

Chapter 3

Consequences of the Shift to Industrialized Housing

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How will increased factory construction affect the quality or cost of products for consumers, the structure of the construction industry, and industry employment? No fixed answers exist for these questions, since factory-based construction takes on a variety of forms. In Sweden, for example, factory produc-

tion signifies quality housing using skilled craft workers in highly automated factories, while in the United States it often relates to low-quality units made by workers with few skills. The outcome hinges on the manufacturer's perception of market demand, and on the effects of public regulation.

EMPLOYMENT IMPACTS

Productivity

Above specific trends in the residential construction industry lies the question of overall productivity: is it going up or down, and how do we know?

Quantitative efforts to assess construction efficiency and productivity in the homebuilding industry resemble the guidelines used to analyze more conventional industries. This approach may be misleading, because conventional indices of economic performance, such as levels of "capitalization" and "value added by manufacture," do not always apply to the residential construction industry. As one economist explains, "the industry is diverse, dispersed, detached, and discontinuous—all characteristics which are viewed with dismay by analysts of more stable, highly-capitalized, conventionally-deployed industries."¹

The diversity of the construction industry stems from the specialized nature of subcontracting units, which constitute over 70 percent of all construction establishments in the United States. This qualitative and geographic "unit spread" has resulted from an uneven distribution of consumer demand, labor markets, and availability of materials. Similarly, detachment of construction enterprises arises from diverse work movement patterns, the predominance of short-term subcontracting arrangements among different specialty firms, and the builders' continued reliance on a shifting array of building material and

component suppliers. Finally, seasonal and annual fluctuations in consumer demand, material availability, and environmental conditions also account for discontinuity.

These characteristics reflect the housing industry's adaptation to the unpredictable social and economic forces that affect demand. However, the fact remains that the measured productivity of the construction industry has fallen in recent years. The Productivity Index, which measures changes in output per man-hour, rose from 70 in 1947 to 110 in the mid-1960s, but it now stands at about 80. While no single consensus explains why new technologies have not increased productivity, several theories have been offered:

- The deflators used to adjust the value of buildings may not properly adjust for improved quality.
- Repair and maintenance may be underreported. Since the productivity of renovation work does not equal that of new construction, the overall productivity of the industry should fall as the ratio of renovation work to new construction increases. However, it is difficult to obtain accurate data on renovation. Because of the unclear ratio between these two activities, changes in their combined productivity are not easily interpreted.
- Increased uncertainty resulting from fluctuations in the demand for buildings has forced the industry to reduce the capital/labor ratio. Capital/labor ratios increased 4.2 percent per year

¹Francis T. Ventre, "Innovation in Residential Construction," *Technology Review*, vol. 11, 1979, pp. 51-59.

from 1950 to 1968, but declined by 0.8 percent per year from 1968 to 1974.²

- Large numbers of young, inexperienced workers entered the work force as the baby-boom generation came of age. Between 1968 and 1978, the number of 16- to 24-year-old workers increased from 15.3 percent of the construction work force to 24.2 percent. There has also been a significant rise in the number of new firms. The fraction of homebuilding firms less than 5 years old increased by a factor of 3 between 1960 and 1976.
- Levels of union participation and apprenticeship are falling.
- Offsite construction work, such as factory component construction, is not counted properly. The ratio of value added by the construction industry—the value of industry sales minus purchases from other industries—to gross output fell from 51.1 percent in 1958 to 44.6 percent in 1979.³ In other words, a growing fraction of the value of homes sold was produced by suppliers to the industry, rather than by the industry itself. Also, between 1967 and 1973, 34 of the 41 industries that produced materials for the construction industry grew faster than the industry itself, and 23 grew twice as fast. The fastest growers made prefabricated wood components and structural wood members for residences, or items like wooden kitchen cabinets. Some of these firms outstripped the construction industry by a factor of 8. This suggests that factory productivity is higher than site productivity for many activities.
- There may be scale effects. Productivity was undoubtedly higher during the boom period of tract home construction.

While the U.S. housing industry may appear unproductive as a whole, it does employ a smaller fraction of the total work force than any other OECD nation, despite high U.S. construction rates. About 5.4 percent of American workers served the construction industry in 1980, compared with 11 percent in Japan, Italy, and The Netherlands, and 7 percent in France and the United Kingdom.⁴

²H. Kemble Stokes, Jr., "An Examination of Productivity Decline in the Construction Industry," *The Review of Economics and Statistics*, vol. 63, No. 4, November 1981, pp. 495-502.

