is scattered among retailers, service contractors, homeowners and others, and is rarely accessible to manufacturers who can use the information to improve home designs.

Research Direction: Devise a system to better track the performance of homes and a feedback process to identify and fix problems. Develop a formalized feedback loop process that tracks problems; identifies the causes; develops technical solutions; integrates the solution into manuals and training programs; and then monitors the results.

3. Improve installation quality (Top Research Initiative)

Context: While the quality of the home delivered to the buyer is paramount, delivering that home on time and on budget requires a team of knowledgeable companies—manufacturer, transporter, retailer or builder and installer—capable of working together and effectively communicating.

Unfortunately, the home sales and delivery process is often too fragmented with incomplete information exchange among the partners involved in the process. In particular, the retailer, who generally coordinates the process on behalf of the buyer, must ensure that all steps are completed properly from the time the home leaves the plant through turnover to the buyer.

In order to do this effectively, the retailer depends on a number of things: knowledgeable, experienced installers; clear documentation of installation requirements; prompt and accurate information from plants; and most importantly, a management system to navigate the myriad details. When one or more of these items are lacking installation quality may suffer.

Research Direction: Two activities are underway to help improve the efficacy of factory homebuilding, including:

- The Manufactured Housing Educational Institute (MHEI) has an installer training program to improve the skill sets of installers.

- MHRA will soon begin development of a model manufacturer's installation manual to assist plants in providing clear, consistent guidance to installers (see below – Model manufacturer installation manual)

An effort is needed, that includes these elements, for creating an integrated home purchase, delivery and construction management system that facilitates clear and timely communication among all parties and assists the retailer in coordinating the entire process. Among the products of the research will be an electronic and/or paper-based information management system that facilitates timely and effective exchange of information between retailers, manufacturers and installers.

4. Model manufacturer installation manual

Context: Most manufacturer installation manuals cover similar information, but often use vastly differing formats and presentation styles. Installers who work on many home types from different manufacturers may not take the time to review the manuals in detail, particularly when dealing with an unfamiliar document. Additionally, in 2006, HUD will implement a new installation program, setting minimum standards for installations. The guidance provided in manufacturer installation manuals will have to conform to these minimum requirements. With effort, installation manuals can serve as an excellent conduit for communicating information to the hard-to-reach installer segment of the industry.

Research Direction: Develop and promote a user-friendly manufacturer installation manual template that conforms to the new national installation standards, captures best practices and enables manufacturers to customize it to their own needs. The model manual would serve as a conduit for introducing best practices to the industry.

Installation requirements will continue to vary depending on state and local jurisdictions and even the minimum requirements will be interpreted differently across political boundaries. The model manual would document the various jurisdictional requirements with information about how and where to obtain the state-based standards, contact information for enforcement agencies and procedures for qualifying for installer certification in each jurisdiction.

5. Reducing time to move-in

Context: Factory built homes are typically constructed in a matter of days, as compared to site built homes which require months to build. However the time in the plant is only a small fraction of the overall time from order to final delivery to the customer. Increasingly, homes are more customized and complex, and are being installed on permanent foundations. The total cycle time (including order processing, engineering, manufacturing, transportation and foundation construction) for homes of this type can be as long as or longer than for site built homes, eliminating one of the major advantages of factory builders.

Research Direction: Using techniques akin to lean production, develop a value map of the typical order to delivery process, analyze it for opportunities to reduce cycle times and shorten the overall lead time. Work with manufacturers, retailers and site contractors to evaluate an improved system for delivering homes faster.

6. Reconditioning and resetting older homes

Context: As soon as a new manufactured home is completed on the site it is no longer subject to the HUD standards. This fact is of little significance unless, as sometimes happens, the home is relocated to another site. The subsequent set up is then subject to local ordinances that are not likely to contain provisions that cover installation issues specific to manufactured homes.

Research Direction: Investigate the creation and implementation of installation guidelines for reconditioned homes. Consider how establishing formal, industry-accepted guidelines for installing older homes might impact resale value and the approach taken by lending institutions when financing homes that have been reconditioned.

7. Design for hurricane resistance

Context: The performance of all types of homes exposed to hurricane forces has dramatically improved over the years due to the use of effective methods for securing the home to the foundation and the foundation to the ground. However, in areas of the nation particularly prone to hurricanes, housing in exposed areas continues to experience damage when subject to severe weather conditions. Some damage is a result of high winds, but with the improvements in structural system design the building science focus has shifted to damage caused by wind-driven rain.

Research Direction: Conduct a thorough investigation of the performance of new homes exposed to hurricanes, documenting material, system and component failures. Priority should be given to research and development on the building's load path and on mitigation measures that protect the roof; the building façade's openings; and on ways to improve quality of construction related to these elements. The top priority should be protection of the roof system, typically the most vulnerable and most expensive component to replace. High priority should be given to protection of windows, garage doors and the building envelope. Research on promising emerging technologies such as window coverings to prevent penetration by debris should be accelerated.

In addition, research should consider rain water intrusion and develop an understanding of the mechanisms by which water penetrates the building envelope; explore in detail structural and material performance identifying the types of damage to new homes that characteristically accompany hurricanes; and develop strategies for abating these problems.

5 THE MARKET

This chapter focuses on the socioeconomic environment within which factory built homes are designed, constructed, sold and installed; in other words, the factory built housing market.

While there is growing acceptance of factory built housing for single-family detached homes, barriers still remain to the widespread, cost-effective use of this type of construction. At the same time, substantial opportunities exist to extend the benefits of factory production to other housing types beyond the traditional single-family home.

The factory built housing industry is committed to both overcoming current barriers within its traditional market, and aggressively exploring new markets where the benefits of factory production can be applied to other housing types.

Design for an Evolving Marketplace

The growth of factory built housing with higher price points increases competition with site builders. To have success in this market segment, factory builders will need to expand the range of designs offered, developing more sophisticated and aesthetically varied architectural solutions that are manufacturable and transportable.

As housing prices continue to rise across the country, demand is growing for housing products of all types that drive down first costs while maintaining quality. The factory built housing industry has traditionally led the nation in providing such housing in its core market: the modestly priced, single-family detached home. The industry's challenge for the next decade will be twofold:

- Continuously improve service to its traditional market: the modestly priced single-family home in both land-lease and private property settings.
- Extend the advantages of factory production to other single-family markets and to other forms of housing such as housing for seniors, new Americans and urban infill.

1. New directions in manufactured housing

Context: Many examples exist of developments using HUD-code homes that blaze new and/or unique trails in terms of design, market segment and/or business model. Some examples include the Mills at Carthage in Cincinnati, OH, where the developer tapped a variety of manufacturers to build and supply homes that meshed with the architecture of the older inner city neighborhood; Lido Peninsula Resort in Newport Beach, CA, where two-story cottage-style homes are transforming an old land-lease community into a highly desirable oceanfront setting; and Saddlebrook Farms in Lake County, IL, a 55-and-older lifestyle-oriented land-lease community offering extremely high-quality manufactured homes to retirees moving from a high-maintenance site built home.

Research Direction: Profile innovative developments in the use of factory built housing. Describe what is new and unique about them; the advantages and disadvantages of their business models; new market opportunities they suggest; how the concepts might evolve; and new markets these concepts might open up.

2. Urban infill housing

Context: Urban infill housing is an increasingly popular response to America's housing needs. Urban infill housing involves additional considerations that may make factory built housing a particularly appropriate solution, such as lack of skilled construction labor, site security and more stringent fire codes.

Research Direction: Characterize inner city markets; understand the nature of typical inner city developments, particularly low income; and evaluate the appropriateness of factory built homes for such applications. Prototype HUD-code home designs suitable for inner city infill housing.

3. Assisted living and accessible housing

Context: As the population ages, affordable assisted living residences continue to be a need that, for some areas of the country, can be met with factory built housing. Seniors represent a ready and growing market for factory built housing. Accessibility features will become increasingly important to this segment as they age.

Research Direction: Characterize assisted living and accessible housing markets; understand the nature of typical assisted living and accessible housing developments, particularly low income; and evaluate the appropriateness of factory built homes for such applications. Develop prototype HUD-code homes that can be used to construct assisted living facilities and/or accessible housing in either single-family detached or attached configurations. Enhance the accessibility and visitability of all factory built homes by developing design guidance specific to factory built housing based upon ADA guidelines. The designs would demonstrate the applicability of ADA guidelines to factory built housing.

4. Ruggedized designs for disaster relief

Context: Following the devastating Florida hurricane season of 2004, FEMA ordered thousands of specially-designed factory built housing units to meet the temporary housing needs of displaced persons. The need for temporary and permanent housing solutions pointed out the benefit of having ready designs that can be quickly fabricated, priced and placed into production to respond to future natural disasters.

Research Direction: Build on the recent experience supplying homes to FEMA to streamline and develop home designs that are highly durable, low-cost and manufacturing-friendly.

5. Sea-transportable designs for disaster relief

Context: The Indian Ocean tsunami and earthquakes in Turkey are only the most recent dramatic events highlighting the frequent need for emergency housing in other parts of the world. Home designs that can be put into production quickly and are low-cost, durable and quick-to-deploy as emergency housing will provide the U.S. government with an international housing solution that is domestically produced.

Research Direction: Characterize the potential market for sea-transportable disaster relief housing and evaluate the appropriateness of factory built homes for such applications. As appropriate, develop prototype designs for homes that can be produced quickly and transported via container ship to areas in need of emergency housing due to natural or other disasters.

Regulatory Environment

Federal standards and enforcement procedures are the benchmark for the design and construction of all HUD-code homes. The revamping of the standards updating process, currently underway, may lead to far-reaching changes in standards and enforcement procedures. Regulation of modular and site built construction will follow a different path shaped by the national trend to standardize building codes, and the willingness of states to allow reciprocity with other state building statutes. The future of HUD-code housing will be strongly influenced by both these trends.

1. Modular housing approval system

Context: The modular housing industry must contend with a patchwork of state-regulated plant inspection, design review and enforcement systems. Typically each state has its own approval process for homes placed within its borders. This maze of inspection and review systems is generally recognized as creating inefficiencies for companies shipping across state lines, driving up cost and construction time of new modular housing.

Research Direction: Assess the current state-based plant inspection and design review processes for the modular housing industry, and develop alternatives that can bring greater levels of efficiency to this sector of the homebuilding industry. Develop a White Paper with recommendations for changes to the current modular approval and inspection process and proposed code language for a new administrative section governing the design approval and plant inspection system for modular buildings. Consider, among other alternatives, multi-state approval for subsystems of the home which could then be integrated for a specific home design. In addition, consider creating a new chapter or appendix for modular home administration in the International Residential Code (IRC) for states to use as a model.

2. Evaluate the benefits of a uniform code

Context: Increasingly, the regulations that govern HUD-code construction (the Manufactured Home Construction and Safety Standards) are being reshaped, in part, to reflect the growing design diversity of and expanding market for manufactured homes. Home manufacturers are offering designs that, from the consumer's standpoint, are indistinguishable from site built construction. At the same time, site building regulations are evolving toward national standards with the IRC emerging as the principal reference document for code-setting bodies. Taken together, these trends create a compelling case for considering a merging of the two documents into a single model statute governing all residential construction.

Research Direction: Evaluate the benefits of a single uniform code for all housing types – manufactured, modular and site built. This research would examine the benefits and drawbacks of a single code on the HUD-code industry and examine, among other factors, how it would impact industry operation and the perception of factory built homes. Such an assessment would need to respect the importance of maintaining preemption for manufactured homes so as to preserve the ability of plants and retailers to ship anywhere in the country homes built to a single standard.

3. Land-use restrictions

Context: In many communities, land-use restrictions and restrictive covenants unfairly limit the sites where factory built homes can be placed. Such restrictions—generally predicated on a lack of appreciation for current factory built housing—reduce consumers' options for affordable, quality housing. Other examples of unfair and exclusionary practices include developers that approach planning boards with subdivision plan reviews that contain "no manufactured homes" provisions.

Research Direction: Evaluate how the regulatory environment, including zoning; deed restrictions; decision makers' perceptions; and covenants, stifle or restrict the use of HUD-code housing. Develop an action plan to address the misconceptions about factory built housing among local officials and decision makers.

4. On-site completion procedures

Context: The HUD Code requires that a home, when completed, conform to its provisions. However, HUD regulators have interpreted this in such a way as to require most activities (outside of a few specific ones such as finishing the siding on the ends of double section homes) to be complete when the home leaves the plant. All other HUD Code-required elements of the home require special permission (the Alternative Construction Approval letter (A/C)) to be completed on-site.

Research Direction: Clarify how far the HUD-code home definition extends with respect to site built constructed elements, particularly components added or homes finished on-site. Explore innovative alternatives to A/C letters and other opportunities for site work to be more explicitly part of the HUD standards and enforcement regulations. Create a more robust set of procedures that obviates the need for A/C letters or other special approvals for on-site completion and provides continuity of regulatory oversight.

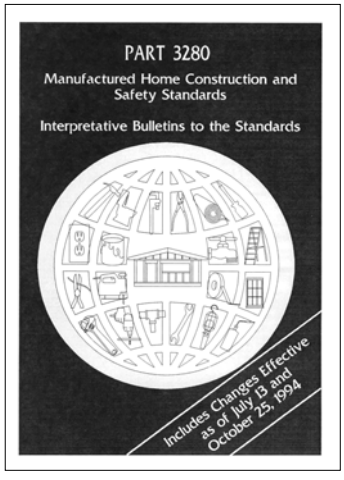
5. Expediting field inspections and permitting

Context: Part of the price advantage afforded by factory built housing is the result of the short time between purchase and completion of the home. In fact, the time in many instances is driven not by the sales and manufacturing process, but by delays by state and local agencies charged with issuing permits and inspecting installations. The slow pace of the approval process is often the result of agencies that have geared their review process to site building practices with far more protracted construction schedules. But for price-sensitive factory built homes, extended permit application periods are particularly burdensome. Some local agencies require scheduling separate inspections for every stage of the site preparation and installation, refusing to schedule a particular phase inspection until the prior phase inspection has been completed.

Research Direction: Evaluate the entire process of factory built home delivery, with particular focus on time delays due to inspections and permitting by government agencies. Develop a set of strategies for expediting this process and recommend how they would be implemented. Finally, recommend uniform standards to expedite the issuance of permits and completion of timely inspections.

6. Code change criteria

Context: Changes to the HUD Code are typically intended to improve home performance, safety or the health of the occupants. These changes often result in higher costs. Significant changes were made to the code in 1994. Yet criteria that could serve as an objective basis for weighing the merits of such regulations, such as cost benefit analysis, are not being broadly and consistently applied or do not exist. Future changes to the code are now being contemplated, yet there is no consistent way of assessing the impacts of these changes on value and cost.



Research Direction: Evaluate the impact of the 1994 change to the HUD Code on cost and value to end users. Use this evaluation to develop criteria that can be applied in evaluating the worth of future code changes.

Influencing Practice and Measuring Research Benefits

Good research solves problems, great research gets results. The research community too often embarks on projects without a clear idea of the forces and business interests that impact how the results will be treated in the marketplace. Worse, rarely are researchers made accountable by objective measurements of how their efforts transformed traditional practice.

1. Measure impact of research

Context: Research focusing on the needs of the factory built housing industry has been conducted for many years. Many products of this research have found their way into widespread use; however, the impact of the research on current practice is not routinely and systematically quantified. A clear understanding of the types of projects that have been most successful would be a valuable tool in the design of future research initiatives.

Research Direction: Develop metrics for evaluating the impact on industry of past research projects. Identify the key barriers to widespread adoption of technologies and information produced by specific research projects and develop strategies for overcoming those barriers.

2. Research dissemination vehicles

Context: Most factory built housing research has focused on the manufacturing segment of the industry. Increasingly, research projects are focusing on the more fragmented retailer and installer segments, requiring different dissemination and promotion methods.

