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BY THE COMPTROLLER GENERAL

# Report To The Congress

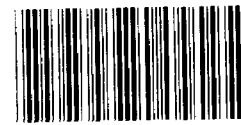
OF THE UNITED STATES

## Greater Use Of Innovative Building Materials And Construction Techniques Could Reduce Housing Costs

Problems exist within different levels of government and the homebuilding industry that hinder the development and use of innovations which could check rising costs. For example:

- Builders are reluctant to accept risks associated with using new technology.
- Local building codes are sometimes restrictive and administered inconsistently.
- Builders lack technical information on innovative technology.

GAO makes several recommendations to the Secretary of Housing and Urban Development and the President of the National Institute of Building Sciences to encourage the development and use of cost-saving innovations in homebuilding.



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COMPTROLLER GENERAL OF THE UNITED STATES  
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To the President of the Senate and the  
Speaker of the House of Representatives

This report discusses the role that innovative technology might play in reducing the cost of homebuilding and evaluates the Federal role in developing and encouraging the use of this technology.

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary, Department of Housing and Urban Development; and the President, National Institute of Building Sciences.

A handwritten signature in black ink that reads "Charles A. Bowsher".

Comptroller General  
of the United States



D I G E S T

Innovative building materials and construction techniques are not being used to the extent they could be to reduce homebuilding costs. Materials and techniques such as underfloor plenum heating systems (in lieu of a duct work system); polybutylene piping for plumbing (in lieu of metal piping); and engineered 2-inch by 4-inch studs with 24-inch oncenter framing (in lieu of 16-inch) are examples of a wide variety of currently available cost-saving opportunities. These particular items could each save between \$300 and \$700 in the cost of a median-priced, single-family detached house. (See pp. 1 to 8.)

The National Association of Home Builders in 1979 demonstrated how to construct houses with savings of about \$7,400 in construction costs using a variety of the latest innovations.

GAO undertook this review to assess the role innovative technology might play in reducing the cost of new single-family detached houses and to evaluate the Federal role in developing and encouraging its use. Housing affordability has become an increasingly serious national problem during the last decade.

Many problems exist at different levels of government and within the homebuilding industry that impede the use of available technological innovations and the development and introduction of new ones. These include

- a low level of effort by the Department of Housing and Urban Development and the National Institute of Building Sciences to encourage the development and use of innovative technology, except for that related to reducing energy costs;
- builders' reluctance to accept risks associated with the use of technology whose long-term performance is not proven;
- restrictive and inconsistently administered local building codes; and

--builders' lack of technical information on the results of using innovative technology.

Research and development of new, cost-saving technologies, except for those directed to reducing energy costs, have declined significantly in recent years, primarily because a substantial increase in governmental regulations has made it more difficult to introduce innovations that meet all requirements. (See pp. 7 to 11.)

GAO noted that the Department recently announced its participation in a new demonstration project to help local governments help each other to reduce housing costs. Under this project, which will begin in 11 communities, the Department will act as a clearinghouse for ideas generated at the local level for modifying or eliminating unnecessary building regulations.

Legislative authority has been given to both the Department of Housing and Urban Development and the National Institute of Building Sciences to encourage the development and use of innovative technology. The Department was directed in the Housing Act of 1949 to encourage and assist the reduction of housing costs, without sacrifice of sound standards, and the use of new designs, materials, techniques, and methods in residential construction (42 U.S.C. 1441). A further and more explicit mandate in this same regard was expressed in title 5 of the Housing and Urban Development Act of 1970. The National Institute of Building Sciences was created by the Congress in 1974 to enlist the voluntary support of all appropriate public and private parties in facilitating the use of technology in building and housing (Public Law 93-383).

HUD COULD DO MORE TO ENCOURAGE  
INNOVATIONS IN HOMEBUILDING

Three major studies during the past 10 years 1/ have recommended actions that the Department

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1/Task Force on Housing Costs report dated May 1978; National Association of Home Builders Research Foundation, Inc., report dated July 1971; and GAO report CED-78-101 dated May 11, 1978.

of Housing and Urban Development should take to encourage the use of innovative technology, but the Department has moved very slowly. These recommendations, in summary, called for the Department to move toward

- identifying, evaluating, and disseminating information on cost-saving innovations;
- encouraging the acceptance of innovations by model building code groups; and
- encouraging local compliance with model codes and consistent administration of local building codes.

GAO also reported on August 29, 1980 (CED-80-134), that the Department needed a better system of setting priorities for the research and technology work it undertakes. For example, GAO pointed out that only about 4 percent of the Department's 1979 research and technology budget was devoted to projects relating to "cost of housing"--a priority area the Department frequently cited as especially important.

Funding of departmental research, development, and demonstration programs during recent years for other than solar technologies has generally declined. In fiscal year 1981, \$4.9 million of the Department's total research and technology allocation was budgeted for housing technology compared with \$6.1 million in fiscal year 1974 and \$17.6 million in fiscal year 1970. (See pp. 12 to 16.)

NATIONAL INSTITUTE OF BUILDING SCIENCES  
COULD ALSO DO MORE TO ENCOURAGE INNOVATIONS  
IN HOMEBUILDING

The National Institute of Building Sciences was intended to encourage all sectors of the building industry to devise voluntarily a more efficient way of introducing technology into housing and building by

- encouraging a more rational building regulatory system through simplification and harmonization of building criteria, standards, and other technical provisions and

--evaluating existing and new technology to facilitate its introduction and acceptance at the Federal, State, and local levels.

Seven years after its creation, however, the Institute has made only limited progress in helping alleviate resistance to the use of innovative technology. (See pp. 16 to 18.)

### CONCLUSIONS

GAO recognizes that resources are required to carry out the congressional authority given to the Department and the Institute and to act on the recommendations made in the above-cited reports. In light of today's emphasis on budget cutting, GAO is not suggesting that additional appropriations be made for these activities. However, GAO does believe that considerable potential exists for reducing homebuilding costs if the Department and the Institute pooled their efforts and sought ways with existing resources to encourage the development and use of innovative homebuilding technology. Lower building costs would benefit the new home buyer through lower purchase prices as well as the Federal Government through reduced financing and subsidy costs for existing housing programs. (See pp. 18 and 19.)

### RECOMMENDATIONS

High housing costs and the unaffordability of new houses to a great majority of families is becoming an increasingly serious national problem. Therefore, GAO recommends that the Secretary of the Department of Housing and Urban Development and the President of the National Institute of Building Sciences reexamine the recommendations made in the reports cited above which call for a more vigorous and effective Federal role in promoting the use of innovative, cost-saving technology in homebuilding. GAO recommends that the Secretary and the President of the Institute (1) determine whether some revision of internal priorities might be possible and desirable in order to direct more resources to encouraging greater use of innovative technology and (2) explore other alternatives for reducing housing costs through greater use of innovative homebuilding technology. (See p. 23.)



## AGENCY COMMENTS AND GAO EVALUATION

The Department agreed fully with the concept put forth in GAO's report; namely, that many existing technical innovations in the homebuilding process, if widely used, could help control the rise in construction costs. It disagreed, however, that it had been delinquent in supporting the use of such innovations or in implementing the recommendations of earlier reports which did not involve significant additional staff.

GAO believes that while the Department has taken actions during the last 10 years to encourage greater use of innovative technology in homebuilding, its overall record shows declining emphasis on this technology during a period of greatly increasing need. (See p. 19 and app. VI.)

The National Institute of Building Sciences pointed out in considerable detail how its discretionary activities had been severely constrained by its limited resources; that the sums that would be needed are not large if properly focused; that it is prepared to work with the Department to define a proper research agenda and then to carry the case for more funds to the Congress; that it is prepared to reexamine the recommendations made in the reports cited by GAO and will seek an opportunity to do so with the Department; but that it would be difficult to redirect Institute resources because there are scant resources to redirect. (See p. 21 and app. VII.)



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#### ABBREVIATIONS

General Accounting Office  
Department of Housing and Urban Development  
Manufactured Housing Institute  
National Association of Home Builders

## CHAPTER 1

### INTRODUCTION

This report discusses innovative technology in the homebuilding industry and its potential for reducing the cost of new single-family detached housing, the predominant and preferred form of housing in the United States.

In the Housing Act of 1949, as amended (42 U.S.C. 1441), the Congress set a national goal of a decent home for every American family. To help achieve this goal, the Congress provided that the Department of Housing and Urban Development (HUD) and other Federal departments and agencies having powers, functions, or duties under this or any other law should work to reduce housing costs, without sacrifice of sound standards, and to use new designs, materials, techniques, and methods in residential construction. More recently, in title 5 of the Housing and Urban Development Act of 1970, the Secretary of Housing and Urban Development was authorized and directed to undertake programs of research, studies, testing, and demonstration relating to the mission and programs of the Department as he deems appropriate. The Secretary was specifically directed to require, to the greatest extent feasible, the use of new and improved technologies under programs administered by HUD with a view to reducing housing costs, and to encourage the acceptance and application of advanced technology by all segments of the housing industry, communities, and the general public.

As a further means of checking rising costs, the Congress created the National Institute of Building Sciences under the Housing and Community Development Act of 1974 (Public Law 93-383) as an independent, nongovernmental body to work with the building community and others to facilitate the introduction and promotion of innovative building technology. The Institute was intended to be a vehicle for encouraging all public and private sectors of the building industry to devise voluntarily a more efficient way of introducing technology into housing and building. A regulatory system was to be developed that would

--simplify and coordinate building criteria, standards, and other technical provisions and

--provide for evaluating existing and new technology to aid its introduction and acceptance at the Federal, State, and local levels.

In fiscal year 1981, \$4.9 million, or about 12 percent, of HUD's \$39.7 million research and technology appropriation was budgeted for housing technology other than that related to reducing energy costs. A total of \$10 million was authorized to be appropriated for the Institute through fiscal year 1982, after which time it is to be self-sustaining; actual appropriations

through fiscal year 1981 have totaled \$3.1 million. In addition, the Institute received \$9.2 million through fiscal year 1981 from other sources. The fiscal year 1982 appropriation was \$1.5 million.

Single-family detached houses make up over 80 percent of the Nation's owner-occupied housing structures, and surveys show they are preferred to other forms by over 90 percent of actual or potential homebuyers. However, over 90 percent of American families seeking to buy their first home cannot afford to buy because the average selling price for new houses rose during 1981 to more than \$80,000.

From 1965 to 1980 the average sales price of new houses rose from \$21,500 to \$76,300, an increase of 255 percent; the median sales price rose from \$20,000 to \$64,600, or 223 percent. 1/ Monthly ownership cost 2/ for the median-price house increased from \$163 to \$720, or 342 percent. In contrast, median family income increased more slowly--by only 175 percent to 1979, the latest year for which data was available. The groups most adversely affected are young, middle-income families and first-time home buyers. During the 1970's middle-income families and first-time buyers, who earlier were the majority of new home buyers, became the minority.

A 1978 GAO report 3/ discussed the extent of housing affordability problems and described local government regulations that influenced rising prices, including restrictive site development specifications and large lot width requirements.

This report supplements our 1978 report on housing affordability by focusing on building technology as one possible means for holding down costs. Technology directly affects the cost of construction material and labor, which form about 47 percent of the cost of a house. The remaining 53 percent is for land, construction financing, overhead, and profit. The relationship between technology-affected costs and other costs is shown in the following diagram.

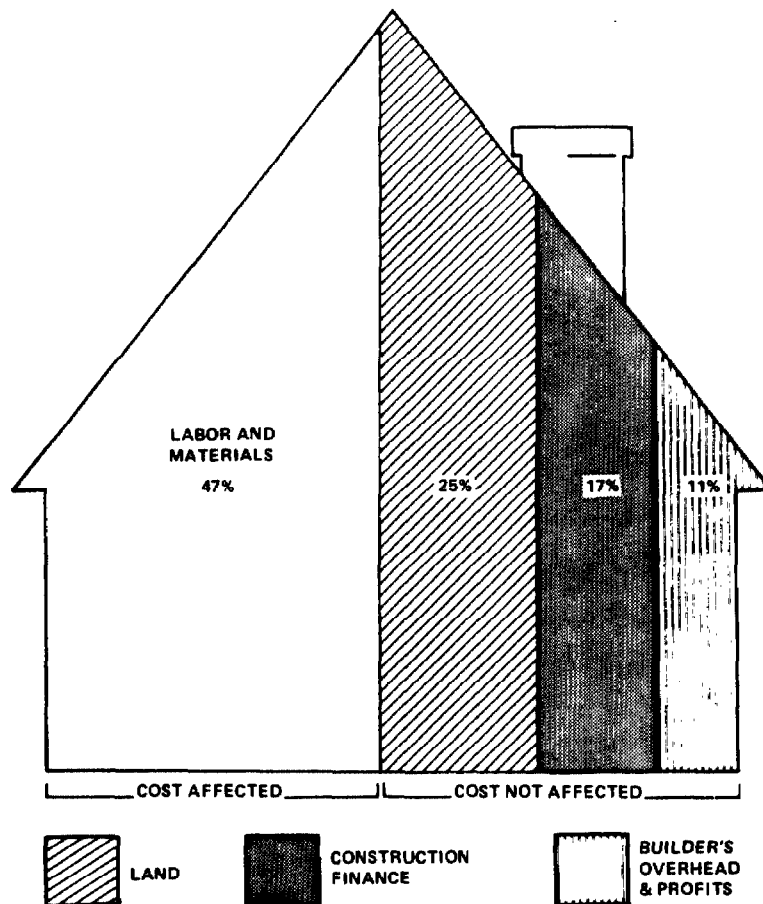
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1/The average price is obtained by dividing the total selling price of all new houses by the number of new houses sold; median price falls directly in the middle between the lowest and highest selling prices.

2/The amount required to amortize the mortgage principal and pay the interest, insurance premiums, property taxes, heat and utility costs, and maintenance and repair expenses.

3/"Why Are New House Prices So High, How Are They Influenced By Government Regulations, and Can Prices Be Reduced?" (CED-78-101, May 11, 1978).

COST COMPONENTS AFFECTED AND NOT AFFECTED BY CONSTRUCTION TECHNOLOGY  
(BASIS: MEDIAN PRICE HOUSE OF 1979)



SOURCE: COST DATA OBTAINED FROM NATIONAL ASSOCIATION OF HOME BUILDERS

OBJECTIVES, SCOPE, AND METHODOLOGY

Our review objectives were to assess the role innovative technology might play in reducing the initial cost of new single-family detached houses and to evaluate the Federal role in developing and encouraging its use.

Technology is considered to be innovative if it is not generally being used in homebuilding, regardless of the length of time the technology may have been available. We reviewed various technologies from the standpoints of (1) whether the technology inherently yielded cost reductions, (2) the potential for savings in relation to total costs, and (3) the likelihood that builders would adopt the technology. We limited our review of innovative technology to that which could be generally applied by the mid-1980's, due to the need for immediate action to deal with high housing costs.

During our review, which was performed in accordance with our current "Standards for Audit of Government Organizations, Programs, Activities, and Functions," we relied heavily on information contained in numerous studies and reports and information obtained by interviewing builders and housing officials in various agencies. (See app. I for a listing of the major studies we considered and app. II for a list of the organizations contacted and geographical locations of builders we interviewed.) Our work was conducted primarily in the metropolitan areas of Detroit, Michigan; Houston, Texas; Los Angeles, California; and Washington, D.C. Work was carried out in Washington, D.C., because most of the agencies and industry associations contacted had headquarters there. The other three areas were selected because they are among the 10 most populous metropolitan areas and in 1980 exhibited a variety of housing market economic conditions.

At Federal agencies, we reviewed available studies, reports, legislation, and other pertinent documents and interviewed officials regarding the cost-saving potential of innovative housing technology and activities the agencies conducted to promote it. We also visited the National Institute of Building Sciences and other major non-Federal housing organizations, such as the Manufactured Housing Institute; the National Association of Home Builders (NAHB); the NAHB Research Foundation, Inc.; and the National Association of Home Manufacturers, to obtain and review similar information.

In metropolitan Detroit, Houston, and Los Angeles, we interviewed a total of 21 builders regarding their experiences with and views of cost-saving technology. These builders were selected because they were relatively large volume builders in their areas and we believed they would have more varied experiences with technology than small builders. In the States where these areas were located, we interviewed, among others, officials of three architectural research centers, six builders associations, and three recipients of HUD research grants.