³J.E. Cremeans, "Productivity in the Construction Industry," *The Construction Review*, May/June 1981, pp. 4-6.

⁴Statistical yearbook, United Nations, 1981 and 1983.

This set of considerations does not explain recent patterns in construction productivity. Answers will arrive with better data.

Employment Levels

Given the annual fluctuation in housing demand and residential construction activity, accurate employment trends are difficult to project. Nevertheless, recent data on employment may help to examine labor requirements.

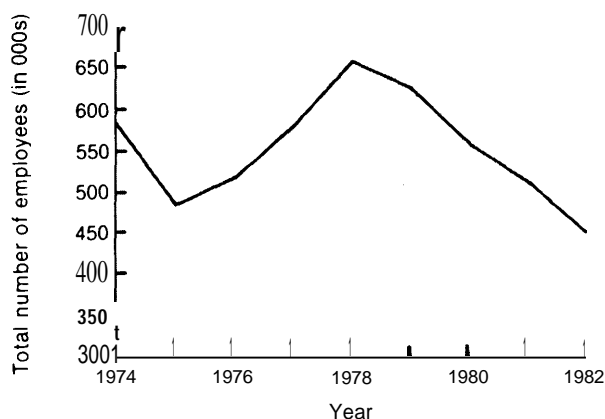
The U.S. Department of Labor estimated that 483,100 persons worked as general building contractors for residential buildings in 1983. Of this total, 346,100, or 72 percent, were classified as construction workers. The "manufactured" (mobile) home industry, according to the most recent *Annual Survey of Manufacturers* report, employed 42,000 persons in 1982, of which 34,600 were classified as production workers.

Detailed labor statistics on the panelized home, the modular home, and component manufacturers do not exist. However, the *Annual Survey of Manufacturers* does compile labor statistics for the prefabricated wood building industry,⁵ which includes panelized homes, modular homes, and building components. While this industry classification also encompasses prefabricated structures, panels, and components for nonresidential uses, products for residential use comprise approximately 75 percent of all industry shipments. [In 1982, employees in the prefabricated wood building industry numbered 16,800; 11,424 of these were classified as production workers.

Figure 7 illustrates employment trends for the general building contractor sector, and figure 8 provides time series employment data for the "manufactured" (mobile) home and prefabricated wood building industries. Both figures reveal that the last peak in employment levels for these employment classifications occurred in the late 1970s. Referring to figure 8, the decline in total employment in both the "manufactured" (mobile) home and the prefabricated wood buildings industries corresponds with an overall decrease in "manufactured" (mobile), modular, and panelized housing units produced between 1978 and 1982.

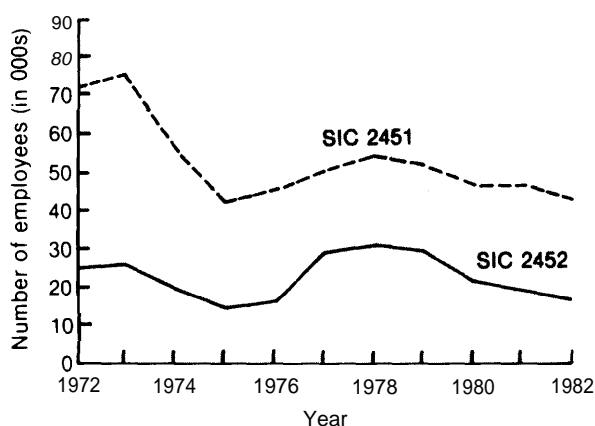
⁵SIC 2452.

Figure 7.—Residential Building Contractors



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics

Figure 8.—Total Number of Employees in the Mobile Home Industry (SIC 2451) and the Prefabricated Wood Buildings Industry (SIC 2452)