Research Direction: Develop vehicles for promoting research results to industry, particularly hard-to-reach segments such as retailers, installers and service contractors. Vehicles might include newsletters distributed by direct mail; a non-commercial information portal (such as, PATH's Toolbase web site); or training programs and/or literature disseminated through distributors and dealers and builders of factory built home parts and supplies.

6 THE CONSUMER

This chapter focuses on the people who underpin the ultimate success or failure of the factory built housing industry: the home-buying and home-owning public. All of the research described in the other chapters of this roadmap can benefit consumers. Considerable opportunities exist for both increasing customer satisfaction with current factory built housing products, and for extending the benefits of factory built housing to new customers. The factory built housing industry is committed to pursuing a vigorous program of research and development along both these tracks.

Creating Value

Among all the various methods to construct housing, HUD-code homes may elicit the strongest preconceived reactions from homeowners, homebuyers, public agencies and the industry itself. Notions about quality, value and other attributes of HUD-code housing are commonly outdated, and are often based on old design, construction and installation practices. Public perception can make or break an industry. Unfortunately, perception of the factory built housing industry is often shaped by older, poorly maintained or abandoned pre-HUD-code mobile homes and has not kept pace with the rapid changes in home design that have dramatically transformed the industry over the last decade. In addition, as HUD-code homes continue to improve, the gap between perception and reality will widen unless the industry undertakes concerted efforts to educate potential consumers.

It is not just the perceptions of consumers of factory built housing that matter to the industry but also the general public's perception of the industry. If the public perceives factory built housing to be inadequate, they may employ a variety of tactics to inhibit the growth of the industry. For example, if local government officials believe factory built housing to be unsafe they can attempt to implement exclusionary zoning practices that limit the placement of factory built housing.

1. Build asset value with manufactured homes (Top Research Initiative)

Context: Wealth creation and the opportunity for property appreciation through home equity is often the key to long-term financial stability for many low and middle-income families. Manufactured housing provides one of the most affordable options for homeownership, and therefore wealth building through ownership of a manufactured home is a critical necessity for many Americans.

Research Direction: Characterize through the collection of empirical evidence the conditions required for homes—particularly manufactured homes—to contribute to long-term wealth creation. Explore ways to promote affordable housing and wealth building with manufactured homes. An example of a program designed to assist homeowners create wealth is the ***I'm Home Program,*** an effort supported by the Ford Foundation and other promoters of affordable housing. This initiative provides resources to local non-profit community organizations to assist them in constructing developments of manufactured homes for sale to low-income residents.

2. Improve customer satisfaction

Context: Both MHI and the Canadian Manufactured Housing Association recently completed market research studies focusing on consumer perceptions. The studies examined at a general level what consumers think about their factory built homes, the home buying experience and why. The research identified shortcomings in the factory built home buying experience and concerns about quality that have resulted in negative perceptions about the industry. Empirical evidence exists that refutes this misconception, but that alone may not be enough to change attitudes. Further research is necessary to identify effective strategies to change this perception.

Research Direction: The research should take the findings of recent consumer research and translate these observations into action items for the industry. Among the challenges to be addressed are: consumers want "seamless service" from sale to warranty follow-up; consumers equate good service with having more control; and consumers want reliable follow-up service.

Operation and Maintenance

Americans who owned their own homes spent over $24 billion on maintenance and repairs in 1999. While some ongoing expenses to operate and maintain a home are to be expected, driving down these costs as much as possible—by constructing more durable homes and by developing cost-effective preventive maintenance programs—will benefit consumers across the country. At the higher end of the factory built home price spectrum—particularly homes that are financed as real estate—consumers will benefit from less out-of-pocket expenses and from the reinforced perception that they have indeed purchased a higher quality home. At the lower end of the spectrum, where money for even modest repairs is often tight, consumers will benefit from durable homes that will not deteriorate, even if some maintenance is deferred.

1. Refurbishment program

Context: As with all older homes, older factory built homes that are in poor condition can be expensive to maintain and repair, may be uncomfortable to live in and perpetuate the negative image of factory built homes. Often these homes can be improved with relatively modest expenditures. However many homeowners do not have the resources, skills or knowledge to do so.

Research Direction: Develop programs to refurbish existing homes. Explore the role of community owners and other third-party organizations, such as the University Cooperative Extension Service, in remodeling/refurbishing older factory built homes. Develop guidelines for remodeling, refurbishing and maintaining existing homes and update the information that currently exists in handbooks and how-to manuals. Investigate financing programs that help underwrite the cost of rehabilitation, including energy-efficient mortgages for existing homes.

2. Home rating system

Context: Having a healthy and robust re-sale market for factory built homes is essential to the future health of the industry. Helping owners realize equity gain through upgrades and assisting potential buyers in evaluating existing homes, particularly homes built before the HUD Code was promulgated, can facilitate the health of the re-sale market.

Research Direction: Develop a process for accurately measuring the value embedded in existing homes that credits renovations and the features associated with a well-maintained home. One option is the creation of a specific designation awarded to homes that meet select criteria. Such a "seal of quality" would be recognized by appraisers, realtors and prospective buyers when assessing the intrinsic value of existing homes. The score might be independently determined and affixed to the home adjacent to the HUD label. Characteristics that would go into the score might include the following: energy features, indication that the home is free of structural defects, systems operation assessment, etc. Benefits of this system include creating an added incentive for homeowners to upgrade their homes and providing better information on specific homes to facilitate the development of the re-sale market.

7 THE ROLE OF ENERGY EFFICIENCY

Background

During the summer of 2005, energy prices soared to record levels, continuing a six-year trend and underscoring the nation's susceptibility to the cost and availability of nonrenewables. Climbing energy costs are felt by everyone and impact every sector of the economy. But for middle- and especially low-income households, escalating energy prices are more likely to translate into real declines in disposable income and pose a major impediment to building equity and financial security.

Among home owners, energy price hikes are felt most acutely among owners of factory built homes, for the simple reason that factory built homes tend to be more affordable than their site built counterparts. Manufactured housing, in particular, is rooted in the demand for affordable homes and today the industry accounts for nearly three quarters of all non-subsidized affordable home construction. While the median household income in the U.S. is over $43,000 (2003)[4] the median for manufactured home owners is 35% lower, closer to $28,000.[5] Not surprisingly, energy costs for factory built homes are a far larger proportion of the total costs of homeownership and family income. Any serious initiative designed to make homeownership more affordable must focus squarely on improving the energy performance of factory built housing.

The fact that affordable home buyers derive the greatest relative benefit from reduced energy costs does not suggest that new homes built offsite in the controlled environment of a manufacturing facility are less energy efficient than site built homes. The evidence suggests otherwise. While there are no authoritative studies comparing energy use as a function of building method, there is evidence that homes built in factories outperform those built on-site. Modular homes must meet the same energy standards as site built homes and manufactured homes are built to the nationally preemptive HUD standards. In some locations, the HUD standards exceed the site built energy codes while in others local site built codes are more stringent. In a few key areas linked to energy use (notably whole house and duct tightness) all forms of factory building routinely outperform site construction practices.

Rising energy prices squeeze homebuyers between increasing energy bills, on the one hand, and, on the other, the often high price of buying more efficiency. Low income households, in particular, typically face severe restrictions on how much they qualify to spend on their home and therefore are constrained in their ability to purchase energy features that might help mitigate the costs associated with higher energy prices. Families that would derive the greatest benefit from energy efficiency improvements are least able to afford them.

The Roadmap is a strategy for getting to zero within fifteen years —implementation in factory built homes of cost-justifiable technologies that virtually eliminate energy bills. As the Roadmap is implemented, factory built homes, already the most cost efficient method of building, will increasingly become more affordable to operate. Reaching this goal is an enormous challenge that

[4] U.S. Census Bureau Press Release, Income Stable, Poverty Up, Numbers of Americans With and Without Health Insurance Rise, Census Bureau Reports (August 2004).

[5] Manufactured Housing Institute, Quick Facts 2005 (2005).

will require a partnership of the public and private sectors united toward this common goal and a leveraging of the industry's diverse resources.

Getting to zero is not exclusively or even principally a technological challenge, although cost-effective ways to deliver energy efficiency will be part of the solution. Nor is it limited to changing the lending process in ways that give more weight to energy cost reductions. Nor will major strides in energy performance be made only by providing incentives that can help efficient methods of building gain critical market share and achieve high sales volumes that can translate into price reductions. Furthermore, reaching this lofty goal is not just a matter of arming home sellers with the tools they need to help buyers appreciate the value of energy savings, although education and outreach are critical elements of the strategy. All of these tactics will need to come into play and reinforce each other in a coordinated and orchestrated approach. The major elements of the approach are embodied in the Roadmap.

Why a Separate Discussion on Energy?

The purpose of this chapter of the Roadmap is to establish a set of broadly agreed upon goals for where the industry ought to be headed with regard to energy performance and a plan for reaching those goals. Like all planning guides it is continually evolving and cannot fully anticipate the forces and events that will shape future views of residential energy use much less how the results of near-term research will alter the priorities for future research.

However, with energy efficiency goals there is an immutable end point that is technologically feasible today, and depending on how it is framed, potentially reachable with cost-effective solutions within 10 to 15 years: homes that are net zero[6] consumers of nonrenewable energy sources. Over the last few years, prototype zero-energy factory built homes have been constructed using off-the-shelf products and technologies. While confirming that net zero homes are technologically feasible and a tangible goal, such designs are far from being cost-effective. That is, in the current environment, the costs associated with the products and materials used to reach net zero are not justified by the energy savings even under the most optimistic of scenarios. However, as a well defined end point, net zero provides a clear and steady target for this Roadmap.

The process of creating a separate, stand alone set of initiatives tied through the goal of improving energy performance engendered consideration of a variety and diversity of ideas for how energy performance could be improved and culling out those that resonated with a broad cross section of industry representatives. The consensus building process tended to favor ideas that many thought would contribute to future leaps in energy efficiency.

Defining criteria—Several constraints help frame the development of the Roadmap, including the following:

- Establish energy-related goals and define a concrete strategy for reaching those goals that is ambitious yet pragmatic and commercially viable.
- Consider separate approaches to energy performance improvements for new and existing homes reflecting the differences in appropriate technologies, audiences and financing, among other factors.
- Apply the litmus test of improved affordability as the core planning principle in charting an energy efficient future. Cost-justified improvements will allow market forces to sustain the Roadmap-identified strategies for reducing energy use.

[6] Net zero energy use homes are defined as homes that at times will use power from external sources (such as utility lines) to meet household needs while at other times will supply power in excess of immediate needs through on-site generation, thereby returning the surplus to the power grid. Over the course of time the home will return as much power to the grid as consumed from nonrenewable sources.

- Create the conditions that support the use of building practices that are substantially more efficient than current practice. Develop and perfect technologies, education programs, incentives and other elements that foster an environment of increased energy performance.

Roadmap Scope and Structure

Two parallel initiatives: new homes and existing homes—In describing approaches for improving the energy performance of all factory built homes, new and existing, the Roadmap contains, in effect, two separate and quite different parts. New and existing homes have distinct target audiences, a different portfolio of appropriate energy technologies, separate mechanisms for delivering energy efficiency guidance and quite different expectations with regard to opportunities for affecting energy use reduction.

Existing homes constitute a large population of households, with many in need of energy efficiency improvements. Reaching out to homeowners is generally a complex and expensive proposition, although there are avenues for aggregating existing homes to reduce the costs of promoting and implementing energy efficiency programs. Existing homes, built in a period of less stringent energy requirements, are where most energy dollars are spent and improvements in this sector can have a huge impact on affordability for the majority of homeowners.

Most of the housing research conducted in the U.S. focuses on new homes and it is easy to understand why. New home construction sets the tone for what is possible and is by nature forward looking, competitive and innovative with regard to product development and technological innovation. The audience for such research, in the case of factory built home companies that build in volume, is highly receptive and capable of implementing results quickly. Cooperative efforts backed by industry historically have had the greatest impact on new homes.

With more differences than similarities, new and existing factory built homes are approached within the Roadmap as separate and distinct, each with its own set of strategies for improving energy performance.

Elements of the Roadmap—The approach taken in this Roadmap is intended, in part, to dispel the idea that a strategy based solely on perfecting technologies will accomplish ambitious energy goals. As noted earlier, methods exist for building highly energy efficiency homes today but these are not being embraced by the housing market and high cost is only one of the reasons. Motivating industry to adopt new and sometimes unproven building practices and consumers to change how they operate their homes are challenges that the Roadmap addresses by combining strategies, including:

1. Market-based programs, such as Energy Star,[7] designed to transform the way the market perceives the value of improved energy performance.
2. Innovations in energy technologies, including developing new products and improving the performance-to-price relationship of existing ones.
3. Incentives that are intended to stimulate the market to embrace preemptively energy efficiency enhancements and/or specific technologies. Such incentives are often intended to build critical market share needed to reduce cost to sustainable levels.
4. Education-based initiatives that help industry evaluate the benefits of energy efficiency and implement techniques that improve energy performance, and help homebuyers and/or homeowners recognize the benefits of reducing energy use.

[7] ENERGY STAR is a national energy efficiency program run jointly by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA). DOE has responsibility for ENERGY STAR products and EPA oversees ENERGY STAR homes.

New Homes

Establishing goals—The Roadmap establishes a goal for future energy efficiency of new factory built homes and a strategy (or set of interlinked strategies) for reaching the goal. While in quantitative terms the goal posited by the Roadmap is to move the industry to exemplary levels of energy performance over the next decade or so, there need to be intermediate goals, signposts that confirm progress toward the more ambitious energy targets with clearly articulated technologies and performance criteria that can be measured and verified.

It is important to emphasize two points about improving efficiency that impact the setting of goals. First, efficiency is a continuum and setting targets is in some measure a highly imprecise science of selecting meaningful points along that continuum. The implied goal of the Roadmap is to create a program that will be a catalyst for accelerating the rate of energy performance improvement in the factory built housing sector. If efficiency is expressed as a curve with the end point zero net energy use, following or implementing the Roadmap would move the industry up the curve at a faster pace than it would move if left only to market forces, such as rising energy prices. In this view, the energy targets expressed below are somewhat arbitrary but useful in gauging progress toward the end point.