Chapter 2 describes opportunities and problems in achieving cost savings through technological innovation, and chapter 3 addresses HUD's and the Institute's efforts to alleviate barriers to the introduction and use of cost-saving technology. Appendix III describes important constraints to builders' use of innovations; appendix IV discusses the potential of innovative architectural designs and general construction methods for reducing housing costs; and appendix V explains various options available to home buyers which can lower housing costs.



## CHAPTER 2

### OPPORTUNITIES AND PROBLEMS IN ACHIEVING COST SAVINGS FROM THE USE OF INNOVATIVE TECHNOLOGY IN HOMEBUILDING

Innovative technology is not being used to the extent it could be to hold down costs in the homebuilding industry. A variety of problems exist both at the different levels of government and within the homebuilding industry itself which discourage and hinder the use of available innovations and the development and introduction of new ones.

#### INNOVATIONS IN MATERIALS AND LABOR-SAVING TECHNIQUES CAN REDUCE HOMEBUILDING COSTS

The full range of available innovative technologies and the cost-saving potential associated with them have not been comprehensively evaluated. However, existing data indicates that innovations in materials and labor-saving techniques, including energy-saving technologies, offer potential savings in both the construction and operating costs of new houses. Today's new single-family housing is less costly than it otherwise would be because it embodies a range of cost-saving materials and labor-saving techniques. Drywall, instead of plaster walls and ceilings, is an example. Drywall was considered innovative but gradually became widely used by builders. Also, labor costs have been reduced through increasing use of power tools, roof trusses, prehung windows, and other manufactured (preassembled or prefabricated) major components.

In a May 1978 report, <sup>1/</sup> a HUD task force on housing costs noted the need to test and demonstrate the cost effects of new innovations, because the extent to which they could cut costs was "a controversial question." The task force estimated that housing construction costs could be reduced "by as much as \$6,000," and twice that amount over the term of an average mortgage, if its recommendations regarding technology were adopted.

We found only one research project (the "cost buster" house) which had been completed since the May 1978 report was issued which addressed the potential of a wide range of available technologies for reducing the initial cost of houses. The NAHB "cost buster" house was completed in 1979 using conventional methods, and included optimum value engineering design and construction techniques and

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<sup>1/</sup>"Final Report of the Task Force on Housing Costs," Department of Housing and Urban Development, May 1978.

various innovative components (for example, a prefabricated plastic plumbing tree). NAHB reported a 25-percent savings in direct construction costs (materials and labor) compared with a home of similar size in the same locality.

The percentage of savings that would be achieved if the innovative features of the "cost buster" house were used in new houses generally has not been determined. It could be greater or smaller because costs vary geographically and by house type and size and by level of housing production.

If the same 25-percent savings in construction cost were achieved in the median-price house of 1979, the savings in initial cost (sales price) would have been \$7,391, or 11.75 percent. Extending the illustration, an 11.75-percent reduction in sales price would have yielded a \$8,143 initial savings in the April 1981 median-price house (\$69,300) and a much larger savings in homeownership cost. For a new house sold under a conventional 30-year mortgage at 15-percent interest, with a 20-percent down-payment, a \$1,000 decrease in price would yield a reduction in monthly cost of \$12.65 and a total reduction in principal and interest of \$4,554. The overall savings in the April 1981 median-price house, based on an 11.75-percent reduction in initial cost, are summarized below.

<u>Savings in initial cost</u>	<u>Savings in ownership cost (principal &amp; interest)</u>	
	<u>Monthly</u>	<u>Total for 30 years</u>
\$8,143	\$82.41	\$29,668

Currently, the primary emphasis in innovative homebuilding technology concerns energy-saving techniques, and extensive research, development, and demonstration activities are underway. The work to date indicates that, in general, energy-saving technology adds to a house's initial cost and thus partially offsets the savings that otherwise might be achieved. To illustrate the point, the NAHB Research Foundation, Inc., found that an energy efficient house it built and monitored under HUD sponsorship during 1977-79, which contained available energy conservation techniques (for example, a heat pump and lower water use devices on faucets), achieved a 48.6-percent reduction in total energy use. Assuming energy cost would increase 10 percent per year, it was calculated that the reduction annually saved \$545 but the technologies involved added \$5,382 to initial house costs and 9.4 years would be required to recoup the added cost through the annual savings.

The extent to which homebuyers realize a net ultimate saving in costs and the period of time needed to recoup added construction costs through energy cost savings will vary. They are affected by such factors as the type and location of the devices, the climate, and the local cost of energy.

While innovations in materials and labor-saving techniques offer savings, they are not a cost panacea. According to NAHB, a new house involves about 38,000 different components, each accounting for a small share of the total cost. Based on the latest available data from NAHB, the construction cost of the median-price single-family house during 1969-79 rose about 93 percent, but certain other costs rose even more. For example, construction finance cost rose 254 percent. Large increases occurred during 1965-79 in various other elements of homeowner-ship cost; for instance, real estate taxes increased 204 percent. Further, our 1978 report on housing affordability problems pointed out that in many communities housing costs have been increased by adoption of restrictive and expensive land development requirements. For example, of the 87 communities we contacted during this 1978 review, some had (1) specifications or standards for streets and related site improvements that in comparison to acceptable less costly alternative standards could increase the cost of a house by as much as \$2,655, (2) requirements for 150- to 200-foot-wide lots that further increased site improvement costs, and (3) expensive municipal fees as high as \$3,265 a house for such items as local reviews, permits, inspections, and utility connections.

In addition to the conventional methods of constructing houses, we reviewed the potential cost savings of alternative architectural designs and methods of construction. The cost-saving potential of the principal current forms of unconventional designs--earth sheltered, dome, and solar--has not yet been established, but indications are that these designs will have only limited impact on initial costs. They do, however, offer an opportunity for energy savings. Further, manufactured housing has been and continues to be inherently restricted by various economic factors. Only one major form--large mobile/manufactured homes--may offer important cost savings in relation to the median-size conventional house. However, the use of these homes is restricted by local zoning regulation. (See app. IV for a further discussion of the cost-saving potential of these forms of housing.)

#### INNOVATION FACES SIGNIFICANT BARRIERS

The maximum savings possible through innovations in materials and labor-saving techniques are unlikely to be achieved quickly. A variety of factors discourage or prevent their rapid, widespread adoption by builders. HUD has characterized technological change in homebuilding as "gradual--evolutionary rather than revolutionary." According to the chief of HUD's building technology research unit, the time required for an innovation to become widely adopted by builders varies from 6 to 30 years. For example, prehung doors became widely used within 2 to 3 years after their development, while roof trusses took 15 to 20 years.

A 1971 study prepared for HUD <sup>1/</sup> regarding builders' use of 12 cost-saving innovations showed that, on the average, 70 percent of the responding builders did not use the innovations. According to building code officials, 73 percent of the time builders in their areas used the innovations occasionally, seldom, or never. Subsequently, a 1973-74 NAHB survey, which included 11 of the 12 items, showed that 8 of the 11 were not used in the great majority of new single-family houses nationally. Our 1978 report, which addressed 8 of the 12 items, showed 3 of the 8 were still widely unused by builders in the 87 communities included in our review. The three still widely unused items and the estimated potential savings per house at the time were: spray painting (\$185), 2x4 studs 24" oncenter for exterior bearing walls (\$119), and the preassembled plumbing tree (\$55).

Examples of available cost-saving innovations currently not widely used by builders, as identified by HUD and NAHB research officials, and estimates of savings they could yield in the medium-price house include:

Engineered 2" by 4" studs, 24" oncenter interior and exterior wall framing (in lieu of 16" oncenter)	\$300 - \$700
Under floor plenum heating system (in lieu of duct work system)	\$400
Polybutylene piping for plumbing (in lieu of metal piping)	\$300
One-piece fiber glass bathtub with integral surround (in lieu of tile- work)	\$50

Rapid, widespread adoption of cost-saving innovations is hindered in part because the traditional onsite homebuilding industry is extremely fragmented--more than 100,000 builders, the majority of which build less than 25 units annually. However, the 1971 HUD study identified and analyzed a range of other factors impeding builders' use of innovations. While the study has not been updated, its results were substantially corroborated by the widely varied sources we consulted during our review. The study ranked in order of importance a total of 20 constraints, of which it called the following "important":

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<sup>1/</sup>"Constraints to Builders' Use of Cost Saving Innovations," NAHB Research Foundation, Inc., July 1971.

- Risk of poor performance.
- Possible damage to builders' reputation.
- Building code prohibitions.
- Lack of technical information.
- Building officials frown on use.
- Inapplicability to builders' design or materials.
- Not marketable in builders' area.

A further discussion of these constraints is provided in appendix III.

RESEARCH AND DEVELOPMENT EFFORTS  
HAVE DECLINED: THE CLIMATE FOR  
NEW TECHNOLOGY IS POOR

Research and development of new, cost-saving technologies, except those to reduce energy costs, have declined considerably and today are very limited. The principal reason for the decline is a substantial increase in Federal and local governmental regulations which have made it more difficult to introduce innovation that meets all requirements. Other reasons include risk of financial loss and lack of information on users' needs. Additionally, potential savings from research and development may be limited by overly rigorous building standards.

Research and development is carried out by product manufacturers--the principal source of new products--universities, laboratories, design firms, the Government, and associations such as NAHB.

A 1979 National Institute of Building Sciences study on the introduction of new technology <sup>1/</sup> stated that (1) economic slumps and high interest rates had cut into the funding of research and development by manufacturers, (2) the number of companies continuing to commit a constant percentage of sales to research and development had shrunk in the recent past, and (3) industry had committed a sizeable portion of its funds earmarked for research and development in response to increased government regulations. It also stated that grant levels in university architectural and engineering research centers had dropped significantly and that in the last decade Federal Government funding had been reduced. We noted that HUD's primary housing technology research unit's budget allocations have generally declined during the past decade. For example, the housing technology allocation was \$17.6 million in fiscal year 1970, \$6.1 million in fiscal year 1974, and \$4.9 million in fiscal year 1981. During this period, some budget fluctuations above or below the yearly allocations cited above did occur.

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<sup>1/</sup>"A Study of Existing Processes for the Introduction of New Products and Technology into the Building Industry," National Institute of Building Sciences, Jan. 8, 1979.

Officials of various organizations we contacted, including national engineering and architectural groups, confirmed that little research was being done to develop cost-saving innovations in homebuilding, apart from energy-saving technology. One builder, nationally recognized for his interest in innovation, who over the years had been heavily involved in advising suppliers and helping test new products, told us that research and development of innovations in housing has almost stopped.

The 1979 Institute study identified the "regulatory environment" as the major constraint on research and development and the introduction of innovations. While regulations and building codes serve the public goal of safe and sound buildings and promote various other aspects of the public welfare, they have, according to a 1980 Federal Trade Commission study, 1/ brought mixed blessings. The study noted specifically that they have added to construction costs and have retarded the introduction of innovative products and construction methods.

A multitude of codes and regulations makes it difficult to introduce innovation which conforms to all requirements, and variation in local approval of new products creates uncertainty about their acceptance. Some States have statewide building codes but local control predominates, and while almost all jurisdictions base their codes upon one of several model codes--developed by voluntary associations known as model code groups--communities often make enough changes to destroy uniformity among jurisdictions. The Institute study also said a "proliferation" of other regulations--covering zoning, site development, environmental protection, consumer safety and protection, and energy--produces uncertainty about the future environment for new products.

The Institute study cited as further major constraints a lack of definitive information on users' needs and perceived risk if a new product fails. It stated that risk liability was increasingly being shifted from the product user to the manufacturer, thus reducing the number of new products and increasing the cost of added insurance. Also, building officials' personal liability may affect their decisions to accept new products under existing code provisions.

In addition, the potential savings possible through housing research and development may be limited by overly rigorous safety standards for building construction which limit the extent to which less costly house components can be developed and accepted. Code- and standard-making bodies do not generally use cost-benefit analysis to assess whether the benefits of these standards justify the cost of meeting them.

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1/"Building Regulatory Practices and the Courts," Federal Trade Commission, Sept. 1980.

The 1971 HUD study and the 1978 task force report recommended actions HUD should take to help reduce barriers to the use and/or development of cost-saving innovations, and Institute studies in 1979 recommended programs the Institute should establish to address problems affecting the introduction of new technology. However, as explained in the following chapter, HUD has moved slowly in this area, and the Institute's accomplishments have been limited.

## CHAPTER 3

### MORE COULD BE DONE TO ENCOURAGE THE USE OF INNOVATIVE TECHNOLOGY

Greater action by HUD, the National Institute of Building Sciences, and a broad range of public and private bodies will be needed to reduce barriers that hinder the development and greater use of innovative technology in the homebuilding industry. While their authority in this area is limited, HUD and the National Institute of Building Sciences have legislative mandates to encourage wider use of new technology and could be a catalyst for encouraging and coordinating the needed actions.

#### HUD COULD DO MORE TO ENCOURAGE INNOVATIONS IN HOMEBUILDING

Various recommendations have been made to HUD over the last 10 years suggesting that it take a more active role in overcoming barriers to the development and use of innovative, cost-saving technology in homebuilding. These recommendations were set forth mainly in three reports. <sup>1/</sup> In substance, these recommendations called for HUD to

- identify, evaluate, and disseminate information on cost-saving innovations;
- encourage the acceptance of innovations by model code groups; and
- encourage local compliance with model codes and consistent administration of codes.

HUD has not moved vigorously to implement these recommendations, as evidenced by its responses to them.

The principal recommendation in the 1971 study by the NAHB Research Foundation, Inc., called for HUD to develop a continuing program to identify and evaluate all cost-saving innovations and

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<sup>1/</sup> Report by NAHB Research Foundation, Inc., Rockville, Maryland, entitled "Constraints to Builders' Use of Cost Saving Innovations" (July 1971).

Final Report of the Task Force on Housing Costs (May 1978).

Report by the General Accounting Office entitled "Why Are New House Prices So High, How Are They Influenced By Government Regulations, And Can Prices Be Reduced?" (CED-78-101, May 11, 1978).



to disseminate information on acceptable innovations to all appropriate parties, including builders, building code officials, and consumers.

HUD had not yet established such a program but was developing one at the time of our review. It was expected to be completed by February 1982 and to entail the dissemination of publications giving examples of accepted innovations, including descriptions of how they work, tests used to prove acceptability, and estimates of possible cost savings. We were told by the chief of HUD's building technology research unit that 8 to 15 publications would be sent annually to builders, model code groups, local building officials, and other elements of the homebuilding industry and would be available to consumers on request. The chief of HUD's building technology research unit told us that HUD identifies and evaluates cost-saving innovations through demonstration projects.

From 1969 to 1974 HUD carried out extensive activities, largely under the Operation Breakthrough program, at a total Federal cost of about \$72 million. This program demonstrated the value of industrialized (factory-built) housing. The program did not, according to HUD's director of energy, building technology, and standards research division, meet its primary objective--creation of a market adequate to support the high production level required for efficient industrialized housing.

Since 1974, HUD's primary emphasis has been the support of over 600 demonstration projects under a residential solar heating and cooling demonstration program mandated by the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409). This program, funded by the Department of Energy, was budgeted in total at \$85 million.

Funding of HUD programs to research, develop, and demonstrate nonsolar innovative housing technologies has been reduced from earlier years, and HUD has directed its efforts away from radical innovation and toward improving, and reducing the cost of, existing, readily adoptable technology. For example, since 1974 HUD has initiated at least nine research projects pertaining to mobile homes and manufactured houses and has also completed or initiated projects to reduce costs by developing more cost-effective specific housing components, such as lumber products, flooring systems, and foundations. In addition, HUD has completed or initiated various demonstration projects, most of which addressed specific kinds of innovations and/or involved development and demonstration of new rather than available innovations. The projects included:

--A 1978 project conducted by the NAHB Research Foundation, Inc., to develop and demonstrate "optimum value engineering" techniques, which compared alternative, least costly materials and methods for house construction.

--A 1977-79 project in which the NAHB Research Foundation, Inc., built and compared the cost and energy use performance of an "energy efficient residence" containing available energy conservation techniques, and a conventional home.

--A "Building Value into Housing Program," initiated in 1980 and continuing in 1981, to develop and demonstrate innovative construction techniques. It has involved 19 projects in scattered locations throughout the Nation.

Since 1974, HUD has funded only one project which demonstrated (in one geographical area) the cumulative cost-saving potential of a wide combination of available innovative technologies. More specifically, it funded the design and monitoring elements of "Approach 80," a project undertaken by NAHB in 1980 in Las Vegas, Nevada, the site of NAHB's annual convention, to demonstrate innovative, cost-saving housing technologies and land development techniques. The project involved construction of 38 housing units which embodied all innovative technology resulting from past HUD research. At the time of our review, the report on the project, which was to identify the cost savings the technology yielded, was still in process of preparation.

