BARRIERS TO IMPLEMENTING ENERGY CONSCIOUS DESIGN IN HOUSING

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B. Arch., B.S. Syracuse University
1975

Submitted in Partial Fulfillment
of the Requirements for the
Degree of

Master of Architecture in Advanced Studies

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1979

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May 11, 1979

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ABSTRACT

Barriers to Implementing Energy Conscious Design in Housing

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Submitted to the Department of Architecture on the 11th of May, 1979, in partial fulfillment of the requirements for the degree of Master of Architecture in Advanced Studies.

This report is an analysis of preconditions necessary for the diffusion of passive heating and cooling into the homebuilding industry in the northeastern United States. Barriers to its implementation are identified through interviews with industry personnel and a literature survey. Emphasis is placed on housing producers and the criteria by which they are governed. Interviews with eight homebuilders whose annual sales volume in the northeast ranged from thirty to three hundred and ten million dollars were conducted in person and on the telephone. The analysis focuses on passive heating and cooling as an innovation and argues that preconditions are necessary for its diffusion into the homebuilding industry. It also suggests that the preconditions for homebuilders are linked to those of consumers and recommends strategies for getting both to implement energy conscious design. For the sake of simplicity, only new construction is considered although many of the findings also apply to the retrofit of existing stock.

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ACKNOWLEDGEMENTS

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Dedication: To my wife for bringing me to BOSTON!

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INTRODUCTION

In 1974, the Energy Research and Development Administration was created by Congress. An initial task of its solar energy division was to demonstrate the feasibility of solar heating and cooling in the United States. The resulting National Solar Heating and Cooling Demonstration Program allocated twelve million dollars over five grant cycles to subsidize residential and commercial applications. Cycles I, II, and III stabilized the fledgling solar industry by creating market demand for active solar systems.[1] Our design consulting firm, TEAMWORKS, received a request for a grant application for Cycle IV on May 15, 1978. Titled the "Passive Residential Design Competition and Demonstration H-8600," the application dealt exclusively with passive heating and cooling. Together with my father, a general contractor, we made a submission on August 2, 1978. The following is an account of that experience.

Cycle 4

The timing seemed right. We had the know how, dad had the means; and the federal government was providing the incentive. We prepared the proposal as a speculative venture, submitted it and then tried not to think about it. 260 person hours of labor performed for a chance; for evaluation of our work and the possibility of success. The months passed as did the awards deadline. The grapevine had it that the winners had been notified. We had not heard.

In preparing the submission, we had visited the site to verify its solar suitability. It was perfect. The design we produced complied with all applicable ordinances and codes. The materials we selected were stock items which were both traditional and available on the market. Assembled, they formed a two-family home; each unit with 1060 square feet of space and a full basement. The market amenities were almost standard--two bedrooms, bath, combined dining/dining room, kitchen, sun deck, backyard and off-street parking. The building was of wood and masonry with a New England Saltbox character. The difference between this and a comparable structure was a passive heating system which gleaned 66 percent of the building's seasonal heating requirements from the sun and a natural ventilation system that decreased the summer cooling load. Significant to us was that the passive heating and cooling system was inherent to the building. They were one and the same.

Prior to submission, we had explained the system very carefully to dad, the builder/developer. Five months later, when we simultaneously received award notifications, our delight was his horror. All we could get out of him was all the ways the project could fail. It won't work. It won't sell. People are not ready for it. It's too risky.

The publicity which followed the awards plus his formal acceptance of the grant agreement (for which we used strong arm tactics to achieve) caused reformulation of his initial response. After all, we had received our award ($5,000.00) and he now had the option of receiving his ($9,000.00) incentive subsidy should he complete the project. His reformulations went like this:

> I have visited local solar homes and have talked to the builder. No one around here really has a lot of experience with solar buildings. Builder X has built three which he's trying to sell for $90,000.00 apiece. That's too much! He has had federal

> grant money on all three but hasn't been able to sell one yet. If he doesn't soon, he'll go under. Do you know what the carrying expenses are? Just the debt service alone could ruin the average builder.
>
> If we go through with it ourselves, it'll be risky; especially at this location. I've been thinking. I have been following the trade literature on developments in the solar area. What we really need on this building are collectors. They'll do something.

We were incredulous. The basic notion of passive heating and cooling systems is that the building is the system and the system is the building. We had explained in great detail how our system worked. In designing it we have utilized the latest and most sophisticated simulation techniques available. And it was modeled after MIT's Solar Five demonstration building which had proven the feasibility of the concept. Yet, here the builder was suggesting that active solar panels be placed on a home which already accomplished what they could do at a fraction of the cost. How could this be? Was his reaction idiosyncratic or was it representative of the industry as a whole? This thesis tries to answer these questions and to investigate what the barriers are to implementing energy conscious design in housing.

Purpose & Scope

Energy conscious design (ECD) can be defined as a combination of energy conservation measures and solar tempering which when optimized within a specific microclimate, dramatically decreases the total generated energy requirements of a building or group of buildings. All residential buildings take account of energy in providing habitable space for human beings. The level of energy consciousness reflected in the design can differ, how-

ever, by degree. Optimally, ECD may result in passive heating and cooling; where the building acts as collector, storage and control mechanism for its own space heating and cooling requirements. This report is an analysis of preconditions necessary for the diffusion of passive heating and cooling into the homebuilding industry in the northeastern United States. Barriers to its implementation are identified through interviews with industry personnel and a literature survey. Emphasis is placed on housing producers and the criteria by which they are governed. Interviews with eight homebuilders whose annual sales volume in the northeast ranged from thirty to three hundred and ten million dollars were conducted in person and on the telephone. The analysis focuses on passive heating and cooling as an innovation and argues that preconditions are necessary for its diffusion into the homebuilding industry. It also suggests that the preconditions for homebuilders are linked to those of consumers and recommends strategies for getting both to implement energy conscious design. For the sake of simplicity, only new construction is considered although many of the findings also apply to the retrofit of existing stock.

Theoretical Framework

The homebuilding industry operates within a highly competitive free market system. The producers of housing are many and varied. The types of firms normally encountered can be classified as custom, spec, package, subsidized and diversified builders or developers. Each type caters to a distinct submarket, or some combination of submarkets. All producers play some role as developers, in fact if not in name. They can enter or leave the housing market easily and generally operate independently of each

other. They closely monitor and respond to market demand which is their livelihood. They must synchronize industry characters and criteria which are often beyond their control. Once the product is there, they must be able to sell it at a profit within a relatively short period of time. The cash flow requirments are tight, the risk is abnormally high as is the markup required to ensure they stay in business.

In getting the product to market, a producer must deal with many actors coordinating their capabilities with his own. He must resolve conflicting criteria of the building process which become increasingly complex as the number of actors increases. Depending on who the producer is and the submarket within which he is dealing, the array of actors and the weight of their different criteria for a specific project will vary. The actors are listed on the accompanying chart. The criteria by which they are governed will differ according to project type, location, feasibility and the personalities involved.

A dynamic relationship exists between housing producers and consumers. It is not entirely clear that demand is the sole determinant of supply.[2] Both must interact quite closely for change to occur. The consumer has to negotiate with an array of actors for his ability to own the product just as the producer has in order to supply it, only to a lessor extent. What he eventually buys is translated into a statistic upon which future supply is determined. For change in the product to occur, a push and pull process between producers and consumers takes place slowly over time, through a cumbersome industry framework. Consecutive cycles of "producing-selling-market demand evaluation" must take place. Producers and the consumers need to be sensitive to and conscious of this process. They need to

understand the industry framework through which change occurs. Innovation must then take place on both sides of the supply/demand equation.

A theory of diffusion of innovative energy conserving techniques among consumers has been advanced by John Darley of Princeton University[3] (theory b). It is based on the Twin Rivers Project, a five year study on energy usage in that residential new town. Darley proposed that:

- only a subset of the consumer population will feel the need for a particular innovation
- a negative state must exist which people believe can be satisfied by the invention
- a solution must be available and must work
- success of the innovation will be defined in terms of the individual user.

His findings were based on field work with clock driven thermostats which automatically lowered interior temperature during unoccupied day periods or at night. The findings comprise a psychologically based theory which identifies variables for voluntary consumer adoption of energy-conserving products and techniques. Given that innovation must take place on both sides of the supply/demand equation, a mirror image must also be true for producers because of the dynamic relationship between consumers and producers in the marketplace.

The beginnings of a diffusion theory of energy conscious design among housing producers implicit in the findings of this report are that: (theory a)

- the availability of reliable information is critical to all participants regarding normal operation of and especially change in the industry

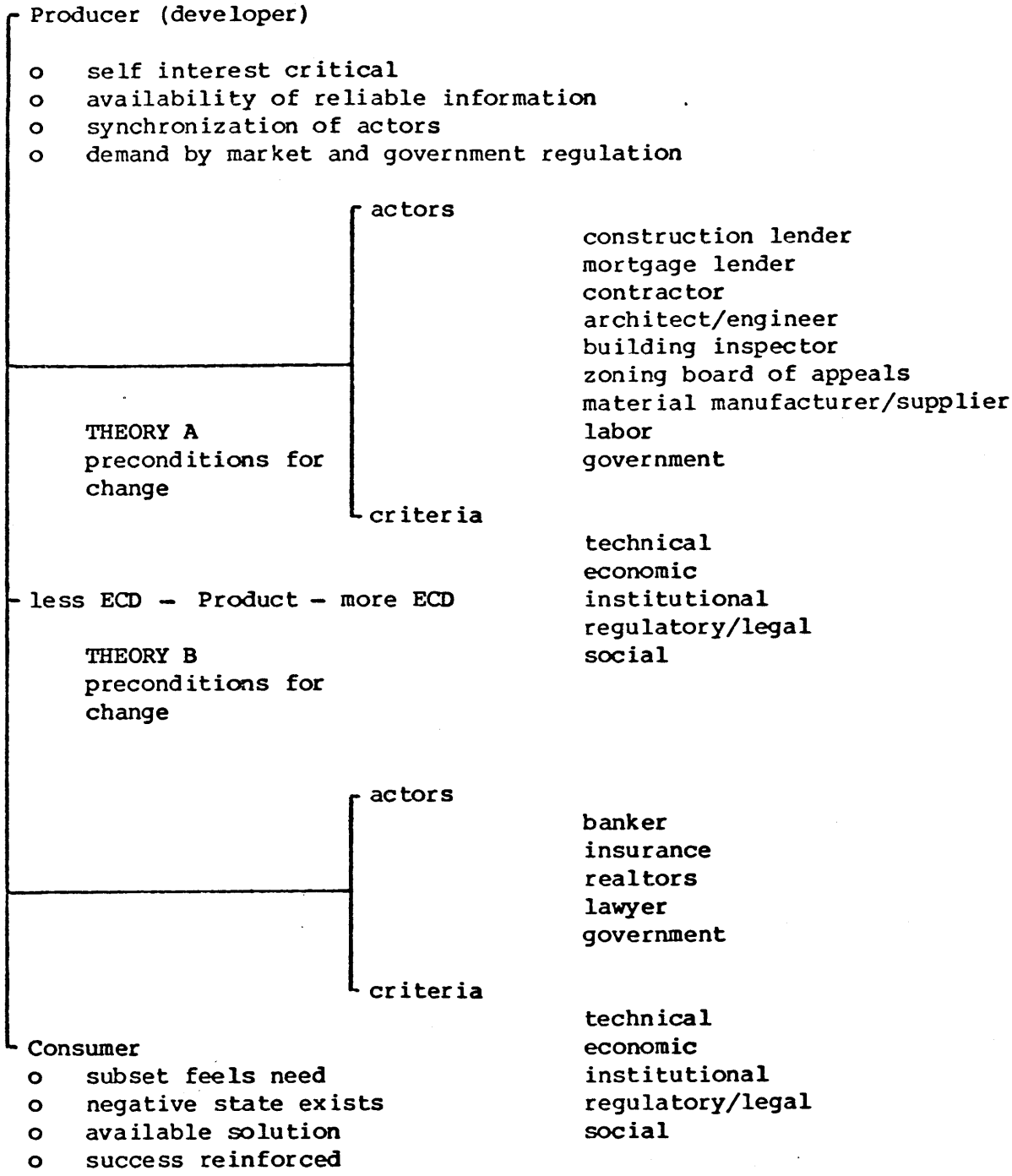
- self interest is the prime motivation among participants of the homebuilding industry
- change requires a high degree of synchronization of industry participants to achieve a predetermined goal
- demand in the marketplace by housing consumers is the most significant determinant of what producers supply after governmental regulation.