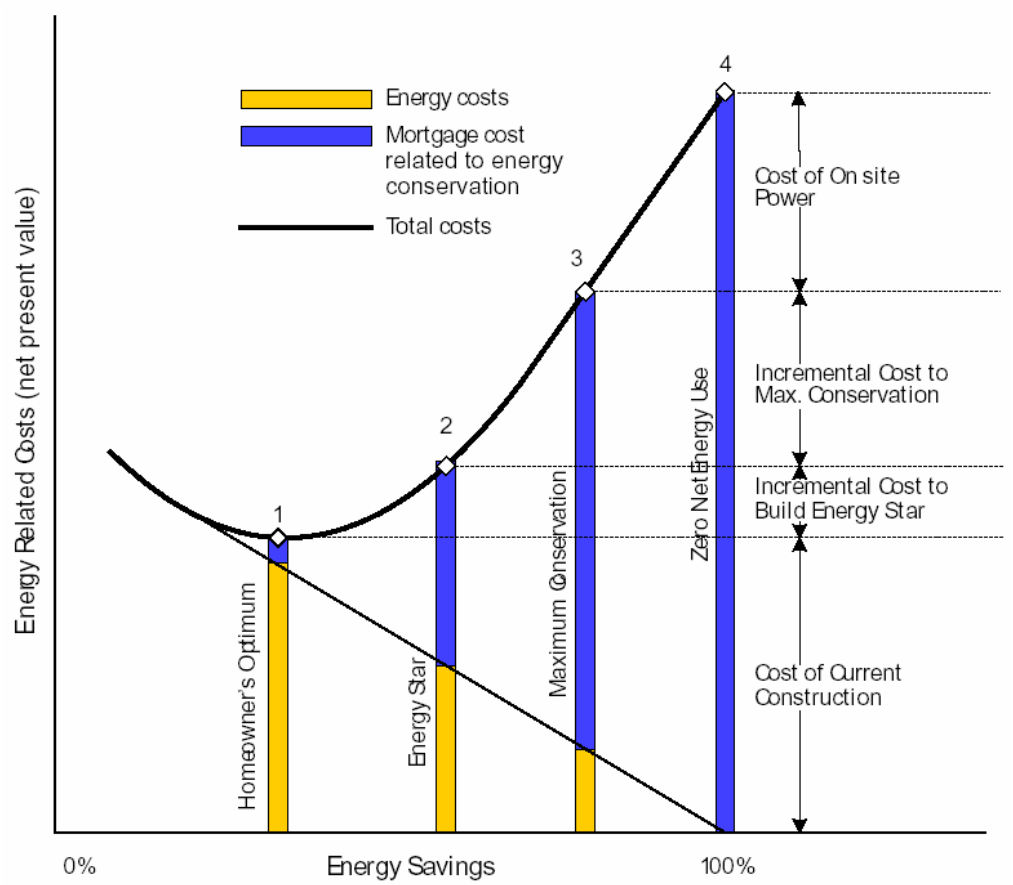
Second, targets mean different things to different audiences, particularly when the subject is cost-effective levels of conservation, including:

1. The goal of a new homebuyer may only be optimizing investment in energy features over the expected period of occupancy.
2. The research community commonly considers cost effectiveness over the expected life of home or the average mortgage term, recognizing that there may be several owners over this period, effectively optimizing their cumulative financial investment.
3. Alternately, the national view on efficiency might relate to reducing dependence on declining supplies of nonrenewable energy sources.

These are rather fluid targets of energy efficiency although they are stated above in what is arguably a system of increasing levels of energy performance. It is generally in the national interest for new homes to be built with little or no demand for nonrenewables, although this would engender, in the current environment, investments in conservation that would not be justified in the homebuyers' view by energy cost savings alone. How these perspectives on energy efficiency might be reconciled in the Roadmap is illustrated in Figure 2.

The curve in Figure 2 is a conceptual construct of energy investments and home performance from the view of the homeowner. The shape of the curve and the relationship of points 1 through 4 will vary depending on the home design, occupant behavior, anticipated duration of ownership and expected future energy costs. For every home, however, there exists an optimum, least cost investment that will provide the best return for a new home buyer (Point 1 on the curve) and combines into a single value all related costs, including principal, interest and energy costs. Absent other financial incentives, this level represents the best investment for the homebuyer. This level is used as a baseline in the comparison for considering the impact that energy improvements have on homeownership costs and affordability. Improving the performance of the home requires an investment in conservation, adding to the mortgage payment but decreasing the home's energy costs. Since any change is beyond the optimum level of efficiency, by definition, adding more conservation features will increase the mortgage payment by an amount greater than the associated reduction in energy costs. The total cost of homeownership rises for the individual homeowner, with a concomitant decrease in energy usage and costs nationwide.

Figure 2 The Cost Effectiveness of Investments in Energy Efficiency



At the far right end of the curve is a point representing the home built to produce as much energy as it consumes, thus the term zero net energy (point 4). With current technology, this is practical only by returning as much electricity to the power grid as the home uses, typically through on-site power production (such as photovoltaic cells). This is technically feasible today but not economically viable without expensive subsidies. For affordable homebuyers, in particular, cost-effective on-site power generation is a long-term prospect.

The cost of on-site power also suggests a limit on the investment in conservation. That is, improving the efficiency of the home makes sense up to a point, referred to here as the maximum conservation investment (point 3). Beyond this point, the incremental cost for conservation per Btu of energy savings exceeds the per Btu cost of providing on-site power generation.

Between the homebuyer's optimum and the maximum conservation levels is a fairly wide band of efficiency levels that can be staked out as target levels for future home construction. The one intermediate level that can command wide acceptance within the factory built housing industry, and therefore is meaningful as a Roadmap milestone, is Energy Star (point 2). As a measure of exemplary performance, the industry has gravitated toward Energy Star. The program has national brand recognition and a strong marketing program that will drive future demand for Energy Star homes. It also represents, on average, a substantial leap in efficiency above current construction, an improvement of approximately 25% to 35% when compared to homes built to code.

The exact positions of the individual points on the cost benefit curve shown in Figure 2 are determined by a host of factors too numerous and variable to approach in depth within this document. However, a few general observations are worth mentioning that are particularly relevant to affordable home buyers (the primary buyers of factory built homes):

- For every home there is an optimal level of conservation investment that represents the best investment for the homebuyer (or homeowner considering renovation) and will minimize the total homeownership costs. While the market generally drives what homebuyers are willing to invest in energy efficiency, it is often difficult to justify from the homebuyer's perspective any level other than the optimum.
- While perhaps not in the financial interest of the homebuyer, moving up the efficiency curve beyond the optimum investment point engenders investments that are meaningful to the nation. Over time, and partly as a result of implementation of the Roadmap recommendations, the buyer's optimum will move in this direction. In the interim, a combination of subsidies and incentives will be required to encourage these levels of investment.
- Markets and buyers generally are not well-informed as to the optimal level of conservation investment. Combined with the variability in important factors, such as energy prices, consumers generally are in a poor position to make informed energy investment decisions.
- The Roadmap initiatives will alter the landscape for energy efficiency investments by developing ways to use energy saving technology more cost effectively and by recommending synergistic public and private sector initiatives that encourage energy-efficient building practices and informed purchasing.

The discussions that follow suggest a series of interlinked strategies for achieving the goals that will move the factory built housing industry toward energy independence at a greatly accelerated pace. By combining and leveraging contributions by the public and private sector, the Roadmap suggests a coherent plan for leapfrogging the advances in energy performance that would have resulted from market forces acting alone.

The goals are expressed as a set of milestones to be reached in the short-term (two to five years), mid-term (five to 10 years) and long-term (10 to 15 years) time frames. These are, in each case, aspirational goals predicated on sustained and substantial commitments by both the private and public sectors. Change comes slowly to the homebuilding industry. Moreover, as stressed throughout this Roadmap, as the major supplier of the nation's affordable homes, and with buyers that may struggle to qualify for a basic home with modest amenities, the barriers to increasing first cost are particularly formidable for factory builders.

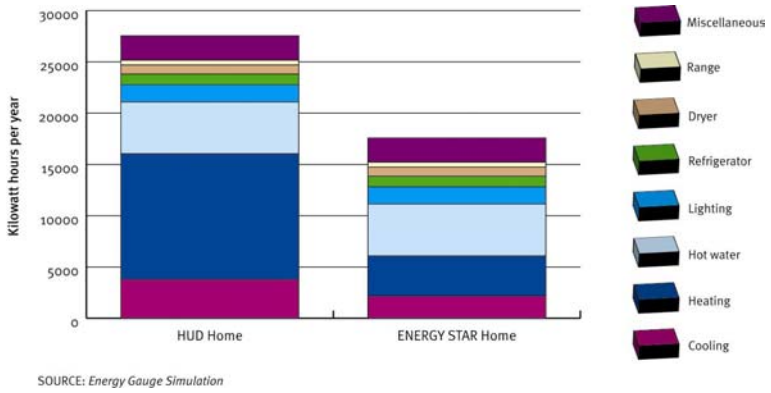
The goals for the short, medium and long-term are far more fluid than what might be suggested in the descriptions. Nearing or achieving the short-term goals will most certainly alter the strategy, targets and time frame for realizing future advancements. Having fixed targets, however imprecise, helps create agreement among industry and between the private and public sector partners as to the expected results of cooperative efforts and provides a baseline for measuring accomplishments. Change is, of course, far more dynamic: while the industry is embracing one level of improvement the seeds are being sowed for future improvements. Therefore, the emphasis of the Roadmap is on a game plan for achieving the short-term goals. The Roadmap will need to be frequently recalibrated as industry advances through these levels of improvement and external factors intervene to alter priorities.

EPA's Energy Star for Homes Program

Over the years, many programs have been developed to encourage greater levels of energy efficiency in factory built construction. Few have been successful and fewer still were a good fit for factory builders that ship across markets and state lines. The one notable exception is the Energy Star program developed and supported by the DOE and EPA. Energy Star has two characteristics that have made it particularly attractive to the factory building industry: it is a national program taking in all markets and types of homes and as a result of DOE's and EPA's brand marketing is widely recognized by consumers and perceived as an objective source of superior energy performance.

Figure 3 provides an example of energy end use estimates for an all-electric double section manufactured home located in Atlanta. The bar on the left represents a home built to the HUD standards and the one on the right the same design but built to Energy Star specifications. Reductions in energy use are seen in space heating and cooling and hot water heating end uses. In this example, the majority of the energy savings realized by the Energy Star home comes from the inclusion of a heat pump and increased cooling equipment efficiency.

Figure 3 Total kWh Consumption for Sample New Manufactured Home by End Use



SOURCE: *Energy Gauge Simulation*

Short-term goals (2 to 5) years: Moving to Energy Star and beyond

Goals—Within the next 2 to 5 years, the factory built housing industry will aim to achieve the following milestones:

- **Energy Star becomes the norm**: Energy Star construction, an exemplary level of performance reached by only a small fraction of new homes, will represent average construction practice for the entire factory built housing industry.
- **Installers and builders become advocates for energy efficiency:** An area that has a sizable impact on total home energy use but is difficult to quantify and measure is the quality of and techniques used in the installation of the home. In the near term, installation contractors will recognize how the methods they use influence energy performance. Installers, builders, community developers and retailers will be equipped with the knowledge and tools they need to install homes in an energy-efficient manner.

- **"Advanced" Energy Star targets set:** Over the next few years as Energy Star builds market share, the very definition of what constitutes an Energy Star home will evolve. As a meaningful target for exemplary performance of new homes, what qualifies for the Energy Star label will be recalibrated based on future advanced energy technologies. Further, the Energy Star for Homes program and Energy Star products programs will be better integrated and combined into a single target of total home energy performance. Design features, such as right-sized cooling equipment, will be incorporated into the program. In general, the program requirements will also more explicitly describe construction procedures, assuring that actual energy use matches expected performance. Advanced Energy Star construction will begin to gain market share.
- **Demonstrate maximum conservation construction:** The construction level representative of maximum conservation will be defined and demonstrated through prototypes built in various parts of the nation.

Challenges—Among the challenges to achieving these goals are the following:

- Proposed targets of efficiency are not cost-effective. This suggests that there is a need for significant external public and private support in the form of incentives, buy-downs, preferential lending treatment or other subsidies to help justify the added investment.
- New home buyers with modest incomes are limited in their ability to qualify for the increase in home price associated with added conservation measures or will be forced to choose between energy savings and basic home amenities.
- Lenders and appraisers do not recognize the value of energy improvements when qualifying buyers and setting home values. The value of energy conservation is therefore discounted by the market relative to other home amenities.
- Increasing conservation relies on customer appreciation of the benefits of energy efficiency. Customers do not currently value this home feature. Both sellers and buyers of factory built homes are, for the most part, ill-equipped to correlate improved levels of energy efficiency with increased home value and lower home operating costs. Industry must find effective strategies for conveying the value of energy efficiency to the homebuyer.

Strategies to reach short-term goals—

- Reduce the cost of building Energy Star homes by seeking ways to build market share for little used but effective energy technologies (such as structural insulated panels).
- Develop/perfect other cost-effective energy conservation measures that can help reach Energy Star levels (see below). Increase the options available for qualifying homes under the Energy Star program.
- Proactively address building science and performance issues that are impacted by energy conservation techniques (see below).
- Work with state and federal agencies on incentives to promote Energy Star construction.
- Develop an effective energy-efficient mortgage program for all types of factory built homes financed through conventional mortgages and chattel loans. Use Energy Star as the benchmark for EEM programs.
- Develop a robust program of retailer, installer and builder education and outreach tied into existing educational programs, such as the Manufactured Housing Educational Institute (MHEI).
- Work with the industry, EPA and DOE on the next generation of Energy Star, considering how the program can be the platform for encouraging cost-effective conservation strategies as the market conditions evolve.

- Explore exemplary levels of energy performance, such as maximum conservation construction through the design, construction and analysis of prototype homes.

Lead technologies linked to strategies—The methods available for managing energy use include mature technologies well-integrated into the fabric of factory building—such as high performance windows and insulation—and less mature technologies that are under development or commercially available but have not made substantial inroads into homebuilding. The latter category includes technologies that will be considered as part of the near term strategies discussed above. Examples include the following culled from a more extensive list of technologies contained in Appendix B.

Design, materials and systems

- Innovative foundation systems that combine economy and energy performance (possibly including sealed, conditioned crawl spaces).
- New envelope designs that combine high thermal performance and ease of manufacture (e.g., SIP-based solutions will eventually emerge driven, in part, by advances in factory efficiency improvements).
- Air treatment systems and heat recovery ventilators that maintain proper pressure profile, create a healthy internal environment and minimize energy loss.
- Greater use of attic and crawl space as thermal buffer spaces.
- Human factors engineering to improve comfort (via fans, radiant heating, etc.) and design of controls.
- Eliminate post-installation envelope penetrations (e.g., cabling) by providing pre-wired connections.

Mechanical equipment and distribution system

- Aggregation of homes to allow for application of community systems. While currently discouraged by sub-metering, this will be driven, in part, by utility programs.
- Equipment that combines related operations that take advantage of operating synergies, (such as a heat pump water heater that also dehumidifies) and the desire to reduce space allocated to equipment (such as tankless water heaters and on-demand systems).
- Zone control allowing supply of conditioned air to be adjusted to reflect occupancy needs.
- More efficient means of heating and cooling distribution (e.g., all internal duct systems).
- Proper ventilation and balancing of air flows within the home.

Construction, installation and operation

- Installation practices particularly related to construction quality and driven in part by current industry efforts to create a model installation manual.
- Plant and field diagnostics and commissioning at multiple stages of construction (duct blaster, blower door, thermograph, etc.).
- Integrated designs that assure that system designs are in balance (envelope tightening and humidity/moisture levels).
- Homeowner feedback (such as monitors that let homeowners know how much power they are using).

Related building science issues—Among the general building performance areas relating directly to efforts to improve energy performance and discussed in depth within the broader industry Roadmap are the following:

- Moisture control/abatement, particularly in hot, humid climates.

- Indoor air quality and ventilation rates.

Medium term goal (five to 10 years): The maximum conservation investment

Goals—Within the next five to 10 years, the factory built housing industry will aim to achieve the following milestones:

- **"Advanced" Energy Star plus the norm:** In the five- to 10-year time frame, construction that will evolve as *Advanced* Energy Star will become the norm for new factory built homes. Market conditions will have changed so that the Energy Star label becomes pervasive and will represent cost-effective construction. Through educational and promotional efforts, the benefits of this level of energy-efficient construction will be familiar to builders and retailers of factory built homes and demanded by new home buyers who will recognize the economic advantages.
- **Widespread adoption of maximum conservation construction:** As conservation costs drop, the maximum conservation construction level will be redefined and factory built homes representative of this level of conservation will be built in various parts of the nation. Barriers to widespread acceptance of maximum conservation construction will be identified and initiatives undertaken to routinely reach this level of home energy performance.
- **Demonstrate net zero energy construction:** Net zero energy use construction will be defined and demonstrated through prototypes built in various parts of the nation. (Net zero energy homes are not intended to be decoupled from the electric grid but rather put back as much power from on-site generation as consumed).

Challenges—

- The levels of energy efficiency suggested above are well beyond what is currently cost-effective.
- This level of energy efficiency engenders a first costs increase that the majority of buyers cannot qualify for even if desired.
- Even today's niche market builders do not push the envelope of energy efficiency to the degree suggested above.