We reported on August 29, 1980 (CED-80-134), that among the improvements needed in HUD's research and technology activities was a better system of setting priorities for work undertaken. We reported that some research goals were receiving little attention while others were too broad to be a meaningful guidance tool for project selection. As an example, we pointed out that only about 4 percent of HUD's 1979 research and development budget had been devoted to projects relating to "cost of housing"--a priority area HUD frequently cited as especially important.

In response to our August 1980 report, HUD officials stated that their previous attempts to develop a specific research agenda had been difficult because by training and experience they were better suited to defining major problems and the priorities for addressing them than to developing measurable research objectives. HUD acknowledged that several in-house and externally funded research strategy papers had been completed with mixed results. HUD officials recently concluded that any further effort to develop a specific research agenda would not now be appropriate because of budget cuts and new HUD research management.

The 1971 NAHB report also recommended that HUD develop a training program for building officials and inspectors to help reduce inconsistent interpretations of building codes and personal preferences and biases affecting acceptance of cost-saving innovations. HUD has recently developed a course, but has not decided whether it should be federally or nonfederally funded.

The 1971 NAHB report also recommended that HUD provide more cooperative assistance to existing State and local code authorities, and especially to model code agencies, with their procedures for acceptance of innovations. The 1978 report of the Task Force on Housing Costs urged HUD to join with the National Institute of Building Sciences and Federal agencies in encouraging standard procedures for rapid review and approval of new technologies. HUD action on this matter is pending. The director of HUD's housing costs staff told us that HUD, at the Institute's request and to avoid possible duplicative efforts, was awaiting completion of a current small scale Institute study of several existing national product approval systems before taking any further action.

To help eliminate excessively vigorous and costly requirements from building codes, the 1978 report of the Task Force on Housing Costs further recommended that HUD support basic research to determine the costs and benefits of safety requirements in codes and identify and immediately remove unjustifiable cost-increasing requirements from HUD's minimum property standards. HUD's minimum property standards must be met by all housing financed with the aid of Federal mortgage insurance programs. A HUD study to develop methods for assessing the costs and benefits of safety requirements was initiated in 1980. The director of HUD's housing costs staff told us that some revisions to the minimum property standards were made in 1980 which reduced certain unnecessary cost-increasing requirements and that further revisions were underway.

As a means of reducing local deviations from model codes, the 1978 report of the Task Force on Housing Costs recommended that HUD require communities applying for grants under the Community Development Block Grant and Urban Development Action Grant Programs to demonstrate that their codes are unmodified versions of the latest nationally recognized model codes and are uniformly and effectively administered. The director of HUD's housing costs staff advised us that a HUD review group suggested to the then Secretary of HUD that the recommendation be deferred for more study and that no further action has been taken.

On January 20, 1982, HUD announced its participation in a demonstration project called the "Joint Venture for Affordable Housing." This project will involve local builders, community groups, the National Association of Home Builders, the National Association of Counties, the International City Management Association, and the Council of State Community Affairs Agencies, and will link local authorities with the builders/developers in all communities during the planning, processing, and construction phases of housing development. The objective of the project is to try to reduce the cost of housing production by modifying or eliminating unnecessary building regulations. Although HUD will not provide funding for the demonstrations, it will act as a clearinghouse for ideas generated at the local level.

The 1971 NAHB report urged more HUD cooperative assistance to State and local building code authorities, and the 1978 Task Force on Housing Costs further recommended that HUD staff its field offices with personnel qualified to give localities limited assistance in maintaining and administering codes. The Director of HUD's Housing Costs staff told us HUD rejected this Task Force recommendation because it did not believe more personnel could be justified in view of higher priority needs. Our 1978 report recommended that HUD (1) establish a program to identify communities that do not allow use of less expensive materials and methods and (2) provide technical data and assistance to encourage their use. In replying to this recommendation, HUD said that it was not adequately staffed to evaluate each community's standards and provide the assistance suggested. We were advised during this review that HUD is still not adequately staffed to do so. We did not attempt to evaluate the adequacy of HUD's staffing.

NATIONAL INSTITUTE OF BUILDING SCIENCES  
COULD ALSO DO MORE TO ENCOURAGE  
INNOVATIONS IN HOMEBUILDING

For various reasons, discussed below, the National Institute of Building Sciences has done little to alleviate barriers and promote development and use of cost-saving technology. In conjunction with HUD, the Institute planned to hold its first new housing technology conference in April 1982. This conference, which HUD requested and is funding, is to bring together officials from different sectors of the housing/building industry to assess new, less expensive construction methods and materials; identify ways in which the information developed could be effectively disseminated; and identify further research, development, and demonstration needed in housing technology.

The legislation creating the Institute provides for an Institute board of directors representing the building industry, regions of the country, and consumers. It also provides for a consultative council open to representatives of all appropriate private, trade, professional, and labor organizations; private and public standards, codes, and testing bodies; public regulatory agencies; and consumer groups. The legislation specifically encourages Federal agencies involved in housing and building to work closely with the Institute in developing appropriate solutions to shared concerns.

The Congress specified that in carrying out its functions the Institute was to make maximum use of existing public and private organizations. In practice the Institute encourages or contracts with others for research support; it does not undertake direct research activities of its own.

The Institute's progress has been hindered in part because it experienced serious delays in becoming fully operational. Although it was authorized to be established in 1974, a board of directors was not appointed to incorporate the Institute and hire a staff until 1976. The consultative council was not established until

1978 and held its first annual meeting in 1979. On the basis of several contractor-prepared studies completed in January and July 1979, a proposed program plan for fiscal years 1980-84 was formulated in 1979 but at the time of our review had not been officially adopted. The Director of Program Planning advised us that the board of directors and the consultative council had been unable to reach agreement on the plan and a revised proposal was being developed.

According to Institute officials, in addition to time delays Institute efforts have been impaired by insufficient funding. The Institute's enabling legislation authorized a total of \$10 million of Federal funds to be appropriated for fiscal years 1975 and 1976 to provide it with initial capital; thereafter, the Institute was to be self-sustaining through acceptance of contracts and grants from Federal, State, and local governmental agencies and donations from private organizations and individuals. The Institute is also authorized to charge for its services. Due to the startup delays, subsequent reauthorization established the period during which the \$10 million could be requested as the 5-year fiscal period 1978-82.

Actual appropriations through fiscal year 1981, however, have totaled only \$3.1 million. According to its budget justifications, which the Institute submitted in connection with appropriation hearings for fiscal year 1982, the Office of Management and Budget determined that the Institute could not request the full \$10 million authorized to be appropriated. It set a schedule in the third year (fiscal 1980) that called for a declining appropriation beginning at \$750,000 and dropping to \$500,000 for fiscal 1982. Through fiscal 1981, the Institute had received about \$9.2 million from outside sources, a substantial portion of which was used for energy-related research. According to the vice chairman of the Institute's board of directors, the restricted appropriations caused the Institute to put in abeyance much of the program it had planned to put in place by the beginning of fiscal 1983. The fiscal year 1982 appropriation was \$1.5 million. The Institute provided additional funding details in its report review comments, which appear on page 53 of appendix VII.

In our 1978 report on the high prices of new homes, we recommended that the Congress provide funds to enable the Institute to identify acceptable, less expensive construction methods and materials. We further recommended that the Institute provide technical data for HUD's use in encouraging communities to allow their use. The Institute's vice president for technology and programs told us that the Institute had not requested or received the funds involved.

The Institute's currently proposed program plan includes 11 programs that directly or indirectly bear on alleviating major constraints to the development and use of innovative technology.

They include, for example, programs aimed at eliminating duplicative and restrictive building regulations, reducing inconsistent interpretation and enforcement of regulations, providing information on innovative technology, and facilitating the process for building code approvals of such technology.

The Institute has initiated projects under certain of its programs and has completed a number of actions. For example, it is implementing a major research management effort for the Department of Energy on the building energy performance standards that the Department is required to develop and promulgate for new residential and commercial buildings. In response to the proposed standards announced in November 1979, the Institute recommended that the standards be deferred and revised and that they be implemented on a voluntary basis pending reassessment. Also, in January 1981 the Institute publicly recommended a 1-year moratorium on all new Federal regulations affecting housing and building and a high-intensity effort to eliminate recommendations adding unnecessarily to costs. The Institute subsequently advised us in December 1981 that the building energy performance standards program is very near completion and that two reports have been delivered to its vice president and to the Congress and that a third report will be issued shortly.

## CONCLUSIONS

The statutory authority given to HUD and the National Institute of Building Sciences to encourage the development and use of innovative technology in homebuilding has been receiving only limited attention by HUD and the Institute. HUD has been very slow to act on the numerous recommendations for action to encourage innovative technology, except for energy-saving technology, made by the Task Force on Housing Costs (report dated May 1978); the NAHB Research Foundation, Inc. (report dated July 1971); and the General Accounting Office (CED-78-101, May 11, 1978). Also, HUD has not taken any substantive action to date on our suggestion of August 29, 1980 (CED-80-134), that improvements be made in its system for setting priorities for research work. We cited in this report the low level of effort being devoted to the "cost of housing" issue.

Information gathered during this review showed that builders and local governments move slowly and cautiously in accepting and adopting cost-saving innovations. This situation could be remedied to some degree if HUD and the Institute took greater initiative to encourage the use of innovative technology in accordance with the recommendations made in the above-cited reports.

We believe that the curtailment of research on new technologies in the homebuilding industry is particularly unfortunate.

We recognize that resources are required to carry out the Congress' mandates to HUD and the Institute and to act on the recommendations made in the above-cited reports. While we are not in a position to suggest additional appropriations for this activity in light of today's budget-cutting necessities, we do believe that considerable potential exists for achieving substantial benefits for home buyers if HUD and the Institute pooled their efforts and sought ways with existing resources to encourage the development and use of innovative technology in homebuilding. The Government could also benefit from reduced homebuilding costs in that its financing and subsidies under existing housing programs would be reduced.

HUD AND INSTITUTE COMMENTS  
AND OUR EVALUATION

Department of Housing and Urban Development

HUD agreed fully with the concept put forth in our report; namely, that many existing technical innovations in the homebuilding process, if widely used, could help stem the rate of increase in construction costs. HUD disagreed, however, that it had been delinquent in supporting the use of such innovations or in implementing the recommendations of earlier reports which did not involve significant additional staff. HUD said it believes that the numerous statements in the body of our report closely support its position that HUD's technical research program has been in the forefront of the effort to introduce innovative building technologies.

We have no intention of minimizing HUD's past efforts at encouraging innovative technology in homebuilding. For this reason, our report describes many of these efforts in some detail. We believe, however, that while HUD can point to a number of actions it has taken during the last 10 years to encourage the greater use of innovative technology, its overall record shows (1) declining emphasis on such technology during a period of greatly increasing need, (2) slowness or failure to act on valid recommendations of long standing to encourage innovative technology, and (3) lack of an appropriate system for setting priorities for research related to the "cost of housing" issue.

In our draft report transmitted to HUD for comment, we suggested that the Secretary of HUD and the President of the National Institute of Building Sciences reexamine recommendations made in the reports cited above which call for a more vigorous and effective Federal role in encouraging the use of innovative, cost-saving technology in homebuilding. We suggested further that the Secretary of HUD and the President of the Institute (1) determine whether some revision of internal priorities might be possible and desirable in order to direct more resources to encourage the

greater use of innovative technology in homebuilding and (2) explore other alternatives for achieving the objective of reducing housing costs through greater use of innovative technology.

HUD replied that most of the suggestions of the various cited studies, which did not involve significant additional staff, have been or are being accomplished in close cooperation with the housing industry and that our first suggestion was not valid. HUD said it had no problem with the suggestion that HUD (1) review its research priorities and (2) explore other alternatives for identifying and encouraging the use of cost-reducing innovative building technology. These were, HUD said, continuing activities. HUD said that its research mission must support its total mission and that the cost of housing, as shown by the exhibits in the report and in many other studies, depends on many factors in addition to the cost of housing construction. HUD said it expected to continue to assess all of its research opportunities in light of available resources.

We continue to believe that it would be worthwhile for HUD, in cooperation with the National Institute of Building Sciences, to reexamine the various recommendations made over the last 10 years by the Task Force on Housing Costs; the NAHB Research Foundation, Inc.; and us for more vigorous and effective action to encourage the greater use of innovative technology in homebuilding. This reexamination needs to consider the current low level effort HUD has committed itself to in relation to current needs, HUD's protracted timetables for completion of action, and the increased significance of these recommendations. Our review findings show that:

- HUD has not involved the National Institute of Building Sciences in a collaborative effort to assess the opportunities and alternatives available, within present funding and staffing limitations, for using innovative technology more effectively in homebuilding, as recommended by the three reports we have cited.
- The need for cost-saving technology grew greatly during the 1970's as the cost of new housing skyrocketed. Therefore, the recommendations made earlier may have even more cost-saving potential now.
- HUD does not appear to adequately recognize the urgency of providing help to new home buyers who must contend with rapidly rising housing costs.

The Institute indicated in its comments on our report a willingness to reexamine the prior recommendations and said it would seek an opportunity to do so with HUD. We believe HUD should respond positively to this offer.



## National Institute of Building Sciences

As noted above, the Institute said that it was prepared to reexamine the recommendations made in the cited reports and would seek an opportunity to do so with HUD, but noted that its resources were very limited.

The Institute pointed out in considerable detail the difficulties it has had since its creation in getting funds with which to operate. The Institute said that while it understands our reluctance to suggest additional funding, the sums that would be needed are not large, if used properly. The Institute also said that it is prepared to work with HUD to define a proper research agenda and then to carry the case to the Congress.

The Institute made numerous other comments which are very informative in further defining the issues being dealt with in this report. Included among these were:

- HUD's Policy Development and Research program could be better structured to accelerate technological development acceptance. The building community's lack of input in program formulation doubtless has had much to do with its lack of support within the Congress as well as within the private sector. The Senate Appropriations Committee expects HUD to work with the Institute in formulating a research program. If this is done, this would enable the Institute to not only solicit input from the private sector for a sound research program but support for that program as well.
- The Institute has asked HUD to help it in developing a nationwide system for evaluating and certifying new and innovative technologies. To date, however, HUD has not shown a willingness to cooperate with the Institute in such an effort. The Institute needs the support of HUD and other Federal agencies involved in housing and building to fashion a nationwide technology certification system. This the Institute currently is seeking to do.
- The Institute concurs in our finding that curtailment of research on new technologies in the homebuilding industry is particularly unfortunate, except that the Institute would prefer to redefine the issue as one of providing fundamental data and information needed to support industrial research and development and efforts to remove barriers to, and facilitate the introduction of, new technology created by the private sector.
- The Senate report on H.R. 4034 which was enacted as the HUD and Independent Agencies appropriation act for fiscal year 1982 stated:

" \* \* \* the Committee expects the Department [HUD] to enter into contractual relations with the National Institute of Building Sciences to perform the following studies \* \* \* [including] creating a system to annually review and assess the status and progress of HUD's research program and to provide input on the following year's research agenda."

Therefore, the comment by HUD, set forth in the General Accounting Office report (p. 13), that HUD officials recently concluded that any further effort to develop a specific research agenda would not now be appropriate because of budget cuts and new HUD research management, would appear to be at odds with the expectation of the Senate Appropriations Committee.

- One of the problems within HUD is the incompatibility between the Federal Advisory Committee Act and Federal procurement policies. Apparently, these requirements are being interpreted to mean that HUD cannot deal with the Institute on a sole source basis or cannot seek Institute advice without violating the Advisory Committee Act. Ultimately, only the Congress can clarify this matter. (The scope of our review did not encompass any evaluation of the legal question the Institute raises here.)
- Although it is true that technical innovations often are not put to use because of a lack of "authoritative" technical information and demonstrated results, and certainly not as rapidly as one might hope, it is also the case that there are deeply held convictions that certain "innovations" will lower quality or endanger health and safety. To the extent that such convictions reflect different perceptions of exposures to risks, they are understandable. Authoritative information can strip away many of the crutches used to justify not accepting new technology, but it is not likely to overcome variations in risk perceptions, nor necessarily should it.
- Insofar as restrictive and inconsistently administered local building codes are concerned, the problem lies in part with political influences and in part with the need to upgrade the capabilities of the building official and his plan reviewers and inspectors. It does little good to berate the code so long as States and communities are not willing to upgrade the building department personnel to true professional status and compensate them accordingly.
- The Institute's authorizing legislation calls upon Federal agencies to utilize services of the Institute and it is

authorized to respond to such requests. If the preponderance of such requests come from one area of technology, this becomes the focus of the Institute's mission-oriented work. The Institute has continued to pursue its primary mission with its appropriated funds and with funds it can raise from other sources and will continue to do so. (This comment refers to our report discussion on p. 17 that most of the Institute's efforts involved energy-related research.) The Institute said it has done and is doing everything within its power to encourage Federal agency cooperation with and support for the Institute but that this assistance has not been forthcoming.