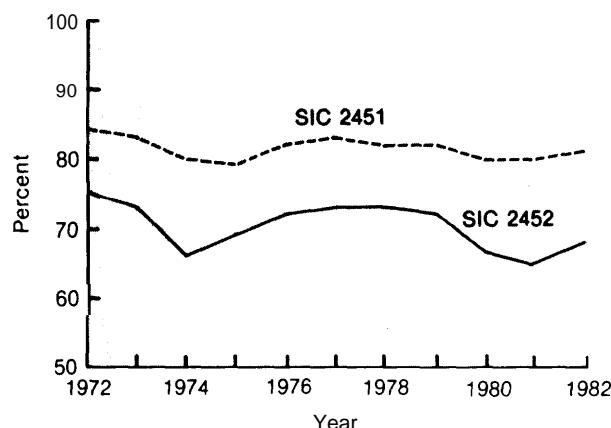


SOURCE: U.S. Department of Labor, Bureau of Labor Statistics

The proportion of production workers to all employees in the prefabricated wood building industry declined from 75 percent in 1967 to 68 percent in 1982. Production workers in the “manufactured” (mobile) home industry fell from 84 to 81 percent of the total work force between 1972 and 1982 (see figure 9). While some analysts attribute the increases in managerial positions to more government regulation, this development remains difficult to explain.

As for regional variation, when demand for new housing expands, firms compete for each others workers. This causes problems in the Northeast, where the number of potential employees is low. In

Figure 9.—Production Workers as a Percent of Total Employment in the Mobile Home Industry (SIC 2451) and the Prefabricated Wood Buildings Industry (SIC 2452)



SOURCE: U.S. Bureau of the Census, Census of Manufacturers

contrast, an ample labor supply exists in the along the Mexican border, where many manufacturers employ alien workers; little skill is required, and the ability to read or write English is not of great importance. However, this creates problems of quality control, which, in turn, requires more super-visors.

Skill Levels and Unionization

Dependence on unskilled and semiskilled labor has been a motivating force in the shift to industrialized housing. One of the principal causes of industrialization is to reduce the ratio of labor costs to total product costs. Systematic, factory-controlled production processes allow manufacturers to train the labor force:

... to repeat only certain tasks, and to repeat them under factory-supervised conditions. This task simplification means that any given worker need not be skilled in a trade, per se. Rather, the worker need only acquire skills necessary for the assigned task. When changes in unit design require a new set of tasks, workers are trained for the new tasks; no necessary, *a priori* generic and transferable skills are presumed.⁶

In other words, workers have neither need nor opportunity to acquire new skills.

⁶Thomas E. Nutt-Powell, *Manufactured Homes: Making Sense of a Housing Opportunity* (Boston, MA: Auburn House Publishing Co., 1982).

Little data exist on skill levels, both because there has been no serious effort to collect the statistics, and as a result of the nature of labor requirements and the work force. To remedy the problem, in preparing this study, OTA project staff contacted 50 companies active in the industrialized housing and component industry. The resulting survey reveals the widespread use of unskilled or semiskilled workers in the component and “manufactured” (mobile) categories—approximately 80 percent of the work force (table 5). Reliance on low-skilled workers stems from the fact that these products involve a great deal of simple assembly of cut-to-size parts.

The greater number of skilled workers in the modular sector—32 percent as opposed to 21 percent—stems from the more specialized tasks associated with modular units, such as plumbing, electrical work, and cabinet work. The higher percentage of college graduates in component and modular manufacturing may be design engineers. Typically, skilled workers in a “manufactured” (mobile) home plant perform tasks associated with chassis welding, plumbing, and electrical wiring. An average plant maintains a skilled worker in each trade area, who supervises the performance of unskilled, factory-trained workers. When skilled or semiskilled labor is required, some “manufactured” (mobile) and modular home producers hire on a fixed-fee, subcontracting basis. Using a subcontracted labor force, manufacturers do not pay overtime or provide worker benefit plans.

While the carpenter’s union has contracts with a number of “manufactured” (mobile) housing firms, the industry as a whole lacks substantial union in-

volvement. Production workers in the industrialized housing industry have relatively low skill levels. In addition to factory employees, the majority of workers who assemble panelized homes or work for large production builders do not belong to unions. Union affiliation in the residential construction industry has fallen steadily since World War II.

Even less unionization occurs in the “manufactured” (mobile) home industry. Possible explanations include: the small size of an average plant; the rural setting of most plants; the industry’s slow beginnings; and the fact that the industry developed after the era of large-scale union organizing. When unionization does occur, it follows industry lines according to task-specific skill requirements and assembly line production methods.