Strategies to reach goal—

- Drive down the cost of conservation by building market share for little used but effective energy technologies.
- Develop/perfect cost-effective energy conservation measures that help reach the target level.
- Institute technology-specific incentives designed to offset substantially higher costs. These may include innovative business approaches that help establish market share (e.g., California's PIER program[8] for promoting photovoltaics).
- Energy-efficient mortgages will become pervasive, driving market demand for greater energy efficiency.

Long-term goal (10 to 15 years): Net zero energy use

The end point of industry's joint efforts with the public sector will be reached when homes constructed in factories are routinely built in a manner that provides the owners with homes that are virtually energy independent and, in some instances, net energy producers. While the technology

[8] PIER is the Public Interest Energy Research Program created by the state of California to encourage innovative public/private partnerships that help commercialize high-risk, high-impact technologies, like photovoltaics.

exists today to approximate this level of performance, it is far from cost-effective or practical. Advances pioneered through Roadmap initiatives and developments in related products and building materials technology will topple the barriers to totally sustainable construction. The energy goals for factory building within 15 years include the following:

- **Most homes built at or near maximum conservation construction:** As conservation costs drop, the construction level representative of maximum conservation will be redefined and factory built homes representative of this level of conservation will be built in various parts of the nation.
- **Widespread construction of zero net energy use factory built homes:** The construction level representative of zero net energy use will be more clearly defined and demonstrated through prototypes built in various parts of the nation.

The strategies for reaching this point will be developed over time and unfold in ways that will begin to be clear within the next decade.

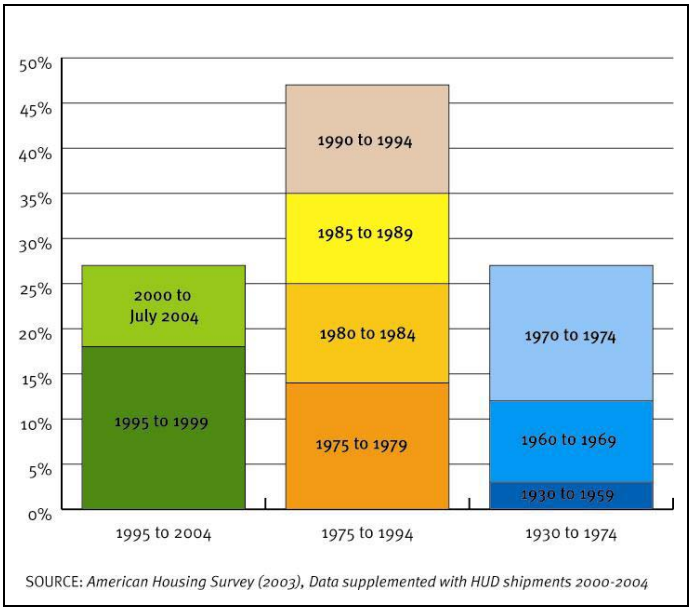
Existing Homes

Establishing goals—For new homes, developing technologies that reduce energy use is a major emphasis of the Roadmap. However, for most existing homes there are plenty of opportunities to reduce energy use with existing proven technologies. The major challenge to improving the energy performance of existing homes is reaching the nearly nine million manufactured homeowners scattered across the nation and motivating those homeowners to make energy efficiency improvements to their homes. Therefore, outreach and motivation programs are the focus of the existing homes portion of the Roadmap.

In 2001 there existed in the U.S. about 2.5 million manufactured homes built before 1975 and about 4.25 million manufactured homes built between 1975 and 1994 (see Figure 4). In addition, several hundred thousand modular homes of varying vintages exist across the nation. An analysis of the attrition rate of manufactured homes indicates that even in ten years, the existing stock will not decrease substantially. Older homes are not removed from service at a faster rate then newer homes and, therefore, barring programs to improve these homes, large numbers of relatively energy-inefficient homes will continue to be in service for years to come.

Figure 5 compares two energy end use profiles for manufactured homes. The profile on the left is for the average existing manufactured home based on data collected by the U.S. Energy Information Agency. On the right is a potential future profile that can be achieved using existing proven technologies and techniques. Both current and potential profiles will differ depending on the vintage and condition of the home, but on average total energy reduction potential is on the order of 25%.

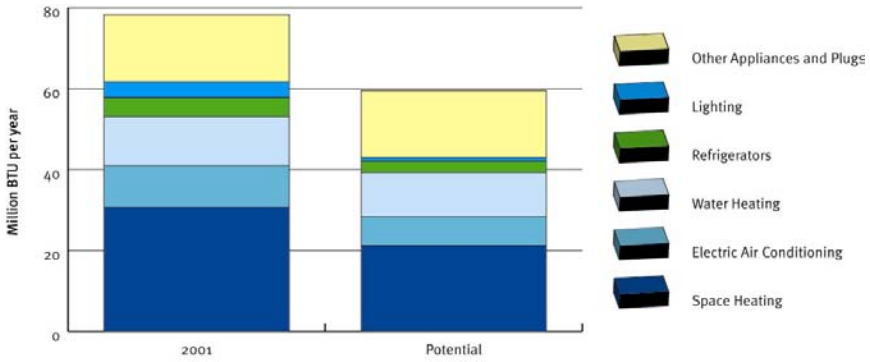
Figure 4 Current Manufactured Housing Stock by Age of Construction



The other major difference in strategy between new and existing homes relates to the economics of making energy improvements. Opportunities to substantially improve energy efficiency in existing factory built homes are often readily available with little to no investment or can be done by ambitious homeowners willing to undertake do-it-yourself projects. However, once these low-cost and no-cost items are done, the cost of energy efficiency improvements

can be prohibitively high for many owners on modest incomes.

Figure 5 Total BTU Consumption per Manufactured Home by End Use



Sources for energy reduction estimates: Lighting: Consumer Guide to Home Energy Savings; Refrigerators: MHRA Rehab Guide estimate; Water heating: Krigger, "Your Mobile Home"; Electric Air Conditioning: ORNL Metaevaluation of WAP results; Space Heating: ORNL Metaevaluation of WAP results.

In approaching existing homes, much can be learned from the Department of Energy's Weatherization Assistance Program (WAP). For 27 years, this program has been funding energy efficiency and life-safety improvements for income-qualified households at no or little cost to the homeowner. Over its lifetime, the program has impacted about 5.3 million homes. Only since 1990 has WAP kept track of the number of manufactured homes that it weatherizes. Since that time, 13% (approximately 164,000) of all homes weatherized under WAP were manufactured homes. A simple extrapolation of this percentage to the entire 27 years yields an estimate of about 689,000 manufactured homes weatherized through WAP.

While WAP is a very effective means to implement energy efficiency improvements in any one home, it is cost-intensive and the number of homes it can affect is limited. At the current rate of manufactured home weatherization (about 13% of the program's 100,000 homes per year yields 13,000 manufactured homes per year), in ten years there will still be millions of pre-1975 and pre-1994 manufactured homes that have not been touched by WAP. This Roadmap addresses the needs of this remaining majority of existing homes.

Other efforts to improve the energy efficiency of existing homes, such as those based on the strategies suggested in this Roadmap, will benefit from the experience gained by the WAP contractors. Specifically, these benefits include the following:

- Hands-on experience with energy retrofit technologies. The agencies conducting WAP recognize the technologies that can effectively be retrofit into existing homes and yield the greatest reduction in actual energy use for the least financial investment;
- WAP has created a steady market for specialized energy retrofit tools and materials that will benefit homeowners and retrofit contractors; and,
- A network of 2,000 qualified weatherization contractors exist across the nation, many of whom have experience working on factory built homes.

Future efforts should build on these resources and experiences.

Scope of existing home program—The overall objective of the energy section of the Roadmap for existing homes is to develop a strategy for reaching homes not being touched by WAP and to suggest ways to reach out to owners of existing homes that will benefit from conservation improvements. Establishing more precise goals predicated on making specific improvements in energy efficiency levels for existing homes is not feasible, in part due to limited knowledge about the existing stock of homes and how they have been maintained over the years.

One method of measuring performance improvements (used by WAP) relies on calculating the average energy savings of a typical home as a result of weatherization improvements and multiplying

by the number of homes weatherized. Goals for existing homes addressed through the Roadmap may be thought of in a similar fashion, as follows:

- Establish a target number of homes to be retrofit in a given period segregated by degree of rehabilitation (i.e., major—insulation added, furnace replaced, duct system sealed; moderate—water heater replaced, storm windows added; or minor—HVAC tuned up, water heater jacket installed). A reasonable goal for industry partnership efforts may be to affect 10 to 15 percent of the non-WAP existing homes with varying levels of measures.
- The average energy-use reduction that is technically and economically feasible or achieved for a typical home. The WAP experience shows that a 25% reduction is achievable with cost-effective methods, although in the future this may be increased as costs to rehabilitate come down or new, more cost-effective energy efficiency techniques are commercialized.

Market Segments—As discussed above, the single biggest challenge to improving energy efficiency in existing homes is reaching out to and motivating the approximately eight million owners (after subtracting out the WAP homes) of existing factory built homes. Strategic ways of aggregating and reaching out to these homeowners has shaped the Roadmap strategies.

The population of existing homes can be divided into two groups distinguished by potentially very different outreach strategies. These two groups are: (1) homes in manufactured home communities (about 34% of existing HUD-code homes); and, (2) homes on scattered private land (about 66% of existing HUD-code homes and most of the estimated several hundred thousand modular homes in existence). Strategies and goals specific to these two primary groups are discussed below.

Communities (34% of existing factory built homes)

These homes include those in land-lease communities (33%) and homes in parks where the land is controlled through condominium or cooperative ownership (1%). Home placements in communities have remained at approximately one third of new manufactured homes since 1998.

Goals—Roadmap goals include the following milestones:

- Develop programs for communities to act as the agents in implementing energy efficiency measures in homes in their communities.
- Demonstrate these programs in a small, but representative, number of communities across the nation. Strategically select communities to participate from at least one of each of the major community owners/management companies.
- Disseminate this experience to a wide audience of community owners and managers.
- Through this process, establish achievable goals for the number of communities involved in ongoing rehab or maintenance programs, the number of homes affected and the number of each category of retrofit performed. Because homes in communities are relatively accessible, a higher proportion of homes (compared to scattered-site homes) will be targeted.

Challenges—

- Communities are businesses and it may not be in their short-term interest to expend resources on energy conservation measures, the benefits of which accrue to homeowners.
- Even if the desire is there, the community staff may not possess the education or skills to convince homeowners of the importance of energy efficiency or to implement rehab measures.
- In some communities, shorter-term ownership of homes makes long-term energy efficiency investments harder to justify from the homeowner's standpoint.

- Low-income households may lack cash or credit needed to finance improvements.
- The benefits of improved energy efficiency are not well appreciated by some homeowners.

Strategies—Strategies specific to this segment are centered on the community owner. These strategies are possible because the long-term fiscal health of the community's residents is in the interest of the community owner, and the community represents an accessible channel to reach large groups of homeowners. A more detailed description of a number of these strategies is included in Appendix B.

- **Maintenance staff:** Enlist community staff to facilitate energy efficiency improvements and perform regular maintenance activities that homeowners cannot or are unwilling to do. Staff may be able to perform simple tasks such as cleaning HVAC filters, clearing debris from air conditioner condensing units and replacing light bulbs with compact fluorescent lamps at a much lower cost and at a higher frequency than is possible with independent service technicians or hired handymen. With minimal training, staff could apply caulking; insulate pipes and water tanks; and repair easy-to-reach duct leaks. A program to equip community maintenance staff with this capability would place the knowledge and tools to make significant energy efficiency improvements close to the homeowner and potentially provide an additional revenue stream for community owners.
- **Rental community upgrades:** For homes that are owned by communities and rented to tenants, a separate program could educate community owners and provide them with the tools they need to upgrade and maintain the energy efficiency of rented homes so as to reduce the energy burden on residents and improve affordability.
- **Re-sale upgrades:** Opportunities may exist to impact homes when they turn over through sales brokered by the community. Improving energy performance will enhance the value of the home—a potential asset at re-sale.
- **Bulk purchase:** Energy retrofit measures are often expensive. Bulk purchases of goods and/or services can leverage the buying power of a community to drive down the cost of improvements for large groups of homes. This might include bulk purchase contracts for appliances or furnaces that include installation and disposal of old units; or arrangements with retrofit contractors for repair, insulation or window replacement of large groups of homes simultaneously, thereby improving efficiencies and lowering costs per unit. Homeowners would be able to buy into the program at discounted prices from what they would pay individually and would not have to deal with contractors. One advantage of this strategy is that it brings a prepackaged opportunity to the homeowner. Coordination, planning, contracting and management would be done by others and amortized over many homes. Payments could be made through the homeowner's normal monthly site rental bills and potentially even financed through the community owner. When implementing large quantities of certain product types (e.g., heat pumps) other advocates for the technology may be willing to underwrite some of the costs.
- **Energy-efficient mortgages:** Improved lending terms for home equity loans or mortgages for energy-efficiency improvements are potentially available predicated on the value of the energy savings. Lending incentives may be underwritten by public and private sources.
- **Home replacement:** In some cases with older (built prior to the HUD standards), inefficient homes in poor condition, it may not make sense to repair or upgrade older manufactured homes. In extreme cases, the cost of replacing an older home with a new, highly energy efficient home may be largely financed by the energy savings. A total home replacement program would leverage this savings, combined with funding from other sources to remove and dispose of the old home and install a new one.

- **Consumer education/outreach:** A number of potential avenues and partners are available for reaching out to homeowners with educational and promotional information on energy efficiency retrofit. Channels include DOE, EPA, state energy offices, industry, homeowner associations, the American Association of Retired Persons and the media. A list of potential outreach partners along with their interest in the subject, applicable resources and potential outreach strategies is contained in Appendix B.

Homes on privately owned land (66% of existing factory built homes)

These homes include those on homeowners' private property (49%), homes on third-party private property (11%), and manufactured homes in subdivisions where the homeowner owns the lot (6%). This group also includes the bulk of the several hundred thousand modular homes across the country.

Goal—Because reaching owners of homes located on private property is cost- and time-intensive, long-term goals for energy rehab activities are more modest than for homes in communities. Goals for the roadmap include:

- Develop materials and identify dissemination vehicles to reach out to groups of existing scattered site homeowners.
- Reach out to existing home owners with information that places greater emphasis, value and recognition on energy efficiency.

Challenges—

- It is difficult and expensive to reach individual homes on scattered sites. Unlike homes located in communities, there are no readily identifiable third-party agents that can act as intermediaries in encouraging and helping to implement energy efficiency improvements.
- The benefits of energy efficiency are not appreciated by some homeowners, particularly as they relate to reducing the total cost of homeownership.

Strategies—Strategies specific to this segment are driven by alternative ways to reach these homeowners and by the need to align the interests of potential partners. Partners might include realtors that specialize in sales of existing factory built homes on private land and/or electric utilities, particularly the cooperatives that are more prevalent in rural areas where manufactured homes tend to be. The cooperatives also are interested in improving the financial viability/health of their member-customers and therefore are interested in improving the energy efficiency of factory built homes on their lines. A more detailed description of a number of these strategies is included in Appendix B.

- **Incentive programs:** Work with organizations such as local governments and utilities to develop marketing and incentive programs. Financial support would be used to spur energy efficiency retrofits or provide free retrofit services.
- **Identify energy-efficient homes:** Develop strategies to identify and boost the market value of energy-efficient homes. This might include working with NADA[9] to establish increased valuations for a broader variety of energy efficiency improvements and/or instituting a rating system or label for homes that have undergone a set series of improvements. By identifying homes that are more energy efficient, buyers and lenders would be able to make more informed decisions and sellers could more easily recover their energy efficiency investments at the time of resale, thereby encouraging them to make those investments in the first place.

[9] The National Automobile Dealer Association publishes the N.A.D.A. Manufactured Housing Appraisal Guide.