Taking the two sides of the issue together, passive heating and cooling must be in the best attainable interest of industry participants and must be founded on widely dispersed and reliable knowledge in order to succeed. All participants must be coordinated to achieve the desired results of ECD. Consumers must discriminate and demand energy efficient housing. When they demand it, builders must be willing and capable of supplying it.

Insight into the role of producers and consumers and the dynamics of change witin the homebuilding industry can be gained by the summary chart. The dynamics of the supply/demand equation, when filtered through all the industry intermediaries, begin to indicate the complexity and variety of situations possible. It is suggested that theories (a) and (b) begin to represent the preconditions of change required by two important parties to the homebuilding industry, producer and consumer, to implement ECD in the Northeastern United States.

The sections following deal with research findings from which the above suggested theory is derived. The findings are organized into the following categories: technical, economic, institutional, regulation/legal, and social.

SUMMARY CHART



This section defines energy cconscious design (ECD) by listing its major characteristics and requirements and by citing the work of existing practitioners in the field. It then documents the lack of knowledge in the homebuilding industry concerning the potential, the use and the implementation of ECD. The research finding presented is that energy conscious buildings are capable of being produced using existing technologies with acceptable payback periods. There is a lack of know how and uncertainty regarding what to do which stymies any willingness of industry participants to exploit its demonstrated potential.

Knowing What

Energy conscious design (ECD) can be defined as a combination of energy conservation measures and solar tempering which when optimized within a specific microclimate dramatically decreases the total energy budget of a building or group of buildings. Performance data on existing energy conscious homes in this country clearly illustrates that significant amounts of energy can be saved.[4] Colorado architect Richard Crowther, among others, has demonstrated in his work that with careful attention to detail, projected energy reductions of 75-95% can be achieved with increased construction costs of only 14-20%.[5]

Energy conscious design requires conservation and solar tempering of buildings to reduce energy consumption. Each can be achieved to varying degrees separately or in unison. To effectively exploit the potential of

ECD, it must be factored into all phases of the speculative development process. Starting with market analysis and land acquisition, prospective parcels must be evaluated for their inherent potential to support energy conscious housing. Climatic data for the region and microclimatic data for the specific site must be obtained and used in the design process. The characteristics of an ECD optimized home can be organized under the following categories; orientation, proportion, form and shape, landscaping, spatial organization, envelope characteristics, space conditioning, and utilities.

Building orientation must respond to a myriad of criteria which are normally less restrictive in a suburban context than in an urban one. Site access and topography, as well as surrounding land uses and built environment, influence the optimal orientation of a new home. Critical to an energy conscious home, however, are the regional climate and the microclimate of the specific site. Regional climatic data deals with the predominant wind directions, the azimuth and altitude of the sun, the amount of solar radiation incident, the percentage cloud over and amount of precipitation, and more--all on an annual, monthly and even daily basis. Microclimatic analysis allows the fine tuning of these orientational criteria to exploit them for optimal energy usage in a building.

The proportions of a building is related to the concept of optimal orientation. Extensive research done by Victor Olgyay[6] has demonstrated that there are optimal proportions of buildings for climatic regions, based on a comparison of building heat loss to heat gain from the sun. For the northeastern United States, the temperate zone, the optimal plan proportion of a home is approximately 1:2 with the long dimension oriented 15 degrees east of due south. Similar proportions are detailed for other

climate zones. It should be noted that these are not precise prescriptions, have deviational tolerances, and are applicable primarily to small buildings such as a suburban home.

The form and shape of the building can minimize adverse climatic forces while maximizing their potential benefits. The building can be profiled to minimize infiltration losses due to prevalent winter winds. It can capture, store and control solar radiation in the winter, when it is most needed, while screening it out in summer, when it is not. It can collect and direct cool summer breezes for natural ventilation of the interior. Minimization of volume can decrease the total heating and cooling loads.

Landscaping compliments form and shape considerations by providing additional means of tempering the microclimate in which the building and its occupants live. Windbreaks and earth berms can deflect and reduce incident winter winds substantially reducing heat loss due to infiltration. To a limited extent, they trap still air next to the building thus creating an insulating barrier. Coniferous trees which keep their foliage year round are most commonly used. Deciduous trees can shade the building in the summer when heat is undesired. They also provide evaporative cooling through evapotranspiration in summer. In winter they lose their leaves allowing exposure to the sun's warmth.

Spatial organization of a home is both internal and external. Internally, spaces less sensitive to temperature fluctuations should be used as buffer zones against the cold winter winds. As mentioned previously, these include corridors, closets, mechanical rooms, garages and kitchens, each of which generates internal gains. Spaces more sensitive to temperature should be located on the south side of the building to exploit the

high incidence of winter radiation striking the vertical south facing surface. These include living, dining and family areas. Entries with double door airlock are best located here to minimize winter heat loss. Bedrooms, which can be kept at lower temperatures and are unoccupied for most of the day, are more flexibly located. Vertical organization of spaces can enhance natural heating and cooling flows seasonally. Exterior spaces complement and enhance the performance characteristics of the ECD home. Patios, gravel beds, and grass can be situated to increase winter solar gains by reflection. Planting can be situated to provide evaporative cooling in front of natural ventilation inlets.

Building envelope characteristics can most effectively be described under the heading of conservation. Overall construction of high quality can significantly reduce infiltration losses. The type, placement and size of glass areas; wall mass for thermal inertia and time lag; the quality, placement and thickness of insulation; and color and texture are all factors which contribute to the energy appetite of a building. Overall surface area to volume ratio is also important to base heating and cooling loads. Special shapes such as wingwalls, overhangs, louvers, and shading devices can regulate heat flow in a number of ways.[7]

Space conditioning requirements are dramatically reduced when the above mentioned parameters are optimized. The result is a building which equilibriates with its seasonal heating load at a higher temperature and with its seasonal cooling load at a lower temperature thus necessitating less auxiliary energy to maintain human comfort conditions. Thermal swings are inherent in a solar tempered home and can be leveled off by the auxiliary heating source if desired. This will result in a commensurate increase in energy required, and thus cost. The significant fact is that

the base load of the building is being supplied by its own ability to conserve, collect, store and control energy from the sun.

Finally, the space conditioning equipment or utilities, can be selected on a basis of efficiencies and life cycle costs as well as lowest initial costs. Lighting, heating, cooling and plumbing apparatus can be selected which save energy derived from non-renewable sources. Use of all equipment, spaces and the building as a whole connotates a lifestyle different from that which abounds in the United States today, change which will occur slowly in response to and in appreciation for energy conscious design. This topic is dealt with in a later chapter.

These characteristics of an ECD optimized home can appear vague and inconclusive compared to current methods for heating and cooling. Combined, however, they allow greater energy efficiency than each alone has to offer; the aggregate efficiency being greater than the sum of the parts. In the context of this thesis, passive heating and cooling has been defined as an optimization of ECD. A more formal definition presented to Congress by Vivian Loftness of the AIA Research Corporation is:

> (a system) in which thermal energy flows through a building from collection to storage to distribution by natural means, enabling--not enforcing--the system to function without external power. The operation of a passive system involves the control of the thermal energy flow and includes the ability to stop energy flow from escaping or entering the building...and the ability to vary the timing or location of energy flow inside the building.[8]

What is significant is that the system is inherent to the building's construction. In a sense, it is the building.

When asked about ECD and passive heating and cooling, Gary Jennison, a prominent Massachusetts housing developer, made the following statement:

> We know about passive solar design because we build and own our own units. We therefore try to be as conscious as possible. We will do as much as is economically feasible. Initially, prior to 1974, we were interested in reducing our operating costs because of the profit motive. Now, post 1974, it is self-servicing to conserve because of rising fuel costs and inflation. Single family market studies performed by us indicate that people want energy conscious design because of inflation and increasing cost of fuels...
>
> The middle income buyer is looking at how much is this going to cost me now and in the future and is willing to accept a smaller house to accomplish this. Operating costs are critical to us. We are a location builder who selects dramatic sites with market appeal. This insures sales although necessitating a higher cost per unit...
>
> Passive solar is a moral obligation to my country because my country is in an energy crisis. I have to try to save a gallon of oil, just as I have an obligation to feed my family.[9]

Gary Jennison is a developer with a diversified portfolio of low density single and multi-family housing projects. His annual volume exceeds 31 million dollars. Both his architect, Sam Knucles of Sasaki Associates, and his competitors verified his stated 'obligation' to passive heating and cooling. Jennison is philosophically motivated to apply ECD within economically feasible parameters. He utilizes a nationally prominent consultant whose reputation lies in landscape and environmental design. He has analyzed a submarket, diagnosed an energy related need and readjusted his development process to accommodate it. To incorporte energy into the conventional process, he decreased the size of his units and emphasized both view and orientation to produce dramatic location homes which sold. The products, however, used only energy conservation techniques and did not fully employ passive heating and cooling. By all reports, Jennison

was motivated to use it. It is theoretically and practically possible to do so with existing technologies which are cost effective. Why didn't he?

One possible explanation is that passive heating and cooling lacks credibility in the housing industry due to lack of empirical performance data and attendant cost analysis. Industry participants rely heavily on procedures, tradition and experience. They do best what they know best. This may sound obvious, but the lack of reliable information in an appropriate format and hands-on experience is impeding penetration in the marketplace.