Contrastingly, workers in site-built housing construction and onsite assembly of factory-built homes do tend to be affiliated with trade unions. One analyst asserts, “the managements of some firms with more than one manufacturing facility have made deliberate efforts to ensure that their plants, if unionized, are unionized by different unions.”⁸ This union fragmentation strategy reflects management efforts to control their bargaining position with the unions. The same writer believes that the classification of union members in the “manufactured” (mobile) home industry as assemblers, rather than on a job or craft basis, has allowed the “mobile home plant management to rearrange tasks and manpower as necessary to increase productivity, a major reason that labor in the mobile home industry shows higher productivity than conventional home building labor.”⁹

⁸Two points about the data are worth noting. First, these numbers can shift as the market changes. Second, the firms that provided this data are a small fraction of the number of companies in the industry, but their average years in the business, 23 for component producers, 22 for “mobile” producers, and 19 for modular producers, would indicate their success, and confirms the credibility of the survey results,

⁸Arthur D. Bernhardt, *Building Tomorrow. The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980),

⁹ Ibid.

Table 5.—Percentage of Work Force in Various Skill Categories

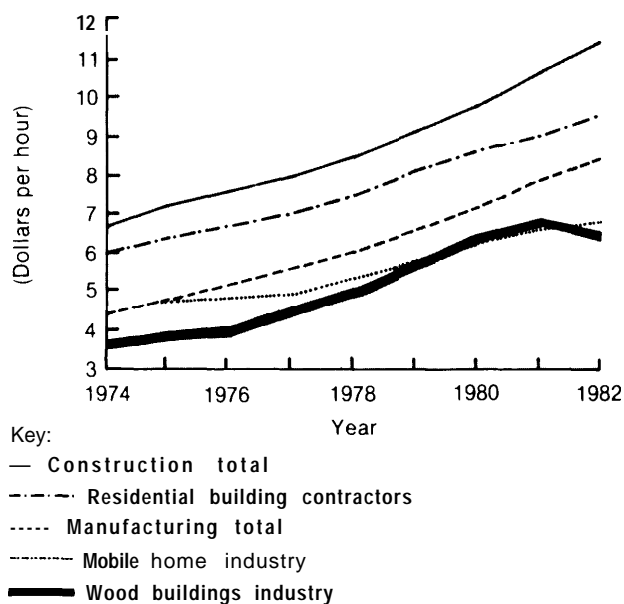
Group	Unskilled (less than 1 month)	Semiskilled (1-12 months)	Skilled		
			Not licensed/ certified	Licensed/ certified	College graduate
Component.	38	41	12	1	8
“Mobile”	41	38	15	1	5
Modular.	33	35	22	3	7

SOURCE Office of Technology Assessment, 1986.

Wage Levels

The housing construction industry's use of unskilled, non-unionized laborers has enabled the average "manufactured" (mobile), modular, and panelized home manufacturer to pay wage rates that fall below national construction industry averages. Figure 10 presents average hourly earnings for the respective housing construction and manufacturing establishments. Production workers in the "manufactured" (mobile) home and prefabricated wood building sectors have earned significantly less per hour than construction industry employees, and less than employees in the housing sector as a whole. Although general contractors have offered higher wage levels than the manufacturing sector, these

Figure 10. —Average Hourly Earnings of Employees by Industry Sector



wage levels do not equal those of the construction industry. Past trends suggest that wage level gaps between the various sectors will not close significantly in the near future.

Potential To Upgrade Job Quality

To date, the U.S. industrialized housing industry has promoted "a clear shift from traditional 'craft' skills to industrial-type 'assembly' skills, even on-site. Some predict that craft skills will become part of a lucrative, but limited market for retrofit, conversion, rehabilitation, and historical preservation."¹⁰ However, factory-based construction may not inevitably lead to the unskilled, routinized assembly-line. New technologies can create attractive, stable jobs for production workers. Employees in such facilities could be treated more like workers in automobile factories than day laborers, enjoying continuity of employment, skill acquisition, and identification with the employer or firm.

The Swedes employ factory-based construction to promote continuity in employment and to facilitate the development of an industry that provides greater returns to wages. Swedish factories resemble craft-based shops, where automated equipment amplifies individual skills. Rather than following an assembly line, Swedish factory workers craft individual structures using specially designed jigs and numerically controlled positioning, cutting, and milling systems. Whether U.S. industrialized housing producers will depart from current practice and opt for a Swedish-style approach will depend on economic and other factors that do not involve the technology itself, such as the status and potential for success of worker retraining programs.

¹⁰Eric Dluhosch, "Expert Panel on Technology Changes and Impacts on the Building Construction Industries," paper submitted to the Office of Technology Assessment, 1984.