RECOMMENDATIONS TO THE SECRETARY OF  
HUD AND THE PRESIDENT OF THE NATIONAL  
INSTITUTE OF BUILDING SCIENCES

In view of the increasingly serious national problem of high housing costs and the unaffordability of new housing to a great majority of families, we recommend that the Secretary of HUD and the President of the National Institute of Building Sciences reexamine recommendations made in the reports cited in this report which call for a more vigorous and effective Federal role in encouraging the use of innovative cost-saving technology in homebuilding. We also recommend that the Secretary of HUD and the President of the Institute (1) determine whether some revision of internal priorities might be possible and desirable in order to direct more resources to encouraging greater use of innovative technology in homebuilding and (2) explore other alternatives for reducing housing costs through greater use of innovative technology.

MAJOR STUDIES CONSIDERED IN OUR REVIEW

- Bernhardt, Arthur D., Building Tomorrow: The Mobile/Manufactured Housing Industry, the MIT Press, 1980
- Burt, Hill, Kosar & Rittleman Associates, Final Report on DOE Minimum Energy Dwelling Research Project (MEDI), August 1979.
- Federal Trade Commission, Building Regulatory Practices and the Courts, September 1980.
- Moore, David C., Lessons Learned From The HUD Solar Demonstration Program, Reprint from the Proceedings of the Annual Meeting of the American Section of the International Solar Energy Society, May 27, 1981.
- National Association of Home Builders Research Foundation, Inc., Constraints To Builders' Use of Cost Saving Innovations, July 1971.
- National Association of Home Builders Research Foundation, Inc., Solar Energy for Homes, Current Status, 1980.
- National Institute of Building Sciences, A Study of Existing Processes for the Introduction of New Products Into the Building Industry, January 1979.
- National Institute of Building Sciences, A Study of Existing Systems for the Identification, Determination and Communication of Research Development and Information Needs of the Building Industry, January 1979.
- National Institute of Building Sciences, A Study of the Regulation and Codes Impacting the Building Process, July 1979.
- United States Department of Energy, The National Passive and Hybrid Solar Energy Dwelling Research Project, August 1979.
- United States Department of Housing and Urban Development, Final Report of the Task Force on Housing Costs, May 1978.
- United States Department of Housing and Urban Development, Earth Sheltered Housing: Code, Zoning, Financing Issues, April 1980.
- United States General Accounting Office, Why Are New House Prices So High, Are They Influenced by Government Regulations, and Can Prices Be Reduced?, Report to the Congress by the Comptroller General of the United States (CED-78-101), May 11, 1978.

ORGANIZATIONS VISITED OR CONTACTED

## State or national organization:

California	Building Industry Association of Southern California Builders Consortium of Affordable Housing Construction Industry Research Board California Manufactured Housing Association Western Manufacturing Institute San Diego Building Contractors Association California State Department of Housing and Community Development State of California Office of Appropriate Technology Southern California Institute of Architecture
Michigan	Michigan Association of Home Builders
Texas	Greater Houston Builders Association Texas Association of Builders Legal Department, City of Houston
Washington, D.C.	National Association of Home Builders American Institute of Architects National Academy of Sciences Council of American Building Officials Association of Collegiate Schools of Architecture
Virginia	Manufactured Housing Institute National Association of Home Manufacturers
Maryland	National Association of Home Builders Research Foundation, Inc.
New York	American Society of Civil Engineers

## Architectural research centers:

California	University of California, College of Environmental Design, Berkeley
Michigan	University of Michigan, College of Architecture and Urban Planning, Ann Arbor
Texas	Rice Center for Community Design and Research, Houston
Georgia	Georgia Institute of Technology, College of Architecture, Atlanta

Arizona                      Arizona State University, College of  
Architecture, Tempe

Others involved in research:

California                      S.R.I. International  
Architectural Research Consultant  
Building Systems Development, Inc.  
University of California - Davis,  
Civil Engineering Department

Illinois                          Small Homes Council - Building Research  
Council, University of Illinois

New York                          Research Architect

Washington, D.C.                  Rand Corporation

Federal agencies:

Agency for International Development  
Department of Housing and Urban Development  
Department of Energy  
Department of Defense  
Department of Labor  
Department of Commerce  
National Aeronautics and Space  
Administration  
National Science Foundation

Other organizations:

National Institute of Building Sciences

Grantees under the HUD "Building Value  
Into Housing Program":

Ohio                                  Huth Westwood Builders, Akron

Texas                                  Texas Tech University, Lubbock

California                          Mark Good and Lee Choitz, Newport Beach  
Edmund Burger, San Francisco

## APPENDIX II

## APPENDIX II

BUILDERS

<u>Principal location of builder</u>	<u>Number of builders contacted</u>	<u>Total number of houses constructed in 1980</u>
California	9	8,146
Michigan	6	917
Ohio	1	200
Texas	9	10,675

MOBILE HOME DEALERS

<u>Principal location of dealer</u>	<u>Number of dealers contacted</u>
California	3
Michigan	2
Texas	2

DESCRIPTION OF PROBLEMS WITH BUILDERS'USE OF COST-SAVING INNOVATIONS

Following is a description of certain problems HUD identified in its 1971 study (discussed on p. 9) concerning the use of selected technological innovations. HUD termed seven problems "important." They are described below, in the order of HUD's ranking.

RISK OF POOR PERFORMANCE

The HUD study explained that expected savings from innovations were almost always modest and that builders were most reluctant to experiment with new items which might lower cost a little if there was a possibility of poor performance. In the building industry, where product life may be expected to be at least 10 to 20 years, an innovation moving from the laboratory into actual use can encounter unforeseen problems because it is sometimes difficult or impossible to simulate actual use conditions or the longevity of a product in a laboratory.

Two examples of innovations that performed poorly after they were used are aluminum wiring and asphalt tile flooring. According to a HUD research official, both were introduced as cost-saving items, had been given standard available testing before introduction, and had met model building code requirements. However, in actual use by builders, the connections of aluminum wiring were found to cause fires and the asphalt tile proved to be easily broken in heavy-traffic areas.

POSSIBLE DAMAGE TO BUILDERS' REPUTATION

Pointing out that builders' reputations among home buyers were "extremely important" to their businesses, the HUD study noted that possible damage to builders' reputations was a real barrier to adopting cost-saving innovations which involve using lesser amounts of material (for example, 2X3 studs) and eliminating components (for example, floor bridging). HUD explained that consumers often mistakenly fear that these innovations weaken the structure of a house and that competing building firms frequently make a sales point out of their own firm's use of traditional material.

BUILDING CODE PROHIBITIONS

The HUD study found that building code prohibitions were an important constraint on builders' use of 5 of the 12 innovative items included in the study that were typically controlled by building codes. Evidently, the finding pertained to a time lag in codes' acceptance of innovations, which primarily affects builders who wish to use innovations quickly.



Building codes affect costs in many cases by requiring certain products, materials, or processes. While some States have enacted statewide codes or minimum State codes which can be exceeded by locally enacted ones, a tradition of local control of codes continues. HUD's 1978 task force on housing costs estimated that local codes existed in half the approximately 20,000 jurisdictions having code authority.

Almost all jurisdictions base their codes upon one or the other of several model codes developed by voluntary associations, known as model code groups. Through a coordinating organization established in 1972, the principal model code groups jointly agreed upon a single one- and two-family dwelling code to eliminate any conflicts and duplications among their respective codes and to achieve national uniformity. In addition to model codes, HUD has established minimum property standards describing the minimum level of quality acceptable under HUD's various mortgage insurance programs for single-family houses.

Allowance for innovations, however, is delayed at the local level because localities often have difficulty maintaining up-to-date code requirements. According to a 1979 study of building regulations, 1/ model code groups annually approve and forward to State and Local governments hundreds of revisions to model codes; however, many local governments have neither the time nor staff to review, approve, and incorporate them--to keep their codes current. A draft of a follow-on report stated in part that recognition and acceptance of new technologies at the local level is not uniform; few local regulations reflect the degree of currency recognized at the national level--most show a time lag of at least 3 years.

A builder having a national reputation for innovation told us that building code prohibitions stemming from local communities' delays in updating codes primarily constrain progressive, innovation-minded builders who want to apply innovations quickly.

#### LACK OF SUFFICIENT TECHNICAL INFORMATION

The 1971 HUD study reported that lack of sufficient technical information was an important constraint that related to one innovation which was quite new and whose installation involved certain technical details not widely known. But it also related to an innovation (preassembled plumbing trees) that was not considered specialized and therefore about which little technical data had been publicized. The study concluded there was a need for dissemination of technical information on certain innovations even when it seemed unnecessary.

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1/"A Study of the Regulations and Codes Impacting the Building Process," National Institute of Building Sciences, July 1979.

BUILDING OFFICIALS FROWN ON USE

The 1971 HUD study referred to cases in which innovations allowed by building codes were nevertheless personally disliked by local building officials and were, for that reason and regardless of the codes, not used by builders.

The fact that building regulations are adopted does not necessarily mean they are administered or enforced as adopted. According to various studies, administration, enforcement, and interpretation of codes is varied and inconsistent. When inspectors frown on innovations allowed by local codes, builders usually do not use the innovations because they usually yield only modest savings and appealing the inspectors' views would only delay construction. A draft of a followup report to the 1979 National Institute of Building Sciences study of building regulations explained that, to avoid time delays or other problems, builders use only methods, materials, and concepts that are acceptable to the code administrator/enforcer, and they do not challenge those views unless it is absolutely unavoidable.

The problem evidently stems from a lack of qualified inspectors. A 1980 Federal Trade Commission study<sup>1/</sup> found the lack of such inspectors a "major barrier" to use of innovations. The report explained that most local building officials come from a traditional construction background and lack adequate training to deal with innovative concepts of construction, with the result that they often look with some disfavor upon new products and other innovations. It further explained that budgets for code departments are "notoriously tight" and that few code departments can afford to provide training to keep their officials current with changes. The Institute also agreed that because inspectors frequently come from the trades, they may have inappropriate education and training backgrounds that make it difficult for many of them to deal with existing, let alone innovative, technology.

INAPPLICABILITY TO BUILDERS'  
DESIGN OR MATERIALS

Inapplicability to builders' design or materials was a factor in nonuse of 10 of the 12 cost-saving innovations addressed in the 1971 HUD study. HUD's report stated that "design decisions" were a limiting constraint for about one of five dwellings.

According to the report, the study results illustrated that it is not always possible to use cost-saving innovations due to inherent design factors or to the demands of the consumer concerning the appearance of the dwellings. It explained, for example, that:

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<sup>1/</sup>"Building Regulatory Practices and the Courts," Federal Trade Commission, Sept. 1980.

"\* \* \* single layer combined siding and sheathing tends to produce siding with vertical lines and a general contemporary appearance. This has limited marketability to the many people who want a colonial, horizontal siding appearance."

The study concluded that this constraint largely could not be remedied--that some markets and some designs eliminated the possibility of using certain innovations.

#### NOT MARKETABLE IN THE BUILDER'S AREA

The final constraint on use of cost-saving innovations that the HUD study found important was that they were sometimes not marketable in the builder's area--that is, were not acceptable to consumers. In this connection, the study report pointed out that innovations which could adversely affect consumer purchase decisions are very important constraints to a builder. It explained that builders' concern about the effect of innovations on their houses' marketability is heightened by the nature of the homebuilding business--lack of a few sales can easily mean bankruptcy.

The study concluded that remedial action should include dissemination to the consumer of information about the acceptability of appropriate cost-saving innovations. It stated that use of cost-saving innovations with adequate performance improves dwelling value, and the consumer gets a better buy per dollar. It added: "Apparently, this story needs to be told and retold by appropriate authorities, such as HUD."

#### OTHER CONSTRAINTS

The 12 other constraints cited in the HUD study, which were ranked as having average to not significant impact, were as follows:

- Expect too many callbacks.
- Appraisal penalty.
- Costs more.
- Lenders frown on use.
- Unsatisfactory experience.
- Material not available.
- Requires subcontractors to change.
- Not worth extra training.
- Union rules prohibit.
- Licensing system prevents.
- Lack of management/supervision.
- Never heard of item.

SUMMARY OF CONSTRAINTS, BY SOURCES

To provide an overview of the study results, HUD's report grouped the various constraints into six categories of sources for the constraints. Ranked in percentage terms, consumer, product/manufacturer, government, and builder sources accounted for 76 percent of all the constraints and were the sources for all seven constraints the report termed important. Of these the consumer source was the largest.

The relationship of important constraints and their sources is summarized in the table below.

<u>Source</u>	<u>Percent ranking</u>	<u>Nature of constraint</u>
Consumer	23	May damage reputation Not applicable to design Not marketable
Product/manufacturer	20	Risk of poor performance
Government	18	Building code prohibits Building officials frown on use
Builder	15	Not enough technical information

Sources for other constraints accounted for the remaining 24 percent in the percent ranking. They consisted of the financial/lender sector (14 percent) and the subcontractor/labor sector (10 percent).

In short, the study highlighted the paramount importance of consumer and performance-related constraints. The HUD report commented that the high ranking of consumer and product/manufacturer (performance) constraints

"would be expected by anyone familiar with the home building process and the overwhelming concern the builder must have for the consumer and his continuing apprehension about the possible deleterious effect on his business of poor performance of 'new' products, methods, etc."

COST-SAVING POTENTIAL OF INNOVATIVE ARCHITECTURAL  
DESIGNS AND GENERAL CONSTRUCTION METHODS

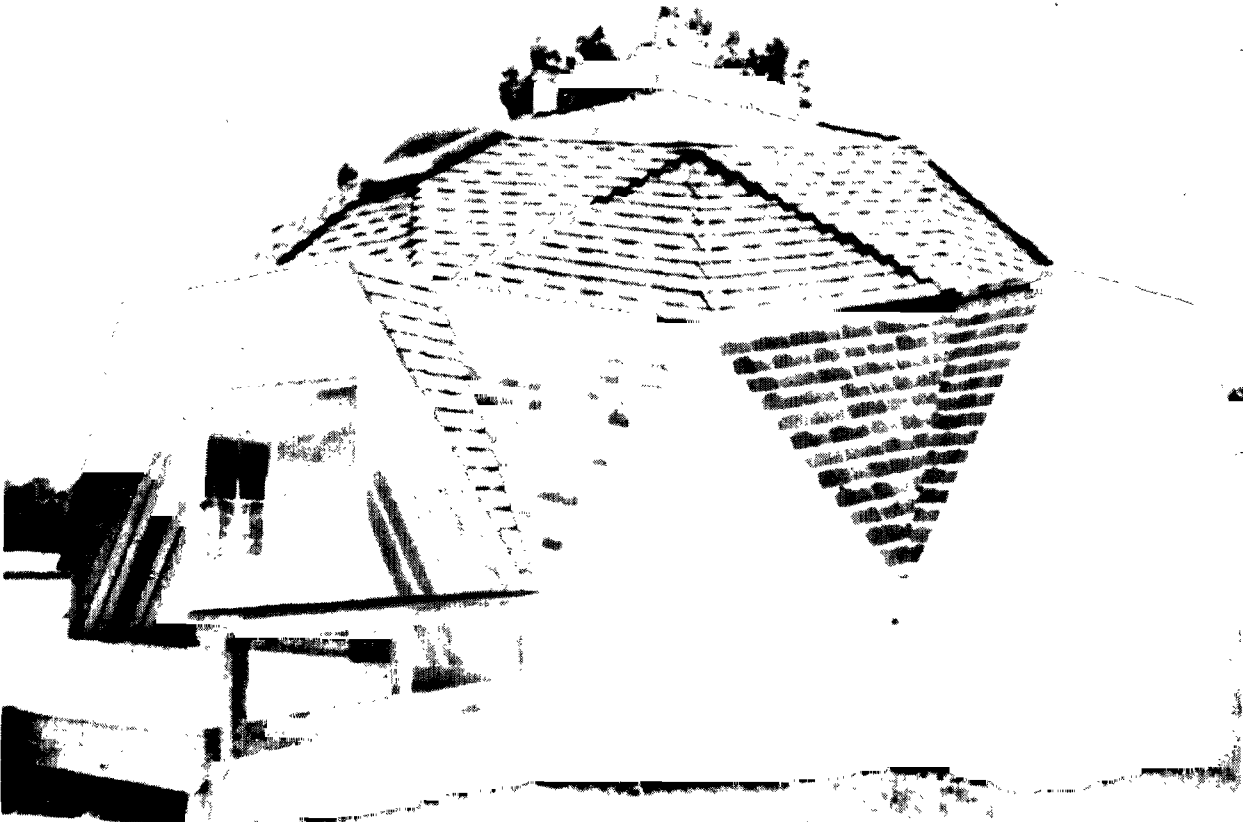
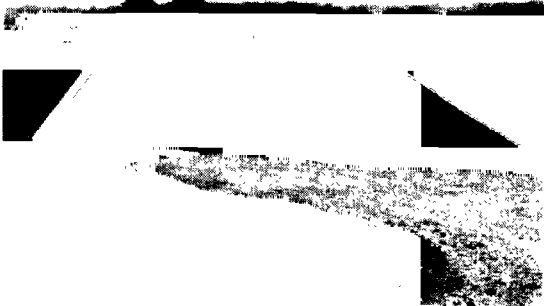
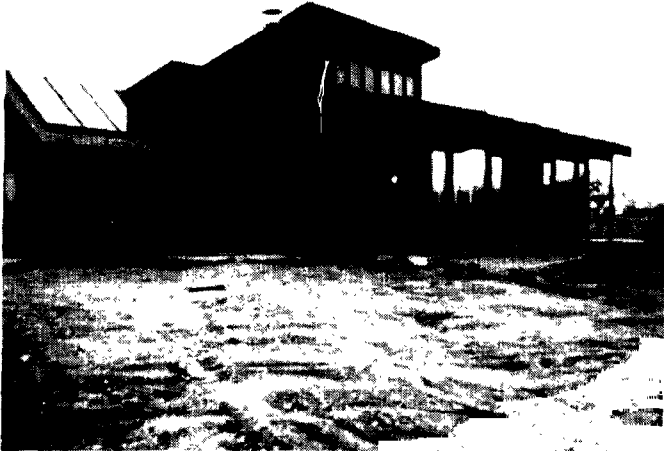
The cost-saving potential of houses embodying the principal current forms of unconventional design, such as earth-sheltered houses and solar houses, has not yet been established. Indications for some of the designs are that they will have little or no impact on constraining initial costs but may offer an opportunity to reduce energy costs.