- **Outreach:** Outreach will be a component of all strategies, but it is the most critical in reaching owners of homes on scattered private lots. Methods and channels must be developed by which energy efficiency materials and information can be distributed to the maximum number of factory built home owners at the lowest cost. A series of partners will be recruited in this effort. Partners would be approached that can provide access to professional trade contractors specializing in energy efficiency retrofits and to owners and residents of manufactured homes. The home owners are the ultimate end-users of the information and the primary targets for dissemination. The professionals can serve as conduits to deliver the materials to consumers.
- **Other:** Energy-efficient mortgages, home replacement and consumer education/outreach. See descriptions above in Communities Strategies, page 50.

Technologies and methods—Technologies that are effective at reducing energy use in existing homes have been identified primarily through the efforts of WAP and described in detail for homeowners in a recent MHRA publication, ***Manufactured Homes: Saving Money by Saving Energy***. [10] The concepts described in this document have been tested over time and their effectiveness for existing homes widely demonstrated. While efforts will continue to find less expensive ways to improve energy performance in existing homes, technology innovation is not the primary area for future initiatives.

[10] ***Manufactured Homes: Saving Money by Saving Energy***, Manufactured Housing Research Alliance and the Partnership for Advancing Technology in Housing (2005).

APPENDIXES

A. ENERGY IN FACTORY BUILT HOMES: CURRENT SITUATION

The discussions that follow set the stage for suggesting research directions that will be effective in reducing energy use in the factory building sector and for focusing the Roadmap recommendations. This appendix offers an overview of the current demographic profile of the industry, depicts the energy-related characteristics of factory built homes and describes in broad terms the financial perspective of the industry's home buyers and home owners. This information provides a baseline for considering future initiatives that will improve energy performance.

Most of the source data referenced distinguishes manufactured from other types of housing. Therefore, for several characteristics, it is possible to characterize manufactured homes and manufactured homeowners. The opposite is the case for modular homes, which are typically grouped with and in most regards indistinguishable from site built homes. This difference is reflected in the imbalance in presenting demographic information that follows. Sections that contain information for manufactured homes only are so designated.

Factory built housing demographics

Current housing stock by age of construction—manufactured homes

With regard to energy performance, manufactured housing construction methods have changed dramatically over the years, but particularly since the mid-1970s with the confluence of two important events: the oil embargo of 1973 that raised the nation's awareness of the need to conserve energy and the passage in 1976 of the HUD preemptive standards for manufactured home construction. The HUD standards set a national baseline for the thermal performance of new homes. In 1994, HUD updated the thermal standards, implementing more stringent thermal envelope requirements.

As a result of these incremental changes in building practices, the population of manufactured homes,[11] when judged from the limited perspective of energy efficiency, roughly divides into three groups, based on when the home was built.

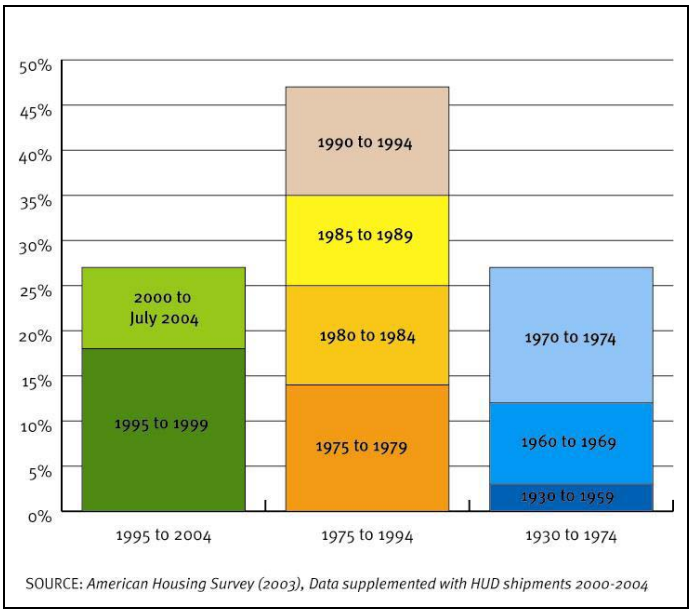
Pre-1975: Homes built prior to 1975 were in some cases subject to state-established energy standards or were not subject to mandated requirements for energy performance. Homes built during these years vary in regard to energy performance but generally are far less efficient than homes built today. Although homes 30 or more years old tend to be considerably smaller on average than homes produced today, they are far less energy efficient. Pre-1975 homes represent about 27 percent of the existing housing stock (see Figure 6).

1975 to 1994: With the passage in 1976 of the HUD standards, minimum energy efficiency levels were set for all manufactured homes produced in the U.S. The standards established limits on the average rate of heat flow across the thermal envelope, impacting energy used for space heating and cooling. The standards set minimum energy performance requirements with many manufacturers opting to exceed these basic levels. About 46 percent of the existing stock of manufactured homes was constructed in the period between by the promulgation of the HUD standards (1976) and the change in the thermal standards (1994).

[11] Similar historical data is not available for modular housing.

Post-1974: In 1994, HUD revised its standards, making changes that included increasing the stringency of the thermal provisions. This was a period of robust sales and the total number of new homes built from 1995 to 2004 roughly equaled the existing stock of homes built in all the years prior to the HUD standards. Further, spurred by market demand and programs like Super Good Cents, many home manufacturers routinely built homes that exceeded the minimum energy requirements. As a result, with energy efficiency as the gauge, there is a large gulf between new and older construction that is particularly marked when comparing new homes with homes built prior to the advent of the HUD standards.

Figure 6 Current Manufactured Housing Stock by Age of Construction



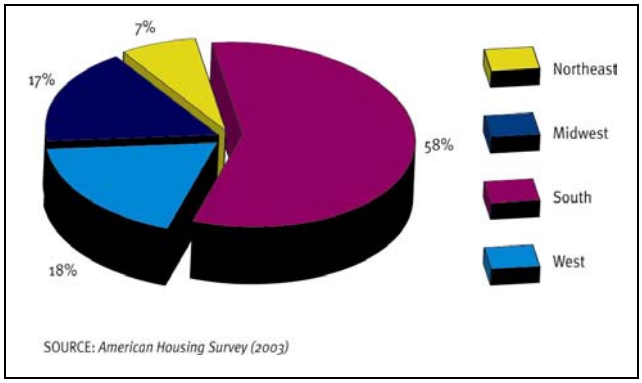
This dramatic change in energy performance over time has profound implications for a research agenda addressing the needs of homeowners currently living in manufactured homes. From the perspective of contemporary criteria for energy performance (minimally the 1994 HUD standards), nearly six million of the existing eight million manufactured homes are underperformers, candidates for energy efficient upgrades. In addition to being built in an era of less attention to energy use, many of the systems that contribute to energy performance in older homes may have reached their useful life and are in need of replacement.

Current housing stock by location—manufactured homes

Manufactured housing is by no means distributed proportional to the nation's population. While the early genesis of the industry was centered in the north central states, nearly 60 percent of all manufactured homes are today located in the South with states like Texas, Florida and North Carolina year in and year out leaders in new home sales. The West and Midwest share equally in the stock of existing home at 18 percent and 17 percent respectively, and the Northeast possesses the smallest slice of the pie with about a seven percent share of the total (see Figure 8).

Figure 7 Region Designations

Figure 8 Manufactured Housing Stock by Region



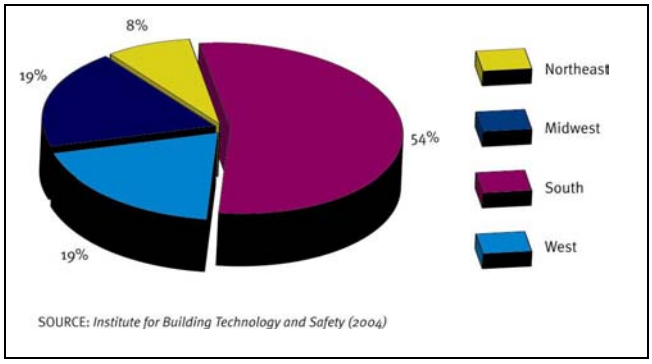
From an energy perspective, the concentration of new and existing housing in the warm Southern and Western states has broad implications for the Roadmap, suggesting a primary emphasis on space cooling issues. Of most interest will be technologies that impact cooling energy use, such as high performance windows, cooling equipment, etc.

How energy issues interplay with other building performance factors such as moisture mitigation, particularly in areas with long hot and humid periods like the Southeast, will continue to demand attention.

New housing stock by location—manufactured homes

The distribution of new manufactured homes is nearly identical to existing stocks, suggesting the same relative research emphasis on cooling issues (see Figure 9).

Figure 9 New Manufactured Home Shipments by Region (2003)

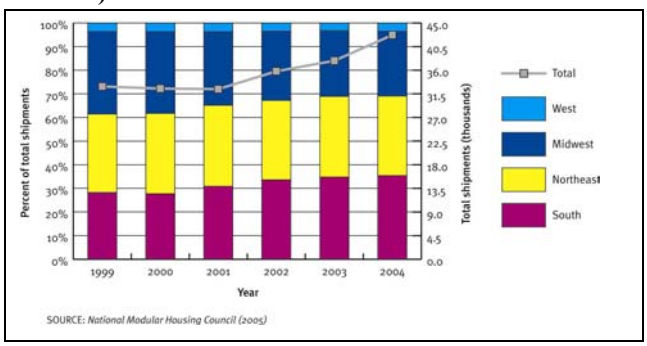


Current housing stock by location—modular homes

Thus far the discussion has centered on manufactured homes. Trends in modular housing have been masked by the dearth of industry data prior to about 1999. Current data shows, however, that modular housing is becoming an increasingly important part of the factory built housing landscape.

Since 1999 modular housing has been the fastest growing segment of the housing market, increasing more than 31% since 2001 (see Figure 10). Continuation of this trend, which depends on many variables and is too early to predict, would demand a shift in research focus toward modular issues.

Figure 10 Shipments by Region and Year (Modular Homes)



While the Northeast and Midwest have historically been the strongest markets for modular housing, as for HUD-code construction, recent growth is in the South.

New housing stock by location—modular homes

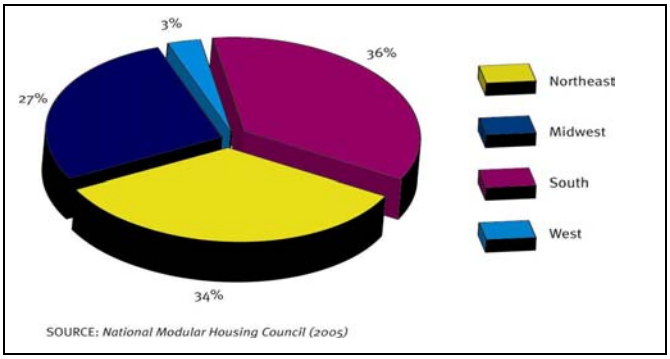
While the South is the most robust market for new modular construction, the regional distinctions are a bit misleading, as modular growth is focused in the northern part of the South, primarily in Virginia and North Carolina (see Table 1). Heating issues are important in these areas and therefore modular research and development will tend to be weighted towards approaches that reduce heating energy use.

Table 1 Five Top States for Modular Construction

State	Modular homes sold (2004)
North Carolina	5,375
New York	3,547
Michigan	3,540
Virginia	2,821
Pennsylvania	2,645

Technologies and approaches for modular housing will in many ways differ from manufactured housing, due in part to the dissimilarities in regulatory framework and application of voluntary programs, like Energy Star. These differences are also reflected in the distinct sales and installation methods of these two housing types.

Figure 11 New Modular Housing Shipments by Region (2004)



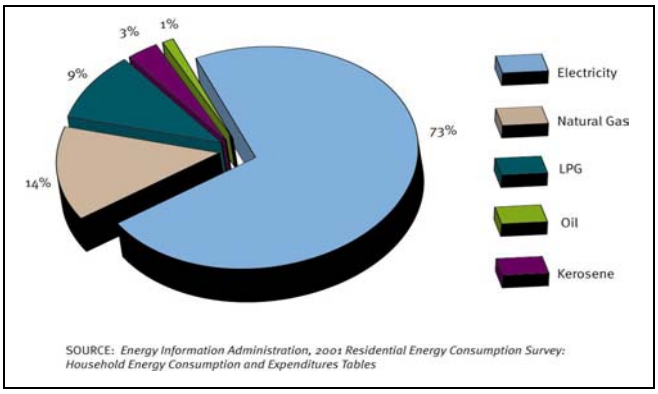
Energy Consumption Patterns

This section focuses on manufactured homes, as comparable data does not exist for modular homes.

Energy use by existing manufactured homes

Due to the lower first cost and resulting popularity of all-electric manufactured homes as compared to homes using multiple fuels, manufactured homes use a disproportionately high amount of electricity. On a per unit basis, electricity accounts for roughly three-quarters of all energy expenditures in manufactured homes. The other one-fourth of household energy expenditures is spent on other natural gas, liquid propane gas, kerosene or oil (see Figure 12).

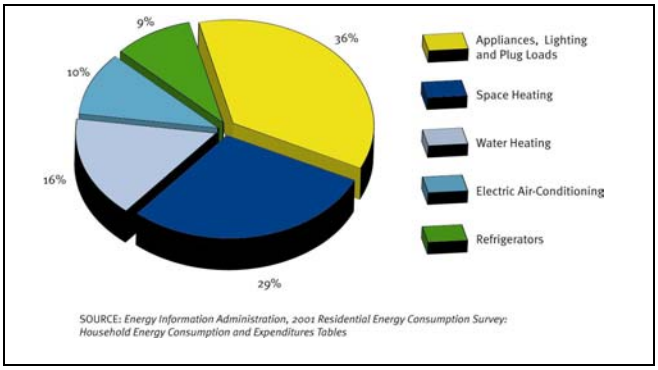
Figure 12 Manufactured Homes Expenditures by Energy Type ($/yr)



Energy end uses in existing manufactured homes

The big three energy end uses (space heating, space cooling and water heating) are together responsible for 55 percent of the total energy consumption in manufactured homes. For both new and existing homes, these end uses will continue to be the prime targets for conservation efforts (see Figure 13).

Figure 13 Energy Consumption End Use (Manufactured Homes)



Appliances (including refrigerators), lighting and other miscellaneous energy uses together claim 45 percent of the total energy consumed in manufactured homes. The increase in the use of electronic products, particularly devices that are powered even when switched off, is a growing proportion of total home energy use.

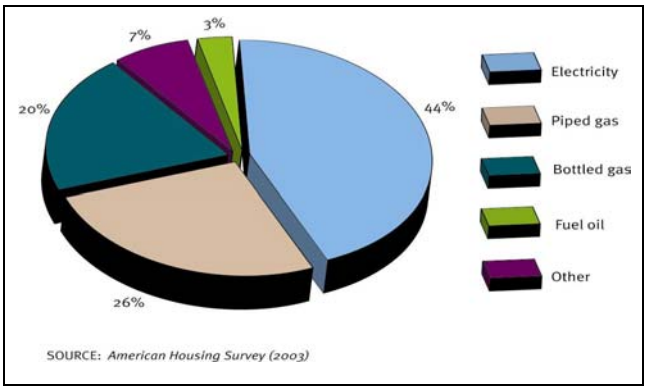
Energy Type and Equipment Holdings

As the data in this section suggests, heating energy use should be a prime focus of research. Despite the fact that most new and existing homes are in the South, heating is still the single biggest end use in manufactured homes. Also, decisions about energy type for heating often, but not always, dictate energy type selection for other end uses, such as cooking and water heating.

Heating energy type of existing homes

Compared with other housing types, manufactured homes are more likely to be have electric heat (these homes are invariably all-electric). Among the reasons for the popularity of electricity are: electric heat is the least expensive to install (particularly appealing for low-income buyers) and manufactured homes are more likely to be sited in rural areas lacking piped gas service (see Figure 14).