> We are not convinced that passive ie cost effective. We cannot prove or disprove whether or not it is. In our business, a definits NO NO is to try to get buters to change lifestyles. You can't do it and stay in this business. We need clean cut design approaches--we need information. We need to know how to modify conventional houses. We need good clean definitive information as to what it (passive heating and cooling) gives you.[10]

Dan Talbott is a staff member of the NAHB Research Foundation, Inc., in Washington. His statement reflects the national perspective of a home-building industry reprensentative on passive heating and cooling. In effect he is saying: quantify what you have to do, how much it will cost and what you get in return and on its own economic merit, passive heating and cooling will or will not penetrate the market. Didier O. Thomas, Passive Program Director of the Northeast Solar Energy Center, a private solar R&D contractor to the Department of Energy (DOE) for the northeast, goes one step further. In recalling a recent industry wide passive solar meeting in Washington hosted by Mr. Talbott et al. and sponsored by DOE, he states that:

> Homebuilders need a piece of paper which says for X dollars, you get Y amount of energy savings. The need this to give to the customer who can then see what he is buying. They also need some sort of document by a qualified professional or organization stating the estimated performance of the passive heating

> and cooling system. This is not a warranty or a certification in a legal sense, but something else.[11]

The lack of organized scientific research to accomplish this is impeding ECD's implementation by the homebuilding industry. The private sector lacks sufficient economic incentive to underwrite it and the public sector has only recently turned its attention in this direction.

Under Title III of Public Law 94-385, the Energy Conservation and Production Act of 1976, Congress specifically enlisted the help of America's designers in the nation's energy crisis. The results were the Baseline Project and new Federal Building Energy Performance Standards (BEPS). Baseline was formally known as the Research for the Development of Energy Performance Standards for New Buildings, a two phase research project carried out the by AIA Research Corporation for the Department of Energy (DOE) and the Department of Housing and Urban Development (HUD) jointly. 200 design projects and more than 750 practicing design professionals across the country were involved in "what has been called the largest architectural research project in U.S. history."[12] Reporting on Baseline, the Quarterly of the AIA Research Corporation stated that:

> Factoring energy consciousness into the design process can indeed lead to more conservation of energy than 1975-76 design practices...The savings are significant, more than 40% on the average.[13]

This assessment of the results of the Baseline Project went on to say that:

> In order for energy performance standards to be realistic, practical, and intelligently applied, it is imperative that accurate estimating tools be developed...estimating designed energy performance is not part of common practice. The task of modeling buildings and assessing their energy performance has been and continues to be an imperfect process.[14]

Existing estimating tools were accurate enough, however, for the government to issue BEPS on the strength of Baseline's research. More than 40 percent of a building's space conditioning load can be met by a more effi-

cient utilization of today's materials, methods and design processes. The effect of this regulatory code will be discussed in a later section. Its implementation demonstrates the very real feasibility of energy conscious design today.

Gary Jennison expresses a 'moral obligation' to reduce the energy consumption of his projects. His market studies indicate that people want ECD because of rising fuel costs and inflation. His prominent architect, Sam Knuches of Sasaki Associates, states:

> We try to direct clients that way (towards ECD) but usually with no success. They are interested in the bottom line...everybody is talking about it (passive solar) and everyone is trying to make the building envelopes more efficient, but they are not interested in doing passive solar...Only when the market demands energy efficiency will developers build it.[15]

A lack of know how and uncertainty regarding what to do exists in the homebuilding industry which successfully stymies the willingness of industry participants to fully exploit the demonstrated potential of passive heating and cooling. Why the private sector cannot underwrite its development within the existing housind production process is the subject of the next section. Government efforts are discussed in the Regulatory/Legal section.

ECONOMIC

This section deals with direct first costs and indirect secondary costs attributable to passive heating and cooling. Development parameters which include energy considerations are presented and the difference between first cost and life cycle cost examined. The section documents that the higher first cost of energy efficient homes impedes their acceptance in the marketplace despite lower life cycle costs and potential payback within 7-10 years. It then goes on to illustrate how indirect costs attributable to passive heating and cooling are greater than currently acceptable by industry standards.

First Cost

Conventional homes cost less to build than comparable energy efficient homes. Increasing a home's energy efficiency requires better construction, materials and design than have been commonplace in the past thirty years. The standard in the U.S. has been the lowest possible first cost with no attention given to operating expenses. This has changed recently as the price of energy needed to operate a building has dramatically increased. Now we in the U.S. are concerned. We are exclusively dependent upon fossil fuels and their price keeps rising--largely outside our national control or influence. Enter life-cycling, a concept giving consideration to the total cost of owning and operating a building over time. It is a new standard which is beginning to replace lowest first cost as a dominant market criteria. The total investment required to own and oper-

ate an energy conscious home is higher initially, but lower in the aggregate--in the life cycle costs. It has been demonstrated that the money saved by reduced operating expenses can offset the increase in first cost due to energy conscious building design within 7 to 10 years.[16] Nevertheless, the higher first cost of energy conscious homes and passive heating and cooling is impeding their acceptance and implementation in the marketplace by homebuilders.

Underlying the competing standards of first cost and life cycle costs is the time value concept of money. Simply stated, a dollar one year from now is worth less than a dollar in hand today. At the current cost of capital, 12%, this would be exactly 89 cents.[17] Two years from now and it would be worth only 79 cents, and so on. This present value of anticipated future cash flows is discounted to account for risk. The longer the term, the higher the risk and therefore the higher the rate of return must be. The result is excessive economic pressure to optimize its use right now; hence the preference for lowest initial cost.

Housing producers are in business to make money. They determine the feasibility of each proposed project according to the projected cash flows and rate of return on the proposed investment. They rely on a projected cash flow statement or 'set-up' to help them evaluate whether or not a project is worth undertaking. Generally, the higher the risk the higher the commensurate rate or return or profit must be. Risk is evaluated by market analysis, economic forecasting and the practical experience of the developer. Together, they allow him to make the critical assumptions upon which is success or failure will depend. Housing markets fluctuate. In the two to three year period necessary to bring units on line, from the idea to actuality, an originally strong housing demand may have evaporated

for reasons wholly outside the developer's control. An example would be changes in economic base, such as industry relocations, or stringent monetary policies of the Federal Reserve Board which reduce available mortgage monies. The assumptions a developer must make about consumer demand for housing are very critical. They determine his risk exposure which usually consists of complete liability for the entire value of the project. This makes him understandably conservative. Insight into the inability of energy consciousness to successfully penetrate current 'set-up' requirements can be gained from recommendations made by industry representatives at a November 1978 DOE Passive Solar Meeting:

> One of the largest contributions you (DOE) could make is the establishment of guidelines on passive solar design and construction techniques. These should develop economically based information pertinent to builders and consumers. Think in terms of expenditures and payback for the addition of solar devices in order that they give an economic benefit during the period the people live in the residence (approximately 7 years). In addition, an educational program in the form of DOE-assisted seminars will be needed across the country to inform the building professionals in the use of the guidelines.
>
> The use of simple passive techniques in conventional homes should save a lot of energy. Keeping it simple is important, for too many solar techniques will scare both the builder and the consumer. Above all, the builder must have freedom of design in order to succeed in the marketplace.[18]

Information is needed about cost and performance of passive heating and cooling systems. Reliable information about expenditures and payback periods will allow producers and consumers to choose knowledgeably between first and life cycle costs. As fuel prices increase the pendulum will swing towards the life cycle standard of energy and cost analysis. Presently however, conventional fuels and HVAC systems enjoy a lower first cost and a resulting higher preference by homebuilders and consumers.

Insight into the dynamics of first cost in the homebuilding industry can be obtained from statements made by Massachusetts developer A.J.

Lane. On the telephone, A.J. Lane sounded harried. He hadn't wanted to talk to anyone. Anxious to end the conversation, he answered the questions tersely and not without some contempt. His statement was:

> We have 6 standard models which we sell to meet the needs of the people. We determine them by what is moving in the market. We do not consider energy at all, there is not reason. We have our design and install standard equipment. Energy conservation and solar tempering would increase the cost of the home which is unacceptable. We would be willing to make reasonable adaptations, if they fit within our budget.
>
> The foremost barrier (to passive heating and cooling) is first cost. What we are trying to do is badly needed--reduce cost and provide a home for the middle class. Increased mortgage amounts are intolerable and paybacks on alternative systems insignificant. It can add as much as 32 dollars per month over the life of the mortgage.[19]

Mr. Lane is a northeast housing producer with an annual dollar volume of construction exceeding thirty million. He has dismissed the feasibility and potential of passive heating and cooling systems as costing too much and being superfluous to providing housing for people. Their effect on mortgages as the primary economic deterant is real, based on a first cost analysis. Based on a life cycle cost analysis and increasing fuel cost, however, it is a myth.

Mortgage payments typically remain constant over the life of the mortgage. Lower operating expenses of a home will increase the disposable income available for these payments, thus cancelling out the increased mortgage expense. The perception of higher mortgage payment as an absolute cost is therefore erroneous. It is, rather, a substitution of a known operating expense in the face of uncertainty and escalating fuel bills. As operating expenses increase, the highest and best use of today's dollar will be to buy fixed operating expenses via passive heating and cooling as a hedge against an uncertain future. Where necessary, it is possible to

ameliorate the effects of higher first cost by utilizing graduated payment mortgages.

Another potential economic barrier which has been anticipated by several states has been increased property valuation due to energy conscious design.[20] Left alone, higher costing homes would incur increased property taxes and would exert a negative impact on disposable income. Given the trend of constant tax increases over the last 30 years, a policy which does not take decreased operating expenses into account could be disastrous. How to best deal with increased property valuation is not known. Typically, states have exempted solar improvements and systems from property taxes for a specified period, usually 3 to 5 years. Given the resurgent housing shortages and rampant inflation of the last five years, however, property taxes will probably continue to rise in the future, thus making state measures only temporary and the issue one in need of futher study. Moreover, in the future ECD homes could be expected to inflate faster than the market because of their advantage of lower operating costs.

According to David Moore, Program Manager of the National Solar Heating and Cooling Demonstration Program, the homebuilding industry is being forced to accept a new equation of financial equilibrium in its production process--principal plus interest plus taxes plus insurance plus energy (PITI+E).[21] For industry participants, energy is a new factor in an already complicated process. The direct implication is the question: What else already in the process has to give? A.J. Lane holds that energy has no place in this equation. He has chosen to ignore the problem entirely and concentrate on the day to day cash flows of business. His motives are the accepted and necessary industry motives--making money on the bottom line. Moore contends that acceptance and recognition of 'E' will occur

only as consumers are forced to demand ECD because of higher fuel costs. This has not yet happened. He says that housing is in such demand that builders can sell anything they produce. They don't have adequate incentive to change. The incentive has to come from consumers in the form of market demand.