The principal alternative to the conventional method of constructing houses at the building site, namely manufactured housing, continues to be restricted by various economic factors, including the highly cyclical nature of the housing market. While manufactured houses have improved in terms of quality and variety, only one major form--large mobile/manufactured homes--seems to offer important cost savings compared to the median-size, conventional house. However, the use of these homes is seriously limited, primarily by restrictive local zoning.

LITTLE SAVINGS AVAILABLE THROUGH  
UNCONVENTIONAL DESIGNS

The major unconventional designs we discuss in this appendix are earth-sheltered, dome, and solar houses. (See photos on next page.) Data on the cost savings achieved by these designs is presently incomplete since not many were built until the early 1970's when people began to realize that energy would be more expensive and/or in shorter supply for the foreseeable future. Information we obtained indicates that these houses could use 10 to 60 percent less energy than conventional houses. However, the long-term energy savings could be offset by extra initial costs of energy savings technology applied to the houses. The cost-saving potential largely depends on the future cost of energy.

Officials involved with houses of these designs believe the initial costs of building them will become more competitive with the cost of conventional houses as they increase in popularity. Furthermore, they also believe the unconventionally designed houses, other than those homes with active solar space heating and solar cooling systems, will probably capture a reasonable share of the new house market in the future as energy costs continue to increase.



### Earth-sheltered houses

An earth-sheltered house is a house in which at least 50 percent of the exterior is covered by earth. A few earth-covered houses were built in the 1960's. However, with the 1973 oil embargo, public interest in earth-sheltered housing increased substantially. In 1976 there were probably fewer than 50 earth-sheltered houses across the country. By the end of 1979, the total number actually completed or under construction was estimated at between 1,500 and 3,000.

Data on savings in earth-sheltered houses is limited since the design is in an early stage of development. Information we received from the Underground Space Center, University of Minnesota, indicated that the savings would not be realized in initial construction costs but rather in costs of energy, maintenance, and insurance. One study <sup>1/</sup> compared a conventional house to an earth-sheltered house and found the earth-sheltered house had 14 percent higher initial construction costs but that the additional cost could be offset by savings in space heating costs in 9 to 15 years, depending on energy cost and use. Earth-sheltered structures save energy by reducing heat loss due to transmission through the building exterior and lower loss due to infiltration.

The higher initial construction costs are attributable mainly to costs for extra supporting structure, waterproofing materials, insulation, and higher architectural fees. Also, the fact that these houses are being built "for the first time" on a scattered basis rather than on a tract basis, as compared to a conventional home, tends to drive up the initial costs. A University of Minnesota official stated that the initial cost will come into line with conventional houses when earth-sheltered houses are constructed on a tract basis and cost elements reduce as the industry gains experience. In addition, he believes that earth-sheltered housing could capture 1 to 10 percent of new house starts by the year 2000 because estimated energy costs will probably go up 15 to 20 percent annually in the near future.

### Dome houses

The dome house is a freestanding, open-space structure with no need for interior load-bearing walls. The structure's strength is in its shell, constructed of triangular panels assembled to form a sphere. Dome designing for housing came into being during the 1970's and is in the early stage of acceptance.

Various sources estimate that from 2,000 to 5,000 dome homes had been built through 1980. Dome home production in 1980 was about 5 times the 1975 level and dome construction is expected

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<sup>1/</sup>"Earth Sheltered Housing: Code, Zoning, and Financing Issues," U.S. Department of Housing and Urban Development, Apr. 1980.

to more than double in 1981. Some dome homes are being built next door to conventional houses in suburbs of Houston, St. Louis, Chicago, Oakland, and Los Angeles. In Michigan and Iowa, three subdivisions of up to 10 to 20 domes each are under-way.

The dome home manufacturers/builders we contacted all cited savings up to \$20 per square foot for professionally built homes compared to conventional homes. In addition, since the dome homes generally are fabricated in a factory, homebuyers can substantially reduce the costs by finishing much of the construction themselves. Further, the manufacturers/builders claimed that dome houses use one-third to one-half less energy than conventional houses.

A dome house design yields cost savings in energy due to its round structure which allows heated or cooled air to circulate more freely. Savings in initial cost are claimed by some manufacturers because a dome house has one-third less exterior surface which reduces construction materials up to one-third of that used for conventional houses with the same square feet of floor space. However, one manufacturer told us even though dome houses use one-third less building materials, such savings are largely offset by the higher costs of roofing and interior finishing.

Most of the dome home officials we contacted were optimistic about more extensive use of the design in the future because of the cost savings. However, they were not sure whether dome designs will substantially replace conventional housing designs, mainly because there is still consumer resistance to their appearance.

### Solar houses

Solar homes use the sun's warmth for space or water heating through design and/or mechanical devices. The upsurge of interest in solar homes was triggered by the Arab oil embargo in 1973. Since then, thousands of new homes each year have been built with solar features. Although the initial cost of a new home is higher when solar features are used, the additional costs may be offset over a few years by reduced energy operating costs.

The three basic types of solar homes are passive, active, and hybrid (a combination of passive and active). A passive-designed solar home taps the freely available resources of the surrounding environment, using natural flows of energy to heat, cool, and light a house. This is accomplished by siting the house to purposely collect, store, and distribute solar energy. Passive techniques include greenhouses, sunspaces, thermal storage walls, and the proper orientation of windows and living spaces. Active-designed solar homes use external energy to move energy around the house through special equipment. The most commonly used systems in active solar homes are space heating and hot water. Hybrid designed homes use combinations of fans, pumps, compressors, dampers, and other energy flow control devices that passive systems normally do not have.



Because solar-designed homes have only recently come into being, data on initial construction and operating costs are not firm. However, HUD's chief of solar demonstration program estimated that the passive and hybrid solar system added \$2,500 to \$5,000 more to the initial construction cost but saved over 50 percent of the annual heating cost. The amount of energy savings depends on many factors, such as the size of the home, the owner's life style, and the type of fuel used to heat the home. However, HUD's experience in its residential solar demonstration program showed that most passive space heating systems are cost efficient.

Active solar homes are also more costly to construct than conventional homes. According to the chief of HUD's solar demonstration program, the solar space heating system added \$10,000 to \$15,000 more to the initial construction costs but yielded a 30- to 40-percent energy savings. The hot water system increased the initial construction cost by \$1,000 to \$4,000 while reducing energy consumption by 60 to 70 percent.

The outlook for solar-designed homes, particularly passive and hybrid, looks promising. Firm estimates on the number of homes currently being built with solar design features are not available, but thousands of homes built today have some design solar features. HUD claims that residential passive heating systems are ready for use and are cost effective but that advanced heating systems and passive cooling systems need further research and development.

HUD's chief of solar demonstration program estimated that the use of passive solar systems in single-family detached houses would significantly increase in the future when home buyers, builders, and financial institutions increasingly realize the benefit passive homes could yield in fuel costs. In addition, this official believed that a hybrid solar home has the best potential among solar designs for greater savings in energy because it generally has the best features of both passive and active solar systems.

MANUFACTURED HOMES MAY YIELD  
COST SAVINGS BUT THEIR USE  
IS LIMITED BY LOCAL REGULATIONS

The conventional method of constructing houses, popularly known as "stick building," involves fabricating the house's major components (walls, roofs, and floors) and assembling the house at the building site itself. The principal alternative method involves moving onsite construction, either totally or substantially, to a factory. The housing produced under this method is variously referred to as industrialized, factory-built, or manufactured housing. It aims at lowering housing costs primarily by

- producing house components and houses using less skilled, more available workers than are required for onsite construction;
- ending the seasonality of homebuilding;
- purchasing large volumes of materials; and
- improving quality control by using precision machinery and jigs.

Manufactured housing is constrained by several factors. To be efficient, it requires substantial investment in plant and equipment and a high level of production. But high levels of production have not been sustained, due primarily to the instability of the housing market. In addition, manufactured housing faces strong competition from conventional homebuilders and obstacles to production economies, such as the many differing State and local building codes.

Despite these constraints, since the early 1970's, manufactured housing has played a larger role in meeting the Nation's housing needs and has contributed to keeping costs below what they otherwise might be.

An increasing number of conventional builders have been using fabricated components, such as wall panels and roof and floor systems, purchased from manufacturers or fabricated in the builders' own plants. According to statistics in "The Red Book of Manufactured Housing '81," 200,000 new 1- to 4-family housing units in 1979 were produced by "major industrialized home builders." Another 768,000 units were constructed by other builders using some fabricated components.

In addition, several types of houses have been produced almost completely in factories by manufacturers who sell to dealers or builders for sale to home buyers. In recent years, the quality of these houses has improved greatly. They include mobile/manufactured homes, panelized, and modular houses. Brief descriptions of each type and units produced in 1979 as cited in the "Red Book" for 1981 follow:

- Mobile/manufactured home, 277,000 units. A three-dimensional structure, transportable in one or more sections, built on a permanent chassis and designed to be used as a dwelling with or without a permanent foundation when connected to utilities. It includes the plumbing, heating/cooling, and electrical systems.
- Panelized house, 127,000 units. A "package" of precut wall panels, that may also include preassembled major components, such as roof and floor systems, plus a wide

variety of building materials and equipment that are shipped in two dimensional form and assembled at the site.

--Modular house, 45,000 units. A three dimensional housing unit produced in a plant and designed for erection on a permanent foundation. Most are shipped to the site in two or more sections.

The potential these manufactured houses have for holding down the cost of median-size single-family housing is discussed in the paragraphs that follow.

Large mobile/manufactured homes may offer important cost savings, but zoning regulations restrict their extensive use

In recent years the mobile home <sup>1/</sup> industry has significantly improved the quality of its housing product. While it has primarily focused on the lower price market, the industry now also addresses the middle and higher price market and produces homes the size of the conventionally built median-size house. Data to compare the cost of a mobile home to the cost of the conventional median-size house was lacking. However, important savings seem possible because the industry is governed by a uniform national construction code and it has achieved a superior efficiency in design, production, and distribution. Widespread use of large mobile homes is restricted by local zoning regulations, which limit their locations, and may also be hindered by consumer acceptance factors, including consumer unawareness of mobile homes' improved quality, appearance, and amenities.

According to the Manufactured Housing Institute, the mobile home industry includes about 170 manufacturers with 450 factories that retail through about 10,000 dealerships. The purchase price of a mobile home includes the home with furniture, appliances, and other basic furnishings and, generally, the cost of setting it up at the buyer's site. The site has to be rented or purchased separately.

All mobile homes built since June 1976 must conform to the HUD Mobile Home Construction and Safety Standards Code, promulgated under the National Mobile Home Construction and Safety Standards Act of 1974.

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<sup>1/</sup>The term "mobile home" in the National Mobile Home Construction and Safety Standards Act of 1974 was changed to "manufactured home" by amendment under the 1980 Housing and Community Development Act (Public Law 96-399). In this appendix we use mobile home to avoid its confusion with other types of manufactured homes discussed.

With units in 1979 averaging 1,050 square feet in size and \$17,600 in price (excluding land), the industry has come to dominate the lower price (under \$35,000) housing market. However, since 1969 it has produced large "multisection" homes--two or more sections transported to the site and then joined together to make one home. By 1979 these accounted for 30 percent of the 277,000 mobile homes shipped. These homes are typically about 1,400 square feet, but some equal or exceed the size (1,595 square feet) of the 1980 median-size conventional house. Some models offer a wide variety of amenities--for example, cathedral ceilings, walk-in closets, sunken tubs, and fireplaces--and such optional features as porches, carports, and pitched shingled roofs.

According to a study published in 1980 by the Massachusetts Institute of Technology, 1/ the industry has achieved a superior degree of efficiency in product design, production processes, and distribution. On the basis of a 7-year review involving over 100 professionals in a range of disciplines, recruited from the various groups at work in or related to the building industry, the study found the mobile home industry to be by far the most efficient building in the United States and probably in the world.

We did not find data on the comparative cost of large mobile homes and similar sized conventional houses of the same quality. However, we did find cost data comparing the two industries' average cost per square foot for their total 1979 production. Based on data in a 1980, Manufactured Housing Institute (MHI) publication, the average sales price per square foot in 1979 for a new mobile home (excluding land but including furnishings and setup costs) and a site-built house (excluding land and furnishings) was \$19.27 and \$32.00, respectively. A similar large gap in average sales prices per square foot was cited in the 1980 Massachusetts Institute of Technology study.

However, calculations based on average prices per square foot do not accurately measure the cost differences stemming from different quality and methods of construction. For example, a conventional house constructed with very high quality materials by a small-volume builder using few preassembled parts in an area where labor costs are high would cost more than one constructed with lower quality materials by a high-volume production builder using preassembled components in an area where labor costs are low. Further, according to a manufacturer quoted in an article in the trade magazine "Housing," the more manufacturers do to bring mobile homes closer to conventional housing, the less the difference in cost.

The president of MHI viewed restrictive zoning regulations as the paramount barrier to extensive use of large multisection mobile

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1/Arthur D. Bernhardt, "Building Tomorrow: The Mobile/Manufactured Housing Industry," the MIT Press, 1980.

homes. Local zoning ordinances usually prohibit mobile homes in neighborhoods where conventional housing is predominant. A 1980 MHI publication reported that about 48 percent of occupied mobile homes were located in mobile home parks, most of which were rented rather than owned. About 52 percent were placed on individually owned lots in rural or small town locations. Some were in mobile home or condominium subdivisions where owners purchase the home and land or an interest in the common grounds.

The situation is beginning to change. The MHI president told us, for example, that laws in three States (California, Indiana, and Vermont) now prevent mobile homes from being "zoned out" of residential areas. Further, some counties in other States also permit them in subdivisions containing site-built houses. In all these cases, the homes must be on permanent foundations, meet local minimum size requirements, and have a conventional house appearance.

Other possible barriers include consumers' lack of awareness of the changed and improved character of mobile homes--the image of them as trailers persists--and technological limitations on the type and variety of exterior designs as compared to conventionally built houses, which may limit consumer acceptance.