Figure 14 Main Heating Fuel Type (Manufactured Homes)

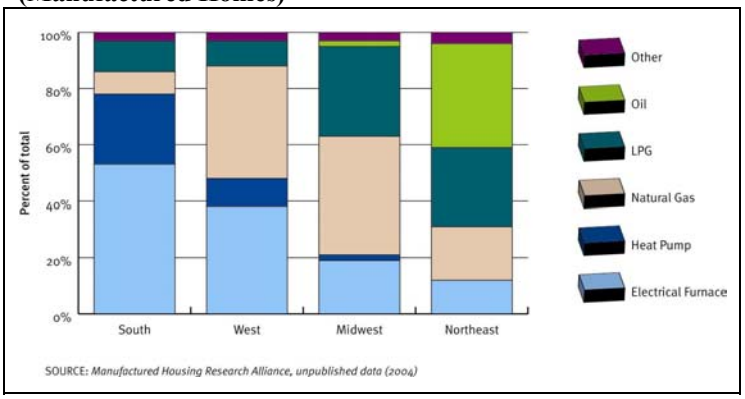


Heating equipment type in homes by region

There is a large variation in the equipment and energy type selection across regions, resulting from an array of factors that include traditional practices, the relative demand for heating and cooling energy use, regional energy costs and lack of availability of natural gas in certain markets (see Figure 15).

Electrically-heated homes tend to be most popular in areas with greater proportions of affordable housing (all electric homes have lower first cost) and more rural sites, conditions most commonly found in the South. Not unexpectedly, the popularity of heat pumps tends to follow the preference for electric heating generally.

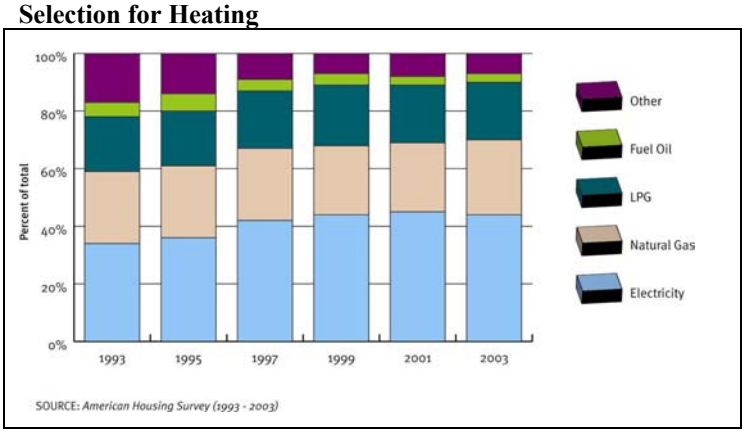
Figure 15 Main Heating Equipment Type by Region (Manufactured Homes)



Trends in heating energy type of existing manufactured homes

For existing homes nationwide, the market share for electricity has grown to about 42% from around 37% in ten years (see Figure 16). It is too early to judge, but the electric heating share appears to be leveling off. Future trends will likely be impacted by projected real growth increases in energy costs, higher standards for space conditioning equipment and the growth in efficiency.

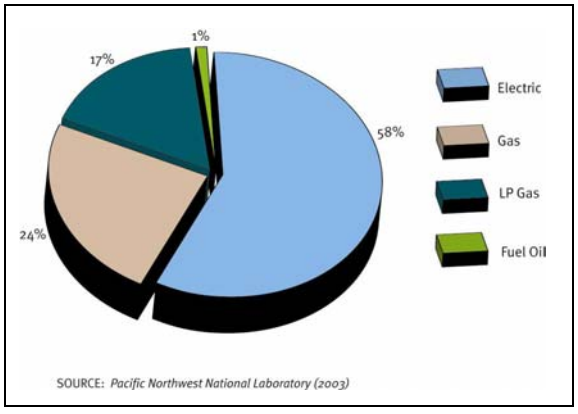
Figure 16 Trends in Manufactured Homes Energy Type Selection for Heating



Energy type in new manufactured homes

In terms of new construction, manufactured homes heated by electricity are running far ahead of the averages for current housing stock. About 58% of these new homes are factory equipped with electric heat compared with about 42% for the existing stock, as noted above. With electricity typically the most expensive source of energy per on a Btu basis, future research should favor a combination of highly efficient electric-based technologies (such as heat pumps) and methods of reducing the first cost of equipment that uses other energy types (see Figure 17).

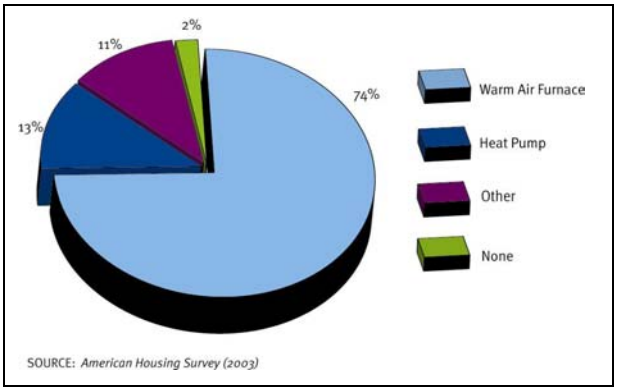
Figure 17 Heating Energy Type in New Manufactured Homes (2003)



Space heating and cooling equipment selection

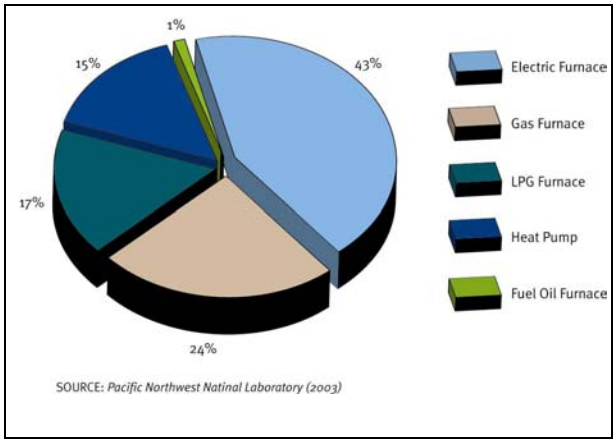
From the very beginnings of the manufactured housing industry, warm air furnaces were the primary method of providing space heat (see Figure 18). As a result, almost all homes in place today use ducted forced air for thermal distribution. For both existing and new homes, therefore tightness of the duct system is critical to energy performance and should continue to be a research major focus.

Figure 18 Main Heating Equipment Type - All Manufactured Homes



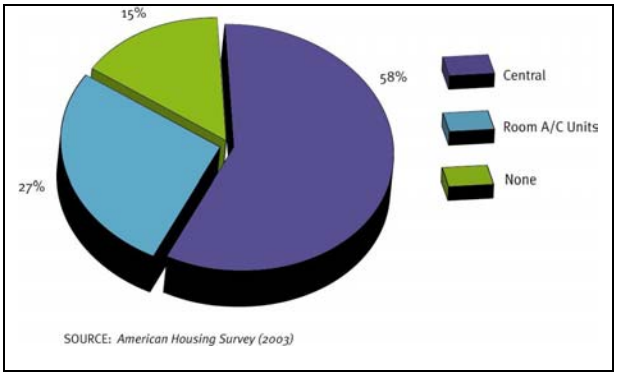
In new homes, heating is primarily provided by a warm air furnace with electric heat accounting for nearly 60% of the total (see Figure 19). Increasingly, heat pumps are the electric heating equipment of choice, capturing about one-quarter of the total electric share of the market and 15% overall. The fact that heat pumps are used in only 15% of the existing and 26% of the new electrically-heated homes suggests that there is plenty of opportunity for efficiency improvements simply by retrofitting heat pumps and more programs are needed to encourage more new home buyers to select heat pumps.

Figure 19 Main Heating Equipment Type Selection in New Manufactured Homes



Almost all manufactured homes have mechanical cooling (see Figure 20). With duct systems already built into most homes, central systems dominate, reinforcing the importance of air distribution to overall energy efficiency.

Figure 20 Cooling Equipment Types - All Manufactured Homes



Financial Implications of Energy Performance

The affordability equation: energy costs in perspective

For all homes (both factory built and site built), about 17% of the total cost of home-ownership goes towards energy costs (see Figure 21).

In contrast, nearly one-quarter of the average manufactured home owner's housing budget goes toward energy (see Figure 22). While this is a large fraction of the cost of owning a home, this statistic alone does not fully convey how energy costs disproportionately burden owners of manufactured homes.

Figure 21 Home Ownership Costs - All Homes[12]

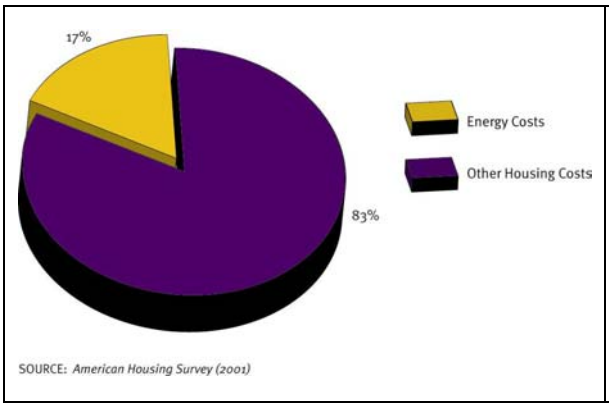
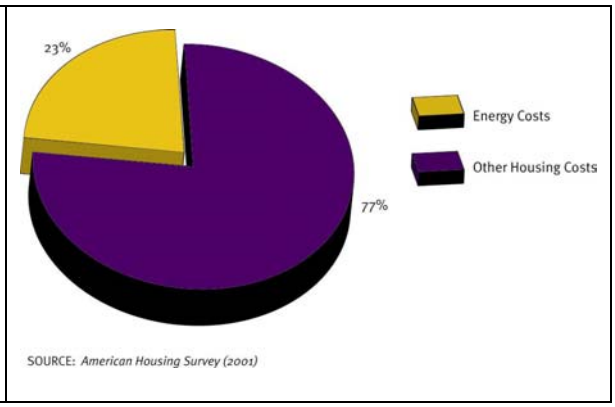


Figure 22 Home Ownership Costs - Manufactured Homes



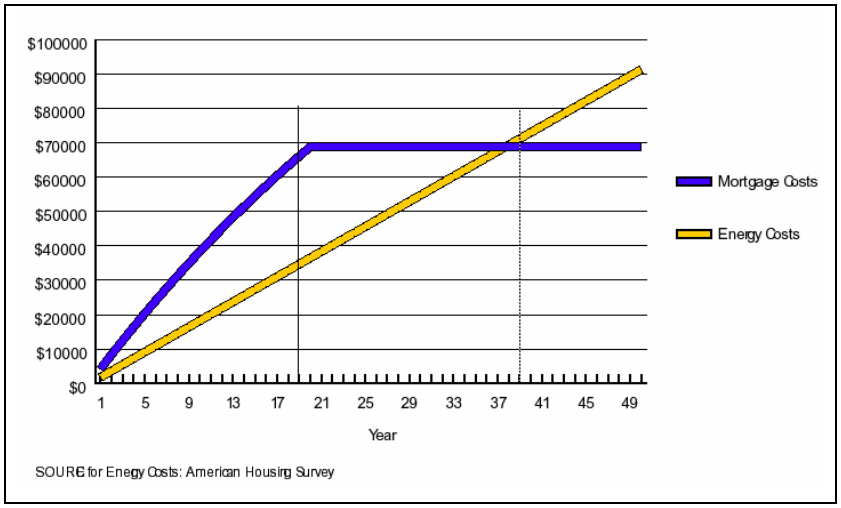
Energy expenditures loom larger as a percentage of total home ownership costs for manufactured homes largely because other home ownership costs are substantially lower than for site built homes. On average, the costs per square foot for new manufactured home construction are about half of the comparable figure for site building, reflecting both the cost advantages of factory construction and the level of amenity.

However, even assuming the same level of energy efficiency, manufactured home buyers do not, in absolute terms spend significantly less on energy costs than owners of site built homes. As a result many manufactured homeowners—particularly the poorest ones living in older homes—devote a substantially higher fraction of their housing budget toward energy costs. These homeowners will derive the greatest absolute and relative economic benefit from energy efficiency improvements.

Marketing and financing energy efficiency: challenges and opportunities

A simple calculation demonstrates the all-too-often overlooked significance of energy bills to manufactured home owners. Over the life of a home, cumulative energy costs can equal or exceed cumulative payments for home mortgage principal and interest. Unlike a fixed rate mortgage, a homeowner's energy bills increase over time as energy costs escalate. Figure 23 illustrates this point, comparing the cumulative expense of mortgage payments to energy costs over a 50-year home lifetime. In this example, the homeowner's cumulative outlay for household energy surpasses their total outlay on their 20-year mortgage in year 38.

Figure 23 Cumulative Energy and Mortgage Costs Through Year 50



Note: 20-year mortgage with interest rate of 6.5%; home cost of $50,000 with 5% down payment; costs are in net present dollars assuming a 2.3% inflation rate; energy costs are assumed to increase with inflation; land and other housing costs are not shown.

[12] Other housing costs include all mortgages or installment loans or contracts, except reverse annuity mortgages and home equity lines of credit; real estate taxes (including taxes on manufactured/mobile homes, and manufactured/mobile home sites if the site is owned); property insurance; homeowner association fees; cooperative or condominium fees; mobile home park fees; and land rent. For renters, the figure also includes the contract rent (not including subsidies). Costs do not include maintenance and repairs.

B. LIST OF ENERGY SAVING TECHNOLOGIES

Table 2 List of Energy Savings Technologies

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
HVAC Equipment		
Condenser fan	A condenser fan moves air across cooling coils to increase the transfer of heat.	**N**
Condensing furnace	A condensing furnace extracts extra heat from the exhaust gases before they exit the furnace. This requires an extra heat exchanger inside the furnace, which condenses the water vapor in the hot exhaust gases back into water.	**N**
Freus evaporative condenser	This is an evaporative water-cooled condensing unit that provides air conditioning, using water rather than air to cool the refrigerant. A water-cooled condenser can be more compact and requires less motor power than an air-cooled condenser.	**N**
Indirect/direct evaporative cooler	Indirect/direct (two-stage) evaporative cooler designs add an indirect evaporative heat exchanger upstream of the direct stage. The indirect stage cools the outdoor air without adding moisture. Depending on conditions, the direct stage can further cool air to below the wetbulb temperature. The result is cooler and drier supply air than can be achieved with a single-stage cooler.	**N**
Geothermal heat pump	Geothermal heat pumps (GHP) are ground-source heat pumps that use the natural heat storage capacity of the earth or ground water to provide energy efficient heating and cooling. GHPs should not be confused with air-source heat pumps that rely on heated air.	**N**
Hydronic floor heating	Hydronic radiant floor heating systems use a boiler to heat hot water and a pump to circulate the hot water in plastic pipes. The pipes, embedded in the floor, carry heated water that conducts warmth to the surface of the floor where it broadcasts energy to the room.	**N**
Night Breeze (DEG)	Night Breeze is an integrated heating, ventilation cooling, air conditioning and fresh air ventilation system that saves energy, improves indoor air quality and enhances comfort.	**N**
A/C maintenance	Air conditioner efficiency is directly related to routine maintenance. Well-maintained air conditioning systems consume from 15% to 40% less energy than neglected air-conditioning systems.	**E**

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
Ceiling fans	Ceiling fans reduce the need for air conditioning by increasing air circulation and the cooling effect it has on the skin. On mildly warm days and nights, ceiling fans may eliminate the need for air conditioning altogether. During the heating season ceiling fans can improve the efficiency of heating by circulating warm air that has risen up to the ceiling back down to where the occupants need it.[13]	**N, E**
Air-source heat pump in place of straight A/C	Air-source heat pumps are an efficient form of electric heating in mild and moderate climates, providing two to three times more heating than the equivalent amount of energy they consume in electricity.	**E**
Programmable thermostat	Most programmable thermostats are able to store and several temperature settings per day and automatically adjust heating or air conditioning accordingly as the outside temperature changes. The thermostat program can be set to turn the heat or air conditioning on at a scheduled time. A programmable thermostat costs $85-$125 and, if used properly, can save $100-$300 per household per year on heating and cooling costs and make a home more comfortable. It also frees the occupant from the need to adjust the temperature manually on a regular basis.[14]	**N**
HVAC Distribution		
Plenum truss	The plenum truss approach uses modified roof trusses which are designed to provide a space in the attic for installation of ductwork. Part, but not all, of the attic is brought into conditioned space.	**N**
Envelope		
Retrofit air sealing technologies	Leak sealing technologies like caulks, urethane foam and special patching materials can be used to seal small, medium and large leaks respectively. The largest and most predictable air leakage reductions come from sealing ducts; patching underbellies; plugging major leaks around plumbing, wiring, flues and joints in the building sections; and sealing return air plenums in the floor and ceiling (in older units).	**E**
Retrofit insulation techniques	In cold climates and sometimes in moderate climates, it is often cost-effective to add insulation to ceiling and/or floor cavities where space allows. Wall insulation is less often cost-effective. A number of insulation products are available for retrofit, including: fiberglass batts, fiberglass blowing wool, mineral (rock) blowing wool, cellulose blowing insulation, polystyrene beads, polystyrene bead board and urethane foam board. Most common techniques for adding roof cavity insulation are blowing fiberglass or cellulose insulation through holes in ceilings or through raised edge of metal roof. Floor insulation is commonly added by blowing these same materials into holes cut in the bottom board. Wall insulation may be added by blowing through holes cut in the wall; stuffing fiberglass batts; or removing exterior siding to install batts. On some homes two or three methods might be combined.	**E**

[13] California Energy Commission, accessed November 2004. "Consumer Energy Center." California Energy Commission, at http://www.consumerenergycenter.org.
[14] U.S. Department of Housing and Urban Development, November 2004. "Energy Efficient Rehab Advisor." U.S. Department of Housing and Urban Development, at http://rehabadvisor.pathnet.org/.