Conventional homes cost less to build than energy conscious homes. They are products of a conventional process whose parameters are PITI and which emphasizes the time value concept of money, lowest first cost and profit margins. Today's development parameters are changing to PITI+E. Altered is lowest first cost which is being supplanted by life cycle costing. The rate of transition will be directly proportional to increases in the cost of 'E'. The implications are that mortgage payments and tax assessments will be higher and that operating expenses will be compensatingly lower. One portrait of how housing producers perceive this transition is delivered in the words of Architect Sam Knucles:

> Our clients are name developers who are well established and very successful. Currently we are working on projects in Massachusetts, Maine and on the Cape.
>
> Motivation in this market is the bottom line profitability. The marketing and costs become overwhelming. It is critical that units sell...energy conscious will not move until the market demands for it. What is being demanded and what the main focus of the design process is is still an internal (room size) function. Design amenities are still the most sellable item. We are trying to upgrade the standard wall and ceiling components that we use. Our envelope work includes devising R 19 walls, R 30-33 roofs and ceilings, using wood windows, etc....wherever possible, except that everything is tempered by--if they (the client) can afford it. The market is slowly starting to demand it. Codes are beginning to force it. This is probably the best way. There are so many trade-offs that must be made...
>
> Views out of the units are also extremely critical as selling amenities. The package of selling amenities needs to be finally tuned to what the market wants...this is determined from what has successfully sold.[22]

Another portrait of how housing producers perceive the energy transition was delivered by Dan Talbott of the NAHB Research Foundation:

> Under what circumstances (would builders implement passive heating and cooling?)...if what they're building now doesn't sell. An additional cost of 12 to 14 percent deters sales. Not being able to sell threatens the financial stability and solvency of the builder because the carrying expenses on units are prohibitively expensive...
>
> Our point of view is that the homebuilding industry is just one of many. We feel that we are one of the few industries that has made a major contribution towards energy conservation. New homes have had their energy use reduced by 60 to 80 percent, whereas other industries have not even started. The retrofit market for instance has not even been touched because it is occupied by the taxpayers.
>
> What can be done to reduce consumption in new construction has already been done really.[23]

Consumer demand will be dealt with in a later section.

Indirect Cost

The PITI process into which "E" is penetrating has been standardized in an industry which is highly diverse, dispersed and disaggregated. Housing producers are generally autonomous within limited geographic markets. Yet their PITI requirements have created nationally standard procedures for processing raw land and developing housing. This is due largely to government manipulations of money markets via the federal reserve system, secondary mortgage markets and taxation which has sponsored continued growth nationally in the housing sector over the last 30 years. PITI is thus the economic standard by which conventional homes are produced. It is the intersection through which all parties to the process must pass either directly or indirectly. It represents the cash flows which establish the bottom line, risk exposure, rate of return and overally feasibil-

ity of building or buying a home. An energy efficient home has a higher initial cost than a conventional one. Not all of the increase lies directly with the building, however. There are indirect costs attributable to passive heating and cooling which exceed those currently acceptable in the homebuilding process. Jim Cardillo, Architectural Designer for Ryan Homes, described them as follows:

> If the lot has to be larger to accommodate solar, then you require sidewalks, driveways, utilities extension, etc....and this means more money. Also, different models will be required and the model flexibility per building per lot will be decreased. We are a proponent of heat pumps and we have a standard energy package. Talk to Dick Tracey who was recently called to Washington to testify before a Senate Subcommittee on this subject.[24]

Their HVAC specialist, Mr. Tracey stated that:

> ...our ability to optimize passive solar potential is limited by the lots available. Each site is unique and requires individual attention. Turning lots to take advantage of solar tempering requires additional land area, and requires larger lots or a variance. Larger lots cost more money and variances require time and politicing and thus money also.[25]

> Regarding conservation, a problem we have is lack of products or technical methods of insulating basements. Also a lack of technology for assessing the benefits of such insulation. Basements are a real energy sink which we are trying to plug up. The problem is that current installation procedures for insulation are not cost effective. There is a lack of knowledge of the results if and when you insulate the walls. The technology for this is somewhat beyond the times. Also, payback to the customer is not clear. There is nothing we can do now that offers economical insulation for the customer. A 7 year payback or less is our target and rule. The average customer buys another house every 7 years. The house will appreciate anyhow at the same rate whether energy efficient or not. There is a real question of whether the resale value of an energy efficient house differs from that of a conventional standard house.[25]

Evidence exists which contradicts Mr. Cardillo's and Mr. Tracey's statements. Passive heating and cooling can be achieved on non-optimal lots. A variation of fifteen degrees east or west of due south will not significantly reduce a building's solar potential.[26] Standard units within

industrial production parameters can be designed to adapt to site specific conditions. Products and technical methods of insulating basements do exist as well as the technology for assessing the benefits of such insulation. They are in fact standard items on the curriculum of Architectural and Mechanical Engineering schools across the country. Results and paybacks are clear, analyzable, and valuable as long as the assumptions they are based upon are informed, reasonable, and unbiased. Regardless, the result of adding "E" to the development PITI process is that standard procedures of land acquisition and development for the production of housing are no longer adequate. Neither are the time proven house designs and construction assemblages. They do not allow or provide for ECD.

Passive heating and cooling requires more sophisiticated site planning and building design. Current practice holds that the value of land is site specific while the energy efficiency of the building on it is not. Highest and best use is a function of location and zoning which both determine the value of the land parcel. Any building of the right use type therefore will do anywhere. This is changing. ECD must respond to regional climatic variations which evoke different design responses for different locations. A land parcel experiences its own microclimate as a function of its natural features. Water, topography, soil, vengetation and orientation cause temperature, solar radiation, wind and relative humidity to establish microclimate.[27] Understanding this allows fine tuning of the building to the environment in which it is located. The result can be significant reduction of the space conditioning requirements and energy consumption.

Land enjoys a pivitol role in the Real Estate and Homebuilding industries. It is the critical commodity. When asked about ECD, Massachusetts

developer Ronald Campanelli responded that the "price and availability of land is the problem." Mr. Campanelli produced 856 single family homes in 1977 for a total dollar volume in excess of 32 million dollars. He didn't want to talk about energy. He emphasized that:

> It is difficult to just be in business today. Housing (in Massachusetts) is a dead issue. It is very unhealthy and is only being produced for syndication purposes. Go to Atlanta or Houston (where land is plentiful and cheap).[28]

The cost of land and its treatment as a commodity for cash flow purposes runs counter to microclimatic concerns. Its development has historically been based on location, accessibility, and cheap power. It is an inherently heterogeneous commodity. Location, purchase price and associated costs, local zoning and politics, applicable codes, regulatory bodies and potential market demand as a function of regional and national economies all influence its use to varying degrees. To the developer, energy conscious land selection means increased costs because it is more difficult and requires more time than current practice allows. His time and capital are risked on the basis of potential rate of return. This hampers ability to provide energy conscious land subdivision due to the nature of land markets and valuation already described. He is competing in a market where excessive risk is tantamount to failure. In addition, the profession's history of unscrupulous land exploitation causes anti-build sentiment among regulators and public, which tends to smother issues of ECD under personal politics, preference and taste. Mr. Campanelli's statement provides insight into this issue. The northeastern megalopolis is densely populated. With good land at a premium and its costs critical to cash flow, developers will not do more than they have to unless it is worth their while economically. Currently it is not.

Other indirect costs can be attributed to the design input necessary in ECD. All land is not optimally suited for passive heating and cooling. On a north facing slope, for example, solar tempering would be difficult to achieve although conservation efforts could reduce the total space heating and cooling loads substantially. Developers are in the best position to select and market land suitable for ECD, but are only slowly realizing their potential and the need to do so. When they are concerned, they often do not know what to do. This is compounded because developer/builders traditionally do not use consultants who might know how or what or have cause to learn. Even when they do, consultants want to get paid more for it. Current consultant fee structures are inadequate for implementation of passive heating and cooling. Architect Sam Knucles of Sasaki Associates, Inc., describes the situation in this way:

> Architectural fees do not allow time for exhaustive energy analysis. Our clients (housing developers) are in the business of making money. You should try to deal with their marketing department. Mass housing requires establishing model units which are placed on the site. You never get the optimum site. The reality of the process precludes most of the (ECD) considerations you are talking about. 1) Usually the developer comes to you (architect) with a piece of land. You look at the zoning and the codes. The codes are restrictive. Dealing with any public body requires trade-offs which are not always efficient for anyone. Given the cost of the land and the suitability of the parcel for its proposed use, the client (developer) knows how much money he needs and the required density. 2) Next, we must deal with the existing infrastructure of the site and the systems involved and lastly 3) you deal with the sun. The constraints are political, economic, building construction, market realities and architecture.[29]

Whether designed by a professional or not, all buildings are designed. The role of designers is subordinated in the homebuilding industry to the cash flows of developers who make the decisions. The site analysis, resulting building design and modeling necessary to exploit ECD's potential

for lower life cycle cost is precluded because it indirectly increases the first cost of the building.

Passive heating and cooling systems are operationally unsophisticated compared to conventional HVAC systems. They represent a simpler, more natural approach to space conditioning which pairs ambient energy with human comfort directly. Yet to accurately design such a system is a more difficult assignment requiring a more sophisticated methodology and design process than conventional systems require. Critical is the experience of the designer gained by physically and mathematically modeling building performance. Adequate tools for this exist.[30] Yet, designers represent the weakest, most flexible and most compromisable link in the production chain of the homebuilding industry. At best the issue is who works for whom? At worst, who needs another specialist?

The indirect costs attributable to ECD are those of introducing a new technology into an ultra-conservative industry. When added to the high first costs, its rate of acceptance will be understandably slow. Changes of method, materials and design process naturally meet resistance which is institutional in nature. This is dealt with in the next section.

This section analyzes the homebuilding industry, its established trend towards industrialization, and specific types of homebuilders. All are examined with regard to passive heating and cooling which requires a new design methodology. The section explains how passive heating and cooling requires a highly sophisticated design process which is difficult to implement within the industry's existing infrastructure. It also explains how industrialization has produced standardized building components which are insensitive to regional climatic design and how new materials, methods and design methodologies require a long gestation period to become part of accepted practice.

Industrialization

The great depression and World War II wrought great change in the American homebuilding industry.[31] Builders were forced to restructure their production process to accommodate large numbers of unskilled workers. The emphasis was away from the craft master and apprentice tradition which had historically dominated construction since the Middle Ages. Instead, the work was molded to meet the average man for whom the government was providing a job. As the work tasks slowly became more structured and standardized, trade unions began to grow and compete over who would control and have the right to perform the increasingly segmented tasks. War then froze the domestic housing industry. All production was for the national military effort. Personal rivalries and preferences were subor-

dinated to a great military machine with sweeping powers. Housing was no longer built, it was manufactured and assembled by a vertically organized entity whose arm reached uncontested into every economic sector. The result was a further standardization and partial industrialization of housing for the military and civilian forces. The buildings were designed to be placed anywhere and were distributed indiscriminately both here and abroad. Many are still visible on army bases and universities as old housing or administrative space. Significant is that commercialization of this homebuilding process following World War II has produced standardized building components and assembly processes which are insensitive to regional climatic variations. Industrialization is an established trend in homebuilding which impedes the acceptance and utilization of passive heating and cooling. The reason lies in the definition of mass production.

Precedent for the industrialization of housing did not exist within the homebuilding industry. Prototypes were drawn from without, most notably the transportation sector. The automobile and the airplane are products of mass production. Henry Ford described it as follows:

> The term mass production is used to describe the modern method by which great quantities of a single standardized commodity are manufactured...Mass production is not merely quantity production...nor is it merely machine production. Mass production is the focusing upon a manufacturing project of the principles of power, accuracy, economy, system, continuity and speed. The interpretation of these principles, through studies of operation and machine development and their coordination, is the conspicuous task of management. And the normal result is a productive organization that delivers in quantities a useful commodity of standard material, workmanship and design at a minimum cost..[32]

The key words are standardization, speed and minimum cost. Standardization under rigidly controlled circumstances allows economies of scale which result in rapid assemble and low cost. Products are differentiated only superficially to cater to consumer tastes.