#### Panelized and modular homes provide little cost savings

Panelized and modular houses are not a means of significant cost savings for new single-family detached housing. A spokesman for the National Association of Home Manufacturers told us the industry does not claim the houses yield such savings in relation to conventionally constructed houses. According to a 1979 independent study made available by the Association, the average selling prices per square foot of panelized and modular homes in 1978 was about the same as for conventionally built houses: \$31.62 and \$31.05, respectively, as compared to \$32.23 for conventional houses.

The industry markets the houses on the basis of their high quality, stemming from quality-controlled factory methods, and their advantages to small builders. Manufacturers sell the houses primarily to small builders (having an annual volume of 25 to 50 units or less) in outlying and rural areas where skilled tradesmen are few. The limited site work needed to finish the houses enables these builders to finance and sell more houses with a given amount of construction finance money than would be possible if they built houses using the conventional stickbuilding method. For various reasons, including plant overhead and transport costs and high-volume production methods used by many conventional builders, there are not significant cost advantages in more populous areas.

According to National Association of Home Manufacturers and MHI spokesmen, the costs of panelized and modular houses are increased unnecessarily because they must be built to comply with differing State and local codes--unlike mobile homes, which are built to one national Federal code. The spokesman for the National Association of Home Manufacturers estimated that a uniform nationwide code for the houses would reduce their cost from 3 to 5 percent.

OPTIONS AVAILABLE TO HOME BUYERS  
WHICH CAN REDUCE HOUSING COSTS

Indications are that the prevailing high cost of housing has caused builders and buyers to give renewed attention to modifications to conventional housing and that they are likely to play a larger role in the future of providing an opportunity for many Americans to purchase a single-family house. Such modifications include expandable houses, attached single-family houses, and smaller houses.

EXPANDABLE HOUSES  
REDUCE INITIAL COSTS

One option available to a first-time home buyer wanting to buy a new single-family detached house but finding it difficult because the house costs too much is to consider buying a house that is expandable. An expandable house is one whose exterior is designed so that additions to the house can be made in the near future or whose exterior is finished but its interior is only partially finished and can be completed by the buyer as he or she becomes financially able to do so. Either one of these options can reduce the cost to the home buyer. Both versions of the expandable house can be built in any size and can sell for any price.

Because the traditional single-family detached home is far and away the favorite type of housing desired by first-time home buyers, many would if necessary accept an expandable house as a means of buying a new single-family home. In a 1980 survey <sup>1/</sup> conducted by NAHB's Economics Department, it was found that more than half of the respondents, 54 percent, indicated a willingness to accept an expandable plan as a way to cut costs and buy a single-family detached house. Further, another survey, <sup>2/</sup> reported in the December 1980 "Professional Builder" magazine, found that over 67 percent of home buyers would, as a means of cutting costs, buy an expandable design home.

Among the builders interviewed during our review, only 3 of the 24 constructed expandable homes in 1980. All three builders were located in the Detroit area. The builders in the Los Angeles and Houston areas believe that expandable homes are not marketable. One builder in the Los Angeles area built a small tract of expandable homes about 7 years ago but had so much trouble selling them that he finished them and sold them as completed houses. Another builder in Houston tried to market an expandable home--two-story units with an unfinished second floor--but stopped because of insufficient demand.

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<sup>1/</sup>Michael Sumichrast and Gopal Ahluwalia, "Decisions for the 80s," National Association of Home Builders, Dec. 1980.

<sup>2/</sup>"What Consumers Expect from Housing in 1981," Professional Builder, Dec. 1980.

In Detroit, 53 percent of the three builders' total new home construction had an expandable design. The size of the expandable houses they constructed in 1980, including unfinished rooms, ranged from 1,000 to 2,600 square feet and cost between \$50,000 to \$100,000. If these homes had been completed by the builders, their estimated price would have been \$5,000 to \$12,000 higher. All three builders said they experienced a strong demand for expandable homes and told us they will probably continue to construct them.

#### SINGLE-FAMILY ATTACHED HOUSING CAN REDUCE COSTS

Another option available to a home buyer entering the housing market for the first time who is attempting to reduce initial cost is to consider attached housing. The principal forms of attached single-family housing include duplexes, townhouses, and condominiums. Some housing experts have contended that the high cost of housing has limited the home buyer's choice to such an extent that more and more are turning to attached housing as a way of entering the housing market.

Many building officials believe the trend to attached forms of single-family homes will continue throughout the 1980's. The December 1980 "Professional Builder" magazine reported on a study entitled "What Consumers Expect From Housing in 1981." The study shows that among all buyers surveyed, 14.5 percent considered an attached house as the best way of entering the housing market. It also shows that nearly 25 percent of people under the age of 25 see attached housing as the best way to enter the housing market. The same study also shows that nearly 55 percent of home buyers who indicated they would accept attached housing would do so because of lower home-maintenance costs.

HUD's chief of building technology research unit told us that he believes attached forms of housing are less expensive alternatives because they use less land and therefore reduce site development costs. In terms of construction costs, however, he said that attached houses may not be less expensive than detached because many times they require fireproofing of the common wall. An NAHB staff assistant stated that attaching two or more houses would save the costs of materials and labor, land and land development, and/or heating and cooling due to the common wall. However, no cost data was available to confirm either official's opinion.

Of the 24 builders we visited in Detroit, Los Angeles, and Houston, 9 constructed attached single-family units during 1980 and 12 expected to begin and/or increase construction in the near future because of increasing demand. For the builders who in 1980 built both attached and detached single-family units, attached housing accounted for 25 percent of units built in the Detroit area, 44 percent in the Houston area, and 51 percent in the Los Angeles area. The size of attached houses these builders constructed in 1980 ranged from 600 to 1,950 square feet and cost from \$32,000 to \$180,000.



Several of the builders we visited felt they could not save money on the construction of attached houses because:

- They include the same or more amenities as detached houses.
- Money is spent on community facilities.
- The land cost for one unit of attached housing is the same as the land cost for one detached house. For example, if a builder pays \$10,000 for land zoned for three detached houses and pays \$25,000 for land zoned for eight units of attached houses, the land cost for one detached house is about the same as for one unit of the attached houses.

Some builders felt, however, that money is saved when constructing attached houses because land density is higher. One builder estimated that land for a detached house cost about \$7,000 more than land for the same size attached house.

#### SMALLER HOUSES CAN ALSO REDUCE COSTS

A further option for first time home buyers to consider as a means of entering the single-family home market is to buy a smaller or basic home. <sup>1/</sup> Smaller homes, attached or detached, generally cost less to buy than today's median-size home. In addition, smaller homes can offer most of the same comforts as larger homes with added advantages such as lower maintenance costs.

In the past few years, most new single-family detached houses have been designed in larger size and with more amenities, which have increased initial costs. The median size of a new single-family house increased from 1,495 square feet in 1965 to 1,595 square feet in 1980. During the same period--1965 to 1980--the price of a median-sized single family detached house increased from \$20,000 to \$64,000. Features such as wall-to-wall carpeting, a family room with fireplace, air conditioning, two to three bathrooms, and four bedrooms were common in a 1980 median-sized and -priced single-family home.

The affordable new house of today is likely to be smaller and is gaining in popularity. For the first time since 1976, single-family houses completed in 1980 were smaller and had fewer amenities than those completed the year before. The median size of houses declined 50 square feet from 1,645 in 1979 to 1,595 in 1980.

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<sup>1/</sup>We defined "smaller" home as a house of 1,600 square feet or less in size: 1,600 square feet represents the median-sized house of 1979--1,645 square feet--rounded to the nearest hundred. "Basic" implies a home with fewer amenities than the typical median-sized home.

At the NAHB's 1981 national convention the consensus among many housing design experts and builders was that the key for success in the 1980's lies in smaller, higher density, energy-efficient homes. The convention's official program included several sessions concerning the trend to smaller, more energy-efficient single-family houses.

The July 1980 "Professional Builder" reported on a comprehensive survey 1/ of builders concerning foreseeable trends in housing. Seventy-eight percent of the builders saw smaller houses and 63 percent saw higher density houses for the future. In addition, 15 percent saw no change in housing size and only 2 percent saw larger houses in the future. In another survey, 2/ reported in the December 1980 "Professional Builder," 28 percent of potential buyers said they would buy, and 41 percent of the builders said they would build, smaller homes as a means of cutting housing costs.

Of the 24 builders we visited in the Detroit, Houston, and Los Angeles areas, 12 constructed homes of 1,600 square feet or less. In 1980, 64 percent of these builders' total construction output consisted of smaller homes ranging in size from 800 to 1,600 square feet. Many of these builders said that the number of smaller homes built by their firms has been increasing and will continue to increase because they are what people can afford.

The price of the smaller homes offered by these builders varied considerably depending upon the size of the house and the amenities included in the package. The ranges of size and price of the smaller homes constructed by the builders we visited are shown below.

	<u>Range of square footage</u>	<u>Price range</u>
Los Angeles	800 - 1,400	\$38,000 - \$80,000
Houston	900 - 1,600	38,000 - 67,000
Detroit	1,000 - 1,600	48,000 - 95,000

Each builder eliminated specific amenities to hold down the price of these smaller homes. For example, a builder in the Los Angeles area eliminated wall-to-wall carpeting, a dishwasher, an oven, and a mini stove and was able to keep the cost of his

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1/Bureau of Building Marketing Research, "1980 Profile of American Builders," Professional Builder, July 1980.

2/"What Consumers Expect from Housing in 1981," Professional Builder, Dec. 1980.

smaller homes roughly \$4,800 less than the cost of his larger home with these amenities included. Many builders, however, included in their small homes all the amenities that were in their larger houses and the cost of their smaller houses was still lower than their larger houses.



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT  
WASHINGTON, D. C. 20410

ASSISTANT SECRETARY FOR  
POLICY DEVELOPMENT AND RESEARCH

1 0 DEC 1981

IN REPLY REFER TO

Mr. Henry Eschwege  
Director  
Community and Economic  
Development Division  
U. S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Eschwege:

This is in reply to your letter of November 10, 1981 to Secretary Pierce, enclosing a draft of the GAO proposed report, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs."

We fully agree with the concept of this report. Many existing technical innovations in the homebuilding process, if used widely, could help stem the rate of rise in construction costs. We strongly disagree, however, with the report's conclusions that suggest that HUD has been delinquent in supporting the use of such innovations. Moreover, we believe that numerous statements in the body of the report closely support our position that HUD's technical research program has been in the forefront of the effort to introduce innovative building technologies.

In Chapter 2, the report states that only one research project funded since 1978 was found to have addressed a wide range of available technologies for reducing the initial cost of housing. This statement overlooks the many other projects started or completed since that date which were specifically cited in the draft report. Two specific examples of such projects are:

1. The Affordable Housing Demonstration, "Approach 80," in Las Vegas, Nevada, as cited on page 14 of your draft report, initiated in 1980 and demonstrated in 1981, in cooperation with the National Association of Home Builders. This demonstration was a major feature of the 1981 NAHB Convention technical program, and has been seen by thousands of homebuilders. This project featured a complete subdivision of new homes, which were constructed utilizing both innovative ideas in building materials and methods and the latest techniques in reducing the cost of land and of land development. The project demonstrated the importance of removing constraining local regulations, by obtaining the cooperation of local government in waiving such restrictive regulations.

2. The Building Value into Housing Demonstration Program, initiated in 1980 and continued in a second round of awards in 1981. This program is not cited at all, other than, on the second page of Appendix II, page 23 of the draft report, where GAO indicates that some of the grantees under the program were interviewed. In this program, HUD solicited builders and developers around the country for the best ideas on reducing housing costs and improving housing values, while providing the builders and developers with our best current information on innovative technology for use in developing their proposals. As the GAO draft report indicates, there is a problem in getting information on new ideas from one builder to another. As part of this program, HUD identified the best ideas and publicized them. Grants for constructing the best of the 1980 houses have been awarded, and designs are being completed on the 1981 award houses. The 1980 ideas were published last spring, and a report on the 1981 designs is in preparation.

[GAO COMMENT: HUD has misinterpreted our chapter 2 comments on research projects which address a wide range of available technologies. We did not say that we found only one research project that had been "funded" since 1978; we said that we found only one project that had been "completed" since 1978. We have revised our description of the Approach 80 project to include the point that it had not yet been completed at the time of our review. HUD correctly points out that our report omitted the Building Value into Housing Program in our discussion of HUD demonstration efforts, and we have revised the report to include it.]

In addition, HUD conducted four other demonstrations in: Hayward, California; Shreveport, Louisiana; Allegheny County, Pennsylvania; and Portland, Oregon. These projects utilized innovative technology to effect significant cost savings.

[GAO COMMENT: HUD officials did not describe these projects to us as significant demonstrations of innovative, cost-saving technology when questioned about them during our review. The chief of HUD's building technology research unit told us that these projects did not demonstrate a full range of innovative technologies, but instead provided information on specific innovative technology applications.]

In Chapter 3, the GAO report states that HUD has not been moving vigorously to implement recommendations of earlier reports on reducing housing costs, citing three specific examples; the chapter then describes many of the activities that HUD has underway to respond to the earlier recommendations. The report states that the principal recommendation in the 1971 NAHB Research Foundation study called for HUD to develop a continuing program to identify and evaluate all cost-savings innovations and to disseminate this information. Following paragraphs in this chapter list many actions HUD has taken to accomplish these steps.

The GAO report also cites a recommendation in the 1971 study for HUD to develop a training program for local building officials and inspectors, since it is agreed that poorly trained building officials can frustrate the potential benefits of a responsive building code. The report recognizes that HUD has completed the development of this training program and is now exploring the best way to implement it.

Finally, the report cites the recommendation of the 1978 Task Force on Housing Costs that HUD support research on the cost and benefits of safety requirements in codes, and identify and remove unjustifiable cost increasing requirements from HUD's Minimum Property Standards. The following statement in the draft report cites that this work is underway.

Most of the recommendations of the various studies, which did not involve significant additional staff, have been or are being accomplished in close cooperation with the housing industry. A number of these activities are described in the report, although the report concludes that HUD "has moved very slowly" to address these previous recommendations.

[GAO COMMENT: We concluded that HUD has moved very slowly on previous report recommendations based on our analysis of the time HUD has taken to act on them. HUD's comments ignore these time frames and do not acknowledge that many of the 1971 NAHB and 1978 Task Force on Housing Cost reports' recommendations were not yet implemented in 1981.]

We disagree with your first recommendation that HUD re-examine recommendations made in the various previous reports which call for a more vigorous and effective Federal role in promoting the use of innovative cost-saving technology in homebuilding. As discussed above, we believe that we have indeed implemented prior study and report recommendations and that your recommendation is not valid.

We have no problem with the recommendation of the GAO draft report, that: (1) HUD review its research priorities and (2) HUD explore other alternatives for identifying and encouraging the use of cost reducing innovative building technology. These are, in fact, continuing activities. I must point out, however, that our research program must support HUD's total mission, and that the cost of housing, as shown by the exhibits in the report and in many other studies, depends on many other factors in addition to the cost of housing construction. We expect to continue to carefully assess all of our research opportunities in light of the resources available to us.

Yours truly,



E. S. Savas



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December 24, 1981

Mr. Henry Eschwege  
Director  
Community and Economic Development Division  
United States General Accounting Office  
441 G Street, N.W.  
Washington, D.C. 20548

Dear Mr. Eschwege:

We have reviewed the proposed GAO report "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," and would like to offer the comments which follow. These comments will be made in two parts: (1) those that deal in general terms with references to NIBS; and (2) those that relate specifically to the text.

GENERAL

NIBS as an Organization

To the reader not familiar with the genesis and unique character of NIBS, there is a likelihood that frequent reference to NIBS as an agency or as though it is an agency might be misunderstood. There is mention of the fact that NIBS is not a federal agency, but more often the term "agency" is used when referring to NIBS, or HUD and NIBS are referred to as though they are alike or similar. The resulting overall impression is that both have a like status.

The NIBS authorizing legislation makes it quite clear that NIBS is not a federal agency. In Sec. 809 (b)(1), it is stated that NIBS is to be a nonprofit, nongovernmental instrument, and "...shall not be an agency or establishment of the United States Government." Further, in the preamble to Sec. 809, it is clear that NIBS is intended to be only advisory.

[GAO COMMENT: We recognize on page 1 of our report that the National Institute of Building Sciences is an independent, nongovernmental organization. However, in order to avoid any misconceptions we have deleted our references to the Institute as an "agency" where appropriate.]