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
Radiant barriers for attic, elsewhere	An attic radiant barrier consists of material with one or two low-emissivity surfaces. The barrier is designed to reduce thermal radiation heat transfer occurring between the roof deck and the top of the attic insulation, thereby reducing the total heat transfer through the ceiling.[15]	**N**
Cellulose insulation	Cellulose insulation is made from recycled wood fiber and is much finer than mineral fiber blowing wool. It is capable of filling existing walls with fewer gaps and voids than mineral fiber materials.	**N**
Insulated, conditioned and unvented crawlspaces	Conditioned crawlspaces, if designed properly, have been demonstrated to be capable of reducing energy use and moisture build-up.	**N**
Insulated concrete forms (ICFs)	ICF's are basically forms for poured concrete walls that stay in place as a permanent part of the wall assembly. The forms, made of foam insulation, are either pre-formed interlocking blocks or separate panels connected with plastic ties. The left-in-place forms not only provide a continuous insulation and sound barrier, but also a backing for drywall on the inside, and stucco, lap siding or brick on the outside.	**N**
Spray foam roof insulation	Spray foam can be used to insulate almost anything, including: roofs, walls; foundations; entry and overhead garage doors; pipes and tanks; under-basement slabs; or over a slab-on-grade floor. Foam insulation sprayed or placed in wall and floor cavities both insulates and offers some degree of soundproofing.	**N**
Skirting	In addition to being an aesthetic amenity, skirting around the perimeter of the home can reduce the intensity of cold winter winds that blow under the home and strip away heat from the floor and crossover duct.[16]	**N, E**
Phase change materials (PCM enhanced cellulose)	This insulation technology can be used to absorb heat during the day and release it at night to reduce operation of heating and cooling equipment.	**N**
Reflective roof	Dark color roofs absorb solar radiation and add to cooling loads. This can impose a significant energy penalty in hot, sunny climates. When re-roofing in these climates, light and/or reflective colors should be selected.[17]	**E**
Reflective exterior wall covering	Dark color walls absorb solar radiation and add to cooling loads. This can impose a significant energy penalty in hot climates. When repainting or residing exterior walls in hot climates, light and/or reflective colors should be selected.[18]	**E**

[15] Ternes, Mark P. and William P. Levins, August 1992. "The Oklahoma Field Test: Air Conditioning Electricity Savings from Standard Energy Conservation Measures, Radiant Burners, and High-Efficiency Window Air Conditioners." Oak Ridge National Laboratory, Oak Ridge, TN.
[16] The Georgia Home-A-Syst Program, November 2002, "Energy Tips for Homes in Georgia", Bulletin #HACE-E-48, University of Georgia.
[17] Ibid.
[18] Ibid.

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
Landscape for shade	Shade the south and west facades of the home with landscaping. Landscaping is a natural and beautiful way to keep a home more comfortable and reduce energy bills. In addition to adding aesthetic value and environmental quality, a well-placed tree, shrub or vine can deliver effective shade, reducing cooling loads in summer, and/or act as a windbreak, reducing heating loads in winter.[19]	**N, E**
Windows		
High-performance spectrally selective windows	Tinted glazing or glazing coated with a material with optical properties that are transparent to some wavelengths of energy and reflective to others. Typical spectrally selective coatings are transparent to visible light and reflect short-wave and long-wave infrared radiation. Low-emittance (Low-E) coating, an example of a spectrally selective coating, is a thin, virtually invisible metal or metallic oxide layer on glass or plastic that modifies surface properties to reflect long-wave infrared radiation thus reducing overall heat loss, and reflects near-IR radiation, thus reducing cooling loads.	**N, E**
Argon-filled windows	An inert, nontoxic gas used in insulating glass units to reduce heat transfer.	**N**
Triple-glazed windows	The use of three layers of glass increases a window's insulation properties, but may also reduce beneficial solar heat gain.	**N**
Aerogel/vacuum windows	A microporous, transparent silicate foam used as a glazing cavity fill material, offering possible U-values below 0.10 BTU/(h-sq ft-°F) or 0.56 W/(sq m-°C).	**N**
Energy-efficient low-E storm windows	Interior storm windows effectively increase the energy performance of a home by updating single-pane windows at significant cost savings over window replacement. Panes are available in low-E glazing to resist heat gain and in UV-resistant glazing to reduce UV damage to interior furnishings.	**N, E**
Integrated window wall	An integrated window wall can be designed to minimize thermal short circuits; reduce air and water leakage; control solar gains; provide superior night insulation; and be self-shading.	**N**
Zero energy dynamic window	This design concept maximizes solar gain when heating is needed; blocks solar gains to minimize peak and reduce cooling energy; and turns windows from energy drain to energy gain.	**N**
Dynamic window with operable shades	This concept integrates operable window shades with window structure and automates shading operation for peak demand control, as well as permitting solar heat gain during the heating season.	**N**
Smart window (electro-chromatic)	Special glazing that can be switched from clear to opaque by an electric current. This concept minimizes unwanted heat gain automatically.	**N**
Solar screens	Solar screens are often the least expensive window-shading option that retains a full view through the window. Solar screens can be removed in winter to permit solar heating.	**E**
Weather-stripping existing doors	When larger air leakage pathways have been remedied, weather-stripping can be a next step in improving air tightness.	**E**
Window repair techniques	Techniques include weatherstripping of sashes, caulking and installation of vinyl jamb liners. This can be cost-effective if the old window is loose and leaky.	**E**

[19] Wilson, Alex and John Morrill, 1996. "Consumer Guide to Home Energy Savings." American Council for an Energy-Efficient Economy, Washington, DC.

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
Interior window treatments	Interior window treatments with reflective surfaces—either metalized or bright white—can block solar heat effectively. Opaque roller shades with white surfaces facing the exterior repel about 80% of the solar heat entering the window.	**E**
Reflective window films	Metalized plastic window films (similar to those applied to automotive windows) can block 50% to 75% of the solar heat transmitted by a single-pane glass.	**E**
Awnings	Awnings are expensive but popular in hot, sunny climates because they intercept solar heat before it gets to the window.	**N, E**
Lighting/Appliances		
Compact fluorescent lamps (CFL)	CFLs use 66% less energy and last up to ten times as long as incandescent bulbs.	**N, E**
Multi-lamp ballast, plug-and-play kitchen lighting system	This multi-lamp system is built around the use of multiple, two-lamp ballasts for a low-cost (one ballast per two down lights), scalable and field-proven design. The plug-and-play wiring connections require 50% less field wiring and improve safety.	**N**
Water heating		
On-demand hot water recirculation	A recirculating pump rapidly pulls hot water from a water heater while simultaneously sending cooled-off water from the hot water lines back to the water heater to be reheated. In addition to having the convenience of hot water on-demand, the system conserves water and can save energy.	**N**
PEX piping (with some copper)	PEX (cross-linked polyethylene) piping consists of molecular chains linked into a three-dimensional network that makes PEX durable over a wide range of temperatures and chemicals. It can be used for manifold piping systems.	**N**
Solar hot water	Solar hot water heaters use the sun to heat either water or a heat-transfer fluid in collectors. There are passive systems and active systems. A typical system will reduce the need for conventional water heating by about two-thirds.	**N**
Tankless water heaters	Tankless water heaters provide hot water when needed without storage, thereby reducing or eliminating standby losses. Tankless water heaters can be used for supplementary heat, such as a booster to a solar hot water system, or to meet all hot water needs.	**N, E**
Water heater insulation	Water heater insulation is one of the most effective and least expensive energy conservation measures possible. Money spent on water heater insulation can repay itself in less than a year. Important safety precautions must be taken when performing this task, however.	**N, E**
Hot water pipe insulation	Pipe insulation slows heat conduction through the water distribution pipes. Pipe insulation also reduces heat losses from convecting hot water, which rises into nearby pipes, cools and then returns to the tank. Pipe insulation is usually either a foam tube slit lengthwise or a fiberglass wrap.[20]	**N, E**

[20] Home Energy Magazine, 2004. "Bathroom Remodeling (Let the Energy Savings Flow)." Home Energy Magazine, Berkeley, CA.

Technology	Description/application	Suitability for New (N) homes /Existing (E) homes
Heat pump water heater	Heat pump water heaters (HPWH) are a good choice for making domestic hot water when the house is in a cooling-dominated climate, or in a very humid climate, or where electric rates are higher than average and the house is totally electric.	**N**
Thermal trap for water heaters	To prevent heat loss caused by convection loops, thermal traps and pipe insulation should be installed on the first few feet leading out of the tank. The simplest thermal trap is a small one-way valve that can be easily inserted where the pipes enter the tank.	**E**

C. DISSEMINATION CONCEPTS

This appendix is divided into two major sections:

1. **Dissemination Strategy** – methods and channels by which energy-efficiency retrofit information may be distributed to the maximum number of people in the target audiences.
2. **Program Concepts** – concepts for energy efficiency programs for existing manufactured homes that have the potential to motivate large segments of the existing home owning and/or used home buying public.

In order to develop the dissemination plan and program concepts, interviews were conducted with a variety of organizations in whose interest it is to improve the energy efficiency of existing manufactured homes. These organizations include consumer representatives; non-profit weatherization agencies; manufactured home community owners; manufacturers; retailers; trade allies; and other organizations vested in the existing home sector. These are groups that understand the motivations of existing homeowners and effective strategies for reaching out to this difficult-to-reach segment of the population.

Dissemination

The dissemination strategy descriptions are segmented by partner organization. Each section is further divided into four parts: 1) the organization's basis of ***Interest*** in improving energy efficiency in existing manufactured homes; 2) the ***Resources*** they have available to offer support; and 3) a description of the ***Dissemination*** path offered by the organization.

The dissemination partners provide access to two primary segments of interest: professional trade contractors specializing in energy efficiency retrofits; and owners and residents of manufactured homes. The home owners are the ultimate end-users of the information and the primary targets for dissemination of information that can be used to improve the energy efficiency of existing manufactured homes. The professionals, while not direct users of this information, can serve as conduits to deliver the materials to consumers.

The potential dissemination partners are listed in Table 3 and described in the section that follows.

Table 3 Summary of Dissemination Partners and Audience They Reach

Dissemination partner(s)	Primary target audience
Manufactured home community owners	Residents of manufactured home communities
University extension programs	Rural homeowners
Weatherization assistance programs	Low-income homeowners Weatherization contractors
U.S. Environmental Protection Agency	Home performance contractors Homeowners
Building Performance Institute	Home performance contractors
Utilities and utility cooperatives	Homeowners within affected utility service territories
Manufactured home finance companies	Homeowners still paying off their loans
State energy offices and programs	Homeowners interested in energy efficiency

Manufactured Home Community Owners

Interest: Lower monthly costs for tenants, thereby improving affordability and reducing defaults and vacancies.

Resources: Access to, and strong relationships with, existing homeowners.

Dissemination: Of the nearly nine million manufactured homes in the nation, about one-third are located in manufactured home communities. MHRA member companies own or manage approximately 2,000 of these communities, containing over a million manufactured homes. This is a direct channel to reach out to a large segment of the existing manufactured housing stock.

Communities might be natural conduits for the following types of initiatives:

1. Provide energy efficiency rehab guidelines to community owners for their maintenance staff, who may be involved in rehabilitating existing homes that are owned by the community or on behalf of individual home owners.
2. Distribute information to park residents through mailings or as handouts in manufactured home community centers.
3. Provide electronic copies of the information on manufactured home community websites.
4. Promote the availability of the guidelines in manufactured home community newsletters.
5. Develop community-based programs to require, assist or convince residents to implement energy efficiency upgrades and maintenance. Community owners could use the guidelines as the foundation for such programs.

University Extension Programs

Interest: The Extension Programs are a national network of university-based groups that conduct educational programs to enhance economic development in rural America. Included in their charter is helping to improve housing affordability. Improving energy is a common theme of Extension activities.

Resources: Network of educators in rural areas who are knowledgeable about housing and energy issues. Extension agents are particularly well positioned to reach out to homeowners in rural areas.

Dissemination: A number of dissemination and education opportunities exist through the University Extension Service program of the U.S. Department of Agriculture. The extension service program maintains representatives in each county in the nation, tied together at the state level through a university and at the national level through a coordinating office.

Discussions were held with representatives from two extension service programs and following are samples of some opportunities:

New York

Consumer Education Program for Residential Energy Efficiency—this program operated by Cornell University is geared towards extension service educators (there is one in each county in New York.) The program conducts a series of "*town meetings*" via wide area network to 10 locations throughout the state. Energy efficiency techniques and energy retrofit materials could be the subject of one of these meetings. Materials could be made available to the extension service educators in each county of the State.

Georgia

The university extension service in Georgia has developed a four-page brochure to promote energy efficiency retrofits and behavior in housing. Many of the techniques mentioned in the brochure are applicable to manufactured housing, but it does not detail techniques that are specific to manufactured housing. Information specific to manufactured housing could be offered on the extension service

website[21] and in their outreach programs. The Georgia Extension Service is an appropriate outlet for dissemination, given their mission and network of representatives in all 159 of Georgia's counties. The extension service can write newsletters and press releases promoting the availability of energy efficiency information.

National

The university extension programs are tied together at the national level through the office of the National Program Leader for Housing and Environment, Cooperative State Research, Education and Extension Service/U.S. Department of Agriculture. Opportunities to promote energy efficiency programs through this office include:

- Publicize the availability of information to the network of extension services through the programs' internal email list serve. This will help identify opportunities in states such as those identified in New York and Georgia.
- Attend and speak at national conferences such as the Housing Education and Research Association conference. Researchers, teachers and state extension specialists from across the country attend this conference.