Ryan Homes is the largest housing manufacturer in the northeast and possibly the entire country. Yearly volume reached 10 thousand units worth over 310 million dollars in 1977. When asked how they obtained their designs, their energy specialist, Richard Tracey, had the following reply:

> Ryan Homes are constructed to obtain the optimum "sex appeal" status with minimum deviation from the standard models we build. We are a panelizer and systems manufacturer. We focus on cosmetics surrounding the standard models within our manufacturing capabilities. We focus upon cosmetics surrounding our basic production parameters...
>
> Yes...energy consciousness is one of our considerations. This is our fourth year to include our standard energy package in our products. This is not an optional upgrading as is standard with other manufacturers, but a standard used universally across the country regardless of climate or the type of housing.[33]

"A standard used universally across the country regardless of climate or the type of housing." This philosophy of industrialism is incompatible with ECD. Passive heating and cooling is a site specific phenomenon to which standardized system must be capable of adapting. Common practice before the environment movement, according to Tracey, was to strip and bulldoze the land bare to make it a standard commodity within the housing production process. He emphasized that it wasn't too long ago that many builders adapted the land to the house instead of vice versa. NAHB's Talbott summarized the situation this way:

> The mass market builder would scratch most of these (ECD) considerations. Everything cost money to do. When it is unnecessary, it is therefore left out. For example, Ryan Homes has a bi-level plan which is panelized and is distributed and marketed for any site over a three state area. Ryan does not develop land. It buys developed lots...The bigger the builder gets, the more he goes for production time. It used to be that they would just strip the land for ease and standardization.[34]

One could argue that it is still common practice.

The designer of a passive solar building is faced with decisions affecting thermal comfort, energy use patterns, and user involvement in the building's functions. Computer simulation techniques can enable the designer to evaluate these decisions at all stages of the design process against short and long term criteria. These short and long term simulations can be performed on the relatively inexpensive ($250 to $700) small, portable programmable calculators which are now available. Their memory capacity is limited, but their speed and accuracy allow utilization of sophisticated mathematical analyses, previously out of the reach of individual designers because of the high cost of larger capacity conventional systems. Although both the programmable calculators and the requisite software are available now, the field is new, with many substantial advances having been only in the past year alone. These design techniques have not yet been disseminated to homebuilders. Industry practice substantially precludes it.

NAHB's Talbott describes standard design procedures in the homebuilding industry as follows:

> Some builders use architects; most work with designs that have evolved from a plan service, from pirating from neighbors or a combination of both. Some of the larger have architects on their staff. The majority, those who produce 20 to 100 houses yearly, work with plans that have evolved to meet market demand. It is a non-professional plan--and usually undergoes an internal evolution.[35]

New designs are adopted with difficulty and only over a long period of time because of the experience intensive nature of the industry and the fact that most builders don't use architects. The value of industry personnel is generally related to their experience on the job: the more a

person has, the more he or she is worth. They have learned what will and will not work firsthand and are therefore more effective at getting things done. Talbott went on to say that:

> Most builders are tradesmen who have come up the hard way or are professionals (doctors, lawyers) who have no technical training...Say "consultants" to a small builder and you'll SCARE HIM OUT OF A NIGHT'S SLEEP.[36]

Most homebuilders learn by experience how to construct and market housing, are nontechnical in nature, and do not use technical design consultants. New design tools and processes for ECD which do exist are therefore not readily utilizable within this industry framework. Their dissemination awaits either the emergence of a new breed of solar design consultants or a simplification of sophisticated mathematical analysis into a form suitable to existing personnel.[37] One reason this has not yet happened is the misleading oversimplicity of passive heating and cooling.

In the U.S., people are familiar with low grade, atmospheric, ambient energy and take it for granted. The sun rises and sets and occasionally it rains or snows depending on the season. We design our buildings to keep out the rain and snow, and decrease the summer cooling load where appropriate. We do not use ambient energy. We mechanically defy and overpower it. We are wedded to a 'technological fix' whereby science and technology can solve any problem without regard to our environment. This state of mind is no longer valid. We must learn to collect, store and control it.

Passive heating and cooling can be accomplished using traditional materials and methods, but requires a highly sophisticated design process. It is the most effective long term solution to increasing the energy efficiency of buildings. It is also the most difficult to implement, as op-

posed to innovatios of materials or method, due to the unique character of the homebuilding industry.

In an extensive analysis, Francis Thomas Ventre clearly characterizes the homebuilding industry:

> (Homebuilding) is a proliferation of autonomous, atomistic, very small and short-lived establishments...(which) function as a collection of small, dispersed businesses, each showing highly differentiated and geographically self-contained sources of supply and demand...(Their) investment is built into human skills of the labor forces (and they) are distributed across the nation as the population is distributed...Power and responsibility is dispersed among large numbers of actors any one of which bears only a small fraction of the resources or power required to redirect the system as a whole...The distinctiveness of local building conditions has been among the historic causes for a localized orientation of the building industry.[38]

In such a disperse, diffuse and disaggregated arena, how can the change required for passive heating and cooling occur? Ventre states that innovation in the homebuilding industry can be of material, method or process and that material supply industries and labor unions have a vested interest in controlling the introduction of new materials and methods. Passive heating and cooling, however, can be accomplished with changes in design processes only. It has demonstrated potential with existing assembly methods and materials. According to Ventre:

> Design changes are those that neither require new material inputs nor alter traditional on-site deployment of construction tradesmen. More often than not, changes of this type involve the physical configuration of the parts in order to effect more economical fabrication and/or shoter assembly time; or for aesthetic reasons such as conformity to images in current vogue. The principal actors in design changes are the design professionals: architects and engineers, technicians whose professional pride is based on an ability to keep up with and to occasionally advance the state-of-the-art in his field. Compared to the two previous types of change--material and method--there are fewer actors who have a prima-facie argument against changes in design. This, plus the progressive ethos of the design profession, suggests that design changes should diffuse the fastest.[39]

The dilemma, cited by Dan Talbott of the NAHB, is that most builders do not use design professionals who are capable of ECD because they are too expensive. Building designs instead, are developed by internal evolution and pirating. Passive heating and cooling, which involves altering the physical configuration of the parts in order to effect greater energy efficiency of the whole, can therefore only occur very slowly.

Even with motivation and knowledge of ECD, there is a lack of new products on the market which could enhance the feasibility and facilitate the implementation of passive heating and cooling. Robert Tracey summarized his experience at Ryan Homes:

> The products that we have investigated all have problems. For example foam sheathing boards used for exterior insulation are not structural (they require additional corner bracing), are flammable (they must be covered), and are not usable on exposed walls in a basement (because they are flammable). They are difficult to seal because of their reflective foil and are difficult to use because they are not compatible with our existing equipment and processes.[40]

Mark Kelley III, an energy system engineer with Acorn Structures Inc., another housing package manufacturer, had this to say:

> Materials are unproven. They can only be proven over time. Murphy's law rules--if a new thing can be installed wrong, it will--new techniques and materials must be absolutely foolproof in order to be successfully implemented in the marketplace.[41]

The minutes of DOE's November 1978 Passive Solar Meeting contained the following comment by one of the builder participants:

> There is a segment of the industry which has not kept up with builders and that is manufacturers. You take a house and get the Btuh's down to 50,000. You ask the manufacturer for a furnace to go with this that has adequate air handling capacity for cooling, and he doesn't have it because he hasn't been keeping up with the industry.[42]

The marketplace is wanting for materials and equipment products suitable for passive heating and cooling. Their development would facilitate ECD's penetration into the homebuilding industry.

The primary source of technical change in the homebuilding industry is "innovation by invasion"--the flow of technology from one industry to another.[43] The fruits of research and development of technologically sophisticated industries are applied to homebuilding. These innovations are introduced and applied usually as a substitution of an improved product for an existing one. They are initially introduced as specialty items which eventually become standard. The MIT Solar Five Building illustrates this clearly. Under the direction of research associate Timothy Johnson, this 810 square foot solar demonstration building utilizes a new three component system to gain approximately 70% of its space conditioning requirements utilizing only 45% of its south wall surface as the solar collector. The system was derived to eliminate the glare problem associated with direct gain systems and the lack of view associated with indirect gain systems. In addition, it moderates internal temperature to prevent overheating; the single largest drawback to passive systems. It does this with three new materials: heat mirror, directional solar louvers and heat tile.[44] Heat mirror is transparent window insulation which has high transmission coefficients for sunlight and low transmission coefficients for long wave radiation. You can see through it and yet it has the insulative value of a conventional wood stud wall. Its application was adopted from the aviation industry where as "Drude Heat Mirror," it was developed to defrost airplane windshields as it also conducts electricity. The window louvers catch the sunlight and reflect it onto the ceiling. The window louvers are an existing product which was modified for this application. The storage tile ceiling contains eutectic phase changing salts which store the energy and release it only when interior room temperature falls below a predetermined temperature. These products have been

developed by government and privately sponsored university research and according to Johnson have come on-line in the market in record time, one to two years. This compares favorably with the ten year plus controversy over acceptance of PVC piping in the industry--a substitution of poly vinyl chloride for copper waste lines which has not replaced tradespeople such as plumbers and still remains to be recognized by some codes and warranties.[45] Traditionally, homebuilding is people, product and site specific which causes it to be dispersed, diffuse and disaggregated. The result is that new building technologies are accepted by housing producers and consumers slowly and require a long gestation period to become part of accepted practice and custom. The MIT Solar Five products have come on-line quickly because they are substitutions of improved products for existing ones which have a significant profit potential for manufacturers.

Further insight can be obtained by looking closer at the types of homebuilders found in the Northeast: custom, package, spec, subsidized, and diversified organization/corporation.

Builders

A custom builder produces housing on location for a specific client. He will provide design and construction services to the client or erect the building according to architectural drawings and specifications provided by the owner. Very often, he designs the building free of cost for or with the owner in order to get the job. Both utilize the information and expertise at their disposal. Yet, neither is formally trained as a designer. They rely upon published house plans, the builder's knowledge, taste, and experience and the owner's taste and budget. When supervised

by an architect, the builder must follow strict written specifications and architectural drawings. He charges more because of the increased administrative burden under the supervisory control of the architect. Usually, the wealthier the person, the greater the probability of a design professional being involved. Custom builders usually take great pride in their work and cater to a wealthy clientele.

Connecticut contractors Andrew and Charles Migani of Chas. Migani & Sons are custom builders. Their clientele consists of light industrial and residential customers. Most of their work is obtained by referrals. Yearly, the two brothers build or renovate homes under contract, on speculation or as rental income property while also catering to their regular customers. They work within a small geographic area encompassing 20 square miles in a small metropolitan area. They are tradesmen whose craft was learned through an apprenticeship in the field. As their father before them, they developed a repertoire of skills which have been tested over time. A lifetime of experience makes them wary of something so simple and fundamentally new as passive heating and cooling.