HOUSING COSTS

Have new building technologies improved the industry's ability to lower housing costs? Unfortunately, examination of the existing data leads to ambiguous and contradictory results. With the exception of component fabrication, it is difficult to document the net economic advantages of factory-based construction in the United States, which is one reason that

new technology has not entered U.S. markets more rapidly.

Homebuilding technologies most directly affect labor and material costs, which account for approximately 50 percent of total housing costs and which have risen at less than half the rate of land costs and

financing¹¹ (see table 6). The extent to which cost savings in home construction will aid the homebuyer, and whether this will appear as increased profit for builders, will depend on the nature of local housing markets.

While precise cost comparisons are virtually impossible to construct, factory-built housing may lower costs by:

- increasing the labor productivity of construction with advanced assembly equipment,
- increasing the role of less-skilled employees willing to work for lower wages,
- decreasing construction time and construction loan costs,
- improving quality control with precision machinery and jigs,
- decreasing defects and site visits needed to repair such problems,
- reducing the seasonal nature of homebuilding, and
- facilitating the purchase of large volumes of materials.

New technologies also affect the 17 percent of total costs taken up by construction finance. Sharp reductions in the amount of time required to build a given unit—more so in the case of a multiunit project like a stacked modular—can save the factory-based builder substantial construction loan interest costs.

Construction time requirements for the various housing types depend on the building technologies employed, the skills of the workers involved, and management effectiveness. Table 7 presents construction time differentials for four types of housing.

¹¹ The Report of the President's Commission on Housing, 1982.

Table 6.—Approximate Cost Breakdown for New Single-Family Homes

	1970		1980		Percent increase
	cost	(%0)	cost	(%0)	
Land.	\$4,450	19%	\$15,500	24%	248%
Onsite labor	4,500	19	10,350	16	130
Materials	8,650	37	22,000	34	154
Financing	1,600	7	7,700	12	381
Overhead/profit . .	4,200	18	9,050	14	115
Total	\$23,400	100%	\$64,600	100%	176%

SOURCE: *The Report of the President's Commission on Housing, 1982.*

Table 7.—Construction Time Comparison

Structure type	Total assembly time
Double section mobile/modular home	1 to 2 weeks
Panelized or precut home	6 to 8 weeks
Componentized home.	4 to 12 weeks
Stick-built home.	12 to 24 weeks

SOURCE: *Automation in Housing.*

As expected, an inverse relationship exists between the use of industrialized building techniques and components and the time required for construction.

To measure the extent that existing homebuilding technologies may reduce initial costs for the homebuyer, the National Association of Home Builders (NAHB) conducted a housing technology research project in 1979. The NAHB reported that its "cost buster" house achieved a 25-percent savings in construction material and labor, compared to other homes of similar size and location. Possible savings in construction finance costs were not considered. These cost savings will vary, depending on region; production levels; and the type, size, and quality of the housing.

To translate this 25 percent labor and material savings into an "overall" scheme, a 1982 report from the U.S. Comptroller General based a cost savings analysis on the National Association of Home Builders' data. Since labor and material costs constituted approximately half of the initial cost, a 25-percent reduction in labor and construction material expenditures decreases the sales price of a home by 11.75 percent, assuming that the cost savings are not retained as builder profits. Given the median price of a house in April 1981 at \$69,300, the initial savings would total \$8,143, assuming a conventional 30-year mortgage at 15 percent interest and a 20 percent downpayment. This would create monthly savings in financing costs of \$82.41, or \$29,668 over the 30-year mortgage period. Because land and financing constitute a growing share of construction and consumer housing cost, this is a high estimate of the cost reductions that may be brought about by existing technologies. Furthermore, the timelag between the introduction and use of new homebuilding technologies suggests that new technologies will not reduce housing costs in the immediate future.

Of the various forms and types of industrialized housing, "panelized and modular homes," the Comp-

troller General's report indicates, "are not a means of significant cost savings of new single-family detached housing. The industry markets the houses on the basis of their high quality, stemming from quality-controlled factory methods, and their advantages to small builders."¹² Although the base prices of panelized and modular homes do compare favorably with conventional construction, additional costs incurred in site acquisition, site development, and utility installation may reduce their affordability.