U.S. Department of Energy Weatherization Assistance Programs

Interest: The goal of the Weatherization Assistance Programs (WAP) is to improve energy efficiency for low-income households.

Resources: Networks of weatherization contractors in each state. Lists of low-income clients who are candidates for weatherization and are interested in improving energy efficiency. The WAPs generally have more clients requesting their services than they are able to accommodate.

Dissemination: The large network (2000+) of weatherization contractors, accessible through weatherization agencies, provides a dissemination channel for professional advice on retrofitting manufactured homes for energy efficiency.

These contractors are also a conduit to reach homeowners interested in energy efficiency with leave-behind educational information. As weatherization agencies often have far more applicants than they can accommodate with their limited budget, the list of waiting applicants is a potential pool of ready and willing homeowners.

The national DOE Weatherization office can coordinate the distribution of electronic and printed information to weatherization agencies, weatherization training centers and contractors.

U.S. Environmental Protection Agency

Interest: EPA is charged with protecting the environment and this agency has included in this mission improving the energy efficiency in existing homes.

Resources: EPA's existing Energy Star Labeled Homes program for new manufactured homes may serve as the template for an energy efficiency program for existing homes. EPA's Home Performance with Energy Star program has partners in six regions of the country with more participating each year. These partners have networks of weatherization contractors trained to perform energy efficiency retrofits.

Dissemination: The large and growing network of trained contractors, accessible through Home Performance with Energy Star program partners, provides a dissemination channel for distributing information to contractors engaged in energy efficiency retrofits. The program focus is on existing site built homes, and therefore the opportunity exists to expand the knowledge of these contractors

[21] http://www.fcs.uga.edu/extension/house_pubs.php.

with respect to the unique energy efficiency techniques, opportunities and challenges of manufactured homes.

These contractors may also serve as a conduit to distribute educational information to manufactured home owners they visit in the course of performing home inspections/audits.

Building Performance Institute

Interest: BPI's mission is to enhance the health, safety, comfort, durability and energy efficiency of residential buildings by providing skills verification and promoting best practices by building trades.

Resources: Network of trained contractors and affiliated training organizations.

Dissemination: BPI is a not-for-profit organization dedicated to promoting excellence in the building trades. BPI sets standards and articulates best practices for residential contractors, particularly those engaged in home performance and energy-related retrofits. Certifications for technicians are provided upon successful completion of a knowledge-based written test and a hands-on performance-based examination demonstrating knowledge of building science principles and competency at diagnostic evaluations and installations. Corporate accreditation is issued to companies employing certified personnel who agree to provide a superior level of service to their customers in compliance with BPI's Accreditation Memorandum of Agreement. Remodelers, builders, insulation contractors and heating and cooling contractors are examples of the trades that may use building performance certification.

Home improvement programs sponsored by government agencies, utilities and other private companies are increasingly adopting credentialing requirements for contractor eligibility. In 2001, the U.S. Environmental Protection Agency expanded their Energy Star program to include an initiative directed at improvement of existing homes. This project, called Home Performance with Energy Star, utilizes BPI contractor accreditation as one of the qualifying credentials for contractor participation.

In addition, some states have adopted BPI certification as a means of ensuring a consistent skill base for technicians delivering low income Weatherization Assistance Program services funded by the U.S. Department of Energy. BPI's Affiliate Network assists in the delivery of a variety of programs across the U.S.

Information may be disseminated to the BPI network of affiliates through direct distribution and via articles in BPI's Performance Matters Newsletter. BPI's affiliates in turn can provide information to their certified contractors and trainees on an ongoing basis.

Utilities and Utility Cooperatives

Interest: Reduce peak power demand.

Resources: Contact information for past homebuyers (particularly Electric Cooperatives that have a disproportionately large percentage of manufactured homes on their service lines). Data on energy costs of current homeowners. Relationships with homeowners.

Dissemination: Identify and coordinate distribution of energy efficiency information with utilities serving large populations of manufactured homes. Candidates include the National Rural Electric Cooperative Association, the Tennessee Valley Authority and other power providers. Information may be distributed as bill stuffers to manufactured home residents. Materials can be developed for use by utility representatives when discussing solutions to large energy costs with manufactured home owners with high bill complaints, a major source of frustration for rural electricity providers.

Manufactured home finance companies

Interest: Lower monthly energy burden, thereby reducing defaults.

Resources: Lists of homeowners; source of funds for financing energy improvements.

Dissemination: Finance companies have a relationship with existing homeowners who are still paying off their loans. The finance companies can provide consumer energy efficiency

State Energy Offices and Programs

Interest: Lower monthly energy burden of state residents and encouragement of energy conservation.

Resources: Extensive websites on energy efficiency subjects.

Dissemination: Information may be made available to visitors to these websites.

Other Organizations

The following additional organizations may provide dissemination opportunities, primarily though their websites.

- Housing Education and Research Association
- Rural Housing Coalition (national and state organizations)
- Consumer Federation of America
- Re-Build America program (DOE) – Energy Smart Communities Program
- National Low Income Housing Coalition

Publications

In addition to the dissemination channels available through the partner organizations listed above, a number of publications could be directly contacted with press releases to promote the availability of energy efficiency information or programs. These publications may be divided into two distinct groups: 1) trade publications primarily serving professional and trade audiences and 2) popular magazines read by homeowners. Consumer publications are listed in Table 4 along with circulation figures and audience type they target. Table 5 contains a list of popular magazines read by manufactured homes residents, along with the percentage homeowners that read the publication.

Among this latter list, home-oriented magazines such as Good Housekeeping, Southern Living and Family Handyman might prove most receptive to printing information about home energy efficiency.

Table 4 Trade Publications to Contact with Press Releases

Name	Type	Relevant audience
Energy Design Update	Newsletter	Home performance contractors
Environmental Building News	Newsletter	Home performance contractors
Manufactured home community newsletters	Newsletters	Manufactured home community residents
Modern Homes (MHI)	Trade magazine	Manufactured home community owners
Home Energy Magazine	Trade magazine	Home performance contractors
Mhvillage.com	Website	Manufactured home buyers and sellers
Manufactured housing state association newsletters	Newsletters	Manufactured home community owners, contractors and other service providers
Crittenden's Manufactured Housing Report	Newsletter	Manufactured home community owners

Table 5 Popular Magazines Read by Residents of Manufactured Homes

Magazine	Respondents (%)	Magazine	Respondents (%)
Reader's Digest	33	Parenting	8
Family Circle	26	Cooking Light	7
Woman's Day	23	Family Handyman	6
Parade (Newspaper Insert)	22	Sports Illustrated	5
Modern Maturity	20	Popular Mechanics	5
TV Guide	19	Car and Driver	4
Good Housekeeping	17	Entertainment Weekly	4
Ladies' Home Journal	13	Mature Outlook	3
People	12	Life	2
McCall's	10	Sunset	2
Southern Living	9	Money	2
Time	8	Fortune	1

Source: Manufactured Homes: The Market Facts 2002 Report, Foremost Insurance, Inc.

Program Concepts

The following section describes program concepts that are intended to motivate owners of manufactured homes to take proactive steps to improve energy performance. The potential exists to bring together the interests of diverse organizations that all have a stake in improving the efficiency of existing homes and, through strategic partnerships, leverage the interests and reach of these organizations. These program concepts need further evaluation and development in consultation with potential program partners to determine their feasibility and likelihood of success.

The six program concepts are summarized in Table 6 and described in the section that follows. Several of these concepts could be used in combination, magnifying their impact.

Table 6 Summary of Program Concepts

Concept	Major partner(s)	Target audience
Certified used home program	Community owners and possibly retailers	Purchasers of used manufactured homes
Increased valuations in the NADA Manufactured Housing Appraisal Guide	NADA	Sellers and purchasers of used manufactured homes
Utility incentive programs	Utilities	Existing homeowners in utility service territories
Energy-efficiency home improvement loan program	Fannie Mae, Freddie Mac, primary lenders	Purchasers and owners of existing homes
Website clearinghouse	Dissemination channels listed above	Homeowners
Energy Star for Homes program	EPA and EPA partners	Home performance contractors

Rehabilitating homes at resale—a certified used home program

In recent years auto makers have used certified pre-owned car programs to bolster sales, develop brand loyalty and extract greater value from their operations. For the consumer, the programs add a level of quality insurance and product performance that did not exist before for used cars. Applying a similar strategy, a certification-type program could be developed for the rehabilitation of older homes that would be performed on behalf of sellers of used manufactured homes.

Such a concept could be used to communicate to consumers and potential buyers of existing manufactured homes that a prescribed set of energy efficiency measures have been installed. Under such a program, the home would be inspected by trained trades people (possibly certified by an organization such as the Building Performance Institute) and a standard set of diagnostic tests would be performed and energy efficiency retrofit measures installed in the home as necessary. These measures would be established by prior analysis and could be based on the most cost-effective techniques.

If the home already contained some or all of the measures required by the program due to previous weatherization efforts or good quality initial construction, then the inspection process would confirm and certify through a label or certificate that these measures exist. Rather than being backed by the manufacturer, as in the case with autos, the energy-inspected/upgraded manufactured home program could be backed by an industry or governmental organization that establishes the contractor credentialing requirements and energy efficiency retrofit measures; issues labels or certificates; ensures program quality through spot checks or other means; and performs overall administrative functions, such as record-keeping.

Possible program partners

- **Manufactured home community home re-sales.** Community owners might facilitate the energy upgrades, using in-house staff and/or an outside contractor.
- **Manufactured home retailers**. Retailers that sell pre-owned homes could certify used homes on their sales lots. Retrofit measures would have to be restricted to those not affected by installation, or the home installation process would have to be incorporated into the program.
- **Real estate agents.** Realtors in rural areas that sell manufactured homes may be a conduit for reaching owners of manufactured homes located on private land.

Benefits of the program

- Guarantee to the consumer that they are buying a home with a baseline of energy efficiency measures installed, although a level of energy performance would not be guaranteed.
- Enable retailers and community owners to differentiate homes that have these upgrades from homes that do not.
- Reduce energy use by increasing the energy efficiency of existing manufactured homes that are on the re-sale market.
- Basic home safety checks (such as combustion safety and smoke alarms) can be incorporated into the program.
- More extensive energy efficiency upgrades can be marketed to the home buyer (and incorporated into the loan).

National Association of Automobile Dealers Manufactured Housing Appraisal Guide

With its Manufactured Housing Appraisal Guide, the National Association of Automobile Dealers sets a value benchmark for existing manufactured homes. This guide, which is updated three times per year, is used by lenders, insurers, home retailers, realtors; and others in the industry to set selling prices for existing manufactured homes.

The NADA guidebook lists an increased value to be added to the base value of the home for certain energy efficiency options, including:

- Upgraded insulation
- Window film coatings

- Dual glazed windows
- Storm windows
- Storm doors
- Super Good Cents/Natural Choice program home (SGC/NC)
- Weather barrier/sheathing board
- Water heater insulation blanket

An additional value could be suggested for homes that have undergone other energy efficiency upgrades not already considered by NADA such as duct sealing, shell sealing or equipment efficiency upgrades. A value increase can also be tied to an energy efficiency rehab program as is done for new homes in the case of SGC/NC. Such a program may include a standard package of energy efficiency measures that are performed on a home as described above under Rehabilitating homes at resale—a certified used home program (page 74).

Utility Incentive Programs

High bill complaints are a source of frustration for electric utilities, costing them money in the form of time spent dealing with the complaints and eventually in lost revenue from unpaid bills. Extreme situations where high electric bills contribute to bankruptcy, foreclosure and eviction of a customer can result in thousands of dollars in lost revenue for the utility. Assisting customers in reining in their burdensome electricity consumption is therefore in the interest of the utility company.

Improving the energy efficiency of their customers' homes also has the benefit of reducing peak heating and cooling loads that may stress a power supplier's generation and/or transmission capacity.

Incentive programs may be used to encourage high-risk homeowners to implement energy efficiency improvements to their homes. High-risk homeowners may be identified as those living in homes with a history of consistently high electric bills; past records of complaints; or a history of unpaid or late-paid bills. This evidence is particularly telling if the same home repeatedly bears these indicators over multiple occupants. Manufactured housing, which often houses the lower-income segment of a population, is particularly exposed to this high-risk group.

Incentive programs may take a number of forms. An electric utility may choose to provide to the at-risk population direct incentives for implementation of energy efficiency improvements or it may wish to underwrite one of the other program types described in this section. For example, the utility may choose to become a backing organization for a certified used home program. In either case, the utility may tie its incentive program to the implementation of energy efficiency recommendations developed through this project.

The first steps in developing a utility incentive program would be to 1) identify utilities interested in implementing such a program and 2) research other energy efficiency incentive programs, past and present, and examining their effectiveness and costs.

Energy-Efficiency Home Improvement Loan Program

Fannie Mae has an energy efficient mortgage program for one-family, new or existing owner-occupied homes called the Energy Efficient Mortgage (EEM). Fannie Mae recognizes that energy-efficient homes cost homeowners less to operate on a monthly basis than standard homes because they use less energy. Therefore, borrowers who choose energy-efficient homes can afford higher mortgage payments because they will likely spend less on energy costs. The EEM allows borrowers to qualify for a larger mortgage as a result of the energy savings. Under the current Fannie Mae program, existing homes can qualify for the EEM if upgraded with cost-effective efficiency measures. One hundred percent of energy improvements can be financed—up to 15% of the value of an existing home. The value of the energy efficiency measures, as determined by a third party energy rater, is

added to the home's appraised value. The estimated monthly energy savings are added to borrower income in the qualification calculation. Ironically, manufactured housing owners cannot take advantage of this program.

Fannie Mae's program benefits purchasers of existing homes. However, to have a greater impact on the population of manufactured homes that can benefit from efficiency upgrades, program development should focus on two areas:

1. Improving the effectiveness of the EEM or similar programs for manufactured homes. This might include eliminating the requirement for a costly HERS rating of each home, possibly though a tie-in to a program like the certified used manufactured home program described above.
2. Making an energy-efficient home improvement loan available to owners of inefficient existing manufactured homes that wish to upgrade without moving.

Programs can be developed for financing energy improvements that capture the many win-win opportunities in the population of existing manufactured homes.

Website Clearinghouse

There are a wide variety of programs presently available for homeowners, but no central location to learn about all the opportunities for a given location. A web-based clearinghouse would serve as a central source of such information with links to energy efficiency retrofit programs available to owners of manufactured homes. The website would provide visitors with guidance on energy efficiency improvements. The website could be promoted through many of the channels listed in the dissemination section above.

Energy Star for Homes Program

EPA's Home Performance with Energy Star program began in 2001 and has partner organizations in six states. Partners are typically non-profit or governmental agencies. The program focus is on establishing a network of trained energy improvement contractors that operate and promote efficiency under the Energy Star brand.

Contractors are required to be certified by the Building Performance Institute or equivalent organization (or be monitored by the partner organization). Contractors must follow an established set of steps in each home, including an audit and presentation of a report detailing savings and costs to the consumer. They must also have the capability to complete the work directly or through subcontractors. Partner programs sign up contractors; ensure their credentials (and in some cases their performance); and direct consumers to them. In some cases, partners offer rebates and/or discounted financing for qualifying consumers who implement measures.

Home Performance with Energy Star is not a labeling program, and homes are not rehabbed to any set level of energy efficiency, nor are there any required sets of measures that must be performed on any given home. Consumers may elect to purchase none, some or all of the options presented by the contractor. Because there are no set energy efficiency standards for the homes worked on under this program, there is limited ability to designate the home with an identifier that might improve resale value or enable the owner to secure superior financing terms (outside of the financing offered by some program partners). As currently structured, this program would not enable manufactured home community owners to designate existing homes as energy efficient and communicate to potential buyers their improved energy efficiency.

In partnership with EPA, a single industry protocol for energy efficiency in existing manufactured homes could be established. This might take on elements of the certified used home program described above, but with an overlay of the Energy Star marketing power.