The package builder is an industrialized manufacturer of housing. He produces standardized panel and component systems which can be fabricated into a variety of different homes. His workshop is a highly automated, controlled plant which is isolated from labor and weather vagaries inherent in conventional on-site construction. He completely fabricates each and every piece of the building in his shop; tags, labels and numbers it; loads it on a tractor trailor and ships it to the site where it is erected according to his instructions by a custom builder. The owner contracts separately with the builder and the manufacturer. He selectes his design from the standard models offered by the manufacturer or by modifying a

standard model with either his own or the manufacturers' architect. Liaison with the manufacturer is almost solely the providence of nationally distributed sales personnel who operate on a percentage commission basis.

Deck House is a national distributor and manufacturer of packaged homes erected on site by a builder. In the words of Molly Tee, Communications Manager:

> We build about 300 houses yearly, coast to coast. Our salesmen work with owners. We have a standard plan book from which clients can choose or we can provide custom homes. All working drawings are done in house. We prefabricate the building and package all the building components (entirely) and ship to the site where a local builder erects the home. Our client operates through the salesman operates through the design department operates through the factory.

Regarding passive heating and cooling, she went on to say that:

> Change is slow, but a need for work on solar here is perceived and accepted by the President (of the Corporation). Why hasn't it happened; 1) the need hasn't been critically felt until now and 2) we do not have the expertise or the time to have someone prepare a proposal to the chain of command...It is happening, but very slowly.[46]

Deck House is responding to the perceived needs of its President. A chain of command also exists which must be informed. When the perceived need become great enough, the in house proposal will be prepared and acted upon. Currently, however, their buildings are not energy conscious to a significant degree. Market phenomena will be dealt with in a following chapter on consumer demand.

Acorn Structures, Incorporated, is a package builder with a national distribution, which offers a model line of solar and conventional homes. According to energy systems engineer, Mark Kelley III:

> The process of producing Acorn houses goes like this: 1) the customer comes, 2) he works with our salesperson and has the option of selecting from a plan book (ours) or planning possible modifications with an architect, 3) the owner gets a builder and contracts out the work, 4) we utilize our computer programs to read out panel schedules and lumber schedules and derive a fixed

> cost, 5) assuming cost is acceptable, we fabricate and ship to the site where 6) the builder puts together all the pieces by the numbers.

Acorn has designed energy conscious models which do achieve significant savings in energy consumption. By their own claim they are "10 years ahead of the industry standard." With improved design in hand, their experience in the field, according to Kelley, has been:

> To succeed in the construction industry, they (ECD techniques) need to be foolproof and simple. Builders must know how to do it in order to do it economically. This means that they have to have done it many times before. Since they usually have not, there are many problems as you would expect.[47]

Acorn works with its builders closely to teach them about ECD. Even as they themselves are experimenting with and refining the energy performance of their products.

The speculative builder produces housing on location without a specific client. Instead he targets his production for a specific market segment of potential buyers which he has thoroughly researched. His profit lies in minimizing his first cost and maximizing the sales price. He offers amenities in his projects based on present and past comparable in the market and sells at whatever the consumer market will bear. Home construction is capital intensive. In personally signing for construction loans, the speculative builders incurs liability for them. His risks are therefore high. If he can't sell within a given period of time, the carrying expenses on his loans will bury him. This situation occurs on every project and only one bad one will be sufficient to cause financial ruin.

A.J. Lane does not consider ECD in his work. He is a speculative developer and it is just not important. It costs more money and that will not do. He states that he would be willing to make reasonable adaptation in what he produces if they could fit within his budget. In other words,

he will do it when there is adequate market demand for higher costing energy conscious homes. He cannot and will not absorb the increase in first cost. It would decrease his profit incentive.[48]

The subsidized builder develops income producing properties which he retains and operates. Rent schedules are subsidized by state and federal programs to provide low rental housing for the elderly and the poor. The rent subsidies enable the developer to realize sufficient income and profits to make the undertaking worthwhile. At this scale, professional designers--architects and engineers--are required to be used by law. They operate closely with the developers and usually develop a close working relationship. Since profit motive is the critical element in the development process, the design of these buildings is ruled completely by numbers.

The Claremont Company, Incorporated, develops predominantly subsidized two story apartment buildings in projects ranging from 130 to 250 units on 12 to 20 acre plots of land. Regarding ECD, spokesman Jay Carney stated that:

> Energy consciousness is not an important (marketing) consideration. Rather, plan and layout, etc., are critical market considerations. You must consider 1) cost--we have a good architect whose plans are expensive to build. Most financing is obtained from (Massachusetts Housing Finance Agency) and/or HUD which necessitates a detailed budget. These budgets are trimmed as necessary to obtain financing. 2) Because we own and operate our projects, we are interested in maintenance and up-keep costs. And 3) we do select the type of energy which goes into the project.[49]

Carney's architect, Steven Nawoichick of Larkin, Glassman & Prager Associated, Inc., said it a little more succinctly:

> Buildings designed to make money are ruled by numbers. The client (Carney) tells you how much money he has to spend and how much he makes yearly. For example, for an elderly housing project, the tolerances are dictated by the clients (developers') cash flow...We have considered solar design and have reached the conclusion that at the present time, it is just too expensive... it blows the (development set-up) numbers.[50]

The diversified organization/corporation is an entity which participates simultaneously in one or more of the foregoing homebuilding specialties. It enjoys greater financial staying power and access to money markets as well as sophisticated management expertise. It characteristically works in two or more distinct geographic markets simultaneously.

Gary Jennison represents a large single and multi-family housing developer active in both the speculative and rental market. As a principal of Corcoran, Mullins and Jennison, Inc., he stated that ECD was one of their marketing considerations:

> ...but on a separate plane because the typical market researcher (who assesses consumer demand and what will sell) does not have the technical expertise necessary to make the required evaluations. The market researchers provide the data analysis and (we) the management decide (how energy efficient our homes are). Indirectly energy consciousness is (thus) taken into account. You can see what is selling in the marketplace. We have found that smaller units are being absorbed. Better energy conserving construction costs more and one way of absorbing these costs is to make the unit size smaller. It decreases the amount of energy required (by the building).
>
> We have been doing this from 1968 up--all during the inflationary period. We know from our market studies that the low price buyer wants the bottom line price.[51]

Recognizing the importance of low first cost, Jennison decreased the size of his units initially to balance out the increases in selling price and operating expenses due to inflation. With the emergence of market demand for energy efficiency, he has decreased the unit sized even further to accommodate the new development standard of PITI+E.

All of these producers are serviced by a materials distribution system which is geographically dispersed as the builders are themselves. Materials manufacturers are out-of-towners whose products reach builders through an army of merchant middlemen distributors and wholesalers. Ventre has expressed this:

> ...the local institutions--not their national counterparts--are the primary agents...Where the builder deals with hundreds of local suppliers and a dozen specialty contractors, the manufacturer is an economic isolate, dealing with far fewer local institutions. These differences...have their consequences in the differential impact that the two groups have on the determination of local regulatory policy and practices.[52]

Regulatory issues are dealt with in the next chapter. Why producers of housing are not exploiting ECD in the marketplace remains, in part, unanswered. Ventre cautions us against oversimplification:

> ...Two or three-actor scapegoating betrays an ignorance of the dynamics and the complexities of the construction enterprise.[52]

In summary, industrialization is an established trend in homebuilding which impedes the acceptance and utilization of passive heating and cooling. The basic philosophy of industrialization, standardization, is incompatible with ECD which is a site specific phenomenon. Standardized systems must be capable of adapting to differing microclimates if passive heating and cooling is to be implemented. New design tools for ECD are adopted with difficulty and only over a long period of time because of the experience intensive nature of the industry and the fact that most builders don't use architects. New building technologies are adopted slowly over time, require a long gestation period, and must be accepted by all participants to the housing process. This is best described in the words of developer Don Lashley of John M. Corcoran & Co., a 30+ million dollar annual volume Massachusetts multi-family housing producer:

> A balance must be achieved. To gain energy, you (the developer) have to face the possibility that you might lose market share. The more energy conscious a unit is, the less rentable (or salable) it becomes because of less window area, poorer views, smaller rooms, views foregone because of optimum solar orientation, etc. This will balance out over time. Over time, things will resolve and change for the better. The industry is a tangled web--one little thing influences other things down the line.[53]

Mr. Lashley is misinformed about the implications of passive heating and cooling. His units should ultimately be more rentable because they must have larger window areas and interior spaces for passive heating and cooling to be implemented. Views can be equal or better and depend ultimately on site selection.

ECD might be influenced by different types of developers within the homebuilding industry in many ways. Custom and other very small package, subsidized and speculative builders will market passive solar homes to a small but growing consumer segment. Their product shall be regarded as a novelty, primarily for the wealthy. The smaller builders will introduce ECD and guide it into public acceptance. The larger building entities, primarily package, subsidized, speculative and diversified, will enter the market once solid demand is established. It is difficult to isolate the market share of each builder type because most are involved in at least two or more of these submarkets. According to NAHB's Talbott, however, "ninety-five percent of all homes produced in the northeastern United States are produced by builders who produce twenty or less units a year."[54] This figure includes those produced by prefabricated housing manufacturers.

This section discusses the regulatory and legal aspects of ECD. Legal precedent, land use control mechanisms, and existing patterns of growth are evaluated in relation to passive heating and cooling. The section argues that a lack of precedence in both regulatory and legal decision making has created a high level of uncertainty for all parties to the construction process; that existing land use patterns, zoning and regulatory requirements are not conducive to energy efficient site planning; and that government policies are inconsistent with the stated goal of energy self-sufficiency.

Precedent

> In 1586, an English landowner planned to build a house so near the property line that it would obstruct light that entered the window of his neighbor's house, which also was very near the line. Because of the importance of that light, his neighbor went to court to prevent construction of the new dwelling. The judge in a very short opinion held that landowners should foresee the consequences of building so near property boundaries and that they could build anywhere they pleased directly above their own property, even if it obstructed light that otherwise would cross the property line.[55]

In rendering his decision, this judge from long ago created a maxim which underlies all property law in the United States--He who owns the soil owns also to the sky and to the depths. Ownership extends vertically up and down from the property's boundaries, but not across adjacent land at angles necessary to intercept the sun. Use of that air space over a long period of time, usually twenty years or more, will establish an affirmative easement. This is a legal right of access to air space above someone else's property and is conferred by its uncontested use over many years.

Its exercise is rare, because of our historically rapid rates of growth and change. More common in dealing with property rights is a negative easement. This allows property owners to covenant not to utilize specific parts of their property. An agreement not to obstruct a neighbor's solar access can thus be purchased. The price is normally so high, however--it usually equals that of the land is urban areas--that guaranteed solar access is prohibitively expensive.[56] Public sector mechanisms which could insure solar access for homeowners, such as zoning, are predicated upon standards having no relation to ECD. Other regulatory mechanisms such as building codes and minimum property standards focus primarily on human comfort and safety, largely ignoring energy consumption as a minor consideration. Private sector mechanisms, such as restrictive covenants, currently deal only with architectural styles and preservation of property values although they could be used to deal with sun rights. How do these all relate to passive heating and cooling? First, existing land use patterns, zoning and regulatory requirements are not conducive to energy efficient site planning and often have conflicting requirements and goals. Second, the lack of some precedence in both regulatory and legal decision making has created a high level of uncertainty for all parties to the construction process. The increased risk to developers, financiers and investors has seriously impaired application of passive heating and cooling in residential construction.