NIBS Role with Respect to Innovation

There is frequent reference to NIBS as having a Congressional mandate to (as shown under Conclusion, p. 18) "...promote the development and use of innovative technology in homebuilding..." This is not entirely true. In Sec. 809 (a)(1)(A), it is stated as a Congressional finding that "...the lack of an authoritative source to make findings and to advise both the public and private sectors of the economy with respect to the use of building science and technology in achieving nationally acceptable standards and other technical provisions for use in Federal, State, and local housing and building regulations is an obstacle...and frequently results in the failure to take full advantage of new and useful developments in technology..." And, in Sec. 809, (a)(1)(D), the Congress found that "...the existence of a single authoritative nationally recognized institution to provide for the evaluation of new technology could facilitate the introduction of such innovations and their acceptance at the Federal, State, and local levels." Then, in Sec. 809 (e)(1), the Congress stated that NIBS "...shall exercise its functions and responsibilities...relating to building regulations..." through "Evaluation and prequalification of existing and new technology in accordance with subparagraph (A)." Subparagraph (A) refers to "Development, promulgation, and maintenance of nationally recognized performance criteria, standards, and other technical provisions for maintenance of life, safety, health, and public welfare suitable for adoption by building regulating jurisdiction and agencies..." Finally, in Sec. 809 (e)(2), the Congress states that the Institute is to assign and delegate, to the maximum extent possible, responsibility for conducting each of the needed activities.

In short, NIBS is to work toward the creation of a regulatory system in the United States--both its public and private elements--that will not pose a barrier to the introduction and use of existing and new technology, but not to "promote" new technology per se. This may appear to be a subtle difference but it is not. Another way of making the point clear, is that NIBS' role is not to promote the use of polybutylene piping for plumbing in lieu of metal piping (to use one of the examples in the report), but to see to it that there are performance-based plumbing criteria, standards and regulatory provisions that are neither material nor product specific, and that there is a system for evaluating and prequalifying existing and new plumbing technologies in relation to them. In this context, whether the piping is plastic or or metal--indeed, whether piping is used at all--is of little consequence. The objective is to provide the innovator with a performance target and a clear understanding of how his technology will be prejudged to ascertain whether it will achieve the performance target. This is a much more objective way to promote innovation. Doubtless there are total sanitary waste handling systems--existing or conceivable--where polybutylene piping is not suitable or where piping is not involved. By promoting the use of polybutylene piping, one is making the same mistake that those who promote metal piping are making--the focus is on a specific solution rather than the performance desired and the means for predicting performance achievement.

[GAO COMMENT: We have clarified the National Institute of Building Sciences' innovative technology role on page 1 of our report.]



The Formation and Funding of NIBS

The report contains references to the sequence of NIBS organizational events and to funding, which, if not accurately presented, would give the reader insufficient information to judge whether NIBS has been as responsive as it should have been to its legislative charge.

NIBS was authorized in the August 22, 1974, Housing and Community Development Act (Sec. 809 as noted above). President Ford appointed the first Board of Directors (18 of 21 authorized) in August 1976. The Board was tasked with incorporating the Institute, which it did in September 1976. The first appropriation to the Institute, which was outside of the President's Budget and for \$1 million, was in FY 1978. The funds did not actually become available until late November 1977. The Board retained its President and the first members of the supporting staff were on board by January 1978. The authorization was for \$10 million over 2 years, but, because of the delay in naming of the Board, this authorization was changed to \$10 million over the five-year period FY 1978-1982. In its first hearings before the appropriations committees of the Congress, it was recommended that NIBS seek to become a part of the President's budget. This the Institute did.

For FY 1979, the Institute requested \$2 million; it was granted only \$750,000. In FY 1980, the Institute requested \$3 million; OMB allowed a request of only \$750,000 and this was the amount granted. In FY 1981, the Institute was required to go to the zero-based budget system. The Institute's Minimum Level request was for \$500,000 (the amount proposed by OMB), the Current Level request was for \$750,000, and the Enhancement Level request was for \$2 million. OMB allowed \$625,000 and this was subsequently reduced to \$613,000. For FY 1982, the Minimum Level was for \$500,000 (the amount proposed by OMB), the Current Level was for \$625,000, and the Enhancement Level was for \$1 million. OMB allowed a request of only \$500,000. However, because the Institute has received only \$3.113 million (as your report points out) and this is the last year of authorized budget requests, the Congress has sent forward a final appropriation of \$1,440,000, which has now been signed by the President. In sum, if the Institute receives the Congressionally proposed 1982 appropriation, it will have received \$4.553 million or 46% of the amount initially authorized. With each year's appropriations request, the Institute has proposed a program designed to achieve its Congressionally set goals, within the limits it believed feasible given the previous request reductions. Each year, the Institute was denied the opportunity to carry out its proposed program. Therefore, the full achievement of its goals as initially envisaged by the Congress should be portrayed in this light. Reprogramming has been required each year because of the failure to receive the requested level of appropriations. With this reprogramming, the Institute has sought other means to the same end, and believes it has a sound record of progress under the circumstances.

The report also notes that a substantial portion of \$9.2 million (actually \$9.213 million through FY 1981) obtained by NIBS from outside sources was used for energy related research. The impression is given that NIBS has used a substantial portion of its discretionary funds for this purpose and, conversely, has not given adequate attention to its primary mission. Very little of NIBS discretionary funds have been used in this manner. The largest element of funding from outside sources has been from service contracts and grants--i.e., funds that have come to the Institute to perform specific services. In the case of energy, HUD

and mainly DOE have contracted with NIBS for specific energy-related tasks, most of which were in response to directives to those agencies from the Congress to do so. It might well have been in some other area of technology. The Congress has cited NIBS in various pieces of legislation that precipitated contracts, grants, or cooperative agreements with the Institute. The NIBS authorizing legislation calls upon federal agencies to utilize the services of NIBS and NIBS, therefore, is obligated to respond to such requests. If the preponderance of such requests come in one area of technology, this does not mean that this is the focus of NIBS' mission-oriented work. Indeed, NIBS has continued to pursue its primary mission with its appropriated funds and with funds it can raise from other sources for this purpose--and will continue to do so.

**[GAO COMMENT: We have noted on page 17 of our report that additional funding information was provided by the Institute and can be found in this appendix.]**

### The Future

NIBS has done and is doing everything within its power to encourage federal agency cooperation with and support of the Institute. To date, no agency has seen fit to act upon the provisions of the Act (Sec. 809 (g) (3)) that states "Every department, agency, and establishment of the Federal Government having responsibility for building or construction, or for building- or construction-related programs, is authorized and encouraged to request authorization and appropriations for grants to the Institute for its general support...." The Department of Energy has provided a general support grant to the Institute under this provision for the past 4 years (the fifth and last year will be FY 1982) but not as a budget line item approved by the Congress. The Congress envisioned this provision as a source of continuing public support for the Institute in carrying out its fundamental mission. Even OMB, after considering a circular to support this concept, decided not to overtly promote carrying out these provisions of the Act by the federal agencies. The Institute was hopeful this also would be the way it could balance public and private support of its fundamental mission work over the long term-- setting its own agenda rather than having it set by others seeking specific services. Without such discretionary funds and in the absence of the anticipated level of appropriations, it is difficult for the Institute to pursue its mission tasks with the vigor it, as well as GAO, would like to see. Ultimately, only the Congress can help in this regard. It would be helpful, therefore, if the report acknowledged that it is not so much a question of NIBS devoting more of its resources to accelerating innovation, but having the resources to do so. As stated above, the Institute feels it has done quite well given the circumstances.

### REPORT TEXT

#### Cover Summary

Although it is true that technical innovations often are not put to use because of a lack of "authoritative" technical information and demonstrated results--and certainly not as rapidly as one might hope-- it also is the case that there are deeply held convictions that certain

"innovations" will lower quality or endanger health and safety. To the extent that such convictions reflect different perceptions of exposure to risks, they are understandable. When quality is a function of livability and/or marketability, there is serious question as to whether levels of performance are the proper concern of building codes. Perhaps more important, however, are actions taken to protect local industries and jobs, and the reluctance to cope with new knowledge and acquire new skills.

Authoritative information can strip away many of the crutches used to justify not accepting new technology, but it is not likely to overcome variations in risk perceptions, nor necessarily should it. Also, the purveyor of "authoritative" information must be prepared to stand behind advice rendered--something that is difficult to do in today's liability-seeking climate.

Finally, we would agree that HUD and NIBS could do more; however, at least in the case of NIBS, help from the Congress--and not just financial help--is a necessity as has already been noted.

#### Digest, page i

The examples cited in para. 1 are reasonable even if not new; however, underfloor plenums have limited application, and 24-in. o.c. stud spacing can increase costs for sheathing and have implications for overall dimensional coordination.

The NAHB demonstration dealt with technology only in the broadest sense. The larger savings were in the development aspects of housing--e.g., increased densities, reduced street sizes, common sewer laterals--and not the house per se.

The criticism that NIBS has put forth only a low level of effort to foster technological improvement, except in the area of energy conservation, was discussed above.

The second and fourth points made i.e., that there is a reluctance of builders to accept risk and that there is a lack of information on demonstrated results achievable from innovative technology seem to pose the question and answer it at the same time.

Insofar as restrictive and inconsistently administered local building codes are concerned, the problem lies in part with political influences and in part with the need to upgrade the capabilities of the building official and his plan reviewers and inspectors. It does little good to berate the code so long as states and communities are not willing to upgrade the building department personnel to true professional status and compensate them accordingly.

The fifth point made does not appear to be supported. Increasing governmental regulation doubtless has had its effect on innovation and risk-taking--and energy saving technologies are no exception--but one needs to look at the increasingly harsh risk and liability environment to understand the dampening of interest in innovation.

[GAO COMMENT: Our fifth point--that research and development of new cost-saving technologies have declined primarily because of a substantial increase in governmental regulations--is based on a 1979 Institute study as discussed on pages 9 to 11.]

The Department of Housing and Urban Development Could Do More to Promote Innovation in Homebuilding, page ii

It must be remembered that HUD's direct impact on housing in the United States is relatively small. Housing has been and remains a largely private activity. For example, in the 1972 peak year, total starts were 2,378,500 units. Of this total, 370,900 were FHA, 104,000 were VA, 91,400 were FmHA subsidized, and 40,000 were HUD public housing, for a total of 605,900 or 25.47%. Picking the depressed 1974 year, total starts were 1,352,500. Of this total, 94,400 were FHA, 72,900 were VA, 41,200 were FmHA subsidized, and 16,700 were HUD public housing, for a total of 225,200 or 16.65%. (As an aside, notice also that rather than being countercyclical as federal housing is supposed to be, it ran with the cycle--which cannot be overly helpful to costs).

HUD could do more to identify, evaluate, and disseminate information on cost-saving innovations, but historically this has been done in the context of HUD's own programs--its activities serving as an example for state and local government and private programs. In this context, HUD has been able to exercise a great deal of leadership.

HUD has supported work in the area of model building codes; however, it should not be presumed that the model code groups are the best mechanism for determining the acceptability of new technologies. This is a task that requires the highest degree of technical competence and is related primarily to criteria and standards and prequalification in relation to them, rather than the code *per se*. Also, many opportunities for cost reduction have nothing to do with codes--the livability and marketability aspects referred to earlier.

The task of promoting local compliance with model codes and consistent administration of codes and competent administration is a difficult one for HUD in that the Federal Government has no authority in this area. HUD has sought to foster the upgrading of code officials through its support of programs of the National Academy of Code Administration, and it is seeking to cooperate with the model codes bodies in the upgrading and utilization of the Council of American Building Officials' "One- and Two-Family Dwelling Code." These are very constructive steps toward achieving better and more uniform application of regulatory requirements.

NIBS would agree that HUD's Policy Development and Research program could be better structured to accelerate technological development and its acceptance. The lack of input from the building community to program formulation doubtless has had much to do with its lack of support within the Congress as well as within the private sector. If the Congressional conference report language survives the current appropriations process, HUD will be directed to work with NIBS in formulating a research program. This would enable NIBS to not only solicit input from the private sector for a sound research program but support for that program as well.

One area that would benefit from greater attention--as it did in the days of FHA and HHFA--is problem solving, using HUD's own housing programs for problem identification. This is a fertile area not only for identifying real problems and opportunities, but for testing the adequacy of proposed solutions as well. HUD also has deep interest in the certification-of-new-technology processes (and has had a good program of its own within FHA). NIBS has asked HUD to help it in developing a nationwide system for evaluating and certifying new and innovative technologies. To date, however, HUD has not evidenced a willingness to cooperate with NIBS in such an effort. Clearly what is needed is an effort by NIBS with the support of HUD and other agencies of the federal government involved in housing and building, to fashion a nationwide technology certification system. This the Institute currently is seeking to do.

National Institute of Building Sciences Could Also Do More to Encourage Innovation in Homebuilding, page iii

The comments made regarding NIBS have been treated above. It could be added that the core staff of the Institute was not actually in place until early 1978; therefore, NIBS has been operational less than 4 years at this point.

Conclusions, pages iii & iv

The report states that NIBS has "...been very slow to act on the numerous recommendations for action to promote innovative technology made by the Task Force on Housing Costs...the National Association of Home Builders Research Foundation..., and GAO..." We would point out that the Task Force and NAHB reports were targeted at HUD and that the initiative must come from HUD to work with the Institute. The Institute has indicated its willingness to do so.

**[GAO COMMENT: We have revised the report's wording to make clear that the recommendations were addressed directly to HUD and not to the Institute.]**

NIBS concurs in the GAO finding that curtailment of research on new technologies in the home building industry is particularly unfortunate, except that NIBS would prefer to redefine the issue as one of providing fundamental data and information needed to support industrial R&D and efforts to remove barriers to, and facilitate the introduction of, new technology created by the private sector.

The Institute understands the reluctance of GAO "...to suggest additional funding..." however, the sums that would be needed are not large if properly focused. NIBS is prepared, as the previously cited Congressional conference report suggested, to work with HUD to define a proper research agenda and then to carry the case to the Congress.

Recommendation, pages iv & v

NIBS is prepared to reexamine recommendations made in the report cited and will seek an opportunity to do so with HUD. It will be difficult to redirect NIBS resources to this end because there are, at this juncture, scant resources to redirect. Nevertheless, every effort will be made to do so within the Congressional mandate to NIBS.

We would hasten to add that, as distinct from HUD, any increased effort by NIBS would not be "...a more vigorous and effective federal role..." because, as has been noted, NIBS is not a federal agency. Also, we would ask where the impetus is coming from for a more vigorous federal role.

Introduction, pages 1-4

We would agree with your opening statement. Regardless of the change in family size and make-up, the fact is that the single-family home is the preferred form of housing whether or not it can be afforded by the American family.

On page 2, there appears to be a problem of clarity in the statistical data between para. 2 and 3. A time is not given for the "more than \$80,000" average price for a new home; however, in para. 3, the average is given as \$76,300. It would be helpful to the reader if a date was given for the former, and it is made clear that the average price includes the developed lot.

**[GAO COMMENT: We have revised the report to show that the average selling price of more than \$80,000 pertained to 1981.]**

Also in para. 3, it would be helpful if the average sales price--which is given for 1980--coincided with medium family income--which is given for 1979. Understandably, comparable data may not be available, but this could be handled by citing the average sales price for 1979 as well as 1980. It should be noted in para. 3, that sales price was far from the most critical factor--it was and remains the cost of money. The cost of money also is a big part of the monthly cost. Indeed, with all of the "innovative" financing schemes, it is difficult to tell what the true price is. It would help, therefore, if this paragraph acknowledged the highly volatile finance picture in housing.

On page 3, the diagram is most helpful; however, it would be even more helpful if put in an historical context. Years ago one used to say that the good builder would get 60% of the price into the house and 40 into land, land development, financing, overhead and profit; this was reversed for the less efficient builder--i.e., 40%-60%. Therefore, getting only 47 into the house does appear to be a slippage. However, this should be documented, and I am sure HUD and NAHB (Dr. Michael Sumichrast) could help.

On page 4, para. 2, line 10, the word should be "headquarters."

In para. 4, the statement is made that relatively large builders were interviewed because it was believed they would have more varied experiences with technology than small builders. In a sense, small builders, who are in the vast majority, may be a more valuable resource. Because their risk exposure is less, some are likely to be more willing to utilize innovations. On the other hand, it is the small builder that often is the least likely to follow technological developments and be willing to invest the time and energy to learn and to innovate on his own.