However, panelized and modular homes can prove economical when site-building is simply not feasible on scattered sites, or in outlying rural areas that lack skilled tradespersons. In addition, panelized and modular homes can yield savings in "soft costs" for builders. Since less site work is needed for these houses than for conventional site-building methods, builders can sell more houses with the same amount of finance money. Reduced work time at the site also negates losses from theft and vandalism.

The one type of factory-built house that does offer real savings in initial cost is the "manufactured" (mobile) home. Table 8 states that the average sales price of a "manufactured" (mobile) home in 1983 was less than 25 percent of that for site-built homes;

however, sales figures for "manufactured" (mobile) homes do not include land costs and "setup" charges, which increase costs by at least 15 percent. Sales prices do reflect differences in product characteristics; while the average size of site-built homes has decreased in recent years, the typical site-built home remains larger than the "manufactured" (mobile) home.

Also included in the table is a time series cost comparison between "manufactured" (mobile) homes and site-built homes. Although the cost differential between "manufactured" (mobile) homes and site-built homes has increased over time, a cost calculation that included both the expected lifetime of each type of unit and the difference in maintenance costs would raise the effective price of the "manufactured" (mobile) units. As a 1985 report for the Department of Energy states: "Manufactured home occupants . . . consume more total energy per heated square foot than do occupants of other single-family detached homes,"¹³—48 percent more from April 1980 to March 1981, and 31 percent more 2 years later. Furthermore, the Technical Advisor for Navy Housing recently concluded that when quality and upkeep costs are taken into account, "the mobile cannot compete economically."¹⁴

¹²U.S. General Accounting Office, Comptroller General, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," Washington, DC, 1982.

¹³Pacific Northwest Laboratory, "Impact of Alternative Residential Energy Standards," November 1985, p. 33.

¹⁴Richard Hibbert, U.S. Navy, correspondence dated Mar. 6, 1986.

Table 8.—Cost and Size Comparisons of "Manufactured" (Mobile) Homes and Site-Built Homes Sold^a

	1976	1977	1978	1979	1980	1981	1982	1983	1984
"Manufactured" (mobile) homes:									
Average sales price ^a (all lengths and widths)	\$12,300	\$14,200	\$15,900	\$17,600	\$19,800	\$19,900	\$19,700	\$21,000	\$21,500
Average square footage	966	1,000	1,010	1,050	1,050	1,040	1,025	1,035	1,050
Cost per square foot ^a	12.73	14.20	15.74	16.76	18.85	19.13	19.22	20.29	20.48
Site-built homes:									
Average sales price ^b	\$48,000	\$54,200	\$62,500	\$71,800	\$76,400	\$83,000	\$83,900	\$89,800	\$97,600
Average square footage (living space)	22.59	25.21	28.49	32.64	35.13	38.60	39.25	41.64	43.87
Cost per square foot ^c	1,700	1,720	1,755	1,760	1,740	1,720	1,710	1,725	1,780

^aIncludes furniture, draperies, carpeting, and appliances but excludes land as well as steps, foundation siding, anchoring, and other applicable setup charges (approximately 15% of home cost).

^bExcludes all furnishings; includes land.

^cExcludes furnishings, appliances, and land.

SOURCE: Manufactured Housing Institute.

HOUSING QUALITY

Objective measures of quality in housing are difficult to construct. The "satisfaction" rating for both site-built and "manufactured" (mobile) housing has increased steadily during the past decade. In a 1983 Department of Census survey, 60 percent of the respondents living in site-built homes constructed in 1976 rated their house as "excellent," and 80 percent of respondents living in a house built in 1983 gave their homes the same rating. For "manufactured" (mobile) homes, "excellent" ratings were given by 30 percent in 1976 and 54.6 percent in 1983.¹⁵ Table 9 compares site-built and "manufactured" (mobile) homes from two different periods. While newer units fared better than older units in most cases, the site-built units were less likely to suffer from any of the defects surveyed. Also, other defects, including inoperative doors and windows, leaky pipes, and electrical wiring problems, have increased substantially in newer "manufactured" (mobile) homes.¹⁶

In an effort to determine whether these reported defects did exist, the RADCO company made several site inspections of units that had been the subject of a previous survey. One or more major problems were discovered in three of every four units.

¹⁵Westat, Inc., "Analysis of Annual Housing (AHS) Data Pertaining to the Durability of Manufactured Housing," February 1986, pp. 4-10.

¹⁶Ibid., pp. 3-17, 3-18, 3-23.