Private sector participants attempt to optimize their economic returns. Public sector participants regulate them to insure minimum standards of health, safety, morals and welfare by representing societal needs and non-economic considerations. The result is a process whereby residential land use patterns are developed slowly over time. It can be charac-

terized as complex, time consuming, costly, and in a state of constant evolution. As it exists today in the United States, this development process does not give credit, recognition or allowance for utilization of decentralized, natural energy sources. Gary Jennison describes it in this way:

> We know what energy conscious building design is. We know what passive solar building is and we know what we have to do to get it. Multi-family housing is so tough that our primary goal is just getting the building permit. There are approximately twenty-one regulatory boards that we have to go through. By the time we get through all of them, the original building that we submitted has always been changed, often to meet the whims of the bureaus. We are lucky to come out with the same plan.
>
> For example, the zoning board as per their ordinance requires one building per lot with a 150 foot legal frontage. They define the lots and require the orientation to be a specific way on each site. We have no say except to seek and request a variance. This is costly as it requires time and delay and therefore money.
>
> Or the Conservation Commission wants drainage to be a certain way. It has to be. They are negotiable, but only to a limited extent. They are not ill intentioned--none of the regulatory boards are--they just follow their rules to the letter of the law. It is not ill intentions of the regulatory bodies, just incongruities and inconsistencies in their regulations which foreclose the passive solar option.
>
> All building is looked at askance by every regulatory body. The builder/developer is the enemy. The apartment builder always gets the second best sites in town. The subsidized housing builder gets even worse sites via zoning. The poor are discriminately zoned away from the wealthy. Unfortunately, the worse the site, the worse the potential to apply and utilize solar design...[57]

Each of these regulatory boards by its nature upholds currently energy-inefficient patterns of residential land use. It reinforces the status quo which is based upon inexpensive, portable, non-ambient energy. They are well intentioned, relying on past experience and their legislative charters for guidance in decision making. To the developer of housing, they appear as obstacles which make his life difficult. Just as he must be

made knowledgeable and be primed for ECD, the regulators and their guiding statutes and codes must also be. All must be upgraded to the new development standard of PITI+E with their competing interests correlated to facilitate, not retard, ECD. NAHB's Tabott emphasizes the inertia inherent in the present process:

> Builders face a time requirement which deters the feasibility of anything touching change in the accepted practice, like passive heating and cooling. Normally, a project may take 2-3 years before permits are obtained. There are so many regulatory bodies and other obstacles in the way. Builders, therefore, avoid all things that delay or have the potential to delay a housing package.[58]

This sentiment is crystallized in a statement by Edward Sidmund, a director of the Real Estate Division of Beacon Properties, a highly successful Real Estate development corporation dealing in both commercial and residential properties in the Northeast. When asked about ECD:

> I am a conservative business man and deal in certainties. Solar is not a proven commodity. I cannot take upon myself the risks inherent in developing a new technology.[59]

Anything not proven experiences difficulty in becoming accepted. One of Sidmund's counterparts in the regulatory sector, Lois Champy, reinforced this sentiment when she stated:

> (ECD is not being implemented in the marketplace because) it is impractical and undesirable to orient all the buildings the same way.[60]

She is the chief architect of the MHFA, who reviews all projects seeking funding from the agency. It is significant that her experience as a regulator of subsidized housing production has lead her to view passive heating and cooling are impractical and undesirable, solely because of orientational criteria. Her experience as an industry participant precludes recognizing the feasibility of ECD. A case can be made for passive heat-

ing and cooling within existing land use patterns. ECD in the form of conservation is, of course, viable regardless of orientation.

Land Use Patterns

The automobile in America has formed unique patterns of land use. Historically, the fringes of the city were populated first by the poor and later by the wealthy. As urban centers matured, except for isolated pockets such as Boston's Beacon Hill or Philadelphia's Society Hill, the bulk of the wealthy and well-to-do left the urban core and settled in less dense fringe areas of the city. Primarily to avoid the real and perceived evils of the central city, these first fringe-urbanites were initiating a process of upward and outward filtration that has characterized the life cycle of our housing stock. Travel time to and fro was measured in terms of the horse drawn carriage. With the advent of the street car trolley, initially horse drawn and later to be electrified, the fringes suddenly became accessible to elements of the rising middle class. These street car suburbs are readily visible today in a city like Boston with its Arlington or Commonwealth Avenue trolley lines. Of significance is the attitudes and perceptions towards the city that these occurrences represent--an overwhelming desire to find the healthiness and qualities associated with the pastoral ideal by leaving the crowded and fearful conditions of the older central city. This societal frame of mind coupled with the availability of inexpensive farm land on the periphery, ripe for speculative development, set the stage for future growth. With the introduction of the mass produced automobile, this play exploded into action drawing the entire audience into the drama of participation. As change and urban-

suburban expansion bred more change and expansion government (subsidation) of the interstate highway system and the aviation industry decreased the age old barriers to land accessibilty thus precipitating a new era of land use. When coupled with government subsidation of individual home ownership via income tax credits and the creation of government sponsored secondary mortgage markets, suburbia quite obviously is not an accidental occurrence. This suburbanization of America today accounts for a significant portion our population.[61] It is characterized by decentralized, low-density sprawl. With its maturation, retail, commercial and industrial interests have followed the work force out into the country. The results are our existing land use patterns.

The merits or lack thereof of these phenomena are not within the purview of this study. Of significance is that low density, decentralized, suburban housing is a major form of housing in this country and that it readily lends itself to the decentralization and diversification of energy usage. High density urban concentrations can achieve greater efficiencies of energy expended per person, but their inherent geometries substantially preclude the use of low grade ambient energy. Suburbia, with its low density land use, allows the utilization of ambient energy to a high degree. Where solar tempering is precluded by existing street patterns, adjacent buildings or natural terrain, energy conservation can still reduce consumption by the building. Efficient building envelopes and equipment are applicable anywhere. ECD is feasibile but difficult. Adequate economic incentives could establish precedent by which regulatory bodies could learn about and adjust their process to PITI+E. Critical to this rate of diffusion in homebuilding will be the role of government.

Henry Lee, a recent director of the Massachusetts Energy Policy Office stated that:

> The primary obstacles (to ECD) are a lack of sensitivity to the energy issue and societal resistance to change. We are concentrating on education of the public and regulatory mechanisms which force compliance to an energy code. It is a slow, time consuming and costly process, but will be effective in the long run...if time doesn't run out.[62]

His strategy is education and regulation, over time. His efforts and those of his agency were mandated by Congress and were paralleled by almost every state in the union. Simultaneously, the federal government was formulating BEPS from the results of the Baseline Project. The strategy was to force, through a federally mandated regulatory code, greater energy efficiency in new construction. The new code is performance oriented and will require knowledge of ECD. The federal government has mandated this based on research which concluded that it was possible to do, but that few people knew how because it was very difficult and new. The results of Baseline also concluded that R&D and educational efforts were critical to the nation's ability to exploit ECD in the near future. Despite these results of its own study, current R&D funding for solar accounts for only 4 percent of DOE's 10 billion dollar budget.[63] When coupled with existing price supports of fossil fuels, government policies are presently inconsistent with the stated goal of energy self-sufficiency. This is due largely to competing special interests which make the political realities of governmental decision making harsh and exacting. Oligopoly, wealth and the brute power of big business and lobbies make the creation of a coherent federal energy policy almost impossible. President Carter's 'moral equivalent of war' declaration of 1977 and his inability to push the related plan through Congress testifies to this.

Despite its cumbersome and overlapping and sometimes conflicting efforts and the small scale of its commitment, the federal government is playing a pivotal role in the development and dissemination of ECD technologies. The National Solar Heating and Cooling Information Center has been established as a clearing house to facilitate dissemination of technical and educational material. The National Solar Heating and Cooling Demonstration Program is creating the needed solar industry and ECD prototypes in the marketplace to teach both housing producers and consumers alike about ECD. The creation of regional Solar Energy Centers and a Passive Solar Plan recognizes the site specific nature of ECD within regional climate zones.[64] Much is happening, but slowly. As a nation, we will achieve self-sufficiency, if, as Henry Lee stated, "time doesn't run out." Regardless of incentives by government and implementation by housing producers, the most critical factor in overcoming this dilemma is the role of the consumer.

SOCIAL

This section assesses why the United States is experiencing an energy shortage and the nature of its energy consumption patterns. It suggests that energy utilization in American society is diffuse and penetrating and that Americans are not aware of the amount of their consumption or the degree of their reliance upon fossil fuels. It concludes that strong demand for passive heating and cooling does not exist in the residential home-building industry in the northeastern United States at the present time.

Historical Context

The arab oil embargo of 1973 signalled the beginning of a new era for America. Propagating a consumer society which was consuming 35 to 40% of the world's energy resources while supporting only 6% of its population had seemed a significant accomplishment. Prosperity based upon economic growth was proof that higher standards of living could be attained readily under our social, economic, and political system. The embargo illustrated the strategic vulnerability that the United States had exposed itself to, increasingly so since the 1960's, when in order to sustain its rapidly escalating appetite for continued growth, it had begun importing foreign oil to meet needs which domestic sources could no longer supply. Yet more distant but of greater significance, the embargo indicated clearly that dependence on one energy source was inherently dangerous, threatening the very continuation of post-industrial societies worldwide. Any one natural resource is finite. Any one depleted resource has the potential to upset

the natural balance of ecological systems evolved over the millenia. Yet, caught in the momentum of our own progressive development, we have pursued growth in a narrow and blatantly exploitive manner oblivious to the longer term implications of our own actions and ultimately, their irresponsibility.[65]

The natural environment has developed on this planet for hundreds of thousands of years. Yet, from 1800 to 1973, we have subdued it in the name of progress at a rate infinitely larger than its capacity to regenerate. We have subordinated it to our immediate goals of growth, progress, and development to the detriment of longer term realities and in the case of the oil embargo, the eventuality of insufficient supply. This will produce chaos in a mono-energy dependent society such as ours--chaos proportional to the degree of our dependency and the curtailment of supply.

Energy usage touches, penetrates, is in some manner related to or responsible for all aspects of everyday living in America today. Its availability in a portable, convenient form which has a high latent potential per unit volume and is inexpensive has dramatically affected us. Our lives are filled with devices designed to eliminate all but the most essential labors in the home and on the job. Our buildings are internally conditioned to a high level of mechanized control supportable only by large stocks of mechanical and electronic hardware and an unlimited supply of energy. Our land use patterns (post-automobile) reflect unlimited personal rapid transit propagated on convenience, economic growth and, by self fulfilling prophecy, necessity. Yet, the "high" standard of living implied above need not be synonymous with conspicuous consumption as it is today. Such a change in our cultural values and perceptions are not only

desirable but necessary as we begin to contemplate the consequences of ignoring this all too real problem.[66]

Energy utilization in American Society is diffuse and penetrating. Americans are not aware of the degree of their reliance upon fossil fuels. The buried cost of energy in our consumer society and our extravagant consumption patterns makes individual efforts of conservation, such as passive heating and cooling, seem unimportant. They lack credibility.