Chapter 2, page 5

In para. 2, drywall is implied to have been introduced quite recently-- a few years ago. Drywall has been around for a good part of the WW II period. The report correctly cites a number of other manufactured and preassembled components; however, the key to most of these developments was the introduction of sheet materials (i.e., 4 x 8 ft) which led to much greater dimensional coordination, and in turn, to prefabricated components.

[GAO COMMENT: We concur and have made an appropriate change in the report wording.]

Chapter 2, page 6

Paragraph 1 should make clear whether the 25% reduction relates to the house structure or to total development and structure costs. Also, are the reported savings replicatable and acceptable?

In para. 2 it might be well to point out that achieving cost savings is strongly related to a reasonably consistent level of housing production.

[GAO COMMENT: We agree that the level of housing production is important and have recognized this on page 6 of our report.]

Chapter 2, page 7

Earth sheltered, dome, and solar designs are cited here for the first time. Post and beam, panelized, and volumetric modules also could have been cited as concepts that have been tried and are still being used. Earth sheltered and dome construction are not new, and it is not clear what is meant by "solar" as a design concept. Experiments in various housing forms have been going on for a long, long time. Much of the difficulty in achieving cost savings, as was noted above, lies in the seeming inability to stabilize housing demand. It also must be remembered that housing is not a high volume business. Even a 2-million unit market becomes quite small when divided into single family attached and detached, garden apartments and other low rise multifamily housing, and high rise multifamily housing--and further divided by unit size, amenities, styles, and accommodation to topography, geological and soil conditions, climate, and other factors. Components on the other hand can and do enjoy a larger share of this market. If roughly 16% (1) of the cost of a single family house is related to the shell, it is difficult to see how major savings can be achieved by focusing attention on the form of the shell. This is not to say that innovation in weather envelopes and structural systems is not important, only that this element of buildings and thus building costs must be kept in the proper perspective.

In this same para. there is mention that large mobile/manufactured homes may offer important cost savings. Here it is important that it be recognized that manufactured housing and site-built housing are built to different standards. Those for manufactured (mobile home) housing are more flexible, therefore, cost comparisons must be made with this fact in mind.

Chapter 2, page 8

Why is there such a great difference between the cost savings for 24-in o.c. stud construction reported in para. 2 (\$119) and in para. 3 (\$300-\$700)? Is it the fact that the latter includes interior framing?

[GAO COMMENT: We have revised the report's description of the latter to make clear that it includes interior framing, which is the reason for the cited difference between the cost savings.]

An earlier comment was made about the underfloor plenum concept. The fiber glass tub and fiber glass tub and shower enclosure was an innovation that gained very rapid acceptance up to a point. Even this innovation, however, has its pluses and minuses--there always are trade-offs. For example, unless the one-piece tub and shower enclosure is sectionalized, thus reintroducing parts, how does one replace it? Replacement units simply won't go through standard doors and windows. Because they are so much lighter, structural support requirements are less, saving money, but rendering such support unsuitable for replacement by conventional tub and tile. The surfaces are less resistant to abrasion; however, use of proper cleaning agents will eliminate erosion damage except for abuse or accidents. The surface is not resistant to intense heat, however, it can be readily repaired--but the materials used must be handled carefully. Finally, some consumers prefer the more conventional tubs and tile. Again, one must be careful to compare equals, and this can be done by basing comparisons--as well as requirements--on performance criteria. The creation of such performance criteria is one of the primary tasks assigned to NIBS.

Chapter 2, page 9. "Corroborated" is misspelled in para. 1.

In para. 4, it might be well to refer to "government" rather than just the federal government, and to include professional societies and profit and nonprofit research organizations as well.

Chapter 2, page 14

It would be only fair to note in para. 3, that federal agencies have had a great deal to do with increasing the rigor of safety standards--witness the issuances of CPSC, OSHA, FTC, and others. Deciding how safe we want to be and how much safety we can afford, and how much we want to be protected in the marketplace, is not a particularly rational process. This fact should be noted.

Chapter 3, page 13

In para. 1, line 2, there appears to be an extraneous "in."

In para. 2, it is not entirely clear whether HUD's intent is to distribute information on innovations it accepts in the context of its own housing programs, or innovations it feels are appropriate to all housing. As noted earlier, NIBS has asked HUD to join with it and help support a major effort to create an effective, nationwide technology evaluation and certification system.

In para. 3, it is stated that Operation Breakthrough "...demonstrated the value of industrialized (factory-built) housing.;" also, that the program did not "...meet its primary objective--creation of a market adequate to support the high production level required for efficient



industrialized housing." Because this was perhaps the most costly program in recent memory, it would be well to check the accuracy of these assertions.\*

[GAO COMMENT: Our discussion regarding Operation Breakthrough was the result of a very careful review of various project reports and other HUD documentation as well as information provided by HUD's Director of Energy, Building Technology and Standards Research Division, that corroborated our project analysis.]

Chapter 2, page 14

It might be well to refer here (para. 4) to the FY 1982 Congressional HUD and Independent Agencies Conference Report cited earlier herein--specifically, the language contained in the Senate bill which was accepted by not contesting it. That language was as follows: "...the Committee expects the Department [HUD] to enter into contractual relations with the National Institute of Building Sciences to perform the following studies...creating a system to annually review and assess the status and progress of HUD's research program and to provide input on the following year's research agenda." Therefore, although it is stated in the GAO report that "HUD officials recently concluded that any further effort to develop a specific research agenda would not now be appropriate because of budget cuts and new HUD research management," it would appear that this is at odds with the will of the Congress.

Chapter 2, page 15

In the first para., there is reference to a HUD-developed training course for building officials and inspectors. It is likely that the course being referred to is one developed for building officials by the National Academy of Code Administration under contract to HUD. The course materials consisting of three modules, (management, legal, and technical) have been published by NACA. It would be helpful to cite this achievement.

In para. 2 it is stated "...HUD, at the Institute's request and to avoid possible duplicative efforts, was awaiting completion of a current small scale Institute study of several existing national product approval systems before taking any further action." A proposed program was discussed with HUD quite some time, before a formal proposal for partial support of this program was submitted to HUD on October 14, 1981. The Institute has

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\* How did Breakthrough demonstrate the "value" of industrialized housing? There were numerous technical failures. Few if any of the units came in at prices that could be said to be cheaper than conventional housing. What "value," therefore, was demonstrated? Wasn't it the case that the primary objective was to demonstrate that housing could be industrialized and that if it was, costs would be reduced and they would capture more of the market? The effort to create markets--indeed the recognition that it would be necessary to create volume markets if there was to be volume consumption adequate to achieve economies of scale--did not come until quite late in the program and was never pushed with the same vigor as the production aspects of the program. Aggregating markets--that is, finding palatable ways of restricting the freedom of consumer choice--suffered from a dearth of ideas. One could refer to the Lustron experiment of the immediate post-WW II years, and the private sector Alsidex and Dyalite efforts of the late 50s and early 60s, as equally valid examples.

submitted the same proposal for partial support to seven other federal agencies and six organizations in the private sector in the belief that wide support and participation is necessary if any effort to forge an effective nationwide technology evaluation and certification system is to succeed. This proposed program already has been referred to several times herein.

It is suggested that para. 3 be updated to reflect the current HUD effort--in response in part to a NIBS recommendation--to phase-out the health and safety aspects of its MPS in favor of the CABO One- and Two-Family Dwelling Code for this type of housing, and any one of the three model building codes (Basic Building Code, Standard Building Code, and Uniform Building Code) for multifamily housing. The NIBS recommendation will be found in its Phase I Report "Federal Regulations Impacting Housing and Land Development: Recommendations for Change," a copy of which is enclosed.

NIBS would agree that it would not be wise for HUD to use its grant program (para. 4) to force local government acceptance of one of the three model codes even though NIBS has taken the position that all regulatory jurisdictions should adopt one of these model codes.

#### Chapter 2, page 16

The housing technology conference NIBS is sponsoring at the request and with the support of HUD (para. 2) is now scheduled for April 27-28, 1982.

In para. 3, it should be noted that the NIBS authorizing legislation provides for a Board of Directors representative of the public interest and industry sectors with the former being in the majority; also, that for the first 5 years (ending in 1981) the Board was totally appointed by the President of the United States with the advice and consent of the Senate. Henceforth, two members of the Board will be appointed each year by the President (total of 6 of 21) and the remainder will be elected by the Board (the first election took place in October 1981 and 3 new Board members were seated in November).

Comment has already been made on the material contained in the last paragraph.

#### Chapter 2, page 17

The Institute has had a program plan each year, beginning with FY 1979. This plan was embodied in the Institute's budget requests to OMB and eventually to the Congress at its request. The source of all anticipated funds--and an historical reporting of past funding--was contained in these requests so that the President and the Congress could see and assess the total Institute program. As noted earlier herein, from the beginning, OMB did not allow the Institute to go forward with its planned programs. For example, for FY 1980, a program of action was outlined for Evaluation and Prequalification of Technology, for Data Collection and Dissemination concerning criteria, standards, codes, and related research and technology issues, and for Performance Criteria, Standards and Codes. The requested sum of \$3 million was reduced by OMB to \$750,000 with no substantive discussion of the program outlined. The Program Plan referred

to by our Director of Program Planning was simply the first plan that was prepared with full participation of the Institute's Consultative Council. This latest plan--for fiscal year 1982--has now been fully approved by the Council and the NIBS Board of Directors and is operational. It anticipates fiscal year 1983 when the Institute will no longer be a part of the federal appropriations process.

In para. 2 it could be noted that the Institute's authorizing legislation also provides for income from service fees.

In para. 3, it is stated that a substantial portion of \$9.2 million in income from outside sources was used for energy related research. This has been addressed earlier herein.

Regarding para. 4, NIBS was not aware that it could request funds of the Congress to conduct a program or activity recommended by GAO. However, NIBS did inquire of GAO what it had done to bring its 1978 recommendations to the attention of the appropriate committees of the Congress. It was fully expected that GAO would press the matter with the Congress, and that NIBS could then respond with a proposed program to achieve the desired objectives. The GAO response was that it had not had time to pursue the matter; therefore, NIBS waited. NIBS was willing to respond and continues to be willing.

**[GAO COMMENT: See our previous comments regarding funding information on page 54.]**

Chapter 2, page 18

In the first para. it should be noted that the BEPS program for DOE is very near completion and that 2 reports have been delivered to the Vice President and the Congress on federal regulations referenced in the last sentence--the third report in this series will be transmitted before the end of this year. The Institute has met with the Vice President on each of the first two reports and plans to do so on the third.

**[GAO COMMENT: The Building Energy Performance Standards Program has been updated appropriately.]**

The second para. starts out with the value judgment "limited," that NIBS naturally hopes would be amended.

Under para. 1, Conclusions, it is definitely implied that NIBS is responsible for not having followed-up on recommendations by a HUD Task Force, NAHB/RF, and GAO. First, in the 4th line, there is another reference to "these agencies." Regarding the HUD Task Force, its recommendations were to HUD.

**[GAO COMMENT: We have revised the report's wording to make clear that the recommendations were addressed to HUD.]**

There is little NIBS can do if HUD chooses not to carry out recommendations made to it by its own task force. We are in close contact with the HUD staff persons assigned the task of executing accepted recommendations of the Task Force; however, to date no substantive action involving NIBS has been taken. One of the problems within HUD that has been expressed to us, are the implications of the Federal Advisory Committee Act and federal procurement policies. Apparently, these requirements are being interpreted to mean that HUD cannot deal with NIBS on a sole source basis or cannot seek NIBS advice without violating the Advisory Committee Act. This is among the issues discussed with OMB in the context of the proposed circular cited earlier. Ultimately, however, only the Congress can clarify this matter. It can be noted that NAHB is a member of the NIBS Consultative Council and is working actively within NIBS. It is to be hoped that NAHB will bring its recommendations to the table along with the many other organizations that have a vital stake in the future of housing in America. The 1978 GAO recommendations have already been discussed.

In the second para. under Conclusions, NIBS would concur that much more needs to be done and with a greater sense of urgency. As has been mentioned, within its limited resources, NIBS is pressing this matter as aggressively as possible.

#### Chapter 2, page 14

In the first para, it is stated that although GAO is not in a position to suggest additional funding, it feels the potential exists for doing more. There is no question that the potential exists, and NIBS will do all possible to fulfill its mission. But, when NIBS must seek public and private funding for such efforts, it must be recognized that progress may not live up to expectations. The President of the Institute and the elected officers of the Institute's Board of Directors are quite prepared to do all possible to cooperate with the Secretary of HUD in achieving the desired objectives.

NIBS would again hasten to add that its efforts should not be characterized as a part of the "federal role." It has the blessing of the Congress and the freedom to bring both the public and private sectors to the table in the national interest. With the help of GAO, perhaps it can garner more cooperation from the executive agencies in carrying out its assigned mission.

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#### Appendix II

Page 22. Under Washington, D.C., the Building Research Advisory Board (now under the new name of Advisory Board on the Built Environment) should be shown as a unit of the National Research Council, and thus the National Academy of Sciences--National Academy of Engineering.

Why is the National Academy of Engineering listed under Texas? It is one of the constituent elements of NAS-NAE-NRC in Washington, D.C.

Page 23. It probably is not appropriate to list NIBS under "other agencies." Perhaps a separate category of "Congressional authorized organization."

Appendix III

Page 23, para. 3. The assertion that aluminum wiring *per se* causes fires may bear more scrutiny.

Page 26, para. 2. The first sentence appears to be incomplete. Building codes set forth requirements for the protection of public health and safety, and, in some instances, public welfare. Building codes reference standards in relation to stipulated requirements. "Specifications" is not a proper term to use in the context of a building code.

Page 27, para. 2 and 4. There appears to be a contradiction between saying that codes are not a major constraint to builders and that there are opportunities for additional savings if communities accepted more cost saving items. It would be well to distinguish between code requirements and product approvals related to those requirements.

[GAO COMMENT: We concur and have clarified our report accordingly.]

Page 28, para. 2. In line 6, it should be "...because they..." and not "...because the..."

Page 28, para. 3. It might be well to point out that inspectors frequently come from the trades as distinct from being qualified professionals; therefore, the problem also stems from an education and training background quite inappropriate for one who seeks to deal with existing, let alone innovative, technology.

[GAO COMMENT: We have included this information in our report as suggested by the Institute.]

Page 30, para. 3. It is surprising that the capability of subcontractors and construction labor were not cited.

Appendix IV

Page 31. It does seem that earth-sheltered, domical, and solar houses are good examples of "unconventional design;" however, as noted earlier, one needs to be careful about references to mobile/manufactured homes which are manufactured to one standard and then must be sited, and site-built housing that is built to another standard that includes siting.

Earth-sheltered housing, domes, and solar homes go back many, many years. Sod and sod-roof houses on the prairie (even cattle grazing on the roof) go to an earlier century. Earth-sheltered structures built for civil defense were common in the 1950s. All manner of dome structures--including those of plastic--were built in the 1950s and 1960s. Many early adobe homes of the Southwest were essentially passive solar houses. But, more important, active solar predates WW II.

Regarding one passage in para. 3, again, it is difficult to see the unique energy-saving features of domes; furthermore, although the dome structure may be reasonably economical--if there is not too much fitting of triangular pieces--this does not mean that partitioning, acoustical isolation, and efficiency of spaces, will carry through the cost savings.

[GAO COMMENT: The cost-saving potential of dome structures are described in further detail on pages 35 and 36 of the report.]

Page 34. Again, the geodesic dome goes back much farther than the 1970s. In para. 3, do you mean "fabricated" or prefabricated? Sweat equity housing is quite old but has not proven successful when dealing with the average consumer--in the past he hasn't demonstrated a willingness to sweat all that much with the result that there were too many unfinished homes that the lender was still responsible for.

Page 35. In para. 3, it should be made clear that the purported savings are related to space heating and water heating respectively.

Didn't HUD report on the performance reliability--and maintenance costs--of active and hybrid systems?

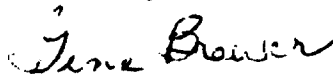
Page 36. There is need to recognize that HUD has preemptive regulatory authority where mobile homes are concerned. (Note that this is mentioned on page 38.)

It was surprising not to see a better breakdown of the cost of housing elements, a discussion of dimensional and functional coordination, and a treatment of the risk and liability question.

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We would like to thank you for the opportunity to comment on the report, and, when completed, we would like to work closely with GAO and the Congress in providing the leadership that we also recognize is needed if housing value is to continue to improve and, more importantly, if good housing is to once again be brought within the cost range of the majority of Americans. Your interest and this report cannot help but contribute to a resurgence of interest in technological development and application.

Sincerely,



Gene C. Brewer  
President



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