Table 9.—Percent of "Manufactured" (Mobile) and Site-Built Homes With Various Problems

	Built before 1977		Built after 1977	
	Manufactured	Site	Manufactured	Site
Holes in floor . . .	5.2	1.8	1.8	0.5
Peeling paint (currently) . . .	1.4	3.9	0.8	0.4
Broken plaster (currently). . .	1.5	3.4	0.9	0.5
Units with nonworking outlets (currently)	2.3	3.6	2.0	1.2
Fuses or switches blown (in last 90 days) . . .	15.8	17.3	16.4	18.1
Exposed wires (currently)	1.9	2.8	1.1	1.9
Heating breakdown . . .	6.8	4.4	5.1	2.2
R o o f l e a k . . .	21.9	6.8	20.0	3.6
Toilet breakdown (in last 90 days) . . .	4.4	4.1	7.0	5.1
Holes or cracks in interior walls/ceilings (currently).	4.7	5.5	2.3	1.8

^aSite-built home respondents were asked about "current" problems manufactured home residents were asked about problems in the "past 12 months."

SOURCE Westat Inc. "Analysis of Annual Housing (AHS) Data Pertaining to the Durability of Manufactured Housing," February 1986, p. 4-3.

Furthermore, field inspectors observed problems that had not been reported by homeowners in approximately 80 percent of the houses. Of the 520 problems identified in 81 homes, 30 percent were due to material defects, 30 percent to poor workmanship, 14 percent to problems occurring during unit setup, and the rest were the result of use or could not be determined.¹⁷

The relatively poor performance of the "manufactured" (mobile) units just cited does not stem from factory production technique. More likely, it reflects the U.S. market for low-cost/low-quality housing. There is no direct equivalent to a "manufactured" (mobile) home in Europe or Japan.

Factory-based technologies can enhance the physical and esthetic quality of housing. In the United States, the term "prefab" still calls to mind inexpensive, monotonous, and drab housing. Consumers tend to believe that American factories produce dreary, shoddy homes. However, the high-quality, high-status houses constructed in Swedish plants prove that factory construction can offer significant advantages at various stages in the homebuilding process, from the initial design phase through the production, assembly, and erection of the end product.

Common stereotypes notwithstanding, the U.S. industrialized housing community has met consumer demand with the development, through basic engineering procedures, of various housing configurations. Units mimic the styling array of conventional "stick" builders: one-story, two-story, split-level, exposed ranch, contemporary, and traditional. They feature varied foundation systems, roof configurations, fenestration, and floor plans.

In certain cases, particular features are limited. For example, while 24-inch stud spacing has proven sufficient for most homes, the interior sheathing used in some industrialized housing is too thin to span this distance and still remain flat. On the whole, however, many options are available to the consumer of industrialized housing. Component and modular manufacturers produce up to 1,000 different models

¹⁷Resources, Applications, Designs & Controls, Inc. (RADCO), "Final Report for Durability in Manufactured Homes," December 1985.

to choose from, and provide custom design options for high-income buyers.

Improvements in computer-assisted design (CAD) should enhance design flexibility still further. Prospective homebuyers may now design their own floor plans, and compare different interior and exterior wall coverings in the unit spaces. The Japanese connect this process directly to production equipment, which then deliver pre-assembled units to a construction site within 3 weeks.

Concerning the manufacture of component parts, the factory setting offers the efficiencies of mass production so that structural components—such as floors, roofs, windows, and doors—can meet uniform tolerances. The high quality of prefabricated building components has contributed to their acceptance by many State and local building codes. Component manufacturers confront markets that can absorb high volumes of production, which helps to offset the fixed costs associated with automated manufacturing equipment.

Factory construction means that homes can be built to more precise standards, and can benefit from more reliable assembly. Onsite construction and assembly work is vulnerable to the vagaries of weather, and workers may cut corners—especially when a layer of drywall and paint will cover a multitude of sins. The incentive and opportunity to do this is reduced in the factory. In Sweden, the resulting quality is such that most firms offer 10-year guarantees on their products.

U.S. manufacturers have only begun to implement technologies that are already realized in Swedish and Japanese industrialized housing. Still, certain advantages of factory construction involve quality improvements that would not be readily accepted by contemporary American markets. Some industry analysts believe that this problem may be solved through a system of rating or labeling houses according to graduations of quality (see ch. 6). Finally, recent improvements in the design and manufacture of commercial structures should affect residential construction, over time.