When asked if Ryan Homes was considering passive heating and cooling for any of its 310 million dollar annual housing volume, Richard Tracey responded:

> No, only to the extent that we have met with DOE and other housing manufacturers at the request of the NAHB in a round panel discussion. The objective was to determine why Passive Solar Systems are not being used by major builders. We are not dismissing the possibility. It is just that it (passive solar) is not easy to implement with our (building) system. DOE has solicited us to do research with our products. We have other priorities right now, however. We are interested in the concept but are not doing anything right now.
>
> We would consider the steps you are talking about only when and if market effects were severe enough to do anything more than what we're doing right now. We are developing means of achieving some of these things now. If we can do some of them, we will. But these are not conducive to mass production. Our projects must be designed to that particular end. We will do these only if it is necessary to save energy at any cost. Now, we will do only what is economically possible.
>
> The homebuilding industry is only reducing energy consumption because it is salable. It is not being done because of the energy crisis. It will not be done because of the energy crisis. Comparative cost is the real motivation...The customers don't care enough to demand it. Energy is not dictating the desires of the populace.[64]

Homebuilders produce only what they believe they can sell. When asked about ECD's relationship to marketing considerations of the typical builder, NAHB's Talbott states:

> the biggest element is WHAT WILL SELL THE GREATEST NUMBER OF HOMES - WHAT WILL SELL THE GREATEST? From there, it depends on

> what the individual (builder) does. Whether he is a custom builder for a high price buyer or a cheapie who will shotgun it to make a buck. Most take a middle of the road marketing approach. They are interested primarily in what will move.... (builders) are doing only what they feel they have to to keep their customers. Builders will not go the energy conscious extreme unless market requires it.
>
> Industry wide...we have not considered passive heating and cooling. Those who have represent such a small percentage that they wouldn't show up nationally...(builders will when) what they're building now doesn't sell.[65]

Given that homebuilders will market whatever they can sell the greatest number of, consumers are not demanding ECD or it would already be available on the market. At present, strong demand for passive heating and cooling does not exist in the residential homebuilding industry in the northeastern United States. Consumers are demanding the status quo. The preconditions necessary for them to demand ECD have been dealt with at length by psychologist John Daley of Princeton University and are presented briefly in the introduction of this report in the section titled "Theoretical Framework."

SUMMARY

ECD has a demonstrated potential to economically reduce residential energy consumption of new homes in the northeastern United States. This report investigates what ECD is and why its potentials have not been exploited to date in the marketplace. The material is presented largely from point of view of producers of housing who monitor consumer demand closely in developing and marketing their products. It may be summarized as follows:

- Energy conscious buildings are capable of being produced using existing technologies with acceptable payback periods. There is, however, a lack of know how and uncertainty regarding what to do which stymies any willingness of industry participants to exploit its demonstrated potential.
- New building technologies are accepted in the marketplace very slowly and require a long gestation period to become part of accepted practice. Materials, methods and design processes of the construction industry are primitive and rudimentary compared to Aerospace and Automobile industries.
- The higher first cost of energy efficient homes impedes their acceptance in the marketplace despite lower life cycle costs and potential payback within seven to ten years.
- Indirect costs attributable to passive heating and cooling are greater than currently acceptable by industry standards. Solar siting requirements conflict with standard real estate procedures for land acquisition and development.

- Post World War II industrialization of the home building process has produced standardized building components and assembly processes which are insensitive to regional climatic variations. This trend impedes acceptance and utilization of passive heating and cooling concepts.
- Passive heating and cooling can be accomplished using traditional materials and methods, but requires a highly sophisticated design process. It is the most effective long term solution to increasing the energy efficiency of buildings. It is also the most difficult to implement, as opposed to innovations of materials or method, due to the unique character of the homebuilding industry.
- The lack of precedence in regulatory decisions has created a high level of uncertainty for all parties to the construction process. The increased risk to developers, financiers and investors has seriously impaired application of passive heating and cooling in residential construction.
- Existing land use patterns, zoning and regulatory requirements are not conducive to energy efficient site planning and often have conflicting requirements and goals.
- Government policies are inconsistent with the stated goal of energy self-sufficiency. Existing artificial price supports by government of fossil fuels is seriously retarding the economic competitiveness of passive heating and cooling in the marketplace.
- Energy utilization in American society is diffuse and penetrating. Americans are not aware of the degree of their reliance upon fossil fuels. The buried cost of energy in our consumer society and our extravagant consumption patterns makes individual efforts of

conservation, such as passive heating and cooling, seem unimportant. They lack credibility.

- Strong demand for passive heating and cooling does not exist in the residential homebuilding industry in the Northeastern United States at the present time. Consumers are demanding the status quo.

The beginnings of a diffusion theory of energy conscious design among housing producers implicit in these findings are that:

- the availability of reliable information is critical to all participants regarding normal operation of and especially change in the industry
- self interest is the prime motivation among participants of the homebuilding industry
- change requires a high degree of synchronization of industry participants to achieve a predetermined goal
- demand in the marketplace by housing consumers is the most significant determinant of what producers supply after governmental regulation.

Passive heating and cooling must be in the best attainable interest of industry participants and must be founded on widely dispersed and reliable knowledge in order to succeed. All participants must be coordinated to achieve the desired results of ECD. Consumers must discriminate and demand energy efficient housing. When they demand it, builders must be willing to and capable of supplying it. Things that can be done to satisfy these preconditions for change and which require further study are now evaluated.

A lack of know how and uncertainty regarding what to do is inhibiting homebuilders from exploiting the potential of ECD. It can be accomplished using existing materials and methods but requies a new design methodology. As a new building technology, it requires a long gestation period to become part of accepted practice. The dissemination of reliable information in a form usable by homebuilders is a precondition for diffusion of ECD into homebuilding. This can be achieved by government sponsored research and development and educational efforts or by private industry when and if market potential justifies underwriting the cost of ECD's development. Specifically, means of certifying and warrantying passive heating and cooling systems need to be developed; regional constraints necessary for ECD must be formalized and quantified; and sophisticated design processes necessary for ECD must be translated into comprehensive design manuals for professionals and simple rules of thumb for laymen.[69] The government through the Department of Energy is sponsoring research and development.[70] It is also prompting the private sector with mixed results as revealed by interview data presented.

The higher first cost of ECD homes impedes their acceptance in the marketplace regardless of a reduction in operating expenses which pays back the additional investment within seven to ten years. Indirect costs attributable to solar site selection and design are also incurred and must either be absorbed by the homebuilder or passed on to his customers. Homebuilders must develop new standard models which are sensitive to ECD and capable of industrialized production. That ECD be in the best self interest of industry participants is a precondition for its implementation. This can be accomplished by restricting standard mortgage instruments to accommodate higher initial costs such as a graduated payment

mortgage or expanding government guaranteed loan programs such as FHA or VA to indirectly subsidize ECD. Incentives can be created for land developers primarily through zoning concessions. The critical importance of cost to housing producers is a theme pervading the research data presented.

Government policies are inconsistent with the stated goal of energy self sufficiency. Existing artificial price supports seriously retard the economic competitiveness of ECD. The lack of regulatory precedence and the existence of land use and zoning patterns non-conducive to ECD is also inhibiting its implementation. A synchronization of national energy policy and local land regulation and building processes is a precondition for diffusion of ECD into the homebuilding industry. Efforts must be coordinated to be in the best interest of builders, regulators and consumers. This can be accomplished by removing artificial price supports and developing a coherent national energy policy and through local legislation and zoning changes which create certainty about solar access and allow for the modification of existing land use patterns to accommodate the new development standard of PITI+E. Again, government, the homebuilding industry, and the public must work towards that end and it must be in their self interest to do so.

Energy utilization in American society is diffuse, penetrating, and extravagant. Passive heating and cooling in comparison lacks credibility. Homebuyers in the northeastern United States are currently demanding the status quo. Demand for ECD by consumers is a precondition for its implementation in the homebuilding industry. This can be achieved by educating consumers about the dangers of and their degree of reliance upon imported fossil fuels and by identifying and exposing wasteful uses of petroleum. Another strategy could be to evaluate the criteria by which consumers make

decisions regarding home purchases and manipulating them to spur demand for ECD. These could readily be implemented by the government or industry research organizations.

Ralph Johnson, the president of the NAHB Research Foundation, Inc., is a nationally recognized expert on the residential home building industry. He summed up the barriers to implementing ECD in housing eloquently when he stated:

> ...the list of obstacles is long and complex. It includes...the fundamental lack of technical information on how to reliably determine cost effectiveness of various energy conserving techniques...the mortgage finance system which does not really adequately consider the total cost of home ownership of energy savings...the reluctance of people to pay higher prices for homes that are more energy conserving because they won't get their money back for quite a few years...code requirements that are anti-energy conserving...cheap energy (gas); inadequate mechanical equiment for space heating and cooling for very well thermally protected homes...inadequate facts and research data...and a number of other items.[71]

Less eloquently, but more to the point, Architect Sam Knucles of Sasaki Dawson, Associates concluded:

> The housing market is an odd ball. You are not dealing with an ordinary building which can be tailored to its site and custom designed...The barriers (to ECD) are all tied together. Developers are marketing what the public wants. When they (the public) start to demand it, developers will offer it. They are oriented towards high volume, high profit operations. Costs are very important, both first and life cycle. It is starting to happen.[72]

A NOTE ON METHODOLOGY

This study was undertaken over a 6 month period from the fall of 1978 to the spring of 1979. The strategy was to cover pertinent literature and focus on in-person and primarily telephone interviews with developers and industry and government personnel. The size of the sample was small due to time and cost constraints. Additional data ceased to be sought when it became overly repetitious with that already obtained. Of the eight developers contacted, the smallest had a dollar volume of 30 million annually and the largest 310 million. All were located and worked in the Northeast. They were asked to respond to the following questions:

- How do you obtain the designs for your buildings?
- What market considerations are involved in choosing the designs?
- Is energy consciousness one of the considerations of your projects?
- Have you considered passive solar design as a means of decreasing energy usage in your buildings--through conservation and solar tempering?
- What problems are there in making energy consciousness one of your considerations?
- Do these problems include cost, reduction of amenities, zoning, code restrictions, financing, or insurance related matters?
- The new federally-sponsored national energy code will require the reduction of energy usage by buildings. How will you comply with these requirements?
- Many things can be done through conservation and solar tempering to decrease energy usage by buildings. This involves the manipu-

lation of proportion, orientation, form, landscaping, spatial organization, and envelope characteristics to minimize heat loss in winter and heat gain in summer, and maximize the collection and storage of solar radiation in the heating season while excluding it in the cooling season.

- Under what circumstances would you be willing to or find it necessary to make energy conscious building design a major consideration in your work?
- Do you recognize any difference between passive solar building design in the homebuilding industry and the energy crisis in general? Are they one and the same?

Their answers provided the primary data for this report.

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